U.S. GEOLOGICAL SURVEY
Water-Resources Investigations Report 88-4045

STREAMFLOWS IN WYOMING

Prepared in cooperation with the
U.S. BUREAU OF LAND MANAGEMENT *and the*
WYOMING HIGHWAY DEPARTMENT

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1988

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CONVERSION FACTORS AND VERTICAL DATUM

For the convenience of readers who may prefer to use metric (International System) units rather than the inch-pound units used in this report, values may be converted by using the following factors:

Multiply	By	To obtain
cubic foot per second	0.02832	cubic meter per second
foot	0.3048	meter
foot per mile	0.1894	meter per kilometer
inch	2.54	centimeter
mile	1.609	kilometer
square mile	2.590	square kilometer

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 "Mean Sea Level of 1929."

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ABSTRACT

A description of the occurrence and variability of surface waters in Wyoming is presented along with explanations of both streamflow-data collection and methods for estimating streamflow characteristics at gaged and ungaged sites. Mountain ranges separate the major drainage basins and have a significant effect on precipitation and runoff that occur in Wyoming. Streams that originate in the mountains provide the most dependable source of runoff; streams that originate in the plains and deserts generally have extended periods of no flow.

Streamflow data for several hundred gaged sites in the State are available for engineering and management purposes. When gaged data are not available, methods for estimating flows are needed. Methods presented in this report for estimating streamflow characteristics have been developed through the use of refined analytical techniques and an updated data base.

Peak-flow characteristics and mean annual flow at ungaged sites can be estimated by using regression equations, with either basin characteristics or channel width as independent variables. Log-linear regression equations are used for depicting streamflow characteristics in the mountains. Curvilinear equations of double-exponential form were determined to be more appropriate than log-linear equations for depicting peak flows in the plains and deserts.

Regression relations were determined to be unsuitable for estimating mean monthly streamflows. Because of geographical differences in runoff patterns, data for streamflow gages near the ungaged site can be used to estimate mean monthly flows. The procedure requires an estimate of mean annual flow, with mean monthly flow determined as a percentage of mean annual flow from records of nearby gaged sites.

INTRODUCTION

Water is one of the most basic and essential of our resources, and surface waters are the main source of water used in Wyoming. The occurrence and availability of surface waters vary greatly throughout the State partly due to the effect that mountain ranges have on the quantity of precipitation and resulting runoff. Although several major rivers flow across the plains and desert areas of the State, the main source of perennial flow in these rivers is from snowmelt in the mountains. Information concerning streamflows, including floodflows, is needed to plan and design irrigation projects, roads, bridges, and other stream-related developments.

This report is the product of several technical investigations of streamflows in Wyoming. The investigations were done by the U.S. Geological Survey in cooperation with the U.S. Bureau of Land Management and the Wyoming Highway Department, to provide streamflow information needed for land-use planning and for design of stream-related developments. This report presents: (1) A history of surface-water use and developments affected by surface water, (2) an explanation of factors affecting streamflow, (3) a description of record collection at sites having streamflow-gaging stations, and information on how users may obtain these records, (4) a description of improved methods for estimating streamflow characteristics at ungaged sites, and (5) a summary of historical floods.

Acknowledgments

The assistance of A. Mainard Wacker, Hydraulics Engineer, Wyoming Highway Department, and W.O. Thomas, hydrologist, Office of Surface Water, U.S. Geological Survey, in developing an improved regression model for depicting peak-flow characteristics in the plains and desert areas of Wyoming is gratefully acknowledged. Mr. Wacker and his staff observed that equations from previous reports did not adequately depict peak-flow characteristics over a complete range of drainage sizes, and they suggested that an improved model was needed. The applicability of a double-exponential equation was suggested by Mr. Thomas, who assisted the author with the development and computer programming of the curvilinear model. The contributions of Mr. Wacker and Mr. Thomas are greatly appreciated.

History of Surface-Water Development in Wyoming

Exploration and Early Development

A group of Spaniards may have been the first explorers, other than the native Indians, to venture into what is now Wyoming. On the basis of scant evidence, historian C.G. Coutant (1899a, p. 23) concluded that one of numerous Spanish expeditions from Mexico traveled as far north as the Missouri River and explored the Yellowstone country during the sixteenth or seventeenth century.

During 1807-08, John Colter explored the headwaters of the Yellowstone and Snake Rivers in northwestern Wyoming while attempting to establish a fur trade with the Indians. This exploration opened up a significant fur trade that flourished from 1823 through the 1830's. Gold miners were next to explore streams of the unknown West. The first discovery of gold in Wyoming was in 1842 along the Sweetwater River (Coutant, 1899b, p. 637-674); this stimulated further exploration and discoveries in other areas.

Trappers and miners led the way to the West and were fundamental to the exploration of the territories; however, the largest number of settlers were drawn by the promise of land ownership and the opportunities of agriculture. "Go West, young man, go West," was the advice given to young Americans in the mid-1800's. The choice land in the East had been settled, and the greatest opportunity for ambitious persons was in the western territories of abundant land and resources.

Thousands of emigrants passed through the Wyoming Territory during 1840-90. Some of them stayed and settled, and the prime croplands along flowing streams were soon claimed. This did not deter the emigrants. "Where the plow goes, the rain will follow," was a notion that was popular among developers and hopeful pioneers when the West was being opened for settlement (Smith, 1947). Many residents of the East actually believed that God or nature would provide rain to fields that were cultivated in arid western lands. Unfortunately, hundreds of settlers lost their life savings or their lives before the notion was abandoned.

Streams were used during the development of the West for the transporting of timber. The building of the transcontinental railroad in 1867 spurred the timber industry to meet the need for railroad ties in the construction and maintenance of the railroad, and also for timbers used in the mines that supplied coal to the railroad. Because the railroad was built mainly across flat areas of the plains and deserts, streams--such as the Laramie, North Platte, Green, and Bear Rivers--that flowed from the mountains to the railroad were used whenever possible to transport the timber.

Some early pioneers and technical persons, who were cautious about full-scale opening of western lands, advised Congress and developers of the realities new settlers might incur (Stegner, 1960). Major John Wesley Powell, one of the most knowledgeable experts on the resources of the West, gained firsthand knowledge of the West and its water resources from expeditions made in 1869 and 1872 down the Colorado River. These expeditions began on the Green River in Wyoming. On the basis of his field investigations, Powell (1878) stated that much of the West was arid grazing land, of value only when used in large quantities. His opinion was that most of the prime and easily-irrigable lands along streams had already been settled. Powell drew up a bill stipulating that new ranches on the remaining lands should be no less than 2,560 acres, but Congress did not pass it (Stegner, 1960, p. 239).

However, in 1877, Congress did pass the Desert Land Act that allowed homesteading of certain 640-acre tracts requiring irrigation in order to raise a crop. Water commonly was not available, and only about a quarter of the filings resulted in patents. The Carey Act, passed by Congress in 1890, transferred land to the states. The states could then grant water rights for 160-acre blocks. After blocks had been settled upon and cultivated, clear title was then granted. Wyoming adopted this plan in 1894.

Irrigation Development

The main use of water in Wyoming is for irrigation. Although growing seasons are sufficient for many crops at lower elevations in Wyoming, the successful growing of these crops generally requires irrigation because precipitation is usually small and unpredictable. Irrigated grass hay lands and pastures constitute a large use of water along streams in Wyoming. Snowmelt from the mountains is the main source of streamflow in the many streams and rivers used for irrigation. Irrigated areas and mountainous regions in Wyoming are highlighted on plate 1a (at back of report), which is a mosaic of infrared imagery taken from a Landsat satellite. The imagery uses false colors that distinctly show certain features, such as vegetation and bedrock.

Exactly when the first irrigation began in Wyoming is subject to debate. Historian David J. Wasden (1973, p. 153-154) presents evidence that the first irrigation ditch in what is now Wyoming may have been constructed along the Hams Fork in the 1830's by a colony of Mexican settlers.

A number of successful irrigation projects were developed by Mormon settlers, who were noted for their irrigation knowledge. A group of Mormons journeyed from Salt Lake City to establish an agricultural settlement known as Fort Supply on the Smiths Fork in 1853 (plate 1a). Fort Supply was later abandoned, but other irrigation projects were developed, including some in the Star Valley and the Bighorn Basin.

Most irrigation began as diversion of natural flows. As development flourished, it was realized that storage was needed to supply water through the complete irrigation season. Landowners subsequently organized and formed development companies to construct and operate reservoirs (Frank J. Trelease, III, Assistant State Engineer for Wyoming, oral commun., 1987). For example, Wyoming Development Company Reservoir No. 1, with a storage capacity of 5,360 acre-feet, was constructed in 1897 as an off-channel reservoir of Sybille Creek, a tributary of the Laramie River. The project was successful, and the development company was changed to an irrigation district. After filing for water rights in 1898, the district also completed Wheatland No. 2 Reservoir, with a storage capacity of 98,300 acre-feet, on the Laramie River in 1904. Similar efforts of group enterprise were instrumental in the development of successful irrigation throughout Wyoming, especially along smaller and medium-sized streams and rivers.

The Federal Reclamation Act of 1902 authorized Congress to allow the Reclamation Service to begin construction of major projects that would develop streamflow for irrigation and power production. As a result, large dams and reservoirs have been constructed on the North Platte, Wind-Bighorn, Shoshone, Green, and Belle Fourche Rivers. These projects have contributed greatly to the agricultural and industrial economies of Wyoming.

Transportation Systems

As the agricultural development in the western states progressed, there was a movement by Congress to assist farmers and ranchers in transporting their products to market by developing paved roads (A. Mainard Wacker, Hydraulic Engineer, Wyoming Highway Department, oral commun., 1987). The construction of paved highways was greatly expanded during the 1920's and 1930's. With the development of improved roads, tourism also began to flourish, especially as a result of travel to Yellowstone National Park, the first area set aside in the United States as a national park.

A major consideration in the design of highways is the size of structure needed for stream and river crossings. Before about 1960, engineers with the Wyoming Highway Department used empirical methods to determine structure size. During the 1960's, the Department began a program with the U.S. Geological Survey to collect and summarize floodflow data specific to Wyoming.

Energy Development and Urbanization

The development of energy minerals, including oil and gas, coal, and uranium, has become a major industry in Wyoming along with agriculture and tourism. Many of the towns and cities in the State have experienced growth and population increases associated with the mineral industry. Information needed by industry regarding surface water generally is for water-supply purposes and also for design of stream-related structures. Municipalities and land-use agencies, such as the U.S. Bureau of Land Management, also are concerned with water-supply and flood information. Planning associated with floods in urban areas was especially strengthened by the National Flood Insurance Act of 1968 (Public Law 90-448) and the closely related Flood Disaster Protection Act of 1973 (Public Law 93-234) (U.S. Water Resources Council, 1979, p. VI-3).

FACTORS AFFECTING STREAMFLOW

Various types of streams exist in Wyoming due to differences in climate and physical features such as geology. Perennial streams generally originate in the mountainous areas as a result of significant annual precipitation and geologic conditions that foster ground-water discharge. Streams originating in the semiarid and arid plains and desert areas generally are ephemeral, flowing mainly in direct response to rainstorms and snowmelt.

The major part of annual runoff in streams draining mountainous areas occurs during spring and early summer as a result of snowmelt. A hydrograph typical of a mountainous stream is shown in figure 1. Streamflow generally peaks during June; however, this varies from year-to-year depending on both local weather conditions and physical features of individual basins. Late summer, fall, and winter flows are largely the result of ground-water inflows. Minimum streamflows generally occur during January through March. The total runoff that occurs during any particular year is closely related to the precipitation for that year.

Intermittent and ephemeral streams draining the plains and desert areas flow only periodically and often have extended periods of no flow (fig. 2). These streams may receive some ground-water inflows in addition to direct surface runoff; however, the ground-water inflows are insufficient to sustain flow throughout the year. Springs are present in some areas of the plains and deserts, and these springs commonly contribute small perennial inflows to streams. However, losses of water to evaporation, transpiration, and seepage, and storage as ice generally limit the extent of these flows to short reaches downstream from the springs.

Climate

Streamflows are closely related to climate, especially precipitation (fig. 3). The climate of Wyoming varies greatly with the season and by location due to the effects of altitude and mountain terrain on wind, air temperature, and precipitation. The distribution of average annual precipitation is shown on plate 1b.

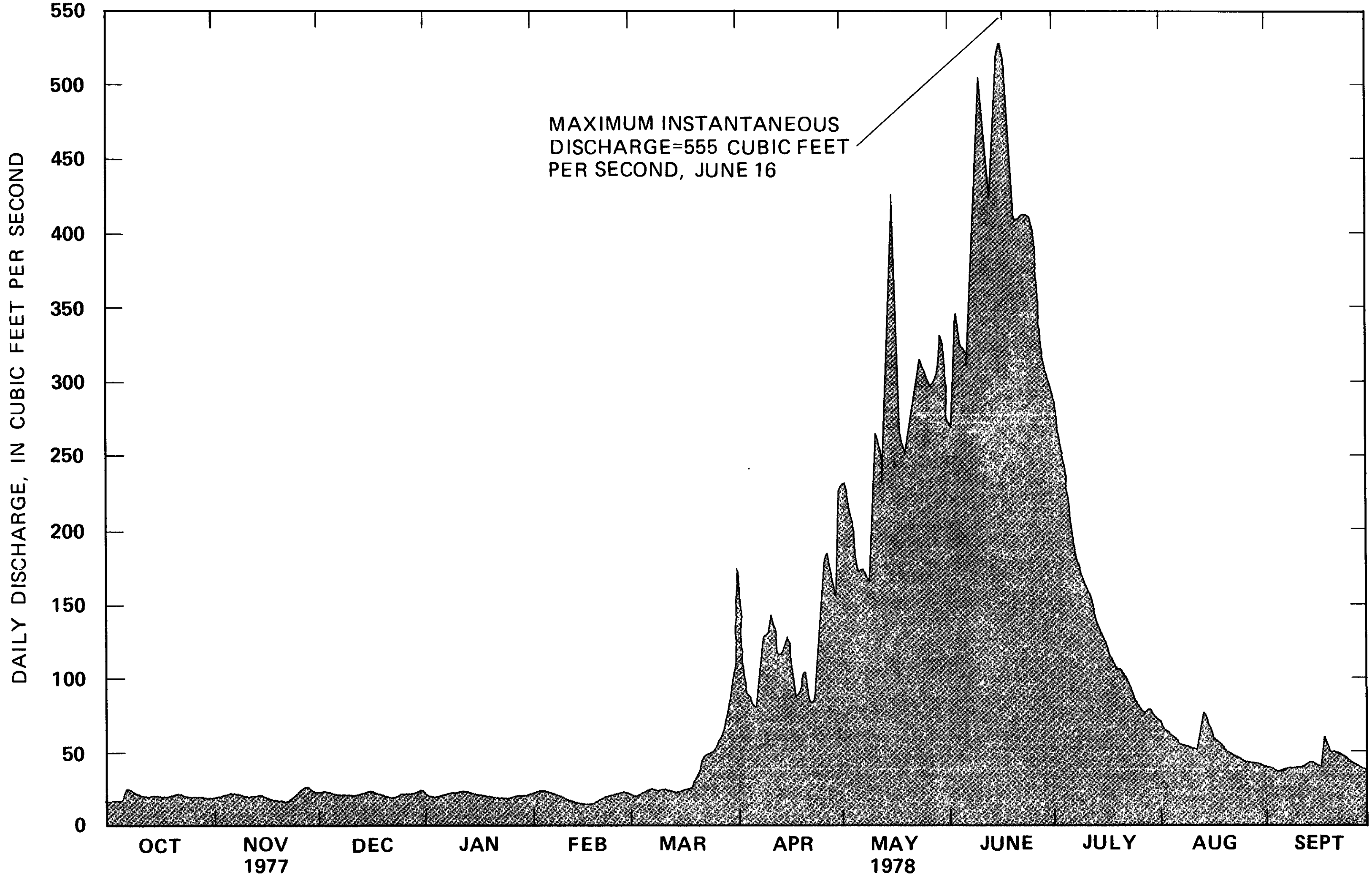


Figure 1.--Daily discharge for Fontenelle Creek, which drains a mountainous area in western Wyoming. (Record is for streamflow-gaging station 09210500, 1978 water year.)

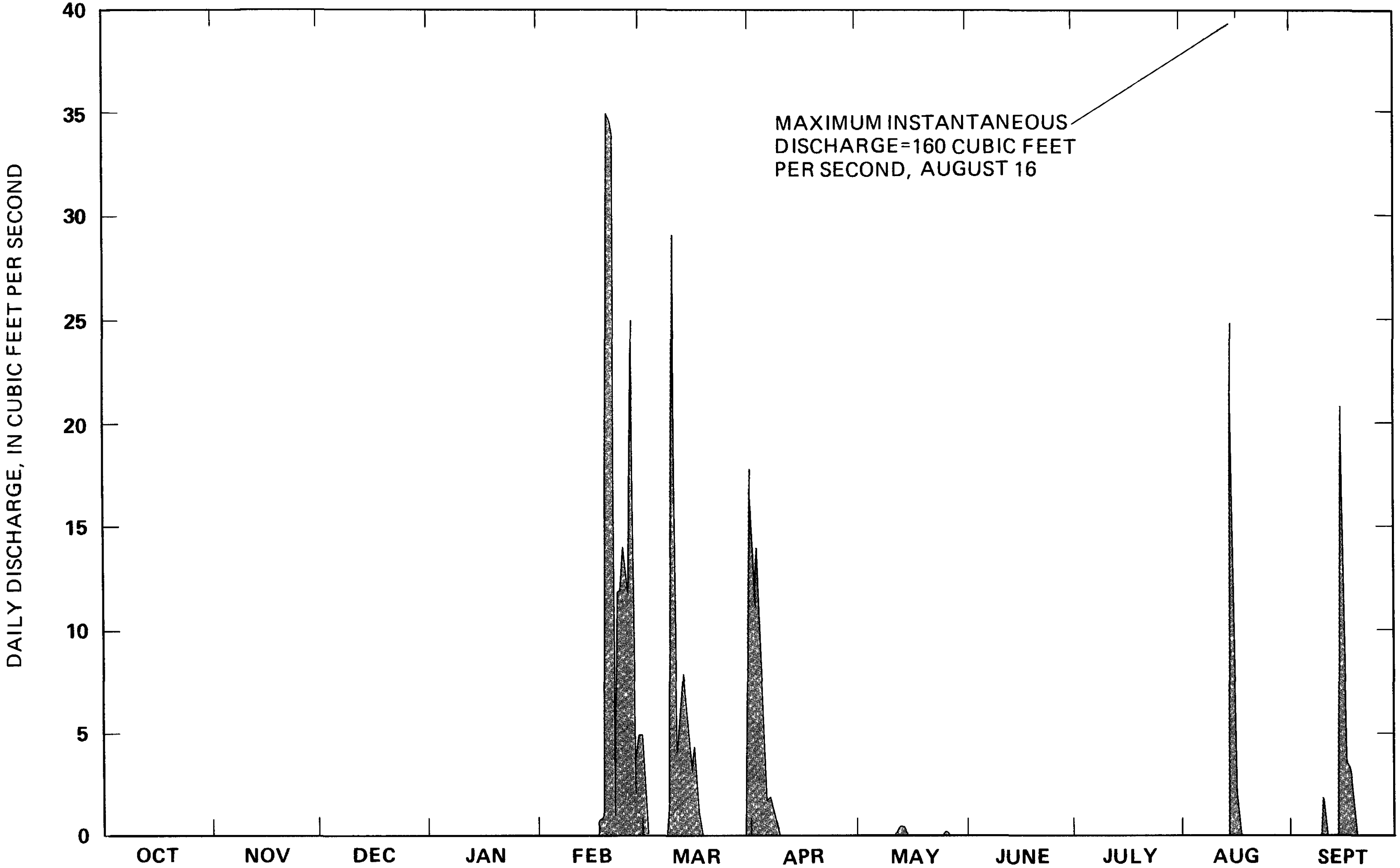


Figure 2.--Daily discharge for East Fork Nowater Creek, which drains a plains area in north-central Wyoming. (Record is for streamflow-gaging station 06267400, 1980 water year.)

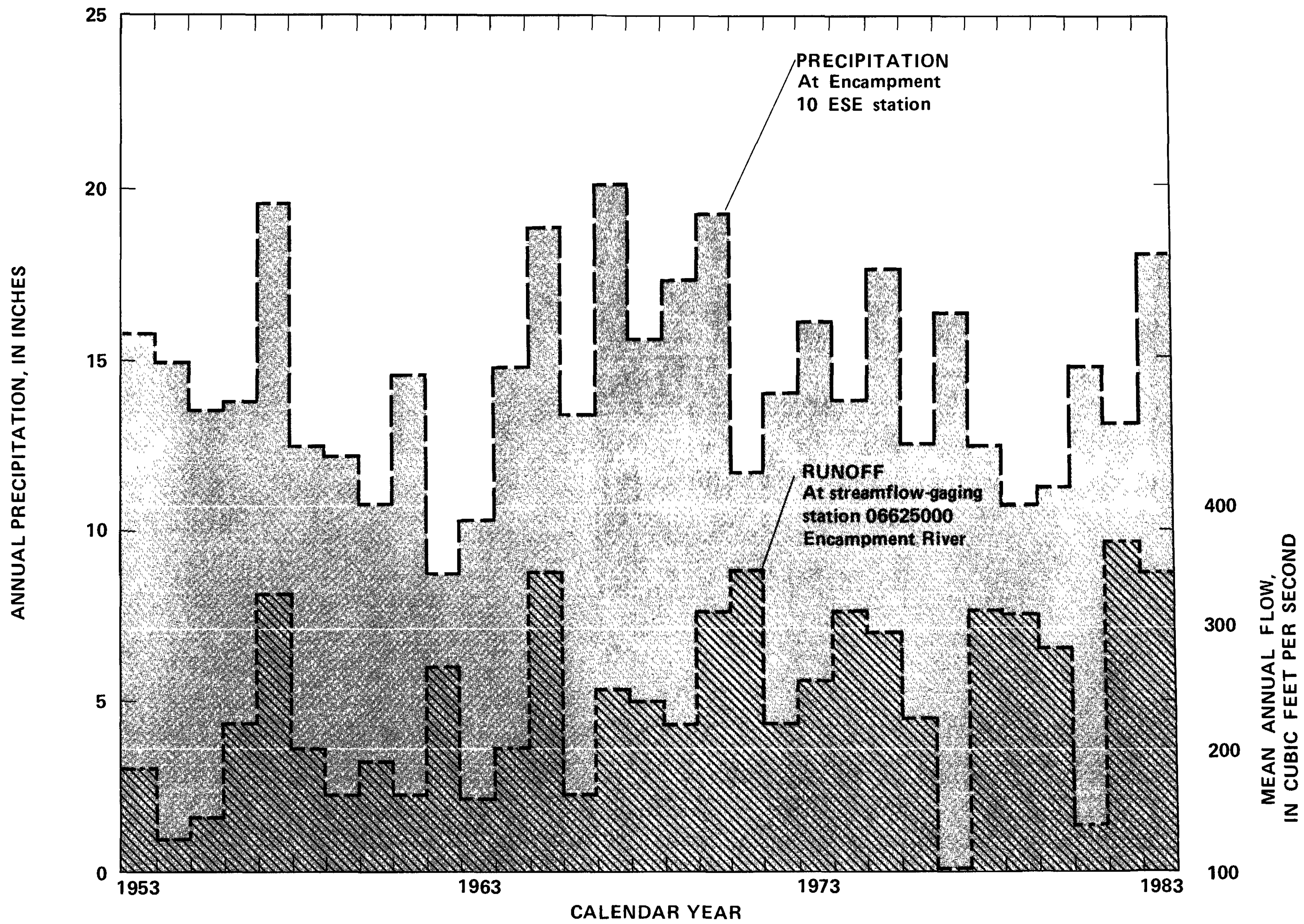


Figure 3.--Comparison of annual precipitation and runoff, 1953-83.

A summary of climate in the State follows. This summary and the precipitation map on plate 1b are based on a report prepared by J.D. Alyea (1980) for the U.S Geological Survey.

Maritime airflows from the Pacific Ocean are the source of moisture for most of the annual precipitation in Wyoming. The air masses are borne eastward by the prevailing westerly winds, although coastal mountain ranges cause much of the moisture to precipitate before reaching Wyoming.

Most wintertime precipitation is in the form of snow. Snowstorms with the greatest precipitation occur when cold airflows from the north move into the area and wedge under the warmer surface air; the warm air is forced upward, causing snow. In the mountains, the cold temperatures allow much of the snow to be retained until spring melting. In the interior plains and deserts, much snowfall is quickly sublimated by the wind and sun, and retention occurs mainly as drifts in draws and shaded areas.

Summertime precipitation occurs as light rain and from occasional, intense convective storms that generally move in an easterly direction. The warmer atmosphere in spring has increased moisture-carrying capacity, which results in the relatively large quantities of precipitation during April, May, and June (fig. 4).

As summer progresses and the atmosphere continues to warm, more moisture is available for precipitation, but the cumulus clouds are formed much higher above the land surface. Precipitation from these clouds has a relatively long path through dry air, and much of it evaporates before reaching the land surface.

Mountain ranges greatly affect the occurrence of precipitation in Wyoming. Precipitation increases with elevation, and the mountainous areas commonly receive 25 inches or more precipitation annually, while the plains and deserts receive as little as 6 or 7 inches.

The precipitation map on plate 1b indicates the average annual precipitation that occurs throughout Wyoming. For the plains and desert areas of the State, the percentage of average annual precipitation that occurs during the months of May through September also is shown. During this period, precipitation in the form of rain or hail generally occurs from convective storms; during the remainder of the year, precipitation generally occurs as light rainfall and snowfall. The percentages infer that precipitation from convective storms is more predominant in the northern and eastern plains than in the southern and central desert areas of the State.

Surficial Geology and Soils

Surficial geology and soil type affect infiltration and thus have a significant effect on streamflow. Generally, coarse-grained surficial materials such as sand and gravel (alluvial and glacial deposits) and sandstone have more rapid infiltration rates than fine-grained materials such as clay, silt, siltstone and shale. However, infiltration rates in some fine-grained rocks and limestone are increased by fracturing resulting from geologic movement. Slow infiltration occurs in areas of clayey soils. The rate of infiltration especially affects runoff resulting from snowmelt and

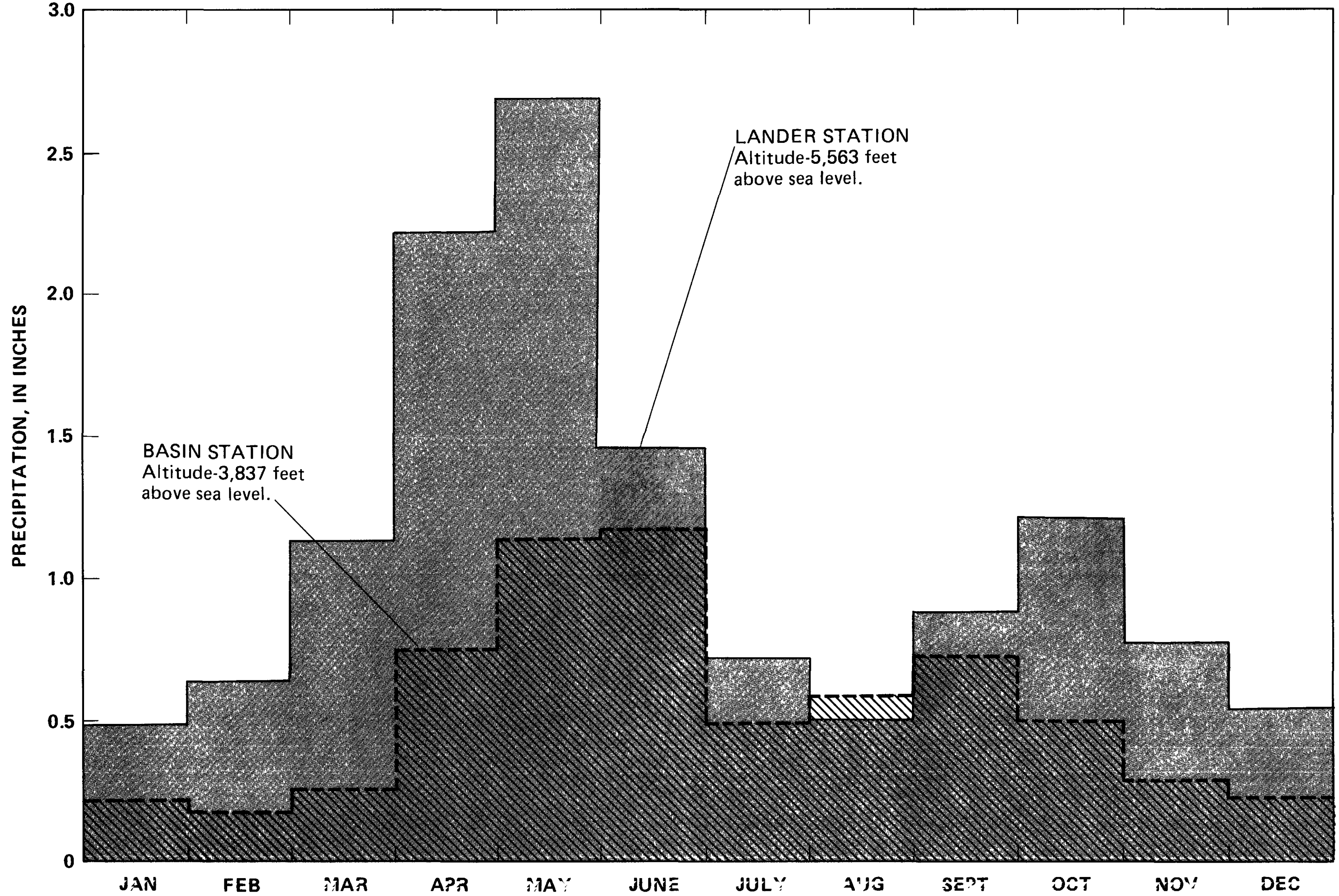


Figure 4.--Normal monthly precipitation at selected weather stations, 1951-80. Warming of the atmosphere causes relatively large amounts of precipitation during April, May, and June. (National Oceanic and Atmospheric Administration, 1982.)

rainstorms of moderate intensity. Intense rainstorms produce runoff that is less affected by infiltration rates than for moderately intense storms because the precipitation and resulting runoff occur very quickly. In addition, for very large storms of high intensity, infiltration is insignificant in affecting runoff because the total precipitation generally is so much greater than the part of the precipitation that infiltrates into the soil.

STREAMFLOW-GAGING STATIONS

When the design or management of a development requires streamflow data, a gaging station may be installed. Streamflow-gaging stations have been operated on Wyoming streams since 1888, when the first gage was installed on the Laramie River by the Wyoming Territorial Engineer and the U.S. Geological Survey. Since then, several hundred gages have been operated throughout the State for differing time periods. The majority of gages are operated by the U.S. Geological Survey in cooperation with other Federal and State agencies. Other gages are independently operated by the University of Wyoming, State agencies, the U.S. Soil Conservation Service, and private concerns such as mining companies.

Continuous Records

A continuous-record station has a recorder whereby a continuous record of stage (water level) is recorded. Using discharge measurements (fig. 5) made at the site, a relation between stage and discharge (stage-discharge rating) is developed to enable discharge to be determined for any stage of the stream. By combining the rating with the record of stage, a continuous record of stream discharge is determined. This record may be expressed as average daily, monthly, and yearly rates, or volumes of flow. Instantaneous peak flows or total runoff for a particular period also may be determined. A diagram summarizing the procedure for streamflow-data collection is shown in figure 6. For a comprehensive description of standardized stream-gaging procedures, the reader is referred to U.S. Geological Survey Water-Supply Paper 2175 (Rantz, 1982).

Peak-Flow Gages

For certain purposes, such as for the design of bridges and culverts, only peak-flow data are needed. A special gage that records the maximum stages of floods is used to collect this type of data (fig. 7).

Visits are made periodically to inspect the gage for high-water marks that may have occurred from intervening floods. The peak discharge for each maximum recorded stage is determined from a stage-discharge rating developed for the site. These gages are often referred to as crest-stage stations (Rantz, 1982, p. 77-79). The amount of equipment and work needed to maintain crest-stage stations are much less than that needed for continuous-record stations; hence, they are less expensive to operate. A statewide network of crest-stage gages was operated during 1959-85 as part of a cooperative program between the Wyoming Highway Department and the U.S. Geological Survey.

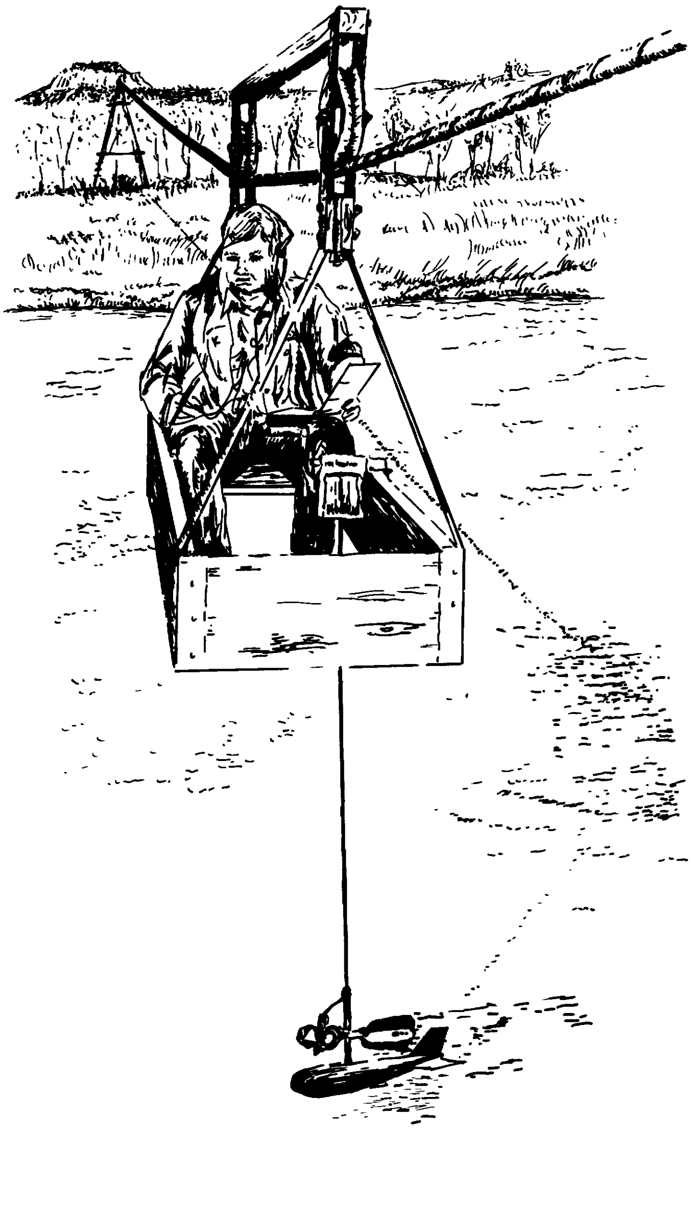


Figure 5.--Discharge being measured from a cableway.

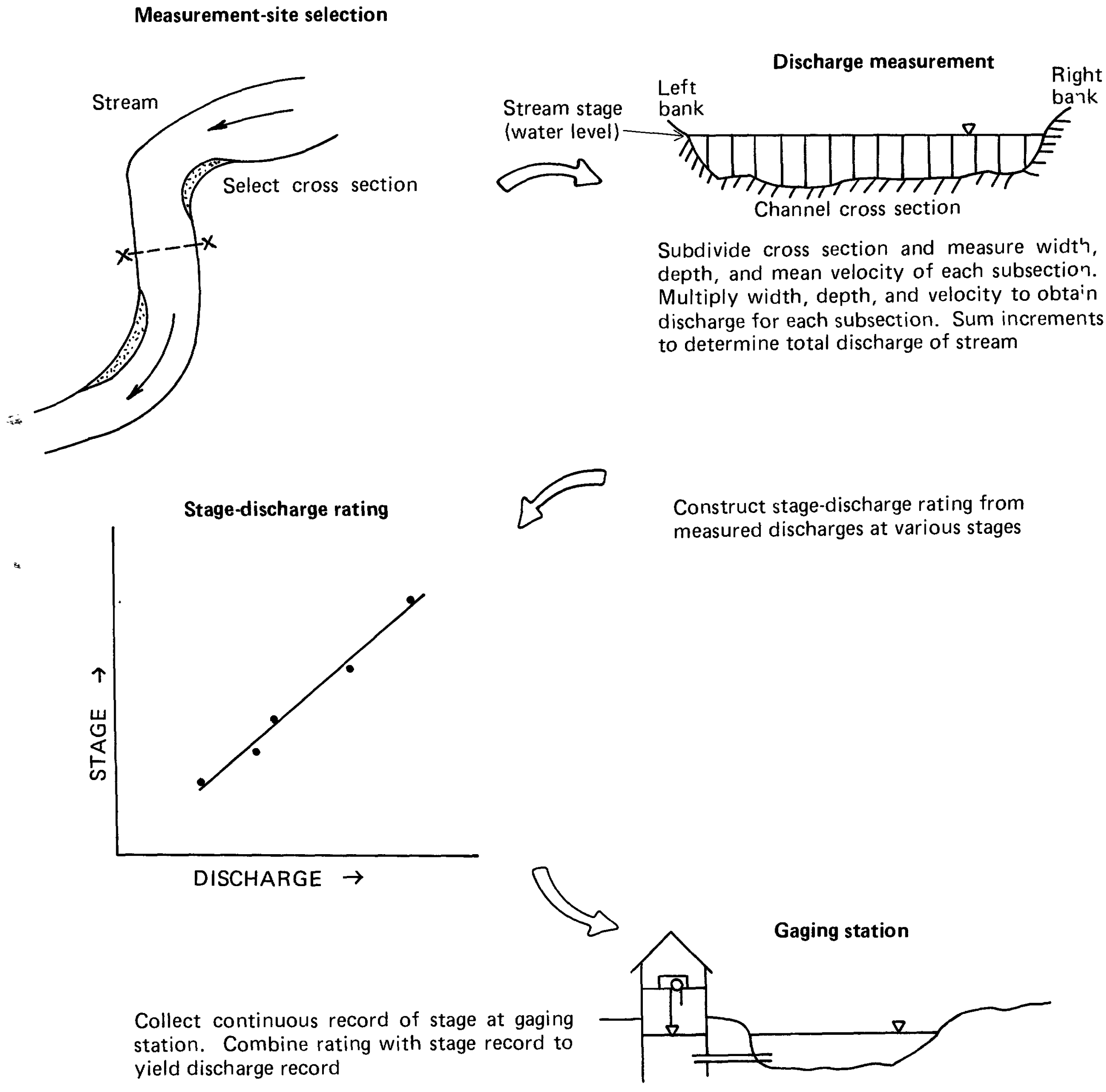


Figure 6.--Procedure for collection of streamflow data.

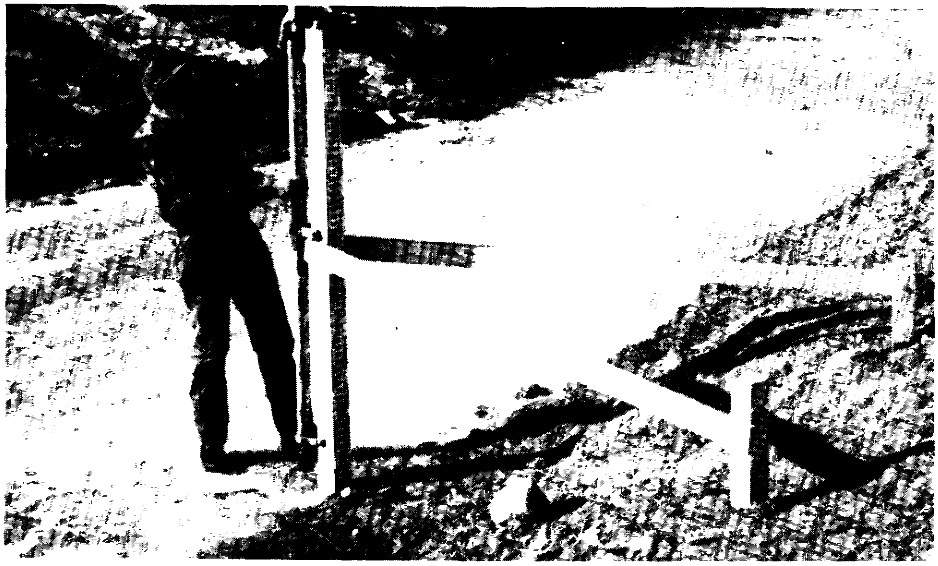


Figure 7.--Peak stages of floods are recorded by a crest-stage gage.

Availability of the Data

Streamflow data collected by the Geological Survey are published in annual reports and also are available from computerized files. Further information concerning streamflow records for Wyoming may be obtained by contacting offices of the Water Resources Division in Cheyenne, Casper, or Riverton.

STREAMFLOW CHARACTERISTICS AT GAGING STATIONS

When streamflow data are needed in planning and engineering, averages or statistical summaries of gaged data are often used. For example, if a planner or builder of an irrigation project were interested in runoff of a stream, monthly and yearly runoff values probably would be examined in comparison with the water demand for the irrigation period. If a bridge or culvert were to be installed on a stream, records and computations of high flows would be used as input to the design.

Streamflow-gaging stations that were used in this study are listed in table 7a; locations of the stations are shown on plate 1c. Peak-flow characteristics and mean annual flows at these stations are listed in table 7b. Drainage-basin characteristics are listed in table 7c. (Tables 7a through 7c are at the end of this report.) Only stations with records representative of natural streamflows, which were virtually unaffected by man-caused effects, were selected; 361 stations were used in the final analysis. The tables summarize data in the computer files of the U.S. Geological Survey as of December 1986, which generally included all data available through the 1985 water year.

As indicated in tables 7a to 7c and on plate 1c, a large data base exists for perennial streams draining mountainous areas of the State; however, a shortage of continuous records exists for small streams in the plains and desert areas of the State. To alleviate this shortage of runoff data, the records of 21 seasonal gages, which were operated during the principal rainfall months of May through September of 1963-73, were included in the analysis. These gages were operated on ephemeral streams to calibrate rainfall-runoff relations for small drainage basins as part of a cooperative program between the U.S. Geological Survey, Wyoming Highway Department, and Federal Highway Administration (Craig and Rankl, 1978). The peak-flow characteristics listed in table 7b for these stations are from the Craig-Rankl report.

The runoff data collected by the 21 seasonal gages were published by Rankl and Barker (1977). A review of similar streams having year-round records indicated that, on a statewide average, 60 percent of the mean annual flow of ephemeral streams in the plains and desert areas occurs during May through September. Therefore, it was assumed that 60 percent of the actual mean annual flow was measured during May through September. An estimated mean annual flow at each of the 21 seasonal gages was computed on this basis. It is realized that differences do occur from year-to-year and from site-to-site, and the values are considered to be approximate; however, they do constitute a valuable data base that was very useful in the subsequent regional analysis.

Flood Magnitude

The floodflow characteristics presented for the stations in table 7b are annual peak discharges for selected recurrence intervals, as determined by the Pearson Type III probability distribution with logarithmic transformation of annual flood data (log-Pearson Type III distribution). The procedure recommended in Bulletin 17B of the U.S. Water Resources Council (1981) was used. Peak-flow characteristics in this report are abbreviated as P_t, with P being the annual peak flow, in cubic feet per second, and t being the recurrence interval, in years. For example, P_{100} refers to an annual peak discharge that would be expected to be exceeded at intervals averaging 100 years.

The technical methods recommended in Bulletin 17B have improved the peak-flow characteristics over those derived by previous methods, especially in the plains and desert areas of Wyoming. When dealing with short periods of record, use of a generalized skew coefficient and addition of historical data from outside the gaged period of record are helpful in refining the frequency curve. Significant adjustments to the records of 10 gaging stations (table 7b) were made on the basis of field investigations of historical floods by Maurice E. Cooley (written commun., 1986).

Annual Runoff

The runoff at gaging stations listed in table 7b is expressed as mean annual flow, in cubic feet per second, which is abbreviated in this report as Q_a. Runoff was computed only for those stations having 5 or more complete years of record.

ESTIMATION OF STREAMFLOW CHARACTERISTICS AT UNGAGED SITES

Time and cost constraints prevent the installation and operation of gages at every site where streamflow information may be needed. If no gaging station has been operated at or near a site where stream-related development is planned, estimates of streamflow are useful. Several methods are available for estimating streamflow; however, one technique has become widely used during recent years, and that is to develop equations that relate streamflow characteristics to features of the drainage basin. The equations are developed through a statistical process known as regression analysis. Data used in the regression analysis are for gaged streams; the resultant equations depict streamflow and may be applied to ungaged streams where estimates are needed. Basin features for an ungaged site are used in the equations to obtain estimated streamflow characteristics at that site.

Methods are presented in this report for estimating peak-flow characteristics and mean monthly and annual flows of Wyoming streams. Two independent methods of estimating peak-flow characteristics and mean annual flow are presented: (1) The basin-characteristics method--developed by relating physical and climatic characteristics of the drainage basin to flow characteristics of the stream, and (2) the channel-geometry method--developed by relating channel features to flow characteristics. The methods were analyzed and developed separately due to inherent differences between basin characteristics and channel features. Basin characteristics (including precipitation) are considered to be cause-effect variables because they produce or affect the outcome of flows. In contrast, channel features are considered to be resultant-effect variables; that is, the dimensions of a channel are the result of past flows. The advantage of presenting both methods in this report is that the users may select the one most suitable for their purposes. If both methods are used, a comparison of the results may be made.

Regression Models

The estimating equations were developed using a digital computer and multiple regression programs of the Statistical Analysis System (SAS Institute, Inc., 1982). The equations express flow characteristics (dependent variables) in relation to either basin characteristics or channel-geometry features (independent variables). The data were transformed to logarithms before relations were developed; experience has proved that linear relations can be approached by such transformation of hydrologic variables. After converting the results to antilogarithms, the form of the resultant equation is:

$$P = aA^{b}B^{c}C^{d}......,$$

where P = the flow characteristic (a dependent variable);
A, B, and C = basin characteristics or channel features (independent variables);
a = the regression constant; and
b, c, and d = regression coefficients.

Equations of the above form plot as straight lines on graph paper having logarithmic scales.

In the analysis for the plains and desert areas of Wyoming, a curvilinear relation (after logarithmic transformation) was determined to be more applicable than a linear relation as a model for estimating peak-flow characteristics when using drainage area as one of the independent variables. The resultant equation uses the following double-exponential form:

$$P = aA^{bA^{c}}C^{d}.....,$$

where P = the flow characteristic;
A = drainage area and C is another basin characteristic;
b and d = regression coefficients; and
c = a coefficient that designates the amount of curvature (or nonlinear component) in the relation.

Equations of the above form plot as a curved line on logarithmic-scaled graph paper.

The curvilinear relations are applicable for describing peak-flow characteristics in the plains and deserts due to the nature of precipitation that occurs in these areas. Precipitation from convective storms often is intense and produces much greater unit runoff than general rainstorms or snowmelt produce. However, convective storms rarely cover areas of more than 10 square miles. In small basins, the largest flows generally are the result of runoff from convective storms. In large basins (several hundred square miles or more), the largest flows generally are the result of widespread general rainstorms or snowmelt. As basin size increases, the unit rate of runoff decreases nonlinearly because the most dominant type of storm-runoff event changes from convective storms to general rainstorms and snowmelt. A curvilinear regression model accounts for this transition. A visual comparison of data plots as well as a comparison of the regression statistics verified that the curvilinear model provided a much better fit than the linear model.

Hydrologic Regions

Wyoming has a diverse terrain, and streamflow varies greatly from the mountains to the plains and deserts due to differences in climate, topography, and geology. These conditions cannot be wholly defined or explained by numeric variables. Therefore, it is necessary to develop more than one set of equations for estimating streamflow throughout the State. Different sets of equations are necessary--one set for each region of hydrologic similarity. In an earlier study, Lowham (1976) analyzed streamflows in the State using four regions. In the current study, advanced analytical methods and more complete streamflow data indicate that three regions are adequate. These regions (shown on plate 1a) were defined initially through the use of color infrared imagery that highlighted areal differences in surface geology, vegetation, and soil moisture. Boundaries of the regions were then refined on the basis of known streamflow and climatic characteristics. The three hydrologic regions are the same for both the basin-characteristics and channel-geometry methods, and for both peak-flow characteristics and mean annual flows.

The major mountainous areas of the State are designated in this report as being in the **Mountainous Regions**. Streamflows in these areas occur mainly as a result of snowmelt runoff. Peak flows in the **Mountainous Regions** are small in relation to flows in the other regions, but annual runoff is larger.

In the plains and desert areas of the State, streamflows occur primarily as a result of rainstorm runoff. In the northern and eastern plains and deserts, intense activity from convective storms causes peak flows to be relatively large but highly variable in occurrence from year-to-year. These areas are mainly high plains and are designated in this report as being in the **Plains Region.**

Streams in the south-central and southwestern plains and desert areas have peak flows that are relatively smaller than those of the **Plains Region.** This is a result of precipitation occurring more in the form of widespread general rainstorms and snow and less as activity from convective storms. These areas are largely desert and are designated as being in the **High Desert Region.**

Geographic Factors

During the analyses of data for streams in the **Plains** and **High Desert Regions** it became apparent that peak-flow characteristics at groups of gaging stations in particular areas had larger or smaller values than would be estimated by the regression equations. The differences between the gaged and estimated values were plotted on a map of the State, and a comparison of the plot with the color infrared imagery of the State showed that certain areas were yielding larger or smaller peak flows due to geographic and orographic differences that were not quantified by the independent variables. For example, several areas of the State have extensive sand dunes where infiltration is high, and for which flood runoff should be relatively small. Using residual values of the regression for groups of stations, and color differences on the imagery that were due to differences in surface geology and vegetation, lines of equal geographic factors (G_f) were constructed that account for part of the differences in peak-flow characteristics. The residual values for regressions from both the basin-characteristics and channel-geometry methods were used to help determine the geographic factor. The lines of equal geographic factors for Wyoming are shown on plate 1d; these factors are included in the equations for estimating peak-flow characteristics in the **Plains** and **High Desert Regions**. Similar development and application of geographic factors in equations for estimation of peak-flow characteristics in Montana have been made by Omang and others (1986, p. 14-17).

Basin-Characteristics Method

Regression using basin characteristics is based on the assumption that certain physical and climatic variables produce or affect streamflow from a basin. The equations express flow characteristics (dependent variables) as being correlated to basin characteristics (independent variables). The method has the advantage of being an "office" technique. The basin characteristics are determined from maps of the drainage basin, and a field visit is not required.

Ten physical variables measured for each of the gaged basins include contributing drainage area; channel slope, length, and aspect; area of lakes and ponds; soils-infiltration rate; mean basin latitude and elevation; percent forest cover; and basin slope. Three climatic variables measured for each basin include average annual precipitation, intensity of rainstorm precipitation, and average length of growing season.

For the **Mountainous Regions**, drainage area, mean basin elevation, and mean annual precipitation were statistically significant as independent variables in estimating peak-flow characteristics and mean annual flow. Mean basin elevation and mean annual precipitation were determined to be highly correlated. Therefore, one set of equations using drainage area and mean basin elevation as independent variables is presented; a second set using drainage area and mean annual precipitation as independent variables is also presented. Based on the regression statistics, the equations using elevation should yield a slightly more accurate estimate of discharge, on the average. However, the equations using precipitation are much simpler to apply and, for most applications, are considered the most feasible to use.

For the **Plains Region**, drainage area and basin slope were determined to be significant as independent variables for estimating peak flows. For the **High Desert Region**, drainage area and mean annual precipitation were determined to be significant for estimating peak-flow characteristics. The geographic factor from plate 1d also is included in the the equations for both of these regions. Mean annual flow in the **Plains** and **High Desert Regions** also was determined to be significantly related to drainage area and average annual precipitation.

A description of the variables that were determined to be significant follows:

Contributing drainage area (A), in square miles, as measured by a planimeter on the best available topographic maps.

Mean basin elevation (ELEV), in feet above sea level, measured on 1:250,000-scale topographic maps. The measurement can be made by either: (1) laying a grid over the map, determining the elevation for at least 25 evenly-spaced intersections within the basin, and averaging those elevations, or (2) by determining the subareas within each contour interval, multiplying the subareas by the intermediate elevation, totaling the products, and then dividing by the total basin area. When possible, the contour intervals selected to be measured should provide not less than four subareas.

Average annual precipitation (PR), in inches. For gaged basins in Wyoming, the value of average annual precipitation was determined from plate 1b; for basins outside Wyoming, it was obtained from similar precipitation maps for the respective states. The measurement is made by sketching the drainage boundary on a transparent overlay on plate 1b, and computing the basin average by weighting subareas for each respective precipitation interval.

Basin slope (S_B), in feet per mile, determined by measuring the lengths, in miles, of contour lines within the drainage boundary, multiplying by the contour interval in feet, and dividing by the drainage area, in square miles. For basins of 50 square miles or less, maps of 1:24,000-scale are recommended to determine the basin slope. Reasonable accuracy generally can be obtained by measuring only the 100-foot contour lines. For basins of 50 to 300 square miles, 1:250,000-scale topographic maps are recommended. For basins larger than 300 square miles, basin slope generally approaches an average value of about 500 feet per mile. Due to the difficulty in measuring this characteristic for large basins, using a value of 500 feet per mile is recommended when the equations are applied to basins larger than 300 square miles.

The basin characteristics of significance in the regression analysis are listed for the gaged sites in table 7c (at end of this report).

Use

The basin-characteristics method requires locating the site in question on the most accurate map available, preferably a 1:24,000-scale Geological Survey topographic map, or equivalent. The basin boundary is then delineated, and the contributing drainage area is determined. Depending on the set of equations used, the geographic factor and other necessary variables are determined. The map of the basin should be examined to determine whether significant manmade works could affect natural streamflows. Although a field visit is not required to use the method, it is advisable to determine any unusual conditions. For example, detention dams and other works may have been constructed after completion of the most recent mapping. Example applications are given in a subsequent section (page 36).

Limitations

The basin-characteristics method is applicable only to sites having virtually natural streamflows. The equations should not be applied to estimate streamflows that are significantly affected by major dams, diversions, or other works of man. The equations could be applied in such cases to estimate what the natural flows were before the manmade works were constructed. In situations where flood characteristics of urban watersheds are needed, the equations for the basin-characteristics method can be used in conjunction with adjustments described by Sauer and others (1983).

Channel-Geometry Method

The size of a natural channel is an indication of flow magnitude. Large flows create large channels; smaller flows create smaller channels. A channel forms primarily during floodflows when a stream has tremendous energy and is transporting large quantities of sediment. Erosion and deposition occur as the stream sculptures its channel to a size large enough to accommodate its flows.

Streamflows of about bankfull magnitude usually dominate channel formation (Wolman and Miller, 1960). Although bankfull discharge, which has a recurrence interval of about 2 years (Lowham, 1982, p. 20-24), is most dominant in channel formation, other discharge characteristics, such as the 50- and 100-year peak flows and mean annual flow, are related to bankfull discharge. These additional characteristics are related to channel size, and estimation equations can be developed through regression analysis.

Several channel-geometry features, including width, depth, and the width-to-depth ratio of the stream channel, were measured and tested as independent variables for determining streamflow characteristics. Channel-geometry features were measured at nearly all of the gaged sites used in this study where the channels were suitable for measurement.

In a previous study (Lowham, 1976) for Wyoming streams, channel width was the only significant variable in estimating discharge. Depth of the channel is difficult to measure accurately and consistently because the streambeds of many channels are scoured during floodflow but fill in as the flow recedes. Rather than using depth or the width-to-depth ratio as independent variables, it was considered that a more accurate measurement of channel shape would be indicated by some measurement of the streambed and bank material. This approach was based on the results of several previous studies. For example, the percentage of silt and clay in the streambed and banks was found by Schumm (1960) to have a significant effect on channel shape. In addition to channel-geometry features, channel sediment properties were used by Osterkamp (1977) to develop equations for estimating mean discharge of Kansas streams, and by Osterkamp and Hedman (1982) to develop equations for perennial streams in the Missouri River basin.

To determine whether channel sediment properties could be used to improve the channel-geometry relations for the plains and desert areas of Wyoming, samples of the streambeds and banks at 23 gaged sites were collected for testing. A regression study was made for just these sites to determine whether the equations, using width as an independent variable, could be improved by the addition of a variable describing channel material. Several measurements of streambed and bank composition (including particle size, percent silt and clay, and soil cohesiveness) were collected and tested; however, none proved to be significant in the analysis. The conclusion was, that although the composition of channel material is presumably interrelated to channel size and discharge, the variable nature of surficial deposits in the plains and deserts of Wyoming masked the attempt to quantitatively describe magnitude of streamflow with any channel feature other than width.

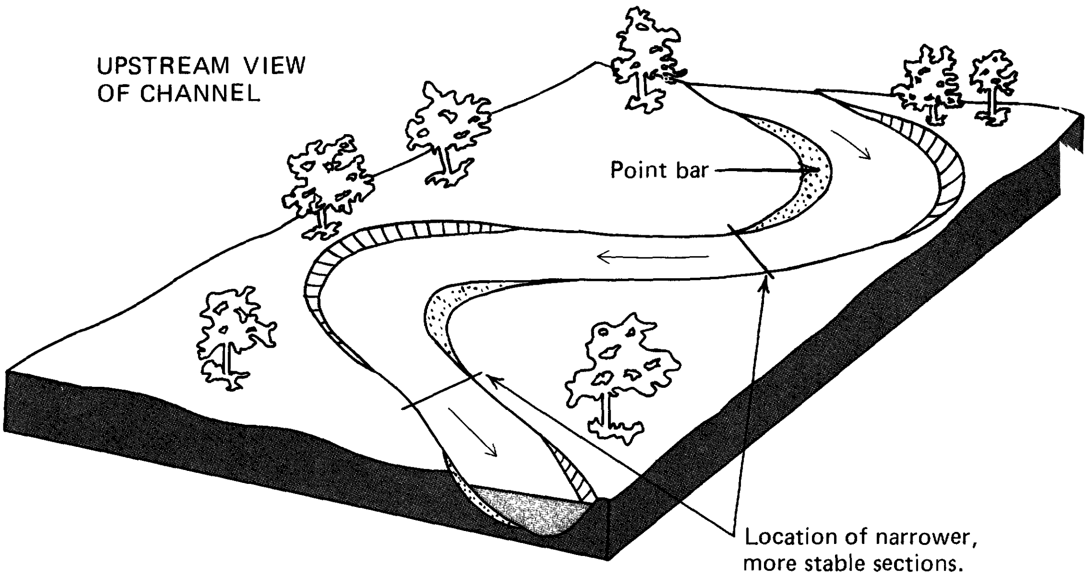
The width (WIDTH) of the channel was determined to be a significant independent variable for estimating streamflow in all regions of the State. Widths of all channels that were measured are listed in table 7c. The geographic factor (G_f) from plate 1d also is included in the equations for estimating peak-flow characteristics in the **Plains** and **High Desert Regions**.

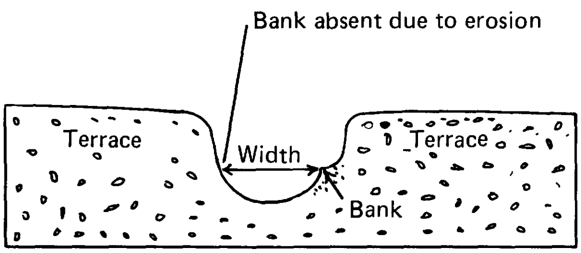
Use

Although measuring channel features is fairly simple, some experience is required. A field visit is necessary to measure the channel width. A width measurement is made of the stream channel at the narrowest section of a straight reach. The section should have a stable appearance; that is, it should be one that has been fairly permanent for several years and not severely disturbed by large floods. It is a good practice to measure channel widths downstream from several meanders and then average the results. The distance from the top of one bank to the top of the adjacent bank of the stream channel is measured. (The top of the bank is defined as that spot where the flood plain and channel meet, and it is distinguished by a break in slope.) If a person were to climb out of a stream channel, they generally would dig in their toes to climb the bank, but could begin walking on flat ground when they reached the top (break in slope) of the bank.

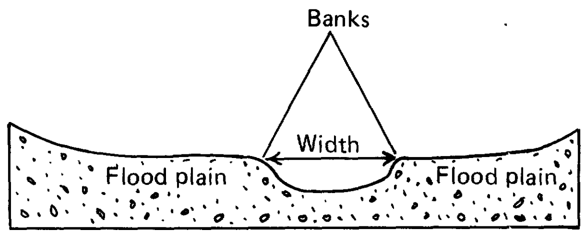
Sketches in figure 8 show where the channel width should be measured. As shown in the sketches, the measurement is made of the narrowest, most stable section of a channel, generally just downstream from a curve or reach of rapids where large amounts of energy are dissipated. Streamflow dissipates energy in curves and rapids; therefore, the channel just downstream from these features reflects the relatively low energy and minimum erosion potential of the streamflow. When a point bar is present, the narrowest section generally will be located at the point where the downstream end of the bar meets the bank. Little or no erosion generally will be evident at this section.

Photographs in figures 9-12 show examples of widths measured in several channels. A large collection of color slides that clearly show where measurements were made on a variety of channel types is on file in the Geological Survey office in Cheyenne. Persons who plan to use the method would benefit from viewing these slides, as well as from field instruction by someone who is experienced with the method.

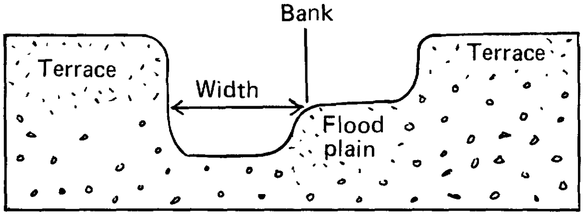




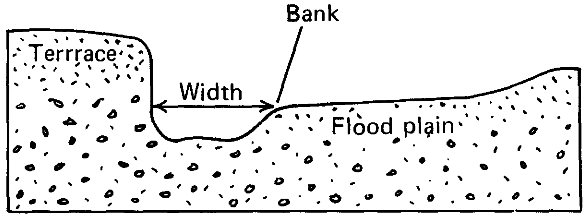
Channel whose streambed has eroded in recent past due to a change in climate or land use. Banks will be present if the channel has stabilized to existing conditions.



Channel with well-developed flood plain.



Channel whose streambed has eroded in past. The channel has stabilized and a new flood plain is developing.



Meandering channel whose lateral movement causes it to be eroding the valley terrace.

Figure 8.--Cross sections of various types of stream channels where width should be measured.

Figure 9.--Tape and stakes show where channel width was measured on North Fork Crazy Woman Creek near Buffalo. View is downstream, width = 24 feet.

Figure 10.--Tape and stakes show where channel width was measured on Cache Creek near Jackson. View is downstream, width = 12 feet.

Figure 11.--Tape and stakes show where channel width was measured on Sand Springs Draw near Pinedale. View is downstream, width = 16 feet.

Figure 12.--Rod and stakes show where channel width was measured on tributary to the New Fork River near Big Piney. View is downstream, width = 12 feet.

Limitations

The channel-geometry method should not be used on certain stream reaches. These include reaches having:

1. Flows that are not frequent enough to form and maintain a channel. Flow is conveyed in a grassy swale that does not have well-defined banks. In general, stream channels with widths less than 2 feet in the **Mountainous Regions** and less than 4 feet in the **Plains** and **High Desert Regions** are not well defined and should not be used.

2. Braided channels. Streambanks in such channels are unstable, and flow often is in multiple channels. A stable channel reach occasionally can be found either upstream or downstream from the braided reach.

3. Potholes. On some intermittent streams the ground-water level is near the streambed elevation but inflow to the stream channel is insufficient to sustain perennial flow. During much of the year evaporation equals or exceeds the seepage inflow. Although the channel contains ponded water, there is no flow in the stream. The dissolved-solids concentration of the ponded water gradually increases to a level that vegetation cannot survive. The bed material of the channel is loosened by the buoyant forces of ground-water seepage, and subsequent flows erode the bed and form potholes.

4. Significant alterations such as diking and channelization, or reaches that are near enough to such alterations to have been significantly influenced or altered.

5. Large reservoirs or diversions upstream. On streams where large dams have been constructed, gaged data generally are available.

The criterion necessary to apply the channel-geometry method is that the channel to be measured should have been formed primarily by the forces of streamflow under its present regime. The method is not applicable when other influences, such as overgrowth of vegetation, wind deposits, movement of livestock and wildlife, and developments of man, are more dominant than the streamflow in forming the size and shape of the channel.

Regression Relations

Tables 1 to 4 present the estimation equations, the number of stations used in each regression analysis, the average standard error of estimate, and the correlation coefficient. The equations were developed using inch-pound units and must be entered with inch-pound units unless applicable conversion factors are applied. The equations should be used for estimating streamflow characteristics only within the ranges of data used for their development. A summary showing the ranges of data available for the regression analyses is listed in table 5. Extending the equations to estimate flow characteristics outside the defined ranges is discouraged.

Table 1.--Summary of regression relations for estimating peak-flow characteristics and mean annual flow of streams in the **Mountainous Regions**

[P_t, annual peak flow, in cubic feet per second, with subscript t designating the recurrence interval, in years; Q_a, mean annual flow, in cubic feet per second; A, contributing drainage area, in square miles; ELEV, mean basin elevation, in feet; PR, average annual precipitation, in inches, as determined from plate 1b; WIDTH, channel width, in feet]

Regression equation (inch-pound units)	Number of stations	Average standard error, in percent	Correlation coefficient
Equations based on contributing drainage area (A) and mean basin elevation (ELEV)			
$P_2 = 0.012\ A^{0.88} \left(\frac{ELEV}{1,000}\right)^{3.25}$	170	55	0.93
$P_5 = 0.13\ A^{0.84} \left(\frac{ELEV}{1,000}\right)^{2.41}$	170	46	.95
$P_{10} = 0.45\ A^{0.82} \left(\frac{ELEV}{1,000}\right)^{1.95}$	170	44	.95
$P_{25} = 1.75\ A^{0.80} \left(\frac{ELEV}{1,000}\right)^{1.46}$	170	44	.94
$P_{50} = 4.29\ A^{0.79} \left(\frac{ELEV}{1,000}\right)^{1.13}$	170	47	.94
$P_{100} = 9.63\ A^{0.77} \left(\frac{ELEV}{1,000}\right)^{0.85}$	170	50	.93
$P_{200} = 25.9\ A^{0.75} \left(\frac{ELEV}{1,000}\right)^{0.47}$	170	54	.91
$P_{500} = 63.4\ A^{0.74} \left(\frac{ELEV}{1,000}\right)^{0.14}$	170	61	.89
$Q_a = 0.0015\ A^{1.01} \left(\frac{ELEV}{1,000}\right)^{2.88}$	140	57	.91

Table 1.--Summary of regression relations for estimating peak-flow characteristics and mean annual flow of streams in the **Mountainous Regions**--Continued

Regression equation (inch-pound units)	Number of stations	Average standard error, in percent	Correlation coefficient
Equations based on contributing drainage area (A) and average annual precipitation (PR)			
$P_2 = 0.51 \; A^{0.81} PR^{1.13}$	170	71	.89
$P_5 = 2.36 \; A^{0.79} PR^{0.78}$	170	56	.92
$P_{10} = 5.35 \; A^{0.78} PR^{0.59}$	170	52	.93
$P_{25} = 13.5 \; A^{0.77} PR^{0.38}$	170	50	.93
$P_{50} = 23.8 \; A^{0.77} PR^{0.25}$	170	50	.93
$P_{100} = 40.7 \; A^{0.76} PR^{0.13}$	170	52	.92
$P_{200} = 73.1 \; A^{0.75} PR^{-0.001}$	170	55	.91
$P_{500} = 136 \; A^{0.74} PR^{-0.15}$	170	61	.89
$Q_a = 0.013 \; A^{0.93} PR^{1.43}$	140	57	.92

Table 1.--Summary of regression relations for estimating peak-flow characteristics and mean annual flow of streams in the **Mountainous Regions**--Continued

Regression equation (inch-pound units)	Number of stations	Average standard error, in percent	Correlation coefficient
Equations based on channel width (WIDTH)			
$P_2 = 1.94\ WIDTH^{1.58}$	98	39	0.96
$P_5 = 4.33\ WIDTH^{1.47}$	98	33	.96
$P_{10} = 6.60\ WIDTH^{1.41}$	98	36	.95
$P_{25} = 10.4\ WIDTH^{1.34}$	98	43	.93
$P_{50} = 13.9\ WIDTH^{1.30}$	98	49	.91
$P_{100} = 18.1\ WIDTH^{1.27}$	98	56	.88
$P_{200} = 28.0\ WIDTH^{1.23}$	98	63	.85
$P_{500} = 31.0\ WIDTH^{1.19}$	98	73	.81
$Q_a = 0.087\ WIDTH^{1.79}$	77	46	.91

Table 2.--Summary of regression relations for estimating peak-flow characteristics of streams in the **Plains Region**

[P_t, annual peak flow, in cubic feet per second, with subscript t designating the recurrence interval, in years; A, contributing drainage area, in square miles; S_B, basin slope, in feet per mile; G_f, geographic factor, as determined from plate 1d; WIDTH, channel width, in feet]

Regression equation (inch-pound units)	Number of stations	Average standard error, in percent	Correlation coefficient
Equations based on contributing drainage area (A), basin slope (S_B), and geographic factor (G_f)			
$P_2 = 41.3\ A^{0.60}\ A^{-0.05}\ G_f$	115	97	0.76
$P_5 = 63.7\ A^{0.60}\ A^{-0.05}\ S_B^{0.09} G_f$	115	71	.85
$P_{10} = 76.9\ A^{0.59}\ A^{-0.05}\ S_B^{0.14} G_f$	115	63	.87
$P_{25} = 94.2\ A^{0.59}\ A^{-0.05}\ S_B^{0.19} G_f$	115	62	.88
$P_{50} = 112\ A^{0.58}\ A^{-0.05}\ S_B^{0.23} G_f$	115	66	.87
$P_{100} = 130\ A^{0.58}\ A^{-0.05}\ S_B^{0.25} G_f$	115	73	.85
$P_{200} = 182\ A^{0.57}\ A^{-0.05}\ S_B^{0.26} G_f$	109	82	.80
$P_{500} = 245\ A^{0.57}\ A^{-0.05}\ S_B^{0.27} G_f$	109	98	.76

Table 2.--Summary of regression relations for estimating peak-flow characteristics of streams in the **Plains Region**--Continued

Regression equation (inch-pound units)	Number of stations	Average standard error, in percent	Correlation coefficient
Equations based on channel width (WIDTH) and geographic factor (G_f)			
$P_2 = 7.60\ WIDTH^{1.18} G_f$	41	59	0.87
$P_5 = 20.5\ WIDTH^{1.14} G_f$	41	45	.91
$P_{10} = 34.6\ WIDTH^{1.11} G_f$	41	44	.91
$P_{25} = 60.9\ WIDTH^{1.09} G_f$	41	48	.90
$P_{50} = 88.0\ WIDTH^{1.07} G_f$	41	53	.87
$P_{100} = 123\ WIDTH^{1.06} G_f$	41	60	.85
$P_{200} = 166\ WIDTH^{1.04} G_f$	41	68	.82
$P_{500} = 239\ WIDTH^{1.03} G_f$	41	78	.77

Table 3.--Summary of regression relations for estimating peak-flow characteristics of streams in the **High Desert Region**

[P_t, annual peak flow, in cubic feet per second, with subscript t designating the recurrence interval, in years; A, contributing drainage area, in square miles; PR, average annual precipitation, in inches, as determined from plate 1b; G_f, geographic factor, as determined from plate 1d; WIDTH, channel width, in feet]

Regression equation (inch-pound units)	Number of stations	Average standard error, in percent	Correlation coefficient
Equations based on contributing drainage area (A), average annual precipitation (PR), and geographic factor (G_f)			
$P_2 = 6.66\ A^{0.59\ A^{-0.03}} PR^{0.60} G_f$	43	67	0.80
$P_5 = 10.6\ A^{0.56\ A^{-0.03}} PR^{0.81} G_f$	43	57	.82
$P_{10} = 13.8\ A^{0.55\ A^{-0.03}} PR^{0.90} G_f$	43	54	.82
$P_{25} = 19.4\ A^{0.53\ A^{-0.03}} PR^{0.98} G_f$	43	53	.81
$P_{50} = 24.2\ A^{0.52\ A^{-0.03}} PR^{1.02} G_f$	43	54	.80
$P_{100} = 30.1\ A^{0.51\ A^{-0.03}} PR^{1.05} G_f$	43	55	.78
$P_{200} = 36.0\ A^{0.51\ A^{-0.03}} PR^{1.07} G_f$	43	58	.75
$P_{500} = 47.1\ A^{0.50\ A^{-0.03}} PR^{1.09} G_f$	43	62	.71

Table 3.--Summary of regression relations for estimating peak-flow characteristics of streams in the **High Desert Region**--Continued

Regression equation (inch-pound units)	Number of stations	Average standard error, in percent	Correlation coefficient
Equations based on channel width (WIDTH) and geographic factor (G_f)			
$P_2 = 5.46\ WIDTH^{1.22}G_f$	27	64	0.82
$P_5 = 14.6\ WIDTH^{1.16}G_f$	27	59	.83
$P_{10} = 25.5\ WIDTH^{1.12}G_f$	27	58	.82
$P_{25} = 47.3\ WIDTH^{1.06}G_f$	27	59	.81
$P_{50} = 71.4\ WIDTH^{1.01}G_f$	27	60	.79
$P_{100} = 105\ WIDTH^{0.97}G_f$	27	61	.77
$P_{200} = 149\ WIDTH^{0.93}G_f$	27	63	.74
$P_{500} = 233\ WIDTH^{0.87}G_f$	27	66	.71

Table 4.--Summary of regression relations for estimating mean annual flow of streams in the **Plains and High Desert Regions**

[Q_a, mean annual flow, in cubic feet per second; A, contributing drainage area, in square miles; PR, average annual precipitation, in inches, as determined from plate 1b; WIDTH, channel width, in feet]

Regression equation (inch-pound units)	Number of stations	Average standard error, in percent	Correlation coefficient
Equation based on contributing drainage area (A) and average annual precipitation (PR)			
$Q_a = 0.0021\ A^{0.88} PR^{1.19}$	45	96	0.95
Equation based on channel width (WIDTH)			
$Q_a = 0.00046\ WIDTH^{2.42}$	20	117	.93

Table 5.--Applicable range of the estimation relations

Region and equation	Drainage area, in square miles	Mean basin elevation, in feet above sea level	Average annual precip- itation, in inches	Basin slope, in feet per mile	Channel width, in feet
Mountainous Regions					
Peak flows	0.52 - 3,465	3,700 - 11,100	12 - 55	--	2 - 180
Annual flow	6.30 - 3,465	5,000 - 10,800	14 - 55	--	12 - 180
Plains Region					
Peak flows	0.04 - 5,270	--	--	115 - 1,620	6 - 120
Annual flow	0.69 - 5,270	--	7 - 22	--	5 - 120
High Desert Region					
Peak flows	1.26 - 1,178	--	7 - 17	--	3 - 60
Annual flow	0.69 - 5,270	--	7 - 22	--	5 - 120

Correlation with Nearby Gaged Streams

In the **Mountainous Regions,** where streamflow occurs mainly from snowmelt and there is relatively low variability of annual and seasonal runoff, an alternative to estimating runoff characteristics by regression is to correlate the discharge of an ungaged stream to the discharge of one or more nearby gaged streams. The gaged streams need to be located in basins having characteristics (drainage area, elevation, and aspect) similar to those of the ungaged basin. Streamflows from both gaged and ungaged basins need to be virtually unaffected by storage reservoirs and diversions.

Mean Annual Flow

Riggs (1969) describes a procedure for estimating mean annual flow by measuring the discharge of the ungaged stream near mid-month each calendar month for a year. These measured discharges are related to concurrent daily mean discharges at a nearby streamflow-gaging station using a separate relation of 45-degree slope for each month. The monthly mean flow at the gaged site is transferred though the appropriate relation to obtain an estimate of the monthly mean at the ungaged site. The annual mean flow for the year is computed from the 12 monthly means; it can be adjusted to an estimate of the mean annual flow on the basis of records for several nearby gaging stations. For a step-by-step description of the procedure, the reader is referred to Riggs (1969).

Mean Monthly Flow

Regression equations were investigated as a possible means of estimating mean monthly streamflows; however, on a statewide basis no useful relations were determined. If mean monthly streamflows are to be estimated, use of data for one or more gaged streams in the vicinity of the ungaged basin is desirable. The procedure is as follows:

> Using the regression relations in this report, or the method of monthly measurements described by Riggs (1969), an estimate of mean annual flow is obtained for the ungaged site. Average monthly flows, expressed in percent of annual flow, are determined for each of the nearby gaged basins. The overall average percentage for each month is computed for the gaged sites, and these averages are multiplied by the estimate of mean annual flow to determine the estimated mean monthly streamflows at the ungaged site.

Flood Characteristics at Gaged Sites with Short Records

If streamflow characteristics are needed for a site that has been gaged, generally the station record is used--provided the period of record is sufficient to adequately define the values. However, when the period of record is relatively short, the distribution of peak discharges at the station may not be representative of the long-term flood history for the site. This is because a short period of record has the possibility of occurring within either a wet or dry climatic cycle. On the basis of the author's experience working with flood data, and a time-error analysis by Wahl (1970), this is especially possible for Wyoming streams having records for less than about 15 years for the **Mountainous Regions** and about 25 years for the **Plains** and **High Desert Regions**.

If the station record is considered to be relatively short and subject to error from a wet or dry climatic cycle, a weighting method (Sauer, 1974) may be used to provide a more accurate estimate of flood frequency at a gaged site on an unregulated stream. The method weights the peak discharge computed from the station flood frequency with the peak discharge estimated from the regional regression equation according to their respective years of record. The equation used for the weighting method is:

$$Q_{t(w)} = \frac{Q_{t(s)}N + Q_{t(r)}E}{N + E}$$

where $Q_{t(w)}$ = the weighted peak discharge, in cubic feet per second, for the recurrence interval of t-years;

$Q_{t(s)}$ = the station value of the flood based on the historical record, in cubic feet per second, for the recurrence interval of t-years;

N = the number of years of station data used to compute $Q_{t(s)}$;

$Q_{t(r)}$ = the regression estimate of the peak discharge, in cubic feet per second, for the recurrence interval of t-years; and

E = the equivalent years of record for $Q_{t(r)}$ = 10 years (based on recommendation by the U.S. Water Resources Council (1981, p. 21) for the 100-year peak discharge, which for the purposes of this report is assumed applicable to other recurrence intervals).

Example Applications

Procedures for estimating streamflow characteristics are given in the following examples:

Example A. Basin-characteristics method--**Mountainous Regions**

An estimate of the 100-year peak discharge is needed for the preliminary design of a bridge. The estimate is needed immediately; time is insufficient to make a field visit to obtain channel measurements at the proposed site. The contributing drainage area is 126 square miles, and the mean basin elevation is 8,350 feet above sea level, both measured from maps. From plate 1b, average annual precipitation for the basin is determined to be 20 inches. The equation (from table 1) based on drainage area and mean basin elevation for P_{100} in the **Mountainous Regions** is:

$$P_{100} = 9.63\ A^{0.77} \left(\frac{ELEV}{1,000}\right)^{0.85}.$$

Substituting A = 126 square miles and ELEV = 8,350 feet,

$$P_{100} = 9.63\ (126)^{0.77}\ \frac{8,350}{1,000}^{0.85}$$

$$= 2,420 \text{ cubic feet per second.}$$

The equation based on contributing drainage area and average precipitation is:

$$P_{100} = 40.7\ A^{0.76} PR^{0.13}.$$

Substituting A = 126 square miles and PR = 20 inches per year,

$$P_{100} = 40.7\ (126)^{0.76}(20)^{0.13}$$

$$= 2,370 \text{ cubic feet per second.}$$

It is decided to use an average of the two results, determined as:

$$\frac{(2,420 + 2,370)}{2} = 2,400 \text{ cubic feet per second.}$$

Example B. Basin-characteristics method--**Plains Region**

An estimate is needed of the 50-year peak discharge for a tributary of Shawnee Creek at the site shown in figure 13. The basin is located about 12 miles southeast of Douglas (plate 1d). The drainage area is 2.12 square miles, and the basin slope is determined as follows: Length of 100-foot contour intervals in the basin (fig. 13) is 14.9 miles; therefore, basin slope is:

$$S_B = \frac{14.9\ (100)}{2.12} = 703 \text{ feet per mile.}$$

The equation (from table 2) based on drainage area and basin slope is:

$$P_{50} = 112\ A^{0.58}\ A^{-0.05 S_B^{0.23}} G_f.$$

From plate 1d, the geographic factor (G_f) is 1.4. Substituting A = 2.12 square miles, S_B = 703 feet per mile, and G_f = 1.4:

$$P_{50} = 112\ (2.12)^{0.58}\ (2.12)^{-0.05 (703)^{0.23}}(1.4)$$

$$= 1,080 \text{ cubic feet per second.}$$

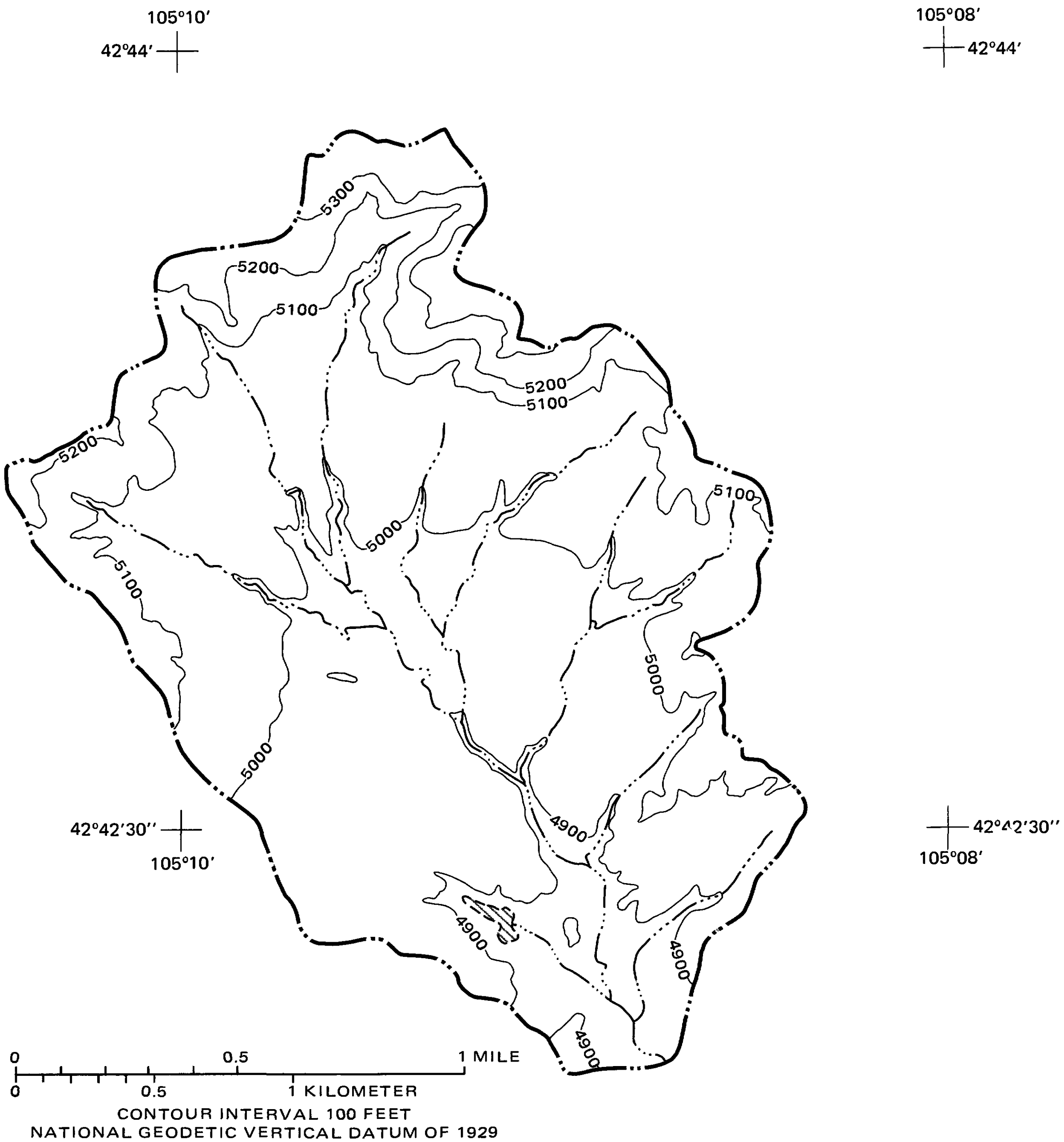


Figure 13.--Drainage basin for tributary of Shawnee Creek near Douglas.

Example C. <u>Comparison of basin-characteristics and channel-geometry methods</u>

A structure is to be built on a tributary to the New Fork River near the site shown in figure 12. The ungaged stream is located in the **High Desert Region** about 16 miles east of Big Piney (plate 1d). The design is to be based on a peak discharge having a 25-year recurrence interval. The channel width is measured at several sections and averages 12 feet. The drainage area measures 10.7 square miles, average annual precipitation as shown by plate 1b averages 9 inches, and the geographic factor as shown by plate 1d is 0.6.

By use of the equations from table 3, the basin-characteristics method indicates:

$$P_{25} = 19.4\ A^{0.53}\ A^{-0.03}\ PR^{0.98} G_f$$

$$= 19.4\ (10.7)^{0.53}\ (10.7)^{-0.03}\ (9)^{0.98}\ (0.6)$$

$$= 323 \text{ cubic feet per second.}$$

The channel-geometry method indicates:

$$P_{25} = 47.3\ \text{WIDTH}^{1.06} G_f$$

$$= 47.3\ (12)^{1.06}(0.6)$$

$$= 395 \text{ cubic feet per second.}$$

The channel-geometry method yields a slightly greater estimated peak discharge than the basin-characteristics method. It is decided to use an average of the two results, determined as:

$$\frac{(323 + 395)}{2} = 359 \text{ cubic feet per second.}$$

Example D. <u>Drainage is situated in more than one hydrologic region</u>

If parts of one drainage area lie in two separate hydrologic regions, a weighted averaging technique may be used to estimate the flow characteristics. An estimate is made for each region assuming the drainage area is contained entirely within that region. The average is computed by weighting each estimate with the proportion of drainage area contained in the corresponding hydrologic region.

A stream has a drainage area of 54 square miles, of which 40 square miles lie in the **Mountainous Region** and 14 square miles lie in the **Plains Region**. That part of the basin in the **Mountainous Region** has an average annual precipitation of 20 inches. The proposed structure needs to be able to withstand a 100-year flood. Equations from table 1 are used to estimate the 100-year peak discharge for the **Mountainous Regions**, thus:

$$P_{100} = 40.7\ A^{0.76} PR^{0.13}.$$

Substituting A = 54 square miles and PR = 20 inches per year,

$$P_{100} = 40.7(54)^{0.76}(20)^{0.13}$$

$$= 1{,}250 \text{ cubic feet per second.}$$

That part of the drainage basin in the **Plains Region** has a geographic factor of 1.2, and a basin slope of 500 feet per mile. From the **Plains Region** equations of table 2, the 100-year peak discharge is:

$$P_{100} = 130\ A^{0.58}\ A^{-0.05}\ S_B^{\ 0.25} G_f$$

$$= 130\ (54)^{0.58}\ (54)^{-0.05}\ (500)^{0.25}(1.2)$$

$$= 4{,}910 \text{ cubic feet per second.}$$

The weighted average of P_{100} is determined as:

$$P_{100} = (1{,}250)\frac{40}{54} + (4{,}910)\frac{14}{54}$$

$$= 2{,}200 \text{ cubic feet per second.}$$

Example E. Mean monthly streamflows

Estimates of mean monthly flows are needed for an ungaged stream in the mountains southwest of Encampment. Runoff from the area is primarily snowmelt, and the runoff pattern of a nearby gaged stream, Encampment River (streamflow-gaging station 06623800), is fairly consistent from year to year. The ungaged stream (drainage area is 40.0 square miles, average annnual precipitation is 28 inches) has basin characteristics similar to the upstream drainage of the Encampment River (drainage area is 72.7 square miles, average annual precipitation is 26 inches).

The regime of the ungaged stream is believed to be similar to that of the Encampment River. Mean monthly flows of the Encampment River at station 06623800 are shown in table 6, expressed both as a rate and percentage of the mean annual flow. The mean monthly flows of the ungaged stream are assumed to occur in the same proportions as those of the Encampment River. Mean annual flow can be estimated either by a regression equation or by the monthly measurement method. The monthly measurement method requires 12 months to complete, which is a greater time period than is available for the project design. Therefore, it is decided to use one of the regression equations to estimate mean annual flow.

The equation (from table 1) for estimating mean annual flow in the **Mountainous Regions**, based on drainage area and average annual precipitation is:

$$Q_a = 0.013\ A^{0.93} PR^{1.43}$$

where A = 40.0 square miles,
PR = 28 inches per year, and
Q_a = 47 cubic feet per second.

The mean monthly flows at the ungaged site are then determined, as shown in table 6, by multiplying the respective percentage for each month by the product of the mean annual flow times 12 months.

Table 6.--Summary of data and results for estimating mean monthly flow

	Encampment River, at station 06623800 — Mean monthly flow: Cubic feet per second	Encampment River, at station 06623800 — Mean monthly flow: Percentage		Ungaged site — Mean monthly flow: Cubic feet per second
October	31	2.2		12
November	24	1.7		9.6
December	22	1.6		9.0
January	19	1.4		7.9
February	18	1.3	x 47 cubic feet per	7.3
March	19	1.3	second x 12 months =	7.3
April	34	2.5		14
May	256	18.1		102
June	653	46.3		261
July	249	17.6		99
August	51	3.6		20
September	34	2.4		14
Annual	117	100		47

Example F. An ungaged site on a gaged stream

A structure is being designed for the Bear River at Evanston, and estimates of the 50- and 100-year peak discharges are needed. These flood characteristics at selected streamflow-gaging stations on the Bear River are plotted against drainage area in figure 14. Drainage area upstream from Evanston is computed and entered on the graph to give estimates of the 50- and 100-year peak discharges of 3,700 and 4,000 cubic feet per second, respectively.

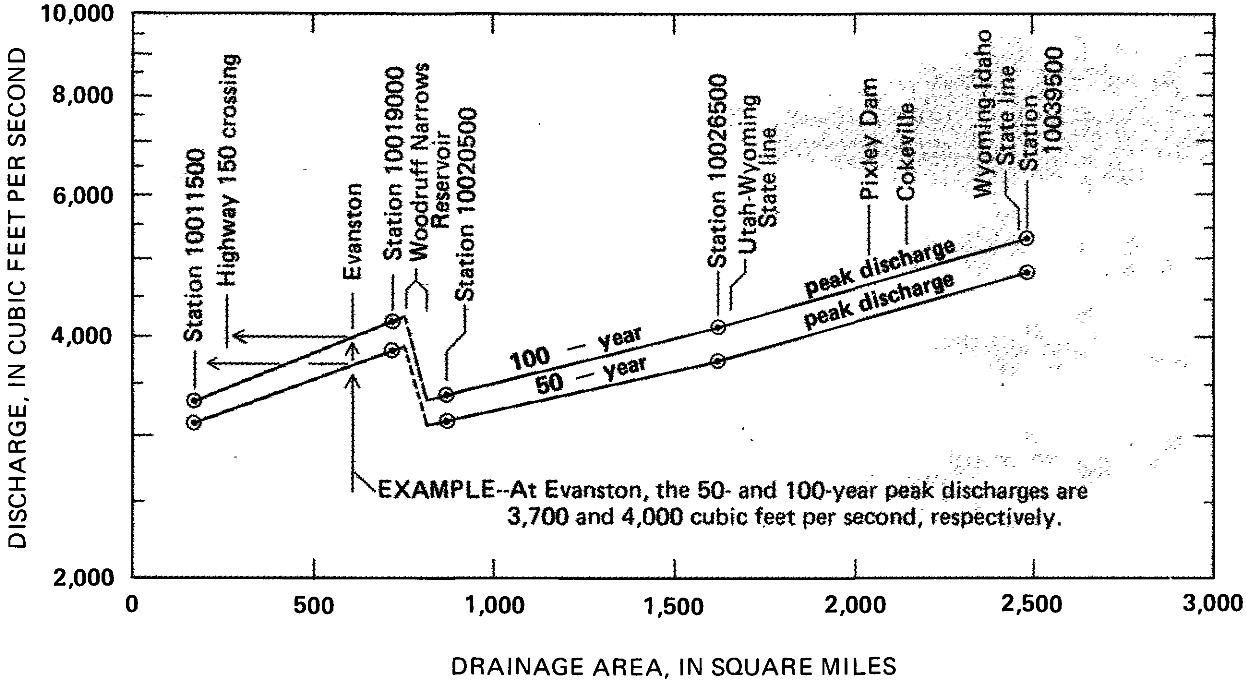


Figure 14.--Relation of peak discharge to drainage area for the Bear River.

HISTORICAL FLOODS IN WYOMING

The flow characteristic most frequently needed for planning and design of stream-related structures is peak discharge. The 100-year flood generally is used for identification of flood-prone areas and in the design of important or expensive structures. The 200- and 500-year floods may be considered in situations where there is potential danger to human life or property. Minor structures, such as culverts on county roads, frequently are designed to pass 10- or 25-year floods.

Lay persons who observe annual snowmelt occurring in the perennial streams of mountainous areas, as compared to the usually dry stream channels of the plains and desert areas, may conclude that mountainous streams have the highest floodflows. Just the opposite is true. For similar-sized drainage areas or channel widths, streams of the **Plains** and **High Desert Regions** have much larger floods than streams of the **Mountainous Regions**. Many of the large floods in plains and desert areas are not observed because they occur in remote areas and at night as a result of late-afternoon or evening convective storms.

Streams in Wyoming may have large floods, even though only minimal or no flows may have been observed for many years. When a large flood does occur, it can cause loss of life and great destruction, as in the case of the August 1, 1985, flood of Dry Creek in Cheyenne (Druse and others, 1986). Twelve deaths, 70 injuries, and $61.1 million in damage were the result of flooding caused by a massive storm that drenched downtown Cheyenne with as much as 7 inches of rain and hail between approximately 6 p.m. and 10 p.m. (figs. 15 and 16).

To illustrate that large floods have occurred in Wyoming, plots that show the relation between known peak discharge and corresponding drainage area are presented for each of the three hydrologic regions (figs. 17-19). The figures include large floods at miscellaneous sites, as well as the largest peaks of record at streamflow-gaging stations. Also shown on the figures are: (1) The relation of 100-year peak discharge to drainage area, computed using equations from tables 1-3; (2) the enveloping line defined by maximum observed discharges; and (3) the enveloping line for maximum discharges of the Rocky Mountain area (Crippen and Bue, 1977).

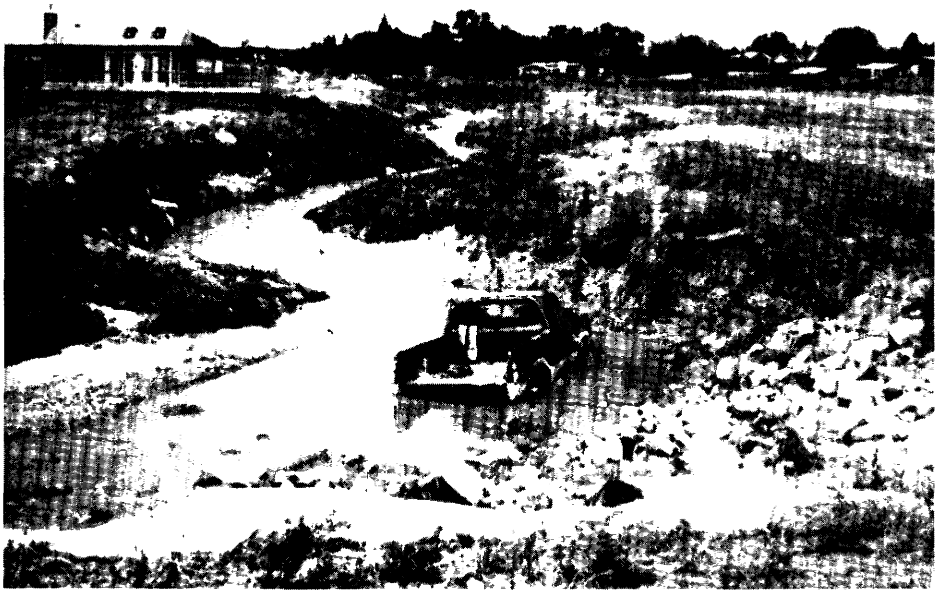


Figure 15.--Dry Creek in north Cheyenne the day after the flood of August 1, 1985. View is upstream.

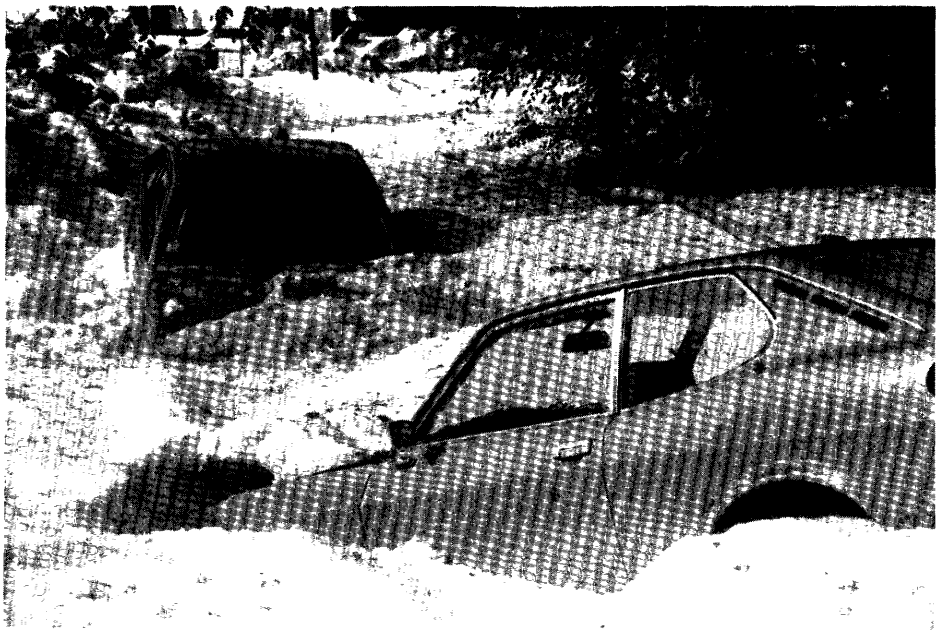


Figure 16.--Hail accumulation in a low area of Cheyenne following the flood of August 1, 1985. Photograph courtesy of Mark Junge.

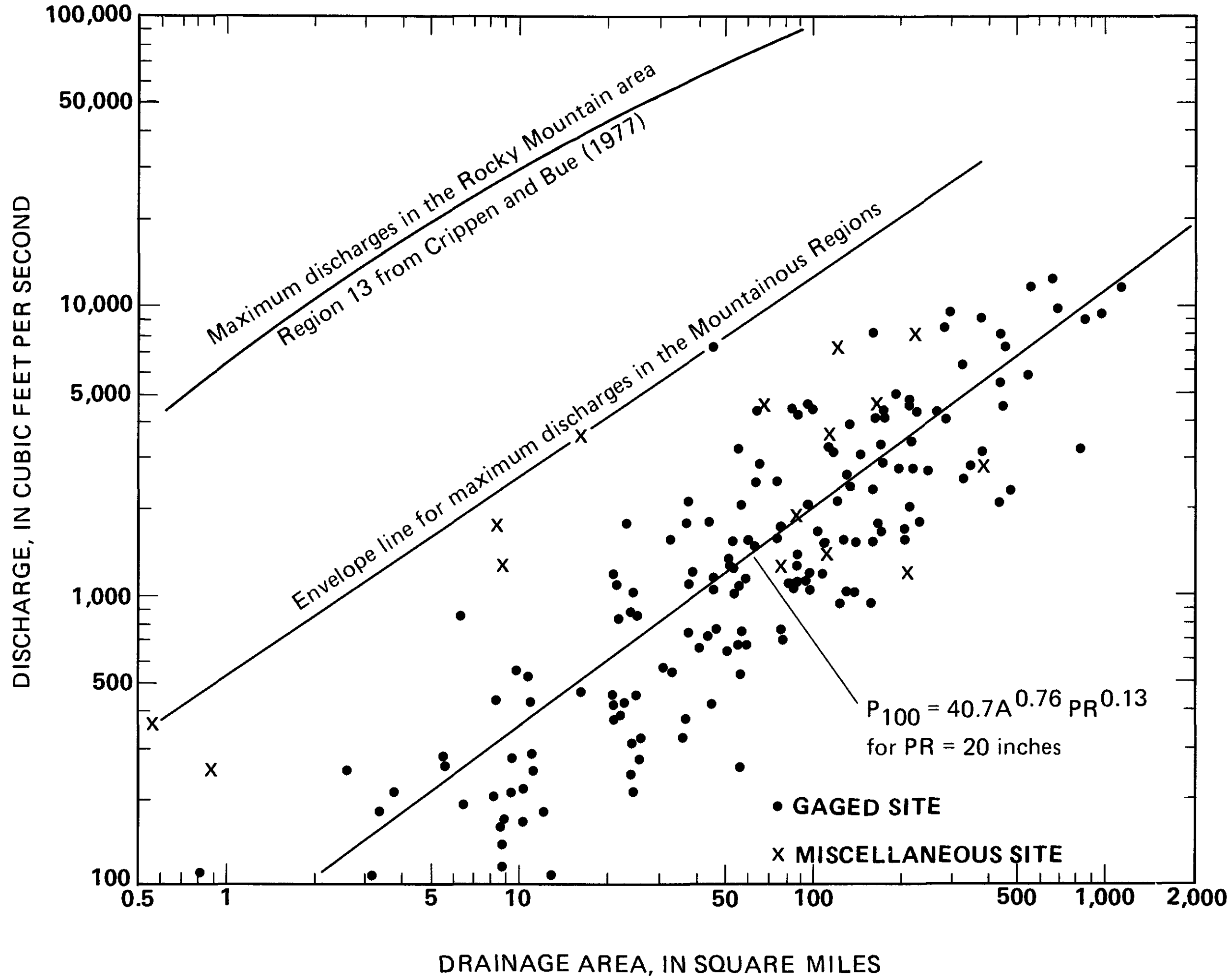


Figure 17.--Relation of maximum known peak discharge to drainage area for the Mountainous Regions.

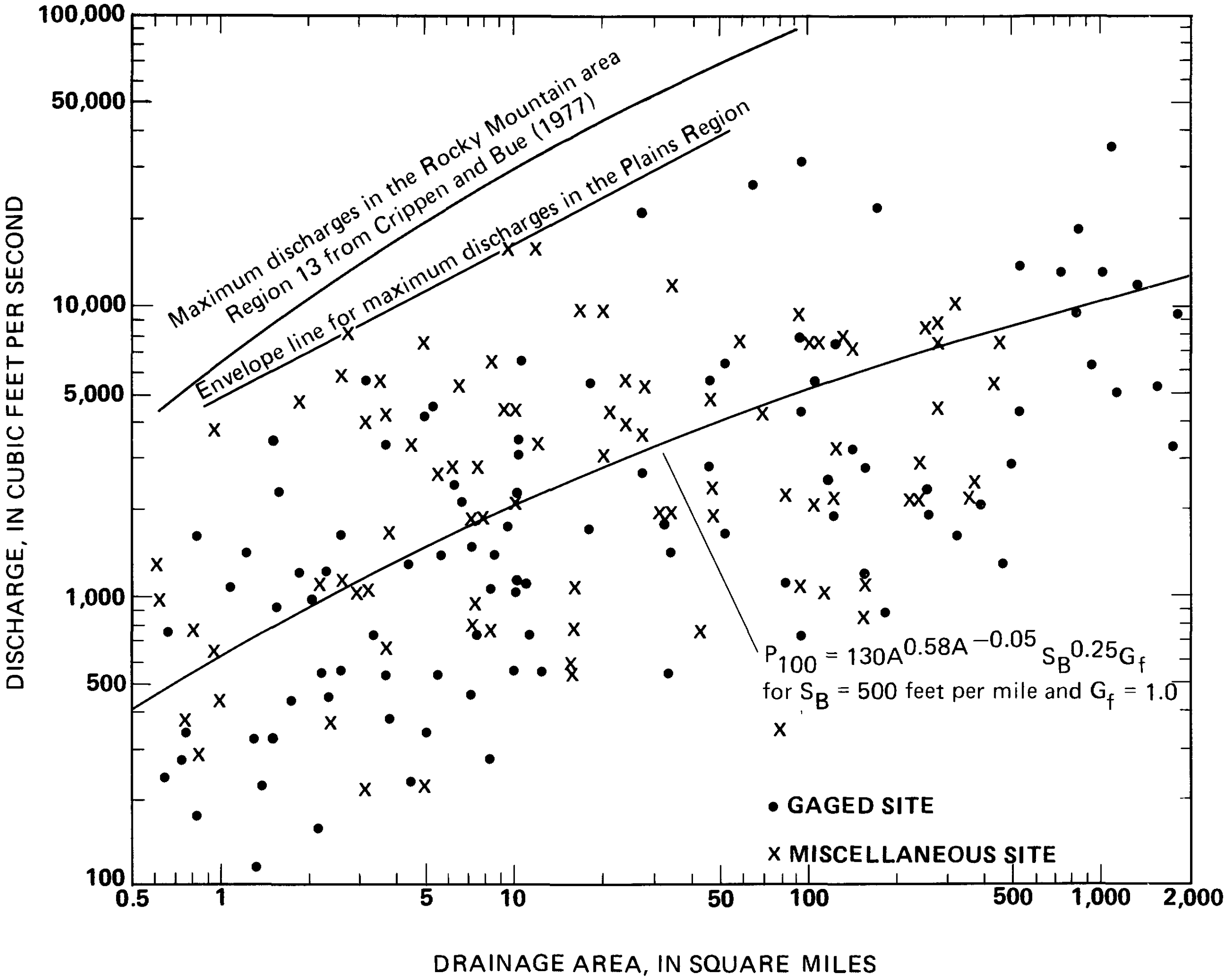


Figure 18.--Relation of maximum known peak discharge to drainage area for the Plains Region.

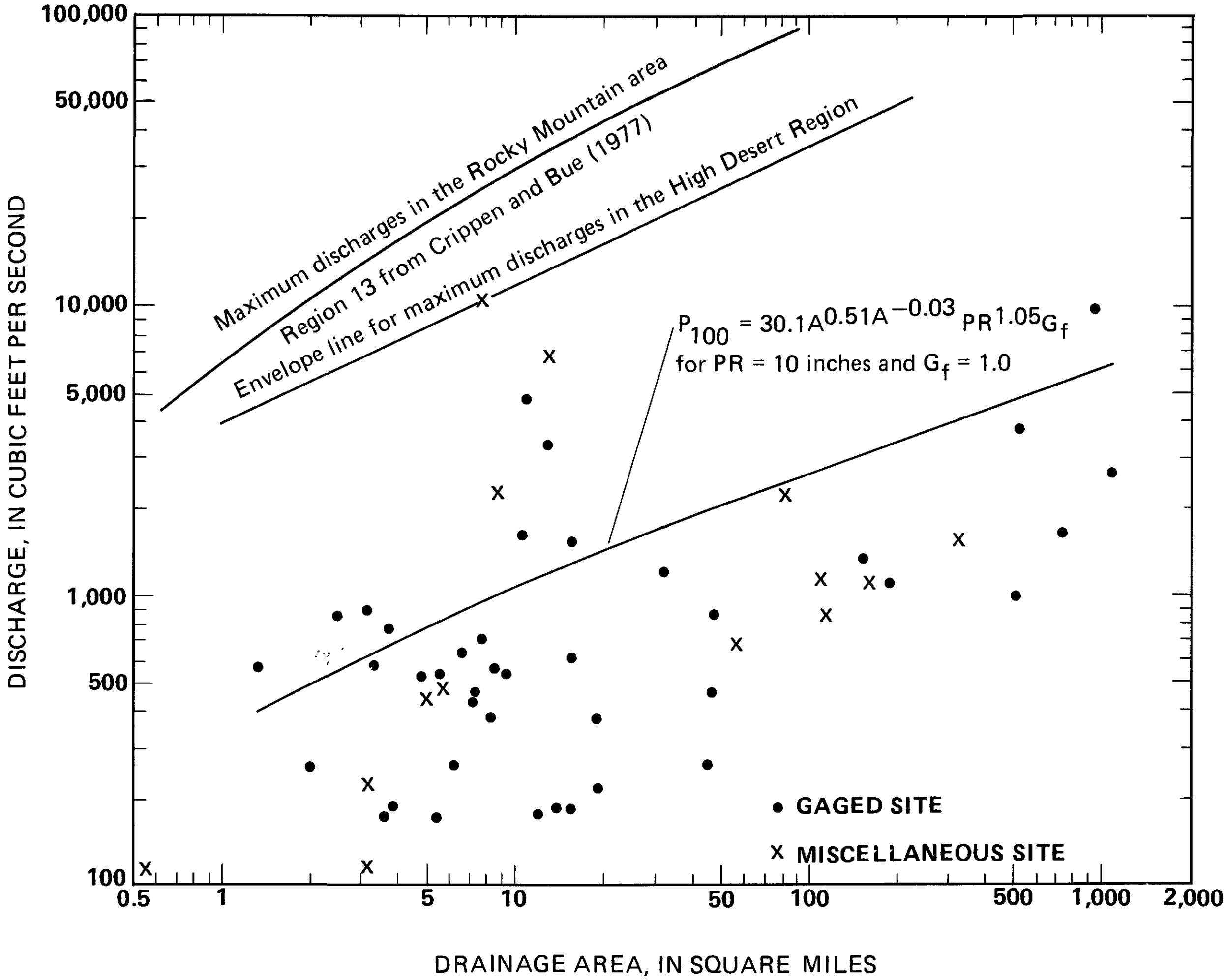


Figure 19.--Relation of maximum known peak discharge to drainage area for the High Desert Region.

SUMMARY

Streams were important in the early development of Wyoming, which included trapping, gold mining, agriculture, and logging. They continue to be a vital natural resource for the above uses and for tourism and the energy-mineral industry. Streams have various characteristics throughout the State due to large differences in climate, geology, and topography. Perennial streams with source drainage areas in the mountains provide the most runoff in Wyoming. However, for similarly-sized drainage areas or channel widths, streams draining the plains and deserts produce much larger peak flows than streams draining the mountains.

Streamflow characteristics are available for several hundred sites in Wyoming where streamflow gages have been operated. Time and cost constraints prevent the installation and operation of gages at every site where data may be needed. Methods of estimating streamflow characteristics at ungaged sites have been developed by using data at gaged sites.

Peak-flow characteristics at streamflow-gaging stations were determined by fitting the data to the Pearson Type III probability distribution using refined procedures recommended by the U.S. Water Resources Council. The procedures include use of (1) a generalized skew coefficient, which improves the accuracy of peak-flow characteristics for gages with short records, and (2) use of an historical adjustment, which allows data from outside the gaged period of record to be used in defining the peak-flow characteristics. The refinements have improved peak-flow determinations, especially for gaging stations in the plains and desert areas where streams are subject to high annual variability.

A large data base is available for defining mean annual runoff of perennial streams draining mountainous areas of the State; however, a shortage of these data exists for small streams in the plains and desert areas. To help overcome this deficiency, the records of 21 seasonal gages, which were operated on small streams in the plains and desert areas during the principal rainfall months of May through September of 1963-73, were used. These partial-year data were adjusted to provide an estimated mean annual flow for each of the sites on the basis of a comparison with year-round records for similar streams. Peak-flow characteristics of these 21 seasonal gages also were used.

Regression equations are presented in this report for estimating peak-flow characteristics and mean annual flows of ungaged Wyoming streams. The equations were developed through an analysis of data for gaged basins that were considered to be representative of natural conditions. Records for 361 streamflow-gaging stations were used in the final analysis.

The regression analysis used equations that express flow characteristics in relation to either basin characteristics or channel-geometry features. The basin characteristics tested in the regression analysis included 10 physical and three climatic variables. Only contributing drainage area, mean basin elevation, average annual precipitation, and basin slope were determined to be significant to various regression relations defining the flow characteristics. The channel-geometry features tested included the width, depth, and width-to-

depth ratio of the stream channel, and measurements of the sediment composition of the streambed and banks. Only channel width was found to be significant for estimating the flow characteristics. The basin characteristics may be measured or determined from maps; whereas, the channel width must be measured on-site.

Due to diverse climatic and physical conditions that cannot be wholly defined by numeric variables, it was necessary to develop separate sets of estimation equations for three regions of different hydrologic settings. The three regions are: (1) The **Mountainous Regions**, which include the major mountainous areas of the State where snowmelt has a dominant influence on streamflows, (2) the **Plains Region**, which includes the northern and eastern plains and deserts where runoff from convective storms has a significant influence on peak flows, and (3) the **High Desert Region**, which includes the south-central and southwestern plains and desert areas where widespread general rainstorms and snow have a major effect on peak flows.

For the **Mountainous Regions**, the regression model uses equations of exponential form, which plot as straight lines on logarithmic graph paper. However, for the **Plains** and **High Desert Regions**, a curvilinear model was determined to be more applicable for estimating peak flows using basin characteristics. The curvilinear model uses equations of double-exponential form, which plot as curved lines on logarithmic graph paper. The curvilinear model has the advantage of converging toward zero runoff for zero drainage area while still fitting the data points for the complete range of drainage sizes for the gaged streams. The need for a curvilinear model is the result of a decrease in precipitation intensity and an associated decrease in unit runoff as drainage area increases. The intensity decreases with basin size as the most dominant type of storm-runoff event changes from convective storms to general rainstorms and snowmelt.

Regression analysis also was investigated as a method for estimating monthly flows; however, it was determined that local differences in runoff characteristics complicated the results. Estimates of monthly streamflows can be more accurately made by correlating with data for nearby gaged streams.

Examples are provided to familiarize users with application of the estimation methods. In addition, a summary of historical floods that have occurred both at streamflow-gaging stations and at miscellaneous sites is presented.

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Table 7a.--Streamflow stations used in the analysis

Station number	Station name
	Mountainous Regions
06037500	Madison River near West Yellowstone, Mont.
06043200	Squaw Creek near Gallatin Gateway, Mont.
06043300	Logger Creek near Gallatin Gateway, Mont.
06043500	Gallatin River near Gallatin Gateway, Mont.
06187500	Tower Creek at Tower Falls, Yellowstone National Park
06188000	Lamar River near Tower Falls ranger station, Yellowstone National Park
06191000	Gardner River near Mammoth, Yellowstone National Park
06191500	Yellowstone River at Corwin Springs, Mont.
06204050	West Rosebud Creek near Roscoe, Mont.
06205500	Clarks Fork Yellowstone River above Squaw Creek, near Painter
06206500	Sunlight Creek near Painter
06207500	Clarks Fork Yellowstone River at Chance, Mont.
06209500	Rock Creek near Red Lodge, Mont.
06218500	Wind River near Dubois
06220500	East Fork Wind River near Dubois
06221400	Dinwoody Creek above lakes, near Burris
06221500	Dinwoody Creek near Burris
06222500	Dry Creek near Burris
06222700	Crow Creek near Tipperary
06223500	Willow Creek near Crowheart
06224000	Bull Lake Creek above Bull Lake
06229000	North Fork Little Wind River at Fort Washakie
06229900	Trout Creek near Fort Washakie
06231600	Middle Popo Agie below The Sinks, near Lander
06232000	North Popo Agie River near Milford
06233000	Little Popo Agie River near Lander
06256000	Badwater Creek at Lybyer Ranch, near Lost Cabin
06260000	South Fork Owl Creek near Anchor
06260500	South Fork Owl Creek above Curtis Ranch, near Thermopolis
06262000	North Fork Owl Creek near Anchor
06265800	Gooseberry Creek at Dickie
06269700	Spring Creek near Ten Sleep
06270000	Nowood River near Ten Sleep
06270200	Leigh Creek near Ten Sleep
06270300	Canyon Creek tributary near Ten Sleep
06271000	Tensleep Creek near Ten Sleep
06272500	Paintrock Creek near Hyattville
06273000	Medicine Lodge Creek near Hyattville
06274500	Greybull River near Pitchfork
06274800	Wood River near Kirwin
06275000	Wood River at Sunshine
06276500	Greybull River at Meeteetse
06278300	Shell Creek above Shell Reservoir
06278400	Granite Creek near Shell Creek ranger station, near Shell
06278500	Shell Creek near Shell
06280300	South Fork Shoshone River near Valley

Table 7a.--Streamflow stations used in the analysis--Continued

Station number	Station name
06289000	Little Bighorn River at state line, near Wyola, Mont.
06290500	Little Bighorn River below Pass Creek, near Wyola, Mont.
06291500	Lodgegrass Creek above Willow Creek diversion, near Wyola, Mont.
06296500	North Tongue River near Dayton
06297000	South Tongue River near Dayton
06298000	Tongue River near Dayton
06298500	Little Tongue River near Dayton
06299500	Wolf Creek at Wolf
06300500	East Goose Creek near Big Horn
06300900	Cross Creek above Bighorn Reservoir, near Big Horn
06301500	West Fork Big Goose Creek near Big Horn
06309200	Middle Fork Powder River near Barnum
06309260	Buffalo Creek above North Fork Buffalo Creek, near Arminto
06309270	North Fork Buffalo Creek near Arminto
06309450	Beaver Creek below Bayer Creek, near Barnum
06309460	Beaver Creek above White Panther ditch, near Barnum
06311000	North Fork Powder River near Hazelton
06311500	North Fork Powder River near Mayoworth
06312795	Sanchez Creek above reservoir, near Arminto
06313900	Caribou Creek near Buffalo
06314000	North Fork Crazy Woman Creek near Buffalo
06315500	Middle Fork Crazy Woman Creek near Greub
06318500	Clear Creek near Buffalo
06320500	South Piney Creek at Willow Park
06321500	North Piney Creek near Story
06406800	Newton Fork near Hill City, S. Dak.
06408900	Heeley Creek near Hill City, S. Dak.
06427700	Inyan Kara Creek near Upton
06429300	Ogden Creek near Sundance
06430500	Redwater Creek at Wyo.-S. Dak. State line
06431500	Spearfish Creek at Spearfish, S. Dak.
06433500	Hay Creek at Belle Fourche, S. Dak.
06616000	North Fork Michigan River near Gould, Colo.
06620400	Douglas Creek above Keystone
06621000	Douglas Creek near Foxpark
06622500	French Creek near French
06622700	North Brush Creek near Saratoga
06623800	Encampment River above Hog Park Creek, near Encampment
06624500	Encampment River at Encampment
06625000	Encampment River at mouth, near Encampment
06628900	Pass Creek near Elk Mountain
06630800	Bear Creek near Elk Mountain
06631100	Wagonhound Creek near Elk Mountain
06632400	Rock Creek above King Canyon Canal, near Arlington
06632600	Threemile Creek near Arlington
06632700	Onemile Creek near Arlington
06634200	Sheep Creek near Marshall
06637550	Sweetwater River near South Pass City

Table 7a.--Streamflow stations used in the analysis--Continued

Station number	Station name
06637750	Rock Creek above Rock Creek Reservoir
06638300	West Fork Crooks Creek near Jeffrey City
06645150	Smith Creek above Otter Creek, near Casper
06646500	Deer Creek at Glenrock
06647500	Box Elder Creek at Boxelder
06647890	Little Box Elder Creek near Careyhurst
06661000	Little Laramie River near Filmore
06661580	Sevenmile Creek near Centennial
06664500	Sybille Creek above Bluegrass Creek, near Wheatland
06667500	North Laramie River near Wheatland
06748200	Fall Creek near Rustic, Colo.
06748510	Little Beaver Creek near Idylwilde, Colo.
06748530	Little Beaver Creek near Rustic, Colo.
06748600	South Fork Cache La Poudre River near Rustic Colo.
06754500	Middle Crow Creek near Hecla
06755000	South Crow Creek near Hecla
09188500	Green River at Warren Bridge, near Daniel
09189500	Horse Creek at Sherman ranger station
09196500	Pine Creek above Fremont Lake, near Pinedale
09198500	Pole Creek below Little Half Moon Lake, near Pinedale
09199500	Fall Creek near Pinedale
09201000	New Fork River near Boulder
09203000	East Fork River near Big Sandy
09204000	Silver Creek near Big Sandy
09204500	East Fork at Newfork
09205500	North Piney Creek near Mason
09208000	La Barge Creek near La Barge Meadows ranger station
09210500	Fontenelle Creek near Herschler Ranch, near Fontenelle
09212500	Big Sandy River at Leckie Ranch, near Big Sandy
09214000	Little Sandy Creek near Elkhorn
09216527	Separation Creek near Riner
09217900	Blacks Fork near Robertson
09218500	Blacks Fork near Millburne
09220000	East Fork of Smiths Fork near Robertson
09220500	West Fork of Smiths Fork near Robertson
09223000	Hams Fork below Pole Creek near Frontier
09224000	Hams Fork at Diamondville
09226000	Henrys Fork near Lonetree
09226500	Middle Fork Beaver Creek, near Lonetree
09227000	East Fork Beaver Creek near Lonetree
09227500	West Fork Beaver Creek near Lonetree
09228500	Burnt Fork near Burntfork
09235600	Pot Creek above diversions, near Vernal, Utah
09241000	Elk River at Clark, Colo.
09244500	Elkhead Creek near Clark, Colo.
09245000	Elkhead Creek near Elkhead Colo.
09245500	North Fork Elkhead Creek near Elkhead, Colo.
09251800	North Fork Little Snake River near Encampment
09251900	North Fork Little Snake River near Slater, Colo.

Table 7a.--Streamflow stations used in the analysis--Continued

Station number	Station name
09253000	Little Snake River near Slater, Colo.
09253400	Battle Creek near Encampment
09254500	Slater Fork at Baxter Ranch, near Slater, Colo.
09255000	Slater Fork near Slater, Colo.
09255500	Savery Creek at upper station, near Savery
09256000	Savery Creek near Savery
09257000	Little Snake River near Dixon
09258000	Willow Creek near Dixon
10010400	East Fork Bear River near Evanston
10011500	Bear River near Utah-Wyo. State line
10012000	Mill Creek at Utah-Wyo. State line
10015700	Sulphur Creek above reservoir, near Evanston
10019700	Whitney Canyon Creek near Evanston
10021000	Woodruff Creek near Woodruff, Utah
10027000	Twin Creek at Sage
10032000	Smiths Fork near Border
10040000	Thomas Fork near Geneva, Idaho
10040500	Salt Creek near Geneva, Idaho
10041000	Thomas Fork near Wyo.-Idaho State line
10047500	Montpelier Creek at weir, near Montpelier, Idaho
10058600	Bloomington Creek at Bloomington, Idaho
10069000	Georgetown Creek near Georgetown, Idaho
10128500	Weber River near Oakley, Utah
13011500	Pacific Creek at Moran
13011800	Blackrock Creek tributary near Moran
13011900	Buffalo Fork above Lava Creek, near Moran
13018300	Cache Creek near Jackson
13019220	Sour Moose Creek near Bondurant
13019400	Cliff Creek near Bondurant
13019500	Hoback River near Jackson
13020000	Fall Creek near Jackson
13021000	Cabin Creek near Jackson
13022500	Snake River above reservoir, near Alpine
13023000	Greys River above reservoir, near Alpine, Idaho
13023800	Fish Creek near Smoot
13025500	Crow Creek near Fairview
13027000	Strawberry Creek near Bedford
13027200	Bear Canyon near Freedom
13029500	McCoy Creek above reservoir, near Alpine, Idaho
13030000	Indian Creek above reservoir, near Alpine, Idaho
13030500	Elk Creek above reservoir, near Irwin, Idaho
13032000	Bear Creek above reservoir, near Irwin, Idaho
13038900	Targhee Creek near Macks Inn, Idaho
13050700	Mail Cabin Creek near Victor, Idaho
13050800	Moose Creek near Victor, Idaho

Table 7a.--Streamflow stations used in the analysis--Continued

Station number	Station name
	Plains Region
06207540	Silver Tip Creek near Belfry, Mont.
06207800	Bluewater Creek near Bridger, Mont.
06226200	Little Dry Creek near Crowheart
06226300	Dry Creek near Crowheart
06234800	Bobcat Draw near Sand Draw
06235700	Haymaker Creek near Riverton
06236000	Kirby Draw near Riverton
06238760	West Fork Dry Cheyenne Creek at upper station, near Riverton
06238780	West Fork Dry Cheyenne Creek Trip near Riverton
06239000	Muskrat Creek near Shoshoni
06255200	Dead Man Gulch near Moneta
06255300	Poison Creek tributary near Shoshoni
06255500	Poison Creek near Shoshoni
06256600	Red Creek near Arminto
06256670	Badwater Creek tributary near Lysite
06256700	South Bridger Creek near Lysite
06256800	Bridger Creek near Lysite
06256900	Dry Creek near Bonneville
06257000	Badwater Creek at Bonneville
06257500	Muddy Creek near Pavillion
06258400	Birdseye Creek near Shoshoni
06260200	Middle Fork Owl Creek above Anchor Reservoir
06265200	Sand Draw near Thermopolis
06265600	Tie Down Gulch near Worland
06266320	Gillies Draw tributary near Grass Creek
06266460	Murphy Draw near Grass Creek
06267260	North Prong East Fork Nowater Creek near Worland
06267270	North Prong East Fork Nowater Creek tributary near Worland
06267400	East Fork Nowater Creek near Colter
06268500	Fifteen Mile Creek near Worland
06274100	East Fork Sand Creek near Worland
06274190	Nowood River tributary number 2 near Basin
06274250	Elk Creek near Basin
06277700	Twentyfour Mile Creek near Emblem
06277750	Dry Creek tributary near Emblem
06279020	Red Gulch near Shell
06286258	Big Coulee near Lovell
06287500	Soap Creek near St Xavier, Mont.
06288200	Beauvais Creek near St Xavier, Mont.
06290000	Pass Creek near Wyola, Mont.
06291000	Owl Creek near Lodgegrass, Mont.
06295100	Rosebud Creek near Kirby, Mont.
06299900	Slater Creek near Monarch
06306900	Spring Creek near Decker, Mont.
06306950	Leaf Rock Creek near Kirby, Mont.
06312700	South Fork Powder River near Powder River
06312910	Dead Horse Creek tributary near Midwest

Table 7a.--Streamflow stations used in the analysis--Continued

Station number	Station name
06312920	Dead Horse Creek tributary number 2 near Midwest
06313000	South Fork Powder River near Kaycee
06313020	Bobcat Creek near Edgerton
06313050	East Teapot Creek near Edgerton
06313100	Coal Draw near Midwest
06313180	Dugout Creek tributary near Midwest
06313200	Hay Draw near Midwest
06313630	Van Houten Draw near Buffalo
06313700	Dead Horse Creek near Buffalo
06316480	Headgate Draw at upper station, near Buffalo
06316700	Coal Draw near Buffalo
06317050	Rucker Draw near Spotted Horse
06319100	Bull Creek near Buffalo
06324700	Sand Creek near Broadus, Mont.
06324800	Little Powder River tributary near Gillette
06324900	Cedar Draw near Gillette
06324910	Cow Creek tributary near Weston
06324970	Little Powder River above Dry Creek, near Weston
06325500	Little Powder River near Broadus, Mont.
06334000	Little Missouri River near Alzada, Mont.
06334100	Wolf Creek near Hammond, Mont.
06334200	Willow Creek near Alzada, Mont.
06334500	Little Missouri River at Camp Crook, S. Dak.
06358550	Battle Creek tributary near Castle Rock, S. Dak.
06358600	South Fork Moreau River tributary near Redig, S. Dak.
06358620	Sand Creek tributary near Redig, S. Dak.
06378640	Lance Creek tributary near Lance Creek
06379600	Box Creek near Bill
06382200	Pritchard Draw near Lance Creek
06386000	Lance Creek at Spencer
06386500	Cheyenne River near Spencer
06387500	Turner Creek near Osage
06388800	Blacktail Creek tributary near Newcastle
06394000	Beaver Creek near Newcastle
06396200	Fiddle Creek near Edgemont, S. Dak.
06396300	Cottonwood Creek tributary near Edgemont, S. Dak.
06396350	Red Canyon Creek tributary near Pringle, S. Dak.
06399300	Hat Creek tributary near Ardmore, S. Dak.
06399700	Pine Creek near Ardmore, S. Dak.
06400000	Hat Creek near Edgemont, S. Dak.
06400900	Horsehead Creek tributary near Smithwick, S. Dak.
06404000	Battle Creek near Keystone, S. Dak.
06406000	Battle Creek at Hermosa, S. Dak.
06422500	Boxelder Creek near Nemo, S. Dak.
06425720	Belle Fourche River below Rattlesnake Creek, near Piney
06426195	Donkey Creek tributary above reservoir, near Gillette
06426500	Belle Fourche River below Moorcroft
06432200	Polo Creek near Whitewood, S. Dak.
06432230	Miller Creek near Whitewood, S. Dak.
06434800	Owl Creek tributary near Belle Fourche, S. Dak.
06436500	Horse Creek near Newell, S. Dak.

Table 7a.--Streamflow stations used in the analysis--Continued

Station number	Station name
06436700	Indian Creek near Arpan, S. Dak.
06436770	Dry Creek tributary near Newell, S. Dak.
06437100	Boulder Creek near Deadwood, S. Dak.
06443200	White River tributary near Glen, Nebr.
06443300	Deep Creek near Glen, Nebr.
06443700	Soldiers Creek near Crawford, Nebr.
06444000	White River at Crawford, Nebr.
06454000	Niobrara River at Wyoming-Nebraska State line
06456200	Pebble Creek near Esther, Nebr.
06644200	Clarks Gulch near Natrona
06644840	McKenzie Draw tributary near Casper
06646700	East Fork Dry Creek tributary near Glenrock
06648720	Frank Draw tributary near Orpha
06648780	Sage Creek tributary near Orpha
06649900	North Platte River tributary near Douglas
06651800	Sand Creek near Orin
06652400	Watkins Draw near Lost Springs
06668040	Rabbit Creek near Wheatland
06671000	Rawhide Creek near Lingle
06675300	Horse Creek tributary near Little Bear
06677500	Horse Creek near Lyman, Nebr.
06679000	Dry Spottedtail Creek at Mitchell, Nebr.
06761900	Lodgepole Creek tributary near Pine Bluffs
06762500	Lodgepole Creek at Bushnell, Nebr.
06762600	Lodgepole Creek tributary number 2 near Albin
	High Desert Region
06218700	Wagon Gulch near Dubois
06229700	Norkok Meadows Creek near Fort Washakie
06233360	Monument Draw at lower station, near Hudson
06234700	South Fork Hall Creek near Lander
06629150	Coal Bank Draw tributary near Walcott
06629200	Coal Bank Draw tributary number 2 near Walcott
06629800	Coal Creek near Rawlins
06630200	Big Ditch tributary near Hanna
06631150	Third Sand Creek near Medicine Bow
06634600	Little Medicine Bow River near Medicine Bow
06634910	Medicine Bow River tributary near Hanna
06634950	Willow Springs Draw tributary near Hanna
06634990	Hanna Draw near Hanna
06636500	Sage Creek above Pathfinder Reservoir
06638350	Coal Creek near Muddy Gap
06641400	Bear Springs Creek near Alcova
06642700	Lawn Creek near Alcova
06642730	Stinking Creek tributary near Alcova
06642760	Stinking Creek near Alcova
06643300	Coal Creek near Goose Egg
09204700	Sand Springs Draw tributary near Boulder

Table 7a.--Streamflow stations used in the analysis--Continued

Station number	Station name
09207650	Dry Basin Creek near Big Piney
09215000	Pacific Creek near Farson
09216290	East Otterson Wash near Green River
09216350	Skunk Canyon Creek near Green River
09216400	Greasewood Canyon near Green River
09216537	Delaney Draw near Red Desert
09216545	Bitter Creek near Bitter Creek
09216550	Deadman Wash near Point of Rocks
09216560	Bitter Creek near Point of Rocks
09216562	Bitter Creek above Salt Wells Creek, near Salt Wells
09216565	Salt Wells Creek near South Baxter
09216580	Big Flat Draw near Rock Springs
09216600	Cutthroat Draw near Rock Springs
09216695	No Name Creek near Rock Springs
09216700	Salt Wells Creek near Rock Springs
09216750	Salt Wells Creek near Salt Wells
09221680	Mud Spring Hollow near Church Butte, near Lyman
09222400	Muddy Creek near Hampton
09224600	Blacks Fork tributary near Granger
09224800	Meadow Springs Wash tributary near Green River
09224810	Blacks Fork tributary number 2 near Green River
09224820	Blacks Fork tributary number 3 near Green River
09224840	Blacks Fork tributary number 4 near Green River
09224980	Summers Dry Creek near Green River
09225200	Squaw Hollow near Burntfork
09225300	Green River tributary number 2 near Burntfork
09229450	Henrys Fork tributary near Manila, Utah
09258200	Dry Cow Creek near Baggs
09258900	Muddy Creek above Baggs

Table 7b.--Streamflow characteristics at gaged sites

[Q_a, mean annual flow, in cubic feet per second; P_t, annual peak flow, in cubic feet per second, with subscript t designating the recurrence interval, in years; --, data either not available or not applicable. The peak flows listed are estimates based on a Pearson Type III probability distribution of gaged discharges. See table 7a for name of stream and plate 1c for location of streamflow-gaging station]

Station number	Q_a	P_2	P_5	P_{10}	P_{25}	P_{50}	P_{100}	P_{200}	P_{500}
Mountainous Regions									
06037500	489	1,340	1,620	1,790	1,960	2,080	2,190	2,290	2,410
06043200	--	265	396	492	621	723	830	943	1,100
06043300	--	15.6	26.0	34.3	46.3	56.4	67.5	79.7	97.7
06043500	814	5,090	6,650	7,650	8,890	9,800	10,700	11,600	12,800
06187500	47.2	320	470	565	680	761	839	915	1,010
06188000	829	8,490	10,500	11,600	12,900	13,800	14,600	15,300	16,200
06191000	220	1,120	1,510	1,760	2,060	2,270	2,480	2,690	2,970
06191500	3,112	17,500	22,000	24,500	27,400	29,200	31,000	32,600	34,500
06204050	129	789	1,170	1,440	1,810	2,100	2,410	2,740	3,200
06205500	420	--	--	--	--	--	--	--	--
06206500	126	1,180	1,480	1,680	1,920	2,100	2,280	2,460	2,700
06207500	953	7,710	9,410	10,400	11,700	12,500	13,300	14,200	15,200
06209500	174	1,230	1,710	2,020	2,420	2,710	3,000	3,300	3,680
06218500	178	1,230	1,540	1,710	1,910	2,050	2,180	2,290	2,440
06220500	273	3,870	5,210	6,000	6,910	7,530	8,100	8,640	9,310
06221400	142	945	1,120	1,240	1,370	1,470	1,570	1,670	1,790
06221500	--	999	1,220	1,350	1,510	1,630	1,740	1,850	1,990
06222500	45.0	418	698	905	1,190	1,410	1,640	1,880	2,220
06222700	22.0	318	420	478	542	585	624	660	703
06223500	15.7	211	403	572	837	1,080	1,350	1,670	2,170
06224000	299	2,270	2,840	3,190	3,600	3,890	4,160	4,440	4,780
06229000	115	1,090	1,710	2,130	2,680	3,090	3,500	3,910	4,460
06229900	--	101	213	309	452	573	705	850	1,060
06231600	123	1,340	2,100	2,650	3,390	3,960	4,570	5,190	6,060
06232000	122	1,190	1,850	2,360	3,090	3,690	4,340	5,040	6,080
06233000	80.4	714	1,110	1,370	1,680	1,900	2,120	2,320	2,590
06256000	--	161	369	574	928	1,270	1,690	2,190	3,030

Table 7b.--Streamflow characteristics at gaged sites--Continued

Station number	Q_a	P_2	P_5	P_{10}	P_{25}	P_{50}	P_{100}	P_{200}	P_{500}
06260000	33.8	483	785	1,030	1,380	1,690	2,030	2,410	2,980
06260500	26.5	592	950	1,220	1,580	1,880	2,190	2,520	2,990
06262000	13.7	304	748	1,230	2,140	3,100	4,350	5,980	8,870
06265800	13.7	247	437	597	838	1,050	1,290	1,560	1,980
06269700	--	102	206	290	407	502	601	704	847
06270000	121	1,210	2,090	2,770	3,720	4,490	5,310	6,190	7,450
06270200	--	56.8	111	158	229	292	362	440	559
06270300	--	17.0	24.1	28.5	33.7	37.3	40.7	43.9	48.0
06271000	146	1,630	2,170	2,510	2,940	3,240	3,550	3,850	4,240
06272500	146	2,240	3,150	3,860	4,860	5,700	6,620	7,630	9,130
06273000	34.3	466	640	763	926	1,050	1,190	1,320	1,520
06274500	182	2,080	3,300	4,280	5,720	6,960	8,330	9,870	12,200
06274800	12.3	--	--	--	--	--	--	--	--
06275000	114	1,160	1,950	2,550	3,370	4,020	4,720	5,450	6,470
06276500	333	4,010	6,390	8,120	10,500	12,300	14,200	16,200	19,000
06278300	36.5	783	961	1,080	1,250	1,380	1,510	1,650	1,850
06278400	--	253	313	353	403	440	478	516	567
06278500	117	1,410	1,810	2,090	2,450	2,730	3,020	3,320	3,730
06280300	425	4,030	5,180	5,990	7,080	7,940	8,830	9,770	11,100
06289000	155	1,050	1,480	1,780	2,190	2,500	2,840	3,190	3,680
06290500	215	1,280	2,050	2,700	3,690	4,580	5,600	6,770	8,610
06291500	49.9	435	624	760	945	1,090	1,250	1,410	1,650
06296500	34.6	256	376	466	591	693	802	919	1,090
06297000	78.8	882	1,190	1,380	1,630	1,810	1,990	2,170	2,400
06298000	187	1,690	2,280	2,640	3,060	3,360	3,640	3,910	4,260
06298500	13.0	123	228	316	448	564	693	838	1,060
06299500	29.3	305	480	621	832	1,010	1,220	1,450	1,800
06300500	32.6	528	716	852	1,040	1,190	1,350	1,520	1,770
06300900	13.2	165	205	230	261	284	307	329	360
06301500	34.3	--	--	--	--	--	--	--	--
06309200	32.4	645	1,090	1,490	2,130	2,730	3,450	4,310	5,710
06309260	3.26	--	--	--	--	--	--	--	--
06309270	5.26	--	--	--	--	--	--	--	--
06309450	7.55	--	--	--	--	--	--	--	--
06309460	15.9	--	--	--	--	--	--	--	--
06311000	14.8	293	422	514	639	738	842	952	1,110

Table 7b.--Streamflow characteristics at gaged sites--Continued

Station number	Q_a	P_2	P_5	P_{10}	P_{25}	P_{50}	P_{100}	P_{200}	P_{500}
06311500	32.7	424	678	863	1,110	1,310	1,520	1,740	2,040
06312795	--	9.8	28.3	50.6	95.6	146	215	308	480
06313900	--	72.5	129	175	242	298	359	426	524
06314000	24.8	--	--	--	--	--	--	--	--
06315500	22.3	292	617	954	1,570	2,210	3,050	4,140	6,070
06318500	61.5	686	1,050	1,320	1,700	2,020	2,350	2,710	3,220
06320500	--	422	649	816	1,050	1,230	1,430	1,640	1,940
06321500	38.8	468	748	977	1,320	1,620	1,950	2,330	2,910
06406800	--	24.0	45.0	62.0	90.0	114	143	--	--
06408900	--	8.0	18.0	28.0	44.0	61.0	80.0	--	--
06427700	--	145	405	739	1,470	2,360	3,680	5,610	9,540
06429300	--	25.0	79.5	145	272	409	589	821	1,230
06430500	32.78	287	766	1,290	2,250	3,220	4,470	6,030	8,690
06431500	46.34	268	728	1,340	2,730	4,500	7,250	11,400	20,500
06433500	0.83	60.6	193	355	682	1,040	1,520	2,160	3,290
06616000	17.0	188	245	278	317	343	368	392	422
06620400	33.0	555	703	796	909	990	1,070	1,150	1,250
06621000	78.7	956	1,280	1,470	1,690	1,840	1,980	2,100	2,260
06622500	88.4	989	1,360	1,580	1,830	2,010	2,170	2,320	2,510
06622700	50.0	600	801	938	1,110	1,250	1,380	1,520	1,720
06623800	117	1,040	1,310	1,470	1,660	1,780	1,900	2,020	2,160
06624500	298	2,870	3,650	4,150	4,760	5,200	5,640	6,070	6,650
06625000	240	2,240	2,970	3,400	3,890	4,230	4,550	4,850	5,220
06628900	39.9	518	741	881	1,050	1,170	1,280	1,390	1,530
06630800	--	55.4	89.1	112	140	161	181	201	226
06631100	--	236	300	337	378	406	432	457	487
06632400	90.1	1,440	2,010	2,370	2,810	3,120	3,420	3,720	4,110
06632600	--	99.5	190	272	406	530	680	858	1,140
06632700	--	56.8	105	143	197	242	290	341	414
06634200	--	650	991	1,230	1,540	1,780	2,030	2,280	2,620
06637550	65.4	664	994	1,200	1,460	1,640	1,820	1,980	2,200
06637750	8.69	113	151	175	203	224	244	263	288
06638300	--	25.7	73.4	123	210	293	391	508	690
06645150	3.13	--	--	--	--	--	--	--	--
06646500	56.9	770	1,270	1,650	2,190	2,620	3,100	3,600	4,340
06647500	38.1	584	1,060	1,490	2,220	2,920	3,780	4,820	6,550

Table 7b.--Streamflow characteristics at gaged sites--Continued

Station number	Q_a	P_2	P_5	P_{10}	P_{25}	P_{50}	P_{100}	P_{200}	P_{500}
06647890	1.38	--	--	--	--	--	--	--	--
06661000	103	1,110	1,560	1,850	2,210	2,460	2,710	2,950	3,260
06661580	--	91.9	185	269	405	531	679	854	1,130
06664500	--	393	1,080	1,820	3,150	4,470	6,100	8,080	11,300
06667500	--	482	1,390	2,460	4,640	7,050	10,300	14,800	22,900
06748200	--	58.0	77.0	89.0	104	114	124	133	146
06748510	--	14.0	21.0	25.0	30.0	34.0	38.0	42.0	47.0
06748530	--	79.0	118	145	180	206	233	259	295
06748600	--	516	734	877	1,050	1,190	1,320	1,440	1,620
06754500	--	53.9	115	171	263	348	449	567	753
06755000	--	17.2	37.5	57.3	91.4	125	165	215	298
09188500	508	2,890	3,590	4,020	4,520	4,880	5,220	5,560	5,990
09189500	69.7	1,100	1,390	1,580	1,820	1,990	2,160	2,340	2,570
09196500	177	1,670	1,960	2,130	2,340	2,490	2,640	2,780	2,970
09198500	109	941	1,130	1,240	1,350	1,420	1,490	1,540	1,610
09199500	40.0	428	551	619	694	742	786	826	873
09201000	392	2,680	3,930	4,780	5,880	6,710	7,550	8,410	9,570
09203000	104	1,300	1,550	1,680	1,800	1,880	1,940	2,000	2,060
09204000	44.1	725	887	976	1,070	1,140	1,190	1,240	1,310
09204500	171	2,210	2,830	3,170	3,520	3,740	3,940	4,110	4,300
09205500	57.1	398	530	606	691	749	801	850	909
09208000	14.4	132	164	183	206	222	236	251	269
09210500	72.7	483	659	763	882	962	1,040	1,100	1,190
09212500	86.0	913	1,200	1,380	1,600	1,760	1,910	2,050	2,240
09214000	--	201	260	295	336	363	390	414	446
09216527	1.36	--	--	--	--	--	--	--	--
09217900	155	1,550	1,990	2,240	2,510	2,690	2,860	3,010	3,200
09218500	155	1,470	1,840	2,070	2,350	2,560	2,760	2,960	3,220
09220000	47.1	501	738	916	1,160	1,370	1,590	1,820	2,160
09220500	21.5	442	708	912	1,200	1,430	1,690	1,960	2,360
09223000	101	839	1,110	1,260	1,400	1,490	1,570	1,640	1,710
09224000	163	1,460	2,230	2,720	3,300	3,710	4,090	4,460	4,920
09226000	43.0	583	900	1,150	1,500	1,790	2,110	2,460	2,980
09226500	34.2	316	490	610	764	880	996	1,110	1,270
09227000	7.19	--	--	--	--	--	--	--	--
09227500	16.2	168	254	315	396	460	525	592	686

Table 7b.--Streamflow characteristics at gaged sites--Continued

Station number	Q_a	P_2	P_5	P_{10}	P_{25}	P_{50}	P_{100}	P_{200}	P_{500}
09228500	30.2	287	506	687	960	1,200	1,470	1,770	2,220
09235600	3.53	66.5	129	182	263	333	411	499	631
09241000	329	2,650	3,260	3,600	3,990	4,250	4,500	4,730	5,010
09244500	35.8	647	898	1,050	1,240	1,370	1,500	1,620	1,770
09245000	53.7	942	1,230	1,400	1,590	1,720	1,850	1,970	2,120
09245500	17.3	412	655	822	1,030	1,190	1,350	1,510	1,710
09251800	25.7	371	468	527	598	647	695	741	801
09251900	44.2	--	--	--	--	--	--	--	--
09253000	227	2,200	2,890	3,280	3,720	4,000	4,260	4,500	4,780
09253400	27.5	--	--	--	--	--	--	--	--
09254500	--	633	803	901	1,010	1,090	1,160	1,230	1,310
09255000	73.7	846	1,170	1,380	1,650	1,840	2,030	2,220	2,470
09255500	45.0	465	840	1,130	1,550	1,890	2,250	2,640	3,200
09256000	104	1,170	1,650	1,950	2,300	2,540	2,760	2,980	3,250
09257000	514	4,660	6,140	7,050	8,110	8,860	9,570	10,200	11,100
09258000	9.65	143	218	266	325	366	405	443	491
10010400	50.2	--	--	--	--	--	--	--	--
10011500	187.1	1,830	2,310	2,590	2,900	3,120	3,310	3,500	3,730
10012000	32.0	391	544	642	760	845	927	1,010	1,110
10015700	11.8	365	545	681	871	1,030	1,190	1,370	1,640
10019700	--	46.9	88.0	121	169	209	253	300	368
10021000	27.1	263	368	427	493	535	573	606	647
10027000	--	243	521	739	1,030	1,260	1,490	1,720	2,020
10032000	192	963	1,220	1,350	1,500	1,590	1,680	1,750	1,830
10040000	17.2	147	250	326	428	506	587	670	783
10040500	20.2	165	294	386	506	595	684	772	887
10041000	52.4	441	790	1,020	1,300	1,500	1,680	1,850	2,050
10047500	21.4	--	--	--	--	--	--	--	--
10058600	27.2	146	202	232	265	285	302	318	335
10069000	31.4	--	--	--	--	--	--	--	--
10128500	220	1,820	2,390	2,740	3,160	3,460	3,750	4,030	4,390
13011500	266	2,410	2,940	3,250	3,600	3,840	4,050	4,260	4,510
13011800	--	42.4	62.9	77.9	98.3	115	132	150	176
13011900	563	4,250	4,870	5,200	5,570	5,810	6,030	6,230	6,480
13018300	13.6	84.2	123	152	190	220	251	285	331
13019220	--	15.3	20.6	23.9	27.7	30.4	33.0	35.5	38.6

Table 7b.--Streamflow characteristics at gaged sites--Continued

Station number	Q_a	P_2	P_5	P_{10}	P_{25}	P_{50}	P_{100}	P_{200}	P_{500}
13019400	--	607	835	987	1,180	1,330	1,470	1,620	1,820
13019500	706	3,820	4,800	5,370	6,020	6,460	6,870	7,250	7,730
13020000	--	387	506	587	689	766	844	924	1,030
13021000	--	128	164	183	204	217	229	240	253
13022500	4,567	18,400	22,900	25,500	28,400	30,400	32,200	33,900	36,000
13023000	622	3,420	4,570	5,280	6,110	6,690	7,240	7,770	8,450
13023800	--	47.3	74.7	91.6	111	124	136	147	160
13025500	60.4	--	--	--	--	--	--	--	--
13027000	62.4	262	320	354	393	420	445	468	498
13027200	--	44.3	83.5	114	156	189	224	260	311
13029500	81.4	895	1,240	1,440	1,690	1,850	2,010	2,160	2,350
13030000	13.7	207	268	304	345	373	400	425	457
13030500	69.0	476	618	702	799	865	928	987	1,060
13032000	74.8	499	650	740	844	915	982	1,050	1,120
13038900	--	273	341	379	423	452	479	505	537
13050700	--	38.8	51.3	58.8	67.5	73.5	79.2	84.6	91.4
13050800	--	281	338	371	407	431	453	473	498
Plains Region									
06207540	--	208	701	1,300	2,460	3,680	5,270	7,280	10,700
06207800	28.2	98.1	259	454	860	1,330	2,000	2,950	4,810
06226200	--	96.0	329	604	1,120	1,660	2,330	3,150	4,500
06226300	--	270	497	674	919	1,120	1,320	1,540	1,850
06234800	--	68.0	272	542	1,100	1,720	2,540	3,610	5,460
06235700	--	321	839	1,370	2,310	3,210	4,320	5,640	7,790
06236000	--	268	770	1,360	2,540	3,830	5,570	7,880	12,100
06238760 s	0.04	51.0	98.0	139	202	259	323	400	500
06238780 s	0.07	68.0	145	219	345	466	615	790	940
06239000	3.53	781	2,020	3,370	5,870	8,450	11,800	16,000	23,200
06255200	--	321	706	1,050	1,600	2,080	2,630	3,260	4,200
06255300	--	18.7	58.2	102	182	261	358	475	663
06255500	--	467	2,020	4,080	8,220	12,600	18,200	25,100	36,400
06256600	--	100	220	331	510	673	864	1,080	1,430
06256670 s	0.10	198	430	644	992	1,310	1,683	2,100	2,800
06256700	--	54.2	154	260	450	636	864	1,140	1,590

Table 7b.--Streamflow characteristics at gaged sites--Continued

Station number	Q_a	P_2	P_5	P_{10}	P_{25}	P_{50}	P_{100}	P_{200}	P_{500}
06256800	--	226	615	1,020	1,710	2,380	3,190	4,140	5,650
06256900	2.85	181	502	854	1,500	2,170	3,010	4,060	5,850
06257000	22.8	1,580	3,820	6,040	9,820	13,400	17,800	22,900	31,300
06257500	--	395	985	1,550	2,480	3,330	4,310	5,430	7,150
06258400	--	221	401	534	711	846	984	1,120	1,310
06260200	0.51	--	--	--	--	--	--	--	--
06265200	--	155	585	1,130	2,240	3,430	4,980	6,960	10,400
06265600	--	100	206	295	429	543	668	805	1,000
06266320 s	0.02	125	264	395	613	818	1,060	1,330	1,770
06266460 s	0.07	189	355	500	725	926	1,158	1,420	1,830
06267260 s	0.08	309	650	950	1,420	1,820	2,280	2,800	3,600
06267270	--	166	351	518	785	1,020	1,300	1,630	2,120
06267400	5.88	599	1,180	1,710	2,560	3,340	4,250	5,320	7,020
06268500	10.7	1,120	1,900	2,490	3,330	4,020	4,760	5,540	6,670
06274100	--	642	1,530	2,510	4,350	6,320	8,920	12,400	18,500
06274190 s	0.02	105	205	286	404	501	606	710	860
06274250	--	1,150	2,270	3,200	4,600	5,800	7,120	8,580	10,700
06277700	--	86.4	309	611	1,280	2,080	3,240	4,880	8,040
06277750	--	56.6	117	169	250	321	402	492	628
06279020	--	217	664	1,250	2,540	4,100	6,400	9,720	16,400
06286258	0.09	174	1,010	2,460	6,210	11,100	18,700	29,900	52,200
06287500	30.6	406	931	1,500	2,600	3,780	5,360	7,480	11,300
06288200	23.6	567	1,160	1,730	2,670	3,560	4,640	5,940	8,060
06290000	36.1	306	591	869	1,350	1,830	2,440	3,190	4,500
06291000	10.2	215	533	868	1,470	2,090	2,860	3,830	5,480
06295100	--	86.4	203	314	495	662	857	1,080	1,430
06299900	--	258	691	1,180	2,100	3,080	4,370	6,040	8,980
06306900	0.89	83.0	313	621	1,280	2,040	3,100	4,530	7,170
06306950	--	19.6	105	236	526	859	1,310	1,900	2,910
06312700 h	--	570	1,060	1,560	2,470	3,430	4,690	6,360	9,390
06312910 s	0.30	223	386	524	733	917	1,130	1,350	1,710
06312920 s	0.11	227	411	565	798	1,000	1,230	1,470	1,850
06313000	35.7	2,760	7,680	13,400	24,400	36,300	52,100	72,900	110,000
06313020 s	0.06	54.2	326	787	1,930	3,370	5,470	8,430	14,000
06313050	--	418	997	1,580	2,610	3,610	4,840	6,300	8,700
06313100	--	660	1,660	2,680	4,460	6,190	8,330	10,900	15,100

Table 7b.--Streamflow characteristics at gaged sites--Continued

Station number	Q_a	P_2	P_5	P_{10}	P_{25}	P_{50}	P_{100}	P_{200}	P_{500}
06313180	0.23	277	473	617	813	968	1,130	1,290	1,470
06313200	--	294	631	933	1,400	1,820	2,300	2,840	3,650
06313630	--	447	1,510	2,840	5,540	8,520	12,500	17,800	27,100
06313700	--	1,040	1,790	2,330	3,050	3,600	4,160	4,720	5,490
06316480 s	0.07	289	773	1,310	2,330	3,400	4,790	6,400	9,200
06316700 h	--	143	538	1,040	2,030	3,090	4,470	6,210	9,170
06317050	--	84.3	335	696	1,530	2,570	4,100	6,300	10,600
06319100	--	52.7	399	1,130	3,370	6,780	12,700	22,300	44,000
06324700	--	19.7	81.4	163	330	511	747	1,050	1,560
06324800	--	9.0	23.6	40.6	74.4	112	163	233	363
06324900	--	140	293	431	650	846	1,070	1,330	1,740
06324910	--	59.3	180	317	572	833	1,160	1,570	2,260
06324970	28.0	--	--	--	--	--	--	--	--
06325500	39.6	1,120	1,750	2,170	2,690	3,070	3,450	3,820	4,300
06334000	77.2	1,890	3,270	4,240	5,470	6,390	7,290	8,180	9,330
06334100	--	233	536	784	1,130	1,400	1,670	1,940	2,310
06334200	--	640	1,170	1,570	2,120	2,560	3,010	3,470	4,110
06334500	125	2,540	4,810	6,510	8,780	10,500	12,300	14,000	16,400
06358550	--	154	326	474	701	902	1,120	--	--
06358600	--	53.6	124	192	302	405	526	666	887
06358620	--	21.0	36.0	46.0	61.0	73.0	85.0	98.0	117
06378640 s	0.08	54.2	234	534	1,350	2,530	4,530	7,840	15,500
06379600	--	91.9	505	1,230	3,190	5,890	10,200	17,000	31,400
06382200 s	0.29	610	1,160	1,660	2,450	3,180	4,030	5,000	6,700
06386000	26.0	1,830	3,540	4,970	7,120	8,960	11,000	13,300	16,600
06386500	58.2	3,160	6,770	10,300	16,200	21,900	28,900	37,400	51,300
06387500	--	1,350	2,460	3,380	4,740	5,910	7,210	8,650	10,800
06388800	--	43.1	80.5	108	146	175	204	234	273
06394000	32.6	1,000	1,860	2,700	4,210	5,750	7,730	10,300	14,800
06396200	--	13.6	45.7	90.4	195	327	529	832	1,460
06396300	--	24.0	46.0	64.0	92.0	116	145	--	--
06396350	--	26.0	61.0	92.0	141	185	235	--	--
06399300	--	137	257	408	794	1,360	2,350	6,950	14,600
06399700	--	709	1,060	1,340	1,760	2,130	2,540	3,010	3,720
06400000	22.3	830	2,230	3,940	7,510	11,600	17,500	25,800	42,000
06400900	--	15.0	34.0	56.0	102	159	250	--	--

Table 7b.--Streamflow characteristics at gaged sites--Continued

Station number	Q_a	P_2	P_5	P_{10}	P_{25}	P_{50}	P_{100}	P_{200}	P_{500}
06404000	--	268	898	1,760	3,700	6,090	9,630	14,800	25,200
06406000	9.06	301	998	1,760	3,070	4,300	5,730	7,360	9,810
06422500	--	191	630	1,220	2,560	4,210	6,660	10,200	17,400
06425720	3.16	--	--	--	--	--	--	--	--
06426195	--	26.5	64.5	99.0	152	198	249	304	383
06426500	24.1	797	1,740	2,770	4,720	6,830	9,660	13,500	20,400
06432200	--	189	515	868	1,510	2,160	2,980	4,000	5,700
06432230	--	13.0	79.0	201	541	1,020	1,810	3,050	5,740
06434800	--	105	174	225	296	356	422	--	--
06436500	--	362	1,860	4,350	10,700	19,100	32,000	51,300	90,800
06436700	--	578	2,060	3,990	8,040	12,600	18,900	27,400	42,800
06436770	--	7.0	15.0	23.0	35.0	47.0	61.0	--	--
06437100	--	44.0	92.0	136	210	281	366	576	791
06443200	--	27.0	161	452	1,460	3,240	6,800	13,700	33,200
06443300	--	26.0	145	392	1,210	2,610	5,340	10,500	24,500
06443700	--	90.0	606	1,810	6,240	14,500	31,800	66,900	170,000
06444000	20.2	362	842	1,360	2,360	3,430	4,860	6,760	10,200
06454000	4.35	66.7	260	557	1,300	2,310	3,930	6,450	12,000
06456200	--	8.7	62.0	194	699	1,670	3,780	8,180	21,500
06644200	--	131	403	743	1,450	2,250	3,370	4,900	7,770
06644840 s	0.04	84.0	218	366	650	952	1,350	1,870	2,800
06646700	--	52.4	135	225	398	580	820	1,130	1,680
06648720 s	0.04	38.0	104	178	319	468	664	910	1,370
06648780 s	0.02	49.0	117	186	307	424	568	730	1,020
06649900	--	130	409	751	1,440	2,200	3,230	4,600	7,050
06651800 h	--	648	1,630	2,740	4,890	7,220	10,400	14,520	22,120
06652400	--	53.8	176	350	768	1,310	2,170	3,510	6,400
06668040	--	30.2	71.4	113	187	261	352	465	653
06671000	--	199	521	919	1,770	2,770	4,240	6,350	10,600
06675300	--	24.2	59.5	96.5	164	231	318	425	609
06677500	--	675	1,280	1,840	2,780	3,680	4,780	6,130	8,360
06679000	--	343	717	1,110	1,820	2,570	3,550	4,840	7,150
06761900	--	28.6	53.9	74.6	105	131	159	190	236
06762500	--	186	876	2,130	5,860	11,600	22,100	40,500	86,500
06762600	--	83.4	273	476	820	1,140	1,500	1,910	2,510

Table 7b.--Streamflow characteristics at gaged sites--Continued

Station number	Q_a	P_2	P_5	P_{10}	P_{25}	P_{50}	P_{100}	P_{200}	P_{500}
High Desert Region									
06218700	--	79.5	165	243	370	487	625	787	1,040
06229700	--	21.2	68.6	126	242	366	532	748	1,130
06233360 s	0.07	232	502	736	1,090	1,400	1,740	2,080	2,570
06234700	--	40.9	113	179	278	361	449	540	666
06629150	--	85.6	215	359	634	927	1,320	1,830	2,750
06629200	--	69.6	208	368	676	1,000	1,420	1,960	2,900
06629800	--	30.8	69.8	109	177	243	326	427	596
06630200	--	92.6	295	499	826	1,110	1,420	1,760	2,220
06631150 hs	0.23	264	572	869	1,370	1,860	2,450	3,160	4,330
06634600	60.3	--	--	--	--	--	--	--	--
06634910 s	0.12	180	367	549	865	1,180	1,560	2,000	2,800
06634950 s	0.03	96	225	335	495	625	762	930	1,140
06634990	0.41	--	--	--	--	--	--	--	--
06636500	18.7	235	550	859	1,390	1,890	2,500	3,220	4,400
06638350	--	44.4	117	192	322	447	599	780	1,070
06641400	--	126	280	422	652	861	1,100	1,380	1,810
06642700	--	133	505	1,030	2,220	3,670	5,800	8,830	14,800
06642730 h	--	119	335	540	861	1,140	1,440	1,760	2,220
06642760	--	657	1,660	2,630	4,230	5,710	7,420	9,400	12,400
06643300	--	84.8	184	271	406	523	654	800	1,020
09204700	--	10.8	29.7	48.5	79.9	109	142	180	238
09207650	--	130	261	364	511	629	752	881	1,060
09215000	4.98	265	557	789	1,110	1,360	1,620	1,880	2,240
09216290	--	154	316	458	680	876	1,100	1,360	1,740
09216350	--	17.5	55.1	104	209	333	512	764	1,260
09216400	--	73.6	150	209	290	352	415	478	562
09216537 h	--	81.0	227	396	730	1,090	1,570	2,210	3,360
09216545	4.08	--	--	--	--	--	--	--	--
09216550	--	404	743	1,010	1,380	1,680	2,000	2,340	2,820
09216560	--	448	970	1,410	2,070	2,630	3,230	3,870	4,800
09216562	7.38	--	--	--	--	--	--	--	--
09216565	1.3	--	--	--	--	--	--	--	--
09216580	--	69.6	163	241	354	446	542	641	776
09216600	--	95.6	193	281	422	550	700	874	1,150

Table 7b.--Streamflow characteristics at gaged sites--Continued

Station number	Q_a	P_2	P_5	P_{10}	P_{25}	P_{50}	P_{100}	P_{200}	P_{500}
09216695	--	80.1	181	275	427	564	724	907	1,190
09216700 h	--	1,100	2,020	2,680	3,510	4,130	4,740	5,330	6,090
09216750	4.13	--	--	--	--	--	--	--	--
09221680 s	0.12	151	352	569	982	1,420	2,010	2,750	4,200
09222400	37.3	--	--	--	--	--	--	--	--
09224600	--	95.8	204	303	462	606	773	966	1,270
09224800	--	41.3	99.9	148	216	268	321	373	442
09224810 h	--	22.0	71.0	130	242	361	513	706	1,040
09224820	--	20.1	70.9	131	242	354	491	657	923
09224840 h	--	16.0	31.0	46.0	71.0	95.0	126	165	231
09224980 h	--	625	1,610	2,560	4,120	5,550	7,190	9,060	11,900
09225200	--	109	232	339	499	636	787	953	1,190
09225300	--	276	1,020	1,890	3,460	4,960	6,750	8,810	11,900
09229450	--	24.3	101	205	427	677	1,020	1,460	2,250
09258200	--	291	588	816	1,120	1,360	1,600	1,840	2,160
09258900	--	662	1,340	1,890	2,660	3,300	3,970	4,670	5,660

s Mean annual flow estimated from records of seasonal gages.

h Peak-flow characteristics were significantly adjusted through the use of historical flood data.

Table 7c.--Basin characteristics and channel width

[A = contributing drainage area, in square miles; S_B = basin slope, in feet per mile; ELEV = mean basin elevation, in feet; PR = average annual precipitation, in inches; WIDTH = channel width, in feet; G_f = geographic factor; --, data either not available or not applicable]

Station number	A	S_B	ELEV	PR	WIDTH	G_f
			Mountainous Regions			
06037500	420	--	7,920	20	92	--
06043200	40.4	--	7,440	35	--	--
06043300	2.48	--	7,120	30	--	--
06043500	825	--	7,960	37	--	--
06187500	50.4	--	8,340	28	--	--
06188000	660	--	7,400	34	128	--
06191000	202	--	7,940	30	56	--
06191500	2,623	--	8,440	33	--	--
06204050	52.1	--	9,560	55	--	--
06205500	194	--	8,760	25	--	--
06206500	135	--	8,500	25	53	--
06207500	1,154	--	7,430	17	180	--
06209500	124	--	9,540	40	--	--
06218500	232	--	8,920	20	54	--
06220500	427	--	9,140	20	--	--
06221400	88.2	--	10,500	25	74	--
06221500	100	--	10,200	22	--	--
06222500	53.2	--	10,100	22	--	--
06222700	30.2	--	9,950	18	24	--
06223500	55.4	--	8,720	17	--	--
06224000	187	--	10,300	25	--	--
06229000	127	--	9,620	21	--	--
06229900	16.1	794	9,620	15	--	--
06231600	87.5	--	9,920	20	--	--
06232000	98.4	--	9,890	22	--	--
06233000	125	--	8,020	18	--	--
06256000	131	1,480	7,320	14	24	--
06260000	87.0	--	9,530	21	37	--
06260500	144	--	8,750	19	--	--
06262000	54.8	--	8,840	19	44	--
06265800	95.0	1,900	7,100	16	17	--
06269700	57.9	1,260	5,800	13	10	--
06270000	803	--	6,050	14	52	--
06270200	2.54	--	9,510	18	--	--
06270300	0.52	--	9,600	20	2	--
06271000	247	--	8,190	17	50	--
06272500	164	--	9,120	16	71	--
06273000	86.8	--	8,070	17	30	--
06274500	282	--	9,740	22	80	--
06274800	7.66	--	10,830	24	--	--
06275000	194	--	9,100	20	50	--
06276500	681	--	7,070	19	--	--
06278300	23.1	--	10,030	18	32	--

Table 7c.--Basin characteristics and channel width--Continued

Station number	A	S_B	ELEV	PR	WIDTH	G_f
06278400	11.1	--	8,950	16	24	--
06278500	145	--	8,810	15	60	--
06280300	297	--	9,250	25	107	--
06289000	193	--	7,830	20	49	--
06290500	428	--	6,140	20	--	--
06291500	80.7	--	6,360	22	--	--
06296500	32.4	--	9,270	17	26	--
06297000	85.0	--	8,920	20	47	--
06298000	204	--	8,330	19	54	--
06298500	25.1	--	7,560	20	16	--
06299500	37.8	--	7,700	20	30	--
06300500	20.1	--	9,560	23	34	--
06300900	9.29	--	9,990	24	--	--
06301500	24.4	--	9,560	20	--	--
06309200	45.2	--	8,000	16	--	--
06309260	8.80	--	8,370	15	--	--
06309270	8.10	--	8,750	15	--	--
06309450	10.9	--	7,620	17	--	--
06309460	24.2	--	7,180	17	--	--
06311000	24.5	--	8,990	20	25	--
06311500	106	--	7,990	17	23	--
06312795	5.53	1,161	8,010	13	7	--
06313900	5.08	--	8,400	13	--	--
06314000	44.9	--	8,440	15	--	--
06315500	82.7	--	8,010	16	35	--
06318500	120	--	8,860	17	62	--
06320500	33.6	--	10,100	24	--	--
06321500	36.8	--	7,920	23	46	--
06406800	8.17	1,470	6,100	22	--	--
06408900	4.88	1,010	6,600	21	--	--
06427700	96.5	760	5,450	17	15	--
06429300	8.42	1,540	5,690	18	--	--
06430500	471	--	5,000	20	30	--
06431500	168	--	5,700	22	--	--
06433500	121	653	3,700	19	--	--
06616000	21.2	--	9,800	26	--	--
06620400	22.1	--	9,740	26	--	--
06621000	120	--	9,190	30	44	--
06622500	59.6	--	9,460	30	43	--
06622700	37.4	--	9,480	28	40	--
06623800	72.7	--	9,700	26	--	--
06624500	211	--	8,950	20	--	--
06625000	265	--	8,900	17	85	--
06628900	91.5	--	8,560	18	30	--
06630800	8.93	659	7,800	12	8	--
06631100	25.6	--	8,500	13	20	--
06632400	62.9	--	9,680	22	62	--
06632600	6.31	--	8,980	14	13	--
06632700	3.59	--	8,660	14	--	--
06634200	61.0	--	8,000	14	44	--

Table 7c.--Basin characteristics and channel width--Continued

Station number	A	S_B	ELEV	PR	WIDTH	G_f
06637550	177	--	8,660	18	33	--
06637750	9.20	--	8,990	17	--	--
06638300	11.6	554	7,010	12	4.8	--
06645150	9.91	--	7,210	15	--	--
06646500	212	--	6,790	15	58	--
06647500	63.0	--	7,960	16	33	--
06647890	7.18	--	6,320	15	--	--
06661000	157	--	9,110	20	58	--
06661580	11.2	264	8,790	13	12	--
06664500	225	--	6,700	14	38	--
06667500	370	--	7,200	14	38	--
06748200	3.64	--	11,100	28	--	--
06748510	0.89	--	10,900	25	--	--
06748530	12.0	--	9,700	23	--	--
06748600	90.3	--	9,900	22	--	--
06754500	25.8	--	8,140	16	10	--
06755000	13.9	--	7,810	16	7.3	--
09188500	468	--	9,320	22	110	--
09189500	43.0	--	8,880	20	44	--
09196500	75.8	--	10,200	23	67	--
09198500	87.5	--	10,000	22	62	--
09199500	37.2	--	9,460	20	34	--
09201000	552	--	8,640	20	100	--
09203000	79.2	--	9,580	22	56	--
09204000	45.4	--	9,750	20	25	--
09204500	348	--	8,380	18	--	--
09205500	58.0	--	8,920	18	--	--
09208000	6.30	--	8,970	25	14	--
09210500	152	--	8,160	18	32	--
09212500	94.0	--	9,250	20	49	--
09214000	20.9	--	9,820	19	23	--
09216527	53.3	--	7,480	13	--	--
09217900	130	--	10,640	20	--	--
09218500	152	--	10,270	19	70	--
09220000	53.0	--	10,250	20	35	--
09220500	37.2	--	9,790	20	28	--
09223000	128	--	8,380	25	44	--
09224000	386	--	7,910	18	--	--
09226000	56.0	--	10,270	23	40	--
09226500	28.0	--	10,480	31	24	--
09227000	8.20	--	10,680	22	--	--
09227500	23.0	--	10,490	32	19	--
09228500	52.8	--	10,300	29	--	--
09235600	25.0	--	8,170	20	--	--
09241000	206	--	9,000	37	--	--
09244500	45.4	--	8,600	27	--	--
09245000	64.2	--	8,400	26	--	--
09245500	21.0	--	8,600	41	--	--
09251800	9.64	--	9,470	30	26	--
09251900	29.3	--	9,010	29	--	--

Table 7c.--Basin characteristics and channel width--Continued

Station number	A	S_B	ELEV	PR	WIDTH	G_f
09253000	285	--	8,600	31	--	--
09253400	12.8	--	9,590	40	--	--
09254500	80.0	--	8,700	24	--	--
09255000	161	--	8,400	22	--	--
09255500	200	--	7,790	21	32	--
09256000	330	--	7,870	19	54	--
09257000	988	--	8,030	18	--	--
09258000	24.0	--	8,200	19	--	--
10010400	34.6	--	10,500	25	--	--
10011500	172	--	9,770	32	69	--
10012000	59.0	--	9,320	24	30	--
10015700	64.0	--	8,050	14	16	--
10019700	8.93	935	7,300	12	--	--
10021000	56.8	1,740	7,900	26	--	--
10027000	246	1,160	7,270	14	--	--
10032000	165	--	8,270	32	47	--
10040000	45.3	--	7,170	19	--	--
10040500	37.6	--	7,390	23	--	--
10041000	113	--	7,290	29	38	--
10047500	49.5	--	7,370	27	--	--
10058600	24.0	--	7,860	31	--	--
10069000	22.2	--	7,830	30	--	--
10128500	163	--	9,090	32	--	--
13011500	169	--	8,160	30	85	--
13011800	0.80	--	9,240	27	9.0	--
13011900	323	--	9,270	41	--	--
13018300	10.6	--	8,430	24	12	--
13019220	2.77	--	7,760	16	3.0	--
13019400	58.6	--	8,200	25	39	--
13019500	564	--	8,000	24	100	--
13020000	46.8	--	7,500	25	24	--
13021000	8.71	--	7,300	25	12	--
13022500	3,465	--	8,150	25	--	--
13023000	448	--	8,080	40	95	--
13023800	3.60	--	7,600	24	--	--
13025500	115	--	7,420	18	--	--
13027000	21.3	--	8,470	25	20	--
13027200	3.30	--	7,200	27	--	--
13029500	108	--	6,960	24	--	--
13030000	36.8	--	7,790	25	17	--
13030500	59.2	--	7,670	32	26	--
13032000	77.1	--	7,130	25	--	--
13038900	20.8	--	8,300	27	--	--
13050700	3.27	--	8,400	23	--	--
13050800	21.4	--	8,300	24	--	--
06207540	88.0	1,140	4,520	8	--	0.9
06207800	28.1	892	4,860	15	--	0.8
06226200	10.5	1,170	8,120	14	11	0.8
06226300	97.9	1,290	7,670	14	18	0.8
06234800	2.39	988	5,790	10	--	1.0

Table 7c.--Basin characteristics and channel width--Continued

Station number	A	S_B	ELEV	PR	WIDTH	G_f
			Plains Region			
06235700	9.52	572	5,320	8	22	1.0
06236000	129	529	5,330	8	43	1.0
06238760	0.69	239	5,490	8	6.2	1.0
06238780	1.85	378	5,470	8	--	0.8
06239000	733	--	5,850	8	--	1.0
06255200	4.46	792	5,620	7	35	1.0
06255300	0.39	492	5,300	7	--	1.0
06255500	500	--	6,000	8	--	1.0
06256600	7.15	1,040	6,690	10	--	0.8
06256670	5.86	526	5,450	7	--	1.0
06256700	10.0	1,060	6,580	14	--	0.8
06256800	182	713	6,190	12	--	0.8
06256900	52.6	1,140	6,160	11	21	0.8
06257000	808	--	6,200	11	120	0.9
06257500	267	658	6,860	12	--	0.8
06258400	13.2	1,620	5,950	12	--	0.8
06260200	33.6	1,310	7,940	18	--	1.2
06265200	6.33	391	5,100	10	20	1.2
06265600	1.78	554	4,390	9	--	1.0
06266320	1.30	779	5,610	9	--	1.2
06266460	2.32	534	5,340	9	10	1.2
06267260	3.77	773	4,420	9	9.0	1.2
06267270	2.11	736	4,520	9	6.0	1.2
06267400	149	491	4,600	9	66	1.1
06268500	518	671	4,940	9	28	1.0
06274100	19.1	1,043	4,600	9	--	1.2
06274190	1.51	437	4,180	7	7.0	1.0
06274250	96.9	691	4,300	8	--	1.2
06277700	12.8	272	5,250	8	17	1.0
06277750	0.65	622	4,920	8	6.0	1.0
06279020	47.8	1,240	5,500	9	--	1.2
06286258	30.1	1,440	5,570	10	--	1.2
06287500	98.3	1,000	4,240	18	--	1.2
06288200	100	818	4,210	15	--	0.9
06290000	111	760	5,570	22	--	1.0
06291000	161	--	4,280	15	--	1.0
06295100	34.2	647	4,650	16	--	0.8
06299900	18.0	884	4,190	17	--	1.4
06306900	34.7	771	4,010	14	--	1.4
06306950	4.53	936	4,240	15	--	1.1
06312700	262	346	6,310	11	30	0.8
06312910	1.53	847	5,390	12	11	1.6
06312920	1.34	1,240	5,390	12	--	1.6
06313000	1,150	--	5,760	11	92	1.5
06313020	8.29	506	5,780	12	--	1.6
06313050	5.44	612	5,700	12	19	1.6
06313100	11.4	863	5,240	12	43	1.6
06313180	0.80	794	5,040	12	12	1.6

Table 7c.--Basin characteristics and channel width--Continued

Station number	A	S_B	ELEV	PR	WIDTH	G_f
06313200	1.60	1,060	5,100	12	13	1.6
06313630	10.8	1,160	4,290	12	20	1.6
06313700	151	822	4,600	13	38	1.5
06316480	3.32	990	4,140	12	--	1.6
06316700	1.64	1,490	4,080	12	10	1.6
06317050	3.98	1,010	4,200	14	7.0	1.6
06319100	10.8	1,390	5,930	13	--	1.6
06324700	10.2	580	3,330	14	--	0.8
06324800	0.81	988	4,320	14	--	1.0
06324900	3.45	1,020	4,300	14	21	1.0
06324910	0.72	667	4,020	14	8.0	1.0
06324970	1,235	--	4,130	14	27	1.0
06325500	1,974	--	3,930	15	30	0.9
06334000	904	--	3,910	16	46	1.0
06334100	10.1	346	3,710	15	--	1.2
06334200	122	193	3,690	15	--	1.2
06334500	1,970	--	3,700	15	--	1.0
06358550	1.57	486	3,090	13	--	1.0
06358600	2.33	224	3,100	13	--	1.0
06358620	0.04	625	3,100	13	--	1.0
06378640	1.20	493	4,300	14	--	1.6
06379600	112	452	5,100	12	--	1.2
06382200	5.10	743	4,400	13	--	1.6
06386000	2,070	--	4,670	13	85	1.3
06386500	5,270	--	4,710	13	120	1.5
06387500	47.8	451	4,400	14	--	1.4
06388800	0.25	304	4,240	14	--	1.0
06394000	1,320	--	4,650	13	24	1.2
06396200	0.64	157	3,800	14	--	1.0
06396300	0.09	933	3,760	14	--	1.0
06396350	0.20	638	4,820	16	--	1.0
06399300	3.74	382	3,600	14	--	1.0
06399700	7.36	329	3,500	14	--	1.0
06400000	1,044	--	3,900	14	--	1.0
06400900	1.52	324	3,410	15	--	1.0
06404000	66.0	--	4,740	18	--	1.0
06406000	178	263	4,500	17	--	1.0
06422500	96.0	--	5,400	19	--	1.0
06425720	495	--	4,970	13	--	1.2
06426195	0.20	344	4,520	14	--	1.4
06426500	1,670	--	4,810	13	27	1.3
06432200	10.3	1,340	4,400	21	--	1.0
06432230	5.23	1,440	4,200	21	--	1.0
06434800	3.06	263	3,100	15	--	1.0
06436500	67.0	--	3,100	14	--	1.0
06436700	315	250	3,300	14	--	1.0
06436770	0.20	469	3,030	14	--	1.0
06437100	1.32	1,150	4,900	21	--	1.0
06443200	7.97	1,010	4,510	17	--	1.0
06443300	10.9	1,280	4,440	17	--	1.0

Table 7c.--Basin characteristics and channel width--Continued

Station number	A	S_B	ELEV	PR	WIDTH	G_f
06443700	52.6	--	4,530	18	--	1.0
06444000	313	--	4,550	17	--	1.0
06454000	400	--	5,080	16	--	0.8
06456200	3.07	331	4,360	17	--	1.0
06644200	2.64	927	6,140	12	--	1.2
06644840	2.02	643	5,850	12	8.0	1.2
06646700	2.60	1,299	5,740	14	--	1.0
06648720	0.79	414	5,420	12	--	1.0
06648780	1.38	463	5,420	12	--	1.0
06649900	8.53	979	5,240	14	14	1.4
06651800	27.8	301	5,000	14	46	1.4
06652400	6.95	477	5,200	14	7.0	1.4
06668040	1.30	726	5,650	14	--	1.0
06671000	522	--	4,700	14	15	0.8
06675300	8.16	445	6,240	16	--	1.0
06677500	1,530	--	5,560	15	--	0.8
06679000	77.2	--	4,240	14	--	0.6
06761900	0.44	115	5,300	16	--	1.0
06762500	1,361	--	5,850	16	--	1.0
06762600	5.69	191	5,330	16	--	1.0
			High Desert Region			
06218700	4.89	1,190	7,600	12	14	1.0
06229700	15.4	721	5,920	11	--	1.0
06233360	8.23	683	5,560	12	12	1.0
06234700	3.88	1,170	6,370	11	--	1.0
06629150	3.65	--	7,100	10	12	1.0
06629200	2.41	--	7,140	10	7.0	1.0
06629800	7.32	831	7,400	10	5.8	0.8
06630200	7.42	342	7,030	10	15	1.4
06631150	10.8	609	7,200	12	18	1.4
06634600	909	--	7,410	13	--	1.2
06634910	3.01	611	6,800	10	5.0	1.4
06634950	1.98	846	6,930	10	--	1.4
06634990	21.6	--	6,980	10	--	1.4
06636500	190	700	7,220	12	--	0.8
06638350	6.08	859	6,810	12	--	0.6
06641400	9.33	763	6,430	12	13	0.8
06642700	11.5	1,130	6,870	12	26	1.4
06642730	1.34	949	6,170	12	--	1.4
06642760	117	913	6,800	13	60	1.2
06643300	5.39	910	5,910	14	17	1.0
09204700	2.77	291	7,300	10	8.0	0.6
09207650	47.2	641	7,280	12	--	0.6
09215000	500	1,021	7,270	10	28	0.6
09216290	16.6	181	6,410	7	18	0.8
09216350	15.7	351	6,940	8	--	0.6
09216400	45.1	984	7,030	9	--	0.6
09216537	32.8	530	7,040	7	11	1.0

Table 7c.--Basin characteristics and channel width--Continued

Station number	A	S_B	ELEV	PR	WIDTH	G_f
09216545	308	--	7,270	8	--	0.6
09216550	152	507	7,000	8	37	0.8
09216560	758	--	7,010	8	25	0.8
09216562	829	--	7,450	8	--	0.6
09216565	34.7	--	7,780	14	--	0.8
09216580	19.5	460	7,070	8	--	0.8
09216600	7.88	856	6,920	8	10	0.8
09216695	18.2	1,170	7,280	9	--	0.8
09216700	515	--	7,340	10	48	0.9
09216750	526	--	7,300	--	--	0.6
09221680	8.83	608	6,800	9	16	1.0
09222400	963	--	7,120	11	--	0.8
09224600	5.03	341	6,460	8	10	1.0
09224800	5.22	127	6,370	8	--	0.6
09224810	12.0	561	6,650	9	6.0	0.6
09224820	3.59	662	6,570	9	--	0.6
09224840	1.26	862	6,570	9	3.0	0.6
09224980	423	426	6,880	12	--	1.2
09225200	6.57	779	6,610	15	15	1.2
09225300	13.0	615	6,540	16	13	1.2
09229450	3.15	968	6,600	17	--	1.0
09258200	49.7	462	6,950	11	--	1.0
09258900	1,178	--	7,000	12	34	0.9