REGIONALIZATION OF PEAK DISCHARGES FOR STREAMS IN KENTUCKY

U. S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 87-4209

Prepared in cooperation with the
KENTUCKY TRANSPORTATION CABINET
and
KENTUCKY NATURAL RESOURCES AND
ENVIRONMENTAL PROTECTION CABINET

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Louisville, Kentucky

1988

DEPARTMENT OF THE INTERIOR

DONALD PAUL HODEL, Secretary

U.S. GEOLOGICAL SURVEY

Dallas L. Peck, Director

For additional information write to:

District Chief
U.S. Geological Survey
2301 Bradley Avenue
Louisville, Kentucky 40217

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GLOSSARY

ANNUAL PEAK FLOW.--The highest instantaneous peak discharge in a water year.

CONTINUOUS-RECORD STATION.--A gaging station where observations of stage are recorded continually, usually at 15-minute, 30-minute, or one hour intervals, throughout the period of record.

CREST-STAGE GAGING STATION.--A site where limited streamflow data are collected systematically over a period of time. The streamflow records at these sites include the annual maximum discharge used in flood-frequency analysis.

DISCHARGE.--The rate of flow of water in a stream at a given place and for a given period of time.

EQUIVALENT YEARS OF RECORD.--The number of years of observed record required to provide an estimate of accuracy equal to that associated with regression equation based on streamflow records at a group of gaging stations.

FLOOD FREQUENCY.--The frequency, often expressed as a unit of time, with which a flood of given magnitude is exceeded.

FLOOD QUANTILE.--A peak discharge with an associated probability of non-exceedance, p, and probability of exceedance, 1-p. In this report, flood quantiles were estimated by fitting a series of logarithms of annual maximum discharges to Pearson Type III frequency distribution and the average recurrence interval is equal to the reciprocal of exceedance probability.

GAGING STATION.--A site on a stream where systematic observations of discharge are obtained.

GEOMETRIC MEAN.--The antilogarithm of the arithmetic mean of the logarithms of observations in a data set. Appropriate only when all observations are positive and allows equal weight to be given to each observation.

INTERQUARTILE RANGE.--The difference between the 25th percentile (lower quartile) and the 75th percentile (upper quartile), where each percentile has an associated probability of non-exceedance. The interquartile range is a measure of the dispersion of a distribution.

LOG-PEARSON TYPE III FREQUENCY DISTRIBUTION.-- A continuous probability distribution recommended by U.S. Water Resources Council (1981) for flood-frequency analysis. The distribution is defined using the mean, standard deviation, and coefficient of skewness of the logarithms of annual peak discharge.

MULTIPLE-REGRESSION ANALYSIS.--A statistical method for defining the degree of mutual association between a dependent variable and two or more independent variables. The result is usually expressed as an equation.

NATURAL-FLOW STREAM.--A term used in this report to denote a stream on which diversions, regulation, and urbanization have insignificant effect on annual peak discharges.

ORDINARY LEAST SQUARES REGRESSION.--A method for determining the relation between a dependent and one or more independent variables in which each observation is given equal weight.

PARAMETER.--A quantity that describes or characterizes a population, such as a mean, a measure of variability, or a regression coefficient.

PARTIAL RECORD GAGING STATION.--In this report refers to a crest stage gaging station where limited discharge data including the annual maximum discharge are recorded.

PEAK DISCHARGE.--The maximum instantaneous streamflow attained during a flood, reported in cubic feet per second.

QUANTILE.--A number that has a non-exceedance probability, p, and an exceedance probability (1-p), where p is a quantity between 0 and 1 and is determined based on a population or sampling distribution.

RECURRENCE INTERVAL.--The average interval of time, in years, within which a given flood will be exceeded once; the recurrence interval for a given flood has a probability equal to the reciprocal of the recurrence interval of being equalled or exceeded in any one year.

REGULATED STREAMFLOW.--Streamflow that is controlled by locks, dams, or constructed structures upstream, in which water discharge is diverted or impounded for release at a later time. On most streams, only large regulation structures influence the magnitude of the annual peak discharge.

RESIDUAL.--The difference between a flood quantile determined from gaged streamflow records and a flood quantile estimated using a regression equation for a given gage site.

RUNOFF RATE.--That part of precipitation that appears in surface streams, expressed as a unit volume per unit time per unit area (e.g., cubic feet per second per square mile).

SIGNIFICANCE LEVEL.--A probability value selected by an investigator as the maximum acceptable probability for making a type I error (rejecting a true null hypothesis) in hypothesis testing.

SKEWNESS.--A numerical measure or index of asymmetry of a frequency distribution.

STANDARD ERROR OF THE ESTIMATE.--A measure of how well the observed data agree with the regression estimates. Calculated as the square root of the sum of the squares of the vertical deviations from the least-squares regression line divided by (n-k-1), where n is the number of observations and k is the number of independent variables in the regression.

STANDARD ERROR OF PREDICTION.--A measure of the error of regression estimates for sites that were not used to define the regression equation but are similar to the sites used in the regression. In this study the square root of the press statistic (SAS Institute Inc., 1982; Montgomery and Peck, 1982) divided by degrees of freedom was used to estimate the standard error of prediction.

WATER YEAR.--Year beginning on October 1 and ending on September 30.

WEIGHTED LEAST SQUARES REGRESSION.--A method for fitting regression models with adjustment for non-constant residual variance. The residuals are multiplied by weighting factors that are inversely proportional to the variance of the dependent variable.

METRIC CONVERSION FACTORS

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

Multiply inch pound units	By	To obtain metric unit
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
inch (in.)	25.40	millimeter (mm)
foot (ft)	0.3048	meter (m)
square mile (mi^2)	2.590	square kilometer (km^2)
cubic foot per second per square mile [$(ft^3/s)/mi^2$]	0.01093	cubic meter per second per square kilometer [$m^3/s)/km^2$]
foot per mile (ft/mi)	5.280	meter per kilometer (m/Km)

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

Multiple regression analysis was used to delineate hydrologically distinct regions in Kentucky and to develop regression models for estimating peak discharge for unregulated streams in these regions. The regression models provide estimates of flood quantiles with associated average recurrence intervals of 2, 5, 10, 25, 50, and 100 years. The data base used in the analysis included annual peak discharge records (through water year 1985) at 266 continuous- and partial-record gaging stations in and adjacent to Kentucky. Selected drainage basin characteristics upstream of each gaging station were used to develop the regression equations. Flood quantiles at the gaged stations were estimated on the basis of log-Pearson Type III distribution and the methodology recommended by the U.S. Water Resources Council. Seven hydrologic regions were delineated in Kentucky on the basis of analysis of residuals from statewide and regional regression models. Regression models for estimating flood quantiles in the hydrologic regions are based on measurements of contributing drainage area, main channel slope, basin shape index, and main channel sinuosity. The regression coefficients indicated an increase in flood discharge with increasing drainage area and channel slope, and a decrease in discharge with increasing channel sinuosity and basin elongation. Accuracy of the discharge estimates from the regression models as measured by the standard error of the estimate ranged from 21 to 52 percent. The procedures for estimating flood quantiles vary depending on whether the estimate is for an ungaged site, an ungaged site near a gaged site on the same stream, or a gaged site, and on whether the drainage area crosses hydrologic-region boundaries or state lines. The methods apply only to natural-flow streams draining areas less than 1,000 square miles.

INTRODUCTION

Determination of streamflow characteristics is one of the primary goals of the U.S. Geological Survey streamflow data-collection program. Information on floods is important for land-use planning, flood-insurance evaluation, and design of structures such as culverts, dams and bridges. Peak-discharge information is applied to a variety of flood-hazard studies that vary from generalized mapping of flood-prone regions (Kentucky Geological Survey, 1982) to detailed delineation of flood plains based on precise hydraulic field measurements (Federal Emergency Management Agency, 1987a).

The statistical models that provide estimates of the peak-discharge characteristics in this study are multiple regression models based on measurements of basin and climatic characteristics in the catchment area upstream of the site of interest. The procedures for estimating peak discharge differ depending on whether the estimate is for a gaged or ungaged site, and whether the upstream drainage area crosses hydrologic region boundaries or state lines.

This study was conducted in cooperation with the Kentucky Transportation Cabinet's Department of Highways and the Kentucky Natural Resources and Environmental Protection Cabinet's Division of Water. Much of the streamflow data for basins smaller than 10 mi^2 resulted from a cooperative funding agreement with Kentucky Transportation Cabinet from 1975 to 1985.

Purpose and Scope

This report describes the results of a study to delineate geographic regions of the State with similar flood-response characteristics, to define regression models to estimate peak discharge for streams in each region, and to develop methods to estimate peak discharge for both gaged and ungaged sites in the regions.

Methods are provided for estimating flood magnitude and frequency on unregulated streams. Regression models based on data collected at gaged sites were developed to estimate flood discharges with average recurrence intervals of 2, 5, 10, 25, 50, and 100 years. These specific flood discharges are termed "flood quantiles" and refer to a quantity of streamflow with an associated probability of being exceeded in any given year. The average recurrence interval associated with a given flood quantile is equal to the reciprocal of the exceedance probability for the quantile.

The regression models were developed using data for 266 continuous-record and partial-record streamflow-gaging stations in and adjacent to Kentucky that had at least 7 years of gaged record through water year 1985. The regression relations are restricted to natural-flow streams in Kentucky not significantly affected by regulation or urbanization and to basins with upstream drainage area less than 1,000 mi^2. Methods for estimating peak discharge on regulated streams in Kentucky are outlined in Hannum (1976).

Previous Studies

Several previous studies for estimating peak discharge for streams in Kentucky have been completed. McCabe (1958, 1962) presented techniques for estimating peak discharge on streams in Kentucky based on the U.S. Geological Survey index-flood method (Dalrymple, 1960). McCabe's (1962) report was based on data through water year 1957 at 116 gaging stations. Two subsequent reports, also based on the index-flood method, were completed for the Ohio River basin (Speer and Gamble, 1965) on the basis of data collected through water year 1962, and for the Cumberland and Tennessee River basins (Speer and Gamble, 1964) on the basis of data collected through water year 1959. The reports by Speer and Gamble (1964, 1965) included summaries of flood records at gaging stations and miscellaneous sites in the study area. Hannum (1976) completed a flood regionalization study for Kentucky based on data collected through water year 1970 at 131 stations. Hannum applied log Pearson Type III flood-frequency analysis (U.S. Water Resources Council, 1967) to annual peak flow records to determine floods with selected recurrence intervals ranging from 2 to 100 years. Regression analysis was used to delineate hydrologic regions and to estimate flood quantiles at ungaged sites on the basis of basin characteristics. The results of Hannum's (1976) study apply to basins that have drainage areas of 10 to 4,300 mi^2 and include additional information for determining flood quantiles on regulated rivers in Kentucky, such as sites on the Cumberland, Kentucky, and Ohio Rivers. Regression models for estimating various streamflow characteristics (including peak flows, mean monthly and annual flows, flow duration, and high- and low-flow volumes) were determined by Wetzel and Bettandorff (1986) for coal provinces in the eastern U.S. and include the Eastern and Western Kentucky Coal Field physiographic regions.

This study differs from previous flood regionalization studies in Kentucky in several respects. The data base used in the study includes 15 additional years of peak-discharge measurements, additional drainage basin characteristics, and 135 additional streamflow gaging stations, including peak-discharge records for basins with drainage areas ranging from 0.1 to 10 mi^2 that were not available at the time of Hannum's (1976) study. Determination of flood quantiles at gaged sites was derived from revised methods (U.S. Water Resources Council, 1981) based on log Pearson Type III probability distribution. The regression analyses were performed by using additional basin characteristics as independent variables and improved statistical techniques for model selection and model verification.

In addition to the flood data presented in this report, several other sources of flood data are available for sites in Kentucky. Detailed flood-profile studies and maps (Federal Emergency Management Agency, 1987a, 1987b), completed under the National Flood Insurance Program, exist for some cities and counties in Kentucky. The maps show topographic boundaries for the 100- and 500-year floods on selected streams. Flood-prone-area maps (scale 1:24,000) exist for some regions in Kentucky (Kentucky Geological Survey, 1982). Records of peak discharge at gaged sites in Kentucky are published annually (Bettandorff and others, 1985) and may also be obtained from U.S. Geological Survey computer files in Reston, Virginia (Hutchinson, 1975).

Acknowledgments

Charles E. Schoppenhorst calibrated and verified a rainfall-runoff model to augment peak discharge records at selected gaging stations. Kirk D. Fauver and Dietrich H. Whitesides measured many of the basin characteristics used in the analysis.

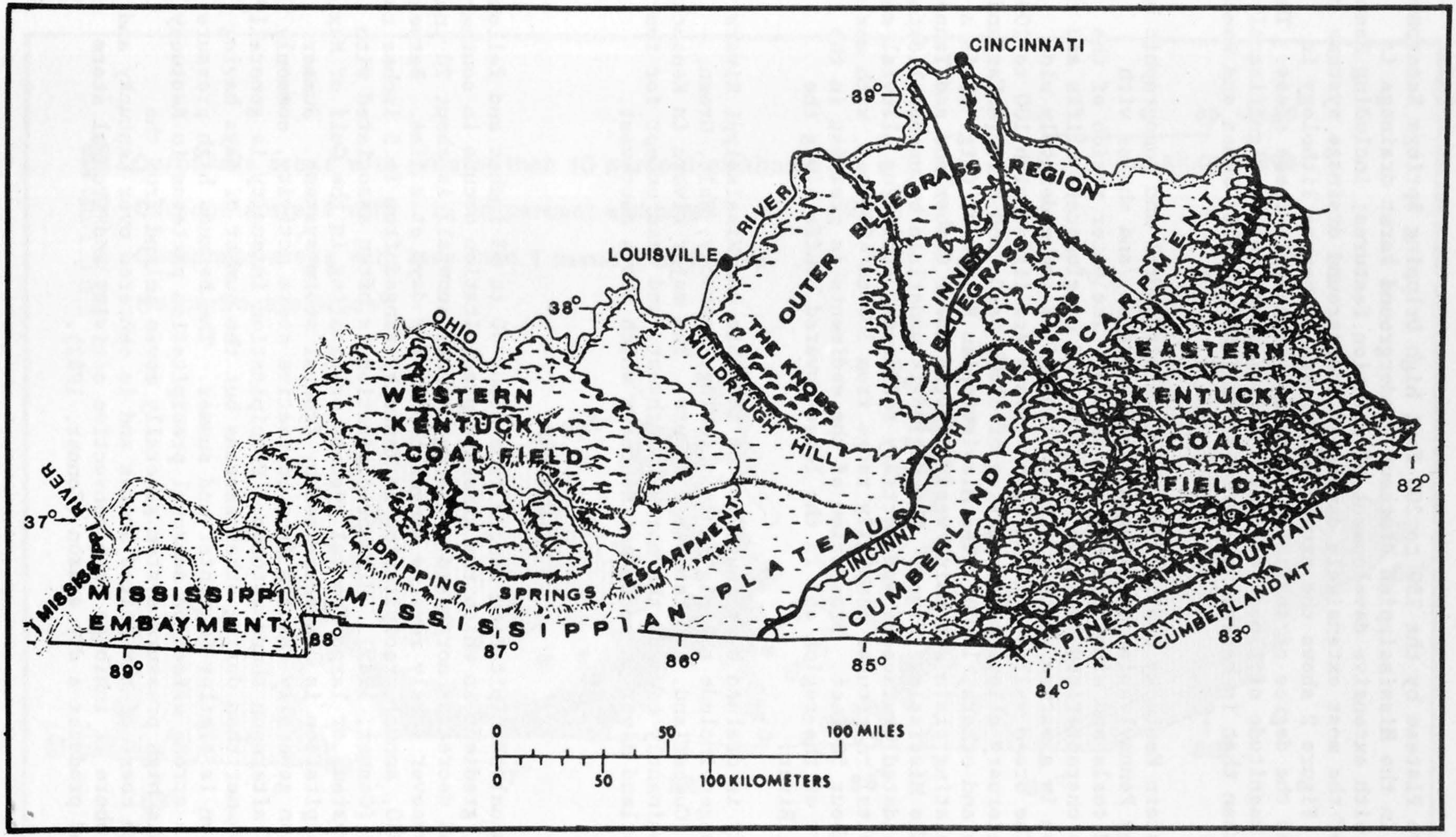
DESCRIPTION OF STUDY AREA

Physiography and Geology

Altitudes in Kentucky range from 270 feet in the western part of the State along the Mississippi River to 4,145 feet above sea level on Black Mountain in eastern Kentucky near the Kentucky-Virginia state line. The western and central parts of Kentucky are characterized primarily by rolling topography, but the eastern part of the state is highly dissected and is characterized by steep slopes and high relief.

Physiographic regions coincide closely with geology in Kentucky. The areal variation in exposed geologic units (Kentucky Geological Survey, 1979) results primarily from lithologic structure associated with the Cincinnati arch, a structural high extending northeastward from Monroe and Cumberland counties in south-central Kentucky through Lexington, Kentucky, northward toward Cincinnati, Ohio. Lithologic units dip from this structural high so that the geology is generally symmetrical on each side of the axis of the arch. The oldest deposits in Kentucky consist of Ordovician limestone, sandstone, and shale and are exposed in the northern core of the Cincinnati arch. Younger deposits occur on each flank of the arch and range in age up to the Pennsylvanian formations exposed in the Eastern and Western Coal Fields. Cretaceous and Tertiary alluvial deposits occur in western Kentucky in the Mississippi Embayment.

The major physiographic regions in Kentucky, from east to west, include the Eastern Kentucky Coal Field, the Bluegrass Region, the Mississippi Plateaus, the Western Kentucky Coal Field, and the Mississippi Embayment (fig. 1). The Eastern Coal Field is underlain by Pennsylvanian and Mississippian sandstones, limestones, shales, and conglomerate and includes coal, natural gas, and oil deposits. The topography is highly dissected and local relief is as much as 3,400 feet in the southeastern part of the region. The Bluegrass consists of the Inner and Outer Bluegrass Regions, separated by a belt of shale deposits. The Bluegrass is underlain primarily by Ordovician limestone and is characterized by gently rolling topography, parts of which are karstic. Deep residual limestone soils occur in extensive rolling interstream areas. The belt between the Inner and Outer Bluegrass is characterized by hilly topography with narrow valleys and ridges and is covered by relatively impervious and easily erodible soils developed in shale. The Knobs, underlain by Silurian and Devonian shales, separates the Bluegrass from the Mississippian Plateaus on the west and the Eastern Coal Field on the east. The Knobs exhibit steep, highly dissected topography covered by poorly drained, highly erodible soils. The Mississippian Plateaus consist of two plateau belts that form a broad arcuate band bordering the Western Coal Field. The plateaus are underlain by a broad belt of Mississippian limestones, with minor beds of sandstone, and exhibit a gently rolling karstic topography. The outer and topographically lower Pennyroyal Plateau is separated from the inner



From Kentucky Geological Survey (1980) and A. K. Lobeck (1930)

Figure 1.--Physiographic regions in Kentucky.

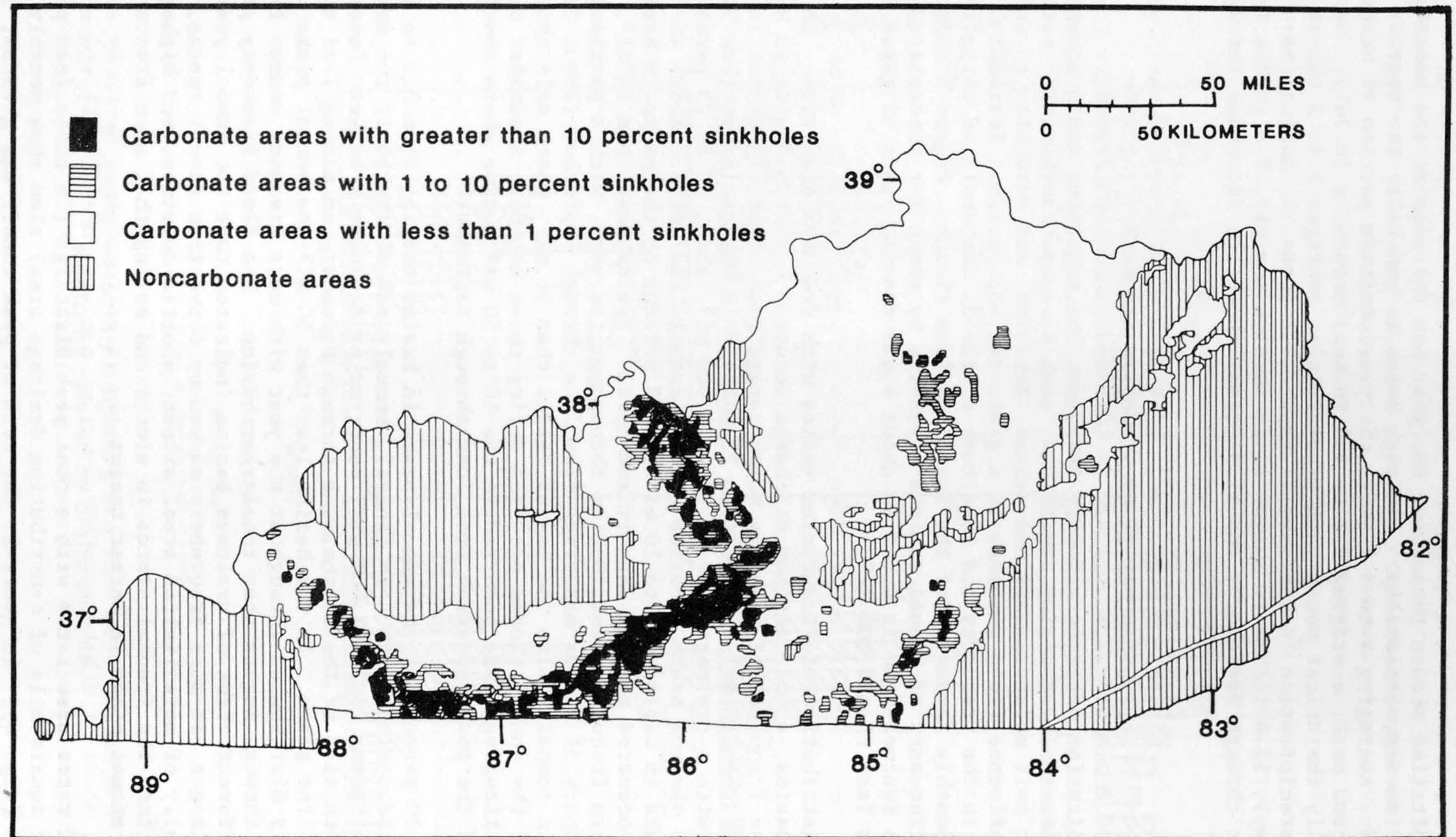
Mammoth Cave Plateau by the 150 to 200 feet high Dripping Springs Escarpment (fig. 1). In the Mississippian Plateaus, underground karst drainage is associated with extensive development of solution features; including Mammoth Cave, one of the most extensively developed underground drainage systems in the world. Figure 2 shows the extent of exposed carbonate lithology in Kentucky and the degree of surficial karst development in these areas. The timing and magnitude of flood response in karst areas can be significantly different than that in nearby non-karst areas (White, 1976; Jones and Rauch, 1977).

The Western Kentucky Coal Field is both a structural and topographic basin underlain by Pennsylvanian sandstones, conglomerates, and shales with interbedded coals and minor oil and gas fields. The outer region of the province is characterized by steep sandstone and conglomerate cliffs and the inner region is a mature plateau with rolling hills and moderately wide valleys. The broad valleys of the major rivers are filled with 100 to 200 feet of Quaternary alluvium, consisting of clay, sand, and silt (McFarland, 1950; Davis and others, 1971). The Mississippian Embayment (fig. 1) is a gently undulating plain extending west from the lower Cumberland and Tennessee Rivers to the Mississippi River. The region is underlain by unconsolidated to semi-consolidated Cretaceous and Tertiary sediments, including alluvial and loess deposits. Altitudes generally range from 300 to 400 feet, with maximum relief of about 50 feet. Dissection of the sediments is greatest in the western part of the region and in the loess-covered bluffs along the Mississippi River.

Kentucky is drained by tributaries of the Ohio and Mississippi Rivers. Major drainages include the Big Sandy, Licking, Kentucky, Salt, Green, Tradewater, Cumberland, and Tennessee Rivers. The major rivers in Kentucky drain predominantly towards the north, northwest, and west except for the upper Cumberland River in southeast Kentucky which flows southwest.

Climate

Mean annual precipitation ranges from about 40 to 53 inches and follows a latitudinal gradient in which the greatest precipitation occurs in southern Kentucky and decreases northward. Average annual snowfall is about 20 inches but the snowcover rarely remains longer than a few days at a time. Between 1951 and 1980, annual precipitation in Kentucky ranged from 14.5 inches to 78.7 inches (Conner, 1982). High precipitation is often associated with hurricane systems or large frontal systems originating in the Gulf of Mexico. Winter precipitation is characterized by frontal storm systems. Summer precipitation generally results from convective storm activity, commonly in the form of afternoon thunderstorms. Precipitation intensity is generally higher in summer than during other seasons but the number of days having precipitation is similar in winter and summer. The Bermuda high pressure system has a strong effect on seasonal precipitation patterns in Kentucky. In the fall this high pressure system generally moves inland from the southeastern coast of the United States and is centered over Kentucky and Tennessee, where it inhibits both convective activity and frontal storm movement and produces a dry season (Conner, 1982).



From N. Crawford and J. Webster (1986)

Figure 2.--Areas of carbonate lithology and surficial karst development in Kentucky. Classification is generalized from map based on evaluation of surface topography over areas of about 1.5 square miles.

Precipitation occurs throughout the year but the sources and amounts of precipitation vary seasonally. Although March is generally the wettest month of the year, averaging 4 to 6 inches, the precipitation pattern is bimodal with a second peak, averaging 3.3 to 5.5 inches, occurring in July. October is generally the driest month when precipitation averages 2 to 3 inches. Mean seasonal precipitation in Kentucky is about 13.5 inches in spring (March through May), 12.4 inches in summer (June through August), 9.8 inches in fall (September through November), and 11.5 inches in winter (December through February).

SEASONALITY OF FLOODS IN KENTUCKY

Precipitation patterns strongly influence the magnitude and frequency of floods. Seasonally changing conditions, such as evapotranspiration rates, antecedent soil moisture, and the extent, duration, and intensity of storm systems influence flood response in a given drainage basin. Seasonal variation in the frequency and magnitude of floods was analyzed using the relative monthly frequency of the annual maximum floods. Figure 3 shows the relative frequency of annual maximum discharge by month for unregulated streams in Kentucky and is based on about 4,600 station years of gaged record for basins less than 1,000 mi^2.

The distribution of frequencies varies with drainage area size. In all sizes of basins, annual maximum discharge occurred most frequently in March. However the frequency of peaks in March ranged from about 15 percent in small basins less than 10 mi^2 to more than 25 percent in basins larger than 500 mi^2. In basins with a drainage area of 50 to 1,000 mi^2, about 70 to 75 percent of the annual maximum peaks occurred between January and April. About 45 percent of the peaks in basins 0.1 to 10 mi^2 and 58 percent of the peaks in basins 10 to 50 mi^2 occurred between January and April. Basins less than 10 mi^2, show a more uniform frequency distribution throughout the year, with a particularly high frequency of floods occurring from June through September (about 28 percent) in comparison to the basins larger than 50 mi^2, where only about 10 percent of the annual floods occurred during these months. A similar pattern of summer flooding, also occurred in the 10 to 50 mi^2 basins where about 20 percent of the peaks occurred from June through September.

About 20 percent of the annual peaks in basins ranging from 0.1 to 1,000 mi^2 occurred during March. In general, annual peak discharge in the medium to large size basins, 50 to 1,000 mi^2, occurred predominantly between December and May with each of the months June through November containing less than 5 percent of the peaks. In the basins less than 50 mi^2 the annual peaks were more evenly distributed throughout the year with more frequent summer flooding from June through August than the larger basins. The flood frequency pattern in the different sizes of drainage basins indicates that the annual peaks in small drainages are more frequently caused by convective summer storms, which are generally of more limited areal extent, shorter duration, and higher intensity than the frontal storms in winter and spring that more frequently cause the annual peaks in larger basins.

Runoff rates associated with annual peak discharge (in cubic feet per second per square mile of contributing drainage area) also show monthly variations (fig. 4). In general, the rate of peak runoff was greatest in

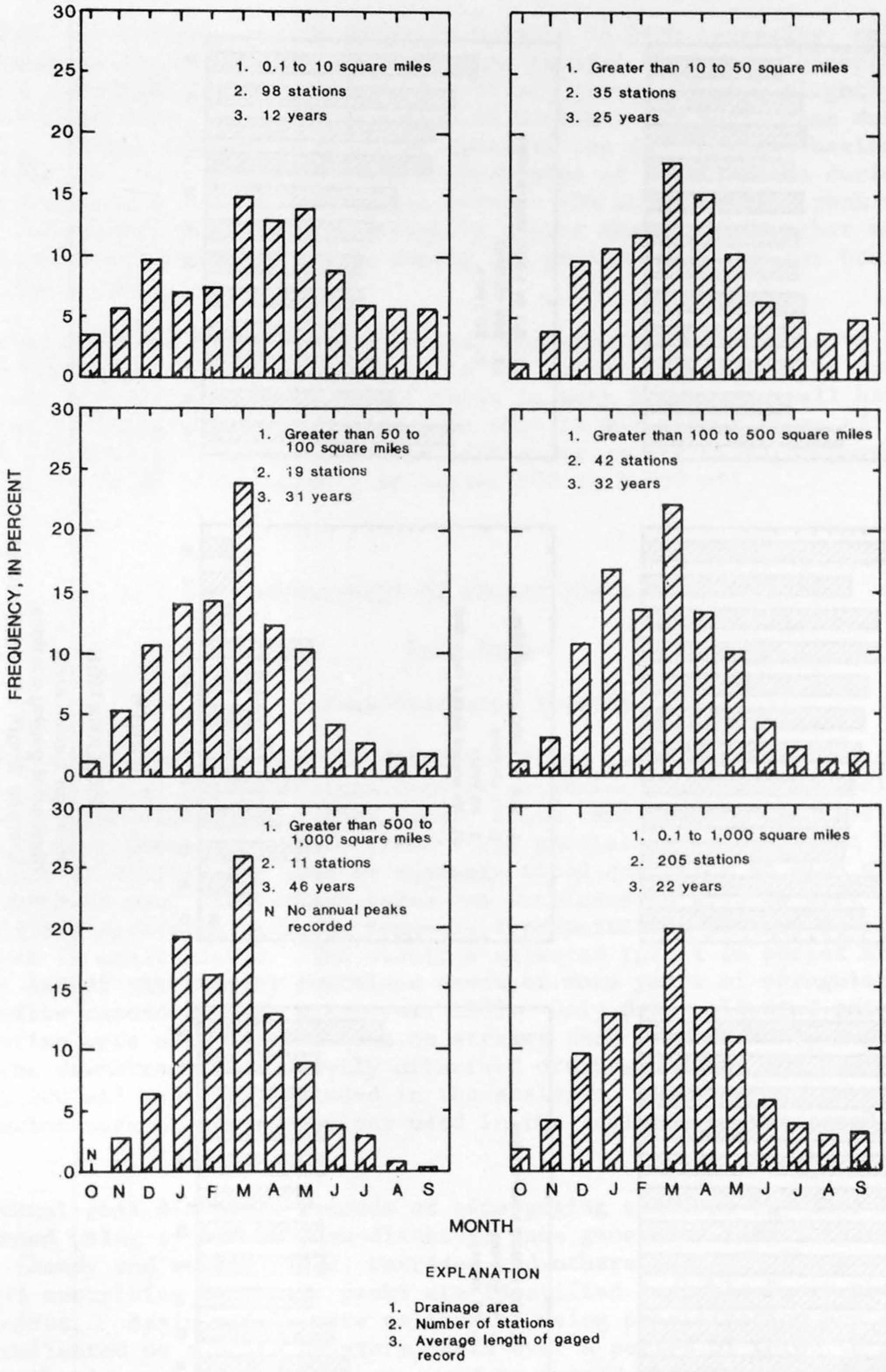


Figure 3.--Monthly frequency of annual peak discharge in Kentucky related to drainage area.

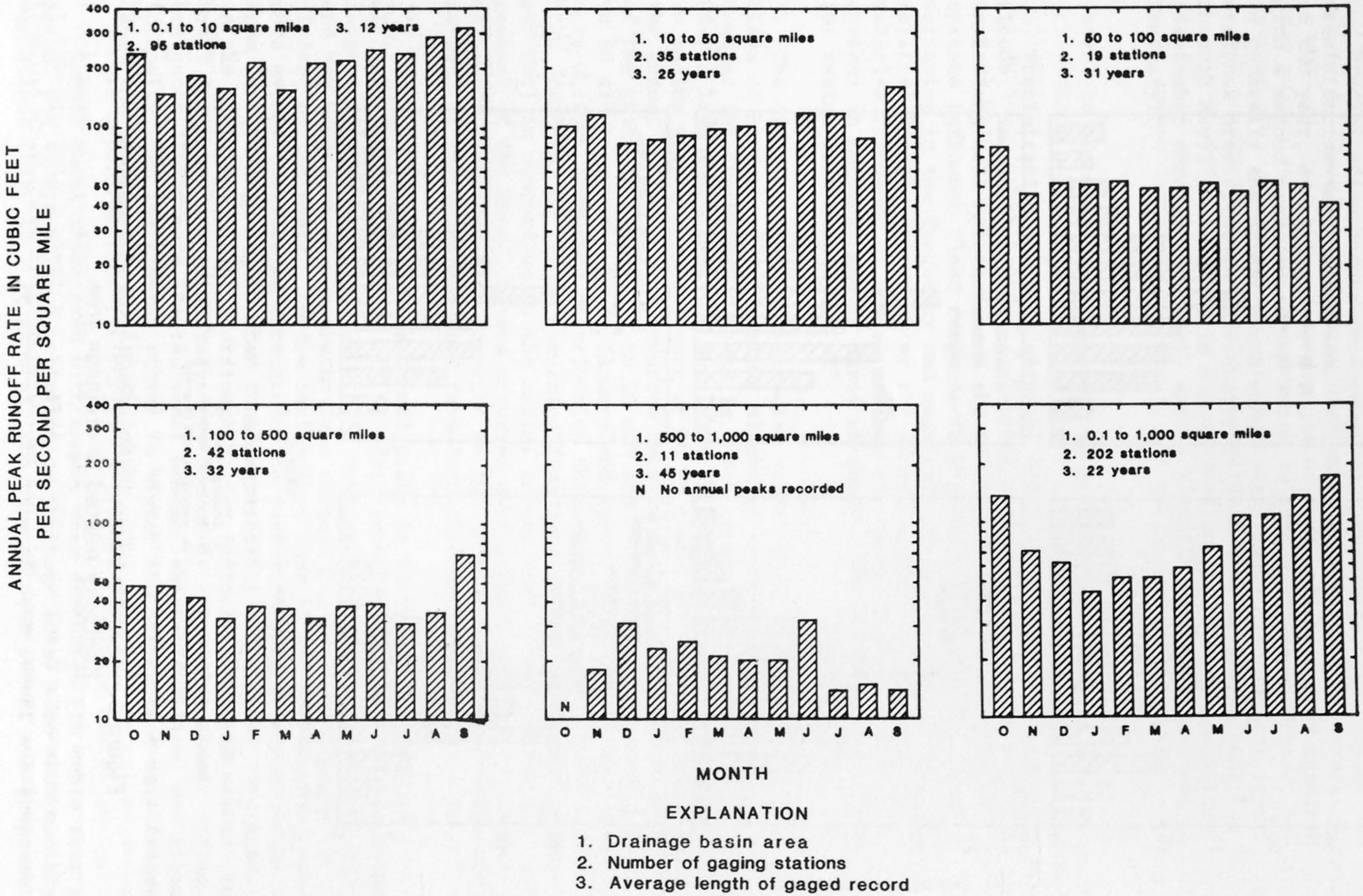


Figure 4.--Monthly variation in annual peak runoff rates in Kentucky related to drainage area. Each monthly value is the median of all peaks occurring during the month.

September and October, and is probably related to high intensity, relatively long duration storms associated with large frontal systems originating in the tropics. Drainage basins smaller than 50 mi^2 generally show slightly lower median runoff rates between the months of December and April than during other periods. Except for the high runoff rates in the fall months, basins between 50 and 500 mi^2 show fairly uniform distribution of runoff rates during the winter and spring months. In basins between 500 and 1000 mi^2, peak runoff rates in December and June were slightly higher than that in other months; no annual peaks occurred in October during the period of record for basins in this size group.

Throughout the range of basin sizes, the runoff rates tended to be lower in the winter and spring, and higher in the summer and fall. The monthly magnitude and variability in runoff rates is much higher in small basins compared to larger basins. Basins less than 10 mi^2 show a range of about 150 to 300 [$(ft^3/s)/mi^2$] (cubic feet per second per square mile) compared to a range of 13 to 33 [$(ft^3/s)/mi^2$] in basins 500 to 1,000 mi^2.

DEVELOPMENT OF REGRESSION MODELS

Data Base

Peak-Discharge Records

Peak-discharge data used to determine flood quantiles were obtained from the surface-water gaging-station network maintained by the U.S. Geological Survey in cooperation with other local, State, and Federal agencies. Data from 266 continuous-record and crest-stage partial-record gages in Kentucky and adjacent States were used to estimate flood quantiles at each site. Data collection at most crest-stage gages was initiated in 1975 as part of a cooperative agreement with the Kentucky Transportation Cabinet to study flood response in small basins. The stations selected (pl. 1 in pocket and table 1, at the end of the report) contained seven or more years of unregulated streamflow record through water year 1985. Only data collected prior to regulation were used for stations on streams that are currently regulated. Stations downstream from heavily urbanized drainage basins and basins larger than 1,000 mi^2 were not included in the analysis. Information on streamflow regulation upstream from stations used in the analysis is presented in table 2.

Annual peak discharge records at nine gaging stations in small basins were augmented using synthetic peak-discharge data generated from a rainfall-runoff model (Dawdy and others, 1972; Carrigan and others, 1977). The station records containing synthetic peaks are identified in table 3, at the end of the report. Basin models were calibrated using precipitation and streamflow data collected on a storm-by-storm basis over a period of three to six years. The synthetic peak discharges were used to extend the gaged streamflow record to improve estimates of flood quantiles at the sites. The components of the model included storm precipitation rates, antecedent soil moisture, storm infiltration, and surface-runoff routing. For a more detailed description of the model, see Dawdy and others (1972). Long-term climate records needed to generate synthetic peaks were obtained by correlating rainfall data collected

Table 2.--Gaging stations on regulated streams. Streamflow data for these stations prior to regulation were used in the regression analysis except where noted otherwise

Station number	Station name	Date regulation began	Regulation structure(s) or impoundment(s)
03203000	Guyandotte River at Man, WV	Feb. 1980	R. D. Bailey Lake
03203600	Guyandotte River at Logan, WV	Feb. 1980	R. D. Bailey Lake
03207020	Twelvepole Creek below Wayne, WV	Mar. 1972	East Lynn Lake
03208000	Levisa Fork below Fishtrap Dam, KY	Oct. 1968	Fishtrap Dam
03209000	Pound River below Flanagan Dam, near Haysi, VA	Mar. 1965	John W. Flanagan Lake; North Fork Pound River Lake (Aug. 1966)
03209300	Russell Fork at Elkhorn City, KY	Mar. 1965	John W. Flanagan Lake; North Fork Pound River Lake (Aug. 1966)
03211500	Johns Creek near Van Lear, KY	May 1950	Dewey Lake
03216500	Little Sandy River at Grayson, KY	Mar. 1968	Grayson Lake
03247500	East Fork Little Miami River at Perintown, OH	1977	William H. Harsha Reservoir; occasional regulation by Stonelick Lake
03249500	Licking River at Farmers, KY	Dec. 1973	Cave Run Dam
03277450	Carr Fork near Sassafras, KY	Jan. 1976	Carr Fork Lake
03277500	North Fork Kentucky River at Hazard, KY	Jan. 1976	Carr Fork Lake; small diversion by city of Hazard above station.
03281000	Middle Fork Kentucky River at Tallega, KY	Dec. 1960	Buckhorn Lake
03296500[a]	Plum Creek near Wilsonville, KY		Flow regulated by seven small detention reservoirs.
03306000	Green River near Campbellsville, KY	Feb. 1969	Green River Lake
03306500	Green River at Greensburg, KY	Feb. 1969	Green River Lake
03311000	Nolin River at Kyrock, KY	Mar. 1963	Nolin Lake
03318500	Rough River at Falls of Rough, KY	Oct. 1959	Rough River Lake
03319000	Rough River near Dundee, KY	Oct. 1959	Rough River Lake
03400800	Martins Fork near Smith, KY	Jan. 1979	Martins Fork Dam
03401000[a]	Cumberland River near Harlan, KY	Jan. 1979	Flow slightly regulated by Martins Fork Dam
03403000[a]	Cumberland River near Pineville, KY	Jan. 1979	Flow slightly regulated by Martins Fork Dam. Low flow regulated by power plant 1.9 mi upstream.
03403500[a]	Cumberland River at Barbourville, KY	Jan. 1979	Flow slightly regulated by Martins Fork Dam. Diversion above station by city of Barbourville for municipal water supply.

[a]All years of station record were used in regression analysis; negligible effects of regulation on annual maximum discharge.

in the basins with U.S. weather station data for Louisville, Kentucky, and Cairo, Illinois. The gaged and synthetic peak records for each station were combined to estimate flood quantiles at the stations where the rainfall-runoff model was applied.

Flood Quantiles

Flood quantiles were determined by fitting the logarithms of the annual peaks from the gaged record to a Pearson Type-III distribution based on the techniques recommended by the U.S. Water Resources Council (WRC) (1981). These data were analyzed using WATSTORE flood frequency programs (Kirby, 1981). Adjustments were made for historic peaks and high outliers, low outliers were omitted, and the coefficient of skew was estimated by the weighted average of systematic and generalized skew coefficients (U.S. Water Resources Council, 1981) using the mean-square error of each skewness coefficient as the weight factors. Results of the flood-frequency analysis based on the WRC guidelines are summarized for the study basins in table 3. Statistics characterizing the distributions of both the peak series with WRC adjustments and the systematic peak series without WRC adjustments are included for comparison in table 3.

Drainage Basin Characteristics

Differences in drainage basin and climate characteristics influence flood response. Measurements of some of these basin characteristics were used in the regression analyses to identify characteristics related to flood response in Kentucky. Selection of basin characteristics for the initial regression analysis was determined based on the following: (1) consideration of physical controls of runoff processes, (2) results from previous studies in similar hydrologic environments, and (3) availability of existing data for the study basins. The following basin characteristics were tested for significance in the regression analyses; abbreviations are listed for the variables used in the final regression equations:

(1) Total drainage area, in mi^2, of the basin;
(2) Contributing drainage area (A_c), in mi^2, of the basin excluding any depressions characterized by internal drainage;
(3) Main channel slope (S_c), in feet per mile, determined by the elevation difference between points located 10 and 85 percent of the distance along the main stream channel from the gage to the drainage basin divide, divided by 0.75 of the length of the main stream channel from the gage to the drainage divide;
(4) Basin shape (B_s), calculated as the ratio of basin length, in miles, squared to total drainage area, in square miles;
(5) Main channel sinuousity (S_s), calculated as the ratio of main channel length, in miles, to basin length, in miles;
(6) Main channel length, in miles, measured along the main stream channel from the gage to the drainage divide, extending the main channel upstream by following the longest tributary;
(7) Storage, in percent of contributing drainage area, defined by the total area in the basin covered by lakes, swamps, or ponds;

(8) Main stream channel elevation, in feet, averaged from the elevations at points located 10 and 85 percent of the length of the main stream channel from the gage to the drainage divide;

(9) Basin length, in miles, measured as the map straight-line distance along a line from the gage to the point on the drainage divide used to determine main channel length;

(10) Mean basin width, in miles, calculated by dividing the total drainage area by basin length;

(11) Azimuth, in degrees from north, of the line defining basin length;

(12) Mean annual precipitation (P), in inches, the mean yearly precipitation amount in the basin determined from Kentucky Department for Natural Resources and Environmental Protection (1979) and Conner (1982);

(13) Maximum 24-hour precipitation intensity, in inches, occurring during the 30-year interval of 1951-1980 (Glen Conner, Kentucky Climate Center, written commun., 1986); and

(14) Soil infiltration index, in inches per hour, based on infiltration rates for the U.S. Soil Conservation Service hydrologic soil groups (Musgrave, 1955) for soil series in Kentucky (U.S. Department of Agriculture, 1975 and 1984).

Additional basin characteristics for a subset of about two-thirds of the study basins were also tested for significance in the regression analyses:

(15) Mean basin elevation, in feet, measured as the average elevation of 20 to 80 points per basin located using the transparent grid sampling method;

(16) Soil runoff index ("S"; U.S. Department of Agriculture, 1969) based on vegetation cover, soil infiltration rate, and soil water storage;

(17) Forested area, in percent of contributing drainage area, measured from topographic maps based on the transparent grid sampling method;

(18-19) Maximum 24-hour precipitation intensity, in inches, with recurrence intervals of 25 and 50 years (Hershfield, 1961).

Physiographic basin characteristics were determined using 1:24,000 and 1:250,000 scale topographic maps. The basin characteristics data are stored in the U.S. Geological Survey National Water Storage and Retrieval System, WATSTORE (Dempster, 1983). For the gaging stations used in the analysis, measurements of basin characteristics used in the final regression models are listed in table 4 at the end of the report.

Regression Analyses

The regression models in this report are equations that relate flood quantiles at gaged sites to basin characteristics upstream of the streamflow gages. In the regression models, the flood quantile, the dependent variable, is estimated based on a selected group of basin characteristics, the independent variables.

For the regression analyses, logarithmic (base e) transformations were performed on all streamflow and basin characteristics. The data were transformed to obtain a constant variance of the residuals about the regression line, and to linearize the relation between the dependent variable and independent variables in order to use linear least squares regression techniques.

The multiple-regression models based on logarithmic transformation of the variables are of the form:

$$\log_e Y = b_0 + b_1 \log_e X_1 + b_2 \log_e X_2 + \ldots + b_n \log_e X_n$$

or, after taking antilogs,

$$Y = e^{b_0} (X_1^{b_1}) (X_2^{b_2}) \ldots (X_n^{b_n}) (C)$$

where, Y is the dependent variable (flood quantile);
X_1 to X_n are independent variables (basin characteristics);
b_0 to b_n are regression model coefficients estimated using least squares; and
C is a correction factor to adjust for transformation bias.

The correction factor, C, is applied to correct for bias that results from detransforming the log variables. A simple detransformation based on antilogs results in a predicted value of Y corresponding to the median rather than the mean value of Y. A correction factor equal to $e^{[0.5 (MSE)]}$, where MSE is the mean square error from the regression model, can be applied to adjust for this bias (Miller, 1984). When the bias correction factor is used with the model, the regression estimate will correspond to the mean value expected for the flood quantile for basins having identical values for the set of independent variables. The mean value will always be larger than the median value because the flood quantiles are log-normally distributed. The bias correction factors are listed for all regression models in this report to allow for calculation of either the mean or the median. All example calculations in this report include the bias correction factor.

Selection of independent variables for the regression models was based on stepwise regression algorithms and all-possible-subsets regression which includes all possible subsets of all combinations of selected independent variables (SAS Institute, 1982; Minitab, 1985). Final regression models were selected based on several factors including: standard error of the estimate, Mallows' C_p statistic (Mallows, 1964, 1973), statistical significance of the independent variables, r^2 adjusted for degrees of freedom, ease of measurement of variables included in the regression equation, and the PRESS statistic--an index of the prediction error associated with the regression equation. Correlation between independent variables and the VIF (variance inflation factor: Marquardt, 1970; Montgomery and Peck, 1982) was used to assess multicollinearity in regression models. Prediction error sum of squares was estimated by the PRESS statistic (Allen, 1971; Montgomery and Peck, 1982). The PRESS statistic is computed by summing the squared residuals from models defined by sequentially deleting an individual observation, redefining the regression equation without that observation, and then calculating the residual for that observation.

The statewide regression models used to delineate hydrologic regions were derived based on ordinary least squares (OLS) regression techniques. Weighted least squares (WLS) regression, based on regional estimates of the standard deviation and skewness coefficients associated with the annual peak discharge record (Tasker, 1980), were used to determine the regional regression models. Regional standard deviation and skew were calculated as the respective average standard deviation and skewness of peak discharge at gaging stations in the region. WLS adjusts for the variation in the reliability of flood quantile estimates due to differences in the length of gaged record at a site. The error associated with flood quantile estimates is inversely proportional to record length; hence, each observed flood quantile used in the regression is weighted based on a function that includes years of gaged peak-flow record. The weighting function (Tasker, 1980) is based, in part, on theory and, in part, on analysis of residuals from the OLS regional model. It assumes that the dependent variable in the model, the flood quantile, is determined by fitting the logarithms (base 10) of observed annual peak discharges to a Pearson Type III distribution.

The variance of the dependent variable, Y_i, must be estimated to determine the appropriate weight factors for the WLS regression. To be effective, the weights should be inversely proportional to the variance of Y_i. The variance of Y_i can be partitioned into two components: the variance due to regression model error, c_o, and the variance due to time-sampling error, t_o, which is related to the distribution of the annual peaks and to the length of gaged record. The weight function has the form:

$$w_i = 1 / (c_o + t_o)$$

The model error is estimated by:

$$c_o = \text{maximum } [0; (SE)^2 - t_o],$$

where, SE is the standard error of the estimate from the OLS model, and t_o is the estimate of time-sampling error. If $[(SE)^2 - t_o]$ is a negative number, c_o is set to 0. The time-sampling error is determined by:

$$t_o = c_1 (1/n_i),$$

where, c_1 is a constant and n_i is the number of years of gaged peak-discharge record. The constant, c_1, is related to the recurrence interval of the flood quantile and to the distribution of the annual peak discharge series, and is determined:

$$c_1 = \text{maximum}\ [0;\ (s^2[1 + [(k^2/\ 2)\ (1+\ (3/4)\ g^2\ )] +\ k\ g\ ])]$$

where s is the standard deviation of the logarithms (base 10) of the annual peaks at a gaged site,
k is the standardized Pearson Type III deviate for recurrence interval T and skew coefficient g (Harter, 1969), and
g is the weighted skew coefficient of the logarithms (base 10) of the peak-discharge series (U.S. Water Resources Council, 1981).

The values s, and g are regional estimates determined by the averages of the respective values in the region. The method is based on the assumption that s and g are approximately constant for all sites in the region.

HYDROLOGIC REGIONS IN KENTUCKY

Regionalization Technique

Regression estimates of flood quantiles can be improved by reducing the variability of the relation between peak discharge and basin characteristics at different gaged sites. Variability can be reduced by regionalization, a process in which an area is divided into hydrologic regions to account for regional differences in flood response and in the factors affecting streamflow. This method is most effective when the hydrologic regions exhibit a more homogeneous flood response to climatic inputs and when the division into hydrologic regions accounts for regional differences in flood response that are not explained by the variables included in the regression model.

Hydrologic regions as defined in this report refer to areas in which streamflow gaging stations indicate a similarity of flood response which differs from the flood response in adjacent regions. These similarities and differences are defined by the regression residuals. A residual is the difference between the flood quantile determined from analysis of peak discharge records and the estimated flood value determined from the regression model.

The hydrologic regions were delineated based on inspection of the areal distribution of the regression residuals. Regions where the model consistently overestimated or underestimated the flood response were delineated as separate hydrologic regions and separate regression models were developed to estimate flood quantiles in each of these regions. These regions were then re-evaluated and refined until residuals failed to show consistent regional differences and further subdivision did not improve the precision of the estimates from the regression relations. Regional differences in physiography, geology, and soils were considered in defining boundaries for the hydrologic regions. Generally the hydrologic region boundaries coincide with drainage basin divides.

Delineation and Evaluation of Regions

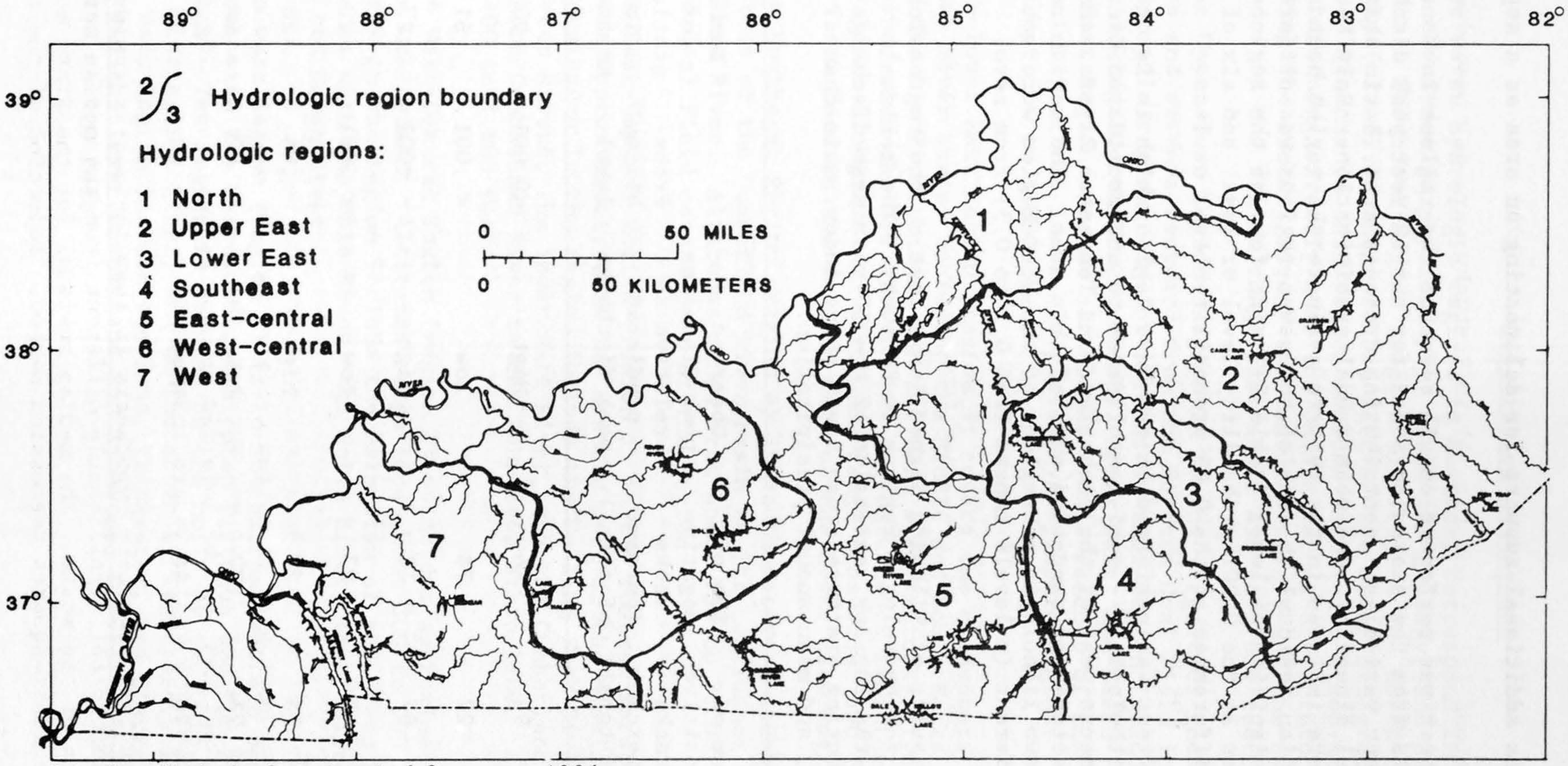
Hydrologic regions (pl. 1 and fig. 5) in Kentucky were delineated using an iterative procedure based on evaluation of the areal distribution of residuals associated with regression models. Initially, two statewide regression models were selected, based on both stepwise and all-possible-subsets regression using data from all stations, to identify hydrologically similar regions. The dependent variable in the models was the peak flow quantile with a 50-year recurrence interval. Independent variables in the first regression model were contributing drainage area, main channel sinuosity, and basin shape; the second model included these three variables and also mean annual precipitation; all variables in both models were significant at the 0.02 probability level. The coefficient of determination (r^2) for both models was 0.91 and the standard error of the estimate ranged from about 55 to 60 percent. Results from the two models were compared in order to verify the consistency of residual distributions. Both models yielded a similar areal distribution in residual sign and magnitude.

Initially five hydrologic regions were delineated based on residuals from the statewide models. The seven final regions in figure 5 were identified based on separate evaluation of residuals from the regression models developed for each of the initial five regions. Consistent areal patterns were not apparent in the residual plots for the final regression models. Plate 1 shows detailed locations of the hydrologic region boundaries and locations of the gaging stations used in the analysis.

Regions 1 through 7 (fig. 5) are designated informally in this report as the North (1), Upper East (2), Lower East (3), Southeast (4), East-Central (5), West-Central (6), and West Regions (7).

Delineation of flood regions using regression residuals requires a certain amount of hydrologic judgement in grouping stations and positioning region boundaries. Geographic areas characterized by regression residuals having a similar sign and magnitude are assumed to represent regions with similar flood-response characteristics. To determine whether the apparent clustering of residuals represented consistent differences in the regression residuals and flood response, the Wilcoxon Signed Ranks test (Conover, 1971) was used to compare residuals between regions (Tasker, 1982). Because the regions were defined based on the residuals, the probabilities associated with the Wilcoxon test results are influenced by the statistical dependence between the regions and the residuals. Hence, the test cannot be used to statistically verify the regions but the test does provide a quantitative index for evaluating the distribution of residuals in each region. In order for the probabilities associated with the test to be statistically valid, the region boundaries would have to be defined based on evidence other than the distributions of the residuals. Because this condition was not met, the probabilities associated with the Wilcoxon test can only be inferred as hypothetical, assuming that the region boundaries and the residuals are independent.

In the Wilcoxon test, the test hypothesis is that the median residual in an hydrologic region is not significantly different from the median residual for the entire area of the state. The median residual for the State must be zero, based on the least-squares regression method. Rejection of the test



Base from Kentucky Department of Commerce, 1964,
Map series B, Frankfort, Ky.

Figure 5.--Hydrologic regions in Kentucky (refer to plate 1 for additional detail).

hypothesis provides additional support for delineating an area as a separate hydrologic region.

The Wilcoxon test was performed on all seven of the regions in Kentucky using the residuals from the statewide model for the 50-year peak discharge based on independent variables: contributing drainage area, basin shape index, main channel sinuosity, and mean annual precipitation. Only Kentucky gaging stations were included in the test to evaluate the region boundaries in Kentucky. The median residual in each of the seven regions was different from zero at the 0.10 significance level (table 5), with four of the regions showing differences at the 0.001 probability level or less, and six of the regions showing differences at the 0.05 probability level or less.

An additional test was performed on the West Region which is is underlain by two distinct lithologies -- semi-consolidated to unconsolidated Cretaceous and Tertiary sediments west of the Cumberland and Tennessee Rivers, and Mississippian limestone and sandstone east of this area. The median residuals in each of these two lithologic subregions of the West Region were not significantly different (p-levels ranged from 0.2 to 0.3) from zero.

Table 5.--Results of Wilcoxon Signed Ranks test on the regression residuals for hydrologic regions in Kentucky. The residuals were from the log-log regression of the 50-year peak discharge on contributing drainage area, basin shape index, main channel sinuosity, and mean annual precipitation.

Hydrologic region	Sum of positive ranks (percent of total)	Sum of negative ranks (percent of total)	Observed peak discharge relative to predicted peak discharge	Probability level	Number of stations in Kentucky
North	94	6	High	<0.001	25
Upper East	22	78	Low	< .001	61
Lower East	87	13	High	.001	23
Southeast	3	97	Low	< .001	20
East-Central	73	27	High	.04	28
West-Central	23	77	Low	.02	24
West	70	30	High	.08	26

Description of Regions

The seven hydrologic regions in Kentucky correspond in part to variations across the State in physiography, soils and geology, and precipitation patterns. The North Region (region 1) occupies the north-central part of Kentucky (pl. 1) in the northern part of the Outer Bluegrass physiographic region. Streams in this region include relatively steep-gradient, small basins draining directly into the Ohio River or drain into larger tributaries including the Licking River, the Kentucky River, and the Salt River. Altitudes in the region range from about 450 to 1,050 feet.

The Upper East Region (region 2) is the largest of the seven hydrologic regions and extends westward from the Eastern Coal Field into the Bluegrass physiographic regions. Major streams in this region include the Big Sandy, upper Licking, North Fork Kentucky, upper Salt, and Beech Fork Rivers. The Upper East Region extends across the middle reaches of the Kentucky River in the vicinity of the Inner Bluegrass physiographic region. Altitudes range from about 500 to 4,000 feet.

The Lower East Region (region 3) covers the headwaters area of the Kentucky River basin, including the Middle and South Forks of the Kentucky River, the Dix River basin, and the main stem Kentucky River to below its confluence with the Dix River. The region extends from the Eastern Coal Field to the Inner Bluegrass and altitudes range from about 500 feet in the west to about 4,150 feet in the eastern part of the Lower East Region.

The Southeast Region (region 4) in southeastern Kentucky occupies the headwaters of the Cumberland River basin to its confluence with the South Fork Cumberland River. Altitudes range from about 750 to 3,000 feet and the Eastern Coal Field covers most of the region.

The East-Central Region (region 5) in the central karst area of Kentucky coincides approximately with the eastern part of the Mississippian Plateaus. Major drainages in the region include the Rolling Fork River, the upper Green and Barren Rivers, the lower Salt River, and the Cumberland River from the South Fork Cumberland River to the Tennessee State line. Altitudes range from about 400 to 1,800 feet.

The West-Central Region (region 6) coincides approximately with the Western Coal Field. Altitudes range from about 300 to 900 feet. The major drainages in the region include the main stem of the Green River to its confluence with the Ohio River, the Nolin River, lower Barren River, Mud River, and Rough River.

The West Region (region 7) is in the extreme western part of Kentucky and coincides with the western Mississippian Plateaus and the Mississippi Embayment. The region is bounded on the north by the Ohio River, on the west by the Mississippi River, and on the south by Tennessee. The Major drainages in the West Region include the Pond, Tradewater, and Clarks Rivers, Mayfield Creek, and the lower Cumberland and Tennessee Rivers. Altitudes range from about 250 to 920 feet.

Regional Basin Characteristics

The hydrologic regions in Kentucky (fig. 5) occupy different geographic positions in the State and are characterized by differing geology and physiography. To further evaluate hydrologic differences between these regions, comparisons were made between basin and peak-discharge characteristics in each region. This information for the independent variables used in the regional regression models for estimating flood characteristics also relates to the application and accuracy of the regression models developed for each region.

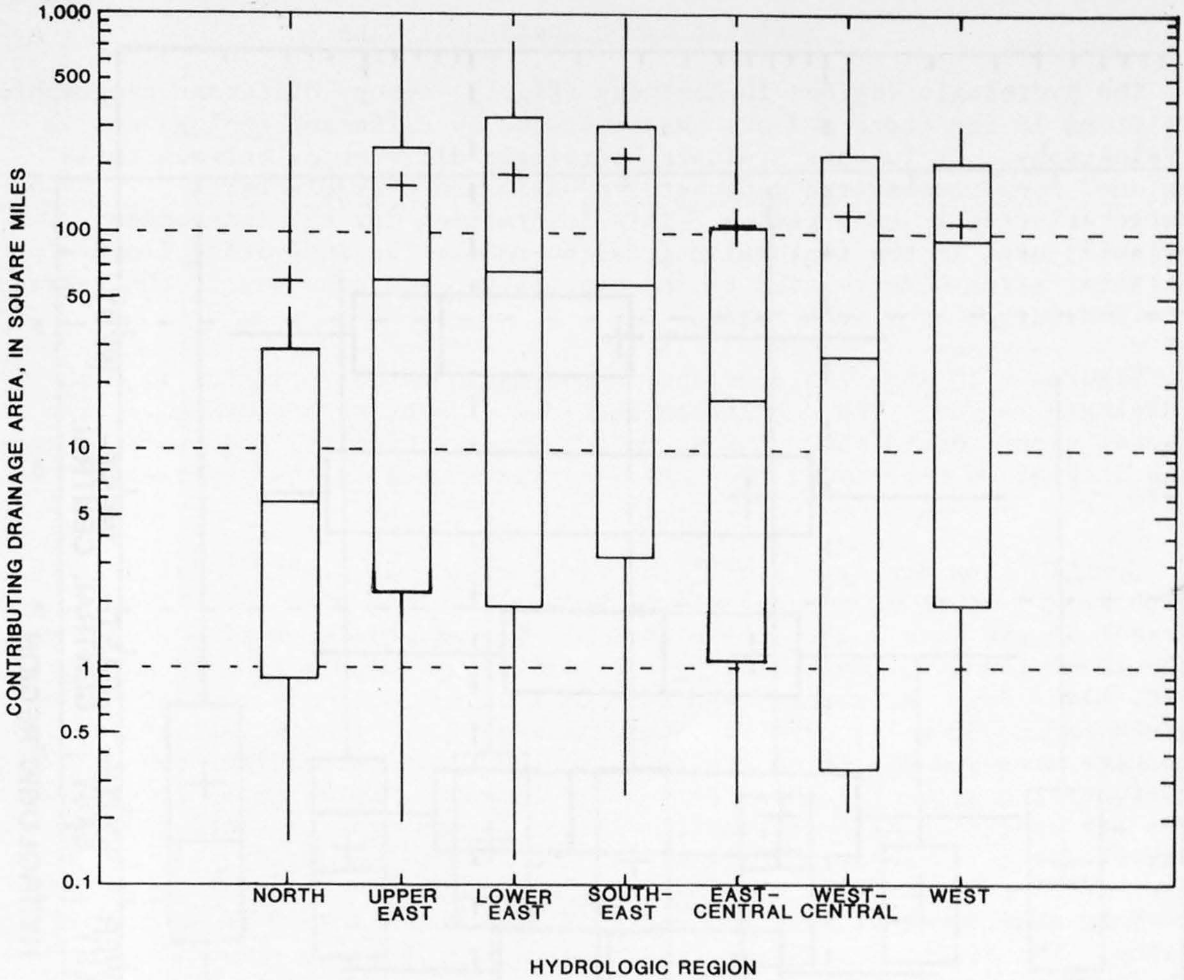
Figures 6-10 show the distribution of basin characteristics in each hydrologic region. The comparison included: contributing drainage area, main channel slope, basin shape index, main channel sinuosity, and years of gaged peak streamflow record for the gaging stations used in the regression analysis.

Contributing drainage area (fig. 6) is generally smallest for stations in North Region where 75 percent of the basins are less than about 30 mi^2, and is largest in the West Region where about 50 percent of the basins are larger than about 100 mi^2. Contributing drainage areas for stations in the Upper East, Lower East, Southeast, and West-Central Regions have similar median values (25 to 70 mi^2). The West-Central Region shows high variability in drainage area and the North Region shows the least variability based on the interquartile range (25 to 75 percentile range) . Differences in drainage area are generally associated with similar differences in other physiographic characteristics such as channel slopes and channel sinuosity.

Main channel slope (fig. 7) ranges from about 2 to 550 ft/mi in the study basins. The North, Lower East, and East-Central Regions show similar channel slopes, with median values of about 25 to 35 ft/mi and an interquartile range of about 12 to 80 ft/mi. In the Upper East and Southeast Regions, the median channel slope is about 20 ft/mi. The West-Central Region shows the highest variability in main channel slope, with an interquartile range of about 4 to 90 ft/mi and a median value of about 18 ft/mi. The channel slope in the Western Region is clearly lower than elsewhere in the State and 75 percent of the basins have a channel slope less than about 28 ft/mi.

The basin shape index (fig. 8) is the ratio of basin length to average basin width; increasing values of the index indicate increasing elongation of the basin. Basin shape index ranges from about 0.3 to 6.9 miles per mile (mi/mi) in the study basins. The range of basin shape is greatest in the North, Upper East, and East-Central Regions. Basins in the Southeast and West-Central Regions tend to be more rounded (median value, 1.7 to 1.8 mi/mi) than those in other regions.

Main channel sinuosity (fig. 9) is the ratio of main channel length to basin length and ranges from about 1.00 to 3.07 mi/mi in the study basins. The North, East-Central, and West Regions have similar distributions of sinuosity with median values of about 1.3 miles per mile, and mean values of about 1.4 miles per mile, which is less than that in other regions. Sinuosity is similar in the Upper and Lower East, Southeast, and West-Central Regions where the mean values exceed 1.5 miles per mile and the interquartile range is about 1.2 to 1.9 miles per mile.



EXPLANATION

for figures 6, 7, 8, 9, and 10

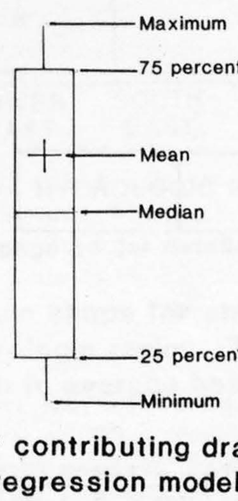
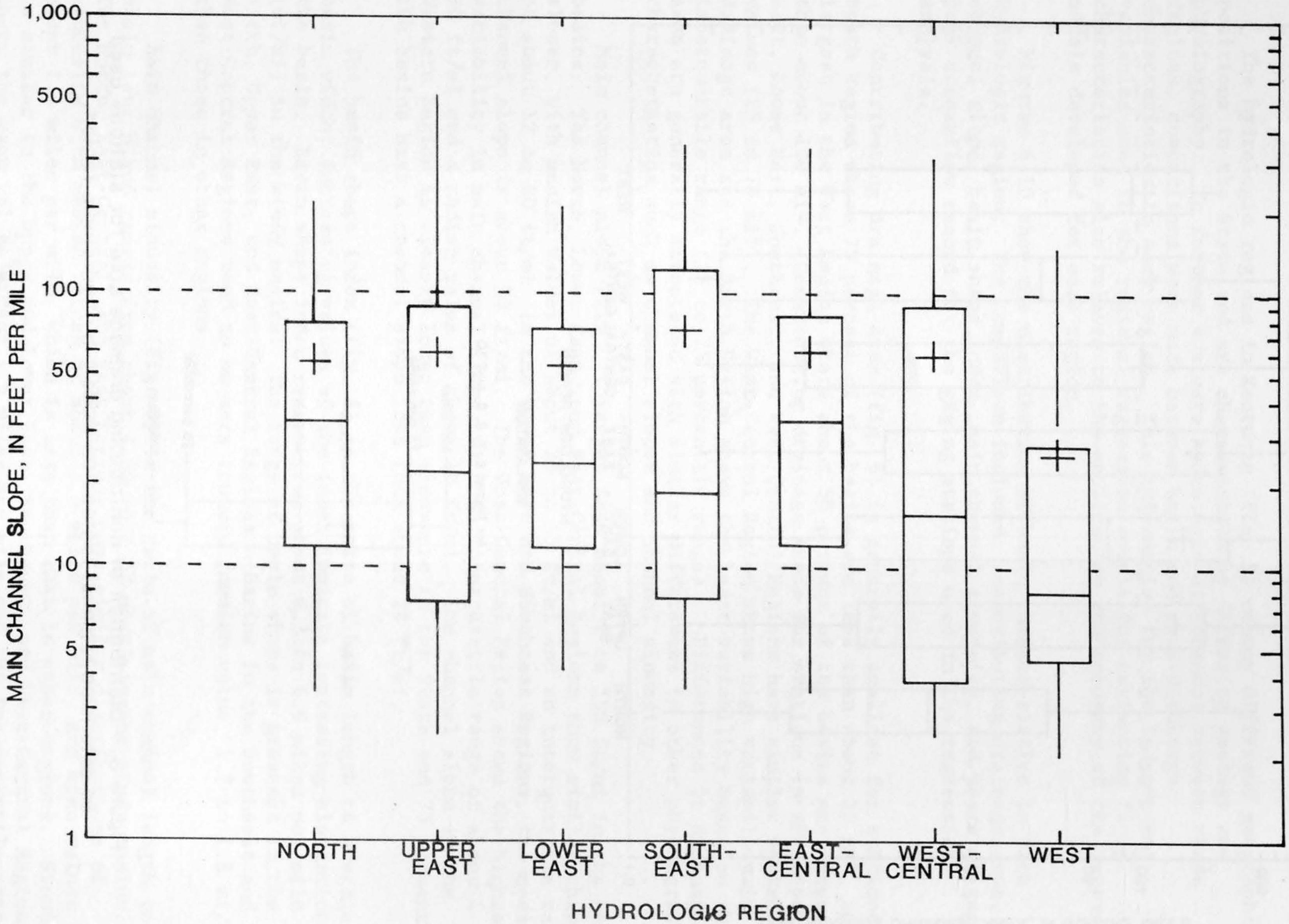
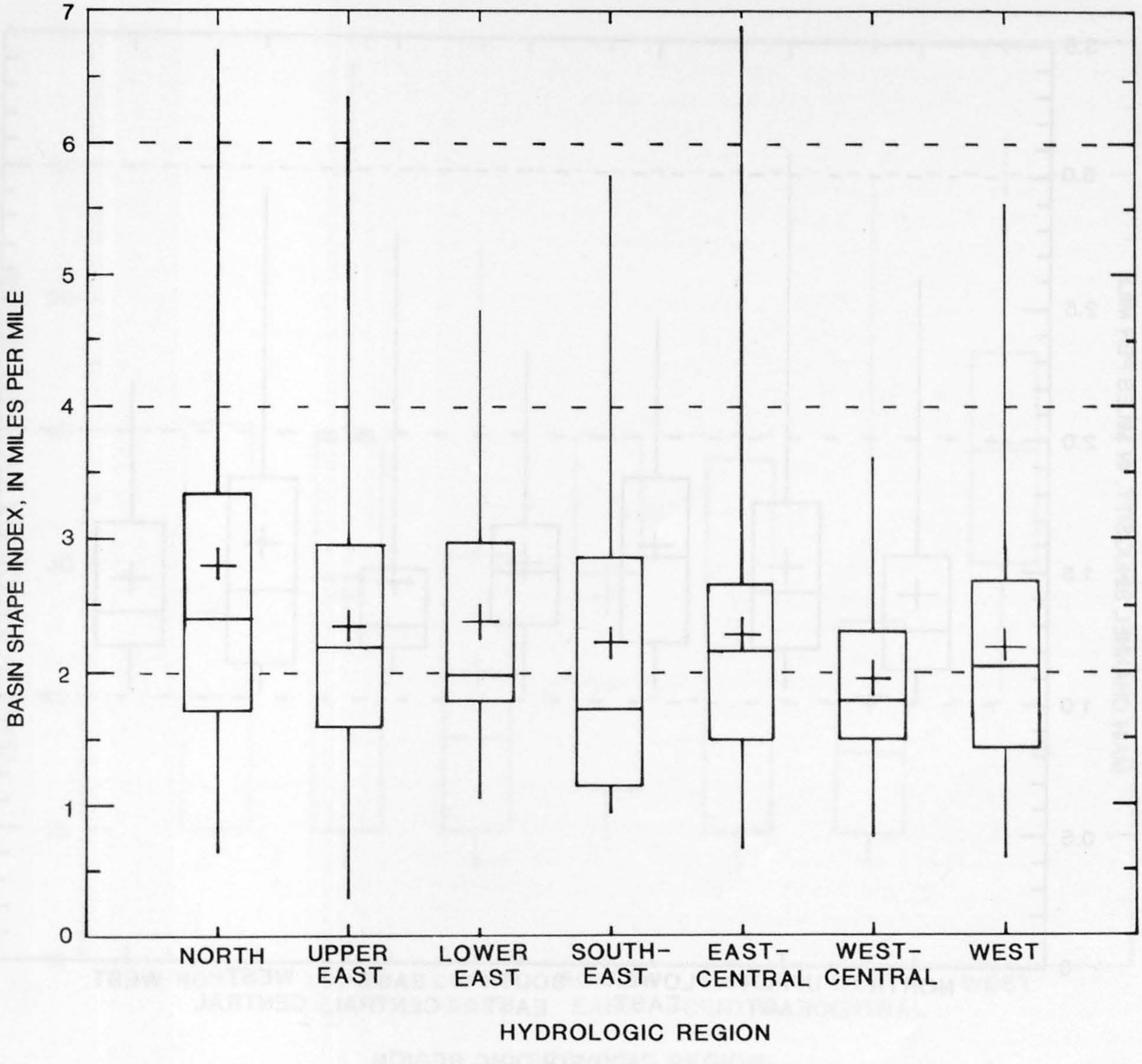


Figure 6.--Distribution of contributing drainage area for stations used to determine regional regression models by hydrologic region.



See page 23 for detailed explanation

Figure 7.--Distribution of main channel slope for stations used to determine regional regression models, by hydrologic region.



See page 23 for detailed explanation

Figure 8.--Distribution of basin shape for stations used to determine regional regression models, by hydrologic region. The basin shape index is equivalent to the ratio of basin length to average basin width.

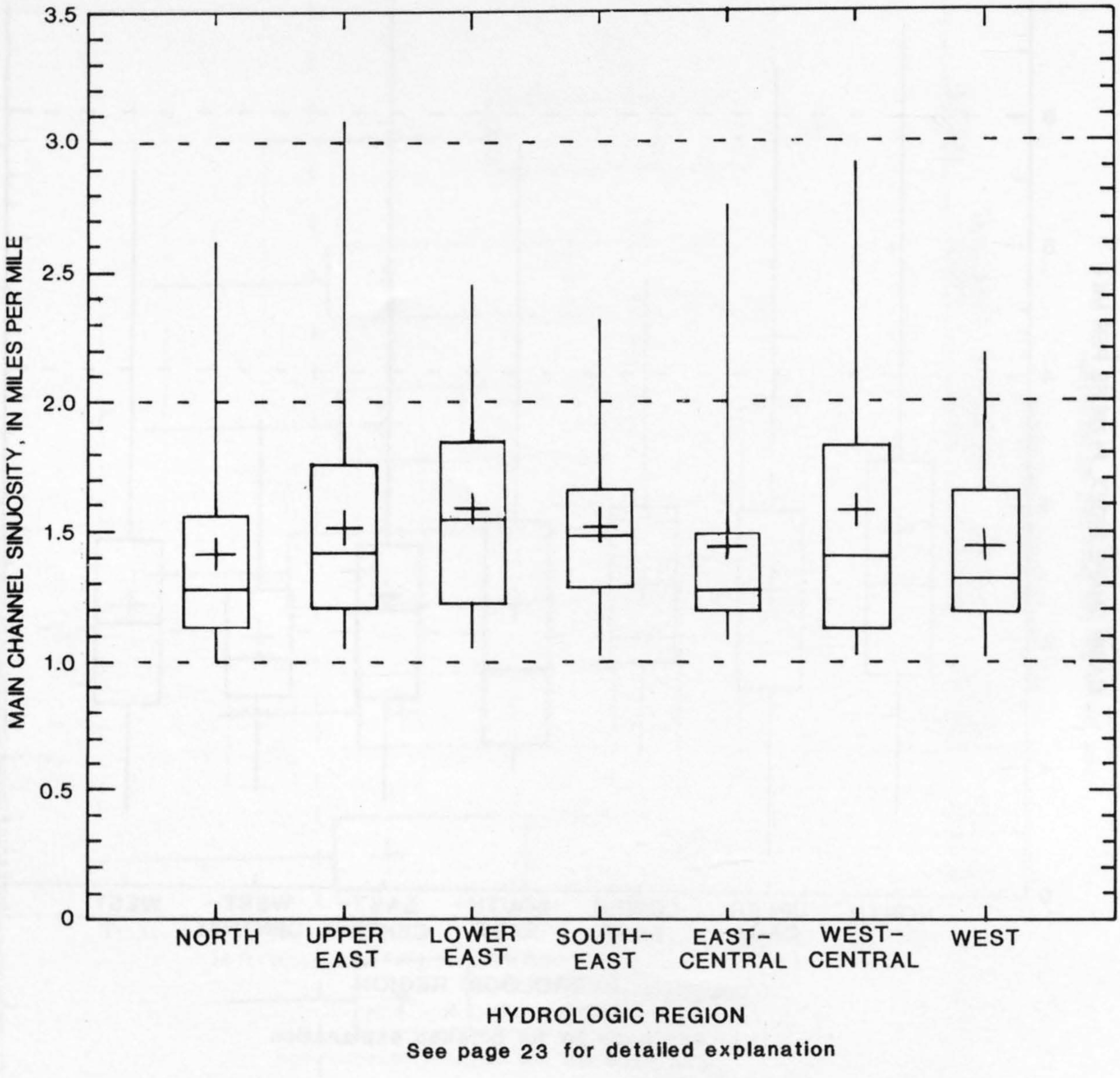
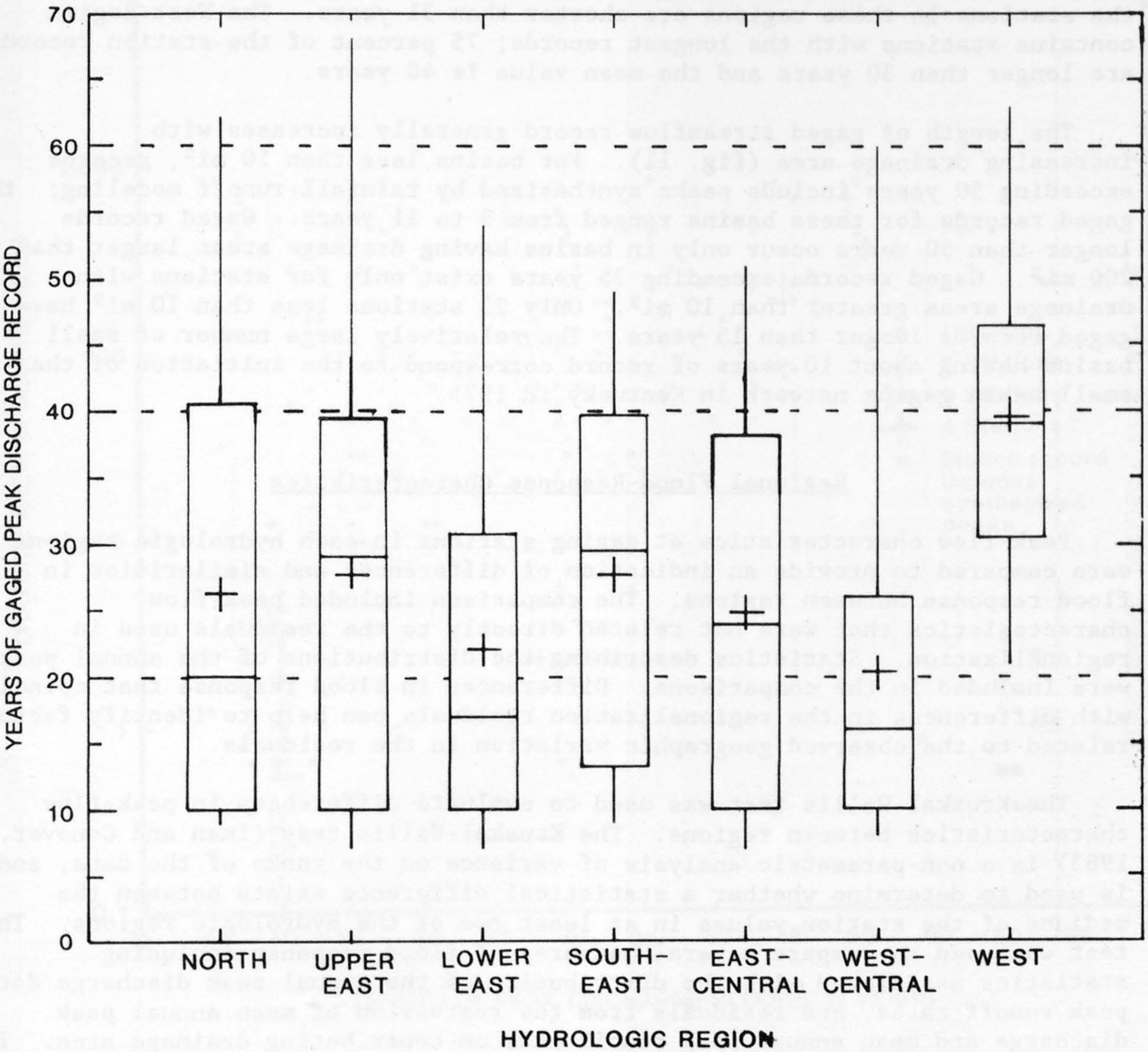


Figure 9.--Distribution of main channel sinuosity for stations used to determine regional regression models, by hydrologic region. Main channel sinuosity is the ratio of main channel length to basin length.



See page 23 for detailed explanation

Figure 10.--Distribution of length of peak discharge for stations used to determine regional regression models, by hydrologic region.

The North, Upper East, Southeast, and East-Central Regions show similar distributions in the length of gaged peak discharge record (fig. 10). The mean record length is about 25 to 27 years and the interquartile range is from about 10 to 40 years. The Lower East and West-Central Regions have slightly shorter records with mean values of 20 to 21 years; records at 75 percent of the stations in these regions are shorter than 31 years. The West Region contains stations with the longest records; 75 percent of the station records are longer than 30 years and the mean value is 40 years.

The length of gaged streamflow record generally increases with increasing drainage area (fig. 11). For basins less than 10 mi^2, records exceeding 50 years include peaks synthesized by rainfall-runoff modeling; the gaged records for these basins ranged from 3 to 11 years. Gaged records longer than 50 years occur only in basins having drainage areas larger than 200 mi^2. Gaged records exceeding 35 years exist only for stations with drainage areas greater than 10 mi^2. Only 23 stations less than 10 mi^2 have gaged records longer than 15 years. The relatively large number of small basins having about 10 years of record correspond to the initiation of the small basin gaging network in Kentucky in 1975.

Regional Flood-Response Characteristics

Peak-flow characteristics at gaging stations in each hydrologic region were compared to provide an indication of differences and similarities in flood response between regions. The comparison included peak-flow characteristics that were not related directly to the residuals used in regionalization. Statistics describing the distributions of the annual peaks were included in the comparisons. Differences in flood response that coincide with differences in the regionalization residuals can help to identify factors related to the observed geographic variation in the residuals.

The Kruskal-Wallis test was used to evaluate differences in peak-flow characteristics between regions. The Kruskal-Wallis test (Iman and Conover, 1983) is a non-parametric analysis of variance on the ranks of the data, and is used to determine whether a statistical difference exists between the medians of the station values in at least two of the hydrologic regions. This test was used to compare several measures of flood response including statistics associated with the distribution of the annual peak discharge data, peak runoff rates, and residuals from the regression of mean annual peak discharge and mean annual peak runoff rate on contributing drainage area. The comparisons focused primarily on the gaged annual peak discharge data for stations in each region.

Results of the Kruskal-Wallis test indicate that significant differences between regions exist for several of the peak-flow characteristics (table 6). At the 0.10 significance level, differences were detected for the standard deviation, coefficient of skew, and the mean annual peak runoff rate, all determined from the gaged annual peak record. The contributing drainage area (mi^2), the 50-year peak discharge (ft^3/sec), and the 50-year peak runoff rate [$(ft^3/sec)/mi^2$] also showed significant differences between hydrologic regions. Residuals from the regressions of mean annual peak runoff rate and mean annual peak discharge on contributing drainage area (coefficent of determination .76 and .94, respectively; standard error of the estimate 47

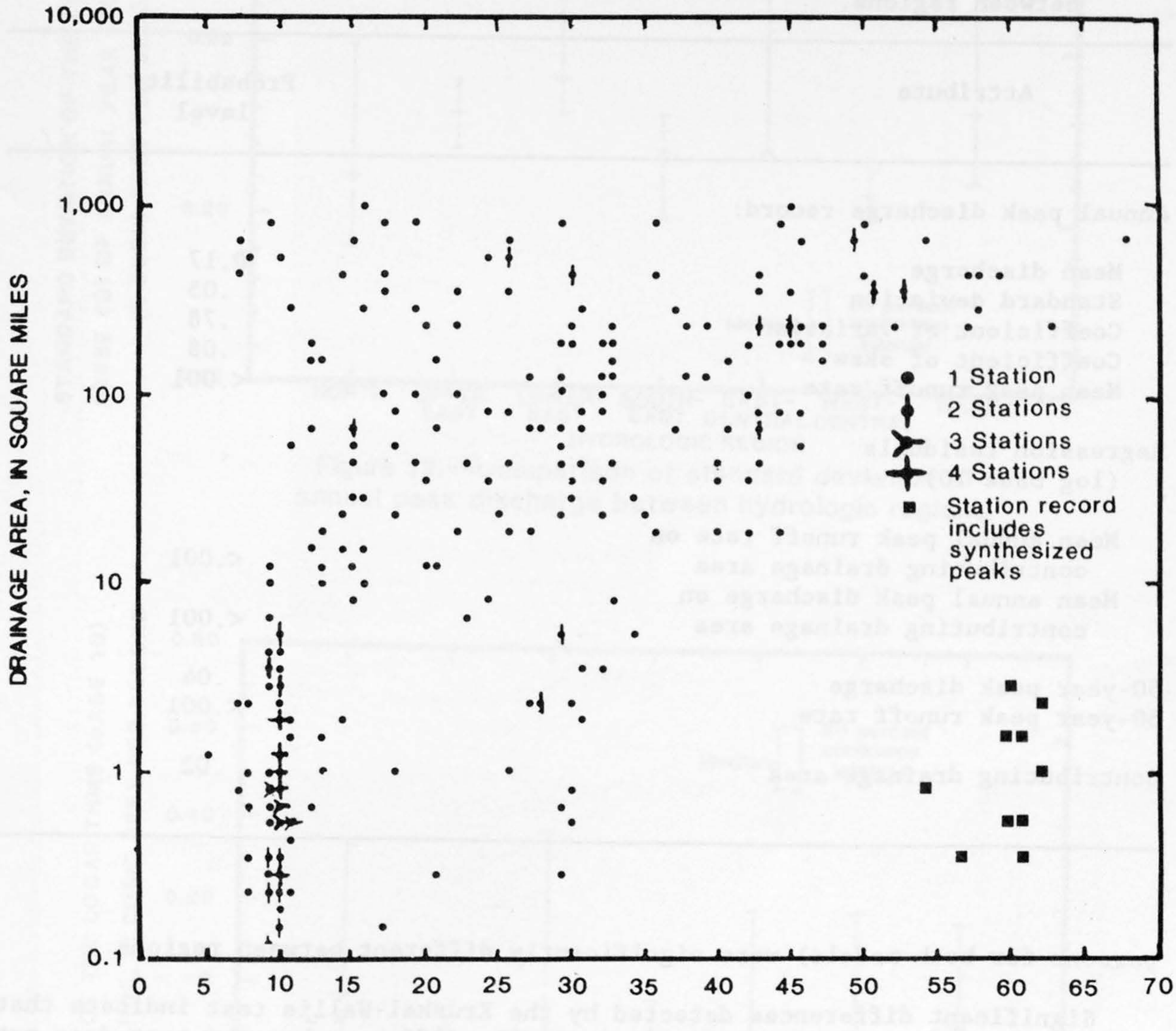


Figure 11.--Basin drainage area and length of peak discharge record for gaging stations used in the analysis.

Table 6.--Kruskal-Wallis test comparing differences in peak discharge characteristics and drainage area between the hydrologic regions. Graphical comparisons are shown in figures 12-17 for selected attributes that were statistically different (significance level = 0.10) between regions.

Attribute	Probability level
Annual peak discharge record:	
Mean discharge	0.17
Standard deviation	.05
Coefficient of variation	.78
Coefficient of skew	.08
Mean peak runoff rate	<.001
Regression residuals (log base 10):	
Mean annual peak runoff rate on contributing drainage area	<.001
Mean annual peak discharge on contributing drainage area	<.001
50-year peak discharge	.04
50-year peak runoff rate	<.001
Contributing drainage area	.02

percent for both models) were significantly different between regions.

Significant differences detected by the Kruskal-Wallis test indicate that at least two of the regions are statistically different but the test does not indicate where the differences exist. For attributes showing significant differences, the 90 percent confidence interval for the medians is shown in figures 12-17. Although the differences between regions vary for different attributes tested, the median values and the confidence intervals for most attributes tend to be similar for the Upper East, Southeast, and West-Central Regions (regions 2, 4, and 6) which differ from the North, Lower East, East-Central, and West Regions (regions 1, 3, 5, and 7). The median residuals from regressions of mean annual peak discharge and mean annual peak runoff rate on contributing drainage area (figs. 16 and 17) show distinct differences between regions 1, 3, 5, and 7, and regions 2, 4, and 6. The statewide regression models of peak discharge on drainage area and of runoff rate on drainage area underestimate the peaks in regions 1, 3, 5, and 7, and overestimate the peaks in regions 2, 4, and 6. Differences in contributing drainage area (fig. 15)

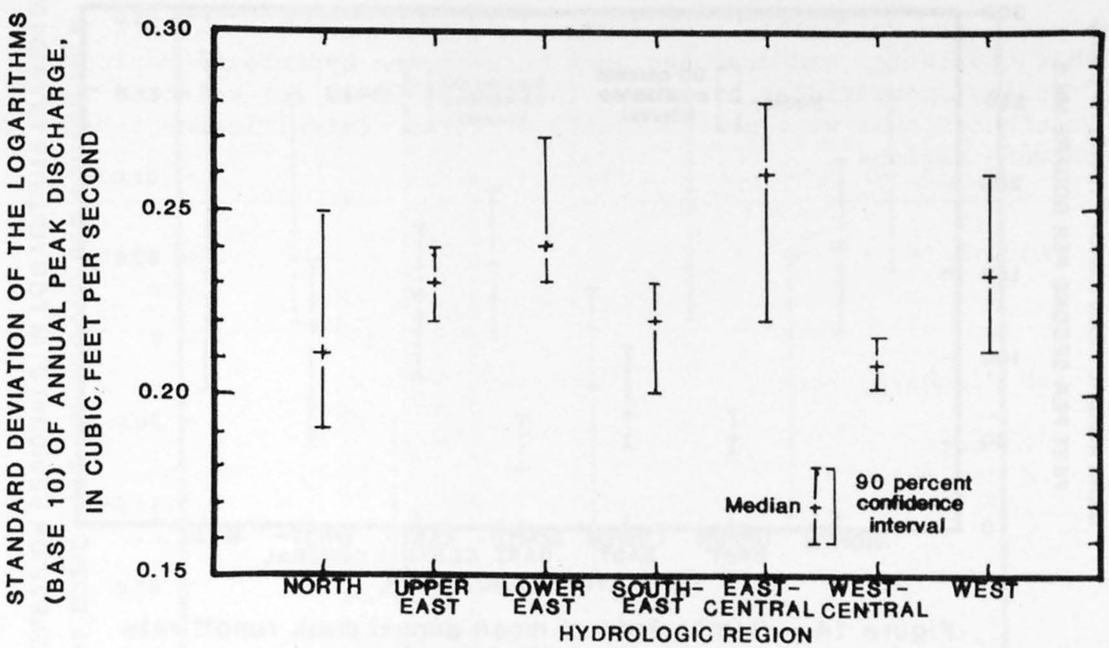


Figure 12.--Comparison of standard deviation of annual peak discharge between hydrologic regions.

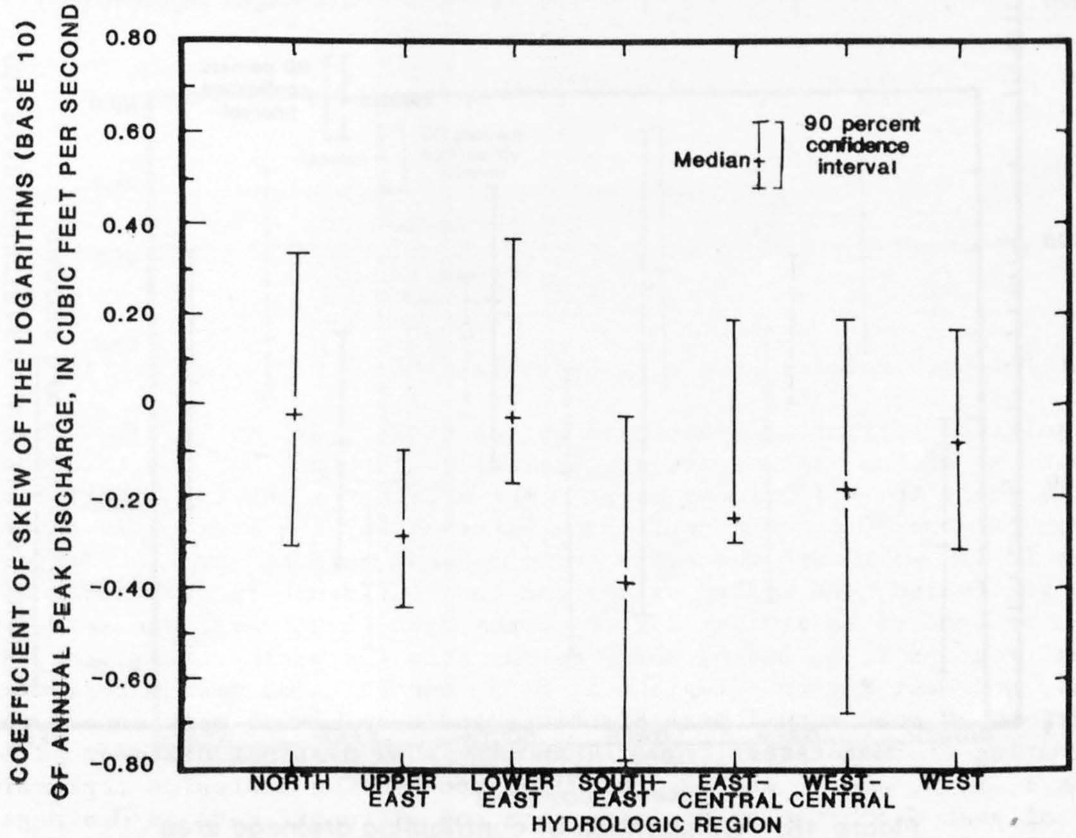


Figure 13.--Comparison of coefficient of skew of annual peak discharge between hydrologic regions.

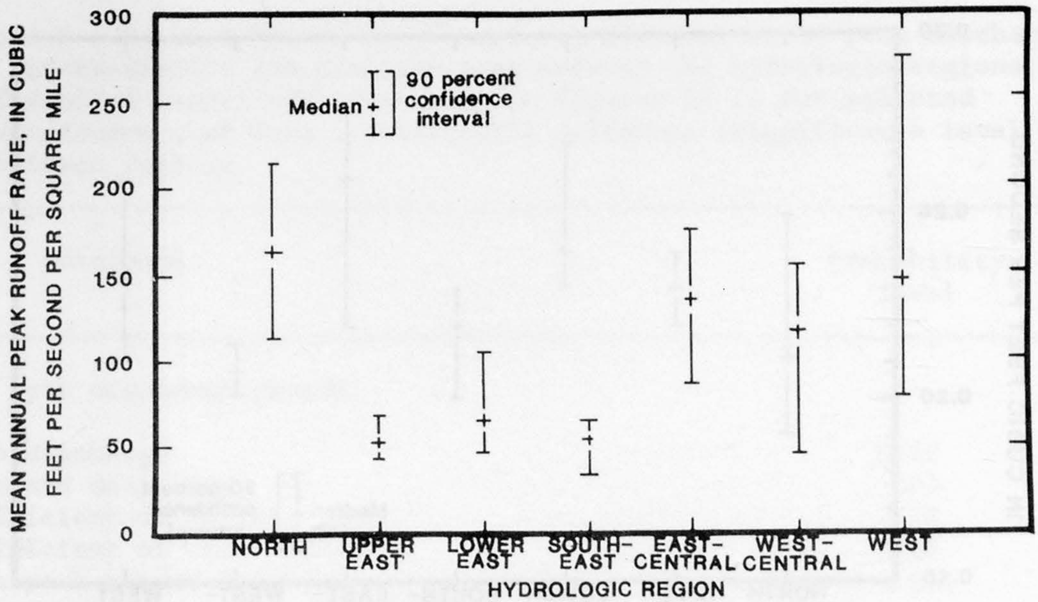


Figure 14.--Comparison of mean annual peak runoff rate between hydrologic regions.

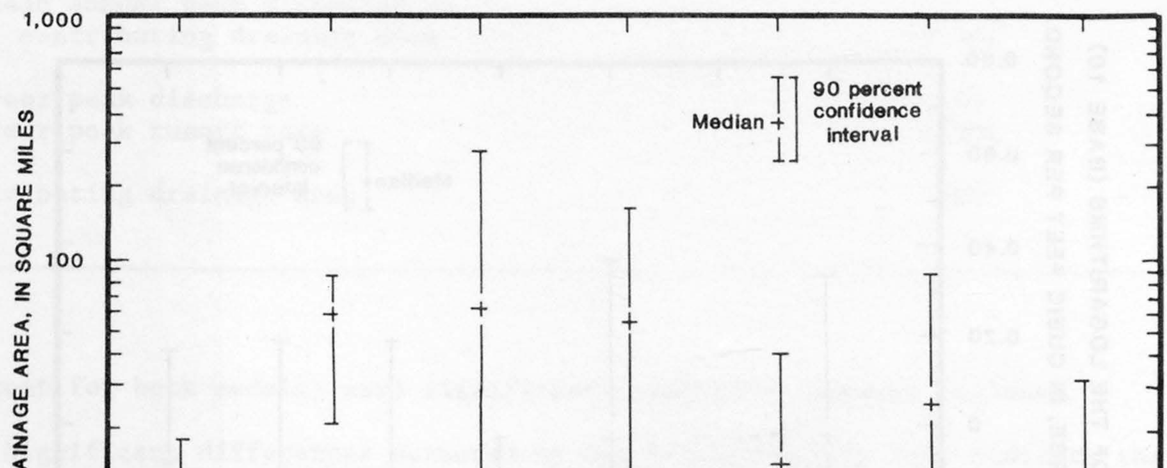


Figure 15.--Comparison of contributing drainage area between hydrologic regions.

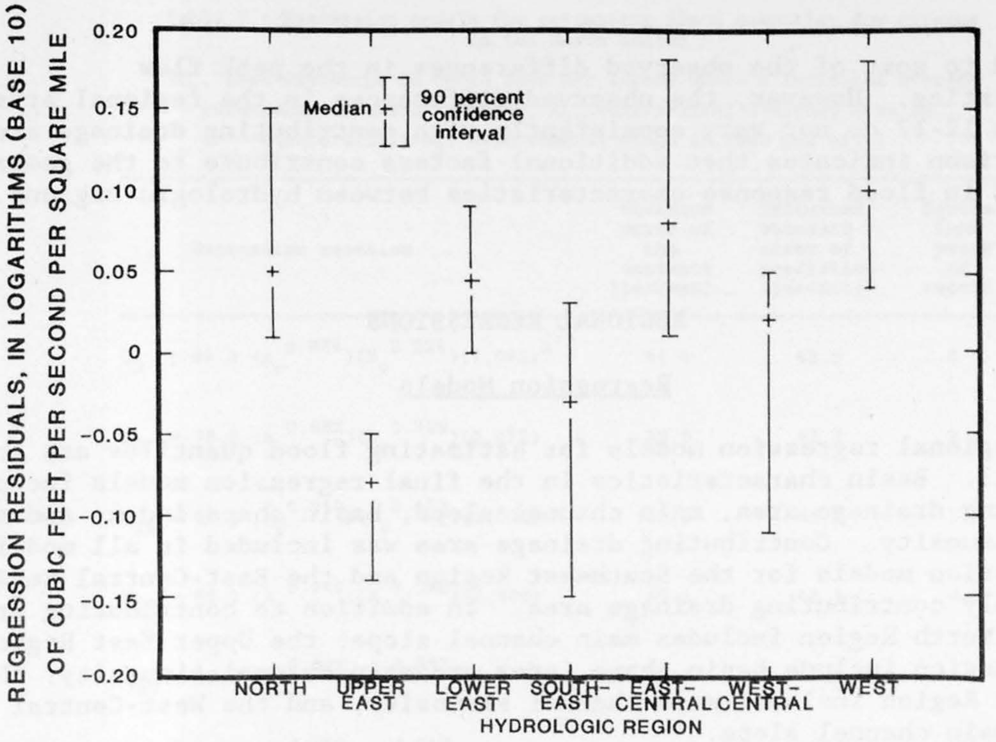


Figure 16.--Comparison of residuals from log-log regression of mean annual peak runoff rate on contributing drainage area between hydrologic regions.

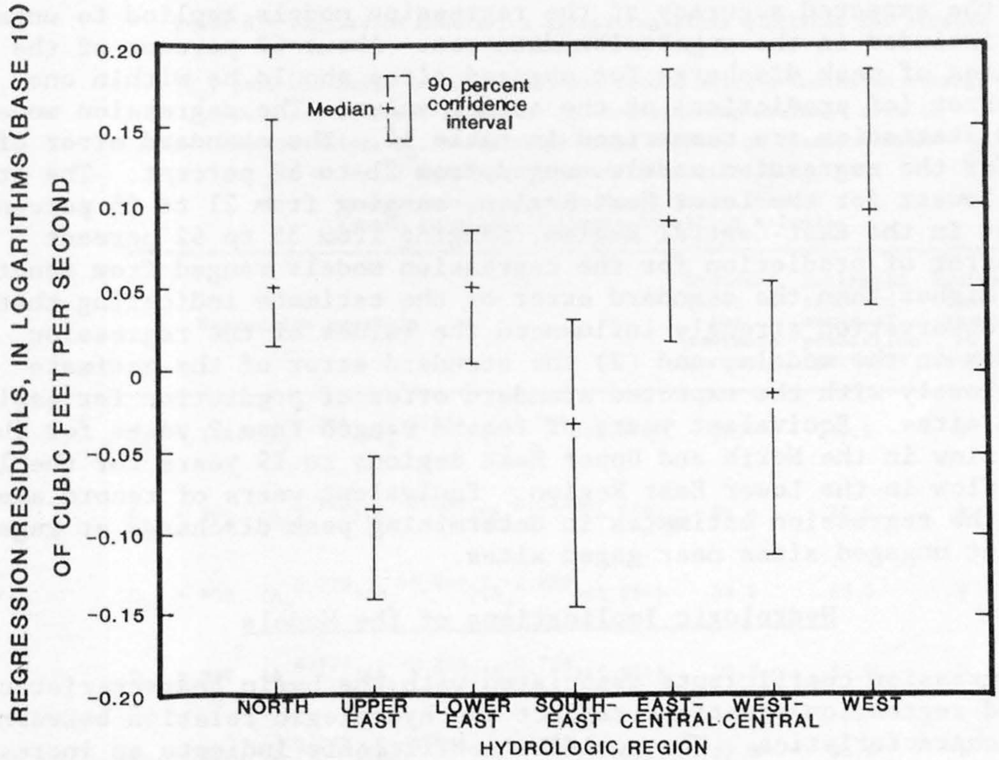


Figure 17.--Comparison of residuals from log-log regression of mean annual peak discharge on contributing drainage area between hydrologic regions.

correspond to some of the observed differences in the peak flow characteristics. However, the observed differences in the regional attributes in figures 12-17 do not vary consistently with contributing drainage area. The comparison indicates that additional factors contribute to the geographic variations in flood response characteristics between hydrologic regions.

REGIONAL REGRESSIONS

Regression Models

The regional regression models for estimating flood quantiles are shown in tables 7-13. Basin characteristics in the final regression models included contributing drainage area, main channel slope, basin shape index, and main channel sinuosity. Contributing drainage area was included in all models. The regression models for the Southeast Region and the East-Central Region include only contributing drainage area. In addition to contributing drainage area, the North Region includes main channel slope; the Upper East Region and the West Region include basin shape index and main channel sinuosity; the Lower East Region includes main channel sinuosity; and the West-Central Region includes main channel slope.

Along with the regression equations, tables 7-13 include the standard error associated with the regression estimates, an estimate of the standard error of prediction, and equivalent years of record. The prediction error indicates the expected accuracy of the regression models applied to ungaged sites not included in the regression data set. About 68 percent of the time, the estimates of peak discharge for ungaged sites should be within one standard error (of prediction) of the actual value. The regression models and associated statistics are summarized in table 14. The standard error of the estimate for the regression models ranged from 21 to 52 percent. The standard error was lowest for the Lower East Region, ranging from 21 to 25 percent, and was highest in the East-Central Region, ranging from 35 to 52 percent. The standard error of prediction for the regression models ranged from about 2 to 7 percent higher than the standard error of the estimate indicating that (1) no single observation strongly influenced the values of the regression coefficients in the models, and (2) the standard error of the estimate compares closely with the expected standard error of prediction for estimates at ungaged sites. Equivalent years of record ranged from 2 years for the 2-year peak flow in the North and Upper East Regions to 19 years for the 100-year peak flow in the Lower East Region. Equivalent years of record are used to weight the regression estimates in determining peak discharge at gaged sites and at ungaged sites near gaged sites.

Hydrologic Implications of the Models

The regression coefficients associated with the basin characteristics in the defined regression equations reflect the hydrologic relation between basin and flood characteristics. The positive coefficients indicate an increase in peak discharge with increasing drainage area, channel slope, and annual precipitation. The negative regression coefficients for basin shape and channel sinuosity indicate a decrease in peak discharge with increasing basin elongation and with increasing sinuosity of the main stream channel.

Table 7.--Regression models for estimating flood quantiles for streams in the North Region

[Q_t, peak discharge in cubic feet per second where t indicates average recurrence interval in years; A_c, contributing drainage area in square miles; S_c, main channel slope in feet per mile]

Regression equation	Standard error of the estimate (percent)	Estimated standard error of prediction (percent)	Equivalent years of record
$Q_2 = 97.4\ (A_c^{0.824})(S_c^{0.224})(1.082)$[a]	41.4	45.6	2
$Q_5 = 76.2\ (A_c^{0.882})(S_c^{0.389})(1.072)$	38.5	42.2	2
$Q_{10} = 67.8\ (A_c^{0.910})(S_c^{0.472})(1.075)$	39.3	43.0	3
$Q_{25} = 60.1\ (A_c^{0.940})(S_c^{0.560})(1.085)$	42.1	46.1	4
$Q_{50} = 55.7\ (A_c^{0.959})(S_c^{0.617})(1.095)$	44.7	49.2	4
$Q_{100} = 51.4\ (A_c^{0.978})(S_c^{0.669})(1.109)$	47.8	52.8	5

[a] Bias correction factor

Table 8.--Regression models for estimating flood quantiles for streams in the Upper East Region

[Q_t, peak discharge in cubic feet per second where t indicates average recurrence interval in years; A_c, contributing drainage area in square miles; B_s, basin shape index = ratio of (basin length in miles) / (average basin width in miles); S_s, main channel sinuosity = ratio of (main channel length in miles) / (basin length in miles)]

Regression equation	Standard error of the estimate (percent)	Estimated standard error of prediction (percent)	Equivalent years of record
$Q_2 = 175.\ (A_c^{0.764})(B_s^{-0.174})(S_s^{-0.304})(1.079)$[a]	40.4	43.1	2
$Q_5 = 304.\ (A_c^{0.773})(B_s^{-0.256})(S_s^{-0.522})(1.058)$	34.6	36.6	3
$Q_{10} = 406.\ (A_c^{0.776})(B_s^{-0.297})(S_s^{-0.628})(1.054)$	33.2	35.0	4
$Q_{25} = 549.\ (A_c^{0.777})(B_s^{-0.330})(S_s^{-0.739})(1.054)$	33.2	35.0	6
$Q_{50} = 670.\ (A_c^{0.777})(B_s^{-0.356})(S_s^{-0.803})(1.056)$	33.9	35.8	8
$Q_{100} = 798.\ (A_c^{0.777})(B_s^{-0.373})(S_s^{-0.862})(1.060)$	35.1	37.1	9

[a] Bias correction factor

Table 9.--Regression models for estimating flood quantiles for streams in the Lower East Region

[Q_t, peak discharge in cubic feet per second where t indicates average recurrence interval in years; A_c, contributing drainage area in square miles; S_s, main channel sinuosity = ratio of (main channel length in miles) / (basin length in miles)]

Regression equation	Standard error of the estimate (percent)	Estimated standard error of prediction (percent)	Equivalent years of record
$Q_2 = 206. (A_c^{0.743})(S_s^{-0.111})(1.022)$[a]	21.0	23.6	6
$Q_5 = 365. (A_c^{0.730})(S_s^{-0.205})(1.021)$	20.8	24.0	8
$Q_{10} = 495. (A_c^{0.723})(S_s^{-0.264})(1.023)$	21.3	25.2	10
$Q_{25} = 687. (A_c^{0.717})(S_s^{-0.338})(1.025)$	22.5	27.0	12
$Q_{50} = 849. (A_c^{0.714})(S_s^{-0.392})(1.027)$	23.4	28.2	16
$Q_{100} = 1,030. (A_c^{0.711})(S_s^{-0.447})(1.030)$	24.6	29.6	19

[a] Bias correction factor

Table 10.--Regression models for estimating flood quantiles for streams in the Southeast Region

[Q_t, peak discharge in cubic feet per second where t indicates average recurrence interval in years; A_c, contributing drainage area in square miles]

Regression equation	Standard error of the estimate (percent)	Estimated standard error of prediction (percent)	Equivalent years of record
$Q_2 = 110. (A_c^{0.825})(1.039)$[a]	28.2	31.5	3
$Q_5 = 182. (A_c^{0.804})(1.028)$	23.6	26.6	5
$Q_{10} = 236. (A_c^{0.794})(1.027)$	23.4	26.3	7
$Q_{25} = 307. (A_c^{0.785})(1.031)$	25.0	28.1	9
$Q_{50} = 363. (A_c^{0.780})(1.035)$	26.7	30.2	10
$Q_{100} = 420. (A_c^{0.775})(1.041)$	28.8	32.5	11

[a] Bias correction factor

Table 11.--Regression models for estimating flood quantiles for streams in the East-central Region

[Q_t, peak discharge in cubic feet per second where t indicates average recurrence interval in years; A_c, contributing drainage area in square miles]

Regression equation	Standard error of the estimate (percent)	Estimated standard error of prediction (percent)	Equivalent years of record
$Q_2 = 271. (A_c^{0.707})(1.060)^a$	35.0	36.9	3
$Q_5 = 453. (A_c^{0.698})(1.068)$	37.4	39.3	3
$Q_{10} = 591. (A_c^{0.695})(1.078)$	40.4	42.4	4
$Q_{25} = 785. (A_c^{0.692})(1.096)$	44.8	47.1	4
$Q_{50} = 940. (A_c^{0.690})(1.112)$	48.5	51.1	5
$Q_{100} = 1,100. (A_c^{0.689})(1.129)$	52.3	55.2	6

[a] Bias correction factor

Table 12.--Regression models for estimating flood quantiles for streams in the West-central Region

[Q_t, peak discharge in cubic feet per second where t indicates average recurrence interval in years; A_c, contributing drainage area in square miles; S_c, main channel slope in feet per mile]

Regression equation	Standard error of the estimate (percent)	Estimated standard error of prediction (percent)	Equivalent years of record
$Q_2 = 51.7 (A_c^{0.821})(S_c^{0.368})(1.065)^a$	36.6	40.9	2
$Q_5 = 62.5 (A_c^{0.839})(S_c^{0.422})(1.056)$	33.9	38.0	2
$Q_{10} = 67.4 (A_c^{0.850})(S_c^{0.454})(1.055)$	33.7	37.8	3
$Q_{25} = 71.3 (A_c^{0.865})(S_c^{0.494})(1.059)$	34.8	38.7	4
$Q_{50} = 74.1 (A_c^{0.873})(S_c^{0.520})(1.064)$	36.2	40.2	5
$Q_{100} = 76.0 (A_c^{0.882})(S_c^{0.545})(1.070)$	38.1	42.1	6

[a] Bias correction factor

Table 13.--Regression models for estimating flood quantiles for streams in the West Region

[Q_t, peak discharge in cubic feet per second where t indicates average recurrence interval in years; A_c, contributing drainage area in square miles; B_s, basin shape index = ratio of (basin length in miles) / (average basin width in miles); S_s, main channel sinuosity = ratio of (main channel length in miles) / (basin length in miles)]

Regression equation	Standard error of the estimate (percent)	Estimated standard error of prediction (percent)	Equivalent years of record
$Q_2 = 601. (A_c^{0.659})(B_s^{-0.569})(S_s^{-0.964})(1.069)$[a]	37.9	43.5	2
$Q_5 = 893. (A_c^{0.647})(B_s^{-0.523})(S_s^{-0.809})(1.059)$	34.9	40.3	3
$Q_{10} = 1{,}090. (A_c^{0.642})(B_s^{-0.501})(S_s^{-0.725})(1.059)$	34.4	40.5	4
$Q_{25} = 1{,}340. (A_c^{0.640})(B_s^{-0.482})(S_s^{-0.635})(1.063)$	36.1	42.3	5
$Q_{50} = 1{,}530. (A_c^{0.639})(B_s^{-0.472})(S_s^{-0.579})(1.069)$	37.6	44.3	6
$Q_{100} = 1{,}710. (A_c^{0.639})(B_s^{-0.466})(S_s^{-0.528})(1.075)$	39.4	46.6	7

[a] Bias correction factor

Table 14.--Summary of the regression models for estimating flood quantiles in Kentucky. The summary is based on information from the regression models for estimating the 2-, 5-, 10-, 25-, 50-, and 100-year peak discharge (tables 6 through 12)

[A_c, contributing drainage area in square miles; S_c, main channel slope in feet per mile; B_s, basin shape index = ratio of (basin length in miles) / (average basin width in miles); S_s, main channel sinuosity = ratio of (stream length in miles) / (basin length in miles)]

Hydrologic region	Independent variables	Standard error of the estimate	Estimated standard error of prediction (percent)	Number of gaging stations
North	A_c, S_c	39 - 48	42 - 53	33
Upper East	A_c, B_s, S_s	33 - 40	35 - 43	77
Lower East	A_c, S_s	21 - 25	24 - 30	26
Southeast	A_c	23 - 29	26 - 33	20
East-Central	A_c	35 - 52	37 - 55	40
West-Central	A_c, S_c	34 - 38	38 - 42	32
West	A_c, B_s, S_s	34 - 39	40 - 47	38

Peak discharge for a given flood quantile increases as the contributing source area for storm runoff increases. Streams having low channel slopes and highly sinuous channels generally have lower peak discharge because channel conditions disperse the energy associated with the storm runoff. Steep channel slopes are generally associated with steep hillslopes where storm runoff occurs rapidly resulting in higher peak discharges. More rounded basins (low basin shape index) tend to have larger peak discharges than elongated basins because the relatively uniform distances from the drainage divide to a point on a stream result in simultaneous arrival of runoff from all parts of the basin. In elongated basins (high basin shape index) this effect is dampened by the varying distances from a point on a stream to the basin divide.

The differences in the basin characteristics found to be statistically significant in the regional models relate to several factors. In general, the variables that are significant are strongly related to flood response in the particular region and exhibit a wide range (high variability) in the region. Figures 6-10 show the regional variability of each independent variable. Also, correlation between independent variables can affect the statistical significance of other variables considered for inclusion in the model.

Regression models for the Southeast and East-central Regions contained only one independent variable (contributing drainage area). In the Southeast Region the physiography is relatively homogeneous and except for contributing drainage area, the variation of other basin characteristics is small (figs. 6-10) which probably accounts for the insignificance of other variables in the models for this region. The relatively low standard error (23 to 29 percent) associated with the Southeast Region models indicates a consistent relation between drainage area and flood response in this region. In the East-Central Region the standard error was considerably higher (35 to 52 percent). The variability associated with basin characteristics in the region is not particularly small but extensive karst terrain in the region probably distorts the relation between peak discharge and other drainage basin characteristics. Most of the East-Central Region and parts of the West Region that coincide with the Mississippian Plateaus are highly karstic (figs. 2 and 5). The groundwater flow system in these areas has a large component of conduit-type flow that is connected directly to the surface water flow system (Quinlan and Ewers, 1985; Palmer, 1985). Except for determining areas of non-contributing drainage area and areas of water storage, the effects of karst drainage such as subsurface conduit flow were not quantified by the basin characteristics included in the study and, hence, may account for a part of the error in the models for the East-Central Region. Unusually rapid storm runoff rates have been noted in drainage basins as large as 190 mi^2 in karst areas of West Virginia (Jones and Rauch, 1977). Variations in development of karst drainage also could effectively confound existing relations between peak discharge and other basin characteristics measured in the East-Central Region, explaining the lack of additional significant variables in the regional models.

ESTIMATION OF PEAK DISCHARGE

The techniques used to determine peak discharge at a specific site depend on whether the site is gaged or ungaged and whether the drainage area crosses hydrologic region boundaries or state lines. For an ungaged site near a gaged site on the same stream, a weighting procedure should be used to estimate peak discharge. To determine the procedure that applies to a given site, the site first should be located on plate 1 to determine whether the site is gaged or near a gaged site, and the drainage basin should be outlined on a topographic map. Basin characteristic data have been compiled for all gaged and many ungaged streams in Kentucky, including information on total and contributing drainage area and the 7.5 minute (scale 1:24,000) topographic map sheets on which the streams are located (Bower and Jackson, 1981). Selected basin characteristics have been measured for most of the gaged sites on unregulated streams (Dempster, 1983; Melcher and Ruhl, 1984; table 4 in this report).

Method for Gaged Sites

The method for determining flood quantiles at a gaged site is based on (1) flood frequency analysis of the gaged record and (2) peak discharge determined using the appropriate regression model(s). The estimate is a weighted average of these values in which the station flood frequency is weighted by the total years of gaged record at the site, and the regression estimate is weighted by the equivalent years of record (Hardison, 1971) associated with the regression equation (tables 6-12).

The regression estimate of peak discharge is combined with the peak discharge estimated from the gaged station record to calculate peak discharge for sites at or near gaging stations. The calculated value is the weighted average of the regression estimate and the station estimate. Equivalent years of record (Hardison, 1971) are used to weight the regression estimate and years of gaged record are used to weight the station estimate.

Equivalent years of record are a function of the variability and skew of the annual flood series at sites in a hydrologic region, the accuracy of the regression equation, and the recurrence interval of the peak flow characteristic. Equivalent years of record for an event with a recurrence interval of T-years were calculated as follows:

$$E = R^2 [s / SE_p]^2 \qquad (1)$$

where E is equivalent years of record;

- R^2 is a factor based on skew (mean skewness coefficient of the logarithms of the annual series at all stations in a hydrologic region) and recurrence interval relating the standard error of a T-year peak discharge to I_v and the number of gaged annual peaks (Hardison, 1971);
- s is an index of variability, equal to the mean standard deviation of the logarithms (base 10) of annual peaks at all stations in a hydrologic region; and
- SE_p is the standard error of prediction, in log (base 10) units, associated with the regression estimate.

The SE_p was estimated using the PRESS statistic.

The weighting procedure for determining peak discharge at a gaged station is based on the following equation:

$$Q_{T(w)} = \frac{Q_{T(g)}(N) + Q_{T(r)}(E)}{(N + E)} \quad (2)$$

where $Q_{T(w)}$ is the weighted peak discharge, in ft³/s, for recurrence interval T-years;

$Q_{T(g)}$ is the T-year peak discharge, in ft³/s, determined by the frequency analysis of the gaged discharge record (table 3);

N is the number of years of discharge record used to determine $Q_{T(g)}$ at the gaging station (table 3);

$Q_{T(r)}$ is the regression estimate of the T-year peak discharge (table 3; tables 6-12), in ft³/s; and

E is equivalent years of record (tables 6-12) associated with the regression model used to determine $Q_{T(r)}$, based on equation 1.

By including the regression estimate and equivalent years of record with the computed flood quantile from the gaged record, flood histories at many gaging stations over a relatively long period of time are incorporated into the estimate and tend to reduce the time-sampling error. Climatic conditions during a short gaging record are often not indicative of long-term climatic variability at a particular gaged site. Such time-sampling error is particularly high when the gaged record coincides with an unusually wet or dry climatic cycle compared to the long-term average climatic conditions. Time-sampling error is therefore minimized by using the weighted peak flow estimate defined in equation 2. Calculations using the weighting procedure for estimating peak discharge at a gaged site are included in an example for estimates at ungaged sites near gaged sites, at the end of the section "Method for ungaged sites." The regression estimates of flood quantiles $Q_{T(r)}$ for gaged stations used in the analysis and the weighted estimates for gaged stations are shown in table 3.

Methods for Ungaged Sites

Flood quantiles for ungaged sites are determined based on the regression equations in tables 6 through 12. Three different techniques are used to estimate peak discharge depending upon whether (1) the drainage area is in a single hydrologic region, (2) the drainage crosses hydrologic region or State boundaries, or (3) the ungaged site is near a gaged site on the same stream.

(1) When the drainage area upstream from the site is entirely within a single hydrologic region in Kentucky (fig. 5 and pl. 1), the regression equations for that region are used to determine flood quantiles.

(2) When a drainage basin encompasses two or more hydrologic regions, the percent of the total contributing drainage area occurring in each region should be determined. These percentages should be used as weighting factors for the flood quantiles determined from the appropriate regional regression models, by multiplying the percentiles by the corresponding peak flow estimate and summing these values together. For example, if 60 percent of the contributing drainage area of the basin is in the North Region and 40 percent is in the Upper East Region, the estimate of the T-year flood should be the sum of 0.6 multiplied by the regression estimate for the North Region and 0.4 multiplied by the regression estimate for the Upper East Region. A similar weighting method could be used when a drainage basin crosses State lines, by weighting the regression estimate for Kentucky and the regression estimate from the adjacent State by the percent of drainage area in each State. The U.S. Geological Survey, in cooperation with other agencies, has published reports containing peak-discharge regression relations for West Virginia (Runner, 1980), Virginia (Miller 1977 and 1978), and Tennessee (Randolph and Gamble, 1976). Similar reports exist for the adjacent states of Ohio, Indiana, Illinois, and Missouri, but because the State boundaries between Kentucky and these States are formed by major regulated rivers -- the Ohio and Mississippi Rivers -- no unregulated basins cross over the Kentucky State line into these States.

(3) When an ungaged site is located near a gaged site on the same stream (see pl. 1) and the drainage area of the ungaged site is between 50 to 150 percent of the drainage are of the gaged site, a weighting procedure is used to determine peak discharge at the ungaged site (Hannum, 1976; Glatfelter, 1984). This procedure applies flood frequency information from the discharge record at the gaged site to the ungaged site to weight the flood estimate determined from the regional regression equation. The weighting procedure for the ungaged site is based on the following calculations, followed by an example problem.

First, estimate peak discharge for the gaged site closest to the ungaged site using the procedure outlined in the section "Method for Gaged Sites" in which a weighted estimate ($Q_{T(w)}$) is determined in equation 2 using: (1) flood frequency analysis of the gaged record (table 3); (2) the years of gaged record (table 3); (3) the flood quantile estimated from the appropriate regression equation (tables 7-13); (4) and the equivalent years of record associated with the regression model (tables 7-13).

The following ratio is then computed from the discharge estimates for the gaged site:

$$C_g = Q_{T(w)} / Q_{T(r)}, \tag{3}$$

where,

C_g is a correction factor for the gaged site;

$Q_{T(w)}$ is the weighted discharge estimate of Q_T for the gaged site;

$Q_{T(r)}$ is the regression estimate of Q_T for the gaged site; and

Q_T is the T-year flood discharge.

The factor C_g for the gaged site is related to the T-year peak discharge determined from the gaged record and from the regression model. For the ungaged site the correction factor to be applied to the regression estimate of Q_T is calculated as follows:

$$C_u = C_g - [2(|A_g - A_u|)/A_g] (C_g - 1) \tag{4}$$

where,

C_u is the correction factor for the ungaged site;
C_g is the correction factor for the gaged site (from equation 3, above);

A_g is the drainage area of the gaged site; and
A_u is the drainage area of the ungaged site.

$|A_g - A_u|$ is the absolute value of the difference between drainage area for the gaged and ungaged sites. The value for C_u is then used to determine the weighted discharge estimate at the ungaged site by adjusting the regression estimate for the ungaged site, based on the equation:

$$Q_{T(w)} = C_u \; (Q_{T(r)}) \tag{5}$$

where,

$Q_{T(w)}$ is the weighted discharge estimate at the ungaged site;
C_u is the correction for the ungaged site (from equation 4, above); and
$Q_{T(r)}$ is the regression estimate for the T-year flood discharge at the ungaged site.

As the difference in drainage area between the gaged site and the ungaged site approaches either 0.5 or 1.5 of the drainage area at the gaged site, the value of C_u approaches 1, in which case the adjustment has no effect on the regression estimate for the ungaged site. In other words when the ungaged basin is 50 percent larger or 50 percent smaller than the gaged basin, no adjustment is applied to the regression estimate for the ungaged site to account for data at the nearby gaged site.

An example of the weighting procedure for ungaged sites near a gaged site on the same stream follows.

Assume that estimate of the 100-year peak discharge is needed for an ungaged site on Blaine Creek near Yatesville, Kentucky. Based on Plate 1, this site is about 4 miles downstream from a gaged site on Blaine Creek at Yatesville (03215500).

1) Determine the 100-year peak discharge at the gaged site:

The 100-year peak based on the gaged record ($Q_{T(g)}$) for station 03215500 is obtained from table 3 as 19,700 ft³/s. The gaged site is in the Upper East Region (pl. 1 and table 4) and the regression model for the 100-year peak discharge (table 8) requires measurements of contributing drainage area (A_c), basin slope index (B_s), and main channel sinuosity (S_s), all listed in table 4 (A_c= 217 mi², B_s= 1.83 miles per mile, and S_s= 2.01 miles per mile). The regression estimate of the 100-year peak for this station is determined by the equation in table 8:

$$Q_{100} = 798.(A_c^{0.777})(B_s^{-0.373})(S_s^{-0.862})(1.060)$$

which yields a value of 24,200 ft³/s (also shown in table 3). The weighted discharge for the gaged site is determined using equation 2 where, for this example, the value for years of gaged record (N) is 52 years from table 3 and for equivalent years of record (E) is 9 years from table 8. Substituting the values in equation 2:

$$Q_{100(w)} = (19{,}700(52) + 24{,}200(9)) \ / \ (52 + 9)$$

which yields a value of 20,400 ft³/s for $Q_{100(w)}$ at the gaged site.

2) Determine the 100-year peak discharge for an ungaged site near the gaged site:

If the drainage area for the ungaged site is between 0.5 and 1.5 of the drainage area for the gaged site, the appropriate correction factors should be calculated. First, the correction factor for the gaged site (Cg) is required to determine the correction factor (Cu) for the regression estimate for the ungaged site. The adjustment factor applied to the regression estimate at the gaged site is determined by substituting the weighted regression estimates into equation 3:

$$C_g = (20{,}400 \ / \ 24{,}200);$$

which yields a value of 0.843 for C_g.

The drainage area for the ungaged site is measured as 260 mi² which is used to determine C_u defined in equation 4,

$$C_u = 0.843 - [2(|217\text{-}260|)/260](0.843 - 1)$$

yielding a value of 0.895 for C_u. Measurements of contributing drainage area (260 mi²), basin shape index (1.77 mi/mi), and main channel sinuosity (2.28 mi/mi) are determined for the ungaged site and based on the regression equation for the 100-year peak for the Upper East Region (table 8) the regression estimate for the ungaged site is 25,300 ft³/s. This estimate is determined as follows:

$$Q_{100} = 798.\ (260)^{0.777} (1.77)^{-0.373} (2.28)^{-0.862} (1.060)$$

which yields a value of 25,300 ft^3/s. This estimate is then adjusted using the correction factor (C_u), previously determined, and equation 5:

$$Q_{100(w)} = (0.895)(25{,}300)$$

yielding a value of 22,600 ft^3/s for the weighted 100-year peak discharge at the ungaged site, downstream from gaging station 03215500.

3) If the ratio of the drainage area for the ungaged site to the drainage area for the gaged site was outside of the 0.5 to 1.5 range, the unadjusted regression estimate, 25,300 ft^3/s, is the correct estimate of the 100-year peak discharge.

LIMITATIONS AND ACCURACY OF REGRESSION MODELS

The regression models defined in this study apply only to streams in Kentucky where peak streamflow is not significantly affected by stream regulation, diversion, or other human influences. The models do not apply to basins in urban areas unless the effects of urbanization on surface runoff are insignificant; for example, a stream in a large rural basin that flows in a natural stream channel through a small urban area. Artificial straightening of stream channels (channelization), channel structures or constrictions, and irrigation, municipal, and industrial withdrawals from the stream may alter flood response such that it differs from that expected under natural conditions. If the effects of urbanization can be quantified, adjustments to the peak discharge estimates can be made using procedures outlined by Sauer and others (1983) to estimate peak discharge for urban areas.

Application of the bias correction factor in the regression models should be determined by the user of the models. The peak discharge is log-normally distributed about the regression curve for any given combination of values for the independent variable set. The regression estimate for the T-year peak at an ungaged site corresponds to the median of this distribution if no bias correction is applied, and to the mean of the distribution if bias correction is applied. The median value, by definition, has a 50 percent exceedance probability. For example, if all basins having identical values for the independent variable set were sampled in a hydrologic region, half of these basins would be expected to have a T-year peak less than the regression estimate and half would have a T-year peak greater than the regression estimate.

The exceedance probability for the mean of a log-normal distribution will be less than that associated with the median and is determined by the variance, or variability, of the distribution. On the basis of the sampled basins, the exceedance probabilities associated with the mean value estimated by regression models for the hydrologic regions range from 41 to 46 percent. The exceedance probabilities for mean estimates from the regional regression models by regions are as follows: North and East-Central Regions, 41 to 42 percent; West Region, 42 to 43 percent; Upper East and West-Central Regions, 43 to 44 percent; Southeast Region, 44 to 45 percent; Lower East Region, 45 to 46 percent. The bias corrections for the regression models (tables 7-13) indicate that the mean values range from about 2 to 13 percent higher than the median values calculated from the models. The mean value, which is a larger discharge than the median, will be a more conservative estimate of peak discharge in terms of minimizing risk of flood damage.

The standard error and equivalent years of record associated with the regression models (tables 7-13) apply only to streamflow estimates for basins which are similar to the basins used to develop the regression model for the region. The range of values of independent variables used to develop the regional regression models limits the range over which the models can be applied and over which the estimated precision of the regression estimates (standard error and equivalent years of record) applies. The distribution and ranges of basin characteristics for each hydrologic region are shown in figures 6-10 and can be used to determine if the ungaged site has similar characteristics to the study sites. The precision of the regression estimates for basins having characteristics outside the range of the unregulated gaged basins in the hydrologic region of interest is untested and therefore is unknown.

The standard error of the estimate and estimated prediction error are indexes of the expected precision of the regression estimates. If all assumptions for applying regression are met, the discrepancy between the regression estimate and actual streamflow will be within one standard error about 68 percent of the time.

Estimates of discharge having average recurrence intervals longer than 10 to 20 years may be subject to an additional but unquantified source of error related to the gaged record for the study basins. This sampling error results from limitations on the number of years of gaged record available and hydrologic conditions during the particular period sampled. The use of weighted least squares regression minimizes but does not preclude this source of error. This time-sampling error is a function of the period and length of gaged record. Length of record has been noted as the most important single factor affecting the accuracy of flood quantiles estimated by the log-Pearson distribution (Ott and Linsley, 1971; Nasseri, 1976). In the flood-frequency analysis, the gaged record is assumed to be representative of long-term conditions. Information on length of record for stations used in the analysis is shown in figures 10 and 11, and in table 3.

In karst areas in Kentucky, primarily the Inner Bluegrass and the Mississippian Plateaus physiographic regions, estimation of flood discharge can be complicated by effects of subsurface drainage development on transport of stormflow. The effects are most pronounced in the East-Central Region and the east part of the West Region where the variability in flood response, as measured by regression residuals, is higher than that observed in other parts of the State. This is likely due in part to the variability in development (size and extent) of subsurface flow conduits. This flow variability is reflected by the relatively large standard error associated with regression estimates in East-Central Region. Similar high variance of streamflow in karst regions has been documented elsewhere (White, 1976; Jones and Rauch, 1977). The regression estimates for ungaged streams in the karstic areas of Kentucky (fig. 2) possibly are subject to an additional error because measures of subsurface karst development are not included in the regression models for these areas.

SUMMARY AND CONCLUSIONS

Models for estimating the 2-, 5-, 10-, 25-, 50-, and 100-year flood quantiles on unregulated streams in Kentucky were developed on the basis of multiple regression and streamflow regionalization techniques. Annual peak flow records for 266 continuous-record and crest-stage partial-record gaging stations in and adjacent to Kentucky were used to determine peak flow quantiles at the gaged sites on the basis of log-Pearson Type III frequency analysis. The peak-flow records at nine stations were generated in part by using a rainfall-runoff model to extend the gaged records. An analysis of the seasonal variation of floods in Kentucky indicated that annual peaks can occur during any month of the year but occur most frequently between January and April. The monthly distribution of flooding varies with drainage area size. Smaller basins, less than 50 mi^2, show a higher frequency of floods occurring during the summer than that observed in the larger basins. The highest rates of storm runoff, however, occurred generally during September or October except in large basins greater than 500 mi^2 where highest runoff occurred during winter and spring.

Regression analysis of streamflow characteristics and selected drainage basin characteristics was used to delineate hydrologically distinct flood regions in Kentucky and to develop models for estimating peak-flow quantiles in each hydrologic region. Procedures for using the regression models to estimate flood quantiles at both gaged and ungaged sites on unregulated streams were described and examples given.

Seven hydrologic regions were delineated in Kentucky on the basis of regional analysis of regression residuals. Basin characteristics in the regional regression models included contributing drainage area, main channel slope, basin shape index, and main channel sinuosity. The regression coefficients indicated an increase in flood discharge with increasing drainage area and channel slope, and a decrease in discharge with increasing channel sinuosity and basin elongation. The standard error of the estimate associated with the regression models ranged from 21 to 52 percent. Estimates of the standard error of prediction for the models generally were 2 to 7 percent higher than the regression standard error of the estimate. The error associated with the regression models tended to be slightly larger in karst areas of Kentucky than in non-karst areas.

Procedures for applying the regression models vary depending on whether the estimate is for an ungaged site, an ungaged site near a gaged site on the same stream, or a gaged site. When drainage basins cross hydrologic region boundaries or State lines, the flood quantile is determined by areally weighting two or more regression estimates. The procedure for an ungaged site near a gaged site is based on information from the regression model and from the discharge record at the gaged site to determine the flood quantile. At gaged sites, flood quantiles are determined as weighted averages on the basis of regression estimate, weighted by equivalent years of record, and on frequency analysis of the gaged record where the quantile estimate is weighted by the number of years of gaged record. The estimation procedures apply only to unregulated streams in Kentucky that drain areas less than 1,000 mi^2.

Included in the report are hydrologic data for the 266 gaging stations used in the analyses. These data include a summary of the gaged streamflow record at each site, largest recorded peak discharges, statistics associated with the flood frequency analysis, and measurements of selected basin characteristics that apply to the regression models. A history of streamflow regulation is included for gaging stations used in the analysis that have 10 or more years of unregulated record measured prior to emplacement of regulation structures. Locations of gaging stations used in the analysis are shown on a map of Kentucky and adjacent states.

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Table 1.--Gaging stations and peak discharge records used in the study

[nr, near; (N, S, E, W, or M) F, North, South, East, West, or Middle Fork; Ln, Lane; mo-da-yr, month-day-year; **, date unknown]

Station number (see pl. 1)	Station name	Drainage area (square miles) Total	Drainage area (square miles) Contributing	Period of unregulated record (water years)	Maximum observed discharge: Water year	Maximum observed discharge: Discharge (cubic feet per second)	Maximum observed discharge: Date (mo-da-yr)
03202400	Guyandotte River nr Baileysville, WV	306	306	1969-1984	1977	36,700	04-05-77
03203000	Guyandotte River at Man, WV	758	758	1929-1978	1963	49,000	03-12-63
32036000	Guyandotte River at Logan, WV	836	836	1961-1978	1963	55,000	03-12-63
03204500	Mud River nr Milton, WV	256	256	1938-1984	1962	15,100	02-27-62
03206600	E F Twelvepole Creek nr Dunlow, WV	38.5	38.5	1965-1984	1979	5,040	12-09-78
03207000	Twelvepole Creek at Wayne, WV	291	291	1916-1922, 1928-1931, 1939, 1947-1966	1939	22,000	02-04-39
03207020	Twelvepole Creek below Wayne, WV	300	300	1916-1922, 1928-1931, 1939, 1947-1971	1939	22,000	02-04-39
03207400	Prater Creek at Vansant, VA	19.8	19.8	1951-1977	1977	8,000	04-04-77
03207500	Levisa Fork nr Grundy, VA	235	235	1942-1974	1957	33,200	01-29-57
03207962	Dicks Fork at Phyllis, KY	.82	.82	1975-1984	1984	178	05-07-84
03207965	Grapevine Creek nr Phyllis, KY	6.20	6.20	1974-1982	1974	1,650	06-01-74
03208000	Levisa Fork below Fishtrap Dam, KY	392	392	1938-1968	1957	33,000	01-29-57
03208500	Russell Fork at Haysi, VA	286	286	1927-1984	1977	59,000	04-05-77
03208950	Cranes Nest River nr Clintwood, VA	66.5	66.5	1964-1984	1977	18,000	04-04-77
03209000	Pound River below Flannagan Dam nr Haysi, VA	221	221	1927-1964	1929	30,000	03-23-29
03209300	Russell Fork at Elkhorn City, KY	554	554	1957-1964	1957	51,200	01-29-57
03209575	Bill D. Branch nr Kite, KY	3.17	3.17	1976-1985	1984	900	05-07-84
03210000	Johns Creek nr Meta, KY	56.3	56.3	1938, 1942-1985	1963	7,380	03-12-63
03210160	Caney Fork nr Gulnare, KY	3.74	3.74	1975-1984	1984	760	05-07-84
03211500	Johns Creek nr Van Lear, KY	206	206	1938-1949	1939	8,500	02-04-39
03212000	Paint Creek at Staffordsville, KY	103	103	1950-1981	1961	17,400	07-30-61
03212515	Rush Fork nr Paintsville, KY	2.10	2.10	1976-1982	1979	380	12-08-78

Table 1.--Gaging stations and peak discharge records used in the study--Continued

Station number (see pl. 1)	Station name	Drainage area (square miles) Total	Drainage area (square miles) Contributing	Period of unregulated record (water years)	Maximum observed discharge: Water year	Maximum observed discharge: Discharge (cubic feet per second)	Maximum observed discharge: Date (mo-da-yr)
03213700	Tug Fork at Williamson, WV	936	936	1968-1984	1977	94,000	04-05-77
03215500	Blaine Creek at Yatesville, KY	217	217	1916-1920, 1938-1984	1962	21,000	02-28-62
03216500	Little Sandy River at Grayson, KY	400	400	1937,1939-1967	1950	24,500	09-22-50
03216505	Beckwith Branch Tributary nr Grayson, KY	.51	.51	1977-1985	1979	80	07-04-79
03216540	E F Little Sandy River nr Fallsburg, KY	12.2	12.2	1973-1985	1979	1,510	07-04-79
03216563	Mile Branch nr Rush, KY	.94	.94	1976-1985	1980	378	07-03-80
03216564	Mile Branch at Coalton, KY	1.61	1.61	1977-1985	1980	450	07-03-80
03216800	Tygarts Creek at Olive Hill, KY	59.6	59.6	1957-1985	1972	9,470	04-22-72
03216901	Trough Camp Creek Tributary nr Olive Hill, KY	1.11	1.11	1976-1985	1979	445	09-21-79
03217000	Tygarts Creek nr Greenup, KY	242	242	1941-1985	1979	30,300	12-09-78
03237280	Upper Twin Creek at McGaw, OH	12.2	12.2	1960, 1964-1984	1960	7,320	07-03-60
03237500	Ohio Brush Creek nr West Union, OH	387	387	1927-1935, 1941-1984	1964	59,200	03-10-64
03237895	Indian Run Tributary nr Tollesboro, KY	.23	.23	1975-1983	1983	170	05-02-83
03237900	Cabin Creek nr Tollesboro, KY	22.4	22.4	1972-1985	1972	8,370	04-22-72
03238030	Lawrence Creek nr Maysville, KY	1.90	1.90	1975-1985	1982	790	01-22-82
03238500	Whiteoak Creek nr Georgetown, OH	218	218	1924-1935, 1940-1984	1964	22,400	03-10-64
03246500	E F Little Miami River at Williamsburg, OH	237	237	1950-1953, 1959, 1961-1975	1964	19,800	03-10-64
03247100	Paterson Run nr Owensville, OH	3.34	3.34	1947-1977	1962	952	07-15-62
03247500	E F Little Miami River at Perrintown, OH	476	476	1916-1920, 1925-1977	1964	42,400	03-10-64
03248500	Licking River nr Salyersville, KY	140	140	1939-1985	1939	14,300	02-03-39
03249500	Licking River at Farmers, KY	827	827	1938-1973	1962	24,000	02-28-62
03250000	Triplett Creek at Morehead, KY	47.5	47.5	1939, 1941-1980	1939	44,000	07-05-39
03250080	Jacks Branch nr Morehead, KY	.19	.19	1976-1985	1979	85	12-08-78

Table 1.--Gaging stations and peak discharge records used in the study--Continued

Station number (see pl. 1)	Station name	Drainage area (square miles) Total	Contributing	Period of unregulated record (water years)	Maximum observed discharge Water year	Discharge (cubic feet per second)	Date (mo-da-yr)
03250100	N F Triplett Creek nr Morehead, KY	84.7	84.7	1968-1985	1979	9,380	12-08-78
03250150	Indian Creek nr Owingsville, KY	2.43	2.43	1975-1985	1979	1,610	07-27-79
03250243	Rose Run Tributary nr Olympia, KY	.70	.70	1975-1983	1980	470	**-**-80
03250320	Rock Lick Creek nr Sharkey, KY	4.01	4.01	1974-1982	1978	1,990	07-30-78
03250620	Johnson Creek Tributary nr Fairview, KY	.33	.33	1976-1985	1979	154	09-14-79
03251000	N F Licking River nr Lewisburg, KY	119	119	1938,1947-1985	1948	11,300	04-13-48
03251008	Wells Creek Tributary nr Washington, KY	.96	.93	1977-1985	1982	398	01-22-82
03251015	Lee Creek Tributary at Mays Lick, KY	.45	.45	1975-1985	1976	285	10-17-75
03252000	Stoner Creek at Paris, KY	239	239	1954-1980, 1982-1985	1979	19,400	12-09-78
03252500	S F Licking River at Cynthiana, KY	621	615	1918-1985	1948	35,300	04-13-48
03254400	N F Grassy Creek nr Piner, KY	13.6	13.6	1968-1980, 1982-1983	1970	20,200	04-30-70
03260010	Pleasant Run Creek at Crescent Springs, KY	.68	.68	1973-1983, 1985	1979	640	06-08-79
03260012	Pleasant Run Creek at Fort Mitchell, KY	1.62	1.62	1973-1985	1973	1,900	07-24-73
03277070	Fowlers Fork at Union, KY	1.54	1.54	1976-1985	1977	1,250	04-02-77
03277185	Craigs Creek Tributary nr Warsaw, KY	.68	.68	1976-1985	1979	455	08-01-79
03277250	Indian Creek Tributary nr Bloomington, IN	.16	.16	1973-1982	1974	66	09-12-74
03277290	Bottom Fork nr Maykin, KY	3.03	3.03	1976-1980, 1982-1985	1982	629	09-14-82
03277300	N F Kentucky River at Whitesburg, KY	66.4	66.4	1957-1983	1957	7,730	01-29-57
03277400	Leatherwood Creek at Daisy, KY	40.9	40.9	1965-1983	1967	7,370	03-07-67
03277437	Breeding Creek nr Isom, KY	.69	.69	1977-1985	1982	310	09-14-82
03277450	Carr Fork nr Sassafras, KY	60.6	60.6	1963-1975	1972	5,420	04-12-72
03277500	N F Kentucky River at Hazard, KY	466	466	1940-1975	1957	47,800	01-29-57
03277630	Brier Fork nr Hazard, KY	1.32	1.32	1976-1985	1984	563	05-07-84
03278000	Bear Branch nr Noble, KY	2.21	2.21	1955-1982	1972	568	04-12-72

Table 1.--Gaging stations and peak discharge records used in the study--Continued

Station number (see pl. 1)	Station name	Drainage area (square miles)		Period of unregulated record (water years)	Maximum observed discharge		
		Total	Contributing		Water year	Discharge (cubic feet per second)	Date (mo-da-yr)
03278500	Troublesome Creek at Noble, KY	177	177	1950-1981	1963	22,800	03-12-63
03280600	M F Kentucky River nr Hyden, KY	202	202	1957-1985	1957	60,000	01-29-57
03280700	Cutshin Creek at Wooton, KY	61.3	61.3	1958-1985	1963	14,200	03-12-63
03280728	Bull Creek nr Hyden, KY	1.84	1.84	1976-1985	1976	890	03-30-76
03280935	Stamper Fork at Canoe, KY	1.57	1.57	1975-1985	1981	1,060	06-06-81
03281000	M F Kentucky River at Tallega, KY	537	537	1931, 1932, 1935, 1937, 1939-1960	1957	52,700	01-30-57
03281040	Red Bird River nr Big Creek, KY	155	155	1973-1985	1984	24 400	05-07-84
03281100	Goose Creek at Manchester, KY	163	163	1965-1985	1984	19,200	05-07-84
03281200	S F Kentucky River at Oneida, KY	486	486	1957-1982	1957	53,000	01-29-57
03281500	S F Kentucky River at Booneville, KY	722	722	1926-1931, 1937, 1939-1985	1957	66,100	01-30-57
03282198	Clear Creek Tributary nr West Irvine, KY	.59	.59	1975-1985	1975	348	04-25-75
03282500	Red River nr Hazel Green, KY	65.8	65.8	1955-1985	1962	9,080	02-27-62
03283000	Stillwater Creek at Stillwater, KY	24.0	24.0	1955-1983	1962	7,390	02-27-62
03283305	M F Red River at Zachariah, KY	.58	.58	1975-1985	1976	250	10-17-75
03283500	Red River at Clay City, KY	362	362	1931-1932, 1937-1985	1979	28,800	12-09-78
03283610	Lulbegrud Creek Tributary nr Westbend, KY	.33	.33	1975-1976 1978-1985	1985	105	08-26-85
03284300	Silver Creek nr Kingston, KY	28.6	28.6	1968-1983	1968	6,410	04-04-68
03284310	Silver Creek nr Berea, KY	53.4	53.3	1959, 1961, 1962, 1965-1967, 1971, 1972, 1974-1983	1962	9,600	03-31-62
03284340	Old Town Branch Tributary nr Richmond, KY	1.83	1.83	1976-1985	1979	860	12-08-78
03284550	West Hickman Creek at Jonestown, KY	11.0	10.9	1975-1979, 1981-1984	1975	3,730	08-11-75

Table 1.--Gaging stations and peak discharge records used in the study--Continued

Station number (see pl. 1)	Station name	Drainage area (square miles) Total	Contributing	Period of unregulated record (water years)	Maximum observed discharge Water year	Discharge (cubic feet per second)	Date (mo-da-yr)
03285000	Dix River nr Danville, KY	318	318	1943-1985	1979	44,400	12-09-78
03285100	Balls Branch Tributary nr Danville, KY	.13	.13	1976, 1978-1985	1978	68	10-01-77
03285500	Dix River nr Burgin, KY	395	379	1916-1922	1917	27,500	01-22-17
03287128	Tanners Creek at Mortonsville, KY	1.26	1.26	1976-1985	1976	680	02-17-76
03287160	Gilbert Creek Tributary nr Salvisa, KY	.81	.81	1976-1978	1976	530	02-17-76
03287534	South Benson Creek nr Frankfort, KY	4.47	4.47	1976-1985	1978	760	12-05-77
03288000	North Elkhorn Creek nr Georgetown, KY	119	111	1951-1983	1979	8,730	12-09-78
03288500	Cave Creek nr Fort Spring, KY	2.53	1.93	1953-1979	1979	405	09-21-79
03289000	South Elkhorn Creek at Fort Spring, KY	24.0	21.0	1951-1985	1983	2,100	05-01-83
03289190	Wolf Run at Lexington, KY	5.30	5.30	1976-1985	1978	1,620	08-25-78
03289500	Elkhorn Creek nr Frankfort, KY	473	403	1916-1920, 1932, 1937, 1940-1983	1932	31,000	08-02-32
03290000	Flat Creek nr Frankfort, KY	5.63	5.63	1952-1985	1979	8,500	09-14-79
03290580	Town Creek at New Castle, KY	5.62	4.87	1976-1985	1979	1,300	09-13-79
03291000	Eagle Creek at Sadieville, KY	42.9	42.9	1941-1983	1943	9,870	03-19-43
03291050	South Rays Fork nr Corinth, KY	.58	.58	1976-1985	1979	525	09-22-79
03291500	Eagle Creek at Glencoe, KY	437	437	1915-1920, 1928-1931, 1937, 1939-1985	1964	58,200	03-10-64
03292200	Jeff Branch nr Sligo, KY	.87	.87	1976-1983, 1985	1978	960	10-01-77
03292460	Harrods Creek nr LaGrange, KY	24.1	24.1	1968-1985	1973	5,320	06-20-73
03292472	S F Harrods Creek nr Crestwood, KY	.97	.97	1975-1985	1978	640	10-01-77
03292500	S F Beargrass Creek at Louisville, KY	17.2	17.2	1940-1983	1964	4,940	04-09-64
03292785	M F Beargrass Creek nr St. Matthews, KY	6.59	6.51	1954, 1958-1964, 1967, 1970-1983	1970	2,200	04-02-70
03293000	M F Beargrass Creek at Cannons Ln Lou., KY	18.9	18.4	1945-1985	1970	5,200	04-02-70
03294000	Silver Creek nr Sellersburg, IN	189	189	1955-1984	1959	19,600	01-22-59

Table 1.--Gaging stations and peak discharge records used in the study--Continued

Station number (see pl. 1)	Station name	Drainage area (square miles) Total	Drainage area (square miles) Contributing	Period of unregulated record (water years)	Maximum observed discharge: Water year	Maximum observed discharge: Discharge (cubic feet per second)	Maximum observed discharge: Date (mo-da-yr)
03295000	Salt River nr Harrodsburg, KY	41.4	39.7	1953-1983	1979	12,000	12-08-78
03295500	Salt River nr Van Buren, KY	196	192	1939-1982	1928	20,000	**-**-28
03295845	Bradshaw Creek nr Shelbyville, KY	1.36	1.36	1976-1985	1984	1,600	06-11-84
03296500	Plum Creek nr Wilsonville, KY	19.1	19.1	1954-1980	1980	7,950	07-02-80
03297000	Little Plum Creek nr Waterford, KY	5.15	5.15	1954-1978, 1980-1983	1980	4,420	07-02-80
03297500	Plum Creek at Waterford, KY	31.8	31.8	1954-1977	1960	13,200	06-23-60
03298000	Floyds Fork at Fisherville, KY	138	138	1945-1985	1970	28,500	04-02-70
03298535	Elm Lick nr Clermont, KY	.68	.68	1976-1985	1979	880	09-19-79
03299000	Rolling Fork nr Lebanon, KY	239	239	1939-1985	1970	54,800	04-28-70
03300000	Beech Fork nr Springfield, KY	85.9	85.9	1952-1985	1970	10,600	04-28-70
03300065	North Prong nr Willisburg, KY	1.71	1.71	1975-1978, 1980-1985	1984	960	05-07-84
03300400	Beech Fork at Maud, KY	436	436	1964, 1973-1985	1979	33,300	12-09-78
03300990	Town Creek Tributary at Bardstown, KY	.32	.32	1975-1985	1979	120	09-22-79
03301000	Beech Fork at Bardstown, KY	669	669	1940-1985	1979	39,900	12-09-78
03302000	Pond Creek nr Louisville, KY	64.0	64.0	1945-1985	1964	8,020	04-09-64
03302085	Otter Creek Tributary nr Vine Grove, KY	.9	.85	1975-1978, 1980-1985	1975	250	03-29-75
03302220	Buck Creek nr New Middletown, IN	65.2	37.1	1970-1984	1970	12,700	04-02-70
03302300	Little Indian Creek nr Galena, IN	16.11	16.11	1969-1984	1973	5,500	07-21-73
03302350	Georgetown Creek Tributary nr Georgetown, IN	.56	.56	1973-1982	1980	1,000	07-02-80
03303000	Blue River nr White Cloud, IN	476	284	1910-1913, 1915-1916, 1932-1984	1959	28,500	01-22-59
03303300	M F Anderson River at Bristow, IN	39.8	39.8	1962-1984	1959	15,000	01-21-59
03303400	Crooked Creek nr Santa claus, IN	7.86	7.86	1970-1984	1970	4,100	04-28-70

Table 1.--Gaging stations and peak discharge records used in the study--Continued

Station number (see pl. 1)	Station name	Drainage area (square miles) Total	Contributing	Period of unregulated record (water years)	Maximum observed discharge Water year	Discharge (cubic feet per second)	Date (mo-da-yr)
03303440	Crooked Creek Tributary nr Fulda, IN	0.26	0.26	1973-1982	1977	182	08-24-77
03303900	Little Red Creek Tributary nr Heilman, IN	.25	.25	1973-1982	1979	120	07-26-79
03304500	McGills Creek nr McKinney, KY	2.14	2.14	1952-1979	1972	1,480	04-12-72
03305000	Green River nr McKinney, KY	22.4	22.4	1952-1983	1974	20,000	01-10-74
03305500	Green River nr Mount Salem, KY	36.3	36.3	1954-1983	1978	16,400	09-21-78
03305559	Carpenter Creek Tributary nr Hustonville, KY	.88	.88	1976-1985	1980	730	11-24-79
03305725	Irvin Branch nr Salem, KY	1.37	1.37	1976-1985	1984	2,650	05-07-84
03305835	Gumlick Creek Tributary nr Clementsville, KY	.71	.71	1976-1985	1976	515	06-03-76
03306000	Green River nr Campbellsville, KY	682	682	1931-1932, 1964-1968	1962	60,700	02-28-62
03306500	Green River at Greensburg, KY	736	729	1940-1968	1962	60,600	02-28-62
03307000	Russell Creek nr Columbia, KY	188	173	1940-1985	1982	40,600	09-01-82
03307100	Russell Creek nr Gresham, KY	265	246	1965-1983	1979	68,000	12-09-78
03307500	S F Little Barren River at Edmonton, KY	18.3	18.3	1942-1983	1975	10,600	03-12-75
03307670	Prices Creek nr Gradyville, KY	2.53	2.34	1976-1985	1984	2,350	05-07-84
03309500	McDougal Creek nr Hodgenville, KY	5.34	5.34	1954-1982	1966	2,890	07-04-66
03310000	N F Nolin River at Hodgenville, KY	36.4	35.6	1942-1978, 1980-1982	1970	9,380	04-28-70
03310300	Nolin River at White Mills, KY	357	237	1960-1985	1970	19,400	04-29-70
03310385	Bacon Creek Tributary nr Upton, KY	.56	.56	1975-1985	1984	440	05-07-84
03310400	Bacon Creek nr Priceville, KY	85.4	54.40	1960-1985	1984	6,800	05-07-84
03310500	Nolin River at Wax, KY	600	378	1937-1962	1937	22,000	01-24-37
03310880	Brier Creek Tributary nr Ollie, KY	.31	.31	1976-1985	1984	280	05-07-84
03311000	Nolin River at Kyrock, KY	703	480	1931-1932, 1940-1950, 1961, 1962	1932	22,700	01-30-32
03311600	Beaverdam Creek at Rhoda, KY	10.9	10.9	1973-1985	1984	4,850	05-07-84

Table 1.--Gaging stations and peak discharge records used in the study--Continued

Station number (see pl. 1)	Station name	Drainage area (square miles) Total	Drainage area (square miles) Contributing	Period of unregulated record (water years)	Maximum observed discharge: Water year	Maximum observed discharge: Discharge (cubic feet per second)	Maximum observed discharge: Date (mo-da-yr)
03312000	Bear Branch nr Leitchfield, KY	30.8	30.8	1950-1983	1979	8,380	09-14-79
03312500	Barren River nr Pageville, KY	531	514	1940-1963	1952	70,000	03-23-52
03312795	Little Beaver Creek nr Glasgow, KY	.89	.89	1976-1979, 1981-1985	1985	345	08-01-85
03313020	Solomon Creek Tributary nr Scottsville, KY	.24	.24	1976-1984	1980	175	12-13-79
03313500	West Bays Fork at Scottsville, KY	7.47	7.47	1951-1983	1969	7,050	06-23-69
03313600	W F Drakes Creek Tributary nr Fountain Head, TN	.95	.95	1967-1985	1984	742	05-06-84
03313700	W F Drakes Creek nr Franklin, KY	110	91	1969-1985	1975	27,300	03-12-75
03313800	Lick Creek nr Franklin, KY	21.6	7.8	1959-1983	1975	11,400	03-12-75
03314000	Drakes Creek nr Alvaton, KY	478	358	1937,1940-1982	1969	96,400	06-23-69
03314750	Barren River Tributary nr Bowling Green, KY	.50	.50	1976-1984	1982	700	08-30-82
03315885	Poindexter Branch Tributary nr Russelville, KY	.25	.22	1976-1985	1979	138	09-14-79
03316000	Mud River nr Lewisburg, KY	90.5	80.8	1940-1983	1958	12,200	11-18-57
03317000	Rough River nr Madrid, KY	225	158	1937-1953, 1955-1959	1958	14,800	11-19-57
03317500	N F Rough River nr Westview, KY	42.0	22.6	1955-1964, 1960-1976, 1978-1983	1983	4,150	05-02-83
03317965	Long Lick Creek Tributary nr Axtel, KY	.38	.38	1975-1985	1984	570	04-29-84
03318000	Rough River nr Falls of Rough, KY	454	344	1940-1956	1952	13,700	03-23-52
03318200	Rock Lick Creek nr Glen Dean, KY	20.1	20.1	1957-1978	1959	8,720	01-21-59
03318500	Rough River at Falls of Rough, KY	504	394	1949-1959	1950	12,400	01-14-50
03318505	Pleasant Run Tributary nr Falls of Rough, KY	.22	.22	1975-1981, 1983-1985	1976	250	02-17-76
03318800	Caney Creek nr Horse Branch, KY	124	124	1957-1985	1984	13,600	05-07-84
03319000	Rough River nr Dundee, KY	757	637	1940-1959	1950	20,000	01-14-50
03319520	W F Adams Tributary nr Fordsville, KY	.26	.26	1976-1985	1983	175	05-02-83

Table 1.--Gaging stations and peak discharge records used in the study--Continued

Station number (see pl. 1)	Station name	Drainage area (square miles) Total	Contributing	Period of unregulated record (water years)	Maximum observed discharge: Water year	Discharge (cubic feet per second)	Date (mo-da-yr)
03320500	Pond River nr Apex, KY	194	194	1941-1985	1984	35,700	05-07-84
03321275	E F Deer Creek Tributary nr Onton, KY	.95	.95	1976-1985	1980	845	07-27-80
03321350	S F Panther Creek nr Whitesville, KY	58.2	58.2	1969-1983	1979	3,860	12-04-78
03321465	Rhodes Creek Tributary nr Owensboro, KY	.29	.29	1975-1980, 1982-1985	1979	295	12-04-78
03322100	Pigeon Creek at Evansville, IN	323	323	1961-1982	1961	12,100	05-10-61
03322360	Beaverdam Creek nr Corydon, KY	14.3	14.3	1973-1985	1985	2,760	06-11-85
03366200	Herberts Creek nr Madison, IN	9.31	9.31	1969-1984	1970	1,540	04-02-70
03366400	Lewis Creek Tributary nr Kent, IN	.16	.16	1973-1982	1979	130	07-28-79
03378550	Big Creek nr Wadesville, IN	104	104	1966-1984	1983	7,880	05-01-83
03378590	Olive Creek Tributary nr Solitude, IN	.32	.32	1973-1982	1974	222	05-03-74
03381600	Little Wabash River Tributary nr New Haven, IL	.16	.16	1960-1976	1974	484	08-03-74
03382520	Black Branch Tributary nr Junction, IL	1.10	1.10	1960-1972	1969	695	06-23-69
03382975	Ward Creek at Lewiston, KY	.91	.91	1975-1979, 1981-1985	1985	1,120	05-22-85
03383000	Tradewater River at Olney, KY	255	246	1941-1983	1937	17,000	01-**-37
03383605	W F Donaldson nr Fredonia, KY	2.52	2.52	1975-1980, 1982-1985	1984	2,000	04-29-84
03384000	Rose Creek at Nebo, KY	2.10	2.10	1952-1981	1969	1,240	06-23-69
03385000	Hayes Creek at Glendale, IL	19.1	19.1	1950-1985	1973	6,400	05-27-73
03385500	Lake Glendale Inlet nr Dixon Springs, IL	1.05	1.00	1955-1980	1958	1,500	07-22-58
03400500	Poor Fork at Cumberland, KY	82.3	82.3	1940-1985	1957	11,800	01-29-57
03400700	Clover Fork at Evarts, KY	82.4	82.4	1960-1985	1977	18,100	04-04-77
03400800	Martins Fork nr Smith, KY	55.8	55.8	1968-1978	1977	9,000	04-04-77
03401000	Cumberland River nr Harlan, KY	374	374	1940-1985	1977	64,500	04-05-77
03401500	Yellow Creek Bypass at Middlesboro, KY	35.3	35.3	1941-1983	1965	10,900	07-24-65

Table 1.--Gaging stations and peak discharge records used in the study--Continued

Station number (see pl. 1)	Station name	Drainage area (square miles) Total	Drainage area (square miles) Contributing	Period of unregulated record (water years)	Maximum observed discharge: Water year	Maximum observed discharge: Discharge (cubic feet per second)	Maximum observed discharge: Date (mo-da-yr)
03402000	Yellow Creek nr Middlesboro, KY	60.6	60.6	1941-1985	1977	11,700	04-04-77
03402020	Shilalah Creek nr Page, KY	2.96	2.96	1976-1985	1977	856	04-04-77
03403000	Cumberland River nr Pineville, KY	809	809	1939-1985	1977	80,500	04-05-77
03403500	Cumberland River at Barbourville, Ky	960	960	1923-1930, 1949-1985	1977	56,100	04-06-77
03403538	Little Richland Creek nr Hinkle, KY	11.5	11.5	1974-1979, 1981-1983	1975	1,890	03-14-75
03403910	Clear Fork at Saxton, KY	331	331	1969-1985	1977	22,800	04-05-77
03404820	Laurel River at Municipal Dam nr Corbin, KY	140	140	1974-1985	1984	18,300	05-07-84
03404867	Gozey Hollow nr Corbin, KY	.31	.31	1976-1985	1984	54	05-07-84
03404900	Lynn Camp Creek at Corbin, KY	53.8	53.8	1957-1985	1957	9,000	01-29-57
03405000	Laurel River at Corbin, KY	201	201	1922-1924, 1943-1973	1957	19,600	01-29-57
03405854	Big Hurricane Branch at Conway, KY	1.91	1.91	1976-1985	1984	1,360	05-07-84
03406000	Wood Creek nr London, KY	3.89	3.89	1954-1985	1984	694	05-07-84
03406500	Rockcastle River at Billows, KY	604	604	1937-1985	1979	50,100	12-09-78
03407000	Rockcastle River at Rockcastle Springs, KY	745	745	1923-1931	1929	36,400	03-24-29
03407100	Cane Branch nr Parkers Lake, KY	.67	.67	1957-1985	1981	411	06-06-81
03407200	W F Cane Branch nr Parkers Lake, KY	.26	.26	1957-1985	1957	129	01-29-57
03407300	Helton Branch at Greenwood, KY	.85	.85	1956-1985	1981	195	06-06-81
03407500	Buck Creek nr Shopville, KY	165	165	1953-1985	1962	19,900	02-27-62
03408500	New River at New River, TN	382	382	1935-1985	1973	63,700	05-27-73
03409000	White Oak Creek at Sunbright, TN	13.5	13.5	1955-1975	1973	5,560	05-27-73
03412500	Pitman Creek at Somerset, KY	31.3	31.3	1954-1983	1962	3,460	02-27-62
03413200	Beaver Creek nr Monticello, KY	43.4	43.4	1969-1983	1979	9,240	12-09-78
03413202	Elk Spring Creek nr Spann, KY	.57	.57	1976-1985	1984	609	05-07-84
03413425	Williams Creek Tributary nr Cartwright, KY	.76	.76	1976-1985	1979	235	12-09-78

Table 1.--Gaging stations and peak discharge records used in the study--Continued

Station number (see pl. 1)	Station name	Drainage area (square miles) Total	Contributing	Period of unregulated record (water years)	Maximum observed discharge Water year	Discharge (cubic feet per second)	Date (mo-da-yr)
03414102	Bear Creek nr Burksville, KY	3.52	3.52	1976-1985	1977	1,750	07-01-77
03414500	E F Obey River nr Jamestown, TN	202	196	1944-1985	1973	44,800	05-27-73
03415000	W F Obey River nr Alpine, TN	115	81	1943-1971, 1980-1983	1955	15,100	03-21-55
03415700	Big Eagle Creek nr Livingston, TN	7.98	4.77	1955-1978	1975	1,740	03-12-75
03416000	Wolf River nr Byrdstown, TN	106	106	1944-1985	1982	23,500	09-02-82
03417700	Matthews Branch Tributary nr Livingston, TN	.49	.49	1955-1985	1979	480	09-28-79
03418000	Roaring River nr Hilham, TN	78.7	51.6	1933-1975	1963	9,770	03-17-63
03435140	Whippoorwill Creek nr Claymour, KY	20.8	20.8	1973-1985	1975	8,380	03-12-75
03435500	Red River nr Adams, TN	706	309	1921-1969, 1975	1975	60,000	03-12-75
03435600	Mill Branch nr White House, TN	3.5	3.5	1967-1975	1975	1,670	03-12-75
03436000	Sulphur Fork Red River nr Adams, TN	186	165	1939-1985	1975	35,400	03-12-75
03436700	Yellow Creek nr Shiloh, TN	124	124	1958-1980, 1982-1985	1984	16,200	05-06-84
03437380	Elbow Creek Tributary nr Canton, KY	.83	.83	1975-1979, 1984-1985	1975	430	03-12-75
03437390	Lick Creek nr Canton, KY	.39	.39	1975-1979, 1982-1985	1984	500	04-29-84
03437490	S F Little River Tributary nr Hopkinsville, KY	2.62	1.41	1977-1985	1984	600	05-07-84
03437500	S F Little River at Hopkinsville, KY	46.5	35.3	1950-1983	1958	9,320	11-18-57
03438000	Little River nr Cadiz, KY	244	150	1940-1985	1984	20,200	05-07-84
03438070	Muddy Fork Little River nr Cerulean, KY	30.5	30.5	1969-1983	1970	7,320	08-10-70
03529500	Powell River at Big Stone Gap, VA	112	112	1945-1983	1977	24,000	04-05-77
03530000	S F Powell River at Big Stone Gap, VA	40.0	40.0	1945-1947, 1951-1977	1977	8,000	04-05-77
03530500	N F Powell River at Pennington Gap, VA	70.0	70.0	1945-1977, 1980-1983	1977	17,000	04-05-77

Table 1.--Gaging stations and peak discharge records used in the study--Continued

Station number (see pl. 1)	Station name	Drainage area (square miles) Total	Drainage area (square miles) Contributing	Period of unregulated record (water years)	Maximum observed discharge Water year	Maximum observed discharge Discharge (cubic feet per second)	Maximum observed discharge Date (mo-da-yr)
03531000	Powell River nr Pennington Gap, VA	290	290	1921-1931	1929	28,900	03-23-29
03531500	Powell River nr Jonesville, VA	319	319	1932-1984	1977	57,000	04-05-77
03610000	Clarks River at Murray, KY	89.7	89.7	1952-1983	1952	32,300	03-22-52
03610470	York Creek nr Benton, KY	.96	.96	1975-1982, 1984-1985	1985	820	09-05-85
03610500	Clarks River nr Benton, KY	227	227	1939-1983	1958	36,000	11-19-57
03610503	Chestnut Creek nr Benton, KY	.82	.82	1975-1979, 1980-1985	1984	1,080	04-29-84
03610545	W F Clarks River nr Brewers, KY	68.7	68.7	1969-1983	1975	9,370	03-12-75
03610820	Clarks River Tributary nr Reidland, KY	.13	.13	1975-1979, 1981, 1983-1985	1975	290	07-04-75
03611260	Massac Creek nr Paducah, KY	14.6	14.6	1972-1985	1985	5,990	09-05-85
03612000	Cache River at Forman, IL	244	244	1923-1985	1935	9,630	03-12-35
03612200	Q Ditch Tributary nr Choat, IL	.27	.27	1956-1976	1967	392	07-10-67
03614000	Hess Bayou Tributary nr Mound City, IL	1.95	1.95	1959-1972	1966	754	05-24-66
07022500	Perry Creek nr Mayfield, KY	1.72	1.72	1953-1965, 1968-1985	1983	2,760	06-03-83
07023000	Mayfield Creek at Lovelaceville, KY	212	212	1937, 1939-1977	1937	19,800	01-**-37
07023040	Lick Creek Tributary nr Kirbyton, KY	.53	.53	1975-1985	1980	438	06-29-80
07023500	Obion Creek at Pryorsburg, KY	36.8	36.8	1952-1983	1979	6,320	12-03-78
07023935	S F Bayou DeChien Tributary at Water Valley, KY	.23	.23	1975-1985	1975	215	03-29-75
07024000	Bayou De Chien nr Clinton, KY	68.7	68.7	1940-1982	1966	9,460	01-02-66
07026500	Reelfoot Creek nr Samburg, TN	110	110	1951-1972	1970	16,600	06-13-70

Table 3.--Flood quantiles and associated statistics for streamflow-gaging stations used in the study. In the three rows of peak-flow quantiles shown for each station, the upper row contains peaks determined from flood-frequency analysis (U.S. Water Resources Council, 1981) of the gaged station data, the middle row contains peaks estimated by the regression equations, and the lower row contains a weighted average of the station peak (upper row) and the regression peak (middle row). All regression estimates include the bias correction factor.

[WRC, based on U.S. Water Resources Council (1981) guidelines; s.d., one standard deviation; --, value not determined]

	Peak-flow quantiles (cubic feet per second)						Peak-flow statistics (log 10 units)						Years of record	
							WRC weighted			Gaged record				
Station number	2-yr peak	5-yr peak	10-yr peak	25-yr peak	50-yr peak	100-yr peak	mean	s. d.	skew	mean	s. d.	skew	Gaged	Historic
03202400	9,160	17,200	23,700	33,500	41,800	50,900	3.959	0.326	-0.048	3.959	0.326	-0.399	16	
	11,600	18,100	22,900	29,300	34,400	39,900								
	9,430	17,300	23,500	32,400	39,300	46,900								
03203000[a]	19,900	29,900	36,600	45,200	51,600	57,900	4.291	.217	- .211	4.291	.217	- .399	50	
	20,800	29,800	36,000	43,900	50,200	56,600								
	19,900	29,900	36,600	45,100	51,400	57,700								
03203600[a,b]	22,800	35,900	44,800	56,100	64,400	72,600	4.344	.247	- .320	4.364	.263	- .463	17	105
	21,700	30,900	37,100	45,200	51,400	58,000								
	22,700	35,200	43,300	53,300	60,200	67,500								
03204500	6,220	9,070	11,000	13,600	15,600	17,600	3.793	.195	- .015	3.793	.195	- .059	43	
	9,070	13,200	16,100	19,900	22,900	26,000								
	6,350	9,340	11,400	14,400	16,700	19,100								
03206600	1,700	2,420	2,960	3,710	4,310	4,960	3.240	.177	.353	3.240	.177	.580	20	
	2,140	3,100	3,780	4,720	5,430	6,220								
	1,740	2,510	3,100	3,940	4,630	5,350								
03207000[b]	6,470	10,100	12,800	16,500	19,400	22,500	3.812	.230	.027	3.802	.221	- .138	31	51
	10,200	15,000	18,300	22,800	26,200	29,900								
	6,700	10,500	13,400	17,500	20,800	24,200								
03207020[a]	6,520	10,200	13,000	16,700	19,700	22,900	3.816	.231	.042	3.816	.231	.031	37	
	10,200	15,000	18,300	22,700	26,100	29,800								
	6,710	10,600	13,500	17,500	20,800	24,300								

Table 3.--Flood quantiles and associated statistics for streamflow-gaging stations used in the study--Continued

Station number	Peak-flow quantiles (cubic feet per second) 2-yr peak	5-yr peak	10-yr peak	25-yr peak	50-yr peak	100-yr peak	Peak-flow statistics (log 10 units) WRC weighted mean	WRC weighted s. d.	WRC weighted skew	Gaged record mean	Gaged record s. d.	Gaged record skew	Years of record Gaged	Years of record Historic
03207400	842	2,000	3,130	5,020	6,800	8,920	2.921	0.451	-0.058	2.894	0.505	-0.695	27	
	1,660	2,700	3,490	4,570	5,470	6,420								
	898	2,070	3,180	4,940	6,500	8,300								
03207500[b]	10,700	17,100	21,400	26,700	30,600	34,300	4.011	.259	- .400	4.011	.262	- .713	34	46
	10,600	17,600	22,800	30,100	36,000	42,300								
	10,700	17,100	21,600	27,200	31,700	36,000								
03207962	52.4	120	184	289	387	502	1.716	.430	- .048	1.716	.430	- .442	10	
	139	215	273	354	421	493								
	66.8	142	209	313	402	498								
03207965	847	1,140	1,340	1,630	1,850	2,080	2.938	.144	.431	2.900	.220	- .067	9	
	584	888	1,110	1,430	1,670	1,950								
	799	1,080	1,270	1,550	1,770	2,020								
03208000[a,b]	12,100	17,600	21,200	25,800	29,100	32,400	4.078	.197	- .177	4.088	.209	- .134	30	107
	13,000	19,700	24,300	30,600	35,500	40,800								
	12,200	17,800	21,600	26,600	30,400	34,300								
03208500	14,000	24,500	32,200	42,500	50,600	58,800	4.133	.299	- .271	4.133	.299	- .469	58	
	12,900	21,500	28,000	36,700	44,000	51,700								
	14,000	24,400	31,900	42,000	49,800	57,800								
03208950	2,740	5,420	7,860	11,800	15,400	19,700	3.449	.344	.185	3.449	.344	.163	21	
	3,650	5,660	7,120	9,130	10,700	12,500								
	2,820	5,450	7,740	11,200	14,100	17,500								
03209000[a]	10,100	15,500	19,400	24,600	28,600	32,700	4.000	.226	- .067	4.000	.226	- .205	38	
	8,360	12,300	15,100	18,800	21,700	24,800								
	10,000	15,300	19,000	23,800	27,400	31,200								

Table 3.--Flood quantiles and associated statistics for streamflow-gaging stations used in the study--Continued

Station number	Peak-flow quantiles (cubic feet per second) 2-yr peak	5-yr peak	10-yr peak	25-yr peak	50-yr peak	100-yr peak	Peak-flow statistics (log 10 units) WRC weighted mean	WRC weighted s. d.	WRC weighted skew	Gaged record mean	Gaged record s. d.	Gaged record skew	Years of record Gaged	Years of record Historic
03209300[a]	23,300	35,900	45,400	58,700	69,600	81,400	4.375	0.217	0.199	4.375	0.217	0.188	8	
	19,900	32,200	41,200	53,100	62,800	73,000								
	22,600	34,900	44,000	56,300	66,200	77,000								
03209575	287	441	566	750	909	1,090	2.475	.210	.487	2.475	.210	1.460	10	
	411	645	821	1,060	1 260	1,470								
	308	488	639	866	1,070	1,270								
03210000	2,710	4,300	5,390	6,770	7,800	8,820	3.420	.250	- .308	3.420	.250	- .541	46	
	2,910	4,220	5,130	6,360	7,320	8,350								
	2,720	4,300	5,370	6,720	7,730	8,740								
03210160	517	674	772	890	974	1,060	2.711	.139	- .110	2.667	.234	-1.766	9	
	446	703	896	1,160	1,390	1,620								
	504	681	810	998	1,170	1,340								
03211500[a,b]	3,910	5,800	7,090	8,740	9,980	11,200	3.588	.207	- .130	3.594	.291	-1.027	12	32
	7,100	9,890	11,800	14,300	16,200	18,300								
	4,370	6,620	8,270	10,600	12,500	14,200								
03212000	5,280	9,200	12,000	15,800	18,600	21,500	3.706	.303	- .343	3.706	.303	- .615	32	
	5,140	7,950	9,990	12,700	14,900	17,300								
	5,270	9,090	11,800	15,300	17,900	20,600								
03212515	154	255	334	448	542	646	2.192	.256	.117	2.192	.256	.256	7	
	296	460	583	750	892	1,040								
	186	317	425	587	729	868								
03213700[b]	18,600	30,900	39,700	51,200	60,000	68,900	4.258	.273	- .274	4.251	.273	- .564	16	110
	23,900	34,700	42,000	51,600	59,000	66,800								
	19,200	31,500	40,200	51,300	59,700	68,100								
03215500	5,910	9,020	11,300	14,500	17,000	19,700	3.776	.215	.113	3.776	.215	.140	52	
	8,390	12,300	15,000	18,500	21,300	24,200								
	6,000	9,200	11,600	14,900	17,600	20,400								

Table 3.--Flood quantiles and associated statistics for streamflow-gaging stations used in the study--Continued

Station number	Peak-flow quantiles (cubic feet per second)						Peak-flow statistics (log 10 units)						Years of record	
							WRC weighted			Gaged record				
	2-yr peak	5-yr peak	10-yr peak	25-yr peak	50-yr peak	100-yr peak	mean	s. d.	skew	mean	s. d.	skew	Gaged	Historic
03216500[a,b]	9,910	13,800	16,400	19,800	22,400	25,100	3.998	0.169	0.065	3.995	0.204	-0.523	30	84
	14,000	21,200	26,300	32,900	38,300	43,800								
	10,200	14,500	17,600	22,000	25,700	29,400								
03216505	35.5	61.0	79.7	105	125	146	1.540	.288	- .217	1.540	.288	- .582	9	
	100	159	204	269	323	382								
	47.2	85.5	118	171	218	264								
03216540	815	1,050	1,210	1,410	1,570	1,730	2.918	.125	.310	2.918	.125	.726	13	
	943	1,390	1,710	2,150	2,490	2,860								
	832	1,110	1,330	1,640	1,920	2,190								
03216563	199	277	14,200	18,400	21,900	25,600	3.863	.222	.181	2.264	.238	-1.144	10	
	153	240	305	399	476	560								
	191	268	322	397	459	526								
03216564[c]	326	448	528	628	701	774	2.511	.166	- .074	2.507	.175	- .340	60	
	218	333	419	542	640	748								
	323	443	521	620	694	771								
03216800	4,850	7,320	8,930	10,900	12,300	13,700	3.673	.225	- .350	3.673	.225	- .575	29	
	3,730	6,040	7,760	10,100	12,100	14,100								
	4,780	7,200	8,790	10,800	12,300	13,800								
03216901	192	263	315	384	439	496	2.293	.156	.355	2.293	.156	1.504	10	
	169	260	328	425	504	590								
	188	262	319	399	468	541								
03217000	7,180	11,200	14,200	18,400	21,900	25,600	3.863	.222	.181	3.855	.238	- .127	45	
	8,040	11,000	13,100	15,700	17,700	19,800								
	7,220	11,200	14,100	18,100	21,300	24,600								

Table 3.--Flood quantiles and associated statistics for streamflow-gaging stations used in the study--Continued

Station number	Peak-flow quantiles (cubic feet per second) 2-yr peak	5-yr peak	10-yr peak	25-yr peak	50-yr peak	100-yr peak	Peak-flow statistics (log 10 units) WRC weighted mean	WRC weighted s. d.	WRC weighted skew	Gaged record mean	Gaged record s. d.	Gaged record skew	Years of record Gaged	Years of record Historic
03237280[b]	1,070	1,970	2,640	3,540	4,230	4,920	3.007	0.337	-0.391	2.995	0.328	-0.777	22	71
	1,020	1,560	1,960	2,500	2,930	3,400								
	1,070	1,920	2,530	3,310	3,870	4,460								
03237500	21,200	30,500	36,900	45,400	51,900	58,600	4.328	.186	.058	4.328	.186	.120	53	
	13,600	20,800	25,900	32,700	38,100	43,800								
	20,900	30,000	36,100	44,100	50,100	56,500								
03237895	82.7	114	135	163	184	206	1.920	.164	.104	1.920	.164	.484	9	
	104	179	238	326	403	483								
	86.6	126	161	213	251	305								
03237900	4,040	5,910	7,100	8,550	9,580	10,600	3.595	.207	- .339	3.595	.207	- .654	14	
	2,960	4,900	6,370	8,490	10,300	12,200								
	3,910	5,780	6,970	8,540	9,740	11,000								
03238030	297	484	628	830	995	1,170	2.476	.249	.073	2.476	.249	.393	11	
	434	675	852	1,100	1,310	1,520								
	318	513	676	902	1,080	1,280								
03238500	10,100	14,100	16,700	19,900	22,400	24,800	4.004	.171	- .053	4.004	.171	- .017	57	
	14,100	21,100	26,000	32,800	38,200	44,100								
	10,200	14,300	17,200	20,700	23,400	26,400								
03246500	10,500	14,300	16,700	19,600	21,800	23,900	4.021	.158	- .084	4.021	.158	.011	20	
	13,800	19,400	23,100	28,200	32,200	36,400								
	10,800	14,800	17,500	21,000	23,500	26,400								
03247100	582	722	800	888	946	999	2.758	.117	- .364	2.749	.139	-1.177	31	
	616	910	1,120	1,410	1,640	1,880								
	584	733	828	948	1,030	1,120								

Table 3.--Flood quantiles and associated statistics for streamflow-gaging stations used in the study--Continued

Station number	Peak-flow quantiles (cubic feet per second) 2-yr peak	5-yr peak	10-yr peak	25-yr peak	50-yr peak	100-yr peak	Peak-flow statistics (log 10 units) WRC weighted mean	WRC weighted s. d.	WRC weighted skew	Gaged record mean	Gaged record s. d.	Gaged record skew	Years of record Gaged	Years of record Historic
03247500[a]	19,700	27,400	32,200	38,000	42,200	46,200	4.288	0.176	-0.247	4.288	0.176	-0.254	57	
	26,100	39,900	49,700	63,400	74,500	86,500								
	19,900	27,800	33,100	39,700	44,300	49,500								
03248500	4,230	6,780	8,600	11,000	12,900	14,800	3.620	.249	- .157	3.611	.267	- .525	47	
	5,720	8,210	9,940	12,200	14,000	15,900								
	4,290	6,870	8,710	11,100	13,100	15,000								
03249500[a]	11,400	15,900	18,600	21,900	24,200	26,300	4.048	.179	- .335	4.048	.179	- .499	36	
	22,700	34,000	41,800	52,300	60,300	69,000								
	12,000	17,300	20,900	26,200	30,800	34,800								
03250000[b]	6,280	10,000	12,800	16,400	19,300	22,300	3.794	.246	- .099	3.789	.241	- .308	41	190
	3,230	5,340	6,930	9,140	11,000	12,900								
	6,130	9,670	12,300	15,500	17,900	20,600								
03250080	37.2	61.7	79.8	104	124	144	1.565	.266	- .131	1.565	.266	- .243	10	
	43.2	65.3	81.8	106	125	146								
	38.2	62.5	80.4	105	124	145								
03250100	6,090	7,490	8,320	9,290	9,960	10,600	3.782	.109	- .131	3.770	.135	-1.019	18	
	4,490	6,930	8,700	11,100	13,000	15,000								
	5,930	7,410	8,390	9,740	10,900	12,100								
03250150[c]	386	611	778	1,008	1,193	1,388	2.588	.236	.030	2.588	.236	.198	62	
	309	476	600	774	917	1,070								
	384	605	767	987	1,160	1,350								
03250243	198	261	302	353	390	426	2.295	.145	- .029	2.295	.145	.059	9	
	126	201	257	338	405	478								
	184	245	287	347	398	454								

Table 3.--Flood quantiles and associated statistics for streamflow-gaging stations used in the study--Continued

Station number	Peak-flow quanti'es (cubic feet per second)						Peak-flow statistics (log 10 units)						Years of record	
	2-yr peak	5-yr peak	10-yr peak	25-yr peak	50-yr peak	100-yr peak	WRC weighted mean	WRC weighted s. d.	WRC weighted skew	Gaged record mean	Gaged record s. d.	Gaged record skew	Gaged	Historic
03250320	980	1,520	1,910	2,450	2,870	3,310	2.992	0.226	0.015	2.992	0.226	0.178	9	
	480	757	965	1,250	1,490	1,740								
	889	1,330	1,620	1,970	2,220	2,530								
03250620	86	129	158	196	225	254	1.931	.211	- .114	1.931	.211	- .075	9	
	66.5	101	127	165	195	228								
	82.5	122	148	184	211	241								
03251000[b]	5,720	7,600	8,860	10,500	11,700	12,900	3.761	.144	.147	3.745	.154	- .677	39	48
	5,030	7,160	8,630	10,600	12,100	13,700								
	5,690	7,570	8,840	10,500	11,800	13,100								
03251008	81.8	186	279	422	548	687	1.894	.440	- .248	1.894	.440	- .458	9	
	208	375	511	705	879	1,060								
	105	233	350	535	704	874								
03251015	87.4	131	164	212	251	293	1.952	.201	.322	1.952	.201	1.711	11	
	73.5	106	129	164	191	220								
	85.3	126	155	195	226	260								
03252000	8,230	11,300	13,200	15,500	17,200	18,900	3.911	.165	- .157	3.892	.218	-1.648	30	
	8,320	11,300	13,400	15,900	17,900	20,000								
	8,240	11,300	13,200	15,600	17,300	19,200								
03252500	17,700	23,800	27,200	30,800	33,200	35,300	4.231	.170	- .622	4.224	.188	-1.316	68	
	17,400	24,200	28,900	34,600	39,300	43,900								
	17,700	23,800	27,300	31,100	33,800	36,300								
03254400	2,780	5,250	7,480	11,100	14,400	18,400	3.461	.316	.303	3.461	.316	1.267	15	
	1,910	3,000	3,790	4,920	5,860	6,840								
	2,680	4,990	6,870	9,800	12,600	15,500								

Table 3.--Flood quantiles and associated statistics for streamflow-gaging stations used in the study--Continued

	Peak-flow quantiles (cubic feet per second)						Peak-flow statistics (log 10 units)						Years of record	
							WRC weighted			Gaged record				
Station number	2-yr peak	5-yr peak	10-yr peak	25-yr peak	50-yr peak	100-yr peak	mean	s. d.	skew	mean	s. d.	skew	Gaged	His-toric
03260010	211	379	508	685	825	972	2.311	0.315	-0.238	2.311	0.315	-0.225	12	
	205	321	409	532	635	740								
	210	371	488	647	778	904								
03260012	249	540	809	1,250	1,650	2,120	2.397	.399	.006	2.397	.399	.341	13	
	471	850	1,160	1,620	2,030	2,470								
	279	581	875	1,340	1,740	2,220								
03277070[c]	259	406	522	689	831	987	2.425	.223	.310	2.398	.331	-3.013	61	
	364	559	702	901	1,070	1,230								
	262	411	530	702	846	1,010								
03277185	252	422	537	681	785	887	2.380	.287	- .463	2.380	.287	- .866	10	
	252	462	635	897	1,130	1,380								
	252	429	560	743	884	1,050								
03277250	35.8	51.7	62.2	75.6	85.3	94.8	1.548	.194	- .163	1.548	.194	.011	10	
	63.9	94.3	116	147	172	196								
	40.5	58.8	74.6	95.9	110	129								
03277290	167	325	464	683	879	1,110	2.230	.338	.115	2.230	.338	.030	9	
	344	515	640	815	956	1,110								
	199	373	518	736	915	1,110								
03277300	2,010	3,490	4,690	6,460	7,970	9,660	3.310	.279	.124	3.310	.279	.102	27	
	3,640	5,610	7,030	8,980	10,500	12,200								
	2,120	3,700	4,990	6,920	8,550	10,300								
03277400	2,530	4,510	6,050	8,200	9,940	11,800	3.395	.306	- .156	3.395	.306	- .427	19	
	3,090	4,880	6,200	8,020	9,480	11,000								
	2,660	4,620	6,100	8,130	9,730	11,400								

Table 3.--Flood quantiles and associated statistics for streamflow-gaging stations used in the study--Continued

Station number	Peak-flow quantiles (cubic feet per second): 2-yr peak	5-yr peak	10-yr peak	25-yr peak	50-yr peak	100-yr peak	Peak-flow statistics (log 10 units), WRC weighted: mean	s. d.	skew	Gaged record: mean	s. d.	skew	Years of record: Gaged	Historic
03277437	97.9	154	200	269	329	397	2.008	0.223	0.455	2.008	0.223	1.314	9	
	122	189	239	309	368	430								
	102	163	212	285	347	414								
03277450[a]	3,140	4,170	4,860	5,760	6,450	7,160	3.502	.142	.220	3.502	.142	.375	12	
	3,200	4,740	5,840	7,310	8,470	9,710								
	3,150	4,280	5,110	6,280	7,260	8,250								
03277500[a,d]	19,200	28,500	34,400	41,700	47,000	52,100	4.273	.213	-.321	4.262	.235	-.919	36	
	15,800	23,200	28,300	35,000	40,300	45,800								
	18,900	27,800	33,400	40,400	45,300	50,300								
03277630	244	387	501	665	805	959	2.398	.230	.286	2.398	.230	.660	10	
	249	423	560	757	918	1,090								
	246	403	531	715	875	1,040								
03278000	243	381	478	606	705	806	2.380	.237	-.140	2.367	.261	-.617	28	
	286	446	565	735	872	1,020								
	246	387	489	629	742	858								
03278500[b]	9,280	15,300	19,300	24,500	28,300	32,000	3.950	.274	-.400	3.953	.276	-.663	32	43
	7,180	10,600	12,900	16,000	18,500	21,100								
	9,160	14,900	18,600	23,200	26,300	29,600								
03280600	12,500	22,100	29,900	41,500	51,300	62,200	4.103	.289	.090	4.103	.289	.099	29	
	10,300	16,300	20,800	27,100	32,200	37,500								
	12,100	20,800	27,600	37,300	44,500	52,400								
03280700	4,420	7,480	9,840	13,200	15,900	18,800	3.644	.273	-.025	3.644	.273	-.090	28	
	4,330	7,020	9,070	12,000	14,400	17,000								
	4,400	7,380	9,640	12,800	15,400	18,100								

Table 3.--Flood quantiles and associated statistics for streamflow-gaging stations used in the study--Continued

Station number	Peak-flow quantiles (cubic feet per second) 2-yr peak	5-yr peak	10-yr peak	25-yr peak	50-yr peak	100-yr peak	Peak-flow statistics (log 10 units) WRC weighted mean	WRC weighted s. d.	WRC weighted skew	Gaged record mean	Gaged record s. d.	Gaged record skew	Years of record Gaged	Years of record His-toric
03280728	276	451	597	819	1,010	1,240	2.459	0.241	0.428	2.459	0.241	1.367	10	
	321	547	726	984	1,200	1,430								
	293	494	662	909	1,130	1,360								
03280935	170	363	549	863	1,160	1,530	2.244	.381	.200	2.244	.381	.464	11	
	291	505	677	930	1,140	1,380								
	213	423	610	898	1,150	1,440								
03281000[a,b]	13,600	21,700	28,100	37,400	45,300	54,000	4.144	.233	.276	4.149	.242	.528	26	32
	21,000	32,200	40,300	51,500	60,500	69,700								
	15,000	24,200	31,500	41,900	51,100	60,600								
03281040	11,800	16,100	19,100	23,000	26,000	29,100	4.075	.160	.154	4.075	.160	.302	13	
	8,460	13,400	17,000	22,100	26,200	30,500								
	10,700	15,100	18,200	22,600	26,100	29,900								
03281100[b]	8,750	12,300	14,700	17,900	20,300	22,800	3.944	.173	.083	3.931	.200	-.529	21	33
	7,620	11,300	13,800	17,200	19,900	22,600								
	8,610	12,100	14,500	17,700	20,200	22,700								
03281200[d]	20,800	31,500	38,900	48,500	55,800	63,200	4.314	.217	-.113	4.314	.217	-.207	26	
	19,400	29,500	36,700	46,700	54,800	63,100								
	20,600	31,100	38,400	48,000	55,500	63,200								
03281500[d]	24,300	37,700	47,200	59,700	69,400	79,200	4.380	.231	-.117	4.380	.231	-.157	54	
	25,900	38,600	47,500	59,800	69,500	79,200								
	24,400	37,800	47,200	59,700	69,400	79,200								
03282198	148	260	345	462	556	654	2.163	.297	-.171	2.163	.297	-.331	11	
	141	248	335	464	572	692								
	146	255	340	463	565	678								

Table 3.--Flood quantiles and associated statistics for streamflow-gaging stations used in the study--Continued

Station number	Peak-flow quantiles (cubic feet per second) 2-yr peak	5-yr peak	10-yr peak	25-yr peak	50-yr peak	100-yr peak	Peak-flow statistics (log 10 units) WRC weighted mean	WRC weighted s. d.	WRC weighted skew	Gaged record mean	Gaged record s. d.	Gaged record skew	Years of record Gaged	Years of record Historic
03282500	2,360	3,800	4,910	6,470	7,740	9,120	3.376	0.244	0.093	3.376	0.244	0.158	31	
	3,490	5,330	6,660	8,510	9,950	11,500								
	2,430	3,940	5,110	6,800	8,190	9,660								
03283000	2,090	3,700	4,930	6,630	7,990	9,430	3.312	.301	-.176	3.312	.301	-.280	29	
	1,870	3,040	3,910	5,130	6,130	7,210								
	2,080	3,640	4,810	6,370	7,590	8,900								
03283305	144	177	199	226	247	268	2.164	.102	.353	2.164	.102	1.140	11	
	112	175	223	291	348	407								
	139	177	205	249	290	331								
03283500	8,720	13,900	17,500	22,200	25,600	29,100	3.929	.252	-.274	3.929	.252	-.358	51	
	11,200	15,700	18,900	23,000	26,100	29,500								
	8,810	14,000	17,600	22,300	25,700	29,200								
03283610	51.1	82.9	105	134	156	177	1.696	.261	-.282	1.696	.261	-.632	10	
	67.1	102	128	166	197	230								
	53.8	87.3	112	146	174	202								
03284300	3,060	5,300	6,890	8,970	10,500	12,100	3.468	.299	-.365	3.468	.299	-.725	16	
	2,430	3,960	5,120	6,760	8,110	9,540								
	2,890	4,850	6,210	8,020	9,310	10,700								
03284310	3,560	5,870	7,660	10,200	12,400	14,700	3.556	.254	.113	3.556	.254	.301	18	
	3,820	6,100	7,800	10,200	12,100	14,200								
	3,630	5,940	7,710	10,200	12,300	14,400								
03284340	298	505	672	915	1,120	1,350	2.480	.268	.132	2.480	.268	.497	10	
	323	555	740	1,010	1,230	1,480								
	307	527	706	967	1,190	1,440								

Table 3.--Flood quantiles and associated statistics for streamflow-gaging stations used in the study--Continued

Station number	Peak-flow quantiles (cubic feet per second) 2-yr peak	5-yr peak	10-yr peak	25-yr peak	50-yr peak	100-yr peak	Peak-flow statistics (log 10 units) WRC weighted mean	WRC weighted s. d.	WRC weighted skew	Gaged record mean	Gaged record s. d.	Gaged record skew	Years of record Gaged	Years of record Historic
03284550	1,250	2,210	3,000	4,180	5,180	6,310	3.102	0.291	0.104	3.102	0.291	0.516	9	
	1,220	2,050	2,700	3,660	4,450	5,310								
	1,240	2,130	2,840	3,880	4,710	5,630								
03285000	13,200	19,200	23,500	29,500	34,200	39,300	4.130	.185	.253	4.123	.199	- .023	43	
	14,100	21,600	27,000	34,400	40,300	46,200								
	13,300	19,600	24,200	30,600	35,900	41,400								
03285100	45.9	63.5	74.9	89.3	99.2	109	1.657	.171	- .153	1.657	.171	- .242	9	
	46.2	83.5	115	161	200	244								
	46.0	72.9	96.0	130	164	201								
03285500	19,300	24,700	27,900	31,700	34,300	36,700	4.281	.131	- .225	4.251	.185	-1.170	7	
	15,700	23,600	29,200	36,600	42,400	48,200								
	17,600	24,100	28,700	34,800	39,900	45,100								
03287128	148	278	392	572	733	920	2.181	.318	.191	2.181	.318	.768	10	
	184	283	356	461	545	638								
	154	279	382	530	649	786								
03287160[c]	173	246	296	358	406	453	2.237	.183	- .051	2.237	.183	- .022	54	
	143	222	282	364	434	506								
	172	245	295	359	410	461								
03287534	548	679	759	855	923	989	2.739	.110	- .003	2.739	.110	.260	10	
	431	624	763	956	1,110	1,270								
	529	666	760	893	1,010	1,120								
03288000	4,150	5,600	6,530	7,680	8,520	9,350	3.616	.157	- .081	3.602	.190	-1.119	33	
	4,900	7,100	8,640	10,700	12,300	14,000								
	4,190	5,730	6,760	8,140	9,260	10,300								

Table 3.--Flood quantiles and associated statistics for streamflow-gaging stations used in the study--Continued

Station number	Peak-flow quantiles (cubic feet per second) 2-yr peak	5-yr peak	10-yr peak	25-yr peak	50-yr peak	100-yr peak	Peak-flow statistics (log 10 units) WRC weighted mean	WRC weighted s. d.	WRC weighted skew	Gaged record mean	Gaged record s. d.	Gaged record skew	Years of record Gaged	Years of record Historic
03288500	114	208	286	403	503	614	2.057	0.312	0.026	2.057	0.312	0.125	27	
	261	408	517	672	798	935								
	124	228	316	452	570	694								
03289000	895	1,350	1,670	2,100	2,430	2,770	2.951	.213	-.018	2.951	.213	.038	35	
	1,570	2,390	2,990	3,790	4,450	5,140								
	931	1,430	1,810	2,350	2,810	3,250								
03289190	1,000	1,430	1,700	2,010	2,230	2,450	2.989	.195	-.370	2.958	.251	-1.215	10	
	537	823	1,030	1,330	1,560	1,820								
	923	1,290	1,510	1,760	1,930	2,150								
03289500[b]	12,200	17,400	20,600	24,200	26,600	28,800	4.068	.203	-.531	4.055	.209	-.927	51	68
	12,300	17,100	20,400	24,500	27,800	31,100								
	12,200	17,400	20,600	24,200	26,800	29,200								
03290000	2,000	3,200	4,130	5,450	6,540	7,740	3.308	.237	.169	3.308	.237	.378	34	
	995	1,570	2,000	2,600	3,110	3,630								
	1,940	3,110	3,960	5,150	6,180	7,210								
03290580	405	701	935	1,270	1,550	1,860	2.609	.281	.029	2.609	.281	.449	10	
	870	1,350	1,700	2,190	2,590	3,010								
	483	809	1,110	1,530	1,850	2,240								
03291000	4,290	5,810	6,850	8,220	9,260	10,300	3.637	.153	.200	3.637	.153	.379	43	
	3,800	5,290	6,290	7,640	8,700	9,790								
	4,270	5,790	6,810	8,170	9,210	10,200								
03291050	212	302	368	456	527	601	2.333	.178	.241	2.333	.178	1.194	10	
	176	269	338	435	515	595								
	206	297	361	450	524	599								

Table 3.--Flood quantiles and associated statistics for streamflow-gaging stations used in the study--Continued

Station number	Peak-flow quantiles (cubic feet per second) 2-yr peak	5-yr peak	10-yr peak	25-yr peak	50-yr peak	100-yr peak	Peak-flow statistics (log 10 units) WRC weighted mean	WRC weighted s. d.	WRC weighted skew	Gaged record mean	Gaged record s. d.	Gaged record skew	Years of record Gaged	Years of record Historic
03291500[b]	21,600	29,700	35,100	42,000	47,200	52,400	4.335	0.163	0.031	4.331	0.178	-0.267	58	73
	20,800	28,300	33,200	39,800	44,900	50,300								
	21,600	29,700	35,000	41,900	47,100	52,200								
03292200	450	626	747	904	1,020	1,150	2.656	.168	.100	2.626	.222	-.571	9	
	283	493	659	907	1,120	1,350								
	420	602	725	905	1,050	1,220								
03292460	3,470	4,440	5,010	5,690	6,150	6,590	3.536	.131	-.215	3.536	.131	-.186	18	
	2,510	3,520	4,220	5,150	5,890	6,650								
	3,370	4,350	4,900	5,590	6,100	6,600								
03292472[c]	307	461	556	667	743	814	2.467	.229	-.523	2.467	.229	-.648	62	
	293	493	649	877	1,070	1,280								
	307	462	560	680	763	849								
03292500	1 170	2,080	2,780	3,760	4,540	5,370	3.057	.307	-.185	3.042	.342	-.700	44	
	2 130	3,180	3,930	4,980	5,820	6,700								
	1,210	2,130	2,850	3,860	4,650	5,510								
03292785	761	1,290	1,680	2,190	2,580	2,980	2.868	.286	-.281	2.868	.286	-.316	23	
	1,000	1,470	1,800	2,250	2,610	2,980								
	780	1,300	1,690	2,200	2,580	2,980								
03293000	1,390	2,100	2,640	3,420	4,060	4,760	3.154	.204	.323	3.154	.204	.662	40	
	2,260	3,410	4,230	5,380	6,300	7,270								
	1,430	2,160	2,750	3,600	4,260	5,040								
03294000	6,340	9,900	12,600	16,200	19,200	22,400	3.806	.227	.098	3.806	.227	.331	30	
	11,600	16,100	19,200	23,400	26,600	30,000								
	6,670	10,300	13,200	17,000	20,100	23,500								

Table 3.--Flood quantiles and associated statistics for streamflow-gaging stations used in the study--Continued

Station number	Peak-flow quantiles (cubic feet per second)						Peak-flow statistics (log 10 units)						Years of record	
							WRC weighted			Gaged record				
	2-yr peak	5-yr peak	10-yr peak	25-yr peak	50-yr peak	100-yr peak	mean	s. d.	skew	mean	s. d.	skew	Gaged	Historic
03295000	3,140	4,900	6,190	7,980	9,410	10,900	3.500	0.227	0.064	3.500	0.227	0.172	31	
	2,230	3,190	3,870	4,770	5,490	6,240								
	3,080	4,750	5,920	7,460	8,610	9,850								
03295500[b]	8,970	12,100	14,000	16,200	17,700	19,100	3.943	.164	-.359	3.927	.169	-.836	45	55
	8,640	13,800	17,600	22,800	27,000	31,400								
	8,960	12,200	14,300	17,000	19,100	21,200								
03295845	282	630	958	1,500	2,000	2,590	2.449	.415	-.007	2.449	.415	.292	10	
	356	575	741	978	1,180	1,380								
	294	621	908	1,350	1,770	2,190								
03296500[a]	2,870	4,180	5,030	6,080	6,840	7,570	3.449	.203	-.273	3.449	.203	-.324	26	
	2,180	3,140	3,800	4,710	5,430	6,180								
	2,820	4,110	4,900	5,900	6,650	7,350								
03297000	1,440	2,360	3,090	4,160	5,070	6,080	3.170	.246	.241	3.170	.246	.563	29	
	982	1,610	2,090	2,780	3,370	3,990								
	1,410	2,310	3,000	3,990	4,860	5,770								
03297500	5,900	8,600	10,300	12,400	13,900	15,300	3.759	.206	-.353	3.759	.206	-.483	24	
	3,330	4,950	6,090	7,670	8,940	10,300								
	5,700	8,320	9,830	11,700	13,200	14,400								
03298000	9,530	13,700	16,900	21,500	25,200	29,400	3.993	.178	.475	3.993	.178	1.003	41	
	8,920	12,200	14,400	17,400	19,700	22,100								
	9,500	13,600	16,700	21,100	24,700	28,600								
03298535	141	298	448	701	944	1,240	2.161	.377	.202	2.161	.377	1.006	10	
	228	387	512	694	851	1,020								
	156	313	463	699	917	1,170								

Table 3.--Flood quantiles and associated statistics for streamflow-gaging stations used in the study--Continued

Station number	Peak-flow quantiles (cubic feet per second): 2-yr peak	5-yr peak	10-yr peak	25-yr peak	50-yr peak	100-yr peak	Peak-flow statistics (log 10 units): WRC weighted mean	WRC weighted s. d.	WRC weighted skew	Gaged record mean	Gaged record s. d.	Gaged record skew	Years of record: Gaged	Years of record: Historic
03299000	14,500	22,200	27,800	35,400	41,400	47,600	4.164	0.217	0.048	4.164	0.217	0.118	47	
	13,800	22,100	28,700	38,000	45,500	54,400								
	14,500	22,200	27,900	35,600	41,800	48,400								
03300000	5,180	7,170	8,530	10,300	11,600	13,000	3.718	.165	.115	3.718	.165	.270	31	
	4,130	5,850	7,060	8,570	9,810	11,100								
	5,120	7,050	8,360	10,000	11,200	12,600								
03300065	522	897	1,150	1,470	1,700	1,930	2.692	.305	-.512	2.650	.366	-1.558	10	
	249	398	510	670	802	945								
	477	782	967	1,170	1,300	1,460								
03300400	17,400	24,700	29,500	35,600	40,100	44,600	4.236	.184	-.117	4.236	.184	-.065	14	
	17,800	29,300	37,800	49,000	58,500	68,100								
	17,500	25,500	31,300	39,600	46,800	53,800								
03300990[c]	50.0	76.2	94.4	118	136	154	1.699	.218	-.111	1.699	.218	-.096	61	
	65.9	101	126	163	194	227								
	50.5	77.2	96.0	122	143	163								
03301000	20,300	27,600	32,000	37,000	40,400	43,600	4.295	.170	-.409	4.290	.182	-.717	46	
	18,200	25,400	30,200	36,100	40,900	45,700								
	20,200	27,500	31,900	36,900	40,500	43,900								
03302000	2,660	3,850	4,670	5,760	6,600	7,470	3.427	.189	.055	3.418	.209	-.404	41	
	5,450	8,820	11,500	15,300	18,300	21,900								
	2,850	4,190	5,280	6,610	7,870	9,310								
03302085	168	257	312	376	420	460	2.204	.240	-.558	2.175	.281	-1.391	9	
	257	432	570	769	930	1,120								
	190	301	391	497	602	724								

Table 3.--Flood quantiles and associated statistics for streamflow-gaging stations used in the study--Continued

Station	Peak-flow quantiles (cubic feet per second)						Peak-flow statistics (log 10 units)						Years of record	
							WRC weighted			Gaged record				
number	2-yr peak	5-yr peak	10-yr peak	25-yr peak	50-yr peak	100-yr peak	mean	s. d.	skew	mean	s. d.	skew	Gaged	His-toric
03302220	4,870	8,760	11,700	15,700	18,900	22,300	3.675	0.315	-0.250	3.675	0.315	-0.237	15	
	3,710	6,030	7,860	10,500	12,600	15,100								
	4,680	8,310	10,900	14,600	17,300	20,200								
03302300	2,840	4,250	5,130	6,160	6,880	7,550	3.436	.225	- .483	3.436	.225	- .741	16	
	2,050	3,370	4,400	5,890	7,080	8,480								
	2,720	4,110	4,980	6,110	6,930	7,800								
03302350	129	270	403	625	835	1,090	2.123	.371	.192	2.123	.371	1.480	10	
	191	323	426	576	697	838								
	143	282	410	611	789	996								
03303000	12,700	18,100	21,500	25,700	28,600	31,400	4.093	.194	- .333	4.086	.209	- .675	59	
	9,300	13,300	15,900	19,300	21,900	24,500								
	12,600	17,900	21,200	25,300	28,100	30,800								
03303300[b]	1,530	2,740	3,840	5,630	7,320	9,350	3.209	.283	.506	3.197	.267	.572	23	80
	3,100	4,600	5,640	7,050	8,140	9,300								
	1,660	2,890	4,050	5,840	7,470	9,340								
03303400	1,110	2,020	2,760	3,870	4,810	5,860	3.047	.307	.032	3.047	.307	.458	15	
	960	1,420	1,730	2,150	2,470	2,810								
	1,090	1,950	2,590	3,510	4,230	4,990								
03303440	93.2	141	171	206	230	252	1.949	.235	- .537	1.904	.321	-1.458	10	
	101	152	187	234	273	312								
	94.5	143	175	214	244	275								
03303900	68.6	90.9	105	121	133	145	1.832	.149	- .168	1.804	.202	-1.006	10	
	89.4	132	162	201	232	264								
	72.1	97.8	118	144	166	190								

Table 3.--Flood quantiles and associated statistics for streamflow-gaging stations used in the study--Continued

Station number	Peak-flow quantiles (cubic feet per second) 2-yr peak	5-yr peak	10-yr peak	25-yr peak	50-yr peak	100-yr peak	Peak-flow statistics (log 10 units) WRC weighted mean	WRC weighted s. d.	WRC weighted skew	Gaged record mean	Gaged record s. d.	Gaged record skew	Years of record Gaged	Years of record Historic
03304500	370	736	1,030	1,450	1,790	2,150	2.550	0.371	-0.297	2.550	0.371	-0.449	28	
	493	823	1,080	1,460	1,760	2,110								
	382	744	1,040	1,450	1,790	2,140								
03305000	4,020	8,240	11,800	17,000	21,500	26,300	3.591	.383	- .213	3.591	.383	- .288	32	
	2,590	4,240	5,540	7,390	8,890	10,600								
	3,900	7,900	11,100	15,900	19,800	23,800								
03305500	5,340	9,630	12,900	17,600	21,300	25,300	3.718	.313	- .190	3.718	.313	- .254	30	
	3,650	5,940	7,740	10,300	12,400	14,800								
	5,190	9,290	12,300	16,700	20,000	23,600								
03305559	387	550	654	783	877	968	2.581	.187	- .217	2.581	.187	- .421	10	
	263	443	584	787	952	1,140								
	358	525	634	784	902	1,030								
03305725	432	885	1,320	2,060	2,780	3,670	2.654	.356	.315	2.654	.356	1.206	10	
	360	603	794	1,070	1,290	1,550								
	415	820	1,170	1,780	2,280	2,880								
03305835	253	348	414	502	570	640	2.408	.161	.205	2.408	.161	.752	10	
	226	381	503	679	821	987								
	247	356	439	553	654	770								
03306000[a,b]	15,100	24,200	31,400	41,800	50,500	60,000	4.186	.239	.205	4.170	.235	.178	7	38
	29,000	46,000	59,500	78,600	93,800	12,044								
	19,300	30,700	41,600	55,200	68,500	84,000								
03306500[a,b]	17,200	26,000	32,500	41,500	48,900	56,700	4.242	.207	.192	4.252	.219	.420	29	56
	30,400	48,200	62,300	82,300	98,200	17,308								
	18,400	28,100	36,100	46,400	56,200	67,100								

Table 3.--Flood quantiles and associated statistics for streamflow-gaging stations used in the study--Continued

Station number	Peak-flow quantiles (cubic feet per second) 2-yr peak	5-yr peak	10-yr peak	25-yr peak	50-yr peak	100-yr peak	Peak-flow statistics (log 10 units) WRC weighted mean	WRC weighted s. d.	WRC weighted skew	Gaged record mean	Gaged record s. d.	Gaged record skew	Years of record Gaged	Years of record Historic
03307000[b]	8,580	14,900	20,200	28,600	36,000	44,600	3.949	0.272	0.345	3.951	0.273	0.568	46	49
	11,000	17,700	22,900	30,400	36,400	43,500								
	8,730	15,100	20,400	28,700	36,000	44,500								
03307100	11,500	21,900	31,500	47,400	62,500	80,800	4.081	.317	.389	4.081	.317	1.101	19	
	14,100	22,600	29,300	38,800	46,400	55,500								
	11,900	22,000	31,100	45,900	59,100	74,700								
03307500	1,790	2,650	3,350	4,370	5,250	6,240	3.272	.190	.594	3.272	.190	1.410	42	
	2,250	3,680	4,810	6,430	7,730	9,260								
	1,820	2,720	3,480	4,550	5,510	6,620								
03307670	1,120	1,640	2,010	2,520	2,920	3,330	3.054	.193	.147	3.015	.268	-.914	10	
	525	876	1,150	1,550	1,870	2,250								
	983	1,460	1,760	2,240	2,570	2,930								
03309500	866	1,500	1,990	2,700	3,280	3,900	2.936	.285	-.035	2.936	.285	.043	29	
	941	1,560	2,040	2,740	3,300	3,960								
	873	1,510	2,000	2,700	3,280	3,910								
03310000	4,280	6,800	8,490	10,600	12,100	13,600	3.615	.254	-.385	3.603	.283	-.901	40	
	3,600	5,860	7,640	10,200	12,200	14,700								
	4,230	6,730	8,410	10,600	12,100	13,700								
03310300[d]	7,860	12,200	15,300	19,600	22,900	26,500	3.896	.225	.027	3.896	.225	.180	26	
	13,000	20,600	26,500	35,000	41,700	49,600								
	8,310	12,900	16,600	21,600	25,900	30,800								
03310385	203	354	462	603	709	815	2.287	.307	-.392	2.240	.384	-1.101	11	
	198	303	378	481	566	654								
	202	346	444	570	664	758								

Table 3.--Flood quantiles and associated statistics for streamflow-gaging stations used in the study--Continued

Station number	Peak-flow quantiles (cubic feet per second) 2-yr peak	5-yr peak	10-yr peak	25-yr peak	50-yr peak	100-yr peak	Peak-flow statistics (log 10 units) WRC weighted mean	WRC weighted s. d.	WRC weighted skew	Gaged record mean	Gaged record s. d.	Gaged record skew	Years of record Gaged	Years of record His-toric
03310400	1,700	3,170	4,330	6,000	7,380	8,860	3.223	0.327	-0.149	3.223	0.327	-0.132	26	
	3,150	4,540	5,460	6,680	7,600	8,570								
	1,800	3,270	4,450	6,090	7,420	8,810								
03310500[d]	9,190	13,000	15,500	18,400	20,400	22,400	3.953	.190	- .327	3.953	.190	- .437	26	
	14,900	22,900	28,900	37,300	43,900	51,600								
	9,700	13,900	17,100	20,900	24,200	27,900								
03310880	105	175	230	307	372	441	2.022	.264	.045	2.022	.264	.423	10	
	174	278	355	466	560	659								
	117	192	259	352	435	523								
03311000[a,d]	9,830	14,300	17,100	20,500	22,800	25,100	3.980	.204	- .367	3.980	.204	- .599	15	
	17,600	26,700	33,600	43,100	50,500	59,100								
	10,900	16,100	20,200	25,300	29,700	34,800								
03311600	1,650	2,830	3,740	5,040	6,100	7,250	3.217	.278	- .024	3.217	.278	.157	13	
	1,260	1,870	2,290	2,860	3,300	3,770								
	1,600	2,700	3,470	4,530	5,320	6,150								
03312000	4,710	6,200	7,110	8,180	8,930	9,640	3.668	.147	- .229	3.668	.147	- .244	34	
	3,080	4,690	5,830	7,430	8,680	10,000								
	4,620	6,120	7,010	8,100	8,900	9,690								
03312500	19,100	33,200	44,700	61,800	76,500	92,800	4.288	.280	.141	4.288	.280	.350	24	
	23,800	37,800	48,900	64,600	77,200	92,200								
	19,600	33,700	45,300	62,200	76,600	92,700								
03312795	153	229	285	362	424	489	2.189	.205	.162	2.189	.205	.746	9	
	265	446	588	793	960	1,150								
	181	283	378	495	615	753								

Table 3.--Flood quantiles and associated statistics for streamflow-gaging stations used in the study--Continued

Station number	Peak-flow quantiles (cubic feet per second) 2-yr peak	5-yr peak	10-yr peak	25-yr peak	50-yr peak	100-yr peak	Peak-flow statistics (log 10 units) WRC weighted mean	WRC weighted s. d.	WRC weighted skew	Gaged record mean	Gaged record s. d.	Gaged record skew	Years of record Gaged	Years of record His-toric
03313020	81.9	129	162	206	239	273	1.906	0.241	-0.171	1.906	0.241	-0.251	9	
	105	179	237	320	388	468								
	87.7	142	185	241	292	351								
03313500	1,450	2,090	2,580	3,290	3,880	4,530	3.178	.177	.526	3.178	.177	1.304	33	
	1,190	1,970	2,580	3,460	4,170	5,000								
	1,430	2,080	2,580	3,310	3,920	4,600								
03313600	210	411	585	853	1,090	1,360	2.325	.345	.024	2.297	.396	-.441	19	
	278	467	616	830	1,000	1,210								
	220	419	591	849	1,070	1,320								
03313700	7,640	11,900	15,100	19,700	23,400	27,400	3.890	.222	.195	3.890	.222	.575	17	
	6,990	11,300	14,700	19,500	23,400	28,000								
	7,540	11,800	15,000	19,700	23,400	27,600								
03313800	2,100	3,790	5,180	7,240	9,000	10,900	3.324	.304	.038	3.324	.304	.166	25	
	1,230	2,030	2,660	3,560	4,290	5,150								
	2,010	3,600	4,830	6,730	8,220	9,790								
03314000[b]	16,300	27,500	37,000	51,900	65,300	80,900	4.229	.257	.433	4.231	.259	.782	43	46
	18,400	29,300	38,000	50,300	60,100	71,900								
	16,400	27,600	37,100	51,800	64,800	79,800								
03314750[c]	133	197	248	323	386	457	2.140	.192	.524	2.140	.192	.868	60	
	230	364	463	604	722	848								
	136	202	258	341	412	493								
03315885	52.1	79.1	99.0	127	150	175	1.724	.210	.202	1.724	.210	1.153	8	
	83.6	124	152	189	219	250								
	58.4	88.1	114	148	177	207								

Table 3.--Flood quantiles and associated statistics for streamflow-gaging stations used in the study--Continued

Station number	Peak-flow quantiles (cubic feet per second) 2-yr peak	5-yr peak	10-yr peak	25-yr peak	50-yr peak	100-yr peak	Peak-flow statistics (log 10 units) WRC weighted mean	WRC weighted s. d.	WRC weighted skew	Gaged record mean	Gaged record s. d.	Gaged record skew	Years of record Gaged	Years of record Historic
03316000	5,230	7,310	8,710	10,500	11,900	13,300	3.720	0.171	0.039	3.707	0.205	-1.036	44	
	4,170	6,010	7,240	8,880	10,100	11,400								
	5,180	7,250	8,620	10,400	11,700	13,100								
03317000	9,060	12,000	13,700	15,600	16,900	18,000	3.945	.158	-.469	3.922	.215	-1.823	22	
	6,310	9,030	10,800	13,200	15,000	16,800								
	8,830	11,800	13,400	15,200	16,500	17,700								
03317500	2,040	2,880	3,410	4,030	4,480	4,900	3.300	.188	-.332	3.300	.188	-.404	26	
	1,950	2,860	3,480	4,320	4,960	5,630								
	2,030	2,880	3,420	4,070	4,560	5,040								
03317965	229	328	399	493	567	645	2.364	.183	.158	2.364	.183	1.021	9	
	182	287	364	472	563	659								
	220	321	390	487	566	651								
03318000	8,640	12,200	14,100	16,300	17,700	19,000	3.915	.198	-.660	3.893	.240	-1.673	17	
	10,500	14,900	17,800	21,600	24,400	27,400								
	8,840	12,500	14,700	17,300	19,200	21,200								
03318200	2,970	4,490	5,630	7,210	8,490	9,870	3.480	.208	.205	3.480	.208	.629	22	
	2,300	3,500	4,350	5,550	6,480	7,490								
	2,910	4,410	5,480	6,950	8,120	9,360								
03318500[a]	8,980	11,800	13,300	15,000	16,100	17,000	3.940	.152	-.550	3.915	.197	-1.469	10	
	10,300	14,500	17,100	20,600	23,100	25,700								
	9,200	12,300	14,200	16,600	18,400	20,300								
03318505	143	221	270	329	371	411	2.138	.240	-.465	2.138	.240	-.889	10	
	121	189	239	309	368	430								
	139	216	263	323	370	418								

Table 3.--Flood quantiles and associated statistics for streamflow-gaging stations used in the study--Continued

Station number	Peak-flow quantiles (cubic feet per second) 2-yr peak	5-yr peak	10-yr peak	25-yr peak	50-yr peak	100-yr peak	Peak-flow statistics (log 10 units) WRC weighted mean	WRC weighted s. d.	WRC weighted skew	Gaged record mean	Gaged record s. d.	Gaged record skew	Years of record Gaged	Years of record Historic
03318800	5,490	7,800	9,410	11,500	13,200	14,800	3.743	0.179	0.102	3.743	0.179	0.320	29	
	4,320	5,990	7,050	8,400	9,380	10,400								
	5,410	7,680	9,190	11,100	12,600	14,000								
03319000[a]	10,200	14,600	17,200	20,300	22,300	24,200	3.990	.203	-.517	3.990	.203	-.828	19	
	16,300	23,300	27,900	34,000	38,500	43,200								
	10,800	15,400	18,700	22,700	25,700	28,800								
03319520	106	156	186	222	247	271	2.011	.211	-.445	2.011	.211	-.778	10	
	107	162	200	252	295	339								
	106	157	189	231	263	297								
03320500	7,290	12,400	16,400	22,100	26,800	31,900	3.863	.275	.001	3.863	.275	.092	45	
	7,050	11,300	14,400	19,100	22,800	26,900								
	7,280	12,300	16,200	21,800	26,300	31,200								
03321275	428	626	757	923	1,050	1,170	2.626	.200	-.166	2.626	.200	.075	8	
	385	591	733	921	1,070	1,210								
	419	616	749	922	1,060	1,190								
03321350	2,640	3,270	3,650	4,070	4,370	4,650	3.419	.114	-.186	3.419	.114	-.103	15	
	3,250	4,670	5,610	6,870	7,800	8,780								
	2,710	3,430	3,980	4,660	5,230	5,830								
03321465	109	164	205	260	305	352	2.041	.209	.129	2.041	.209	1.166	9	
	91.1	133	162	199	229	259								
	106	158	194	241	278	315								
03322100[b]	4,640	6,400	7,520	8,900	9,890	10,900	3.662	.170	-.169	3.671	.181	.066	22	40
	8,730	12,200	14,400	17,200	19,300	21,400								
	4,980	6,880	8,350	10,200	11,600	13,200								

Table 3.--Flood quantiles and associated statistics for streamflow-gaging stations used in the study--Continued

Station number	Peak-flow quantiles (cubic feet per second) 2-yr peak	5-yr peak	10-yr peak	25-yr peak	50-yr peak	100-yr peak	Peak-flow statistics (log 10 units) WRC weighted mean	WRC weighted s. d.	WRC weighted skew	Gaged record mean	Gaged record s. d.	Gaged record skew	Years of record Gaged	Years of record Historic
03322360	2,280	2,600	2,770	2,940	3,050	3,140	3.350	0.076	-0.540	3.338	0.099	-1.384	12	
	1,280	1,850	2,230	2,730	3,120	3,510								
	2,140	2,490	2,660	2,890	3,070	3,260								
03366200	1,070	1,340	1,480	1,630	1,730	1,820	3.018	.126	- .545	3.018	.126	- .868	16	
	1,270	1,810	2,190	2,700	3,120	3,530								
	1,090	1,390	1,590	1,840	2,010	2,230								
03366400	76.3	101	115	131	141	150	1.870	.157	- .503	1.844	.204	-1.272	10	
	60.3	85.2	103	127	146	164								
	73.6	98.4	112	130	142	155								
03378550	4,150	5,580	6,520	7,700	8,580	9,470	3.619	.152	.034	3.619	.152	.431	19	
	4,080	5,710	6,750	8,110	9,100	10,100								
	4,140	5,590	6,550	7,770	8,690	9,620								
03378590	89.1	141	179	230	270	313	1.949	.237	- .031	1.949	.237	.296	10	
	108	161	197	245	284	323								
	92.3	144	183	234	275	317								
03381600	89	157	211	288	352	422	1.948	.295	- .036	1.948	.295	.314	17	
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03382520	156	305	430	615	772	946	2.186	.353	- .118	2.186	.353	.172	13	
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03382975	359	671	907	1,230	1,480	1,740	2.536	.340	- .343	2.536	.340	- .465	10	
	433	676	848	1,080	1,270	1,460								
	371	672	890	1,180	1,400	1,620								

Table 3.--Flood quantiles and associated statistics for streamflow-gaging stations used in the study--Continued

Station number	Peak-flow quantiles (cubic feet per second) 2-yr peak	5-yr peak	10-yr peak	25-yr peak	50-yr peak	100-yr peak	Peak-flow statistics (log 10 units) WRC weighted mean	WRC weighted s. d.	WRC weighted skew	Gaged record mean	Gaged record s. d.	Gaged record skew	Years of record Gaged	Years of record Historic
03383000[b]	3,850	5,950	7,570	9,860	11,800	13,800	3.594	0.218	0.244	3.581	0.200	0.147	43	47
	6,980	11,200	14,400	19,200	23,000	27,100								
	3,990	6,290	8,150	10,800	13,200	15,700								
03383605	1,300	1,790	2,090	2,430	2,670	2,890	3.101	.177	-.400	3.101	.177	-.612	8	
	735	1,140	1,420	1,800	2,110	2,410								
	1,190	1,610	1,870	2,190	2,430	2,670								
03384000	599	848	1,000	1,180	1,300	1,420	2.764	.192	-.412	2.764	.192	-.500	30	
	676	1,040	1,290	1,630	1,900	2,180								
	604	865	1,030	1,240	1,400	1,560								
03385000	2,180	3,450	4,360	5,560	6,490	7,450	3.333	.242	-.137	3.333	.242	-.043	35	
	1,570	2,540	3,260	4,290	5,110	5,980								
	2,200	3,630	4,700	6,200	7,400	8,670								
03385500	582	935	1,170	1,470	1,690	1,900	2.748	.261	-.387	2.748	.261	-.433	26	
	376	608	778	1,010	1,210	1,410								
	567	901	1,120	1,400	1,600	1,800								
03400500	3,620	5,900	7,550	9,760	11,500	13,300	3.552	.258	-.155	3.552	.258	-.289	46	
	3,890	5,680	6,930	8,620	9,930	11,300								
	3,630	5,890	7,500	9,630	11,300	13,000								
03400700	5,820	9,880	13,000	17,600	21,300	25,400	3.766	.272	.028	3.766	.272	-.039	24	
	5,420	8,800	11,400	15,100	18,200	21,500								
	5,740	9,610	12,500	16,800	20,100	23,700								
03400800[a]	3,570	6,280	8,430	11,500	14,100	17,000	3.553	.291	-.002	3.553	.291	-.184	11	
	3,930	6,220	7,910	10,300	12,100	14,100								
	3,700	6,250	8,180	10,900	12,900	15,200								

Table 3.--Flood quantiles and associated statistics for streamflow-gaging stations used in the study--Continued

Station number	Peak-flow quantiles (cubic feet per second): 2-yr peak	5-yr peak	10-yr peak	25-yr peak	50-yr peak	100-yr peak	Peak-flow statistics (log 10 units): WRC weighted mean	WRC weighted s. d.	WRC weighted skew	Gaged record mean	Gaged record s. d.	Gaged record skew	Years of record: Gaged	His-toric
03401000[a]	17,000	26,900	34,200	44,100	51,900	60,100	4.230	0.237	-0.023	4.230	0.237	-0.072	45	
	16,700	26,600	34,000	44,700	53,500	62,900								
	17,000	26,900	34,200	44,200	52,300	60,900								
03401500	3,140	4,650	5,770	7,320	8,580	9,930	3.505	.196	.252	3.505	.196	.342	42	
	2,160	3,300	4,100	5,180	6,040	6,920								
	3,070	4,510	5,530	6,940	8,090	9,310								
03402000[b]	3,830	5,750	7,220	9,310	11,000	12,900	3.594	.202	.327	3.597	.205	.449	43	57
	3,370	5,100	6,300	7,920	9,210	10,500								
	3,800	5,680	7,090	9,070	10,700	12,400								
03402020	561	742	850	975	1,060	1,140	2.740	.153	- .340	2.721	.183	-1.464	10	
	279	450	573	741	874	1,010								
	496	645	736	864	967	1,070								
03403000[a,b,d]	27,900	40,200	48,700	59,700	68,100	76,800	4.447	.188	.016	4.449	.191	.060	44	57
	27,600	41,000	50,400	63,300	73,700	84,200								
	27,900	40,300	48,900	60,300	69,200	78,500								
03403500[a,d]	26,400	36,800	43,900	53,000	59,900	66,900	4.422	.171	.047	4.422	.171	.055	45	
	31,800	46,700	57,000	71,200	82,600	94,000								
	26,800	37,800	45,700	56,000	64,500	73,000								
03403538	771	1,490	2,070	2,870	3,520	4,200	2.870	.358	- .294	2.870	.358	- .976	9	
	855	1,340	1,680	2,150	2,520	2,900								
	792	1,440	1,900	2,510	2,990	3,490								
03403910	11,600	17,900	22,200	27,800	32,000	36,200	4.056	.232	- .216	4.056	.232	- .476	17	
	13,700	20,000	24,200	30,000	34,600	39,200								
	11,900	18,400	22,800	28,600	33,000	37,400								

Table 3.--Flood quantiles and associated statistics for streamflow-gaging stations used in the study--Continued

Station number	Peak-flow quantiles (cubic feet per second) 2-yr peak	5-yr peak	10-yr peak	25-yr peak	50-yr peak	100-yr peak	Peak-flow statistics (log 10 units) WRC weighted mean	WRC weighted s. d.	WRC weighted skew	Gaged record mean	Gaged record s. d.	Gaged record skew	Years of record Gaged	Years of record Historic
03404820	6,020	9,910	12,800	16,900	20,200	23,700	3.778	0.258	-0.026	3.778	0.258	0.209	12	
	6,720	9,990	12,200	15,300	17,700	20,100								
	6,160	9,930	12,600	16,200	19,100	22,000								
03404867	34.0	49.7	59.0	71.8	80.5	88.8	1.520	.207	- .346	1.520	.207	-1.090	10	
	43.4	73.3	95.5	126	150	176								
	36.2	57.6	74.4	97.5	115	134								
03404900	2,410	3,820	4,910	6,470	7,760	9,160	3.389	.233	.187	3.389	.233	.311	29	
	3,050	4,630	5,730	7,220	8,400	9,590								
	2,470	3,940	5,070	6,650	7,920	9,280								
03405000	6,620	10,300	13,000	16,600	19,500	22,400	3.819	.232	- .054	3.819	.232	- .078	33	
	9,060	13,400	16,300	20,300	23,500	26,600								
	6,820	10,700	13,600	17,400	20,400	23,500								
03405854	526	1,010	1,390	1,920	2,340	2,780	2.703	.352	- .298	2.703	.352	- .711	10	
	335	578	772	1,060	1,290	1,560								
	454	818	1,080	1,450	1,690	1,980								
03406000	303	468	572	693	777	856	2.459	.247	- .550	2.459	.247	-1.051	32	
	350	560	712	918	1,080	1,250								
	307	480	597	742	849	957								
03406500[d]	21,800	31,800	38,300	46,200	52,000	57,600	4.330	.202	- .269	4.330	.202	- .371	49	
	22,400	32,600	39,500	48,800	56,200	63,600								
	21,900	31,900	38,500	46,700	52,900	59,000								
03407000	23,200	33,100	39,300	46,700	52,000	56,900	4.353	.196	- .363	4.353	.196	-1.183	9	
	26,700	38,300	46,200	56,800	65,200	73,500								
	24,100	35,000	42,300	51,800	58,900	66,000								

Table 3.--Flood quantiles and associated statistics for streamflow-gaging stations used in the study--Continued

	Peak-flow quantiles (cubic feet per second)						Peak-flow statistics (log 10 units)						Years of record	
							WRC weighted			Gaged record				
Station number	2-yr peak	5-yr peak	10-yr peak	25-yr peak	50-yr peak	100-yr peak	mean	s. d.	skew	mean	s. d.	skew	Gaged	His-toric
03407100	83.2	161	226	321	402	491	1.913	0.348	-0.122	1.913	0.348	-0.186	29	
	81.9	136	176	231	274	320								
	83.1	157	216	300	369	444								
03407200	40.7	65.6	84.0	109	130	151	1.608	.248	-.029	1.608	.248	-.034	29	
	37.5	63.6	83.0	110	131	154								
	40.4	65.3	83.9	109	130	152								
03407300	53.3	107	149	204	247	291	1.694	.393	-.499	1.672	.438	-1.146	30	
	99.7	165	213	278	330	385								
	57.5	115	161	221	268	316								
03407500	9,170	14,100	17,400	21,600	24,700	27,800	3.952	.231	-.269	3.952	.231	-.404	33	
	7,700	11,400	13,900	17,400	20,100	22,900								
	9,050	13,700	16,800	20,700	23,600	26,600								
03408500[b]	24,400	34,500	41,800	51,500	59,100	67,100	4.393	.174	.215	4.388	.168	.115	51	83
	19,300	30,700	39,800	52,600	62,900	75,200								
	24,100	34,300	41,700	51,600	59,400	68,000								
03409000[b]	1,980	2,810	3,370	4,090	4,640	5,200	3.297	.179	.009	3.310	.196	.208	20	47
	1,810	2,980	3,890	5,210	6,270	7,510								
	1,960	2,830	3,460	4,280	4,970	5,730								
03412500	2,070	2,730	3,120	3,570	3,880	4,180	3.307	.151	-.336	3.300	.165	-.798	30	
	1,950	3,000	3,730	4,720	5,500	6,300								
	2,060	2,770	3,240	3,840	4,290	4,750								
03413200	3,440	5,730	7,420	9,730	11,500	13,400	3.530	.269	-.137	3.530	.269	-.241	15	
	4,140	6,730	8,770	11,700	14,000	16,800								
	3,560	5,900	7,700	10,100	12,100	14,400								

Table 3.--Flood quantiles and associated statistics for streamflow-gaging stations used in the study--Continued

	Peak-flow quantiles (cubic feet per second)						Peak-flow statistics (log 10 units)						Years of record	
							WRC weighted			Gaged record				
Station number	2-yr peak	5-yr peak	10-yr peak	25-yr peak	50-yr peak	100-yr peak	mean	s. d.	skew	mean	s. d.	skew	Gaged	His-toric
03413202	149	303	447	687	915	1,190	2.189	0.353	0.254	2.189	0.353	0.949	10	
	194	327	432	583	706	849								
	159	309	443	657	845	1,060								
03413425	161	198	219	245	262	279	2.204	.109	- .138	2.204	.109	- .277	10	
	237	400	527	711	861	1,030								
	179	245	307	378	462	561								
03414102	593	1,060	1,430	1,960	2,390	2,850	2.767	.306	- .106	2.652	.572	-2.003	10	
	701	1,170	1,530	2,050	2,480	2,970								
	618	1,090	1,460	1,990	2,420	2,900								
03414500	16,400	24,700	30,500	37,900	43,400	49,000	4.208	.219	- .166	4.208	.219	- .233	42	
	12,000	19,300	25,000	33,200	39,700	47,500								
	16,100	24,300	30,000	37,500	43,000	48,800								
03415000[b]	6,720	9,960	12,000	14,500	16,300	18,100	3.814	.215	- .366	3.824	.221	- .498	32	55
	6,440	10,400	13,500	18,000	21,600	25,800								
	6,700	10,000	12,200	14,900	17,000	19,300								
03415700	726	1,120	1,370	1,670	1,870	2,060	2.838	.249	- .556	2.818	.291	-1.592	24	
	869	1,440	1,890	2,540	3,060	3,670								
	742	1,160	1,440	1,790	2,080	2,380								
03416000[b]	6,940	9,970	11,900	14,400	16,100	17,900	3.834	.193	- .221	3.830	.213	- .480	42	57
	7,790	12,500	16,300	21,700	26,000	31,100								
	7,000	10,100	12,300	15,000	17,200	19,600								
03417700	133	242	330	456	560	674	2.119	.314	- .088	2.119	.314	- .123	30	
	174	294	389	525	636	765								
	137	247	337	464	571	689								

Table 3.--Flood quantiles and associated statistics for streamflow-gaging stations used in the study--Continued

Station number	Peak-flow quantiles (cubic feet per second) 2-yr peak	5-yr peak	10-yr peak	25-yr peak	50-yr peak	100-yr peak	Peak-flow statistics (log 10 units) WRC weighted mean	WRC weighted s. d.	WRC weighted skew	Gaged record mean	Gaged record s. d.	Gaged record skew	Years of record Gaged	Years of record Historic
03418000	3,370	5,420	6,850	8,700	10,100	11,500	3.517	0.255	-0.256	3.517	0.255	-0.364	43	
	4,680	7,590	9,890	13,200	15,800	18,900								
	3,460	5,560	7,110	9,080	10,700	12,400								
03435140	3,310	5,240	6,690	8,720	10,400	12,100	3.523	.234	.089	3.523	.234	.465	13	
	3,010	4,610	5,750	7,380	8,690	10,100								
	3,270	5,120	6,470	8,350	9,860	11,400								
03435500[b]	14,100	21,200	26,300	33,400	39,000	44,900	4.154	.206	.135	4.139	.208	-.445	50	63
	11,100	17,300	21,800	28,600	34,100	39,900								
	14,000	21,000	26,000	33,000	38,500	44,300								
03435600	583	1,020	1,370	1,880	2,310	2,780	2.769	.285	.058	2.769	.285	.397	9	
	737	1,140	1,430	1,820	2,130	2,440								
	611	1,050	1,390	1,860	2,240	2,630								
03436000	7,050	10,900	13,900	18,200	21,800	25,700	3.858	.218	.276	3.858	.218	.485	47	
	6,630	10,300	13,000	16,900	20,100	23,300								
	7,030	10,900	13,800	18,100	21,600	25,400								
03436700	5,820	9,110	11,500	14,600	17,000	19,500	3.762	.234	-.092	3.762	.234	-.040	27	
	6,310	9,660	12,100	15,500	18,200	21,000								
	5,850	9,170	11,600	14,700	17,200	19,800								
03437380	230	349	430	532	609	685	2.354	.223	-.223	2.354	.223	-.164	7	
	273	431	542	691	808	923								
	240	374	471	598	701	804								
03437390	198	294	364	459	535	615	2.302	.199	.160	2.302	.199	1.268	8	
	256	399	499	634	740	848								
	210	323	409	526	623	724								

Table 3.--Flood quantiles and associated statistics for streamflow-gaging stations used in the study--Continued

	Peak-flow quantiles (cubic feet per second)						Peak-flow statistics (log 10 units)						Years of record	
							WRC weighted			Gaged record				
Station number	2-yr peak	5-yr peak	10-yr peak	25-yr peak	50-yr peak	100-yr peak	mean	s. d.	skew	mean	s. d.	skew	Gaged	His-toric
03437490[c]	130	273	391	564	707	861	2.094	0.401	-0.304	2.081	0.428	-0.613	60	
	359	570	719	922	1,080	1,240								
	137	287	412	592	741	901								
03437500	2,770	4,410	5,670	7,450	8,910	10,500	3.448	.236	.138	3.448	.236	.349	33	
	2,510	3,960	5,020	6,530	7,730	8,990								
	2,760	4,370	5,600	7,330	8,730	10,200								
03438000	6,680	10,300	13,000	16,900	20,100	23,500	3.834	.214	.252	3.834	.214	.487	46	
	5,430	8,670	11,100	14,600	17,400	20,400								
	6,630	10,200	12,800	16,700	19,800	23,100								
03438070	3,560	4,580	5,260	6,140	6,810	7,490	3.557	.126	.276	3.557	.126	1.198	15	
	5,080	7,390	8,970	11,200	12,900	14,800								
	3,740	5,050	6,040	7,410	8,550	9,820								
03529500	5,050	8,020	10,400	14,000	17,100	20,700	3.719	.227	.416	3.719	.227	.553	38	
	5,410	8,180	10,200	12,800	14,900	17,100								
	5,070	8,030	10,400	13,800	16,700	20,000								
03530000	2,350	3,520	4,400	5,640	6,640	7,730	3.379	.203	.249	3.366	.229	- .352	29	
	2,400	3,620	4,500	5,700	6,640	7,660								
	2,350	3,530	4,410	5,650	6,640	7,710								
03530500	4,180	6,590	8,530	11,400	13,900	16,700	3.636	.224	.401	3.636	.224	.552	37	
	4,980	8,360	11,000	15,000	18,400	22,100								
	4,290	6,900	9,060	12,300	15,300	18,500								
03531000	13,200	18,800	22,900	28,600	33,100	37,900	4.127	.178	.281	4.127	.178	.474	11	
	13,400	20,800	26,300	33,900	40,000	46,300								
	13,300	19,600	24,500	31,400	37,200	43,200								

Table 3.--Flood quantiles and associated statistics for streamflow-gaging stations used in the study--Continued

Station number	Peak-flow quantiles (cubic feet per second): 2-yr peak	5-yr peak	10-yr peak	25-yr peak	50-yr peak	100-yr peak	Peak-flow statistics (log 10 units): WRC weighted mean	WRC weighted s. d.	WRC weighted skew	Gaged record mean	Gaged record s. d.	Gaged record skew	Years of record: Gaged	Years of record: Historic
03531500	12,000	18,700	24,000	31,700	38,200	45,400	4.089	0.223	0.307	4.089	0.223	0.371	53	
	14,400	22,300	28,100	36,200	42,700	49,400								
	12,200	19,200	24,700	32,500	39,200	46,500								
03610000	5,890	10,600	14,600	20,900	26,400	32,800	3.781	.295	.229	3.781	.295	.549	32	
	8,990	13,200	16,100	20,200	23,500	27,000								
	6,070	10,800	14,800	20,800	25,900	31,800								
03610470	430	629	757	913	1,030	1,130	2.623	.206	-.311	2.623	.206	-.388	10	
	354	554	694	882	1,030	1,180								
	417	612	739	903	1,030	1,150								
03610500	9,930	16,900	22,100	29,300	34,900	40,900	3.990	.280	-.139	3.976	.313	-.702	45	
	8,400	12,700	15,800	20,200	23,600	27,100								
	9,860	16,600	21,600	28,400	33,600	39,000								
03610503	694	1,010	1,210	1,430	1,590	1,730	2.824	.211	-.496	2.824	.211	-.915	10	
	413	630	779	979	1,130	1,290								
	647	922	1,090	1,280	1,420	1,550								
03610545	5,260	7,720	9,240	11,000	12,300	13,500	3.705	.213	-.452	3.705	.213	-.693	15	
	5,910	8,700	10,600	13,300	15,400	17,500								
	5,340	7,880	9,530	11,600	13,200	14,800								
03610820	81.4	150	209	299	379	469	1.917	.312	.123	1.917	.312	.991	9	
	92.1	147	185	236	275	314								
	83.3	149	202	277	337	401								
03611260	2,250	3,610	4,570	5,810	6,740	7,690	3.342	.254	-.244	3.342	.254	-.184	14	
	2,240	3,360	4,130	5,200	6,030	6,880								
	2,250	3,570	4,470	5,650	6,530	7,420								

Table 3.--Flood quantiles and associated statistics for streamflow-gaging stations used in the study--Continued

Station number	Peak-flow quantiles (cubic feet per second) 2-yr peak	5-yr peak	10-yr peak	25-yr peak	50-yr peak	100-yr peak	Peak-flow statistics (log 10 units) WRC weighted mean	WRC weighted s. d.	WRC weighted skew	Gaged record mean	Gaged record s. d.	Gaged record skew	Years of record Gaged	Years of record Historic
03612000	3,820	6,250	7,940	10,100	11,700	13,400	3.568	0.267	-0.321	3.568	0.267	-0.320	63	
	7,460	12,000	15,400	20,500	24,600	29,000								
	3,930	6,510	8,390	10,900	12,800	15,000								
03612200	137	226	293	386	460	539	2.134	.260	- .041	2.134	.260	.182	21	
	187	304	390	509	605	705								
	141	236	309	410	492	581								
03614000	454	598	690	804	887	969	2.657	.142	- .009	2.643	.168	- .406	14	
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07022500	714	1,110	1,400	1,790	2,100	2,420	2.852	.230	- .029	2.852	.230	.104	31	
	549	844	1,050	1,330	1,540	1,760								
	704	1,090	1,360	1,730	2,010	2,300								
07023000[b]	6,850	9,860	12,000	15,000	17,400	19,900	3.843	.182	.237	3.825	.184	- .125	39	41
	6,840	10,500	13,200	16,900	19,800	22,900								
	6,850	9,910	12,100	15,200	17,700	20,400								
07023040[c]	138	225	284	358	412	465	2.121	.270	- .403	2.121	.270	- .438	61	
	292	449	558	702	814	926								
	143	236	301	384	448	512								
07023500	3,810	4,960	5,640	6,440	7,000	7,520	3.574	.142	- .269	3.574	.142	- .268	32	
	3,480	5,190	6,360	7,980	9,240	10,500								
	3,790	4,980	5,720	6,650	7,350	8,050								
07023935	120	164	191	223	244	265	2.067	.173	- .361	2.067	.173	- .510	11	
	120	197	253	328	388	449								
	120	171	208	256	295	337								

Table 3.--Flood quantiles and associated statistics for streamflow-gaging stations used in the study--Continued

Station number	Peak-flow quantiles (cubic feet per second) 2-yr peak	5-yr peak	10-yr peak	25-yr peak	50-yr peak	100-yr peak	Peak-flow statistics (log 10 units) WRC weighted mean	WRC weighted s. d.	WRC weighted skew	Gaged record mean	Gaged record s. d.	Gaged record skew	Years of record Gaged	Years of record Historic
07024000	3,320	4,870	5,880	7,130	8,040	8,930	3.511	0.207	-0.271	3.511	0.207	-0.269	43	
	4,410	6,700	8,320	10,600	12,400	14,200								
	3,370	4,990	6,090	7,490	8,570	9,670								
07026500	5,580	9,130	11,900	15,800	19,000	22,500	3.751	.251	.104	3.751	.251	.438	22	
	5,840	8,980	11,200	14,500	17,000	19,700								
	5,600	9,110	11,800	15,600	18,600	21,800								

[a] Streamflow regulated during part of gaged record (see Table 2). Only unregulated peak discharges at these stations were used in flood-frequency analysis.

[b] Station record contains historic peak(s).

[c] Synthetic record (1912-1961) was combined with observed record for frequency analysis.

[d] Stations having drainage area extending into two or more hydrologic regions. The regression estimates for these stations are obtained by weighting the estimates from the regional equations by the relative percentage of drainage area in each hydrologic region.

Table 4.--Selected drainage basin characteristics for gaging stations used in the regression analyses

[Hydrologic regions: 1, North; 2, Upper East; 3, Lower East; 4, Southeast; 5, East-Central; 6, West-Central; 7, West]

Station number	State	Hydro-logic region	Drainage area (square miles)	Contributing drainage area (square miles)	Basin length (miles)	Stream length (miles)	Basin shape index (mile per mile)	Main channel sinuosity (mile per mile)	Main channel slope (feet per mile)
03202400	WV	2	306	306	30.0	37.5	2.94	1.25	35.2
03203000	WV	2	758	758	39.5	86.9	2.05	2.20	12.9
03203600	WV	2	836	836	49.1	99.2	2.89	2.02	10.4
03204500	WV	2	256	256	30.3	48.5	3.57	1.60	4.1
03206600	WV	2	38.5	38.5	13.4	18.3	4.69	1.36	21.7
03207000	WV	2	300	300	36.4	52.3	4.42	1.44	5.7
03207020	WV	2	300	300	35.5	52.3	4.21	1.47	5.7
03207400	VA	2	19.8	19.8	4.73	6.30	1.13	1.33	119.0
03207500	VA	2	235	235	21.3	23.5	1.93	1.10	36.6
03207962	KY	2	.82	.82	1.16	1.46	1.64	1.26	509.9
03207965	KY	2	6.20	6.20	5.02	5.39	4.06	1.07	128.6
03208000	KY	2	392	392	39.5	52.7	3.98	1.33	16.9
03208500	VA	2	286	286	17.0	23.5	1.01	1.38	19.3
03208950	VA	2	66.5	66.5	13.8	17.0	2.87	1.23	42.5
03209000	VA	2	221	221	25.8	41.3	3.02	1.60	10.2
03209300	KY	2	554	554	26.2	40.3	1.24	1.54	21.2
03209575	KY	2	3.17	3.17	1.47	2.59	.68	1.76	180.9
03210000	KY	2	56.3	56.3	13.2	21.5	3.09	1.63	24.3
03210160	KY	2	3.74	3.74	2.41	3.07	1.55	1.27	101.9
03211500	KY	2	206	206	32.4	55.1	5.10	1.70	6.4
03212000	KY	2	103	103	14.6	21.0	2.07	1.44	8.3
03212515	KY	2	2.10	2.10	1.26	2.19	.76	1.74	91.2
03213700	WV	2	936	936	56.2	99.6	3.38	1.77	10.2
03215500	KY	2	217	217	20.0	40.1	1.83	2.01	3.5
03216500	KY	2	400	400	26.5	47.2	1.76	1.78	3.7
03216505	KY	2	.51	.51	.96	1.02	1.81	1.06	169.4
03216540	KY	2	12.2	12.2	6.16	8.73	3.11	1.42	18.3
03216563	KY	2	.94	.94	1.50	1.57	2.39	1.05	85.0
03216564	KY	2	1.61	1.61	2.26	2.43	3.17	1.08	74.0
03216800	KY	2	59.6	59.6	9.09	12.0	1.39	1.32	17.8
03216901	KY	2	1.11	1.11	1.66	1.87	2.48	1.13	103.8
03217000	KY	2	242	242	28.6	61.2	3.38	2.14	4.6
03237280	OH	2	12.2	12.2	4.73	6.91	1.83	1.46	67.0

Table 4.--Selected drainage basin characteristics for gaging stations used in the regression analyses--Continued

Station number	State	Hydro-logic region	Drainage area (square miles)	Contributing drainage area (square miles)	Basin length (miles)	Stream length (miles)	Basin shape index (mile per mile)	Main channel sinuosity (mile per mile)	Main channel slope (feet per mile)
03237500	OH	2	387	387	29.6	45.9	2.26	1.55	8.3
03237895	KY	1	.23	.23	1.05	1.08	4.79	1.03	209.1
03237900	KY	1	22.4	22.4	4.77	5.77	1.02	1.21	32.4
03238030	KY	1	1.90	1.90	1.60	2.28	1.35	1.43	53.1
03238500	OH	1	218	218	25.3	44.4	2.92	1.76	7.9
03246500	OH	1	237	237	28.4	52.7	3.41	1.85	5.3
03247100	OH	1	3.34	3.34	--	--	--	--	31.9
03247500	OH	1	476	476	33.9	80.3	2.42	2.37	6.9
03248500	KY	2	140	140	20.2	36.4	2.91	1.80	4.7
03249500	KY	2	827	827	54.8	81.0	3.63	1.48	3.3
03250000	KY	2	47.5	47.5	8.16	9.70	1.40	1.19	29.4
03250080	KY	2	.19	.19	.72	.80	2.73	1.11	164.4
03250100	KY	2	84.7	84.7	11.8	18.5	1.64	1.57	15.8
03250150	KY	2	2.43	2.43	2.13	2.76	1.87	1.30	45.5
03250243	KY	2	.70	.70	1.16	1.23	1.92	1.06	81.0
03250320	KY	2	4.01	4.01	2.10	3.05	1.10	1.45	95.7
03250620	KY	2	.33	.33	.91	1.03	2.51	1.13	130.1
03251000	KY	2	119	119	18.0	34.3	2.71	1.91	2.7
03251008	KY	2	.96	.93	.53	.65	.29	1.23	123.3
03251015	KY	2	.45	.45	1.69	1.76	6.35	1.04	81.2
03252000	KY	2	239	239	18.3	56.2	1.40	3.07	2.4
03252500	KY	2	621	615	31.4	85.9	1.59	2.73	2.4
03254400	KY	1	13.6	13.6	4.59	5.71	1.55	1.24	28.3
03260010	KY	1	.68	.68	.97	1.32	1.38	1.36	81.1
03260012	KY	1	1.62	1.62	1.77	2.22	1.93	1.25	138.1
03277070	KY	1	1.54	1.54	.99	1.40	.64	1.41	52.7
03277185	KY	1	.68	.68	1.24	1.72	2.26	1.39	206.0
03277250	IN	1	.16	.16	--	--	--	--	92.2
03277290	KY	2	3.03	3.03	2.81	3.69	2.61	1.31	276.1
03277300	KY	2	66.4	66.4	12.7	17.2	2.43	1.35	19.5
03277400	KY	3	40.9	40.9	6.89	13.5	1.16	1.96	51.2
03277437	KY	2	.69	.69	1.03	1.34	1.54	1.30	366.0
03277450	KY	2	60.6	60.6	12.7	19.8	2.66	1.56	17.1
03277500	KY	3	466	466	27.2	61.6	1.59	2.26	7.4
03277630	KY	3	1.32	1.32	1.60	2.33	1.94	1.46	188.4

Table 4.--Selected drainage basin characteristics for gaging stations used in the regression analyses--Continued

Station number	State	Hydro-logic region	Drainage area (square miles)	Contributing drainage area (square miles)	Basin length (miles)	Stream length (miles)	Basin shape index (mile per mile)	Main channel sinuosity (mile per mile)	Main channel slope (feet per mile)
03278000	KY	2	2.21	2.21	2.37	2.60	2.54	1.10	125.0
03278500	KY	2	177	177	19.6	35.7	2.17	1.82	8.8
03280600	KY	3	202	202	17.1	27.2	1.45	1.59	24.5
03280700	KY	3	61.3	61.3	13.1	18.4	2.80	1.40	44.6
03280728	KY	3	1.84	1.84	1.39	1.88	1.05	1.35	202.7
03280935	KY	3	1.57	1.57	2.39	2.73	3.64	1.14	129.4
03281000	KY	3	537	537	50.4	95.0	4.73	1.88	4.7
03281040	KY	3	155	155	17.7	29.3	2.02	1.66	16.4
03281100	KY	4	163	163	16.0	24.4	1.57	1.53	13.7
03281200	KY	3	486	486	27.6	45.5	1.57	1.65	7.6
03281500	KY	3	722	722	36.2	77.0	1.82	2.13	5.1
03282198	KY	3	.59	.59	1.06	1.19	1.90	1.12	149.0
03282500	KY	2	65.8	65.8	16.0	18.7	3.89	1.17	9.9
03283000	KY	2	24.0	24.0	6.26	7.40	1.63	1.18	23.6
03283305	KY	2	.58	.58	.77	1.09	1.02	1.42	160.0
03283500	KY	2	362	362	38.9	68.9	4.18	1.77	6.0
03283610	KY	2	.33	.33	.85	1.01	2.19	1.19	105.0
03284300	KY	3	28.6	28.6	8.98	13.7	2.82	1.52	22.2
03284310	KY	3	53.4	53.3	9.45	16.0	1.67	1.69	11.0
03284340	KY	3	1.83	1.83	1.91	2.37	1.99	1.24	61.9
03284550	KY	3	11.0	10.9	4.60	5.58	1.92	1.21	19.1
03285000	KY	3	318	318	24.6	50.5	1.90	2.05	4.1
03285100	KY	3	.13	.13	.54	.56	2.24	1.04	143.4
03285500	KY	3	395	379	31.9	78.9	2.58	2.47	5.3
03287128	KY	2	1.26	1.26	1.83	2.05	2.66	1.12	58.0
03287160	KY	2	.81	.81	.85	1.34	.89	1.58	60.5
03287534	KY	2	4.47	4.47	4.01	5.53	3.60	1.38	12.1
03288000	KY	2	119	111	17.6	31.4	2.60	1.78	3.8
03288500	KY	2	2.53	1.93	2.35	2.70	2.18	1.15	38.5
03289000	KY	2	24.0	21.0	5.73	9.60	1.37	1.68	16.5
03289190	KY	2	5.30	5.30	3.80	4.55	2.72	1.20	28.9
03289500	KY	2	473	403	32.7	78.2	2.26	2.39	3.6
03290000	KY	1	5.63	5.63	3.01	3.40	1.61	1.13	39.8
03290580	KY	1	5.62	4.87	3.29	3.69	1.93	1.12	37.2
03291000	KY	1	42.9	42.9	8.27	16.0	1.59	1.93	9.0

Table 4.--Selected drainage basin characteristics for gaging stations used in the regression analyses--Continued

Station number	State	Hydro-logic region	Drainage area (square miles)	Contributing drainage area (square miles)	Basin length (miles)	Stream length (miles)	Basin shape index (mile per mile)	Main channel sinuosity (mile per mile)	Main channel slope (feet per mile)
03291050	KY	1	0.58	0.58	1.19	1.21	2.44	1.02	73.9
03291500	KY	1	437	437	30.8	80.8	2.17	2.62	3.5
03292200	KY	1	.87	.87	1.96	2.06	4.42	1.05	139.0
03292460	KY	1	24.1	24.1	6.77	9.66	1.90	1.43	11.7
03292472	KY	1	.97	.97	1.54	1.83	2.44	1.19	109.0
03292500	KY	1	17.2	17.2	7.00	8.90	2.85	1.27	19.4
03292785	KY	1	6.59	6.51	3.95	5.34	2.37	1.35	24.0
03293000	KY	1	18.9	18.4	5.73	9.60	1.74	1.68	20.0
03294000	IN	1	189	189	16.2	25.1	1.38	1.55	5.5
03295000	KY	2	41.4	39.7	10.6	18.7	2.71	1.76	8.5
03295500	KY	2	196	192	19.7	25.3	1.97	1.29	3.7
03295845	KY	1	1.36	1.36	1.76	1.80	2.28	1.03	75.1
03296500	KY	1	19.1	19.1	8.82	9.94	4.07	1.13	14.8
03297000	KY	1	5.15	5.15	3.85	4.40	2.88	1.14	52.1
03297500	KY	1	31.8	31.8	11.8	14.9	4.36	1.26	15.0
03298000	KY	1	138	138	18.2	34.7	2.40	1.91	5.5
03298535	KY	1	.68	.68	1.51	1.60	3.35	1.06	130.5
03299000	KY	5	239	239	25.7	38.6	2.76	1.50	9.1
03300000	KY	2	85.9	85.9	9.74	26.2	1.10	2.69	5.8
03300065	KY	2	1.71	1.71	1.75	1.94	1.79	1.11	75.6
03300400	KY	2	436	436	16.7	29.9	.64	1.79	3.8
03300990	KY	2	.32	.32	.81	.98	2.05	1.21	106.0
03301000	KY	2	669	669	34.7	92.6	1.80	2.67	3.7
03302000	KY	5	64.0	64.0	12.7	15.2	2.52	1.20	11.7
03302085	KY	5	.90	.85	1.57	2.00	2.74	1.27	60.5
03302220	IN	5	65.2	37.1	11.2	14.4	1.94	1.28	18.6
03302300	IN	5	16.1	16.11	7.89	10.2	3.86	1.29	19.0
03302350	IN	5	.56	.56	--	--	--	--	140.0
03303000	IN	6	476	284	33.1	77.1	2.31	2.33	3.8
03303300	IN	6	39.8	39.8	10.5	14.0	2.75	1.34	15.4
03303400	IN	6	7.86	7.86	4.14	4.35	2.18	1.05	23.7
03303440	IN	6	.26	.26	--	--	--	--	104.5
03303900	IN	6	.25	.25	--	--	--	--	82.0
03304500	KY	5	2.14	2.14	1.76	2.10	1.45	1.19	150.0
03305000	KY	5	22.4	22.4	5.32	8.30	1.26	1.56	32.1
03305500	KY	5	36.3	36.3	6.56	9.10	1.19	1.39	28.4

Table 4.--Selected drainage basin characteristics for gaging stations used in the regression analyses--Continued

Station number	State	Hydro-logic region	Drainage area (square miles)	Contributing drainage area (square miles)	Basin length (miles)	Stream length (miles)	Basin shape index (mile per mile)	Main channel sinuosity (mile per mile)	Main channel slope (feet per mile)
03305559	KY	5	0.88	0.88	1.85	1.95	3.89	1.05	104.9
03305725	KY	5	1.37	1.37	1.33	1.84	1.29	1.38	82.9
03305835	KY	5	.71	.71	1.49	1.71	3.13	1.15	154.2
03306000	KY	5	682	682	40.5	79.1	2.41	1.95	3.9
03306500	KY	5	736	729	45.8	103	2.85	2.24	3.5
03307000	KY	5	188	173	18.7	28.4	1.86	1.52	9.4
03307100	KY	5	265	246	23.1	58.7	2.01	2.54	5.1
03307500	KY	5	18.3	18.3	6.17	9.00	2.08	1.46	16.4
03307670	KY	5	2.53	2.34	2.50	3.03	2.47	1.21	78.7
03309500	KY	5	5.34	5.34	4.19	4.90	3.29	1.17	24.0
03310000	KY	5	36.4	35.6	8.57	10.7	2.02	1.25	20.0
03310300	KY	6	357	237	23.8	46.3	1.59	1.95	4.2
03310385	KY	6	.56	.56	.65	.85	.75	1.31	117.2
03310400	KY	6	85.4	54.4	15.2	27.2	2.71	1.79	8.0
03310500	KY	6	600	378	31.3	91.4	1.63	2.92	2.6
03310880	KY	6	.31	.31	.74	.79	1.77	1.07	309.9
03311000	KY	6	703	480	38.9	75.5	2.15	1.94	3.2
03311600	KY	6	10.9	10.9	4.80	6.71	2.11	1.40	23.9
03312000	KY	6	30.8	30.8	5.40	7.70	.95	1.43	26.8
03312500	KY	5	531	514	23.9	65.8	1.08	2.75	4.3
03312795	KY	5	.89	.89	.77	.86	.67	1.12	186.1
03313020	KY	5	.24	.24	.62	.66	1.60	1.06	121.6
03313500	KY	5	7.47	7.47	4.27	4.80	2.44	1.12	47.2
03313600	TN	5	.95	.95	--	--	--	--	73.9
03313700	KY	5	110	91.0	17.0	22.8	2.63	1.34	9.1
03313800	KY	5	21.6	7.80	7.23	9.20	2.42	1.27	19.5
03314000	KY	5	478	358	28.3	41.7	1.68	1.47	6.6
03314750	KY	6	.50	.50	.82	1.09	1.34	1.33	226.7
03315885	KY	6	.25	.22	.64	.73	1.64	1.14	91.0
03316000	KY	6	90.5	80.8	13.4	24.4	1.99	1.82	7.1
03317000	KY	6	225	158	16.9	39.8	1.26	2.36	4.9
03317500	KY	6	42.0	22.6	7.46	11.3	1.33	1.51	15.3
03317965	KY	6	.38	.38	.73	1.02	1.40	1.40	222.7
03318000	KY	6	454	344	27.9	49.2	1.71	1.76	3.4
03318200	KY	6	20.1	20.1	5.63	6.30	1.58	1.12	31.3

Table 4.--Selected drainage basin characteristics for gaging stations used in the regression analyses--Continued

Station number	State	Hydro-logic region	Drainage area (square miles)	Contributing drainage area (square miles)	Basin length (miles)	Stream length (miles)	Basin shape index (mile per mile)	Main channel sinuosity (mile per mile)	Main channel slope (feet per mile)
03318500	KY	6	504	394	26.9	73.3	1.43	2.73	2.4
03318505	KY	6	.22	.22	.76	.82	2.63	1.08	246.0
03318800	KY	6	124	124	19.3	29.6	3.00	1.53	3.0
03319000	KY	6	757	637	40.2	74.5	2.13	1.85	2.9
03319520	KY	6	.26	.26	.89	.93	3.05	1.04	121.6
03320500	KY	7	194	194	18.9	40.3	1.84	2.13	4.6
03321275	KY	7	.95	.95	1.45	1.49	2.21	1.03	51.8
03321350	KY	6	58.2	58.2	14.5	19.5	3.61	1.34	7.5
03321465	KY	6	.29	.29	.67	.75	1.55	1.12	62.1
03322100	IN	6	323	323	23.5	42.0	1.71	1.79	2.4
03322360	KY	6	14.3	14.3	5.73	5.91	2.30	1.03	13.5
03366200	IN	1	9.31	9.31	5.72	8.90	3.51	1.56	18.3
03366400	IN	1	.16	.16	.99	.99	6.13	1.00	71.0
03378550	IN	6	104	104	14.0	18.6	1.89	1.33	3.8
03378590	IN	6	.32	.32	--	--	--	--	79.5
03381600	IL	7	.16	.16	--	--	--	--	89.8
03382520	IL	7	1.10	1.10	--	--	--	--	28.3
03382975	KY	7	.91	.91	.91	1.36	.91	1.49	10.7
03383000	KY	7	255	246	25.6	53.3	2.56	2.08	2.0
03383605	KY	7	2.52	2.52	1.92	2.51	1.46	1.31	111.5
03384000	KY	7	2.10	2.10	1.79	2.20	1.53	1.23	28.8
03385000	IL	7	19.1	19.1	6.71	12.0	2.36	1.79	21.4
03385500	IL	7	1.05	1.05	.99	1.86	.93	1.88	145.2
03400500	KY	2	82.3	82.3	16.5	25.8	3.31	1.56	28.1
03400700	KY	3	82.4	82.4	18.3	24.4	4.06	1.33	38.8
03400800	KY	3	55.8	58.8	10.2	19.0	1.88	1.86	33.0
03401000	KY	3	374	374	38.4	51.3	3.94	1.34	13.0
03401500	KY	4	35.3	35.3	9.49	9.90	2.55	1.04	127.1
03402000	KY	4	60.6	60.6	9.53	12.7	1.50	1.33	74.4
03402020	KY	4	2.96	2.96	4.13	5.87	5.76	1.42	342.6
03403000	KY	4	809	809	60.6	94.9	4.54	1.57	8.2
03403500	KY	4	960	960	66.0	106.9	4.53	1.62	7.4
03403538	KY	4	11.5	11.5	3.32	5.99	.96	1.80	23.1
03403910	KY	4	331	331	19.2	27.7	1.11	1.44	15.4
03404820	KY	4	140	140	14.2	30.8	1.44	2.17	3.7

Table 4.--Selected drainage basin characteristics for gaging stations used in the regression analyses--Continued

Station number	State	Hydro-logic region	Drainage area (square miles)	Contributing drainage area (square miles)	Basin length (miles)	Stream length (miles)	Basin shape index (mile per mile)	Main channel sinuosity (mile per mile)	Main channel slope (feet per mile)
03404867	KY	4	0.31	0.31	1.00	1.22	3.23	1.22	98.3
03404900	KY	4	53.8	53.8	7.08	10.0	.93	1.41	10.3
03405000	KY	4	201	201	16.9	28.4	1.42	1.68	5.8
03405854	KY	3	1.91	1.91	1.89	2.24	1.87	1.19	102.9
03406000	KY	4	3.89	3.89	1.99	2.60	1.02	1.31	49.2
03406500	KY	4	604	604	24.8	57.3	1.02	2.31	3.6
03407000	KY	4	745	745	37.4	74.7	1.88	2.00	3.6
03407100	KY	4	.67	.67	1.07	1.31	1.71	1.22	206.0
03407200	KY	4	.26	.26	.83	1.00	2.65	1.20	186.7
03407300	KY	4	.85	.85	1.00	1.55	1.18	1.55	223.7
03407500	KY	4	165	165	19.5	30.0	2.30	1.54	10.1
03408500	TN	5	382	382	23.9	46.2	1.49	1.94	7.1
03409000	TN	5	13.5	13.5	4.54	5.70	1.53	1.26	54.5
03412500	KY	4	31.3	31.3	9.55	12.2	2.91	1.28	21.3
03413200	KY	5	43.4	43.4	10.6	17.5	2.59	1.65	20.2
03413202	KY	5	.57	.57	.87	1.10	1.33	1.26	333.3
03413425	KY	5	.76	.76	1.09	1.16	1.56	1.06	189.7
03414102	KY	5	3.52	3.52	2.44	3.13	1.69	1.28	49.4
03414500	TN	5	202	196	26.8	37.6	3.56	1.40	37.0
03415000	TN	5	115	81.0	17.0	20.5	2.50	1.21	33.6
03415700	TN	5	7.98	4.77	3.35	4.40	1.41	1.31	68.5
03416000	TN	5	106	106	15.6	23.4	2.29	1.50	12.3
03417700	TN	5	.49	.49	--	.90	--	--	161.4
03418000	TN	5	78.7	51.6	10.5	20.1	1.39	1.92	14.6
03435140	KY	7	20.8	20.8	4.41	7.37	.94	1.67	13.8
03435500	TN	7	706	309	33.9	66.9	1.63	1.97	4.4
03435600	TN	7	3.50	3.50	2.96	3.52	2.50	1.19	51.7
03436000	TN	7	186	165	22.7	36.3	2.77	1.60	6.6
03436700	TN	7	124	124	18.4	25.7	2.72	1.40	12.3
03437380	KY	7	.83	.83	1.57	1.77	2.97	1.13	76.0
03437390	KY	7	.39	.39	.64	.85	1.05	1.33	140.7
03437490	KY	7	2.62	1.41	2.82	3.39	3.04	1.20	27.1
03437500	KY	7	46.5	35.3	11.1	17.4	2.65	1.57	7.1
03438000	KY	7	244	150	25.7	48.0	2.71	1.87	3.6
03438070	KY	7	30.5	30.5	5.52	6.70	1.00	1.21	20.0

Table 4.--Selected drainage basin characteristics for gaging stations used in the regression analyses--Continued

Station number	State	Hydro-logic region	Drainage area (square miles)	Contributing drainage area (square miles)	Basin length (miles)	Stream length (miles)	Basin shape index (mile per mile)	Main channel sinuosity (mile per mile)	Main channel slope (feet per mile)
03529500	VA	2	112	112	13.2	23.4	1.56	1.77	41.2
03530000	VA	2	40.0	40.0	10.5	14.6	2.74	1.40	156.0
03530500	VA	3	70.0	70.0	11.8	16.5	1.99	1.40	59.4
03531000	VA	3	290	290	26.0	45.9	2.34	1.76	21.5
03531500	VA	3	319	319	33.1	58.9	3.44	1.78	16.8
03610000	KY	7	89.7	89.7	9.76	13.2	1.06	1.35	8.6
03610470	KY	7	.96	.96	1.39	1.66	2.01	1.19	57.7
03610500	KY	7	227	227	31.2	37.5	4.29	1.20	6.2
03610503	KY	7	.82	.82	1.09	1.21	1.45	1.11	52.9
03610545	KY	7	68.7	68.7	12.9	13.8	2.42	1.07	11.6
03610820	KY	7	.13	.13	.56	.62	2.41	1.11	75.2
03611260	KY	7	14.6	14.6	5.47	6.13	2.05	1.12	17.8
03612000	IL	7	244	244	22.5	49.3	2.07	2.19	2.7
03612200	IL	7	.27	.27	.40	.80	.59	2.00	141.0
03614000	IL	7	1.95	1.95	--	--	--	--	23.9
07022500	KY	7	1.72	1.72	1.87	2.10	2.03	1.12	28.1
07023000	KY	7	212	212	34.3	41.8	5.55	1.22	5.3
07023040	KY	7	.53	.53	.94	1.02	1.67	1.09	58.6
07023500	KY	7	36.8	36.8	11.1	13.9	3.33	1.25	10.9
07023935	KY	7	.23	.23	.63	.95	1.73	1.51	59.3
07024000	KY	7	68.7	68.7	15.1	18.2	3.32	1.21	8.0
07026500	TN	7	110	110	16.8	24.3	2.56	1.45	3.7