MEAN ANNUAL RUNOFF AND PEAK FLOW ESTIMATES BASED ON CHANNEL GEOMETRY OF STREAMS IN SOUTHEASTERN MONTANA

by R. J. Omang, Charles Parrett, and J. A. Hull

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CONTENTS

ILLUSTRATIONS

TABLES

CONVERSION FACTORS

For those readers who may prefer to use the International System of Units (SI) rather than inch-pound units, the conversion factors for the terms used in this report are listed below.

Multiply inch-pound unit	By	To obtain SI unit
acre-foot	1233	cubic meter
cubic foot per second	0.02832	cubic meter per second
foot	0.3048	meter
mile	1.609	kilometer
square mile	2.590	square kilometer

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 mean sea level. NGVD of 1929 is referred to as sea level in this report.

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ABSTRACT

Equations using channel-geometry measurements were developed for estimating mean annual runoff and peak flows of ungaged streams in southeastern Montana. Two separate sets of estimating equations were developed for determining mean annual runoff: one for perennial streams and one for ephemeral and intermittent streams. Data from 23 gaged sites on perennial streams and 21 gaged sites on ephemeral and intermittent streams were used in these analyses. Data from 78 gaged sites were used in the peak-flow analyses. Southeastern Montana was divided into three regions and separate multiple-regression equations for each region were developed that relate channel dimensions to peak discharges having recurrence intervals of 2, 5, 10, 25, 50, and 100 years.

Channel-geometry relations were developed using measurements of the active-channel width and bankfull width. Active-channel width and bankfull width were the most significant channel features for estimating mean annual runoff for all types of streams. Use of this method requires that onsite measurements be made of channel width.

The standard error of estimate for predicting mean annual runoff ranged from 38 to 79 percent. The standard error of estimate relating either active-channel width or bankfull width to peak flow ranged from 37 to 115 percent.

INTRODUCTION

Information concerning streamflow characteristics is essential to planning and design activities involving streams. Land-use managers need information on all aspects of streamflow to evaluate various land-use alternatives. Design engineers need information about the magnitude and frequency of peak flows for bridge and culvert design and for flood-plain management.

Streamflow characteristics can be reliably estimated from stream-gaging data, but only after records have been collected for several years. Streamflow characteristics can also be estimated using channel-geometry measurements of widths and mean depths. This quick and reliable technique does not require years of record collection. The purpose of this report is to describe the channel-geometry technique and to present equations for estimating mean annual runoff and peak flows for ungaged streams in southeastern Montana. This study used the active-channel and bankfull-channel methods. The width and average depth of cross sections were measured and were related to the mean annual runoff and flood-frequency characteristics. This report was prepared in cooperation with the U.S. Bureau of Land Management.

Several previous studies have described peak flows. A recent report by Parrett and Omang (1981) presented methods for estimating peak discharges. Other studies (Berwick, 1958; Boner and Omang, 1967; Patterson, 1966; Boner and Buswell, 1970; Dodge, 1972; and Johnson and Omang, 1976) also provided techniques for estimating flood magnitude and frequency. A report by Boner and Buswell (1970) related mean annual flow characteristics to physical and climatic basin characteristics.

GENERAL DESCRIPTION OF THE AREA

Montana is a large area having widely varying geographic and climatic conditions. The southeastern part of the State is generally flat or rolling prairie land with deeply incised large streams. The channels of most of the streams are of three principal types: the narrow, deep low-water channel within a larger main channel; the vegetated ephemeral channel; and the sand-bed channel. Most of the streams have relatively flat slopes and fairly broad flood plains. The location of the area studied is shown in figure 1.

The principal source of precipitation during the spring and summer for southeastern Montana is the warm moist air from the Gulf of Mexico. Winter precipitation comes from the Pacific Coast. Annual precipitation is more variable, more intense, and generally less in amount than in the mountains of the western part of the State. The streams are all subject to snowmelt runoff during the spring and flood peaks from thunderstorms during the summer. Occasionally, late snowmelt and rain combine to cause runoff. The snowmelt runoff is generally of fairly long duration with diurnal fluctuations, whereas the flood peaks from thunderstorms occur quickly and are short in duration.

DATA USED

Streamflow data

Data from continuous-record, crest-stage, and two coal company gages were used in this study. For the mean annual runoff analysis, data were from 23 continuous-record gaging stations on perennial streams and 21 continuous-record gaging stations on ephemeral and intermittent streams. Data for the peak-flow analyses were from 78 partial-record gaging stations. The continuous-record stations are operated by the U.S. Geological Survey in cooperation with other Federal and State agencies; they provide mean annual runoff as well as peak flows. The partial-record stations, operated in cooperation with State and Federal agencies, are on small streams and provide only peak-flow information. Data from the coal company gages, which are operated by Peter Kiewit Sons Co., were reviewed and used in the mean annual runoff analyses.

The location and station number of all gaging stations from which data were used are shown in figures 1 and 2. Station data were used if the period of record was at least 10 years for peak-flow data and 4 years for mean annual runoff data. The latest date for data used in the analyses was the 1980 water year for mean annual runoff (table 1) and the 1978 water year for peak flow (table 2).

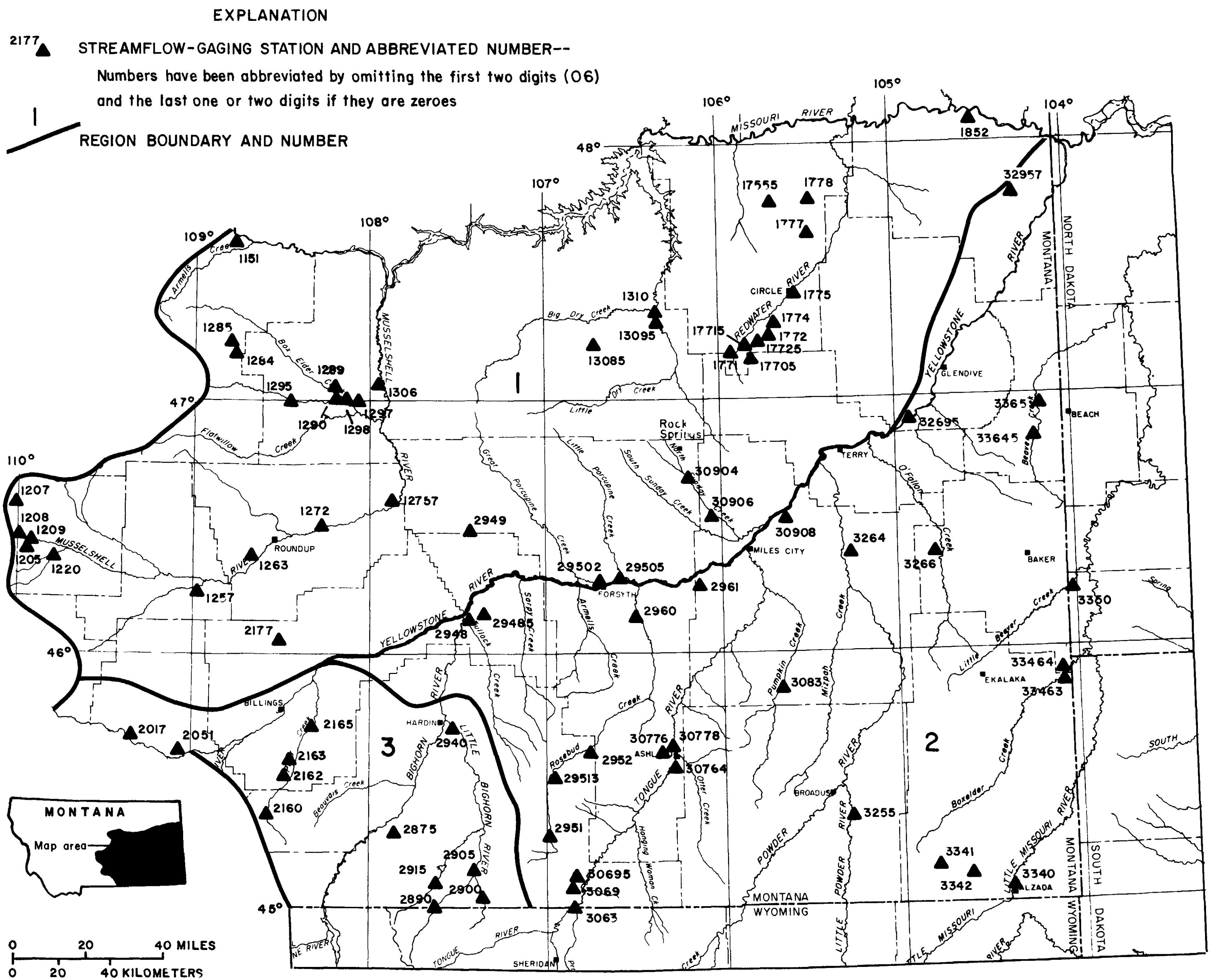

Figure 1.--Location of study area, region boundaries, and selected streamflow-gaging stations used for peak-flow analyses.

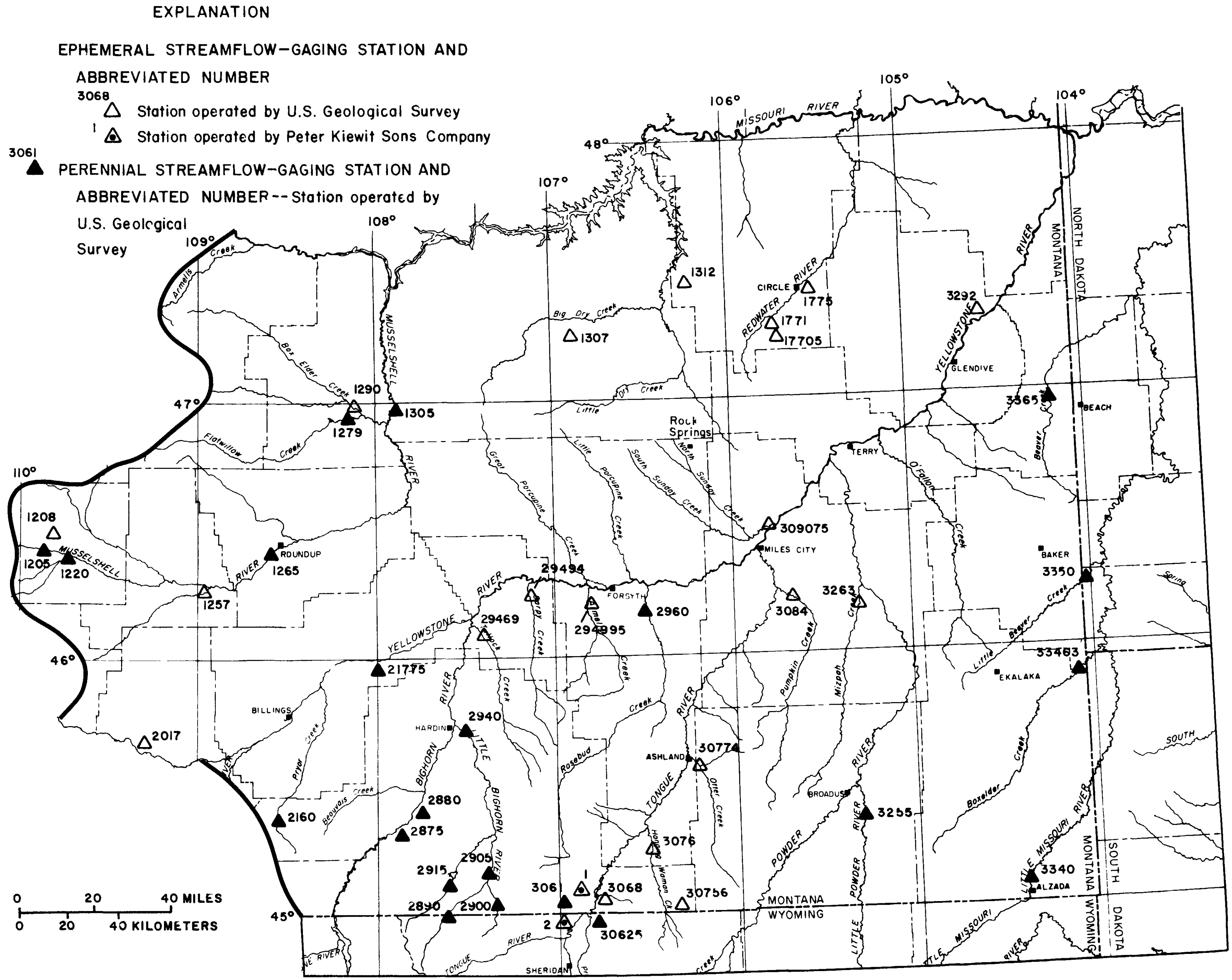

Figure 2.--Location of selected streamflow-gaging stations used for mean annual runoff analyses in southeastern Montana and adjoining areas.

The mean annual runoff is the average discharge for the period of record. Flood magnitudes for recurrence intervals of 2, 5, 10, 25, 50, and 100 years were determined at each gaging station by using a log-Pearson type III probability distribution to develop a flood-frequency curve. Techniques recommended by the U.S. Water Resources Council (1977) were used to fit the log-Pearson type III distribution to the annual peak discharges at each site. The techniques used skew coefficients as recommended by the Water Resources Council, and historical data where available.

Channel-geometry data

The channel dimensions of 44 streams with continuous record were measured for analysis of mean annual runoff. Channel measurements were made at 54 additional partial-record stations for use in the flood-frequency analyses. Channel-geometry measurements were made during the 1978 and 1979 water years by personnel of the Geological Survey. The measurement sites were chosen near gaging stations where runoff data were available. Streamflow stations used in the mean annual runoff analyses are listed in table 1. The type of stream (perennial, intermittent, or ephemeral), length of record, bed material, and basin and streamflow characteristics for each stream are also given. Streamflow stations used in the peak-flow analyses are listed in table 2. The length of record, bed material, basin characteristics, and peak discharges for each stream are also given.

CHANNEL-GEOMETRY METHOD

It has long been known that stream channels are shaped by the magnitude and velocity of flow and the materials which they transport. Most of the channel shaping occurs during times of high flow.

Studies by Scott and Kunkler (1976) in New Mexico, by Hedman and Kastner (1977) in the Missouri River basin, by Lowham (1976) in Wyoming, by Moore (1974) in Nevada, by Riggs and Harenberg (1976) in Idaho, and by Hedman and Osterkamp (1981) in the western United States have shown the feasibility of relating flood-flow magnitude to channel features. Because mean annual runoff is related to flood flows, mean annual runoff can also be related to channel features. Studies by Lowham (1976) in Wyoming, by Hedman, Kastner, and Hejl (1974) in Kansas, by Hedman (1970) in California, by Fields (1975) in Utah, by Hedman and Kastner (1977) in the Missouri River basin, and by Hedman and Osterkamp (1982) in the western United States have shown that the relationship is useful.

Several channel-geometry features have been investigated in the past as reference levels for estimating streamflow characteristics. For this study two reference levels were used: the active-channel width and the bankfull width. The geometry of these two features was measured, and the measurements were related to mean annual runoff and selected flood-frequency discharges.

The active channel is described by Hedman and Kastner (1977) as the lower part of the channel that is actively involved in transporting water and sediment. The upper limit, which defines the active-channel reference level, is identified by a change in the relatively steep slope of the channel banks to a more gently sloping surface upward beyond the channel edge. The change in slope normally coincides with the lower limit of permanent vegetation.

The active channel on all perennial streams and most intermittent and ephemeral streams in the study area generally was defined by a line of vegetation on one or both sides. If there was a distinguishing feature on one side of the channel but none on the other side, and a better reach could not be found, the distance was measured from the distinguishing feature, level across the channel, to the point of intersection with the channel bank. On grassy channels with defined banks, the change in slope was the indicator of the reference level.

The highest reference level measured was the bankfull width. This reference level is described by Riggs (1974) as the horizontal distance between the tops of the banks of the main channel. The top of the bank is defined as the place where the flood plain and the channel slope intersect, and usually is distinguished by a change in slope. The slope changes from vertical or near-vertical to horizontal at the change in slope. This reference level is virtually the same as the bankfull stage for perennial streams described by Wolman (1955) as the stage at which overbank flooding occurs. On ephemeral streams, especially in the plains areas, the channel width is subject to more uncertainty. Some stream channels have downcut, owing to a change in hydrologic conditions. The old banks then form terraces. Distance between them is much wider than the width of the new channel. Too high a reference level would not reflect the present flow regime.

The channel surveys were made at or near each of the streamflow-gaging stations shown in figures 1 and 2. An onsite visit was necessary to obtain the channel measurements. Each stream to be measured was inspected upstream and downstream from the gaging station for a straight stable reach and recurring, uniform channel shapes. Channel banks for bankfull measurements needed to have been permanent for several years. Two to three cross sections separated by at least one channel width were selected, if suitable ones could be found. Measurements were made of the top width of both the active and the bankfull sections, and sufficient depth measurements were made to determine an average depth of each section. If practical, measurements were made of the local channel-bed slope or water-surface slope. The reach and cross sections, including the features at the ends of the section, were photographed and the type of bed and bank material was recorded.

A sketch (fig. 3) modified from Lowham (1976) shows the best location for measurement of channel-geometry features in a meandering reach. The location is at the narrowest, most stable section of the channel. This section is the most stable because energy is dissipated in the curve, and as the flow leaves the curve it has a minimum amount of erosive potential. The section, therefore, has channel features that have formed over a longer period of time and thus represents a greater length of record than at other sections. A sketch showing reference levels for active-channel width and bankfull width is also shown in figure 3.

Active-channel widths and bankfull widths for typical sites in southeastern Montana are shown in figures 4-9. Grassed channels without well-defined banks, which are common on small streams in the area, are shown in figures 10 and 11.

Use of the channel-geometry method requires onsite training and experience for effective selection of the reference levels. Numerous photographic slides showing channel features at sites in addition to those of figures 4-11 are available for inspection in the Helena, Mont., office of the U.S. Geological Survey. Individuals who expect to utilize the method would benefit by viewing the slides and visiting several streams in the area with someone who is experienced with the method.

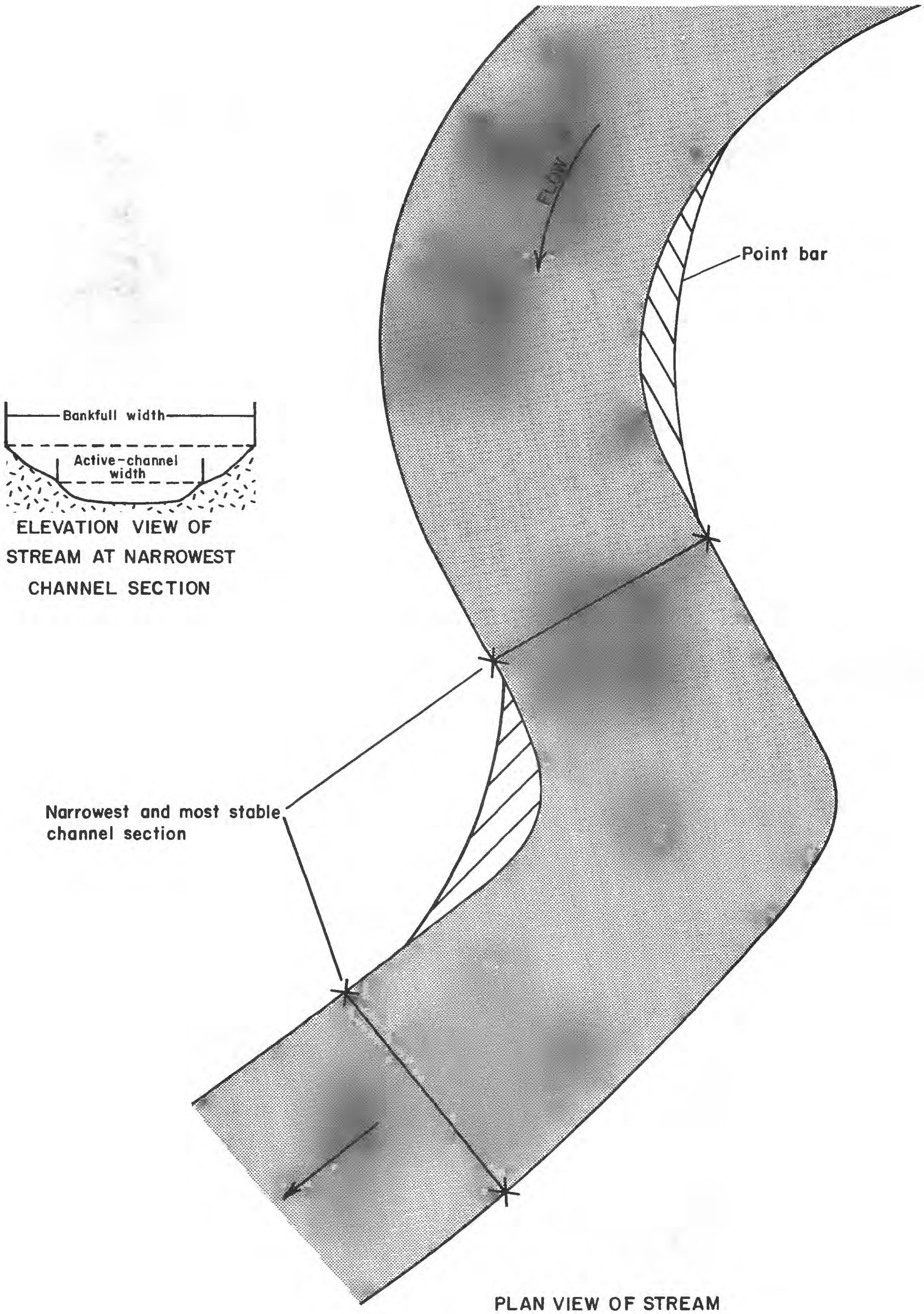

Figure 3.--Best location for measurement of channel-geometry features in a meandering reach.

Figure 4.--Active-channel section on Spring Creek near Decker, Montana. Section is defined by vegetation and change in slope; width is about 13 feet. Site is near station 06306900. View is upstream.

Figure 5.--Active-channel section on Deer Creek near Decker, Montana. Section is defined by vegetation; width is about 8 feet. Site is near station 06306800. View is upstream.

Figure 6.--Active-channel section on North Fork Coal Bank Creek near Mill Iron, Montana. Section is defined by vegetation and change in slope; width is about 14 feet. Site is at station 06334640. View is downstream.

Figure 7.--Bankfull section on Tullock Creek near Bighorn, Montana. Section is defined by change in slope between bank and flood plain; width is about 25 feet. Site is near station 06294690. View is downstream.

Figure 8.--Bankfull section on Pearson Creek near Decker, Montana. Section is defined by change in slope; width is about 4 feet. Site is near station 1. View is upstream.

Figure 9.--Bankfull section on Mizpah Creek near Mizpah, Montana. Section is defined by change in slope on the left bank; width is about 58 feet. Site is near station 06326300. View is upstream.

Figure 10.--Grassed channel without well-defined banks on Leaf Rock Creek near Kirby, Montana. Tape shows measurement of bankfull section defined by change in slope; width is about 8 feet. Site is near station 06306950. View is upstream.

Figure 11.--Grassed channel on Rock Springs Creek tributary at Rock Springs, Montana. Channel-geometry features could not be measured or applied at this site, because of the absence of well-defined reference levels. Site is upstream from station 06309075. View is upstream.

The channel-geometry method will not give good results in stream reaches having the following conditions:

1. Braided channels.

2. Small streams that are entirely vegetated and have not formed or maintained a channel.

3. Channels containing bedrock in the bed or banks.

4. Reaches having large pools or steep inclines.

5. Channels that have been widened or realined by an extreme flood or by construction work and have not had time to return to normal conditions.

METHOD OF ANALYSIS

Relations for estimating various flow characteristics are presented in this report in the form of mathematical equations. All values in the data set were transformed to logarithms before the relations were defined by multiple-regression techniques. After taking antilogs, the resulting equations have the form

$$Q = aA^bB^cC^d \ldots N^m \qquad (1)$$

where

Q is either Q_A, the mean annual runoff, in acre-feet, or $Q_2, Q_5 \ldots Q_{100}$, the peak discharge, in cubic feet per second, for the indicated recurrence interval, in years;
a is a regression constant;
b, c, d, and m are regression coefficients, and
A, B, C, and N are channel features or basin characteristics.

Flow characteristics were used as the dependent variables, and channel features and basin characteristics were used as the independent variables.

The multiple-regression analyses were performed using a computer program (SAS Institute, Inc., 1979) with a "maximum R^2 improvement" routine for adding or deleting independent variables to the model. R is the coefficient of correlation. This procedure determines the "best" one variable model (largest R^2), the best two-variable model (greatest increase in R^2), and so forth until the specified maximum number of independent variables has been included.

For this report, separate analyses were made for perennial streams and for ephemeral and intermittent streams to determine the mean annual runoff prediction equations. The analyses used to develop peak-flow prediction equations considered all types of streams in the area. Different independent variables were considered for each analysis.

For the mean annual runoff analysis, active-channel width (W_{AC}) proved to be the most significant parameter for ephemeral-intermittent and perennial streams. Bankfull width (W_{BF}) was also significant for all three classes of streams. Mean basin elevation was also included in the regression equation for perennial streams because it decreases the standard error considerably and appears to indicate that there is a distinct difference between mountainous streams and prairie streams. Mean basin elevation index ($E/1000$) is the mean basin elevation, in feet above sea level, divided by 1,000. Mean basin elevation can be determined by using a transparent grid overlay on a topographic map. The basin elevation at each grid intersection is determined, and the mean basin elevation is calculated by averaging. For mean annual runoff analysis, local slope, map slope, channel area, and channel conveyance were also tested and determined to be insignificant. A summary of the regression results for these relations and the standard error of estimate are given in table 3. Relationships for estimating mean annual runoff using channel geometry are presented in graphical form in figures 12 and 13.

Table 3.--*Mean annual runoff equations and standard error of estimate*

Mean annual runoff (acre-feet)		Equations	Standard error of estimate (percent)
		Ephemeral and intermittent streams (21 stations)	
Q_A	=	$18.5\ W_{AC}^{2.01}$	58
Q_A	=	$4.83\ W_{BF}^{2.03}$	79
		Perennial streams (23 stations)	
Q_A	=	$277\ W_{AC}^{1.43}$	47
Q_A	=	$48.4\ W_{AC}^{1.43}\ (E/1000)^{1.17}$	38
Q_A	=	$325\ W_{BF}^{1.24}$	73

Relationships developed for ephemeral streams were based on the use of some streams that had 4 or 5 years of record. These relationships are considered to have a poorer reliability than others and, therefore, are considered to be approximate.

For ephemeral streams, a nonlinear regression equation of the following form was investigated:

$$Q_A = a\ W_{AC}^{\ (b\ W_{AC}^{x})} \qquad (2)$$

where

Q_A is mean annual runoff, in acre-feet;
a is a regression constant;
W_{AC} is active-channel width, in feet; and
b and x are regression coefficients.

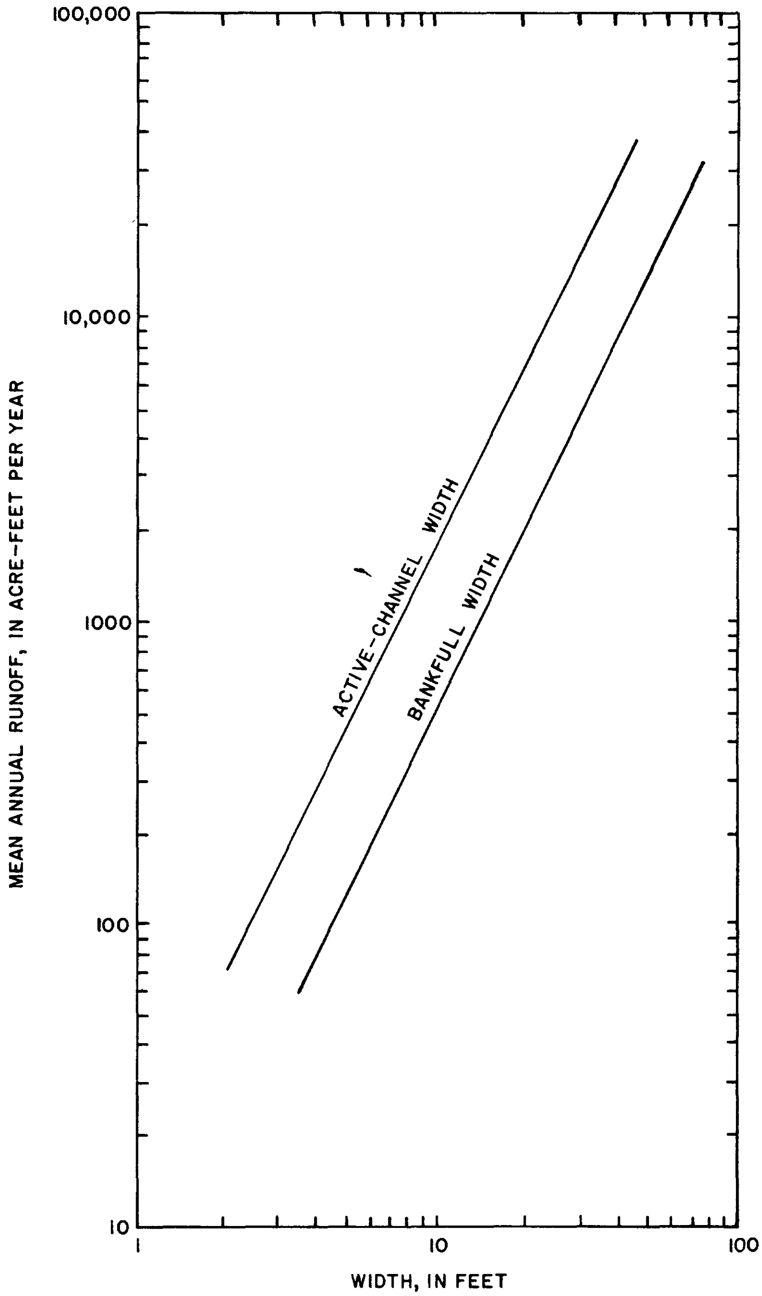

Figure 12.--Relationships for estimating mean annual runoff for ephemeral-intermittent streams in southeastern Montana.

The value of x was varied from 0.1 to -0.1 and the minimum standard error of estimate was found to occur when $x = 0$. Because the nonlinear form reduces to the linear form $Q_A = a\ W_{AC}{}^{b}$ when $x = 0$, it has no advantage over the linear form.

For the peak-flow analysis, an initial multiple-regression run was made for the entire area. The regression residuals (differences in log units between the observed and computed peak values) were plotted on a map and used to divide the area into three regions. These regions are illustrated in figure 1. Region 1,

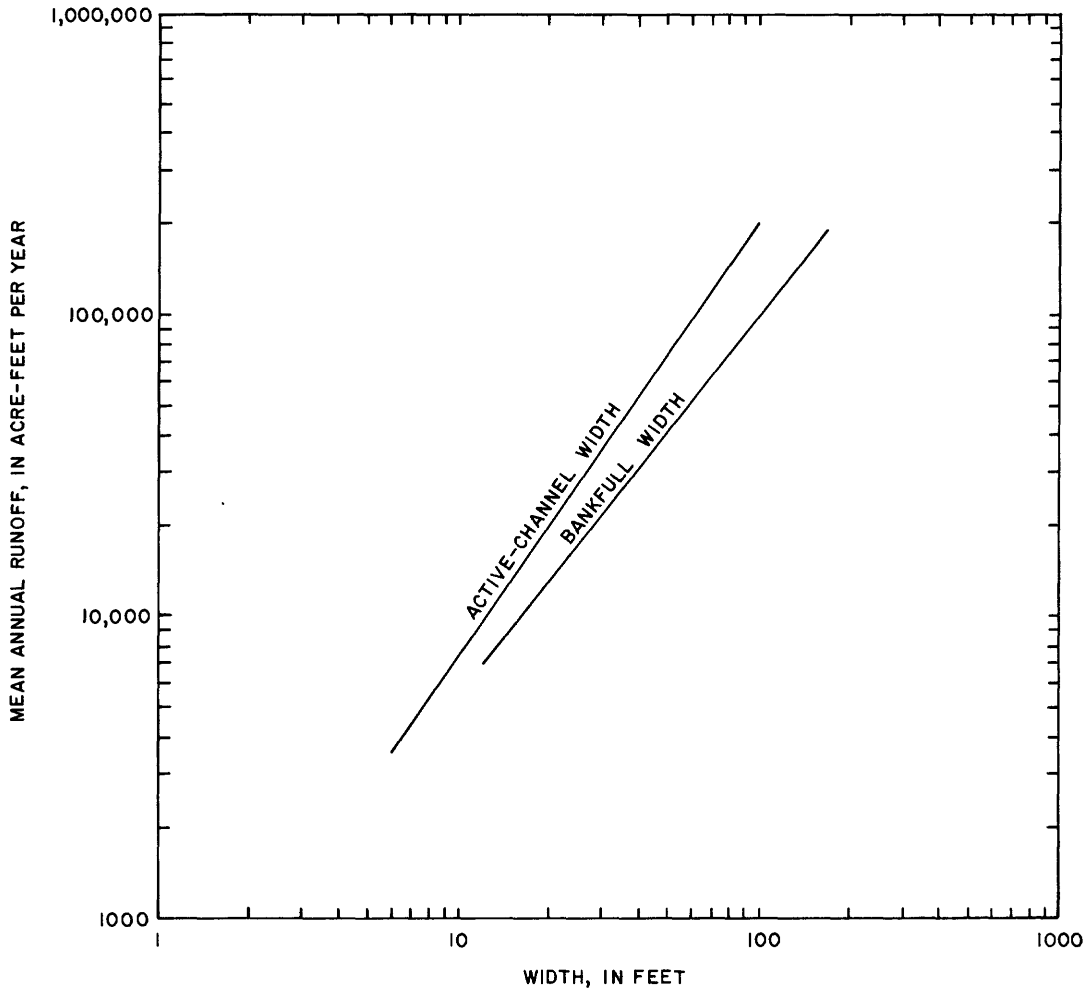

Figure 13.--Relationships for estimating mean annual runoff for perennial streams in southeastern Montana.

generally flat plains land, is the area most affected by intense summer thunderstorms. Runoff is largely variable, with most smaller streams flowing only intermittently. Flood peaks are produced by prairie snowmelt and rainfall. Region 2 is similar in topography to Region 1 but intense thunderstorms are not as prevalent. Flood peaks are not as variable or as large as in Region 1. Region 3 contains mountainous areas and is generally forested. Annual precipitation is large, resulting in accumulated snowpack, and runoff occurs primarily as a result of snowmelt. Separate multiple-regression analyses were then made for each of the three regions. Bankfull width and depth and active-channel width and depth were tested as independent variables; width was found to be the most significant. The final regression equations developed for each region and the standard errors of estimate are given in table 4. Relations for estimating peak flows using the channel-geometry method are presented in graphical form in figures 14-19.

Table 4.--*Peak-flow equations and standard error of estimate*

Discharge (cubic feet per second for given recurrence interval, in years)	Equations	Standard error of estimate (percent)	Discharge (cubic feet per second for given recurrence interval, in years)	Equations	Standard error of estimate (percent)
Region 1 (38 stations)					
Q_2	$= 10.0\ W_{AC}^{1.16}$	87	Q_{25}	$= 39.9\ W_{AC}^{1.36}$	98
Q_2	$= 2.87\ W_{BF}^{1.32}$	83	Q_{25}	$= 24.5\ W_{BF}^{1.30}$	70
Q_5	$= 44.4\ W_{AC}^{1.01}$	68	Q_{50}	$= 59.6\ W_{AC}^{1.33}$	106
Q_5	$= 14.3\ W_{BF}^{1.16}$	62	Q_{50}	$= 39.4\ W_{BF}^{1.25}$	74
Q_{10}	$= 93.8\ W_{AC}^{0.93}$	70	Q_{100}	$= 85.9\ W_{AC}^{1.29}$	115
Q_{10}	$= 32.4\ W_{BF}^{1.08}$	64	Q_{100}	$= 60.1\ W_{BF}^{1.20}$	78
Q_{25}	$= 204\ W_{AC}^{0.85}$	80	Region 3 (12 stations)		
Q_{25}	$= 76.2\ W_{BF}^{0.99}$	75	Q_2	$= 10.7\ W_{AC}^{1.14}$	44
Q_{50}	$= 333\ W_{AC}^{0.80}$	90	Q_2	$= 2.50\ W_{BF}^{1.41}$	62
Q_{50}	$= 132\ W_{BF}^{0.94}$	85	Q_5	$= 33.9\ W_{AC}^{0.99}$	37
Q_{100}	$= 512\ W_{AC}^{0.76}$	100	Q_5	$= 9.24\ W_{BF}^{1.23}$	49
Q_{100}	$= 213\ W_{BF}^{0.89}$	96	Q_{10}	$= 63.4\ W_{AC}^{0.90}$	37
Region 2 (28 stations)			Q_{10}	$= 18.9\ W_{BF}^{1.13}$	47
Q_2	$= 3.52\ W_{AC}^{1.59}$	73	Q_{25}	$= 126\ W_{AC}^{0.81}$	42
Q_2	$= 1.47\ W_{BF}^{1.58}$	73	Q_{25}	$= 41.6\ W_{BF}^{1.02}$	48
Q_5	$= 12.2\ W_{AC}^{1.48}$	76	Q_{50}	$= 196\ W_{AC}^{0.76}$	47
Q_5	$= 5.95\ W_{BF}^{1.46}$	56	Q_{50}	$= 69.7\ W_{BF}^{0.96}$	52
Q_{10}	$= 20.7\ W_{AC}^{1.43}$	88	Q_{100}	$= 296\ W_{AC}^{0.71}$	53
Q_{10}	$= 11.5\ W_{BF}^{1.38}$	66	Q_{100}	$= 112\ W_{BF}^{0.89}$	57

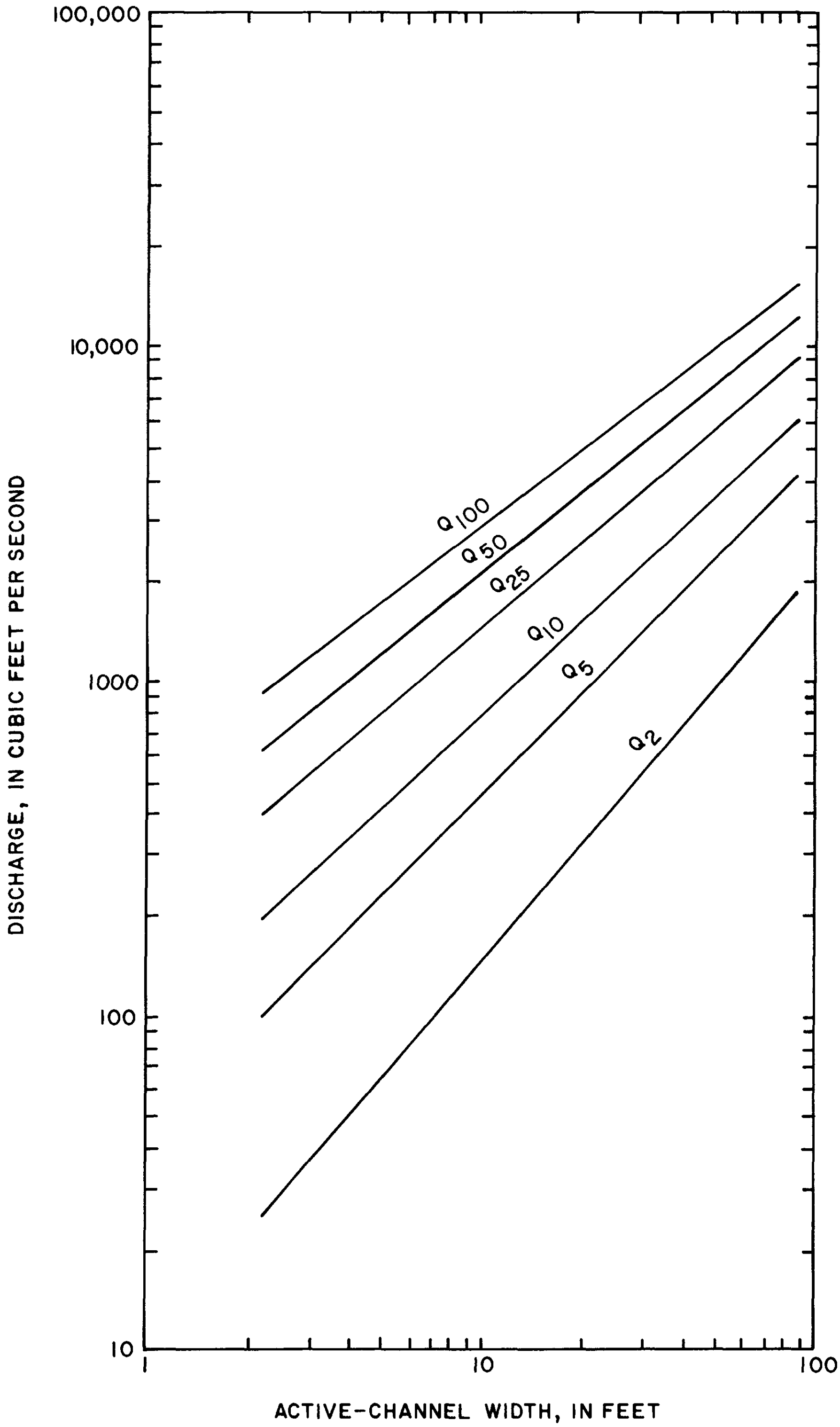

Figure 14.--Relationships for estimating peak discharges (*Q*) in Region 1 by using the active-channel width.

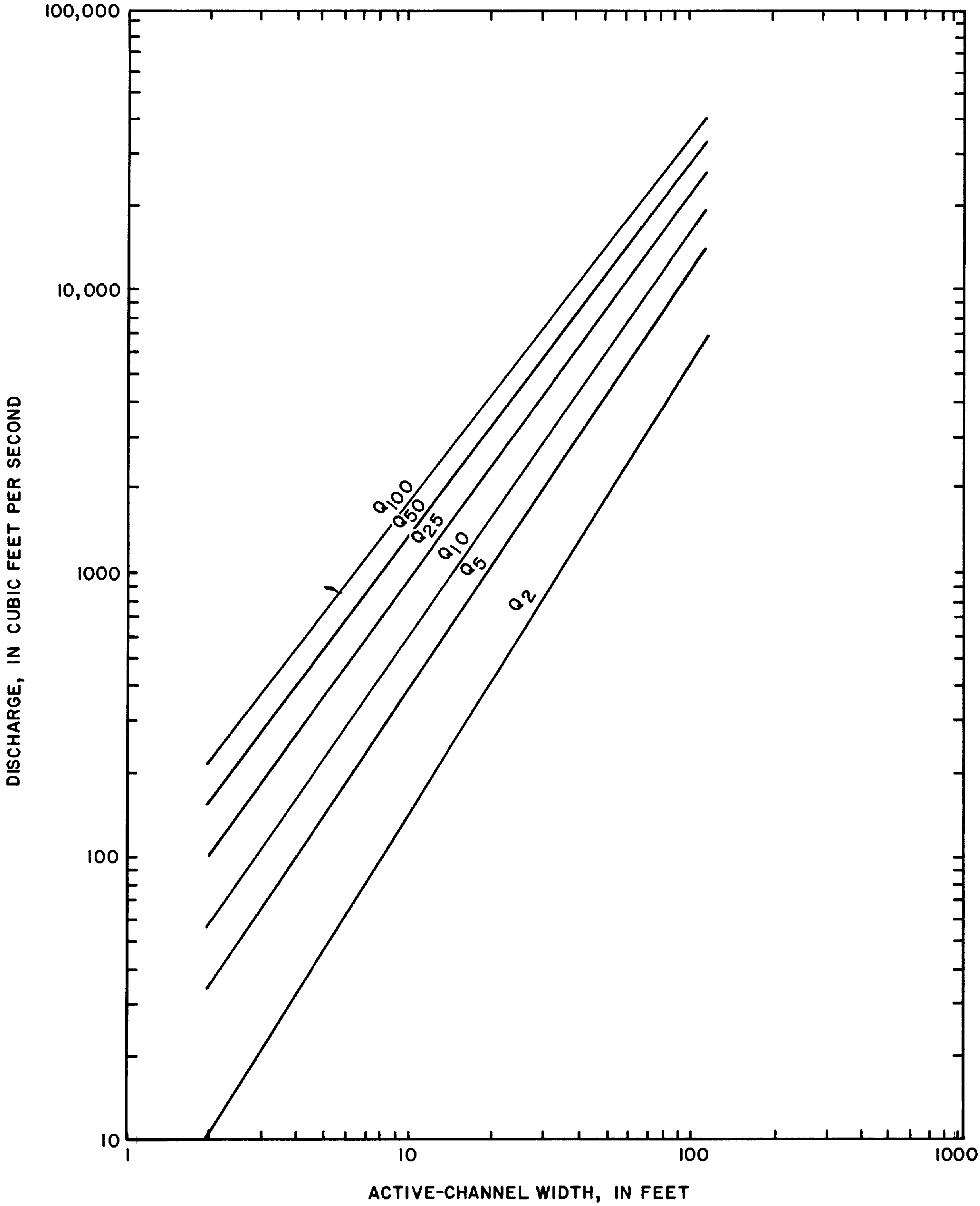

Figure 15.--Relationships for estimating peak discharges (Q) in Region 2 by using the active-channel width.

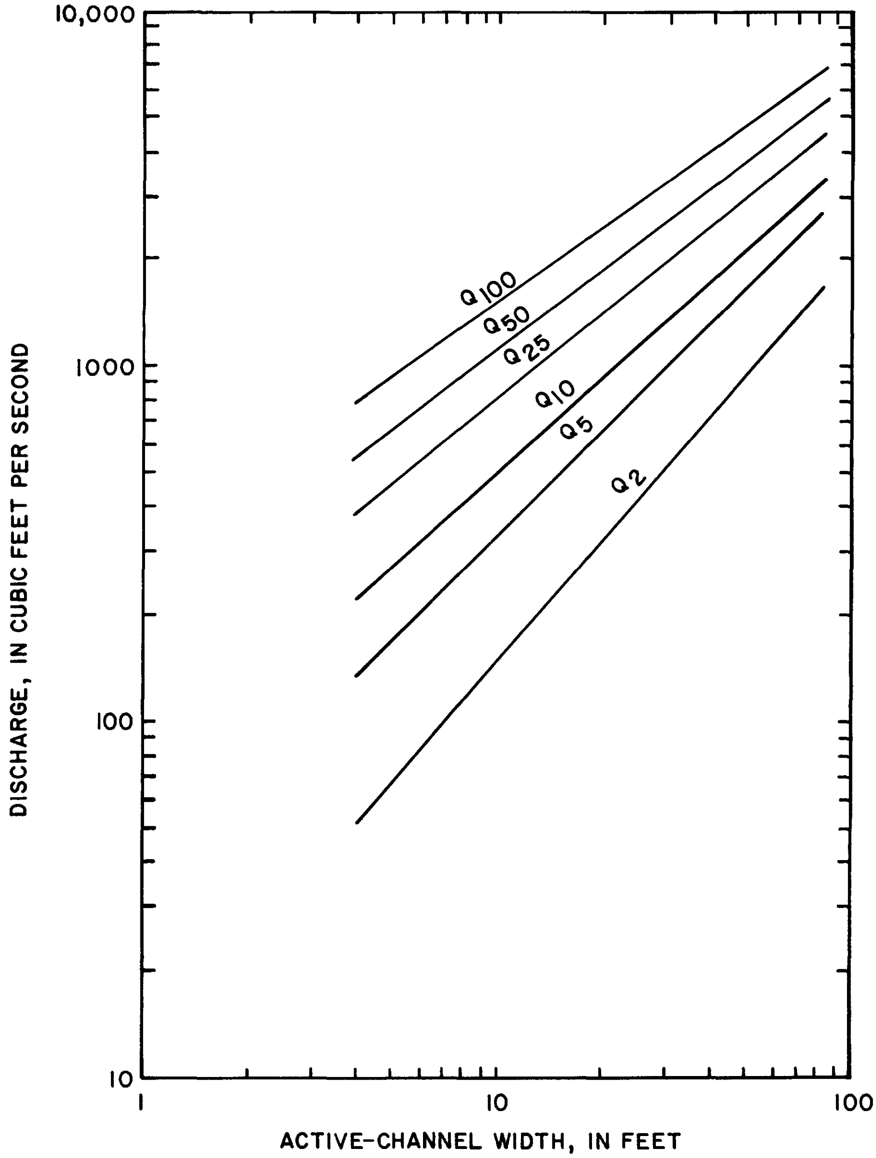

Figure 16.--Relationships for estimating peak discharges (Q) in Region 3 by using the active-channel width.

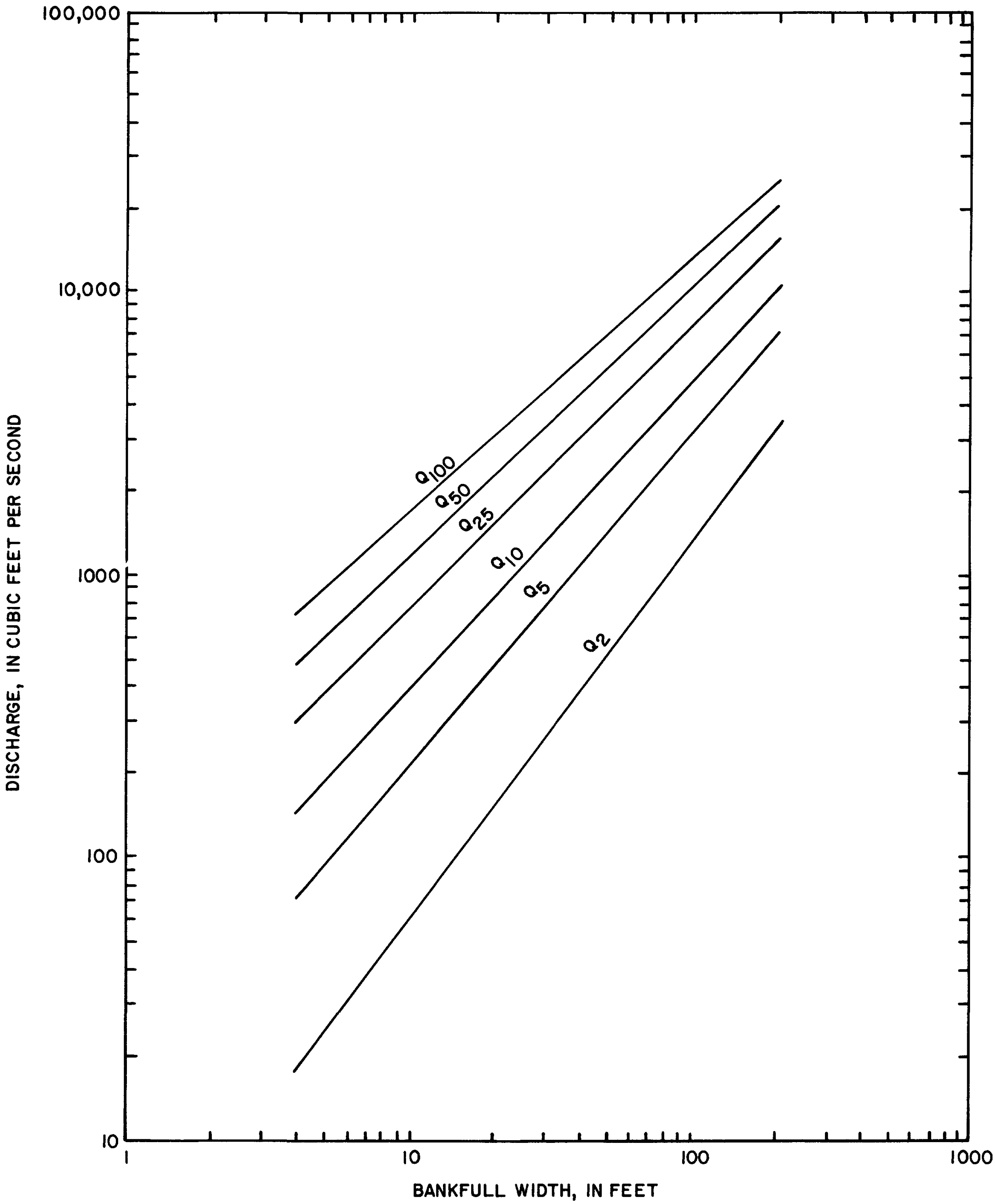

Figure 17.--Relationships for estimating peak discharges (*Q*) in Region 1 by using the bankfull width.

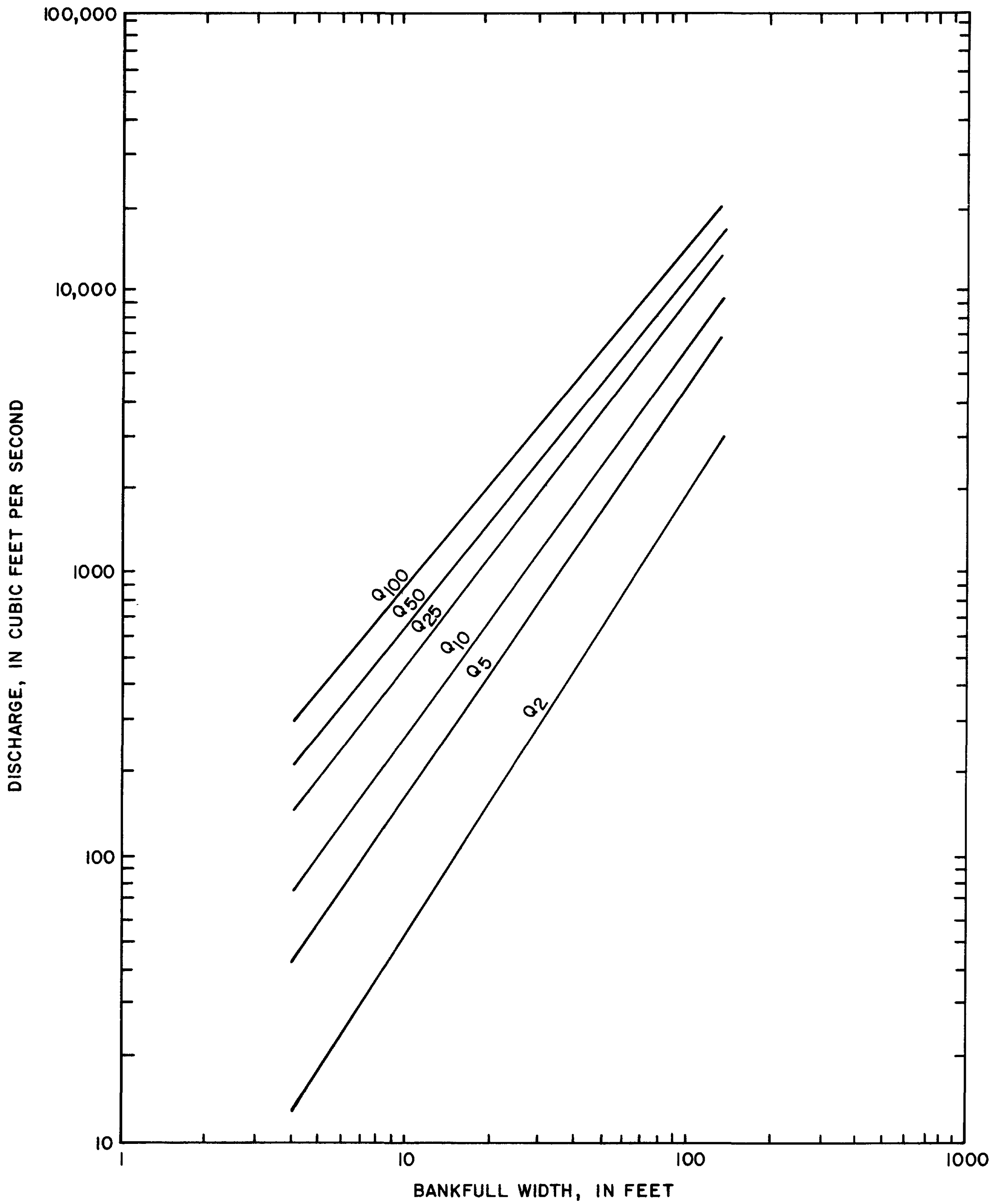

Figure 18.--Relationships for estimating peak discharges (*Q*) in Region 2 by using the bankfull width.

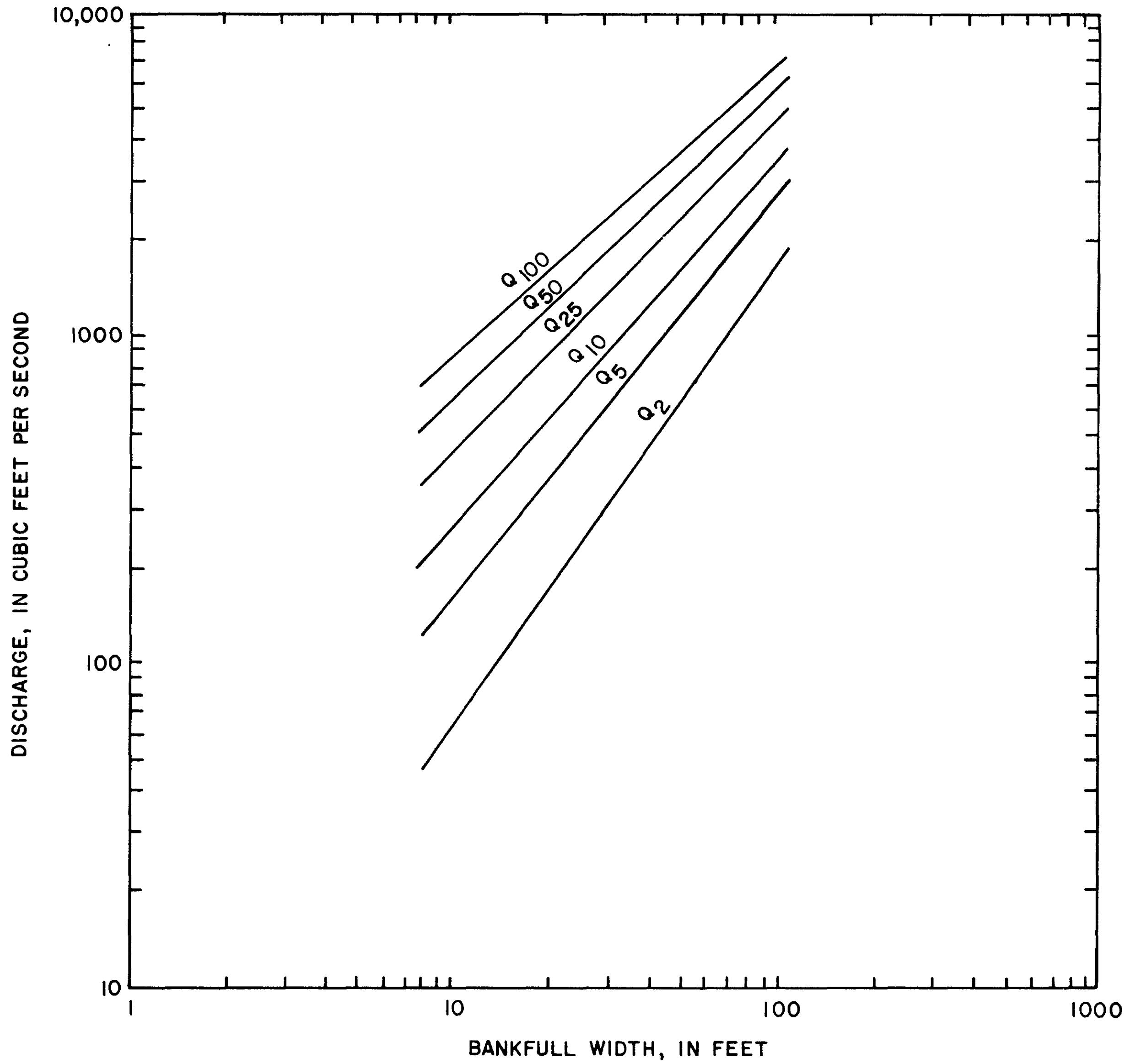

Figure 19.--Relationships for estimating peak discharges (Q) in Region 3 by using the bankfull width.

Limitations of definition

The estimating relations in this report are known to apply only within the range of variables tested or sampled, because regression analyses do not define actual physical relations. Equations were defined from data on streams virtually unaffected by urbanization, regulation, or diversion, and do not apply to streams subject to these conditions. For this study the range of values of the channel characteristics and basin characteristics used are given in table 5. Values obtained outside the ranges listed may not give reliable results.

Table 5.--*Range of channel and basin characteristics used*

Streamflow characteristics	Active-channel width (W_{AC}) (feet)	Active-channel depth (D_{AC}) (feet)	Bankfull width (W_{BF}) (feet)	Bankfull depth (D_{BF}) (feet)	Mean basin elevation (E) (feet above sea level)	Drainage area (A) (square miles)
Mean annual runoff						
Perennial streams	6.0-98	0.3-5.0	12-170	1.0-10.0	3,020-7,830	33.6-7,846
Ephemeral and intermittent streams	2.2-47	--	3.5-78	--	--	7.61-797
Peak flow						
Region 1	1.0-91	.2-5.0	4.0-220	.5-10.0	--	.22-2,554
Region 2	1.0-119	.2-5.0	4.0-131	.4-8.5	--	.87-1,970
Region 3	4.0-85	.4-6.5	8.0-110	1.1-10.5	--	2.64-1,290

Accuracy of estimating relations

The accuracy of a multiple-regression equation is most often measured by the standard error of estimate. The standard error of estimate is a measure of the standard deviation of the residuals about the regression line and is usually expressed in percent of the estimated value when log-transformed variables are used. The difference between the estimated and the actual peak discharge or runoff for two-thirds of the estimates will be within plus or minus one standard error of estimate. The use of logarithms of variables in the analyses causes the standard errors to be larger in the positive direction.

APPLICATION TO UNGAGED SITES

The use of the predicting equations in this report for estimating mean annual runoff at ungaged sites requires both a width measurement and a determination that the stream is perennial or ephemeral. The following definition (modified from Meinzer, 1923) was used: "A perennial stream, or reach of stream, is one which flows continuously. Perennial streams generally receive inflow of ground water, and the streambed commonly is lower than the water table." An ephemeral stream, or reach of a stream, is one that flows only in direct response to precipitation. This type of stream receives no water from springs and no long-continued supply from melting snow or other surface sources. Its channel is at all times above the water table. An onsite visit during a period of no direct runoff is required to make this determination.

Some advantage may be gained in using both active-channel width and bankfull width to estimate the streamflow characteristics. Where the widths are considered to be equally reliable, an average of the two discharges could be used. If one width measurement appears to be more reliable than the other, that one probably will give a more accurate estimate of flow characteristic. Also, on some streams it would be possible to obtain only one of the widths; then only one estimating equation could be used.

For peak-flow estimation, results can be compared with a recent flood-frequency report (Parrett and Omang, 1981), which uses basin characteristics for estimating the 2-, 5-, 10-, 25-, 50-, and 100-year floods. This report updates the earlier flood-frequency reports and is considered to be more accurate. The two methods could be used to check each other or channel geometry could be used as an alternative technique for predicting peak flows. The standard errors of estimate for these two methods are considered to be equivalent. A study in progress will also develop methods for determining mean annual runoff using basin characteristics.

ILLUSTRATIVE EXAMPLES

The procedure for determining mean annual runoff and flood magnitudes at ungaged sites is shown by the following examples:

Example 1.

The mean annual runoff is desired for an ungaged site in southeastern Montana. A visit to the site indicated that the stream was ephemeral.

Onsite measurements were 12 feet for the active-channel width and 23 feet for the bankfull width.
From table 3:

$$Q = 18.5\ W_{AC}^{2.01} \quad \text{and} \quad Q = 4.83\ W_{BF}^{2.03}$$

Solving for the Q gives:

$$Q = 18.5(12)^{2.01} = 18.5(148) = 2{,}700 \text{ acre-feet}$$

$$Q = 4.83(23)^{2.03} = 4.83(581) = 2{,}800 \text{ acre-feet}$$

Estimates of the mean annual runoff are about the same using either width. Using an average of the two estimates gives a Q of 2,750 acre-feet.

Example 2.

Determine the flood magnitude for a recurrence interval of 100 years (Q_{100}) for an ungaged site near Broadus that is south of the Yellowstone River and is in Region 2. The mean annual runoff is also needed for the same site. The mean basin elevation is 4,000 feet.

A visit to the site was made and widths were determined to be: W_{AC} = 39 feet and W_{BF} = 48 feet. An inspection of the stream indicated that it was perennial. Bankfull width was considered to be the most reliable width measurement.

Using the equation for Region 2 (table 4), solve for the 100-year flood.

$$\begin{aligned} Q_{100} &= 60.1\, W_{BF}^{\;1.20} \\ &= 60.1(48)^{1.20} \\ &= 60.1(104) \\ &= 6{,}300 \text{ cubic feet per second} \end{aligned}$$

Using the recent flood-frequency report (Parret and Omang, 1981), with a drainage area of 195 square miles, a forest cover of 5 percent, and a geographical factor of 1.0, the 100-year flood is computed using the equation:

$$\begin{aligned} Q_{100} &= 2{,}770\, A^{0.53}\, (F + 10)^{-0.76}\, G_f \\ &= 2{,}770(195)^{0.53}(15)^{-0.76}\, 1.0 \\ &= 2{,}770\, (16.4)^{0.13}(1.0) \\ &= 5{,}900 \text{ cubic feet per second} \end{aligned}$$

Estimates of the peak flow from the two methods compare fairly well and standard errors are about equal, so an average of the two figures could be used.

To determine the mean annual runoff, use the following equation from table 3:

$$Q = 48.4\, W_{AC}^{\;1.43}\, (E/1000)^{1.17}.$$

Thus

$$\begin{aligned} Q &= 48.4(39)^{1.43}(4000/1000)^{1.17} \\ &= 48.4(188)5.06 \\ &= 46{,}000 \text{ acre-feet} \end{aligned}$$

CONCLUSIONS

This study indicates that channel-geometry measurements can be used to estimate mean annual runoff for ephemeral, intermittent, and perennial streams in southeastern Montana. For ephemeral and intermittent streams, the active-channel width and the bankfull width were the most significant parameters. For perennial streams, active-channel width, bankfull width, and mean basin elevation proved to be the most significant parameters. The standard error of estimate is 58 percent for ephemeral streams using active-channel width and 79 percent using bankfull width. For perennial streams the standard error of estimate is 47 percent using active-channel width and 73 percent using bankfull width. With the addition of mean basin elevation the standard error was reduced to 38 percent.

The analyses also indicate that peak discharge at selected recurrence intervals can be estimated by using channel-geometry measurements. Separate equations for three different regions are presented. Bankfull width was determined to be the most significant parameter in two of the regions, and active-channel width was most significant in the third region. The standard error ranged from 62 to 100 percent for Region 1, 56 to 115 percent for Region 2, and 37 to 62 percent for Region 3.

Before using the estimating equations, an onsite trip is necessary to measure the channel width and to determine whether the stream is perennial or ephemeral. Experience in determining the reference levels is needed before the method is used.

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Table 1.--*Basin and streamflow characteristics used in the mean annual runoff analyses at selected gaging stations*

[Stream type: E, ephemeral; I, intermittent; P, perennial. Bed material: cl, clay; gr, gravel; sd, sand; st, silt. Abbreviations: ft, feet; ft^3/s, cubic feet per second; mi^2, square miles]

					Basin and channel characteristics						Streamflow characteristics	
Station number (fig. 2)	Station name	Stream type	Length of record (years)	Bed material	Drainage area (mi^2)	Mean basin elevation (ft above sea level)	Active-channel width (ft)	Active-channel depth (ft)	Bank-full width (ft)	Bank-full depth (ft)	Mean annual runoff (acre-feet per year)	Mean annual runoff (ft^3/s)
06120500	Mussellshell River at Harlowton, Mont.	P	68	gr	1,130	5,650	61	2.5	78	4.0	118,800	164
06120800	Antelope Creek trib. No. 2 nr Harlowton, Mont.	I	6	gr	21.2	4,570	7.5	1.8	18	3.5	659	.91
06122000	American Fork bl Lebo Creek nr Harlowton, Mont.	P	21	gr	166	5,480	24	1.6	32	5.0	22,450	31.0
06125700	Big Coulee nr Lavina, Mont.	E	15	st	232	4,230	16	1.5	26	2.5	5,344	7.38
06126500	Musselshell River at Roundup, Mont.	P	32	gr	4,020	4,750	88	2.7	108	8.7	160,000	221
06127900	Flatwillow Creek nr Flatwillow, Mont.	P	24	st	188	5,170	19	1.5	36	---	10,360	14.3
06129000	Box Elder Creek nr Winnett, Mont.	I	20	st, gr	684	3,470	47	1.7	59	3.0	16,660	23.0
06130500	Musselshell River at Mosby, Mont.	P	47	sd, gr	7,850	4,130	98	2.8	170	---	215,100	297
06130700	Sand Creek nr Jordan, Mont.	E	10	gr	317	3,050	11	.7	---	---	3,758	5.19
06131200	Nelson Creek nr Van Norman, Mont.	E	4	cl	100	2,620	11	.9	25	2.3	2,505	3.46
06177050	East Fork Duck Creek nr Brockway, Mont.	E	6	st, cl	12.4	2,910	4.0	.4	12	2.0	319	.44
06177100	Duck Creek nr Brockway, Mont.	E	6	st, cl	54.0	2,910	9.5	1.2	34	3.2	659	.91
06177500	Redwater River at Circle, Mont.	I	40	st, cl	547	2,810	16	2.5	32	6.9	10,060	13.9
06201700	Hump Creek nr Reed Point, Mont.	E	6	st, gr	7.61	4,420	4.0	.7	8.0	1.1	174	.24
06216000	Pryor Creek at Pryor, Mont.	P	12	sd, gr	117	5,280	18	2.5	27	4.5	30,630	42.3
06217750	Fly Creek at Pompeys Pillar, Mont.	P	10	st, cl	285	3,470	24	2.3	55	10.0	27,370	37.8
06287500	Soap Creek nr St. Xavier, Mont.	P	19	gr	98.3	4,240	20	2.0	23	3.0	22,160	30.6
06288000	Rotten Grass Creek nr St. Xavier, Mont.	P	5	st, gr	147	4,390	21	2.3	24	8.0	22,590	31.2
06289000	Little Bighorn River at State line nr Wyola, Mont.	P	39	sd, gr	193	7,830	39	2.5	48	4.0	114,400	158
06290000	Pass Creek nr Wyola, Mont.	P	18	st, gr	111	5,570	28	2.0	37	3.0	26,140	36.1
06290500	Little Bighorn River bl Pass Creek, nr Wyola, Mont.	P	37	sd, gr	428	6,140	51	3.3	64	4.5	157,900	218

Table 1.--*Basin and streamflow characteristics used in the mean annual runoff analyses at selected gaging stations*--Continued

					Basin and channel characteristics						Streamflow characteristics	
Station number (fig. 2)	Station name	Stream type	Length of record (years)	Bed material	Drainage area (mi^2)	Mean basin elevation (ft above sea level)	Active-channel width (ft)	Active-channel depth (ft)	Bankfull width (ft)	Bankfull depth (ft)	Mean annual runoff (acre-feet per year)	Mean annual runoff (ft^3/s)
06291500	Lodge Grass Creek ab Willow Creek diversion, nr Wyola, Mont.	P	35	gr	80.7	6,360	24	1.6	39	2.0	36,140	49.9
06294000	Little Bighorn River nr Hardin, Mont.	P	25	sd, gr	1,290	4,770	85	5.0	110	8.0	235,400	325
06294690	Tullock Creek nr Bighorn, Mont.	I	5	st, gr	446	3,470	15	1.1	25	4.1	10,210	14.1
06294940	Sarpy Creek nr Hysham, Mont.	I	6	st, cl	453	3,420	13	3.9	24	6.9	7,046	9.73
06294995	Armells Creek nr Forsyth, Mont.	I	5	st, gr	370	3,280	19	1.4	24	4.0	7,234	9.99
06296000	Rosebud Creek nr Forsyth, Mont.	P	10	st	1,280	3,610	29	2.0	38	4.0	31,940	44.1
[1]1	Pearson Creek nr Decker, Mont.	E	4	st, cl	8.65	3,860	2.2	.3	3.5	.9	174	.24
06306100	Squirrel Creek nr Decker Mont.	P	5	st, gr	33.6	4,460	6.0	.3	12	1.0	3,780	5.22
06306250	Prairie Dog Creek nr Acme, Wyo.	P	8	sd, gr	358	4,250	17	2.1	28	4.6	33,460	46.2
06306800	Deer Creek nr Decker, Mont.	E	4	st, cl	47.7	3,920	8.5	.4	17	.6	847	1.17
[1]2	Youngs Creek nr Acme, Wyo.	P	4	sd, gr	63.0	4,220	10	2.5	13.5	4.5	6,894	9.52
06307560	East Trail Creek nr Otter, Mont.	E	4	st, cl	31.3	3,900	4.0	.6	9.0	2.5	166	.23
06307600	Hanging Woman Creek nr Birney, Mont.	I	6	st, gr	470	3,880	14	1.2	26	3.2	4,671	6.45
06307740	Otter Creek at Ashland, Mont.	I	6	st, gr	707	3,730	16	2.0	26	5.0	6,307	8.71
06308400	Pumpkin Creek nr Miles City, Mont.	E	6	st, gr	697	3,290	30	.9	60	9.0	15,210	21.0
06309075	Sunday Creek nr Miles City, Mont.	I	4	sd, gr	714	2,890	45	3.0	78	9.0	38,160	52.7
06325500	Little Powder River nr Broadus, Mont.	P	20	st, sd	1,970	3,930	42	2.0	65	4.5	28,680	39.6
06326300	Mizpah Creek nr Mizpah, Mont.	I	4	st, gr	797	3,210	35	1.1	58	7.0	17,310	23.9
06329200	Burns Creek nr Savage, Mont.	I	13	sd, st	233	2,320	15	1.3	50	7.0	5,330	7.36
06334000	Little Missouri River nr Alzada, Mont.	P	53	sd, gr	904	3,910	40	4.6	---	---	55,900	77.2
06334630	Box Elder Creek nr Webster, Mont.	P	14	sd, gr	1,090	3,440	59	2.2	116	5.0	64,520	89.1
06335000	Little Beaver Creek nr Marmarth, N. Dak.	P	40	sd, st	587	3,280	42	1.7	115	3.7	28,100	38.8
06336500	Beaver Creek at Wibaux, Mont.	P	29	st, gr	351	3,020	28	2.5	55	5.5	16,150	22.3

[1]Streamflow-gaging station operated by Peter Kiewit Sons Company.

Table 2.--*Basin and streamflow characteristics used in the peak-flow analyses at selected gaging stations*

[Bed material: cl, clay; gr, gravel; rk, rock; sd, sand; st, silt. Abbreviations: ft, feet; mi^2, square miles]

				Channel characteristics					Peak discharges, in cubic feet per second, for indicated recurrence interval, in years					
Station number (fig. 1)	Station name	Length of record (years)	Drainage area (mi^2)	Bed material	Active-channel width (ft)	Active-channel depth (ft)	Bank-full width (ft)	Bank-full depth (ft)	Q_2	Q_5	Q_{10}	Q_{25}	Q_{50}	Q_{100}
06115100	Missouri River trib. nr Landusky, Mont.	16	3.39	st	8.0	0.3	16	2.0	47	305	798	2,190	4,160	7,380
06120500	Musselshell River at Harlowton, Mont.	68	1,130	gr	61	2.5	78	4.0	1,060	2,040	2,790	3,820	4,630	5,470
06120700	Antelope Creek trib. nr mouth nr Harlowton, Mont.	18	1.92	st, cl	2.5	.2	5.0	.5	42	113	188	320	449	608
06120800	Antelope Creek trib. No. 2 nr Harlowton, Mont.	23	21.2	gr	7.5	1.8	18	3.5	77	420	1,060	2,900	5,630	10,300
06120900	Antelope Creek at Harlowton, Mont.	21	88.7	st, cl	15	1.1	23	3.1	115	695	1,760	4,730	8,910	15,700
06122000	American Fork bl Lebo Creek nr Harlowton, Mont.	21	166	gr	24	1.6	32	5.0	328	727	1,100	1,690	2,240	2,870
06125700	Big Coulee nr Lavina, Mont.	15	232	st	16	1.5	26	2.5	115	388	717	1,360	2,030	2,910
06126300	Currant Creek nr Roundup, Mont.	16	220	st, gr	26	2.7	28	2.0	138	437	788	1,460	2,170	3,090
06127200	Musselshell River trib. nr Musselshell, Mont.	15	10.8	cl, st	6.0	.8	14	1.8	48	115	182	300	414	554
06127570	Butts Coulee nr Melstone, Mont.	16	6.71	sd, gr	5.5	.4	15	.8	99	228	352	557	750	980
06128400	South Fork Bear Creek nr Roy, Mont.	15	39.6	st, sd	13	1.2	21	3.2	249	669	1,120	1,960	2,800	3,870
06128500	South Fork Bear Creek trib. nr Roy, Mont.	17	5.40	st, cl	8.0	.4	12	.9	66	115	155	213	261	313
06128900	Box Elder Creek trib. nr Winnett, Mont.	19	16.2	cl, st	9.5	.4	14	1.4	123	279	426	669	894	1,160
06129000	Box Elder Creek nr Winnett, Mont.	20	684	st, gr	47	1.7	59	3.0	1,270	3,050	4,710	7,350	9,700	12,400
06129500	McDonald Creek at Winnett, Mont.	36	421	gr	26	1.7	44	3.0	346	691	986	1,440	1,830	2,260
06129700	Gorman Coulee nr Cat Creek, Mont.	18	2.32	st, cl	7.0	1.0	7.5	1.5	73	253	481	951	1,470	2,180
06129800	Gorman Coulee trib. nr Cat Creek, Mont.	24	.81	st, cl	2.5	.6	5.0	1.5	40	125	224	418	624	893
06130600	Cat Creek nr Cat Creek, Mont.	16	36.5	st, cl	4.0	1.0	11	1.7	78	212	356	616	876	1,200
06130850	Second Creek trib. No. 2 nr Jordan, Mont.	21	2.08	st	3.0	.3	8.0	.7	42	129	225	399	571	782
06130950	Little Dry Creek nr Van Norman, Mont.	18	1,220	st, gr	24	.9	38	2.5	1,780	3,660	5,210	7,470	9,330	11,300
06131000	Big Dry Creek nr Van Norman, Mont.	38	2,554	rk, gr, st	91	1.7	220	7.0	2,780	8,270	14,000	23,700	32,800	43,400
06175550	East Fork Sand Creek nr Vida, Mont.	15	8.51	cl, st	9.0	1.2	17	2.5	180	478	763	1,220	1,620	2,070
06177050	East Fork Duck Creek nr Brockway, Mont.	24	12.4	st, cl	4.0	.4	12	2.0	94	253	411	672	910	1,180
06177100	Duck Creek nr Brockway, Mont.	17	54.0	st, cl	9.5	1.2	34	3.2	215	632	1,070	1,820	2,520	3,340
06177150	Redwater River at Brockway, Mont.	17	216	st, gr	14	1.6	54	4.0	486	1,340	2,190	3,590	4,870	6,340

Table 2.--*Basin and streamflow characteristics used in the peak-flow analyses at selected gaging stations*--Continued

				Channel characteristics					Peak discharges, in cubic feet per second, for indicated recurrence interval, in years					
Station number (fig. 1)	Station name	Length of record (years)	Drainage area (mi^2)	Bed material	Active-channel width (ft)	Active-channel depth (ft)	Bank-full width (ft)	Bank-full depth (ft)	Q_2	Q_5	Q_{10}	Q_{25}	Q_{50}	Q_{100}
06177200	Tusler Creek nr Brockway, Mont.	16	90.2	cl	12	1.2	35	3.0	130	339	539	860	1,150	1,470
06177250	Tusler Creek trib. nr Brockway, Mont.	17	3.17	st, cl	4.5	.2	12	1.0	7	75	234	742	1,510	2,790
06177400	McCune Creek nr Circle, Mont.	18	29.9	st, cl	12	1.4	22	1.7	92	363	706	1,380	2,080	2,970
06177500	Redwater River at Circle, Mont.	40	547	st, cl	16	2.5	32	6.9	1,130	2,950	4,650	7,340	9,680	12,300
06177700	Cow Creek trib. nr Vida, Mont.	16	1.71	st, cl	3.0	.6	10	1.0	73	265	489	905	1,320	1,820
06177800	Wolf Creek trib. nr Vida, Mont.	17	.91	st, cl	3.0	.2	11	.8	46	271	629	1,460	2,430	3,770
06185200	Missouri River trib. No. 3 nr Culbertson, Mont.	15	1.23	cl	4.0	1.1	7.0	2.8	12	131	409	1,270	2,520	4,540
06201700	Hump Creek nr Reed Point, Mont.	19	7.61	st, gr	4.0	.7	8.0	1.1	40	123	228	447	696	1,040
06205100	Allen Creek nr Park City, Mont.	18	7.17	gr	7.0	.5	28	3.0	86	246	436	811	1,220	1,780
06216000	Pryor Creek at Pryor, Mont.	12	117	sd, gr	18	2.5	27	4.5	177	331	468	686	844	1,120
06216200	West Wets Creek nr Billings, Mont.	24	8.80	sd, st	4.0	.5	9.0	1.5	121	228	320	464	591	738
06216300	West Buckeye Creek nr Billings, Mont.	19	2.64	sd, gr	8.0	.4	16	3.0	80	197	321	551	786	1,090
06216500	Pryor Creek nr Billings, Mont.	48	440	st, sd	50	6.5	60	10.5	651	1,300	1,920	3,010	4,090	5,440
06217700	Crooked Creek trib. nr Shepherd, Mont.	17	7.21	st, cl	4.5	.2	12	1.2	156	653	1,410	3,260	5,650	9,310
06287500	Soap Creek nr St. Xavier, Mont.	19	98.3	gr	20	2.0	23	3.0	408	941	1,530	2,660	3,880	5,530
06289000	Little Bighorn River at State line nr Wyola, Mont.	39	193	sd, gr	39	2.5	48	4.0	1,080	1,520	1,800	2,150	2,410	2,670
06290000	Pass Creek nr Wyola, Mont.	18	111	st, gr	28	2.0	37	3.0	316	615	906	1,420	1,920	2,570
06290500	Little Bighorn River bl Pass Creek nr Wyola, Mont.	37	428	sd, gr	51	3.3	64	4.5	1,310	2,130	2,820	3,890	4,830	5,920
06291500	Lodge Grass Creek ab Willow Creek diversion, nr Wyola, Mont.	35	80.7	gr	24	1.6	39	2.0	440	634	773	961	1,110	1,270
06294000	Little Bighorn River nr Hardin, Mont.	25	1,290	sd, gr	85	5.0	110	8.0	2,050	3,750	5,160	7,250	9,040	11,000
06294800	Unknown Creek nr Bighorn, Mont.	15	14.6	cl	6.5	.4	14	2.0	123	455	904	1,880	3,030	4,640
06294850	Buckingham Coulee nr Myers, Mont.	15	2.63	gr	3.5	.2	7.0	.5	25	84	158	309	478	706
06294900	M. Fk. Froze to Death Creek trib. nr Ingomar, Mont.	15	1.36	st, cl	4.5	.2	8.0	1.0	63	151	237	382	519	683
06295020	Short Creek nr Forsyth, Mont.	17	3.23	st, gr	4.0	.5	16	1.3	116	490	1,030	2,250	3,710	5,790
06295050	Little Porcupine Creek nr Forsyth, Mont.	18	614	st, gr	44	5.0	65	10.0	1,650	3,200	4,490	6,410	8,040	9,850
06295100	Rosebud Creek nr Kirby, Mont.	15	34.2	gr	9.0	1.8	10	5.0	96	214	328	520	702	921

Table 2.--*Basin and streamflow characteristics used in the peak-flow analyses at selected gaging stations*--Continued

Station number (fig. 1)	Station name	Length of record (years)	Drainage area (mi^2)	Channel characteristics: Bed material	Active-channel width (ft)	Active-channel depth (ft)	Bankfull width (ft)	Bankfull depth (ft)	Peak discharges, in cubic feet per second, for indicated recurrence interval, in years: Q_2	Q_5	Q_{10}	Q_{25}	Q_{50}	Q_{10}
06295130	Rosebud Creek trib. nr Busby, Mont.	15	1.14	st, cl	3.0	.4	---	---	5	8	9	12	13	15
06295200	Whitedirt Creek nr Lame Deer, Mont.	15	1.58	st	3.5	.4	---	---	9	23	39	66	94	129
06296000	Rosebud Creek nr Forsyth, Mont.	18	1,280	st	29	2.0	38	4.0	321	695	1,070	1,730	2,390	3,230
06296100	Snell Creek nr Hathaway, Mont.	15	10.5	gr, rk	4.0	.2	6.5	.7	102	236	362	566	753	970
06306300	Tongue River at State line nr Decker, Mont.	19	1,480	gr	119	3.0	131	6.0	4,020	5,870	7,150	8,810	10,100	11,400
06306900	Spring Creek nr Decker, Mont.	21	34.7	gr	13	.7	20	1.4	120	383	709	1,380	2,120	3,150
06306950	Leaf Rock Creek nr Kirby, Mont.	21	4.53	st, gr	4.0	.4	8.0	1.0	42	115	198	353	516	728
06307640	Spring Creek nr Ashland, Mont.	15	1.56	st, gr	---	---	14	1.0	131	278	411	623	815	1,040
06307760	Stebbins Creek nr Ashland, Mont.	15	5.41	cl	1.0	.2	4.0	1.1	3	9	15	29	43	61
06307780	Stebbins Creek at mouth nr Ashland, Mont.	16	19.9	st, cl	8.0	.7	14	2.5	83	302	593	1,210	1,930	2,920
06308300	Basin Creek nr Volborg, Mont.	19	10.9	st, cl	10	2.0	15	3.0	163	519	944	1,770	2,650	3,800
06309040	Dry House Creek nr Angela, Mont.	15	38.6	st, cl	17	1.0	25	3.5	132	459	858	1,640	2,460	3,520
06309060	N. Fk. Sunday Creek trib. No. 2 nr Angela, Mont.	17	.22	st, sd, cl	2.0	.2	4.0	1.0	47	111	173	272	363	467
06309080	Deep Creek nr Kinsey, Mont.	17	11.5	st, sd, gr	17	.9	32	2.0	614	1,320	1,940	2,880	3,680	4,580
06325500	Little Powder River nr Broadus, Mont.	20	1,970	st, sd	42	2.0	65	4.5	1,130	1,830	2,350	3,060	3,620	4,220
06326400	Meyers Creek nr Locate, Mont.	15	9.42	st, cl	9.0	1.2	21	2.1	252	492	687	971	1,210	1,460
06326600	O'Fallen Creek nr Ismay, Mont.	17	669	gr, st	25	.5	37	4.0	1,220	2,870	4,390	6,790	8,920	11,300
06326950	Yellowstone River trib. No. 5 nr Marsh, Mont.	16	.87	st	2.5	.3	5.0	.4	21	78	145	271	398	553
06329570	First Hay Creek nr Sidney, Mont.	16	29.1	st, cl	12	1.0	26	5.0	46	159	289	523	751	1,020
06334000	Little Missouri River nr Alzada, Mont.	53	904	sd, gr	40	4.6	---	---	1,820	3,340	4,490	6,040	7,260	8,510
06334100	Wolf Creek nr Hammond, Mont.	24	9.09	st, sd, gr	14	.9	31	2.0	261	567	850	1,300	1,720	2,200
06334200	Willow Creek nr Alzada Mont.	16	123	st	18	5.0	46	8.5	558	1,270	1,940	3,050	4,080	5,290
06334630	Box Elder Creek nr Webster, Mont.	14	1,090	sd, gr	59	2.2	116	5.0	2,000	4,900	7,720	12,400	16,700	21,700
06334640	N. Fk. Coal Bank Creek nr Mill Iron, Mont.	15	15.0	st	14	1.5	30	2.1	122	459	865	1,630	2,400	3,340
06335000	Little Beaver Creek nr Marmarth, N. Dak.	40	587	sd, gr	42	1.7	115	3.7	3,410	5,950	7,810	10,300	12,200	14,200
06336450	Spring Creek nr Wibaux, Mont.	18	3.88	st, cl	4.0	.8	8.5	1.7	67	156	235	353	453	562
06336500	Beaver Creek at Wibaux, Mont.	29	351	st, gr	28	2.5	55	5.5	899	3,470	6,830	13,800	21,400	31,700