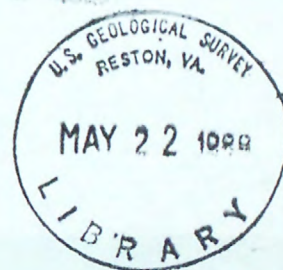# METHODS FOR ESTIMATING

# MONTHLY STREAMFLOW CHARACTERISTICS

# AT UNGAGED SITES IN WESTERN MONTANA

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## U.S. GEOLOGICAL SURVEY

Open—File Report 89–40

Prepared in cooperation with the

U.S. BUREAU OF INDIAN AFFAIRS and the

CONFEDERATED SALISH AND KOOTENAI TRIBES

METHODS FOR ESTIMATING MONTHLY STREAMFLOW CHARACTERISTICS

AT UNGAGED SITES IN WESTERN MONTANA

By Charles Parrett, U.S. Geological Survey, and Kenn D. Cartier, Confederated

  Salish and Kootenai Tribes

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## CONVERSION FACTORS

The following factors can be used to convert inch-pound units in this report
to metric (International System) units.

| Multiply inch-pound unit | By | To obtain metric unit |
|---|---|---|
| cubic foot per second ($ft^3/s$) | 0.028317 | cubic meter per second ($m^3/s$) |
| foot (ft) | 0.3048 | meter (m) |
| inch (in.) | 25.4 | millimeter (mm) |
| mile (mi) | 1.609 | kilometer (km) |
| square mile ($mi^2$) | 2.590 | square kilometer ($km^2$) |

Sea level: In this report "sea level" refers to the National Geodetic Vertical
Datum of 1929 (NGVD of 1929)--A geodetic datum derived from a general adjustment
of the first-order level nets of both the United States and Canada, formerly called
"Sea Level Datum of 1929."

# METHODS FOR ESTIMATING MONTHLY STREAMFLOW CHARACTERISTICS AT UNGAGED SITES IN WESTERN MONTANA

by

Charles Parrett and Kenn D. Cartier

## ABSTRACT

Three methods for estimating mean monthly discharge and various points on the daily mean flow-duration curve for each month (daily mean discharges exceeded 90, 70, 50, and 10 percent of the time each month) were developed for western Montana. A procedure for weighting two or more individual estimates to provide a minimum-variance-weighted-average estimate also was developed. This report describes the estimation methods developed and their reliability and limitations.

The first method is based on multiple-regression equations relating the monthly streamflow characteristics to various basin and climatic variables. Standard errors of the basin-characteristics equations range from 43 to 107 percent. The basin-characteristics equations are generally not applicable to streams that receive or lose water as a result of localized geologic features or to stream sites with appreciable upstream storage or diversions.

The second method is based on regression equations relating the monthly streamflow characteristics to channel width. Standard errors of the channel-width estimating equations range from 41 to 111 percent. The channel-width equations are generally not applicable to stream sites with exposed bedrock, with braided or sand channels, or with recent alterations.

The third method requires 12 once-monthly streamflow measurements at the ungaged site of interest. The 12 measured flows are then correlated with concurrent flows at some nearby gaged site using the curve-fitting technique MOVE.1 (Maintenance of Variance Extension, Type 1), and the relation defined is used to estimate the required monthly streamflow characteristic at the ungaged site from the streamflow characteristic at the gaged site. Standard errors, which are estimated by applying the method to 20 other gaged sites, range from 19 to 92 percent. Although generally substantially more reliable than either the basin-characteristics method or the channel-width method, this method may yield unreliable results if the measurement site and the index gaged site are not hydrologically similar.

The procedure for weighting individual estimates is based on the variance and degree of independence of the individual estimating methods. Standard errors for the weighted estimates of the monthly flow characteristics range from 15 to 43 percent when all three methods are used. The weighted-average estimates from all three methods are generally substantially more reliable than any of the individual estimates.

INTRODUCTION

Although western Montana generally has abundant surface water, shortages are common because of the large areal and seasonal variability of runoff. Making sound management decisions to relieve periodic shortages and to most efficiently allocate the supply among competing users thus requires reliable information about the variability of streamflow. In particular, the distribution of daily mean discharge by month is of interest to fish and wildlife managers, water-rights administrators, and other land- and water-use planners and managers. Unfortunately, techniques for estimating monthly streamflow characteristics are not as readily available as techniques for estimating annual and peak streamflow characteristics. For example, the only U.S. Geological Survey report containing estimating equations for mean monthly discharge in Montana is one by Boner and Buswell (1970); that report is based on a relatively small number of streamflow-gaging stations having at least 10 years of record then available. A more recent report by Parrett and Hull (1985, p. 8,9) indicates that mean monthly discharge can be estimated at an ungaged site by using existing techniques to estimate a mean annual discharge and then assuming that the monthly distribution of the annual discharge follows the same distribution as some nearby gaged site. The accuracy of the estimated monthly mean discharge using this technique, however, is not completely satisfactory in western Montana.

Because of the dearth of techniques available for estimating monthly streamflow characteristics at ungaged sites in western Montana, the present study was undertaken in 1985 in cooperation with the U.S. Bureau of Indian Affairs and the Confederated Salish and Kootenai Tribes of the Flathead Indian Reservation. The objective of the project was to develop techniques for estimating long-term mean monthly discharge and various points on the daily mean flow-duration curve for each month (daily mean discharges exceeded 90, 70, 50, and 10 percent of the time each month) that would be applicable within the boundaries of the Flathead Indian Reservation in western Montana.

## Purpose and Scope

The purposes of this report are to describe the estimation methods that were developed and to discuss their reliability and limitations. Three methods for estimating the required discharges were developed. One method is based on the relation between streamflow and various basin and climatic variables. The second method is similar to the first and is based on the relation between discharge and channel width. The third method requires once-monthly measurements of discharge at the ungaged site of interest and is based on the relation between the measured discharges and concurrent daily mean discharges at a similar, nearby gaged site. A procedure also is presented for weighting the individual estimates of discharge made from two or more of the three separate methods. The weighted-average estimate is based on the variance and degree of independence of the individual estimating methods. Calculated standard errors of prediction are used as a measure of reliability of each estimating method, and experience gained in the development and application of the methods is used to describe the major limitations.

## Description of Study Area

Because of the small number of streamflow-gaging stations with monthly discharge data within the Flathead Indian Reservation, the study area was expanded to

include the entire part of the State within the upper Columbia River basin as well as the adjacent eastern side of the Rocky Mountains (fig. 1). This area, termed "western Montana" for the purposes of this report, is composed largely of north- to northwest-trending mountain ranges separated by long, fairly narrow valleys. Except for the valley-floor areas, the study area is generally rugged and forested. The flatter valleys are mostly cultivated or grazed. The Flathead Indian Reservation, like the larger study area, is composed of both mountains and valleys. The reservation is bounded on the east by the rugged Mission Mountains and on the south and west by less rugged and prominent mountains. Much of the interior part of the reservation includes broad intermontane valleys and gently rolling prairies.

Annual precipitation varies widely in the study area, primarily because of orographic effects. Annual precipitation tends to be greatest in the mountains, where it is as much as 100 in. in the northeastern corner of the study area and in the Mission Mountains on the eastern edge of the Flathead Indian Reservation (U.S. Soil Conservation Service, 1981, p. 1-2). In the drier valley areas, including the Little Bitterroot River valley within the Flathead Indian Reservation, annual precipitation is as little as 12 in.

Annual runoff generally follows the precipitation pattern, with greater quantities occurring in the higher elevation areas. Streamflows vary greatly on a seasonal basis, as snowmelt provides the bulk of annual runoff in May, June, and July for the mountain streams and in March, April, and May for the streams draining the lower foothills and valley-floor areas. The smallest streamflows generally occur in late fall and winter when streamflows are almost entirely the result of ground-water inflow. Smaller streams draining the valleys may become dry during this period.


## Streamflow Data Used

Monthly streamflow characteristics were computed from data at 59 streamflow-gaging stations within the study area, including 12 stations within the Flathead Indian Reservation. All stations used in the analysis had at least 5 years of record through water year 1986, although some stations did not have complete record for all months. Streamflow-gaging stations where flows are substantially regulated or where large diversions substantially affect most flows were not used in the analyses. The location of the streamflow-gaging stations used is shown in figure 1. The monthly streamflow characteristics computed for each station are listed in table 11 in the Supplemental Data section at the back of the report.


## METHODS FOR ESTIMATING MONTHLY STREAMFLOW

### Basin-Characteristics Method

One method for estimating streamflow characteristics at ungaged sites uses multiple-regression equations that relate streamflow characteristics at gaged sites to various measured basin and climatic variables. This method, termed the "basin-characteristics method" in this report, has commonly been used in Montana to estimate flood flows and mean annual flows (Omang and others, 1986; Parrett and Omang, 1981; Parrett and Hull, 1985).
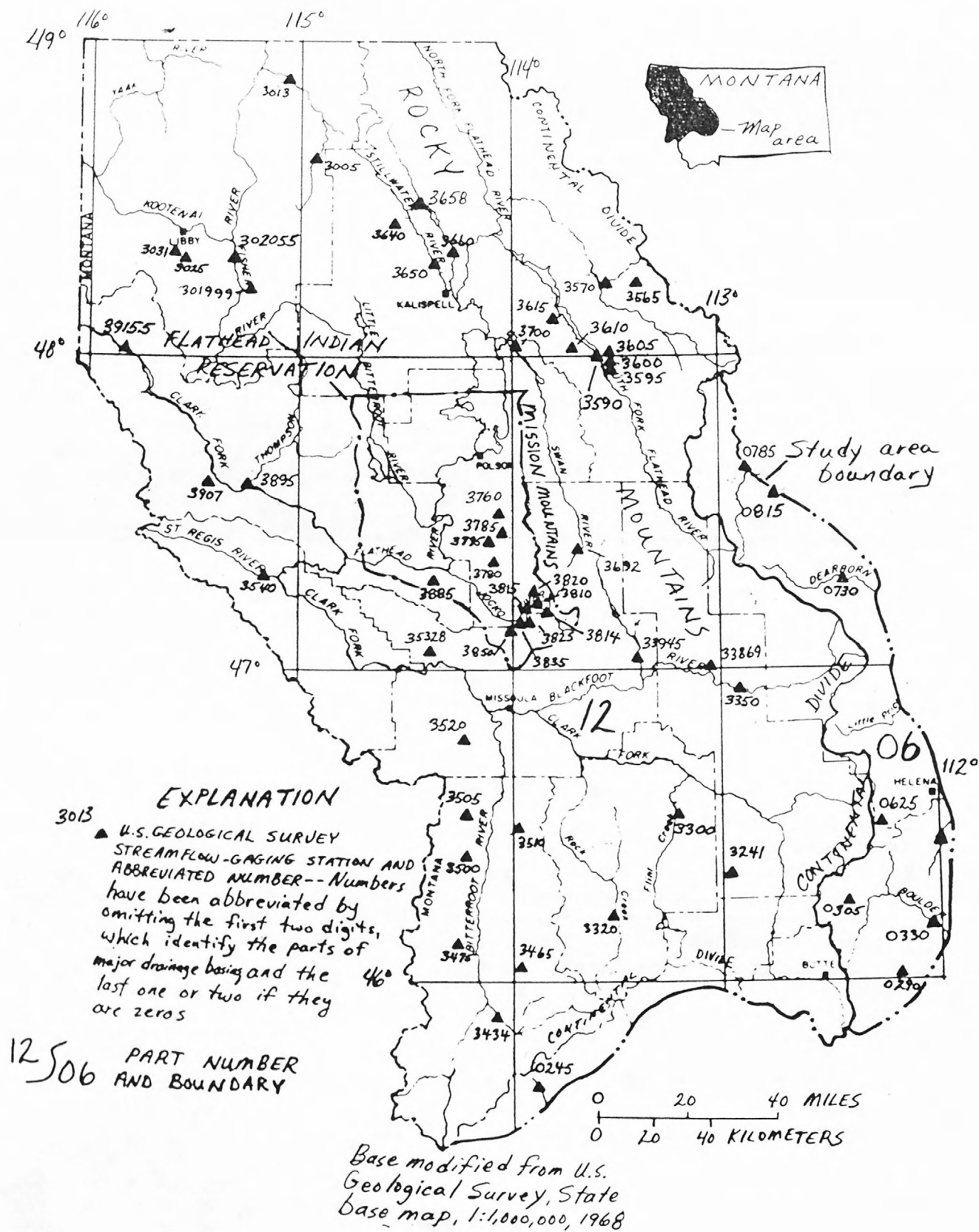
Figure 1.--Location of streamflow-gaging stations.

Because the basin-characteristics method has been widely used, several basin and climatic variables have been previously measured at virtually every U.S. Geological Survey streamflow-gaging station in Montana. These measurement data are stored in the Basin Characteristics File of the U.S. Geological Survey's Water Data Storage and Retrieval System (WATSTORE).

Boner and Buswell (1970) used basin characteristics to develop estimating equations for mean monthly flow in Montana, but the reported accuracy was generally unacceptable. According to Riggs (1972, p. 13-14), the basin-characteristics method is not well suited for the estimation of low flows, because low flows are largely affected by localized geology that cannot be quantified easily. For this study, several previously unmeasured basin characteristics that might be indicative of basin geology were investigated. Eighteen streamflow-gaging stations (table 1) in the study area were randomly selected, and the following geomorphic variables were measured at each site on U.S. Geological Survey topographic maps: basin perimeter, basin slope, circularity ratio, maximum basin relief, drainage density, stream frequency, and aspect.

Table 1.--*Streamflow-gaging stations used to investigate new basin characteristics*

| Formal station No. | Abbreviated station No. (fig. 1) | Stream name |
|---|---|---|
| 06062500 | 0625 | Tenmile Creek |
| 06078500 | 0785 | North Fork Sun River |
| 12300500 | 3005 | Fortine Creek |
| 12301999 | 301999 | Wolf Creek |
| 12302055 | 302055 | Fisher River |
| | | |
| 12302500 | 3025 | Granite Creek |
| 12303100 | 3031 | Flower Creek |
| 12324100 | 3241 | Racetrack Creek |
| 12330000 | 3300 | Boulder Creek |
| 12338690 | 33869 | Monture Creek |
| | | |
| 12343400 | 3434 | East Fork Bitterroot River |
| 12347500 | 3475 | Blodgett Creek |
| 12350500 | 3505 | Kootenai Creek |
| 12356500 | 3565 | Bear Creek |
| 12357000 | 3570 | North Fork Flathead River |
| | | |
| 12359500 | 3595 | Spotted Bear River |
| 12361500 | 3615 | Graves Creek |
| 12364000 | 3640 | Logan Creek |

Basin perimeter, expressed in miles, was determined by measuring the basin drainage area outline on the best-scale topographic map available. Basin slope, which is dimensionless, was determined by measuring the lengths of all contours at a fixed contour interval within the basin, multiplying by the contour interval, and dividing by the basin drainage area. Because the number of contours is largely dependent on the map scale, a single scale (1:24,000 U.S. Geological Survey 7.5-minute quadrangle maps) was used for determining basin slope at all sites; the contour interval selected was 400 ft. The map scale used at any ungaged site needs to be the same to ensure that the equations are applicable. Circularity ratio, which is also dimensionless, was determined by dividing the basin drainage area by the area of a circle with the same basin perimeter. Maximum basin relief, expressed in thousands of feet, was determined by subtracting the elevation of the stream at the basin outlet from the maximum elevation contour within the basin boundary shown on the contour map. Drainage density, expressed in miles per square mile, was determined by measuring and totaling the lengths of all channel segments shown on the contour map and dividing the result by the basin drainage area. As with basin slope, only 1:24,000 quadrangle maps were used to determine drainage density and the closely related variable, stream frequency. Stream frequency, expressed as a number per square mile, was determined by dividing the total number of stream segments by the basin drainage area. Aspect, expressed in degrees, was determined by measuring the angle from north to the line connecting the basin centroid to the basin outlet. Measurements of aspect were made either clockwise or counterclockwise from north so that the maximum possible aspect was 180°. Thus, a line from the centroid to the outlet oriented due west would result in an aspect of 90°, as would a line from the centroid to the outlet oriented due east.

The newly measured basin characteristics were combined with 10 standard basin and climatic characteristics previously measured at the 18 stations and treated as independent variables in a multiple-regression analysis. The 10 standard basin and climatic characteristics used were the following: drainage area, percentage of basin above 6,000 ft elevation, main-channel length, mean annual precipitation, mean basin elevation, main-channel slope, percentage of basin covered by forest, percentage of basin composed of lakes and ponds, precipitation, intensity of a storm of 24 hours duration with a recurrence interval of 2 years, and mean January minimum temperature. Individual equations for five monthly flow characteristics for each month (60 equations) were developed using a computerized step-wise regression procedure. Based on this initial analysis, the only new basin characteristics that were significant were basin perimeter, basin slope, circularity ratio, and maximum basin relief. Accordingly, these four new basin characteristics were considered to be worthy of inclusion in a regression analysis using all available streamflow-gaging-station data in the study area, and they were subsequently measured at 54 gaged sites. Suitable topographic maps were not available for four gaged sites (stations 06030500, 06033000, 06061500, and 06081500), so these sites were excluded from the regression analysis. In addition, station 12359000 was excluded from the regression analysis because total streamflows at this site are substantially greater than at any other site used in the analysis.

In the multiple-regression analysis using the 54 gaged sites, the following basin and climatic variables were significant in at least one regression equation:

A      drainage area,
E6    percentage of basin above 6,000 ft elevation, plus 1,

```
PE    basin perimeter,
BSL   basin slope,
L     main-channel length,
P     mean annual precipitation,
E     mean basin elevation,
BR    maximum basin relief.
```

The most significant variable in almost all instances was main-channel length. Main-channel length is more susceptible to human change and measurement error than is drainage area, however, so drainage area was substituted for main-channel length and the regressions were repeated. Because main-channel length and drainage area are highly correlated, the substitution produced no substantial change in regression reliability. Although circularity ratio was determined to be significant in the initial regression analysis using 18 test sites, it was not significant in the analysis using all 54 gaged sites.

Drainage area, expressed in square miles, was determined by planimetering on the best-scale topographic map available. Percentage of basin above 6,000 ft elevation above sea level was determined by planimetering the drainage area above the 6,000-ft contour on the best available topographic map, dividing by the total drainage area, multiplying by 100, and adding 1 to ensure that 0 values did not occur. Mean annual precipitation, expressed in inches, was the basin average precipitation as determined from maps published by the U.S. Soil Conservation Service (1981). Mean basin elevation, expressed in thousands of feet, was determined by overlaying a transparent grid on the basin outline on a topographic map, reading the elevation at the grid intersections, and averaging the readings. The basin and climatic characteristics measured at each streamflow-gaging station used in the regression analysis are listed in table 12 at the back of the report.

Monthly streamflow data and basin and climatic characteristics at the 54 gaged sites in the study area were converted to logarithms and used in a multiple-regression analysis to derive estimating equations of the following linear form:

$$\log Q = \log a + b1 \log B + b2 \log C + \ldots bn \log N, \qquad (1)$$

where

   $Q$ (dependent variable) is the desired monthly streamflow characteristic in cubic feet per second (daily mean discharge exceeded 90, 70, 50, or 10 percent of the time during the given month, or mean discharge for the month);

   $a$ is the multiple-regression constant;

   $b1$, $b2$, $\ldots$ $bn$ are the regression coefficients; and

   $B$, $C$, $\ldots$ $N$ are values of the significant basin characteristics (independent variables).

Taking antilogarithms yields the following nonlinear form of the regression equation:

$$Q = aB^{b1}\ C^{b2} \ldots N^{bn}, \qquad (2)$$

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The regressions were performed using a computerized step-wise regression procedure that adds independent variables to the equation one at a time until all significant variables are included. In this study, a variable was included in the model if the F statistic was greater than 5. The computerized procedure also provided statistical measures of the applicability of the derived equations such as standard errors of estimate and coefficients of determination. In general, the smaller the standard error and the larger the coefficient of determination, the more reliable is the estimating equation.

To ensure that estimates from the regression equations for any month would be consistent, the initial equations for some streamflow characteristics were modified. In these instances, variables that were significant in most of the equations for any given month were selected as key variables, and the regressions were repeated using the key variables as the only independent variables. For any given month, the equations for all streamflow characteristics thus have the same independent variables. Complete results of the regression analysis using basin characteristics are given in table 2, along with the coefficients of determination and standard errors associated with each estimating equation.

As indicated by the results in table 2, the basin-characteristics equations generally are more reliable for estimating the higher-flow monthly characteristics (for example, Q.50, Q.10, and QM) than the lower-flow characteristics (Q.90 and Q.70) in any given month. The basin-characteristics equations also generally are more reliable for estimating flow characteristics for the months of high runoff (May and June) than for the months of generally low runoff (July through April).

## Channel-Width Method

The second method used in this study for estimating monthly streamflow characteristics at ungaged sites also uses multiple-regression equations developed from gaged data. In this instance, however, monthly streamflow characteristics at gaged sites are related to measured-channel widths at the gaged sites rather than to measured-basin characteristics. This method, termed the "channel-width method" in this report, has been used with generally good success in Montana and elsewhere for the estimation of flood flows and mean annual flows (Cartier, 1984; Parrett and others, 1983; Omang and others, 1983; Hedman and Osterkamp, 1982; Wahl, 1984). Because channel size is presumed to be largely the result of bankfull or near-bankfull flows, the channel-width method generally has not been used for monthly or low-flow characteristics. Nevertheless, the method was investigated for this study because the channel width had previously been measured at most of the gaged sites and because the relation between monthly flow characteristics and bankfull flows is fairly consistent for most perennial streams in the study area.

Channel features previously measured at gaged sites were active-channel width and bankfull width. At most sites the two features were about equally prominent and identifiable.

Osterkamp and Hedman (1977, p. 256) described the active channel as "...a short-term geomorphic feature subject to change by prevailing discharges. The upper limit is defined by a break in the relatively steep bank slope of the active channel to a more gently sloping surface beyond the channel edge. The break in slope normally coincides with the lower limit of permanent vegetation so that the two features, individually or in combination, define the active channel reference

Table 2.--*Results of regression analysis based on basin characteristics*

[$R^2$, coefficient of determination; Q.xx, daily mean discharge exceeded xx
percent of the time during the specified month, in cubic feet per second; A,
drainage area, in square miles; BR, maximum basin relief, in thousands of feet;
BSL, basin slope, dimensionless; QM, mean monthly discharge, in cubic
feet per second; P, mean annual precipitation, in inches; E, mean
basin elevation, in thousands of feet; PE, basin perimeter, in miles;
E6, percentage of basin above 6,000 feet elevation, plus 1]

| Month and number of sites | Stream-flow characteristic | Equation | $R^2$ | Standard error (logarithm, base 10) | Standard error (percent) |
|---|---|---|---|---|---|
| October | Q.90 | $= 0.123\ A^{0.84}\ BR^{1.31}\ BSL^{0.70}$ | 0.69 | 0.31 | 82 |
| (50) | Q.70 | $= 0.246\ A^{0.84}\ BR^{1.21}\ BSL^{0.92}$ | .76 | .26 | 66 |
| | Q.50 | $= 0.521\ A^{0.80}\ BR^{1.07}\ BSL^{1.06}$ | .77 | .24 | 60 |
| | Q.10 | $= 4.68\ A^{0.73}\ BR^{0.40}\ BSL^{1.19}$ | .69 | .25 | 63 |
| | QM | $= 1.69\ A^{0.78}\ BR^{0.59}\ BSL^{1.16}$ | .77 | .22 | 54 |
| November | Q.90 | $= 0.140\ A^{0.89}\ BR^{1.21}\ BSL^{0.86}$ | .76 | .27 | 69 |
| (49) | Q.70 | $= 0.294\ A^{0.84}\ BR^{1.22}\ BSL^{1.05}$ | .76 | .25 | 63 |
| | Q.50 | $= 0.711\ A^{0.82}\ BR^{1.00}\ BSL^{1.28}$ | .77 | .24 | 60 |
| | Q.10 | $= 3.45\ A^{0.85}\ BR^{0.59}\ BSL^{1.74}$ | .76 | .24 | 60 |
| | QM | $= 1.19\ A^{0.84}\ BR^{0.83}\ BSL^{1.48}$ | .79 | .23 | 57 |
| December | Q.90 | $= 0.132\ A^{0.92}\ BR^{1.18}\ BSL^{1.01}$ | .76 | .27 | 69 |
| (49) | Q.70 | $= 0.258\ A^{0.87}\ BR^{1.17}\ BSL^{1.11}$ | .79 | .24 | 60 |
| | Q.50 | $= 0.552\ A^{0.88}\ BR^{0.95}\ BSL^{1.33}$ | .79 | .24 | 60 |
| | Q.10 | $= 2.00\ A^{0.94}\ BR^{0.64}\ BSL^{1.76}$ | .79 | .25 | 63 |
| | QM | $= 0.874\ A^{0.91}\ BR^{0.84}\ BSL^{1.57}$ | .79 | .24 | 60 |

Table 2.--*Results of regression analysis based on basin characteristics*--Continued

| Month and number of sites | Stream-flow charac-teristic | | Equation | $R^2$ | Standard error (loga-rithm, base 10) | Stand-ard error (percent) |
|---|---|---|---|---|---|---|
| January | Q.90 | = | $0.117 \ A^{0.96} \ BR^{1.23} \ BSL^{1.25}$ | .77 | .29 | 75 |
| (47) | Q.70 | = | $0.276 \ A^{0.93} \ BR^{0.96} \ BSL^{1.26}$ | .80 | .24 | 60 |
| | Q.50 | = | $0.431 \ A^{0.94} \ BR^{0.82} \ BSL^{1.27}$ | .81 | .24 | 60 |
| | Q.10 | = | $0.855 \ A^{0.96} \ BR^{0.79} \ BSL^{1.36}$ | .79 | .25 | 63 |
| | QM | = | $0.424 \ A^{0.96} \ BR^{0.88} \ BSL^{1.30}$ | .82 | .24 | 60 |
| February | Q.90 | = | $0.176 \ A^{0.98} \ BR^{0.99} \ BSL^{1.32}$ | .81 | .25 | 63 |
| (47) | Q.70 | = | $0.301 \ A^{0.97} \ BR^{0.84} \ BSL^{1.28}$ | .82 | .23 | 57 |
| | Q.50 | = | $0.405 \ A^{0.99} \ BR^{0.75} \ BSL^{1.35}$ | .84 | .22 | 54 |
| | Q.10 | = | $1.34 \ A^{1.07} \ BR^{0.37} \ BSL^{1.66}$ | .80 | .26 | 66 |
| | QM | = | $0.590 \ A^{1.03} \ BR^{0.63} \ BSL^{1.53}$ | .83 | .23 | 57 |
| March | Q.90 | = | $0.174 \ A^{0.99} \ BR^{1.03} \ BSL^{1.24}$ | .82 | .24 | 60 |
| (48) | Q.70 | = | $0.307 \ A^{1.00} \ BR^{0.87} \ BSL^{1.31}$ | .84 | .23 | 57 |
| | Q.50 | = | $0.369 \ A^{1.01} \ BR^{0.86} \ BSL^{1.32}$ | .84 | .23 | 57 |
| | Q.10 | = | $0.629 \ A^{1.05} \ BR^{0.77} \ BSL^{1.23}$ | .79 | .27 | 69 |
| | QM | = | $0.366 \ A^{1.03} \ BR^{0.86} \ BSL^{1.22}$ | .83 | .24 | 60 |

Table 2.--*Results of regression analysis based on basin characteristics*--Continued

| Month and number of sites | Stream-flow characteristic | Equation | $R^2$ | Standard error (logarithm, base 10) | Standard error (percent) |
|---|---|---|---|---|---|
| April | Q.90 | = | $0.0103\ A^{0.97}\ P^{1.43}\ E^{-0.86}$ | .82 | .23 | 57 |
| (49) | Q.70 | = | $0.0271\ A^{0.98}\ P^{1.50}\ E^{-1.29}$ | .85 | .22 | 54 |
| | Q.50 | = | $0.0758\ A^{0.96}\ P^{1.48}\ E^{-1.55}$ | .83 | .24 | 60 |
| | Q.10 | = | $0.119\ A^{1.01}\ P^{1.48}\ E^{-1.36}$ | .80 | .28 | 72 |
| | QM | = | $0.0708\ A^{1.00}\ P^{1.46}\ E^{-1.38}$ | .83 | .25 | 63 |
| May | Q.90 | = | $0.00100\ A^{1.00}\ P^{1.96}$ | .80 | .27 | 69 |
| (52) | Q.70 | = | $0.00321\ A^{1.04}\ P^{1.75}$ | .83 | .25 | 63 |
| | Q.50 | = | $0.00802\ A^{1.01}\ P^{1.64}$ | .82 | .24 | 60 |
| | Q.10 | = | $0.106\ A^{0.91}\ P^{1.25}$ | .84 | .21 | 51 |
| | QM | = | $0.0249\ A^{0.96}\ P^{1.43}$ | .84 | .22 | 54 |
| June | Q.90 | = | $0.122\ A^{0.87}\ BSL^{1.06}\ P^{1.00}\ E6^{0.17}$ | .77 | .25 | 63 |
| (53) | Q.70 | = | $0.144\ A^{0.92}\ BSL^{0.98}\ P^{1.00}\ E6^{0.18}$ | .85 | .20 | 49 |
| | Q.50 | = | $0.245\ A^{0.91}\ BSL^{0.95}\ P^{0.95}\ E6^{0.19}$ | .86 | .19 | 46 |
| | Q.10 | = | $0.511\ A^{0.90}\ BSL^{0.79}\ P^{0.89}\ E6^{0.19}$ | .87 | .18 | 43 |
| | QM | = | $0.284\ A^{0.90}\ BSL^{0.87}\ P^{0.92}\ E6^{0.19}$ | .87 | .18 | 43 |

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Table 2.--*Results of regression analysis based on basin characteristics*--Continued

| Month and number of sites | Stream-flow charac-teristic | | Equation | $R^2$ | Standard error (loga-rithm, base 10) | Stand-ard error (percent) |
|---|---|---|---|---|---|---|
| July | Q.90 | = | $0.192\ PE^{1.37}\ BR^{0.96}\ BSL^{1.31}$ | .62 | .33 | 88 |
| (53) | Q.70 | = | $0.173\ PE^{1.33}\ BR^{1.28}\ BSL^{1.06}$ | .72 | .27 | 69 |
| | Q.50 | = | $0.296\ PE^{1.33}\ BR^{1.18}\ BSL^{1.10}$ | .75 | .25 | 63 |
| | Q.10 | = | $0.871\ PE^{1.35}\ BR^{1.01}\ BSL^{1.20}$ | .80 | .21 | 51 |
| | QM | = | $0.485\ PE^{1.33}\ BR^{1.03}\ BSL^{1.18}$ | .78 | .22 | 54 |
| August | Q.90 | = | $0.105\ PE^{1.43}\ BR^{0.65}\ BSL^{1.11}$ | .57 | .38 | 107 |
| (53) | Q.70 | = | $0.0931\ PE^{1.39}\ BR^{0.92}\ BSL^{0.90}$ | .63 | .34 | 92 |
| | Q.50 | = | $0.0978\ PE^{1.33}\ BR^{1.12}\ BSL^{0.75}$ | .66 | .31 | 82 |
| | Q.10 | = | $0.209\ PE^{1.26}\ BR^{1.07}\ BSL^{0.64}$ | .72 | .26 | 66 |
| | QM | = | $0.136\ PE^{1.32}\ BR^{0.97}\ BSL^{0.77}$ | .69 | .28 | 72 |
| September | Q.90 | = | $0.0420\ PE^{1.46}\ BR^{0.90}\ BSL^{0.92}$ | .60 | .37 | 103 |
| (53) | Q.70 | = | $0.0522\ PE^{1.42}\ BR^{0.93}\ BSL^{0.72}$ | .65 | .33 | 88 |
| | Q.50 | = | $0.0604\ PE^{1.35}\ BR^{1.12}\ BSL^{0.67}$ | .66 | .30 | 78 |
| | Q.10 | = | $0.202\ PE^{1.24}\ BR^{0.98}\ BSL^{0.70}$ | .74 | .23 | 57 |
| | QM | = | $0.102\ PE^{1.33}\ BR^{0.97}\ BSL^{0.78}$ | .73 | .25 | 63 |

level. The section beneath the reference level is that portion of the stream entrenchment in which the channel is actively, if not totally, sculpted by the normal process of water and sediment discharge."

The bankfull-channel section (also referred to as the main-channel or whole-channel section) was described by Riggs (1974, p. 53) as "...variously defined by breaks in bank slope, by the edges of the flood plain, or by the lower limits of permanent vegetation." On perennial streams, the upper extent of the bankfull-channel section corresponds to the bankfull stage at a narrow stream section described by Leopold and others (1964). For most sites in the study area, the bankfull width was only slightly larger than the active-channel width. The lower limit of permanent vegetation was most commonly the recognizable reference feature for active-channel width, whereas the prominent break in slope was most commonly used to define bankfull width.

In this study, the monthly streamflow characteristics and measured-channel widths were converted to logarithms, and multiple-regression techniques were used to derive estimating equations relating monthly streamflow to either active-channel or bankfull width:

$$\log Q = \log a + b \log W, \tag{3}$$

where

$Q$ is a monthly streamflow characteristic as previously defined,
$a$ is the regression constant,
$b$ is the regression coefficient, and
$W$ is the significant independent variable, either
   active-channel width ($W_{AC}$) or bankfull width ($W_{BF}$).

The nonlinear form of equation 3, obtained by taking antilogarithms, is the following:

$$Q = a W^b. \tag{4}$$

The final regression equations derived using channel widths and their coefficients of determination and standard errors are given in table 3. As with the basin-characteristics equations, the channel-width equations are generally more reliable for the higher-flow characteristics (Q.50, Q.10, and QM) than for the lower-flow characteristics (Q.90 and Q.70). Likewise, the channel-width equations are more reliable for the months of high runoff than for the months of low runoff and base flow. Ignoring measurement error, comparison of results in tables 2 and 3 indicates that the basin-characteristics equations and channel-width equations are about equally reliable for most flows for most months.

## Concurrent-Measurement Method

The third method for estimating monthly streamflow characteristics at an ungaged site requires a series of discharge measurements at the site. The measured discharges at the ungaged site are correlated with concurrent discharges at some nearby, hydrologically similar gaged site, and the relation between the discharges at the two sites is used to transfer the desired long-term streamflow characteristic

Table 3.--*Results of regression analysis based on channel width*

[$R^2$, coefficient of determination; Q.xx, daily mean discharge exceeded xx percent of the time during the specified month, in cubic feet per second; $W_{AC}$, active-channel width, in feet; QM, mean monthly discharge, in cubic feet per second; $W_{BF}$, bankfull width, in feet]

| Month and number of sites | Stream-flow charac-teristic | Equation | $R^2$ | Standard error (loga-rithm, base 10) | Stand-ard error (percent) |
|---|---|---|---|---|---|
| October | Q.90 = | $0.0521 \ W_{AC}^{1.58}$ | 0.59 | 0.35 | 96 |
| (44) | Q.70 = | $0.0774 \ W_{AC}^{1.56}$ | .67 | .29 | 75 |
| | Q.50 = | $0.116 \ W_{AC}^{1.51}$ | .72 | .25 | 63 |
| | Q.10 = | $0.383 \ W_{AC}^{1.38}$ | .73 | .22 | 54 |
| | QM = | $0.186 \ W_{AC}^{1.44}$ | .78 | .20 | 49 |
| November | Q.90 = | $0.0508 \ W_{AC}^{1.60}$ | .66 | .30 | 78 |
| (43) | Q.70 = | $0.0875 \ W_{AC}^{1.55}$ | .69 | .27 | 69 |
| | Q.50 = | $0.124 \ W_{AC}^{1.52}$ | .74 | .24 | 60 |
| | Q.10 = | $0.215 \ W_{AC}^{1.55}$ | .78 | .21 | 51 |
| | QM = | $0.138 \ W_{AC}^{1.53}$ | .77 | .22 | 54 |
| December | Q.90 = | $0.0356 \ W_{AC}^{1.66}$ | .67 | .31 | 82 |
| (43) | Q.70 = | $0.0695 \ W_{AC}^{1.58}$ | .71 | .26 | 66 |
| | Q.50 = | $0.0896 \ W_{AC}^{1.57}$ | .74 | .25 | 63 |
| | Q.10 = | $0.118 \ W_{AC}^{1.68}$ | .79 | .23 | 57 |
| | QM = | $0.0875 \ W_{AC}^{1.63}$ | .76 | .24 | 60 |

| Month and number of sites | Stream-flow charac-teristic | Equation | $R^2$ | Standard error (loga-rithm, base 10) | Stand-ard error (percent) |
|---|---|---|---|---|---|
| January | Q.90 | $= 0.0270\ W_{AC}^{1.71}$ | .69 | .31 | 82 |
| (41) | Q.70 | $= 0.0398\ W_{AC}^{1.69}$ | .75 | .26 | 66 |
| | Q.50 | $= 0.0557\ W_{AC}^{1.66}$ | .76 | .24 | 60 |
| | Q.10 | $= 0.0735\ W_{AC}^{1.76}$ | .80 | .23 | 57 |
| | QM | $= 0.0509\ W_{AC}^{1.73}$ | .78 | .24 | 60 |
| February | Q.90 | $= 0.0265\ W_{AC}^{1.73}$ | .71 | .29 | 75 |
| (41) | Q.70 | $= 0.0389\ W_{AC}^{1.71}$ | .75 | .26 | 66 |
| | Q.50 | $= 0.0444\ W_{AC}^{1.72}$ | .77 | .25 | 63 |
| | Q.10 | $= 0.0659\ W_{AC}^{1.80}$ | .77 | .26 | 66 |
| | QM | $= 0.0476\ W_{AC}^{1.75}$ | .77 | .26 | 66 |
| March | Q.90 | $= 0.0320\ W_{AC}^{1.74}$ | .74 | .27 | 69 |
| (42) | Q.70 | $= 0.0416\ W_{AC}^{1.74}$ | .75 | .26 | 66 |
| | Q.50 | $= 0.0529\ W_{AC}^{1.74}$ | .75 | .26 | 66 |
| | Q.10 | $= 0.0633\ W_{AC}^{1.85}$ | .75 | .28 | 72 |
| | QM | $= 0.0519\ W_{AC}^{1.79}$ | .75 | .27 | 69 |

| Month and number of sites | Stream-flow characteristic | Equation | $R^2$ | Standard error (logarithm, base 10) | Standard error (percent) |
|---|---|---|---|---|---|
| April | Q.90 | $= 0.0535\ W_{AC}^{1.75}$ | .76 | .26 | 66 |
| (43) | Q.70 | $= 0.0695\ W_{AC}^{1.82}$ | .79 | .25 | 63 |
| | Q.50 | $= 0.115\ W_{AC}^{1.81}$ | .76 | .27 | 69 |
| | Q.10 | $= 0.271\ W_{AC}^{1.85}$ | .76 | .27 | 69 |
| | QM | $= 0.144\ W_{AC}^{1.83}$ | .77 | .25 | 63 |
| May | Q.90 | $= 0.0548\ W_{BF}^{1.95}$ | .80 | .25 | 63 |
| (46) | Q.70 | $= 0.0698\ W_{BF}^{2.03}$ | .86 | .21 | 51 |
| | Q.50 | $= 0.128\ W_{BF}^{1.96}$ | .86 | .20 | 49 |
| | Q.10 | $= 0.392\ W_{BF}^{1.85}$ | .88 | .18 | 43 |
| | QM | $= 0.175\ W_{BF}^{1.91}$ | .87 | .19 | 46 |
| June | Q.90 | $= 0.265\ W_{BF}^{1.58}$ | .68 | .27 | 69 |
| (47) | Q.70 | $= 0.300\ W_{BF}^{1.67}$ | .78 | .22 | 55 |
| | Q.50 | $= 0.423\ W_{BF}^{1.67}$ | .81 | .21 | 50 |
| | Q.10 | $= 0.657\ W_{BF}^{1.72}$ | .86 | .17 | 41 |
| | QM | $= 0.445\ W_{BF}^{1.68}$ | .84 | .19 | 46 |

Table 3.--*Results of regression analysis based on channel width*--Continued

| Month and number of sites | Stream-flow charac-teristic | Equation | $R^2$ | Standard error (loga-rithm, base 10) | Stand-ard error (percent) |
|---|---|---|---|---|---|
| July | Q.90 = | $0.162\ W_{AC}^{1.51}$ | .58 | .34 | 92 |
| (47) | Q.70 = | $0.258\ W_{AC}^{1.51}$ | .67 | .29 | 75 |
| | Q.50 = | $0.372\ W_{AC}^{1.51}$ | .72 | .25 | 63 |
| | Q.10 = | $0.857\ W_{AC}^{1.51}$ | .80 | .20 | 49 |
| | QM = | $0.498\ W_{AC}^{1.49}$ | .77 | .22 | 54 |
| August | Q.90 = | $0.0746\ W_{AC}^{1.54}$ | .55 | .37 | 103 |
| (47) | Q.70 = | $0.107\ W_{AC}^{1.54}$ | .59 | .34 | 92 |
| | Q.50 = | $0.163\ W_{AC}^{1.49}$ | .60 | .33 | 88 |
| | Q.10 = | $0.347\ W_{AC}^{1.44}$ | .68 | .26 | 66 |
| | QM = | $0.191\ W_{AC}^{1.47}$ | .65 | .29 | 75 |
| September | Q.90 = | $0.0545\ W_{AC}^{1.57}$ | .54 | .39 | 111 |
| (47) | Q.70 = | $0.0741\ W_{AC}^{1.56}$ | .60 | .34 | 92 |
| | Q.50 = | $0.112\ W_{AC}^{1.51}$ | .62 | .32 | 85 |
| | Q.10 = | $0.278\ W_{AC}^{1.42}$ | .72 | .24 | 60 |
| | QM = | $0.142\ W_{AC}^{1.48}$ | .69 | .27 | 69 |

at the gaged site to the ungaged site. This estimation method, referred to in this report as the "concurrent-measurement method," has been used previously in Montana to estimate mean annual streamflow (Parrett and Hull, 1985; Parrett, 1985) and selected flows on a duration curve of monthly mean streamflow (Parrett and Hull, 1986). According to Searcy (1959, p. 17) and Riggs (1972, p. 15), the concurrent-measurement method generally provides more reliable estimates of low-flow characteristics than other methods not using discharge measurements.

The concurrent-measurement method investigated in this study requires 12 measurements (1 per month) at the ungaged site of interest. The measurements are paired with concurrent daily mean discharges obtained from a similar, nearby gaged site, and a straight line is plotted through the logarithms of the data points. The curve-fitting technique used (MOVE.1) is described by Hirsch (1982). The MOVE.1 technique is similar to an ordinary least-squares regression, except that ordinary regression minimizes the squared vertical deviations of the dependent variable from the regression line, whereas the MOVE.1 technique minimizes the areas of the right triangles formed by the horizontal and vertical deviations from the regression line (Hirsch and Gilroy, 1984, p. 707). The equation describing the ordinary least-squares regression line is the following:

$$y = \bar{y} + r (S_y/S_x) ( x - \bar{x} ), \tag{5}$$

where

$y$    is the dependent variable,

$\bar{y}$    is the sample mean of the dependent variable,

$r$    is the sample correlation coefficient between the dependent and independent variables,

$S_y$    is the sample variance of the dependent variable,

$S_x$    is the sample variance of the independent variable,

$x$    is the independent variable, and

$\bar{x}$    is the sample mean of the independent variable.

The following equation describing the MOVE.1 best-fit line is identical to equation 5 except that $r$ is not included:

$$y = \bar{y} + (S_y/S_x) ( x - \bar{x} ), \tag{6}$$

where all terms are as defined above. An example of an ordinary regression line and a MOVE.1 line fit to concurrent daily-mean discharges at two gaged sites is shown in figure 2. Although the two best-fit lines in figure 2 are similar, Stedinger and Thomas (1985) have shown that the MOVE.1 line is an unbiased estimator of low flows, whereas the ordinary regression line is a biased estimator of low flows. An alternative approach to the MOVE.1 or ordinary least-squares
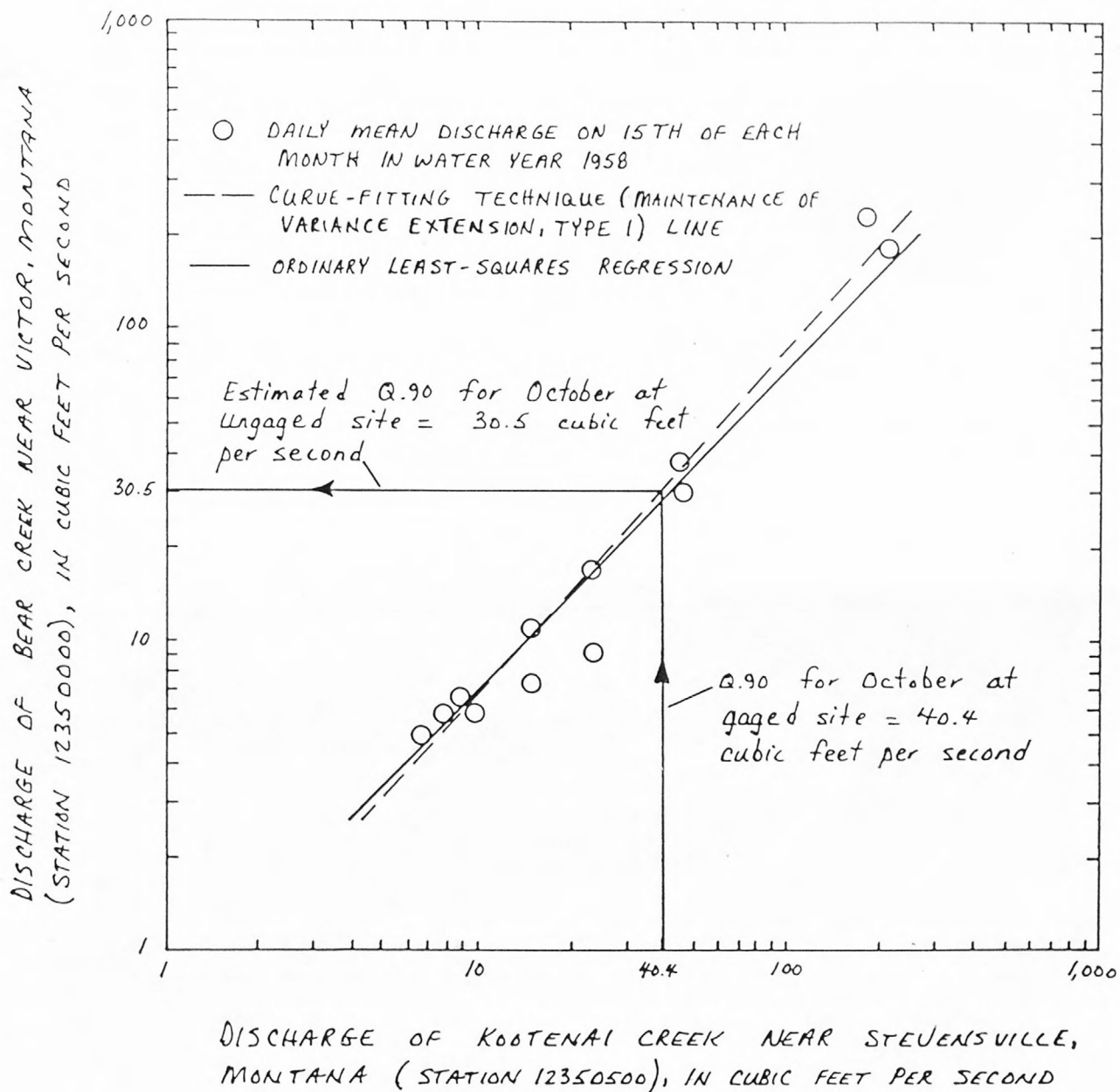
Figure 2.--Comparison between lines for the curve-fitting technique and ordinary least-squares regression lines.

regression would be a visual fit to the 12 data points. Although a visual fit would be subjective, it would allow the fitting of curves or multiple straight-line segments rather than a simple straight line.

To obtain an estimate of a particular monthly flow characteristic at the ungaged site, the value of the flow characteristic at the gaged site is located along the horizontal axis and projected to the MOVE.1 line. The horizontal projection from the MOVE.1 line to the vertical axis yields the estimate at the ungaged site

as shown in figure 2. As indicated by Searcy (1959, p. 20), the relation between concurrent high flows may be different from the relation between concurrent base flows so that a single straight line may not provide a good fit to the data. Riggs (1969) also showed that a difference in timing of runoff at two sites will result in a concurrent discharge plot that resembles a loop. Nevertheless, an examination of concurrent discharges from pairs of streamflow-gaging stations within the study area indicated that, in most instances, either the deviation from a single straight-line fit was not significant or the scatter about the line was great enough to mask any deviations. Accordingly, the reliability tests of the concurrent-measurement method are all based on a single MOVE.1 fit to the concurrent-measurement data. In applying the method at any particular site, however, the reader needs to be aware that a single straight line may not fit the data as well as two straight-line segments or that a timing-effects loop may exist. Using more complicated curve-fitting procedures in those instances will probably yield more accurate estimates than using the single MOVE.1 line.

To estimate the standard error of estimate of the concurrent-discharge method, the 20 pairs of streamflow-gaging stations listed in table 4 were tested. One

Table 4.--*Streamflow-gaging stations used in the test of the curve-fitting technique*[1]

| Station used as pseudo-ungaged site | Station used as index gaged site | Year of record used in test |
|---|---|---|
| 06024500 | 06061500 | 1951 |
| 06030500 | 06033000 | 1947 |
| 06062500 | 06061500 | 1969 |
| 06073000 | 06078500 | 1951 |
| 06081500 | 06061500 | 1912 |
| 12301300 | 12302055 | 1980 |
| 12301999 | 12302055 | 1970 |
| 12303100 | 12302500 | 1968 |
| 12324100 | 12330000 | 1966 |
| 12346500 | 12343400 | 1967 |
| 12350000 | 12350500 | 1958 |
| 12351000 | 12350500 | 1958 |
| 12356500 | 12359000 | 1952 |
| 12360000 | 12359500 | 1953 |
| 12360500 | 12359500 | 1956 |
| 12361000 | 12359500 | 1956 |
| 12361500 | 12359500 | 1956 |
| 12365800 | 12366000 | 1979 |
| 12369200 | 12370000 | 1976 |
| 12390700 | 12389500 | 1983 |

[1]Maintenance of Variance Extension, Type 1 (MOVE.1).

station of each pair was selected to be the test site (herein called the pseudo-ungaged site) for which estimates of monthly streamflow were required, and the other station served as the nearby, hydrologically similar index site. The stations were chosen such that the degree of similarity between the pseudo-ungaged and gaged sites was about the same as would be expected in actual practice. Thus, in some instances both sites were located in adjacent drainages and were very similar, and in other instances the sites were many miles apart and probably not so similar. One year from the concurrent period of record at each pair of stations was randomly selected, and the recorded daily mean discharge on the 15th of each month was used as the measured discharge at the pseudo-ungaged site and as the concurrent discharge at the gaged site. The MOVE.1 technique was then used to fit a line to the 12 data points, and the fitted line was used to estimate the monthly flow characteristics at the pseudo-ungaged site from the known monthly flow characteristics at the gaged site as described above.

The standard deviation of the differences (residuals) between the actual monthly flow characteristics at the 20 pseudo-ungaged sites and the estimated monthly flow characteristics from the MOVE.1 line was considered to be analogous to the standard error of estimate computed for the basin-characteristics method and the channel-width method. The resultant calculated "standard errors" for the monthly flow characteristics as determined from the 20 pairs of stations are presumed to be a reasonable approximation of the expected reliability of the concurrent-measurement method and are listed in table 5. Comparison of the standard errors in table 5 with the standard errors for the basin-characteristics method

Table 5.--*Standard errors for concurrent-measurement method based on 12 measurements*

[Q.xx, daily mean discharge exceeded xx percent of the time during the specified month, in cubic feet per second; QM, mean monthly discharge, in cubic feet per second]

| Month | Standard error, in percent, for specified monthly flow characteristic | | | | |
|-------|-------|-------|-------|-------|-------|
|       | Q.90 | Q.70 | Q.50 | Q.10 | QM |
| Oct. | 69 | 38 | 31 | 36 | 26 |
| Nov. | 46 | 28 | 21 | 31 | 21 |
| Dec. | 41 | 21 | 19 | 31 | 26 |
| Jan. | 38 | 21 | 21 | 28 | 26 |
| Feb. | 28 | 21 | 21 | 33 | 26 |
| Mar. | 26 | 23 | 26 | 38 | 28 |
| Apr. | 33 | 38 | 36 | 38 | 41 |
| May | 51 | 43 | 43 | 41 | 38 |
| June | 66 | 46 | 38 | 46 | 38 |
| July | 85 | 51 | 43 | 49 | 43 |
| Aug. | 92 | 66 | 54 | 38 | 46 |
| Sept. | 85 | 54 | 46 | 33 | 33 |

in table 2 and with the standard errors for the channel-width method in table 3 indicates that the concurrent-measurement method is substantially more reliable than the other methods for all months and nearly all monthly flow characteristics.

Using the concurrent-measurement method with 12 once-monthly measurements requires a large investment of time and money. Therefore, it is of some interest to investigate whether a program of fewer measurements might provide estimates of acceptable accuracy. Accordingly, the concurrent-measurement method was tested for the situation where only five once-monthly discharge measurements were available. For the same randomly selected year of record used in the 12-measurement test, the mid-monthly recorded discharge for the base-flow months November through March were used as data points for the 20 gage pairs, and the test described above was repeated. The five base-flow months were chosen for testing because many ungaged sites on the Flathead Indian Reservation had discharge measurements available for only those months. The computed standard errors for the concurrent-measurement method based on the five base-flow measurements are given in table 6. In this instance, the computed standard errors are substantially larger than the computed standard errors for the 12-measurement situation for most months when flow measurements were not available. The computed standard errors for the five-measurement situation are particularly large, substantially larger even than the standard

Table 6.--*Standard errors for concurrent-measurement*
*method based on five measurements*

[Q.xx, daily mean discharge exceeded xx percent of the time during the specified month, in cubic feet per second; QM, mean monthly discharge, in cubic feet per second]

| Month | Standard error, in percent, for specified monthly flow characteristic | | | | |
| --- | --- | --- | --- | --- | --- |
| | Q.90 | Q.70 | Q.50 | Q.10 | QM |
| Oct. | 82 | 49 | 38 | 75 | 49 |
| Nov.[1] | 57 | 36 | 36 | 60 | 38 |
| Dec.[1] | 43 | 28 | 28 | 60 | 36 |
| Jan.[1] | 36 | 26 | 31 | 51 | 31 |
| Feb.[1] | 31 | 23 | 26 | 46 | 31 |
| Mar.[1] | 28 | 28 | 31 | 54 | 33 |
| Apr. | 38 | 54 | 103 | 258 | 149 |
| May | 179 | 326 | 471 | 772 | 471 |
| June | 214 | 353 | 415 | 737 | 451 |
| July | 120 | 129 | 160 | 339 | 214 |
| Aug. | 99 | 92 | 96 | 116 | 92 |
| Sept. | 92 | 69 | 63 | 69 | 60 |

[1]Months when measurements were made.

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errors for the basin-characteristics method or the channel-width method, April through July. Thus, the concurrent-measurement method based on fewer than 12 measurements may provide monthly flow estimates with an acceptable accuracy only for those months when measurements were made.

## Weighted-Average Estimate

When different methods are available for estimating streamflow characteristics, it seems reasonable to assume that a weighted average of the individual estimates might provide a better answer than any of the individual estimates. When the individual estimates are independent, E.J. Gilroy (as cited by the U.S. Water Resources Council, 1981, p. 8-1) showed that the individual estimates could be weighted inversely proportional to their variances, and the resultant weighted average would have a smaller variance than any of the individual estimates.

To test whether the three estimating methods yield independent estimates, the cross-correlation coefficient between the residuals from the different methods was computed for 18 of the gaged sites used as pseudo-ungaged sites (table 4) in the concurrent-measurement method test. Two sites used in the concurrent-measurement test (stations 06030500 and 06081500) could not be used in this test because not all required basin-characteristics data were available. The equation used to compute the cross-correlation coefficient is the following:

$$r_{xy} = \frac{\sum\limits_{i=1}^{N} x_i y_i - N \, \bar{x} \, \bar{y}}{(N-1) \, S_x \, S_y} \quad , \tag{7}$$

where

$r_{xy}$ is the correlation coefficient between the residuals from method x and method y (ranges from -1.0 to 1.0),

$N$ is the total number of sample residuals (18 in this computation),

$x_i$ and $y_i$ are the $i$-th residuals from methods x and y,

$\bar{x}$ and $\bar{y}$ are the mean values of the residuals from methods x and y, and

$S_x$ and $S_y$ are the standard deviations of the residuals from methods x and y.

If the computed correlation coefficients between the residuals from any two estimating methods are zero or near-zero, the two methods may be considered to be independent. The results of the correlation-coefficient computations for all methods are listed in tables 7-9.

Table 7.--*Correlation between residuals from basin-characteristics method and channel-width method*

[Q.xx, daily mean discharge exceeded xx percent of the time during the specified month, in cubic feet per second; QM, mean monthly discharge, in cubic feet per second]

| Flow charac-teristic | Correlation coefficient between residuals for specified month | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. |
| Q.90 | 0.73 | 0.63 | 0.63 | 0.60 | 0.57 | 0.50 | 0.35 | 0.36 | 0.62 | 0.79 | 0.85 | 0.84 |
| Q.70 | .63 | .58 | .54 | .52 | .51 | .46 | .10 | .18 | .40 | .68 | .80 | .79 |
| Q.50 | .57 | .52 | .51 | .49 | .43 | .45 | .18 | .18 | .31 | .60 | .77 | .76 |
| Q.10 | .68 | .45 | .41 | .42 | .49 | .52 | .30 | .19 | .16 | .45 | .68 | .65 |
| QM | .54 | .44 | .45 | .43 | .45 | .46 | .17 | .17 | .23 | .52 | .74 | .69 |

Table 8.--*Correlation between residuals from basin-characteristics method and concurrent-measurement method*

[Q.xx, daily mean discharge exceeded xx percent of the time during the specified month, in cubic feet per second; QM, mean monthly discharge, in cubic feet per second]

| Flow charac-teristic | Correlation coefficient between residuals for specified month | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. |
| Q.90 | -0.34 | -0.22 | -0.11 | -0.17 | -0.16 | -0.05 | -0.18 | -0.52 | -0.46 | -0.49 | -0.42 | -0.44 |
| Q.70 | -.47 | -.56 | -.27 | .02 | -.08 | -.15 | -.38 | -.41 | -.29 | -.42 | -.42 | -.44 |
| Q.50 | -.53 | -.51 | -.34 | .01 | -.03 | -.12 | -.36 | -.33 | -.24 | -.32 | -.38 | -.44 |
| Q.10 | -.46 | -.47 | -.34 | -.21 | -.37 | -.26 | -.56 | -.09 | .03 | -.05 | -.22 | -.30 |
| QM | -.18 | -.34 | -.20 | .19 | -.09 | -.09 | -.36 | -.20 | -.16 | -.06 | -.24 | -.28 |

Table 9.--*Correlation between residuals from channel-width method and concurrent-measurement method*

[Q.xx, daily mean discharge exceeded xx percent of the time during the specified month, in cubic feet per second; QM, mean monthly discharge, in cubic feet per second]

| Flow charac- teristic | Correlation coefficient between residuals for specified month | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. |
| Q.90 | -0.45 | -0.30 | -0.21 | -0.19 | -0.05 | 0.18 | -0.12 | -0.42 | -0.50 | -0.47 | -0.47 | -0.51 |
| Q.70 | -.48 | -.37 | -.09 | -.01 | -.06 | -.13 | -.10 | -.39 | -.52 | -.49 | -.54 | -.59 |
| Q.50 | -.43 | -.19 | -.03 | .10 | -.07 | -.03 | -.11 | -.38 | -.53 | -.50 | -.58 | -.63 |
| Q.10 | -.46 | -.44 | -.26 | .01 | -.02 | .08 | -.23 | -.17 | -.23 | -.57 | -.65 | -.55 |
| QM | -.05 | -.02 | -.05 | .34 | .06 | .11 | -.03 | -.30 | -.46 | -.36 | -.50 | -.49 |

As indicated by the results in table 7, the basin-characteristics method and the channel-width method yield monthly flow estimates that generally are not independent from each other. The results in tables 8 and 9 indicate that the concurrent-measurement method provides monthly flow estimates that are independent from either of the other two methods for some monthly flow characteristics for some months. For other flow characteristics and months, however, the concurrent-measurement method estimates are not independent from estimates made from the other two methods. Results in tables 8 and 9 also indicate that the correlation between the concurrent-measurement method and the other two methods commonly is negative. The negative correlations are an indication that the two methods being compared are providing estimates on either side of the true value, and that the errors of the individual estimates might be compensating when the estimates are combined.

If the individual estimates are not independent, the following equations (E.J. Gilroy, U.S. Geological Survey, written commun., 1987) can be used to weight the individual estimates so as to yield the weighted average estimate with the smallest variance:

$$Z = a1 \cdot X1 + a2 \cdot X2 + a3 \cdot X3, \tag{8}$$

where

$Z$ is the unbiased, weighted estimate of some flow characteristic,

$a1$, $a2$, and $a3$ are weights which result in a minimum-variance, unbiased, linear combination of $X1$, $X2$, and $X3$, and

$X1$, $X2$, and $X3$ are estimates of the flow characteristic from three different methods.

Equations for the weights are as follows:

$$a1 = [C\ (SE_3^2 - S_{1,3}) - B\ (SE_3^2 - S_{2,3})]/(A\ C - B^2), \tag{9}$$

$$a2 = [A\ (SE_3^2 - S_{2,3}) - B\ (SE_3^2 - S_{1,3})]/(A\ C - B^2), \tag{10}$$

$$a3 = 1 - a1 - a2, \tag{11}$$

where

$$C = SE_2^2 + SE_3^2 - 2\ S_{2,3},$$

$SE_1$, $SE_2$, $SE_3$ are the standard errors of the three different estimating methods,

$S_{1,2} = r_{1,2}\ (SE_1 \cdot SE_2)$ and is the covariance of methods 1 and 2,

$S_{1,3} = r_{1,3}\ (SE_1 \cdot SE_3)$ and is the covariance of methods 1 and 3,

$S_{2,3} = r_{2,3}\ (SE_2 \cdot SE_3)$ and is the covariance of methods 2 and 3,

$r_{i,j}$ is the cross-correlation coefficient between estimates from methods $i$ and $j$.

$$A = SE_1^2 + SE_3^2 - 2\ S_{1,3}, \text{ and}$$

$$B = SE_3^2 + S_{1,2} - S_{1,3} - S_{2,3}.$$

The estimated standard error of the weighted estimate, $SE_z$, is determined as follows:

$$SE_z = [(a1 \cdot SE_1)^2 + (a2 \cdot SE_2)^2 + (1 - a1 - a2)^2\ SE_3^2$$

$$+ 2\ a1 \cdot a2 \cdot S_{1,2} + 2\ a1\ (1 - a1 - a2)\ S_{1,3}$$

$$+ 2\ a2\ (1 - a1 - a2)\ S_{2,3}]^{0.5}, \tag{12}$$

where all terms are as previously defined.

If only two of the estimating methods are used, the following equations for computing weights and standard error are applicable:

$$z = a1 \cdot X1 + a2 \cdot X2, \text{ and} \tag{13}$$

$$SE_z = \sqrt{(SE_1^2\ SE_2^2 - S_{1,2}^2)/(SE_1^2 + SE_2^2 - 2\ S_{1,2})} \tag{14}$$

where

$$a1 = (SE_2^2 - S_{1,2})/(SE_1^2 + SE_2^2 - 2\ S_{1,2}), \text{ and}$$

$$a2 = (SE_1^2 - S_{1,2})/(SE_1^2 + SE_2^2 - 2\ S_{1,2}).$$

The above equations were used to calculate weights and standard errors for all combinations of the three estimating methods. For the basin-characteristics method and the channel-width method, the standard errors are based on the regression data from 54 gaged sites. The standard errors for the concurrent-measurement method are based on data from 20 gaged sites (table 4). The results, listed in table 13 at the back of the report, indicate that considerably more weight is given to the concurrent-measurement method estimates than either the basin-characteristics method or channel-width method estimates for all monthly streamflow characteristics for all months. Likewise, the weighted standard errors are substantially less when the concurrent-measurement estimates are included in the weighting procedure than when only estimates from the basin-characteristics method and channel-width method are used.

## RELIABILITY AND LIMITATIONS OF ESTIMATING METHODS

Graphical comparisons of the standard errors for the individual methods of estimation and for the weighted-average estimates using all three methods are shown in figures 3-7. The standard errors, expressed in percent, range from 43 to 107 for the basin-characteristics method, from 41 to 111 for the channel-width method, from 19 to 92 for the concurrent-measurement method, and from 15 to 43 for the weighted-average estimates using all three methods. As indicated, the weighted-average estimates have the smallest standard errors for all monthly flow characteristics for all months. The weighted-average estimates thus are considered to be generally substantially more reliable than estimates from any of the three individual methods.
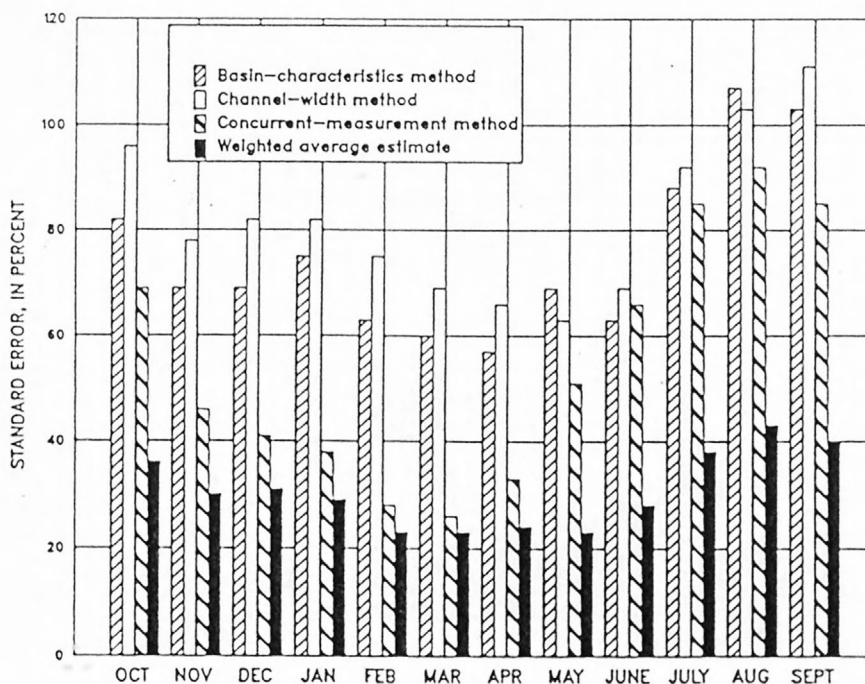


Figure 3.--Standard error for daily mean discharge exceeded 90 percent of the time based on different methods of estimation.
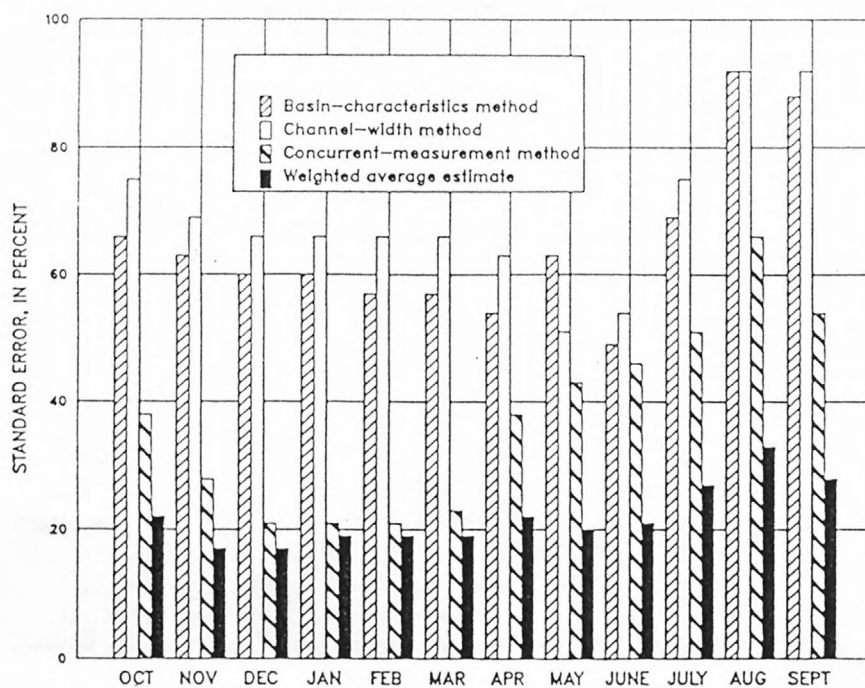
Figure 4.--Standard error for daily mean discharge exceeded 70 percent of the time based on different methods of estimation.
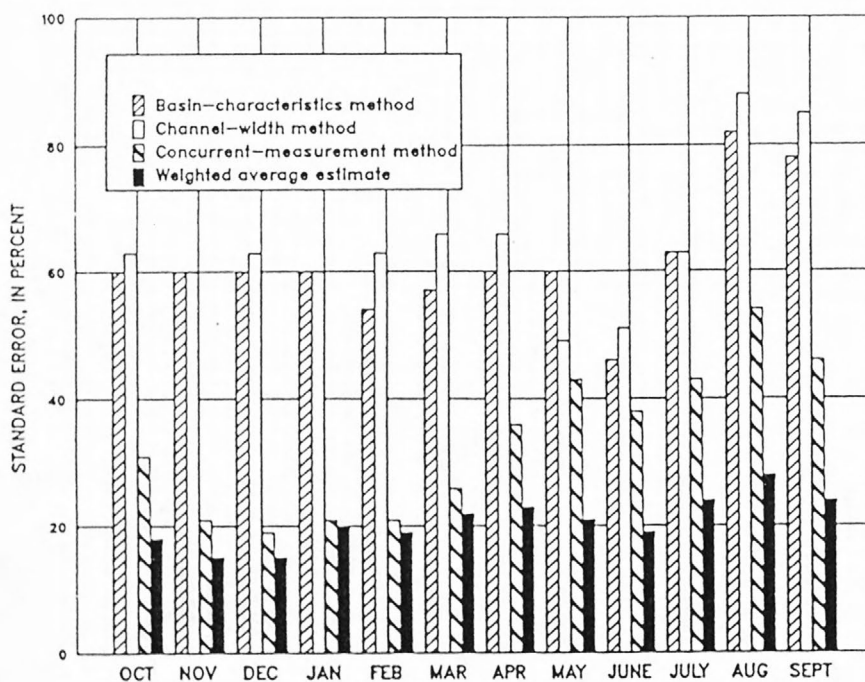


Figure 5.--Standard error for daily mean discharge exceeded 50 percent of the time based on different methods of estimation.
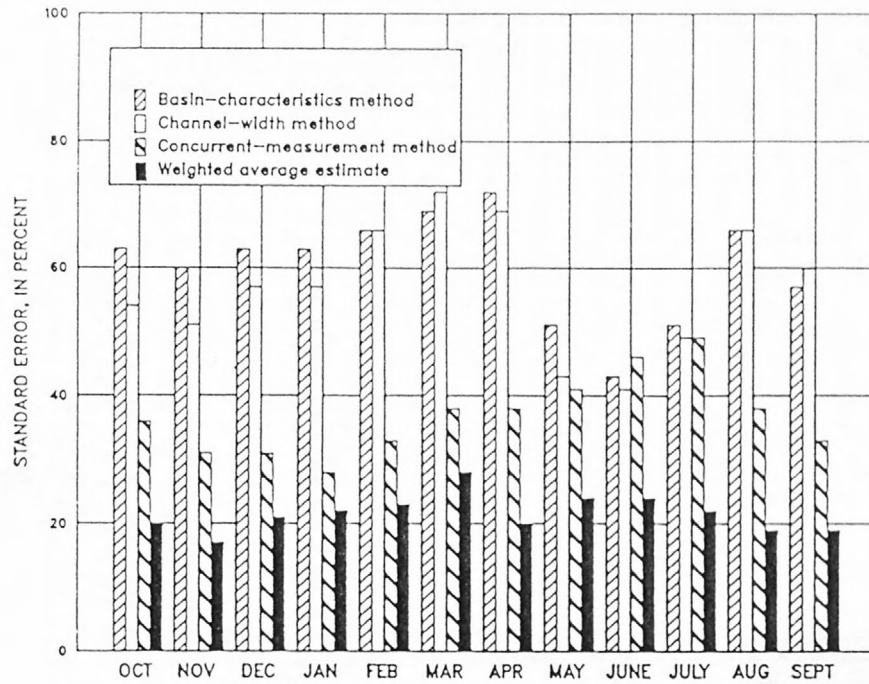
Figure 6.--Standard error for daily mean discharge exceeded 10 percent of the time based on different methods of estimation.
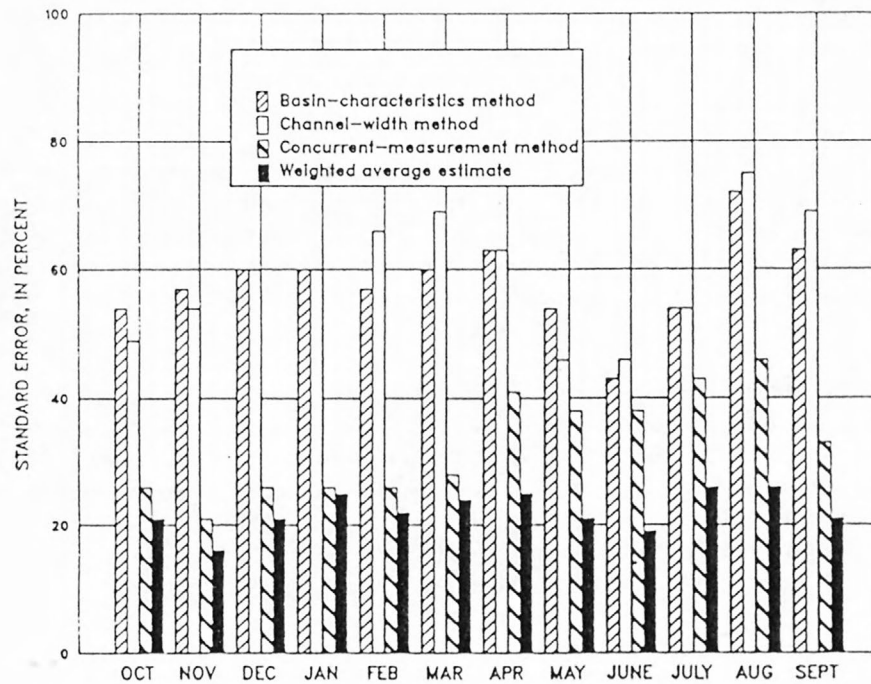


Figure 7.--Standard error for mean monthly discharge based on different methods of estimation.

Although figures 3-7 indicate the general reliability of the different estimating methods, the reader needs to be aware of certain limitations associated with the individual methods that may limit their applicability. Both the basin-characteristics method and the channel-width method, for example, are based on regression analyses, and the resultant regression equations may not be applicable beyond the range of variable values used to derive the equations. The ranges of basin and climatic characteristics and channel widths used in this study are given in table 10. Extrapolation beyond the values listed may yield erroneous estimates. Regression equations based on basin characteristics are also generally not applicable to streams that receive their water from springs or that lose substantial flows because of permeable streambeds or other localized geologic features. The equations also may not be applicable to stream sites with appreciable upstream lake storage or diversions.

Table 10.--*Range of basin and climatic characteristics and channel widths used in the regression analyses*

| Basin or width characteristic | Range of values |
|---|---|
| Drainage area (A), in square miles | 3.59 - 838 |
| Percentage of basin above 6,000 feet elevation, plus 1 (E6), | 1.00 - 101 |
| Basin perimeter (PE), in miles | 11.4 - 172 |
| Basin slope (BSL), dimensionless | 0.19 - 0.64 |
| Mean annual precipitation (P), in inches | 15 - 69 |
| Mean basin elevation (E), in thousands of feet | 4.10 - 7.60 |
| Maximum basin relief (BR), in thousands of feet | 2.04 - 7.09 |
| Active-channel width ($W_{AC}$), in feet | 12 - 172 |
| Bankfull width ($W_{BF}$), in feet | 16 - 192 |

Regression equations based on channel width are probably more reliable than equations based on basin characteristics in such instances, because channel width is formed by the recent flow regime, no matter how anomalous the regime may be. Conversely, however, the channel-width method is generally not applicable where exposed bedrock occurs in either the streambed or banks, on braided or sand-channel streams, or on streams that have recently flooded or been altered by human activities.

In addition, accurate measurements of channel width require training and experience, and, even among experienced individuals, the variability in measured widths can be large. On the basis of a test in Wyoming, Wahl (1977) reported that the standard error in estimated flood discharge that could be attributed solely to measurement error might be as large as 30 percent. The total standard error of estimate for discharge using the channel-width method thus is comprised of both regression error and some unknown measurement error.

Because the concurrent-measurement method is based only on measured streamflow, the method is generally applicable where a suitable flow-measurement section can be found and where a suitable, nearby, concurrent streamflow-gaging station is available. Thus, the method can be used for sites where neither the

basin-characteristics method nor the channel-width method provides reliable esti-
mates, but the reliability of the estimates made using the concurrent-measurement
method is dependent on the degree of correlation between the measurement site and
the index gaged site.  If the concurrent measurements at the two sites are poorly
correlated and show a large amount of scatter about the best-fit MOVE.1 line, the
estimates made using the concurrent-measurement method may be unreliable.  Exten-
sion of the MOVE.1 line beyond the range of discharge measurements may also result
in errors in the long-term estimates.  Additional limitations on the use of the
concurrent-measurement method are the expense and time required to make the required
12 monthly flow measurements.  Alternative measuring programs using fewer measure-
ments can be devised, but the standard errors of the method may increase substan-
tially.


## APPLICATION OF ESTIMATING METHODS

The general procedures for using all methods to make estimates of monthly flow
characteristics and for weighting the individual estimates are illustrated in the
following examples.  The examples are varied to illustrate typical applications of
the various methods.


## Example 1.

Estimates of the daily mean discharges exceeded 90 and 10 percent of the time
(Q.90 and Q.10) during July are required for a stream located within the study area.
The basin perimeter (PE), maximum basin relief (BR), and basin slope (BSL) were
measured on suitable topographic maps and determined to be 13.1 mi, 5.22 thousands
of feet, and 0.55, respectively.  The site was visited and the active-channel width
($W_{AC}$) was determined to be 16 ft.  Using the applicable basin-characteristics equa-
tions from table 2, the required monthly streamflow characteristics are calculated
as follows:

$$Q.90 = 0.192 \; PE^{1.37} \; BR^{0.96} \; BSL^{1.31}$$
$$Q.90 = 0.192 \; (13.1)^{1.37} \; (5.22)^{0.96} \; (0.55)^{1.31}$$
$$\underline{Q.90 = 14.5 \; ft^3/s}$$


$$Q.10 = 0.871 \; PE^{1.35} \; BR^{1.01} \; BSL^{1.20}$$
$$Q.10 = 0.871 \; (13.1)^{1.35} \; (5.22)^{1.01} \; (0.55)^{1.20}$$
$$\underline{Q.10 = 72.7 \; ft^3/s}$$


Similarly, the required monthly streamflow characteristics are calculated from
the applicable channel-width equations in table 3:

$$Q.90 = 0.162 \; W_{AC}^{1.51}$$
$$Q.90 = 0.162 \; (16)^{1.51}$$
$$\underline{Q.90 = 10.7 \; ft^3/s}$$


$$Q.10 = 0.857 \; W_{AC}^{1.51}$$
$$Q.10 = 0.857 \; (16)^{1.51}$$
$$\underline{Q.10 = 56.4 \; ft^3/s}$$

A program of once-monthly streamflow measurements was also instituted, and the measured flows were correlated with concurrent flows at a nearby, gaged correlating site as previously described. The MOVE.1 line through the plotted concurrent flows yielded the following estimates at the ungaged site:

$Q.90 = 13.1 \text{ ft}^3/\text{s}$
$Q.10 = 53.0 \text{ ft}^3/\text{s}$

Weights for July were determined from table 13 for all three methods. Weighted estimates were calculated as follows:

$Q.90 = 14.5 (0.294) + 10.7 (0.210) + 13.1 (0.496)$
$\underline{Q.90 = 13.0 \text{ ft}^3/\text{s}}$


$Q.10 = 72.7 (0.006) + 56.4 (0.496) + 53.0 (0.498)$
$\underline{Q.10 = 54.8 \text{ ft}^3/\text{s}}$


## Example 2.

Estimates of the daily mean discharge exceeded 50 percent of the time (Q.50) and the mean monthly discharge (QM) for June are required for a site in the study area. Insufficient time was available to use the concurrent-measurement method. The following basin and climatic characteristics were measured from topographic and precipitation maps:

Drainage area (A) = 22.6 $\text{mi}^2$,
Basin slope (BSL) = 0.62,
Mean annual precipitation (P) = 40 in., and
Percentage of basin above 6,000 ft elevation, plus 1 (E6) = 61.0.

On a site visit, the bankfull width ($W_{BF}$) was measured as 35 ft.

Using the applicable basin-characteristics equations in table 2, the required monthly flow characteristics were calculated as follows:

$Q.50 = 0.245 \; A^{0.91} \; BSL^{0.95} \; P^{0.95} \; E6^{0.19}$
$Q.50 = 0.245 \; (22.6)^{0.91} \; (0.62)^{0.95} \; (40)^{0.95} \; (61.0)^{0.19}$
$\underline{Q.50 = 193 \text{ ft}^3/\text{s}}$


$QM = 0.284 \; A^{0.90} \; BSL^{0.87} \; P^{0.92} \; E6^{0.19}$
$QM = 0.284 \; (22.6)^{0.90} \; (0.62)^{0.87} \; (40)^{0.92} \; (61.0)^{0.19}$
$\underline{QM = 202 \text{ ft}^3/\text{s}}$


Using the appropriate channel-width equations in table 3, the monthly flow characteristics were calculated as follows:

$Q.50 = 0.423 \; W_{BF}^{1.67}$
$Q.50 = 0.423 \; (35)^{1.67}$
$\underline{Q.50 = 160 \text{ ft}^3/\text{s}}$

$$QM = 0.445 \ W_{BF}{}^{1.68}$$
$$QM = 0.445 \ (35)^{1.68}$$
$$\underline{QM = 175 \ ft^3/s}$$

Using the appropriate weights from table 13 for June, the weighted estimates based on the basin-characteristics method and the channel-width method were calculated as follows:

$$Q.50 = 193 \ (0.572) + 160 \ (0.428)$$
$$\underline{Q.50 = 179 \ ft^3/s}$$

$$QM = 202 \ (0.535) + 175 \ (0.465)$$
$$\underline{QM = 189 \ ft^3/s}$$

Example 3.

Estimates of mean monthly discharge for January and February are required for a site in the study area. The following basin characteristics were measured on available topographic and precipitation maps:

Drainage area (A) = 21.0 mi$^2$,
Maximum basin relief (BR) = 4.01 thousands of feet, and
Basin slope (BSL) = 0.37.

On a site visit, the active-channel width ($W_{AC}$) was measured as 30 ft. During the site visit, the stream appeared to receive its water from a spring because streamflow was greater than at nearby, similar streams in the area. A concurrent-measurement program was instituted, and the 12 visits for measurements also confirmed that the site had greater flows than nearby, similar streams. Based on the concurrent-measurement program, estimates of the required monthly flow characteristics were as follows:

QM for January = 22.5 ft$^3$/s
QM for February = 24.2 ft$^3$/s

Using the appropriate basin-characteristics equations in table 2, mean monthly flow estimates were calculated as follows:

QM for January = $0.424 \ A^{0.96} \ BR^{0.88} \ BSL^{1.30}$
QM for January = $0.424 \ (21.0)^{0.96} \ (4.01)^{0.88} \ (0.37)^{1.30}$
$\underline{\text{QM for January} = 7.35 \ ft^3/s}$

QM for February = $0.590 \ A^{1.03} \ BR^{0.63} \ BSL^{1.53}$
QM for February = $0.590 \ (21.0)^{1.03} \ (4.01)^{0.63} \ (0.37)^{1.53}$
$\underline{\text{QM for February} = 7.11 \ ft^3/s}$

Using the appropriate channel-width equations in table 3, the estimates of mean monthly flow were calculated as follows:

$$QM \text{ for January} = 0.0509 \ W_{AC}^{1.73}$$
$$QM \text{ for January} = 0.0509 \ (30)^{1.73}$$
$$\underline{QM \text{ for January} = 18.3 \ ft^3/s}$$

$$QM \text{ for February} = 0.0476 \ W_{AC}^{1.75}$$
$$QM \text{ for February} = 0.0476 \ (30)^{1.75}$$
$$\underline{QM \text{ for February} = 18.3 \ ft^3/s}$$

Because the flow estimates made from the basin-characteristics equations were substantially smaller than the estimates made from the other two methods, and because the site appeared to receive its water from a spring during the site visits, the basin-characteristics estimates were considered to be erroneous. The final weighted estimates of mean monthly flow thus were made using only the concurrent-measurement method estimates and the channel-width method estimates from table 13 for January and February as follows:

$$QM \text{ for January} = 18.3 \ (0.060) + 22.5 \ (0.940)$$
$$\underline{QM \text{ for January} = 22.2 \ ft^3/s}$$

$$QM \text{ for February} = 18.3 \ (0.136) + 24.2 \ (0.864)$$
$$\underline{QM \text{ for February} = 23.4 \ ft^3/s}$$

The above examples were selected to illustrate how the various methods for estimating monthly streamflow characteristics could be used and combined in typical applications to provide the most reliable estimates. Considerable judgment is required to decide which methods may be appropriate or cost-and-time effective, however. Situations requiring the most accurate and reliable estimates will almost always require use of the concurrent-measurement method, but the additional time and cost required may be prohibitive.

## SUMMARY AND CONCLUSIONS

Three methods for estimating mean monthly discharge and various points on the daily mean flow-duration curve for each month (daily mean discharges exceeded 90, 70, 50, and 10 percent of the time each month) were developed for western Montana. The first method was based on a multiple-regression analysis that related the streamflow characteristics to various basin and climatic variables. Several new basin characteristics were measured and tested to determine whether the regression equations might be improved. New characteristics that were found to be significant were basin perimeter, basin slope, and maximum basin relief. The estimating equations based on basin characteristics had standard errors ranging from 43 to 107. The standard error was smallest in the estimating equations for daily mean discharge that was exceeded 10 percent of the time (Q.10) for June and for mean monthly discharge for June. The standard error was largest in the estimating equations for daily mean discharge that was exceeded 90 percent of the time (Q.90) for August. Regression equations based on basin and climatic characteristics are generally not

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applicable to streams that receive or lose water as a result of localized geologic features. They also may not be applicable to stream sites with appreciable upstream storage or diversions.

The second method for estimating monthly streamflow characteristics was based on a regression analysis relating the streamflow characteristics to channel width. The channel-width features used were active-channel width ($W_{AC}$) and bankfull width ($W_{BF}$). Most of the derived regression equations were based on active-channel width, but the equations for May and June were based on bankfull width. The standard errors for the estimating equations based on channel width ranged from 41 to 111. The standard error was smallest in the estimating equation for daily mean discharge that was exceeded 10 percent of the time (Q.10) during June, and was largest in the estimating equation for daily mean discharge that was exceeded 90 percent of the time (Q.90) in September. Regression equations based on channel width are generally not applicable where bedrock is exposed in the channel, on braided or sand-channel streams, or on streams that have recently been altered by floods or human activities. Proper application of the channel-width method also requires training and experience.

The third method for estimating monthly streamflow characteristics, termed the "concurrent-measurement method," required 12 once-monthly measurements of streamflow at the ungaged site of interest. The streamflow measurements at the ungaged site were correlated with concurrent discharges at a nearby gaged site using a MOVE.1 curve-fitting technique. The relation between flows at the two sites defined by the MOVE.1 curve then was used to compute the required monthly flow characteristics at the ungaged site from the monthly flow characteristics at the gaged site. Standard errors for the concurrent-measurement method were estimated by applying the method to 20 gaged sites and computing the standard deviation of the differences between the monthly flow characteristics determined from the estimation method and the monthly flow characteristics determined from the actual flow record. On this basis, the standard errors of the concurrent-measurement method ranged from 19 to 92 percent. The standard error was smallest in the estimate for the daily mean discharge that was exceeded 50 percent of the time (Q.50) during December, and was largest in the estimate for the daily mean discharge that was exceeded 90 percent of the time (Q.90) during August. Although the concurrent-measurement method is generally substantially more accurate than either the basin-characteristics method or the channel-width method, it may yield unreliable results if there is poor correlation between the measurement site and the index gaged site. In addition, the monthly flow measurement method may be too expensive and time-consuming for some applications.

A procedure for weighting individual estimates from any combination of the three different estimating methods to provide a minimum-variance-weighted-average estimate also was developed. The standard errors for the weighted estimates of monthly flow characteristics when all three methods were used ranged from 15 to 43 percent. The standard error was smallest for the weighted estimates for the daily mean discharge that was exceeded 50 percent of the time (Q.50) during November and December, and was largest for the daily mean discharge that was exceeded 90 percent of the time (Q.90) during August.

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SUPPLEMENTAL DATA

[Monthly streamflow characteristic: Q.90, daily mean discharge exceeded 90 percent of the time; Q.70, daily mean discharge exceeded 70 percent of the time; Q.50, daily mean discharge exceeded 50 percent of the time; Q.10, daily mean discharge exceeded 10 percent of the time; QM, mean monthly discharge; --, no data]

Monthly streamflow characteristic, in cubic feet per second, for specified month

| Gaging station | October | | | | | November | | | | | December | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Q.90 | Q.70 | Q.50 | Q.10 | QM | Q.90 | Q.70 | Q.50 | Q.10 | QM | Q.90 | Q.70 | Q.50 | Q.10 | QM |
| 06024500 | 16.0 | 19.1 | 21.7 | 29.8 | 21.8 | 14.1 | 17.0 | 19.4 | 30.7 | 21.0 | 10.6 | 13.8 | 16.6 | 21.4 | 15.6 |
| 06029000 | 2.1 | 2.7 | 4.1 | 15.9 | 7.3 | 1.6 | 2.1 | 2.3 | 3.6 | 2.6 | 1.3 | 1.7 | 2.0 | 3.0 | 2.1 |
| 06030500 | 1.5 | 1.9 | 2.3 | 3.9 | 2.4 | 1.4 | 1.8 | 2.2 | 3.2 | 2.2 | 1.1 | 1.4 | 1.8 | 3.0 | 1.9 |
| 06033000 | 13.7 | 22.7 | 31.7 | 66.7 | 36.0 | 17.8 | 26.6 | 33.2 | 54.3 | 34.4 | 15.5 | 23.0 | 28.0 | 42.4 | 28.1 |
| 06061500 | 18.0 | 23.1 | 30.7 | 58.2 | 32.7 | 18.5 | 23.4 | 28.3 | 47.7 | 30.7 | 14.9 | 20.9 | 25.5 | 37.9 | 25.1 |
| 06062500 | .4 | .6 | 1.1 | 8.1 | 3.0 | .4 | .7 | 1.3 | 5.6 | 2.2 | .3 | .7 | 1.1 | 4.4 | 1.8 |
| 06073000 | 15.9 | 28.2 | 39.7 | 80.7 | 43.7 | 25.2 | 30.4 | 37.6 | 82.7 | 44.8 | 22.1 | 27.5 | 33.7 | 67.3 | 39.2 |
| 06078500 | 73.9 | 88.4 | 106 | 185 | 122 | 65.4 | 79.3 | 93.3 | 148 | 102 | 54.4 | 66.5 | 75.1 | 124 | 83.0 |
| 06081500 | 3.2 | 7.0 | 12.5 | 25.7 | 12.7 | 4.3 | 8.8 | 12.0 | 21.5 | 12.1 | 4.9 | 7.0 | 9.3 | 17.3 | 10.2 |
| 12300500 | 8.8 | 10.8 | 13.9 | 80.3 | 27.3 | 9.0 | 11.6 | 17.0 | 55.8 | 25.0 | 8.4 | 11.6 | 18.8 | 44.1 | 23.8 |
| 12301300 | 69.0 | 87.1 | 103 | 163 | 114 | 73.6 | 94.6 | 108 | 169 | 118 | 68.1 | 82.5 | 96.0 | 158 | 108 |
| 12301999 | 7.3 | 8.8 | 10.3 | 14.3 | .10.5 | 7.9 | 9.1 | 10.8 | 17.0 | 11.4 | 7.0 | 8.5 | 9.6 | 23.1 | 12.0 |
| 12302055 | 94.0 | 112 | 125 | 182 | 132 | 103 | 127 | 147 | 294 | 174 | 97.9 | 132 | 163 | 366 | 223 |
| 12302500 | 6.7 | 10.5 | 18.8 | 60.7 | 27.4 | 7.8 | 15.4 | 24.4 | 63.4 | 32.6 | 11.6 | 16.6 | 22.1 | 71.5 | 38.8 |
| 12303100 | 5.4 | 6.8 | 8.0 | 15.2 | 9.0 | 6.0 | 7.7 | 9.2 | 19.3 | 11.5 | 5.3 | 6.5 | 7.8 | 15.6 | 10.8 |
| 12324100 | 24.4 | 27.6 | 30.0 | 49.3 | 33.2 | 18.7 | 22.2 | 24.8 | 36.0 | 25.3 | 16.5 | 19.4 | 21.6 | 29.3 | 21.5 |
| 12330000 | 13.5 | 19.0 | 23.8 | 38.6 | 24.7 | 16.7 | 21.0 | 24.2 | 34.7 | 24.8 | 14.8 | 19.4 | 21.5 | 30.0 | 21.9 |
| 12332000 | 35.9 | 41.9 | 46.5 | 68.7 | 51.6 | 28.5 | 36.3 | 41.1 | 64.0 | 43.8 | 23.4 | 30.3 | 35.0 | 52.1 | 36.4 |
| 12335000 | 111 | 144 | 162 | 204 | 159 | 111 | 130 | 150 | 194 | 149 | 93.3 | 120 | 135 | 173 | 132 |
| 12338690 | 37.1 | 41.8 | 45.4 | 60.3 | 46.4 | 34.7 | 38.7 | 41.8 | 61.0 | 45.6 | 31.2 | 35.1 | 38.3 | 84.3 | 45.2 |
| 12339450 | 51.3 | 61.4 | 75.3 | 123 | 81.7 | 54.4 | 66.7 | 74.3 | 156 | 86.1 | 63.2 | 70.2 | 76.6 | 180 | 99.8 |
| 12343400 | 83.6 | 97.5 | 108 | 151 | 113 | 72.3 | 89.7 | 102 | 142 | 104 | 52.7 | 75.0 | 87.5 | 126 | 92.4 |
| 12346500 | 30.7 | 36.2 | 41.2 | 53.9 | 41.5 | 26.9 | 31.3 | 35.1 | 45.8 | 35.4 | 23.0 | 26.3 | 29.0 | 39.1 | 30.0 |
| 12347500 | 3.5 | 8.8 | 16.8 | 59.7 | 27.3 | 5.6 | 12.2 | 18.3 | 56.6 | 25.6 | 6.2 | 11.6 | 16.6 | 42.4 | 22.2 |
| 12350000 | 2.9 | 6.4 | 14.1 | 55.2 | 22.2 | 5.7 | 11.2 | 15.4 | 51.2 | 22.5 | 5.2 | 8.4 | 13.7 | 40.2 | 19.2 |
| 12350500 | 5.9 | 15.8 | 27.9 | 85.4 | 40.4 | 7.1 | 16.5 | 23.4 | 74.1 | 33.5 | 6.1 | 12.5 | 14.8 | 41.6 | 21.1 |
| 12351000 | 15.8 | 17.9 | 20.2 | 31.8 | 21.8 | 16.0 | 18.2 | 20.9 | 33.3 | 22.3 | 14.3 | 17.3 | 19.3 | 27.9 | 19.6 |
| 12352000 | 15.0 | 39.0 | 52.1 | 138 | 65.1 | 26.4 | 53.5 | 75.7 | 179 | 88.9 | 39.4 | 54.1 | 66.3 | 163 | 87.3 |
| 12353280 | 23.1 | 29.0 | 31.3 | 39.2 | 30.9 | 22.5 | 28.5 | 31.7 | 44.7 | 32.2 | 23.3 | 27.2 | 31.4 | 82.9 | 42.7 |
| 12354000 | 89.8 | 108 | 122 | 207 | 143 | 99.2 | 118 | 153 | 519 | 235 | 86.9 | 105 | 143 | 431 | 214 |
| 12356500 | 8.8 | 10.9 | 17.5 | 37.7 | 21.9 | 8.7 | 14.4 | 18.1 | 27.5 | 18.4 | 7.3 | 10.8 | 12.9 | 26.4 | 16.1 |
| 12357000 | 148 | 187 | 225 | 678 | 347 | 132 | 177 | 280 | 702 | 355 | 121 | 166 | 246 | 643 | 333 |
| 12359000 | 261 | 316 | 433 | 1090 | 623 | 253 | 323 | 444 | 880 | 529 | 214 | 288 | 369 | 832 | 452 |
| 12359500 | 43.8 | 48.5 | 60.8 | 179 | 93.7 | 41.3 | 50.9 | 83.2 | 168 | 93.9 | 36.9 | 49.3 | 69.4 | 145 | 81.6 |
| 12360000 | 8.7 | 12.0 | 18.9 | 59.4 | 29.2 | 8.7 | 15.0 | 31.5 | 69.9 | 34.9 | 10.4 | 18.3 | 27.5 | 57.3 | 36.3 |
| 12360500 | 6.7 | 8.0 | 10.9 | 48.2 | 21.6 | 5.7 | 8.0 | 23.1 | 56.7 | 26.1 | 4.2 | 9.0 | 19.8 | 43.1 | 23.4 |
| 12361000 | 22.5 | 31.5 | 55.2 | 199 | 89.3 | 25.5 | 51.5 | 74.5 | 190 | 96.5 | 23.1 | 37.8 | 58.7 | 158 | 80.4 |
| 12361500 | 10.1 | 20.9 | 39.9 | 147 | 63.4 | 12.1 | 34.6 | 54.0 | 116 | 60.3 | 14.0 | 27.8 | 41.8 | 103 | 54.1 |
| 12364000 | 5.7 | 10.8 | 14.6 | 62.0 | 38.3 | 11.8 | 14.8 | 18.7 | 36.2 | 20.9 | 12.5 | 15.6 | 19.5 | 41.6 | 22.5 |
| 12365000 | 67.1 | 89.8 | 110 | 142 | 110 | 71.4 | 95.8 | 113 | 180 | 121 | 65.4 | 81.8 | 94.6 | 167 | 107 |
| 12365800 | 25.1 | 31.5 | 37.0 | 48.9 | 36.2 | 18.5 | 26.4 | 32.2 | 69.8 | 37.3 | 11.5 | 21.3 | 26.5 | 58.7 | 34.3 |
| 12366000 | 22.1 | 50.6 | 68.6 | 127 | 70.7 | 26.8 | 57.1 | 70.3 | 122 | 73.7 | 40.1 | 51.0 | 59.1 | 123 | 71.8 |
| 12369200 | 37.2 | 44.4 | 51.2 | 85.9 | 56.4 | 35.0 | 45.2 | 52.1 | 91.0 | 58.4 | 34.7 | 41.6 | 46.4 | 102 | 59.5 |
| 12370000 | 350 | 416 | 507 | 860 | 560 | 358 | 444 | 529 | 846 | 582 | 350 | 425 | 484 | 862 | 567 |
| 12376000 | 15.8 | 22.6 | 27.9 | 53.3 | 31.9 | 11.5 | 22.2 | 29.0 | 50.8 | 31.4 | 7.4 | 18.3 | 22.9 | 35.2 | 22.4 |
| 12378000 | 30.1 | 38.3 | 44.7 | 57.7 | 43.5 | 25.2 | 28.5 | 330 | 47.6 | 34.0 | 13.8 | 20.7 | 24.9 | 37.1 | 24.3 |
| 12378500 | 31.7 | 35.7 | 42.3 | 59.7 | 43.1 | 28.9 | 36.6 | 45.5 | 71.4 | 47.7 | 26.6 | 30.0 | 35.4 | 51.5 | 37.1 |
| 12379500 | 28.0 | 33.1 | 41.0 | 78.4 | 47.8 | 32.0 | 50.0 | 56.3 | 70.0 | 54.1 | 24.7 | 43.7 | 49.5 | 55.5 | 45.0 |
| 12381000 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 12381400 | 21.0 | 24.0 | 26.0 | 68.4 | 34.4 | 19.0 | 23.0 | 26.0 | 38.8 | 27.6 | 6.0 | 13.0 | 17.0 | 22.0 | 15.5 |
| 12381500 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 12382000 | -- | -- | -- | -- | .-- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 12382500 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 12383500 | 6.8 | 9.1 | 9.7 | 11.4 | 9.3 | 6.0 | 7.7 | 8.1 | 9.3 | 7.9 | 6.3 | 6.9 | 7.3 | 8.7 | 7.3 |
| 12385000 | 4.9 | 5.9 | 6.8 | 8.9 | 7.6 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 12388500 | 7.2 | 7.9 | 8.4 | 14.3 | 9.6 | 7.6 | 8.1 | 11.1 | 14.7 | 10.6 | 6.6 | 7.5 | 8.0 | 12.7 | 10.0 |
| 12389500 | 140 | 173 | 189 | 241 | 191 | 146 | 168 | 185 | 247 | 194 | 128 | 157 | 179 | 305 | 203 |
| 12390700 | 43.3 | 51.4 | 56.9 | 68.0 | 59.7 | 41.1 | 47.9 | 52.8 | 122 | 69.7 | 41.4 | 48.9 | 57.8 | 228 | 113 |
| 12391550 | 76.8 | 91.8 | 102 | 135 | 103 | 80.2 | 95.6 | 116 | 267 | 157 | 79.0 | 109 | 182 | 551 | 282 |

Monthly streamflow characteristic, in cubic feet per second, for specified month

| Gaging station | January | | | | | February | | | | | March | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Q.90 | Q.70 | Q.50 | Q.10 | QM | Q.90 | Q.70 | Q.50 | Q.10 | QM | Q.90 | Q.70 | Q.50 | Q.10 | QM |
| 06024500 | 9.6 | 12.3 | 14.8 | 20.5 | 14.2 | 8.6 | 11.5 | 12.7 | 27.7 | 14.9 | 9.5 | 13.3 | 14.8 | 23.1 | 15.5 |
| 06029000 | .5 | 1.4 | 1.6 | 2.0 | 1.4 | 1.5 | 1.8 | 1.9 | 2.3 | 1.8 | 1.1 | 1.7 | 1.8 | 2.6 | 1.8 |
| 06030500 | .9 | 1.4 | 1.7 | 2.6 | 1.7 | 1.0 | 1.4 | 1.8 | 2.4 | 1.7 | .9 | 1.5 | 2.0 | 4.1 | 2.1 |
| 06033000 | 14.7 | 21.6 | 27.4 | 38.8 | 26.1 | 16.2 | 24.1 | 29.1 | 41.3 | 29.7 | 24.2 | 30.5 | 36.1 | 73.3 | 45.4 |
| 06061500 | 13.5 | 19.8 | 23.2 | 32.6 | 22.2 | 15.1 | 20.8 | 24.0 | 37.0 | 25.0 | 17.4 | 24.2 | 29.2 | 50.1 | 32.0 |
| 06062500 | .3 | .7 | 1.1 | 3.1 | 1.5 | .4 | .7 | 1.1 | 3.0 | 1.4 | .5 | 1.0 | 1.6 | 5.6 | 2.4 |
| 06073000 | 20.1 | 23.9 | 28.2 | 52.1 | 32.6 | 19.9 | 23.6 | 27.8 | 49.5 | 31.1 | 22.2 | 26.4 | 30.8 | 51.2 | 36.4 |
| 06078500 | 46.6 | 56.7 | 64.6 | 89.6 | 66.6 | 47.3 | 56.3 | 65.0 | 87.4 | 66.3 | 46.8 | 55.3 | 61.5 | 92.0 | 67.7 |
| 06081500 | 4.0 | 6.0 | 7.2 | 18.3 | 10.1 | 3.3 | 6.4 | 7.9 | 22.7 | 14.1 | 5.8 | 9.3 | 12.8 | 30.8 | 15.8 |
| 12300500 | 8.0 | 11.0 | 20.6 | 32.7 | 19.1 | 7.7 | 15.0 | 20.2 | 52.0 | 27.9 | 13.1 | 19.3 | 28.9 | 45.0 | 33.7 |
| 12301300 | 61.7 | 75.4 | 90.6 | 144 | 101 | 64.5 | 80.2 | 96.4 | 150 | 103 | 75.3 | 94.7 | 114 | 203 | 138 |
| 12301999 | 4.7 | 8.2 | 10.7 | 26.0 | 22.2 | 5.5 | 9.5 | 13.4 | 58.3 | 26.6 | 11.1 | 15.8 | 31.8 | 127 | 68.8 |
| 12302055 | 86.0 | 126 | 173 | 437 | 265 | 119 | 158 | 210 | 679 | 308 | 172 | 238 | 356 | 1120 | 529 |
| 12302500 | 9.9 | 15.4 | 19.1 | 33.1 | 20.0 | 8.6 | 12.3 | 14.7 | 50.5 | 24.6 | 11.7 | 15.8 | 22.0 | 55.6 | 29.8 |
| 12303100 | 4.6 | 5.8 | 7.2 | 14.0 | 9.7 | 4.6 | 5.7 | 7.0 | 17.8 | 10.1 | 4.8 | 6.2 | 8.3 | 19.1 | 10.7 |
| 12324100 | 16.4 | 18.6 | 20.8 | 26.0 | 20.4 | 16.6 | 18.5 | 20.0 | 24.5 | 19.8 | 16.6 | 18.3 | 19.7 | 24.4 | 19.8 |
| 12330000 | 12.3 | 17.4 | 19.7 | 25.5 | 19.2 | 13.9 | 17.4 | 19.2 | 24.6 | 19.0 | 15.1 | 17.3 | 18.8 | 24.6 | 18.9 |
| 12332000 | 20.0 | 26.0 | 30.1 | 45.5 | 31.5 | 19.2 | 27.4 | 31.9 | 45.0 | 32.0 | 22.4 | 28.9 | 33.3 | 49.0 | 35.2 |
| 12335000 | 82.7 | 108 | 125 | 155 | 119 | 90.0 | 106 | 120 | 157 | 121 | 93.9 | 106 | 116 | 156 | 125 |
| 12338690 | 27.6 | 32.9 | 36.9 | 86.2 | 46.9 | 28.0 | 33.1 | 37.9 | 69.3 | 43.5 | 29.2 | 34.4 | 51.9 | 93.9 | 55.9 |
| 12339450 | 58.1 | 67.7 | 77.3 | 179 | 94.7 | 51.3 | 65.0 | 77.3 | 140 | 84.5 | 61.1 | 78.9 | 96.8 | 198 | 124 |
| 12343400 | 57.9 | 71.4 | 81.1 | 118 | 85.6 | 65.7 | 75.6 | 82.9 | 132 | 94.1 | 72.8 | 85.3 | 95.7 | 180 | 112 |
| 12346500 | 20.0 | 23.6 | 26.3 | 36.1 | 27.0 | 20.4 | 23.4 | 25.6 | 32.1 | 25.7 | 20.6 | 23.6 | 25.7 | 34.3 | 26.2 |
| 12347500 | 6.4 | 8.4 | 11.4 | 27.8 | 14.7 | 6.3 | 9.3 | 13.2 | 25.7 | 15.4 | 7.6 | 12.1 | 15.5 | 30.4 | 17.6 |
| 12350000 | 5.2 | 7.7 | 11.8 | 21.8 | 12.7 | 5.4 | 8.1 | 11.4 | 19.5 | 11.9 | 6.8 | 11.1 | 13.4 | 24.5 | 15.6 |
| 12350500 | 6.9 | 10.1 | 11.7 | 22.6 | 13.1 | 7.9 | 10.5 | 13.8 | 34.7 | 18.7 | 9.6 | 14.8 | 17.7 | 28.7 | 18.8 |
| 12351500 | 11.7 | 14.9 | 16.8 | 22.8 | 16.7 | 11.7 | 14.6 | 16.6 | 22.4 | 16.4 | 11.5 | 14.6 | 16.0 | 23.3 | 16.8 |
| 12352000 | 37.6 | 52.9 | 60.3 | 150 | 76.8 | 49.7 | 61.5 | 72.5 | 141 | 90.9 | 48.3 | 64.3 | 91.2 | 161 | 101 |
| 12353280 | 19.1 | 23.3 | 30.4 | 66.5 | 53.7 | 23.0 | 29.1 | 35.4 | 91.1 | 47.6 | 33.0 | 48.0 | 84.6 | 187 | 109 |
| 12354000 | 88.7 | 129 | 169 | 487 | 282 | 114 | 162 | 215 | 610 | 305 | 138 | 206 | 307 | 854 | 412 |
| 12356500 | 6.3 | 7.7 | 9.8 | 16.7 | 10.9 | 6.1 | 7.1 | 8.1 | 15.2 | 9.6 | 6.3 | 7.0 | 8.6 | 15.7 | 10.0 |
| 12357000 | 112 | 148 | 197 | 387 | 223 | 112 | 148 | 203 | 394 | 238 | 130 | 171 | 211 | 394 | 251 |
| 12359000 | 220 | 271 | 321 | 518 | 349 | 223 | 283 | 328 | 595 | 386 | 237 | 309 | 352 | 544 | 395 |
| 12359500 | 31.1 | 47.2 | 56.6 | 102 | 61.0 | 31.8 | 42.6 | 51.0 | 91.7 | 63.0 | 34.7 | 46.9 | 57.1 | 92.2 | 61.8 |
| 12360000 | 9.2 | 17.1 | 20.6 | 41.4 | 23.1 | 12.3 | 17.5 | 20.1 | 44.0 | 26.7 | 15.5 | 19.7 | 28.7 | 46.3 | 30.6 |
| 12360500 | 3.6 | 9.5 | 13.2 | 26.9 | 14.2 | 5.8 | 11.0 | 12.8 | 27.8 | 15.6 | 8.5 | 10.6 | 14.7 | 27.0 | 16.2 |
| 12361000 | 23.5 | 36.0 | 45.0 | 110 | 63.9 | 24.4 | 36.1 | 45.1 | 131 | 69.0 | 31.0 | 41.6 | 53.1 | 142 | 75.0 |
| 12361500 | 13.7 | 22.5 | 26.9 | 53.0 | 31.1 | 16.0 | 20.2 | 24.0 | 53.0 | 31.4 | 17.1 | 21.2 | 25.1 | 44.6 | 28.7 |
| 12364000 | 8.4 | 15.4 | 21.7 | 45.1 | 22.2 | 9.7 | 13.4 | 18.4 | 49.5 | 20.6 | 14.7 | 18.0 | 20.3 | 46.6 | 25.6 |
| 12365000 | 60.5 | 75.4 | 88.7 | 144 | 108 | 63.3 | 76.9 | 89.4 | 137 | 99.2 | 77.9 | 93.5 | 113 | 223 | 140 |
| 12365800 | 8.0 | 13.4 | 18.9 | 79.0 | 30.0 | 11.1 | 14.6 | 18.7 | 59.2 | 26.0 | 14.6 | 17.9 | 25.3 | 68.4 | 34.0 |
| 12366000 | 34.0 | 47.8 | 58.6 | 121 | 68.9 | 35.3 | 48.9 | 59.6 | 122 | 67.7 | 52.7 | 66.4 | 79.3 | 153 | 95.7 |
| 12369200 | 29.6 | 37.3 | 47.4 | 78.0 | 54.4 | 30.2 | 36.2 | 42.9 | 70.5 | 47.6 | 33.8 | 39.3 | 50.4 | 92.8 | 59.8 |
| 12370000 | 335 | 390 | 453 | 681 | 499 | 311 | 376 | 436 | 699 | 491 | 335 | 431 | 500 | 935 | 588 |
| 12376000 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 20.1 | 25.5 | 39.0 | 70.7 | 43.4 |
| 12378000 | 10.3 | 15.1 | 16.5 | 28.4 | 17.4 | 9.9 | 12.3 | 13.9 | 19.4 | 13.7 | 11.1 | 12.5 | 13.9 | 19.4 | 14.4 |
| 12378500 | 19.9 | 22.8 | 26.6 | 43.6 | 27.6 | 20.5 | 23.1 | 26.2 | 43.5 | 28.1 | 22.8 | 28.1 | 32.4 | 39.9 | 32.1 |
| 12379500 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 12381000 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 12381400 | 10.0 | 12.0 | 17.0 | 30.0 | 18.0 | 10.7 | 14.0 | 15.0 | 17.0 | 14.3 | 14.0 | 15.0 | 17.0 | 20.3 | 17.6 |
| 12381500 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 12382000 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 12382500 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 12383500 | 4.9 | 5.3 | 6.0 | 6.9 | 5.9 | 4.3 | 4.5 | 4.6 | 5.1 | 4.6 | 4.2 | 4.6 | 5.0 | 5.7 | 5.0 |
| 12385000 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 12388500 | 5.6 | 6.6 | 7.4 | 33.0 | 15.2 | 3.3 | 6.1 | 7.4 | 8.6 | 6.6 | 4.0 | 7.1 | 7.9 | 34.3 | 13.0 |
| 12389500 | 123 | 148 | 179 | 303 | 213 | 134 | 161 | 196 | 389 | 242 | 155 | 202 | 262 | 535 | 334 |
| 12390700 | 41.7 | 53.7 | 78.2 | 215 | 128 | 43.4 | 68.2 | 104 | 312 | 154 | 63.0 | 117 | 165 | 389 | 215 |
| 12391550 | 73.0 | 126 | 170 | 420 | 261 | 100 | 128 | 154 | 489 | 246 | 152 | 201 | 257 | 510 | 300 |

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Monthly streamflow characteristic, in cubic feet per second, for specified month

| Gaging station | April | | | | | May | | | | | June | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Q.90 | Q.70 | Q.50 | Q.10 | QM | Q.90 | Q.70 | Q.50 | Q.10 | QM | Q.90 | Q.70 | Q.50 | Q.10 | QM |
| 06024500 | 16.0 | 26.6 | 45.4 | 208 | 81.2 | 80.2 | 251 | 434 | 711 | 409 | 108 | 180 | 269 | 693 | 340 |
| 06029000 | 2.3 | 2.8 | 3.5 | 5.5 | 3.6 | 3.9 | 5.4 | 8.3 | 67.0 | 22.9 | 19.6 | 27.9 | 36.4 | 78.4 | 41.9 |
| 06030500 | 2.3 | 4.7 | 11.7 | 45.5 | 18.2 | 12.1 | 26.8 | 44.9 | 88.8 | 49.9 | 11.5 | 17.5 | 27.2 | 70.0 | 34.9 |
| 06033000 | 43.2 | 72.1 | 117 | 392 | 169 | 172 | 282 | 395 | 909 | 484 | 90.4 | 218 | 346 | 939 | 434 |
| 06061500 | 27.0 | 38.7 | 48.5 | 95.2 | 54.5 | 52.8 | 79.2 | 102 | 188 | 118 | 49.3 | 81.0 | 116 | 274 | 144 |
| 06062500 | 1.9 | 4.8 | 9.4 | 46.5 | 17.5 | 22.2 | 44.8 | 71.0 | 183 | 88.7 | 10.4 | 26.4 | 54.9 | 194 | 79.9 |
| 06073000 | 26.8 | 42.9 | 71.2 | 328 | 129 | 106 | 201 | 318 | 737 | 375 | 72.0 | 204 | 345 | 967 | 451 |
| 06078500 | 67.1 | 93.1 | 121 | 505 | 225 | 351 | 749 | 1170 | 2400 | 1260 | 648 | 1080 | 1390 | 2590 | 1543 |
| 06081500 | 8.7 | 13.1 | 22.0 | 43.7 | 23.8 | 10.8 | 31.1 | 48.4 | 142 | 67.5 | 8.1 | 30.4 | 55.9 | 239 | 98.7 |
| 12300500 | 47.6 | 88.3 | 223 | 611 | 273 | 130 | 208 | 360 | 754 | 412 | 42.1 | 69.8 | 105 | 245 | 125 |
| 12301300 | 136 | 205 | 302 | 760 | 380 | 437 | 607 | 771 | 1260 | 808 | 405 | 607 | 742 | 1230 | 783 |
| 12301999 | 28.9 | 70.4 | 130 | 656 | 263 | 50.0 | 164 | 261 | 580 | 296 | 18.0 | 46.4 | 64.1 | 168 | 82.2 |
| 12302055 | 313 | 553 | 818 | 2240 | 1110 | 646 | 1330 | 1450 | 2690 | 1570 | 330 | 637 | 856 | 1580 | 910 |
| 12302500 | 39.5 | 61.9 | 85.8 | 226 | 116 | 110 | 156 | 215 | 399 | 234 | 101 | 150 | 207 | 374 | 224 |
| 12303100 | 9.4 | 14.5 | 20.4 | 59.6 | 28.3 | 33.3 | 53.3 | 78.0 | 153 | 86.0 | 41.6 | 67.9 | 91.4 | 161 | 96.3 |
| 12324100 | 18.0 | 21.0 | 23.5 | 39.2 | 26.3 | 32.0 | 49.8 | 86.2 | 198 | 101 | 112 | 174 | 222 | 341 | 221 |
| 12330000 | 17.3 | 20.5 | 24.2 | 52.7 | 29.6 | 36.7 | 62.2 | 94.4 | 249 | 121 | 75.6 | 126 | 178 | 333 | 191 |
| 12332000 | 30.6 | 39.8 | 53.2 | 146 | 73.0 | 101 | 196 | 290 | 693 | 347 | 229 | 357 | 463 | 840 | 509 |
| 12335000 | 103 | 133 | 170 | 577 | 271 | 125 | 517 | 806 | 2070 | 970 | 458 | 756 | 1130 | 2370 | 1264 |
| 12338690 | 45.3 | 77.8 | 130 | 490 | 211 | 250 | 404 | 592 | 1250 | 668 | 271 | 501 | 667 | 1380 | 746 |
| 12339450 | 89.3 | 241 | 431 | 1240 | 579 | 562 | 847 | 1070 | 1810 | 1140 | 361 | 622 | 769 | 1250 | 792 |
| 12343400 | 111 | 158 | 206 | 469 | 248 | 355 | 568 | 869 | 1740 | 972 | 437 | 812 | 1080 | 1900 | 1160 |
| 12346500 | 24.8 | 30.9 | 39.2 | 98.3 | 51.3 | 64.0 | 120 | 190 | 474 | 233 | 170 | 320 | 397 | 562 | 386 |
| 12347500 | 20.7 | 34.9 | 51.6 | 165 | 75.3 | 97.5 | 157 | 240 | 457 | 254 | 137 | 196 | 257 | 427 | 269 |
| 12350000 | 17.1 | 36.9 | 62.4 | 171 | 81.1 | 85.7 | 151 | 229 | 468 | 252 | 108 | 158 | 218 | 430 | 243 |
| 12350500 | 25.0 | 43.8 | 63.2 | 184 | 83.6 | 87.2 | 148 | 213 | 454 | 246 | 147 | 212 | 291 | 508 | 309 |
| 12351000 | 16.6 | 22.2 | 31.3 | 85.5 | 42.1 | 46.9 | 76.0 | 106 | 277 | 139 | 74.9 | 118 | 167 | 302 | 180 |
| 12352000 | 96.9 | 202 | 314 | 663 | 372 | 412 | 650 | 809 | 1260 | 838 | 316 | 483 | 630 | 1030 | 652 |
| 12353280 | 70.5 | 120 | 231 | 551 | 271 | 140 | 328 | 453 | 821 | 479 | 93.0 | 213 | 290 | 633 | 339 |
| 12354000 | 472 | 784 | 1080 | 2290 | 1240 | 929 | 1510 | 1970 | 3830 | 2210 | 468 | 833 | 1320 | 3060 | 1542 |
| 12356500 | 9.0 | 24.0 | 47.9 | 140 | 63.9 | 90.8 | 141 | 174 | 304 | 187 | 44.0 | 64.3 | 113 | 246 | 127 |
| 12357000 | 285 | 600 | 906 | 2940 | 1322 | 1840 | 2880 | 4130 | 7440 | 4350 | 1230 | 2180 | 3170 | 7580 | 3800 |
| 12359000 | 476 | 771 | 1290 | 3780 | 1760 | 2520 | 4110 | 6380 | 12000 | 6800 | 3400 | 5680 | 7730 | 12700 | 7950 |
| 12359500 | 73.4 | 119 | 253 | 880 | 394 | 504 | 1040 | 1480 | 2830 | 1590 | 487 | 1020 | 1340 | 2580 | 1449 |
| 12360000 | 43.0 | 88.0 | 158 | 452 | 205 | 245 | 377 | 477 | 931 | 545 | 121 | 247 | 358 | 696 | 385 |
| 12360500 | 26.3 | 41.6 | 83.5 | 250 | 112 | 140 | 212 | 263 | 466 | 284 | 76.3 | 141 | 202 | 395 | 219 |
| 12361000 | 72.8 | 137 | 204 | 586 | 272 | 369 | 584 | 780 | 1440 | 837 | 369 | 538 | 713 | 1360 | 797 |
| 12361500 | 27.9 | 46.7 | 86.5 | 266 | 117 | 130 | 271 | 395 | 784 | 429 | 264 | 391 | 504 | 837 | 532 |
| 12364000 | 30.7 | 64.1 | 108 | 332 | 167 | 83.1 | 203 | 296 | 610 | 341 | 38.0 | 84.1 | 114 | 297 | 141 |
| 12365000 | 125 | 248 | 400 | 1290 | 586 | 445 | 847 | 1170 | 1990 | 1213 | 311 | 577 | 811 | 1570 | 880 |
| 12365800 | 24.0 | 68.8 | 105 | 365 | 152 | 260 | 387 | 481 | 796 | 507 | 171 | 321 | 427 | 911 | 499 |
| 12366000 | 78.5 | 128 | 175 | 421 | 216 | 296 | 416 | 517 | 848 | 540 | 291 | 474 | 611 | 928 | 621 |
| 12369200 | 46.1 | 86.9 | 145 | 394 | 186 | 206 | 311 | 397 | 739 | 435 | 295 | 387 | 467 | 818 | 520 |
| 12370000 | 608 | 922 | 1330 | 2690 | 1500 | 1580 | 2160 | 2760 | 4530 | 2910 | 1890 | 2630 | 3240 | 5120 | 3390 |
| 12376000 | 17.7 | 33.2 | 48.2 | 106 | 55.9 | 37.5 | 86.8 | 137 | 244 | 139 | 133 | 219 | 269 | 450 | 302 |
| 12378000 | 12.8 | 17.0 | 22.6 | 53.2 | 28.6 | 25.9 | 53.0 | 78.6 | 174 | 88.5 | 120 | 199 | 229 | 380 | 273 |
| 12378500 | 26.4 | 30.9 | 37.6 | 72.6 | 44.7 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 12379500 | 31.8 | 43.0 | 53.0 | 90.5 | 56.8 | 43.5 | 71.4 | 102 | 220 | 120 | 162 | 221 | 273 | 406 | 283 |
| 12381000 | -- | -- | -- | -- | -- | 32.8 | 41.1 | 59.0 | 102 | 60.2 | 36.3 | 42.7 | 70.0 | 105 | 68.0 |
| 12381400 | 15.6 | 21.0 | 62.0 | 125 | 62.7 | 75.0 | 143 | 194 | 387 | 217 | 145 | 196 | 269 | 446 | 280 |
| 12381500 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 196 | 253 | 361 | 590 | 378 |
| 12382000 | -- | -- | -- | -- | -- | 93.2 | 134 | 175 | 370 | 200 | 104 | 168 | 231 | 363 | 235 |
| 12382500 | -- | -- | -- | -- | -- | 12.2 | 16.9 | 31.5 | 86.0 | 41.5 | 27.3 | 36.0 | 45.5 | 92.2 | 51.2 |
| 12383500 | 4.4 | 4.9 | 5.4 | 9.1 | 5.8 | 7.7 | 9.2 | 12.6 | 28.0 | 15.4 | 21.2 | 28.0 | 31.6 | 43.0 | 32.5 |
| 12385000 | -- | -- | -- | -- | -- | 11.2 | 16.7 | 23.4 | 54.2 | 28.4 | 27.4 | 36.8 | 44.3 | 83.5 | 50.2 |
| 12388500 | 16.5 | 29.1 | 47.5 | 88.1 | 49.9 | 52.1 | 71.9 | 96.9 | 183 | 110 | 34.0 | 52.2 | 81.0 | 207 | 105 |
| 12389500 | 279 | 437 | 620 | 1400 | 769 | 629 | 1030 | 1360 | 2430 | 1450 | 496 | 788 | 1040 | 2070 | 1160 |
| 12390700 | 171 | 283 | 420 | 924 | 499 | 415 | 648 | 825 | 1490 | 902 | 228 | 377 | 543 | 1150 | 615 |
| 12391550 | 206 | 328 | 442 | 991 | 531 | 562 | 804 | 1030 | 1680 | 1080 | 424 | 659 | 900 | 1880 | 1030 |

Monthly streamflow characteristic, in cubic feet per second, for specified month

| Gaging station | July | | | | | August | | | | | September | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Q.90 | Q.70 | Q.50 | Q.10 | QM | Q.90 | Q.70 | Q.50 | Q.10 | QM | Q.90 | Q.70 | Q.50 | Q.10 | QM |
| 06024500 | 32.8 | 42.8 | 55.8 | 102 | 61.6 | 17.4 | 21.4 | 24.8 | 39.2 | 26.2 | 14.9 | 17.2 | 19.7 | 30.9 | 21.0 |
| 06029000 | 13.4 | 19.2 | 24.9 | 40.2 | 25.1 | 17.9 | 20.7 | 28.0 | 40.3 | 27.7 | 7.9 | 15.2 | 18.0 | 26.7 | 17.4 |
| 06030500 | 2.5 | 3.8 | 5.5 | 17.1 | 7.8 | 1.3 | 1.8 | 2.2 | 4.6 | 2.5 | 1.4 | 1.7 | 2.0 | 3.3 | 2.2 |
| 06033000 | 13.4 | 33.0 | 60.3 | 211 | 93.9 | 7.6 | 13.5 | 19.8 | 56.8 | 26.5 | 7.5 | 15.2 | 21.7 | 47.9 | 26.7 |
| 06061500 | 20.9 | 34.8 | 50.5 | 125 | 61.1 | 13.9 | 21.2 | 28.3 | 56.5 | 31.2 | 15.0 | 20.7 | 26.5 | 56.1 | 30.5 |
| 06062500 | .7 | 2.1 | 5.2 | 34.7 | 12.7 | .3 | .6 | 1.2 | 6.1 | 2.3 | .3 | .5 | .9 | 5.3 | 2.0 |
| 06073000 | 20.1 | 43.3 | 84.0 | 287 | 123 | 12.6 | 20.0 | 31.3 | 95.6 | 47.5 | 11.2 | 21.2 | 27.9 | 62.9 | 34.6 |
| 06078500 | 199 | 275 | 373 | 935 | 483 | 114 | 138 | 156 | 241 | 167 | 84.8 | 100 | 115 | 169 | 124 |
| 06081500 | 1.8 | 11.3 | 25.2 | 82.1 | 39.0 | 1.6 | 7.4 | 15.5 | 39.8 | 17.9 | 2.7 | 6.6 | 11.0 | 30.0 | 13.2 |
| 12300500 | 15.8 | 22.3 | 30.8 | 69.5 | 36.3 | 7.9 | 9.8 | 14.1 | 27.3 | 16.4 | 7.3 | 9.0 | 10.2 | 20.7 | 12.2 |
| 12301300 | 133 | 208 | 281 | 563 | 319 | 69.4 | 104 | 127 | 195 | 130 | 71.4 | 92.5 | 112 | 158 | 115 |
| 12301999 | 6.9 | 15.8 | 21.8 | 57.1 | 29.6 | 4.7 | 10.0 | 12.2 | 17.8 | 11.4 | 4.9 | 8.0 | 9.1 | 13.0 | 9.2 |
| 12302055 | 126 | 208 | 276 | 586 | 313 | 81.4 | 113 | 145 | 213 | 144 | 90.1 | 112 | 126 | 162 | 130. |
| 12302500 | 27.0 | 42.8 | 56.4 | 136 | 71.6 | 9.5 | 14.6 | 20.4 | 37.7 | 21.6 | 7.2 | 10.1 | 13.0 | 35.8 | 18.3 |
| 12303100 | 11.6 | 18.1 | 25.9 | 63.5 | 31.9 | 6.1 | 8.2 | 10.4 | 16.8 | 10.6 | 5.8 | 7.0 | 8.1 | 12.2 | 8.7 |
| 12324100 | 65.5 | 84.1 | 97.7 | 160 | 105 | 45.1 | 57.0 | 68.5 | 98.1 | 68.9 | 28.7 | 35.2 | 40.8 | 62.6 | 43.2 |
| 12330000 | 20.9 | 38.2 | 52.4 | 132 | 65.7 | 9.1 | 14.7 | 19.5 | 41.7 | 22.4 | 8.1 | 12.8 | 17.4 | 34.5 | 19.2 |
| 12332000 | 76.7 | 119 | 161 | 349 | 191 | 42.6 | 57.6 | 68.7 | 107 | 72.4 | 36.3 | 44.4 | 51.2 | 75.4 | 53.0 |
| 12335000 | 222 | 311 | 417 | 943 | 500 | 145 | 185 | 224 | 359 | 235 | 121 | 154 | 172 | 226 | 173 |
| 12338690 | 83.4 | 139 | 193 | 463 | 247 | 53.0 | 71.3 | 81.5 | 115 | 82.6 | 37.7 | 48.3 | 55.3 | 70.9 | 55.1 |
| 12339450 | 78.9 | 147 | 230 | 530 | 274 | 42.4 | 60.8 | 79.8 | 148 | 87.0 | 38.4 | 48.6 | 57.9 | 127 | 75.4 |
| 12343400 | 144 | 202 | 266 | 561 | 313 | 82.7 | 106 | 126 | 189 | 131 | 84.5 | 95.4 | 110 | 161 | 116 |
| 12346500 | 73.8 | 101 | 127 | 280 | 153 | 43.9 | 54.8 | 65.4 | 97.9 | 67.9 | 35.3 | 41.0 | 46.1 | 62.5 | 47.6 |
| 12347500 | 24.9 | 45.2 | 70.2 | 195 | 90.7 | 7.4 | 14.0 | 20.7 | 36.8 | 21.1 | 3.9 | 6.6 | 11.7 | 30.8 | 16.5 |
| 12350000 | 17.4 | 33.9 | 57.2 | 192 | 84.2 | 4.3 | 7.3 | 10.3 | 24.8 | 12.7 | 2.6 | 3.9 | 6.0 | 23.0 | 10.7 |
| 12350500 | 38.2 | 65.9 | 100 | 247 | 125 | 10.3 | 14.7 | 19.1 | 42.7 | 24.1 | 6.6 | 9.2 | 13.2 | 33.6 | 18.0 |
| 12351000 | 29.7 | 41.3 | 51.9 | 123 | 65.8 | 19.8 | 23.6 | 29.1 | 42.7 | 29.5 | 16.4 | 19.5 | 21.7 | 28.9 | 21.9 |
| 12352000 | 60.4 | 118 | 176 | 424 | 211 | 18.7 | 31.9 | 47.7 | 84.8 | 49.7 | 14.0 | 23.8 | 40.0 | 76.0 | 42.9 |
| 12353280 | 38.1 | 73.7 | 96.6 | 179 | 104 | 22.0 | 34.2 | 41.3 | 59.9 | 41.5 | 21.1 | 30.2 | 34.4 | 44.5 | 33.4 |
| 12354000 | 178 | 242 | 313 | 746 | 400 | 106 | 132 | 155 | 240 | 165 | 92.4 | 110 | 127 | 177 | 132 |
| 12356500 | 15.8 | 21.6 | 28.4 | 88.2 | 39.1 | 10.2 | 12.8 | 15.6 | 25.1 | 16.1 | 9.3 | 10.8 | 12.0 | 19.7 | 13.4 |
| 12357000 | 363 | 535 | 747 | 2090 | 1041 | 194 | 254 | 306 | 495 | 326 | 170 | 201 | 227 | 339 | 244 |
| 12359000 | 969 | 1450 | 2080 | 5290 | 2720 | 431 | 546 | 648 | 1140 | 730 | 305 | 357 | 412 | 825 | 500 |
| 12359500 | 140 | 227 | 338 | 960 | 470 | 66.6 | 92.5 | 115 | 178 | 119 | 52.5 | 61.5 | 68.3 | 104 | 75.7 |
| 12360000 | 31.3 | 44.7 | 65.0 | 169 | 86.7 | 14.1 | 18.2 | 22.5 | 35.2 | 23.1 | 10.3 | 12.3 | 13.9 | 25.0 | 17.9 |
| 12360500 | 24.4 | 35.7 | 56.9 | 130 | 68.9 | 12.3 | 15.2 | 17.8 | 27.9 | 18.9 | 8.1 | 9.3 | 10.7 | 16.5 | 11.4 |
| 12361000 | 75.0 | 107 | 151 | 382 | 197 | 35.4 | 44.5 | 54.2 | 91.2 | 60.0 | 27.0 | 32.7 | 38.3 | 104 | 59.2 |
| 12361500 | 55.4 | 88.4 | 149 | 373 | 193 | 22.1 | 27.9 | 34.7 | 71.0 | 41.1 | 13.5 | 17.7 | 23.2 | 63.7 | 33.2 |
| 12364000 | 8.3 | 23.9 | 40.1 | 126 | 55.6 | 3.9 | 7.1 | 9.6 | 34.2 | 15.7 | 2.4 | 6.3 | 8.8 | 29.1 | 12.5 |
| 12365000 | 127 | 230 | 333 | 665 | 370 | 68.6 | 119 | 166 | 278 | 170 | 64.9 | 90.6 | 123 | 186 | 124 |
| 12365800 | 64.7 | 99.2 | 133 | 338 | 173 | 34.6 | 51.9 | 69.8 | 114 | 70.5 | 27.5 | 36.9 | 46.4 | 72.7 | 47.6 |
| 12366000 | 100 | 160 | 230 | 491 | 270 | 39.5 | 74.2 | 105 | 184 | 107 | 28.4 | 62.8 | 82.3 | 133 | 83.7 |
| 12369200 | 103 | 185 | 263 | 523 | 296 | 53.0 | 74.7 | 98.8 | 182 | 109 | 38.8 | 56.5 | 69.2 | 124 | 78.7 |
| 12370000 | 734 | 1090 | 1470 | 2890 | 1660 | 416 | 545 | 663 | 1060 | 705 | 353 | 435 | 513 | 769 | 550 |
| 12376000 | 31.5 | 73.8 | 103 | 243 | 122 | 22.7 | 31.5 | 36.3 | 66.0 | 41.2 | 19.2 | 23.2 | 27.6 | 44.3 | 31.6 |
| 12378000 | 78.6 | 148 | 201 | 344 | 204 | 34.0 | 69.1 | 83.4 | 155 | 87.7 | 27.0 | 43.0 | 52.9 | 85.1 | 55.3 |
| 12378500 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 12379500 | 73.5 | 173 | 214 | 370 | 222 | 25.6 | 41.0 | 101 | 172 | 93.8 | 24.8 | 31.8 | 63.0 | 118 | 64.2 |
| 12381000 | 30.4 | 35.8 | 50.2 | 71.2 | 50.7 | 21.8 | 26.3 | 32.4 | 55.8 | 34.6 | 18.8 | 20.8 | 23.3 | 37.9 | 25.5 |
| 12381400 | 70.0 | 89.0 | 104 | 183 | 124 | 34.0 | 45.0 | 57.5 | 88.1 | 60.5 | 24.0 | 30.0 | 35.0 | 54.0 | 37.2 |
| 12381500 | 112 | 139 | 156 | 273 | 190 | 55.9 | 80.0 | 109 | 140 | 103 | 42.0 | 52.5 | 61.9 | 98.0 | 65.0 |
| 12382000 | 37.8 | 49.0 | 72.8 | 145 | 89.2 | 14.1 | 21.1 | 26.5 | 37.9 | 26.0 | 11.0 | 17.0 | 21.9 | 31.9 | 21.1 |
| 12382500 | 7.7 | 12.2 | 16.7 | 32.0 | 20.4 | 3.5 | 4.9 | 6.2 | 12.3 | 6.8 | 2.6 | 4.4 | 6.8 | 12.5 | 6.7 |
| 12383500 | 14.7 | 19.4 | 23.3 | 41.2 | 25.9 | 9.8 | 12.9 | 15.1 | 20.9 | 15.4 | 9.0 | 10.6 | 11.9 | 15.7 | 11.7 |
| 12385000 | 11.0 | 15.8 | 22.3 | 47.5 | 26.9 | 5.9 | 7.8 | 9.8 | 14.5 | 9.8 | 4.8 | 6.0 | 7.6 | 10.4 | 7.6 |
| 12388500 | 12.1 | 17.2 | 21.2 | 48.9 | 29.3 | 5.5 | 9.0 | 11.3 | 16.2 | 10.8 | 4.6 | 6.1 | 8.2 | 13.6 | 8.4 |
| 12389500 | 246 | 337 | 405 | 696 | 443 | 171 | 225 | 256 | 338 | 255 | 147 | 187 | 210 | 269 | 208 |
| 12390700 | 100 | 126 | 149 | 276 | 171 | 69.1 | 80.3 | 88.1 | 112 | 88.4 | 52.0 | 61.7 | 67.6 | 78.7 | 66.0 |
| 12391550 | 145 | 244 | 323 | 740 | 396 | 84.7 | 120 | 149 | 237 | 155 | 78.8 | 101 | 116 | 160 | 118 |

# Table 12.—*Basin and climatic characteristics and channel widths for selected streamflow-gaging stations*

[Basin/climatic characteristic: A, drainage area, in square miles; E6, percentage of basin above 6,000 feet elevation, plus 1; PE, basin perimeter, in miles; BSL, basin slope, dimensionless; L, main-channel length in miles; P, mean annual precipitation, in inches; E, mean basin elevation, in thousands of feet; BR, maximum basin relief, in thousands of feet. Channel width: $W_{AC}$, active-channel width, in feet; $W_{BF}$, bankfull width, in feet; --, no data]

| Gaging station | A | E6 | PE | BSL | L | P | E | BR | $W_{AC}$ | $W_{BF}$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 06024500 | 71.4 | 101 | 44.6 | 0.25 | 19.3 | 30 | 7.11 | 2.04 | 39 | 48 |
| 06029000 | 30.8 | 98.2 | 29.9 | .22 | 8.80 | 21 | 7.33 | 2.91 | -- | -- |
| 06062500 | 32.7 | 87.2 | 27.9 | .30 | 8.80 | 24 | 6.58 | 3.41 | 16 | 25 |
| 06073000 | 123 | 77.0 | 66.3 | .41 | 21.8 | 37 | 6.23 | 4.66 | 54 | 83 |
| 06078500 | 258 | 62.0 | 84.5 | .35 | 27.4 | 42 | 6.15 | 4.62 | -- | -- |
| | | | | | | | | | | |
| 12300500 | 110 | 2.00 | 47.1 | .19 | 18.7 | 28 | 4.55 | 3.27 | 22 | 29 |
| 12301300 | 440 | 6.00 | 126 | .24 | 40.2 | 32 | 4.17 | 4.99 | 48 | 58 |
| 12301999 | 216 | 1.00 | 96.2 | .23 | 29.4 | 27 | 4.10 | 4.03 | 40 | 47 |
| 12302055 | 838 | 1.00 | 169 | .24 | 66.4 | 32 | 4.10 | 5.13 | 111 | 130 |
| 12302500 | 23.6 | 32.0 | 25.0 | .56 | 9.40 | 67 | 5.26 | 5.97 | -- | -- |
| | | | | | | | | | | |
| 12303100 | 11.1 | 44.9 | 16.8 | .52 | 5.90 | 67 | 5.24 | 4.83 | 17 | 24 |
| 12324100 | 39.5 | 94.0 | 33.9 | .37 | 12.7 | 35 | 7.60 | 4.31 | 22 | 28 |
| 12330000 | 71.3 | 84.0 | 41.1 | .33 | 13.5 | 31 | 6.98 | 4.77 | 28 | 32 |
| 12332000 | 123 | 90.0 | 61.3 | .29 | 20.2 | 35 | 7.18 | 5.08 | 56 | 71 |
| 12335000 | 481 | 48.0 | 114 | .34 | 47.7 | 15 | 5.89 | 5.10 | 100 | 120 |
| | | | | | | | | | | |
| 12338690 | 140 | 55.0 | 72.3 | .36 | 26.0 | 35 | 5.91 | 4.05 | 52 | 68 |
| 12339450 | 345 | 27.0 | 112 | .25 | 35.7 | 37 | 5.28 | 5.27 | 90 | 110 |
| 12343400 | 381 | 62.0 | 116 | .40 | 35.3 | 32 | 6.45 | 5.10 | 70 | 90 |
| 12346500 | 87.8 | 83.0 | 52.4 | .43 | 12.9 | 36 | 6.80 | 4.61 | 34 | 44 |
| 12347500 | 26.4 | 68.0 | 30.5 | .62 | 12.3 | 64 | 6.73 | 4.96 | 30 | 38 |
| | | | | | | | | | | |
| 12350000 | 26.8 | 69.0 | 27.2 | .54 | 11.8 | 63 | 6.43 | 5.01 | 41 | 47 |
| 12350500 | 28.9 | 66.0 | 25.6 | .62 | 10.5 | 64 | 6.35 | 5.69 | 38 | 46 |
| 12351000 | 73.2 | 71.0 | 44.8 | .37 | 16.7 | 32 | 6.57 | 4.41 | 20 | 28 |
| 12352000 | 250 | 34.3 | 93.6 | .42 | 30.9 | 52 | 5.43 | 5.82 | 51 | 60 |
| 12353280 | 170 | 25.0 | 66.6 | .35 | 25.1 | 38 | 4.92 | 4.96 | 48 | 60 |
| | | | | | | | | | | |
| 12354000 | 303 | 2.00 | 99.3 | .43 | 37.1 | 52 | 4.52 | 4.67 | 130 | 136 |
| 12356500 | 20.7 | 33.2 | 23.8 | .27 | 8.10 | 47 | 5.77 | 4.13 | 25 | 36 |
| 12357000 | 510 | 47.0 | 126 | .44 | 60.0 | 52 | 5.90 | 4.83 | 172 | 192 |
| 12359500 | 184 | 56.5 | 75.3 | .40 | 29.8 | 56 | 6.00 | 5.17 | 65 | 105 |
| 12360000 | 47 | 58.0 | 36.3 | .48 | 15.4 | 53 | 5.30 | 4.16 | 41 | 59 |

Table 12.--*Basin and climatic characteristics and channel widths for selected streamflow-gaging stations*--Continued

| Gaging station | A | E6 | PE | BSL | L | P | E | BR | $W_{AC}$ | $W_{BF}$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 12360500 | 22.4 | 31.4 | 25.2 | .49 | 8.90 | 56 | 5.49 | 4.16 | 32 | 44 |
| 12361000 | 71.3 | 39.0 | 50.3 | .47 | 13.0 | 35 | 5.51 | 4.03 | 63 | 78 |
| 12361500 | 27.0 | 43.0 | 24.8 | .50 | 9.00 | 67 | 5.43 | 3.96 | 40 | 60 |
| 12364000 | 183 | 7.00 | 71.3 | .24 | 34.9 | 28 | 4.91 | 2.95 | 47 | 67 |
| 12365000 | 524 | 4.00 | 158 | .25 | 50.5 | 31 | 4.32 | 4.39 | 70 | 85 |
| 12365800 | 78.0 | 30.0 | 54.8 | .35 | 26.3 | 51 | 5.20 | 4.44 | 44 | 56 |
| 12366000 | 170 | 12.0 | 97.4 | .23 | 36.9 | 37 | 4.17 | 4.48 | 64 | 82 |
| 12369200 | 73.3 | 40.0 | 49.8 | .33 | 19.0 | 54 | 5.83 | 5.36 | 72 | 84 |
| 12370000 | 671 | 27.0 | 172 | .33 | 84.5 | 23 | 5.02 | 6.33 | 165 | 185 |
| 12376000 | 50.6 | 17.7 | 37.9 | .38 | 16.9 | 45 | 4.85 | 5.60 | 30 | 42 |
| 12378000 | 74.8 | 31.0 | 40.9 | .33 | 14.8 | 48 | 4.84 | 6.63 | -- | -- |
| 12378500 | 22.6 | 15.4 | 26.8 | .64 | 12.7 | 66 | 6.12 | 6.76 | 35 | 40 |
| 12379500 | 67.1 | 22.0 | 39.0 | .40 | 17.3 | 45 | 4.75 | 7.09 | 28 | 33 |
| 12381000 | 15.9 | 5.74 | 21.4 | .46 | 10.9 | 38 | 5.65 | 3.69 | 22 | 25 |
| 12381400 | 58.3 | 32.5 | 42.3 | .35 | 18.6 | 39 | 6.06 | 4.23 | 32 | 36 |
| 12381500 | 74.2 | 37.2 | 49.4 | .38 | 18.7 | 39 | 5.97 | 4.26 | 35 | 42 |
| 12382000 | 20.0 | 14.3 | 23.1 | .41 | 9.10 | 64 | 6.15 | 4.08 | 32 | 38 |
| 12382500 | 3.59 | 3.76 | 11.6 | .48 | 5.46 | 69 | 6.63 | 4.88 | 17 | 23 |
| 12383500 | 6.90 | 5.57 | 12.8 | .55 | 5.92 | 40 | 6.32 | 4.29 | 12 | 16 |
| 12385000 | 6.51 | 5.44 | 11.4 | .58 | 5.27 | 40 | 6.41 | 4.66 | 18 | 22 |
| 12388500 | 26.3 | 37.0 | 21.8 | .29 | 9.35 | 33 | 5.56 | 4.21 | -- | -- |
| 12389500 | 642 | 6.00 | 145 | .36 | 48.7 | 41 | 4.71 | 5.03 | 95 | -- |
| 12390700 | 182 | 4.00 | 72.2 | .47 | 21.5 | 54 | 4.41 | 4.39 | 44 | 67 |
| 12391550 | 139 | 10.0 | 58.3 | .51 | 26.4 | 65 | 4.47 | 6.53 | 64 | 70 |

[Q.xx, daily mean discharge exceeded xx percent of time during specified
month, in cubic feet per second; QM, mean monthly discharge, in cubic feet
per second; log, logarithm, base 10; pct, percent]

| Combinations of methods of estimation | Weights for specified month and monthly flow characteristic | | | | |
|---|---|---|---|---|---|
| | Q.90 | Q.70 | Q.50 | Q.10 | QM |

OCTOBER

| | | | | | |
|---|---|---|---|---|---|
| Basin-characteristics method | 0.197 | 0.203 | 0.219 | 0.153 | 0.170 |
| Channel-width method | .255 | .159 | .121 | .233 | .114 |
| Concurrent-measurement method | .548 | .638 | .660 | .614 | .716 |
| Weighted standard error (log) | .153 | .094 | .076 | .087 | .088 |
| Weighted standard error (pct) | 36 | 22 | 18 | 20 | 21 |
| | | | | | |
| Basin-characteristics method | .719 | .646 | .547 | .305 | .397 |
| Channel-width method | .281 | .354 | .453 | .695 | .603 |
| Weighted standard error (log) | .302 | .246 | .217 | .212 | .183 |
| Weighted standard error (pct) | 79 | 61 | 53 | 52 | 44 |
| | | | | | |
| Concurrent-measurement method | .551 | .659 | .689 | .667 | .762 |
| Basin-characteristics method | .449 | .341 | .311 | .333 | .238 |
| Weighted standard error (log) | .166 | .101 | .081 | .096 | .090 |
| Weighted standard error (pct) | 40 | 24 | 19 | 22 | 21 |
| | | | | | |
| Concurrent-measurement method | .588 | .690 | .712 | .628 | .757 |
| Channel-width method | .412 | .310 | .288 | .372 | .243 |
| Weighted standard error (log) | .159 | .104 | .090 | .092 | .094 |
| Weighted standard error (pct) | 38 | 24 | 21 | 21 | 22 |

NOVEMBER

| | | | | | |
|---|---|---|---|---|---|
| Basin-characteristics method | 0.181 | 0.235 | 0.209 | 0.176 | 0.190 |
| Channel-width method | .203 | .063 | .015 | .202 | .023 |
| Concurrent-measurement weight | .616 | .702 | .776 | .622 | .787 |
| Weighted standard error (log) | .129 | .073 | .063 | .075 | .071 |
| Weighted standard error (pct) | 30 | 17 | 15 | 17 | 16 |
| | | | | | |
| Basin-characteristics method | .641 | .591 | .500 | .380 | .460 |
| Channel-width method | .359 | .409 | .500 | .620 | .540 |
| Weighted standard error (log) | .255 | .230 | .209 | .190 | .191 |
| Weighted standard error (pct) | 64 | 57 | 51 | 46 | 46 |

| Combinations of methods of estimation | Weights for specified month and monthly flow characteristic | | | | |
|---|---|---|---|---|---|
| | Q.90 | Q.70 | Q.50 | Q.10 | QM |

NOVEMBER--Continued

| Combinations of methods of estimation | Q.90 | Q.70 | Q.50 | Q.10 | QM |
|---|---|---|---|---|---|
| Concurrent-measurement method | .640 | .718 | .782 | .696 | .798 |
| Basin-characteristics method | .360 | .282 | .218 | .304 | .202 |
| Weighted standard error (log) | .138 | .075 | .063 | .085 | .071 |
| Weighted standard error (pct) | 33 | 17 | 15 | 20 | 16 |
| Concurrent-measurement method | .667 | .763 | .835 | .661 | .852 |
| Channel-width method | .333 | .237 | .165 | .339 | .148 |
| Weighted standard error (log) | .135 | .090 | .078 | .085 | .083 |
| Weighted standard error (pct) | 32 | 21 | 18 | 20 | 19 |

DECEMBER

| | Q.90 | Q.70 | Q.50 | Q.10 | QM |
|---|---|---|---|---|---|
| Basin-characteristics method | 0.158 | 0.163 | 0.168 | 0.182 | 0.197 |
| Channel-width method | .167 | .026 | .000 | .161 | .037 |
| Concurrent-measurement weight | .675 | .811 | .832 | .657 | .766 |
| Weighted standard error (log) | .130 | .075 | .065 | .089 | .091 |
| Weighted standard error (pct) | 31 | 17 | 15 | 21 | 21 |
| Basin-characteristics method | .683 | .586 | .542 | .430 | .500 |
| Channel-width method | .317 | .414 | .458 | .570 | .500 |
| Weighted standard error (log) | .258 | .218 | .213 | .201 | .204 |
| Weighted standard error (pct) | 65 | 54 | 52 | 49 | 50 |
| Concurrent-measurement method | .697 | .820 | .832 | .725 | .783 |
| Basin-characteristics method | .303 | .180 | .168 | .275 | .217 |
| Weighted standard error (log) | .136 | .075 | .065 | .096 | .091 |
| Weighted standard error (pct) | 32 | 17 | 15 | 22 | 21 |
| Concurrent-measurement method | .728 | .872 | .900 | .712 | .839 |
| Channel-width method | .272 | .128 | .100 | .288 | .161 |
| Weighted standard error (log) | .134 | .082 | .076 | .099 | .102 |
| Weighted standard error (pct) | 32 | 19 | 18 | 23 | 24 |

| Combinations of methods of estimation | Weights for specified month and monthly flow characteristic | | | | |
|---|---|---|---|---|---|
| | Q.90 | Q.70 | Q.50 | Q.10 | QM |

### JANUARY

| | Q.90 | Q.70 | Q.50 | Q.10 | QM |
|---|---|---|---|---|---|
| Basin-characteristics method | 0.159 | 0.091 | 0.099 | 0.189 | 0.115 |
| Channel-width method | .139 | .060 | .042 | .086 | .009 |
| Concurrent-measurement method | .701 | .849 | .859 | .726 | .875 |
| Weighted standard error (log) | .124 | .083 | .084 | .096 | .106 |
| Weighted standard error (pct) | 29 | 19 | 20 | 22 | 25 |
| | | | | | |
| Basin-characteristics method | .583 | .583 | .500 | .428 | .500 |
| Channel-width method | .417 | .417 | .500 | .572 | .500 |
| Weighted standard error (log) | .267 | .217 | .207 | .201 | .203 |
| Weighted standard error (pct) | 68 | 53 | 51 | 49 | 49 |
| | | | | | |
| Concurrent-measurement method | .733 | .872 | .879 | .769 | .881 |
| Basin-characteristics method | .267 | .128 | .121 | .231 | .119 |
| Weighted standard error (log) | .129 | .084 | .085 | .098 | .106 |
| Weighted standard error (pct) | 30 | 19 | 20 | 23 | 25 |
| | | | | | |
| Concurrent-measurement method | .751 | .891 | .903 | .788 | .940 |
| Channel-width method | .249 | .109 | .097 | .212 | .060 |
| Weighted standard error (log) | .130 | .085 | .087 | .107 | .109 |
| Weighted standard error (pct) | 31 | 20 | 20 | 25 | 26 |

### FEBRUARY

| | Q.90 | Q.70 | Q.50 | Q.10 | QM |
|---|---|---|---|---|---|
| Basin-characteristics method | 0.196 | 0.114 | 0.101 | 0.276 | 0.183 |
| Channel-width method | .036 | .058 | .085 | .024 | .041 |
| Concurrent-measurement method | .768 | .828 | .814 | .700 | .776 |
| Weighted standard error (log) | .100 | .080 | .080 | .100 | .095 |
| Weighted standard error (pct) | 23 | 19 | 19 | 23 | 22 |
| | | | | | |
| Basin-characteristics method | .669 | .624 | .611 | .500 | .610 |
| Channel-width method | .331 | .376 | .389 | .500 | .390 |
| Weighted standard error (log) | .236 | .211 | .197 | .224 | .207 |
| Weighted standard error (pct) | 58 | 52 | 48 | 55 | 50 |
| | | | | | |
| Concurrent-measurement method | .778 | .848 | .849 | .710 | .793 |
| Basin-characteristics method | .222 | .152 | .151 | .290 | .207 |
| Weighted standard error (log) | .101 | .081 | .082 | .100 | .096 |
| Weighted standard error (pct) | 23 | 19 | 19 | 23 | 22 |

| Combinations of methods of estimation | Weights for specified month and monthly flow characteristic | | | | |
|---|---|---|---|---|---|
| | Q.90 | Q.70 | Q.50 | Q.10 | QM |

FEBRUARY--Continued

| | | | | | |
|---|---|---|---|---|---|
| Concurrent-measurement method | .844 | .881 | .869 | .769 | .864 |
| Channel-width method | .156 | .119 | .131 | .231 | .136 |
| Weighted standard error (log) | .109 | .084 | .083 | .122 | .103 |
| Weighted standard error (pct) | 26 | 19 | 19 | 29 | 24 |

MARCH

| | | | | | |
|---|---|---|---|---|---|
| Basin-characteristics method | 0.186 | 0.138 | 0.171 | 0.304 | 0.208 |
| Channel-width method | .000 | .086 | .069 | .000 | .025 |
| Concurrent-measurement method | .814 | .776 | .760 | .696 | .767 |
| Weighted standard error (log) | .098 | .084 | .093 | .120 | .103 |
| Weighted standard error (pct) | 23 | 19 | 22 | 28 | 24 |
| Basin-characteristics method | .616 | .612 | .610 | .538 | .608 |
| Channel-width method | .384 | .388 | .390 | .462 | .392 |
| Weighted standard error (log) | .219 | .207 | .207 | .240 | .216 |
| Weighted standard error (pct) | 54 | 51 | 50 | 60 | 53 |
| Concurrent-measurement method | .814 | .807 | .787 | .696 | .778 |
| Basin-characteristics method | .186 | .193 | .213 | .304 | .222 |
| Weighted standard error (log) | .098 | .086 | .094 | .120 | .103 |
| Weighted standard error (pct) | 23 | 20 | 22 | 28 | 24 |
| Concurrent-measurement method | .909 | .841 | .841 | .773 | .862 |
| Channel-width method | .091 | .159 | .159 | .227 | .138 |
| Weighted standard error (log) | .107 | .089 | .100 | .144 | .113 |
| Weighted standard error (pct) | 25 | 21 | 23 | 34 | 27 |

APRIL

| | | | | | |
|---|---|---|---|---|---|
| Basin-characteristics method | 0.222 | 0.315 | 0.271 | 0.256 | 0.286 |
| Channel-width method | .132 | .147 | .131 | .131 | .159 |
| Concurrent-measurement method | .645 | .538 | .597 | .613 | .555 |
| Weighted standard error (log) | .104 | .095 | .097 | .087 | .105 |
| Weighted standard error (pct) | 24 | 22 | 23 | 20 | 25 |

| Combinations of methods of estimation | Weights for specified month and monthly flow characteristic | | | | |
|---|---|---|---|---|---|
| | Q.90 | Q.70 | Q.50 | Q.10 | QM |

APRIL--Continued

| | | | | | |
|---|---|---|---|---|---|
| Basin-characteristics method | .593 | .571 | .549 | .474 | .500 |
| Channel-width method | .407 | .429 | .451 | .526 | .500 |
| Weighted standard error (log) | .200 | .174 | .192 | .222 | .191 |
| Weighted standard error (pct) | 49 | 42 | 46 | 55 | 46 |
| | | | | | |
| Concurrent-measurement method | .698 | .613 | .666 | .671 | .638 |
| Basin-characteristics method | .302 | .387 | .334 | .329 | .362 |
| Weighted standard error (log) | .109 | .103 | .103 | .095 | .114 |
| Weighted standard error (pct) | 26 | 24 | 24 | 22 | 27 |
| | | | | | |
| Concurrent-measurement method | .750 | .692 | .729 | .691 | .671 |
| Channel-width method | .250 | .308 | .271 | .309 | .329 |
| Weighted standard error (log) | .117 | .128 | .123 | .118 | .135 |
| Weighted standard error (pct) | 27 | 30 | 29 | 28 | 32 |

MAY

| | | | | | |
|---|---|---|---|---|---|
| Basin-characteristics method | 0.257 | 0.220 | 0.207 | 0.209 | 0.194 |
| Channel-width method | .235 | .290 | .320 | .346 | .316 |
| Concurrent-measurement method | .508 | .490 | .474 | .445 | .490 |
| Weighted standard error (log) | .097 | .086 | .089 | .101 | .090 |
| Weighted standard error (pct) | 23 | 20 | 21 | 24 | 21 |
| | | | | | |
| Basin-characteristics method | .440 | .395 | .390 | .406 | .413 |
| Channel-width method | .560 | .605 | .610 | .594 | .587 |
| Weighted standard error (log) | .214 | .174 | .167 | .149 | .155 |
| Weighted standard error (pct) | 52 | 42 | 40 | 35 | 37 |
| | | | | | |
| Concurrent-measurement method | .582 | .614 | .606 | .596 | .629 |
| Basin-characteristics method | .418 | .386 | .394 | .404 | .371 |
| Weighted standard error (log) | .115 | .113 | .118 | .126 | .116 |
| Weighted standard error (pct) | 27 | 26 | 28 | 30 | 27 |
| | | | | | |
| Concurrent-measurement method | .561 | .555 | .538 | .524 | .565 |
| Channel-width method | .439 | .445 | .462 | .476 | .435 |
| Weighted standard error (log) | .122 | .106 | .105 | .112 | .102 |
| Weighted standard error (pct) | 29 | 25 | 24 | 26 | 24 |

| Combinations of methods of estimation | Weights for specified month and monthly flow characteristic | | | | |
|---|---|---|---|---|---|
| | Q.90 | Q.70 | Q.50 | Q.10 | QM |

JUNE

| | | | | | |
|---|---|---|---|---|---|
| Basin-characteristics method | 0.274 | 0.203 | 0.179 | 0.241 | 0.192 |
| Channel-width method | .260 | .315 | .305 | .402 | .331 |
| Concurrent-measurement method | .465 | .482 | .516 | .357 | .478 |
| Weighted standard error (log) | .119 | .091 | .080 | .101 | .081 |
| Weighted standard error (pct) | 28 | 21 | 19 | 24 | 19 |
| | | | | | |
| Basin-characteristics method | .601 | .579 | .572 | .466 | .535 |
| Channel-width method | .399 | .421 | .428 | .534 | .465 |
| Weighted standard error (log) | .233 | .175 | .161 | .133 | .145 |
| Weighted standard error (pct) | 58 | 42 | 38 | 31 | 34 |
| | | | | | |
| Concurrent-measurement method | .487 | .520 | .569 | .472 | .551 |
| Basin-characteristics method | .513 | .480 | .431 | .528 | .449 |
| Weighted standard error (log) | .132 | .116 | .107 | .133 | .110 |
| Weighted standard error (pct) | 31 | 27 | 25 | 31 | 26 |
| | | | | | |
| Concurrent-measurement method | .513 | .548 | .588 | .455 | .558 |
| Channel-width method | .487 | .452 | .412 | .545 | .442 |
| Weighted standard error (log) | .132 | .100 | .088 | .111 | .089 |
| Weighted standard error (pct) | 31 | 23 | 20 | 26 | 21 |

JULY

| | | | | | |
|---|---|---|---|---|---|
| Basin-characteristics method | 0.294 | 0.196 | 0.116 | 0.006 | 0.088 |
| Channel-width method | .210 | .236 | .304 | .496 | .367 |
| Concurrent-measurement method | .496 | .568 | .580 | .498 | .545 |
| Weighted standard error (log) | .158 | .115 | .101 | .093 | .111 |
| Weighted standard error (pct) | 38 | 27 | 24 | 22 | 26 |
| | | | | | |
| Basin-characteristics method | .571 | .611 | .500 | .456 | .500 |
| Channel-width method | .429 | .389 | .500 | .544 | .500 |
| Weighted standard error (log) | .317 | .255 | .224 | .174 | .192 |
| Weighted standard error (pct) | 84 | 64 | 55 | 42 | 46 |

| Combinations of methods of estimation | Weights for specified month and monthly flow characteristic | | | | |
|---|---|---|---|---|---|
| | Q.90 | Q.70 | Q.50 | Q.10 | QM |

JULY--Continued

| | | | | | |
|---|---|---|---|---|---|
| Concurrent-measurement method | .510 | .587 | .622 | .523 | .594 |
| Basin-characteristics method | .490 | .413 | .378 | .477 | .406 |
| Weighted standard error (log) | .164 | .127 | .121 | .141 | .135 |
| Weighted standard error (pct) | 39 | 30 | 28 | 33 | 32 |
| | | | | | |
| Concurrent-measurement method | .521 | .606 | .608 | .500 | .573 |
| Channel-width method | .479 | .394 | .392 | .500 | .427 |
| Weighted standard error (log) | .170 | .122 | .104 | .093 | .112 |
| Weighted standard error (pct) | 41 | 29 | 24 | 22 | 26 |

AUGUST

| | | | | | |
|---|---|---|---|---|---|
| Basin-characteristics method | 0.137 | 0.079 | 0.020 | 0.000 | 0.000 |
| Channel-width method | .342 | .344 | .360 | .358 | .364 |
| Concurrent-measurement method | .520 | .577 | .621 | .642 | .636 |
| Weighted standard error (log) | .180 | .140 | .119 | .081 | .113 |
| Weighted standard error (pct) | 43 | 33 | 28 | 19 | 26 |
| | | | | | |
| Basin-characteristics method | .411 | .500 | .635 | .500 | .567 |
| Channel-width method | .589 | .500 | .365 | .500 | .433 |
| Weighted standard error (log) | .360 | .323 | .300 | .238 | .265 |
| Weighted standard error (pct) | 99 | 86 | 78 | 59 | 67 |
| | | | | | |
| Concurrent-measurement method | .539 | .593 | .621 | .688 | .651 |
| Basin-characteristics method | .461 | .407 | .379 | .312 | .349 |
| Weighted standard error (log) | .193 | .158 | .142 | .122 | .138 |
| Weighted standard error (pct) | 47 | 38 | 34 | 29 | 33 |
| | | | | | |
| Concurrent-measurement method | .529 | .586 | .625 | .642 | .636 |
| Channel-width method | .471 | .414 | .375 | .358 | .364 |
| Weighted standard error (log) | .182 | .141 | .119 | .081 | .113 |
| Weighted standard error (pct) | 44 | 33 | 28 | 19 | 26 |

Table 13.--*Weights and standard errors for various combinations
of methods of estimation*--Continued

| Combinations of methods of estimation | Weights for specified month and monthly flow characteristic | | | | |
|---|---|---|---|---|---|
| | Q.90 | Q.70 | Q.50 | Q.10 | QM |

SEPTEMBER

| | | | | | |
|---|---|---|---|---|---|
| Basin-characteristics method | 0.149 | 0.053 | 0.040 | 0.045 | 0.049 |
| Channel-width method | .303 | .322 | .314 | .301 | .259 |
| Concurrent-measurement method | .548 | .625 | .646 | .654 | .693 |
| Weighted standard error (log) | .169 | .120 | .102 | .083 | .091 |
| Weighted standard error (pct) | 40 | 28 | 24 | 19 | 21 |
| | | | | | |
| Basin-characteristics method | .663 | .571 | .633 | .561 | .623 |
| Channel-width method | .337 | .429 | .367 | .439 | .377 |
| Weighted standard error (log) | .363 | .317 | .289 | .213 | .238 |
| Weighted standard error (pct) | 100 | 84 | 75 | 52 | 59 |
| | | | | | |
| Concurrent-measurement method | .550 | .637 | .653 | .681 | .711 |
| Basin-characteristics method | .450 | .363 | .347 | .319 | .289 |
| Weighted standard error (log) | .181 | .139 | .122 | .101 | .105 |
| Weighted standard error (pct) | 44 | 33 | 29 | 24 | 25 |
| | | | | | |
| Concurrent-measurement method | .565 | .633 | .654 | .666 | .706 |
| Channel-width method | .435 | .367 | .346 | .334 | .294 |
| Weighted standard error (log) | .172 | .120 | .102 | .083 | .092 |
| Weighted standard error (pct) | 41 | 28 | 24 | 19 | 21 |