USGS
science for a changing world

Prepared in cooperation with the North Carolina Department of Transportation

Rec'd 11/29/01

Estimating the Magnitude and Frequency of Floods in Rural Basins of North Carolina—Revised

U.S. Geological Survey
Water-Resources Investigations Report 01–4207

(Supersedes WRIR 99-4114) JAB

U.S. Department of the Interior
U.S. Geological Survey

Estimating the Magnitude and Frequency of Floods in Rural Basins of North Carolina—Revised

By Benjamin F. Pope, Gary D. Tasker, and Jeanne C. Robbins

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 01–4207

Prepared in cooperation with the
North Carolina Department of Transportation

Raleigh, North Carolina
2001

U.S. DEPARTMENT OF THE INTERIOR
GALE A. NORTON, Secretary

U.S. GEOLOGICAL SURVEY
CHARLES G. GROAT, Director

For additional information write to:

District Chief
U.S. Geological Survey
3916 Sunset Ridge Road
Raleigh, NC 27607
Email: dc_nc@usgs.gov

Copies of this report can be purchased from:

U.S. Geological Survey
Branch of Information Services
Box 25286, Federal Center
Denver, CO 80225
1-888-ASK-USGS

Information about U.S. Geological Survey programs in North Carolina can be obtained on the Internet at http://nc.water.usgs.gov.

PREFACE

This report revises and supersedes U.S. Geological Survey Water-Resources Investigations Report 99–4114. The revised flood-discharge values are listed in table 2 (Q2, Q5, Q10, Q25, Q50, Q100, Q200, and Q500). The revised flood discharges, for all recurrence intervals, vary by as much as 17 percent from the earlier published values, with 80 percent of all values within 7 percent of the earlier published data. Differences in the values for the 100-, 200-, and 500-year discharges are greater than in the values for the 2-, 5-, 10-, 25-, and 50-year discharges, 80 percent of which are within 3 percent of the earlier published values.

The revised *t*-year discharges were used to update the regional regression equations and the region-of-influence data base, as indicated in revised text tables 5, 6, and 7 and in appendix table 1. The maximum difference in computed results for the regional regression equations was noted for the Coastal Plain equations, where application of the revised equations to small drainage areas, less than 10 square miles, resulted in discharges that are about 3 to 9 percent greater than those values obtained using equations from the previous report. Computed flood discharges using the revised Blue Ridge-Piedmont equations generally were within about 2 percent of the values from the previously published equations, except for results for drainage areas less than 10 square miles, which ranged from about 3 to 7 percent less than the previously published values. Application of the revised regression equations to the Sand Hills hydrologic area shows results in discharges that are up to 3 percent less than those computed using the equations published in the earlier report. The average error of prediction for the revised equations was nearly the same as for the earlier published Blue Ridge-Piedmont equations, lower for the Coastal Plain equations, and higher for the Sand Hills equations.

As in the previous report, the root mean square error (RMSE) for the region-of-influence method was only marginally better than the RMSE reported for the regional regression equations, resulting in neither method being clearly superior. The revised computer program for computing the estimates of flood-frequency discharges, using either the regional regression equations or the region-of-influence method, and the associated site-specific errors of prediction are available at the North Carolina District Web site http://nc.water.usgs.gov/reports/wri014207.

CONTENTS

FIGURES

TABLES

CONVERSION FACTORS and ABBREVIATIONS/ACRONYMS

Multiply	By	To obtain
	Length	
mile (mi)	1.609	kilometer
	Area	
square mile (mi^2)	2.590	square kilometer
	Flow	
foot per mile (ft/mi)	0.1894	meter per kilometer
cubic foot per second (ft^3/s)	0.02832	cubic meter per second

Abbreviations/Acronyms:

BRP	Blue Ridge-Piedmont hydrologic area
BSLOPE	basin slope
CP	Coastal Plain hydrologic area
CSLOPE	channel slope
DA	drainage area
DEM	digital elevation model
GIS	geographic information system
L	channel length
REG	region variable
RMSE	root mean square error
SH	Sand Hills hydrologic area
SHAPE	basin shape
USGS	U.S. Geological Survey

Estimating the Magnitude and Frequency of Floods in Rural Basins of North Carolina—Revised

By Benjamin F. Pope, Gary D. Tasker, and Jeanne C. Robbins

ABSTRACT

A statewide study was conducted to develop two methods for estimating the magnitude and frequency of floods in rural ungaged basins in North Carolina. Flood-frequency estimates for gaged sites in North Carolina were computed by fitting the annual peak flows for each site to a log-Pearson Type III distribution. As part of the computation of flood-frequency estimates for gaged sites, new values for generalized skew coefficients were developed. Basin characteristics for these gaged sites were computed by using a geographic information system and automated computer algorithms. Flood-frequency estimates and basin characteristics for 317 gaged sites were combined to form the data base that was used for this analysis.

Regional regression analysis, using generalized least-squares regression, was used to develop a set of predictive equations that can be used to estimate the 2-, 5-, 10-, 25-, 50-, 100-, 200-, and 500-year recurrence interval discharges for rural ungaged basins in the Blue Ridge-Piedmont, Coastal Plain, and Sand Hills hydrologic areas. The predictive equations are all functions of drainage area. Average errors of prediction for these regression equations range from 36 to 65 percent.

A region-of-influence method also was developed that interactively estimates recurrence interval discharges for rural ungaged basins in the Blue Ridge-Piedmont and Coastal Plain hydrologic areas of North Carolina. Regression techniques are used to develop a unique relation between flood discharge and basin characteristics for a subset of gaged sites with similar basin characteristics. This, then, can be used to estimate flood discharges at ungaged sites. Because the computations required for this method are somewhat complex, a computer application was developed that performs the computations and compares the predictive errors for this method. The computer application also includes the option of using the regression equations to compute estimated flood discharges and errors of prediction specific to each ungaged site.

Root mean square errors, computed for each recurrence interval and hydrologic area, are generally only slightly lower for the region-of-influence method than for the regression equations and do not provide sufficient basis for recommending one method over the other. In addition, the region-of-influence method is a new method that is still being improved. As a result, the regional regression equations are considered to be the primary method for computing flood-frequency estimates at ungaged sites.

INTRODUCTION

Reliable estimates of the magnitude and frequency of floods are needed by State and local designers and managers. The design of highway and railroad stream crossings, delineation of flood plains and flood-prone areas, management of water-control structures, and management of water supplies are all activities that require estimates of the frequency distribution of flood events. Such estimates can be computed directly by using statistical methods at gaged sites that have at least 10 years of annual peak record; the longer the record of annual peak flows, the more reliable the estimate. It is not feasible, however, to collect 10 years of annual peak record for every location where an estimate of the flood-frequency distribution is needed, nor is it reasonable to wait 10 years for an estimate once a site has been identified.

Estimates that are derived solely from gage records do not provide sufficient spatial coverage to satisfy the need for reliable estimates of the magnitude and frequency of floods. Traditionally, to meet this need, annual peak records at gaged sites have been regionalized, or extended in space. By this process, flood-frequency estimates at gaged sites are related to measurable basin characteristics so that reliable flood-frequency estimates can be made at ungaged sites. In response to the need to improve the accuracy of estimates of flood discharges for ungaged rural basins, the U.S. Geological Survey (USGS), in cooperation with the North Carolina Department of Transportation, initiated an investigation in 1996 to further define the relation between flood discharges of selected recurrence intervals and selected basin characteristics for rural North Carolina basins.

In the past, regionalization was achieved by means of regional regression analysis. Data from gaged sites were used to define a set of relations between selected recurrence interval discharges and drainage area. Once defined, these relations were then used to estimate discharges at selected recurrence intervals for ungaged sites. Often the area of study was subdivided into regions of similar hydrology in order to improve the predictive ability of the equations. Gunter and others (1987) used this approach to develop regional relations for estimating the magnitude and frequency of floods in rural North Carolina basins.

Recently, however, a different approach to regionalization has been developed. This new approach, known as the region-of-influence method, interactively estimates recurrence interval discharges for ungaged sites based on data from gaged sites with similar basin characteristics. For each ungaged site selected, a subset of gaged sites having similar basin characteristics is selected from the entire data base of rural gaged sites. Regression techniques are used to develop a unique relation between flood discharge and basin characteristics for this subset of gaged sites. This relation is then used to estimate flood discharges at the ungaged site. Although computationally intensive, the region-of-influence method is easily automated and performed by a computer application that is discussed later in this report. Because only gaged sites with similar basin characteristics are used to estimate flows at ungaged sites, there is less chance of extrapolation beyond the limits of the explanatory data. Tests of this approach in Texas (Tasker and Slade, 1994) and in Arkansas (Hodge and Tasker, 1995) yielded estimates with lower prediction errors than those produced by using traditional regional regression techniques.

Gunter and others (1987) contains annual peak-flow data collected from gages throughout North Carolina through the 1984 water year[1], whereas this report contains peak-flow data collected through the 1996 water year. Thus, gaged sites that have continued in operation since 1984 have as much as 12 additional years of peak-flow data available for computation of flood-frequency estimates. The 12 intervening years (1985–96) include several years of pronounced drought (1985–88) as well as years in which maximum peaks of record were recorded (1992–93, 1996) for North Carolina streams. In addition, 64 gaged sites that were not used in Gunter and others (1987) are now available for analysis.

Purpose and Scope

This report describes the development, application, and evaluation of two methods for estimating the magnitude and frequency of floods at ungaged, unregulated, rural basins in North Carolina—(1) the regional regression method and (2) the region-of-influence method. A comparison of these two methods, based on their predictive ability and ease of application, also is presented. In order to compare the two methods on an equal basis, each method was applied to the same available data. The regional regression and region-of-influence methods of estimation were applied to the current data base of 317 sites with at least 10 years of unregulated peak-flow record and evaluated.

Approach

A set of eight basin characteristics was computed and compiled for each of 366 gaged rural sites in North Carolina that have peak-flow record. Sites that have

[1]Water year is the period October 1 through September 30 and is identified by the year in which it ends.

flows affected by regulation or channelization were identified, and where possible, records for such sites were divided into periods of unregulated and regulated flows. Weighted regional average skew values were used to compute flood-frequency estimates for 317 sites with at least 10 years of unregulated peak-flow record. Flood-frequency estimates and the computed basin characteristics for these 317 sites were combined to form the data base used in the regional analyses.

Generalized least-squares regression analysis was used to develop predictive equations relating the 2-, 5-, 10-, 25-, 50-, 100-, 200-, and 500-year recurrence interval flood discharges to selected basin characteristics for rural basins throughout North Carolina. In addition, a region-of-influence method was developed that interactively estimates the recurrence interval flood discharges for ungaged rural basins in the Blue Ridge-Piedmont and Coastal Plain hydrologic areas.

Computation and compilation of basin characteristics and of the selected recurrence interval discharges are described in the following sections. All aspects of each analysis, including the initial exploratory multiple regression analysis using ordinary least-squares regression, final regional regression using generalized least-squares regression, and the region-of-influence analysis, are described. Finally, a comparison of the results of each method is presented.

Data Compilation

The first step in the regionalization of flood-frequency estimates is the compilation of a list of all gaged sites with annual peak-flow record. Such sites are either continuous-record sites or crest-stage sites. At continuous-record sites, the water-surface elevation, or stage, of the stream is recorded at fixed intervals, typically ranging from 5 to 60 minutes. At crest-stage sites, only the crest, or highest, stages that occur between site visits, usually 6 to 8 weeks, are recorded. Regardless of the type of gage, measurements of discharge are determined throughout the range of recorded stages, and a relation between stage and discharge is developed for the gaged site. Using this stage-discharge relation, or rating, discharges for all recorded stages are determined. The highest peak discharge that occurs during a given year is the annual peak for the year, and the list of annual peaks is the annual peak-flow record. The three hydrologic areas identified and described by Gunter and others (1987), consisting of (1) the combined Blue Ridge and Piedmont physiographic provinces, (2) the Coastal Plain Province, and (3) a subdivision of the Coastal Plain Province known as the Sand Hills, also were used in this study (fig. 1).

An initial list of 366 rural sites with annual peak-flow record was compiled (fig. 1; table 1, p. 19–30). Records for these sites were then examined to determine the extent of available basin characteristic data and to identify sites with flows affected by channelization or regulation. The only consistently available basin characteristics for most sites were drainage area and location. A complete evaluation of all possible relations between flood discharges and other characteristics of rural basins requires a more complete set of basin characteristics. The computation and compilation of the required basin characteristics for all of the 366 initial sites are described in the following section.

Examination of the flow records for the 366 sites revealed 19 sites with record containing only regulated/channelized flows, 27 sites with record that could be divided into periods of unregulated/unchannelized and regulated/channelized flows, and 320 sites with records unaffected by any known regulation/channelization. Of the 347 sites with at least some period of unregulated flow record, 317 sites had the requisite 10 or more years of record for computation of flood-frequency estimates (table 1). Flood-frequency estimates for these sites were computed and combined with the basin characteristics to form the data base that was used for the regional analyses (table 2, p. 31–42). This data base contained 222 sites in the Blue Ridge-Piedmont hydrologic area, 80 sites in the Coastal Plain hydrologic area, and 15 sites in the Sand Hills hydrologic area (table 2). Of the 46 sites with regulated flow records, flood-frequency estimates were computed for 42 sites with periods of regulated flow longer than 10 years but were not included in either regional analysis.

Acknowledgments

The authors gratefully acknowledge the assistance and support of Mr. Archie Hankins of the North Carolina Department of Transportation. The peak-flow data used in the analyses described herein were collected throughout North Carolina at stream gages operated in cooperation with a variety of Federal, State, and local agencies. The authors also would like to recognize the dedicated work of the USGS field

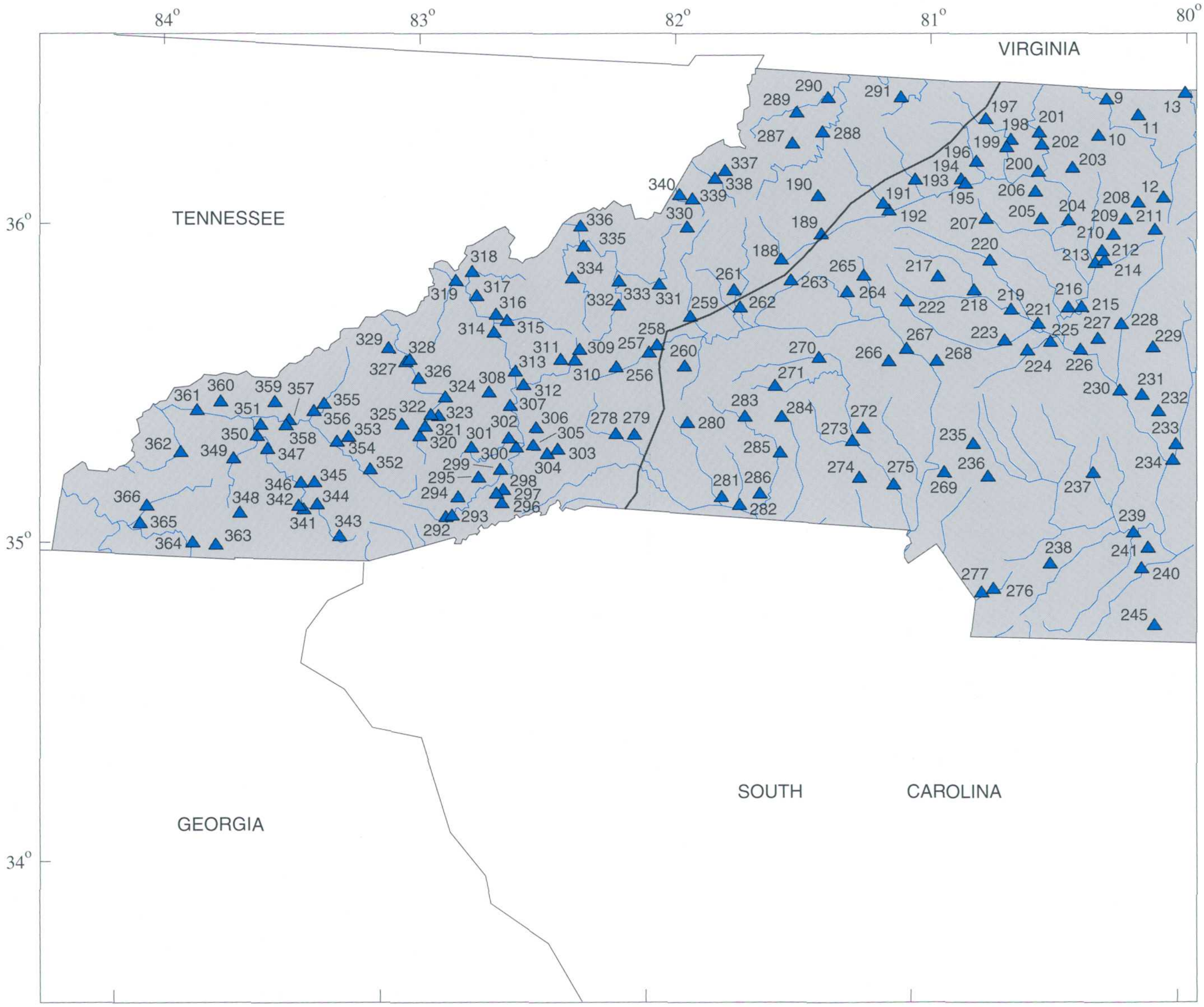
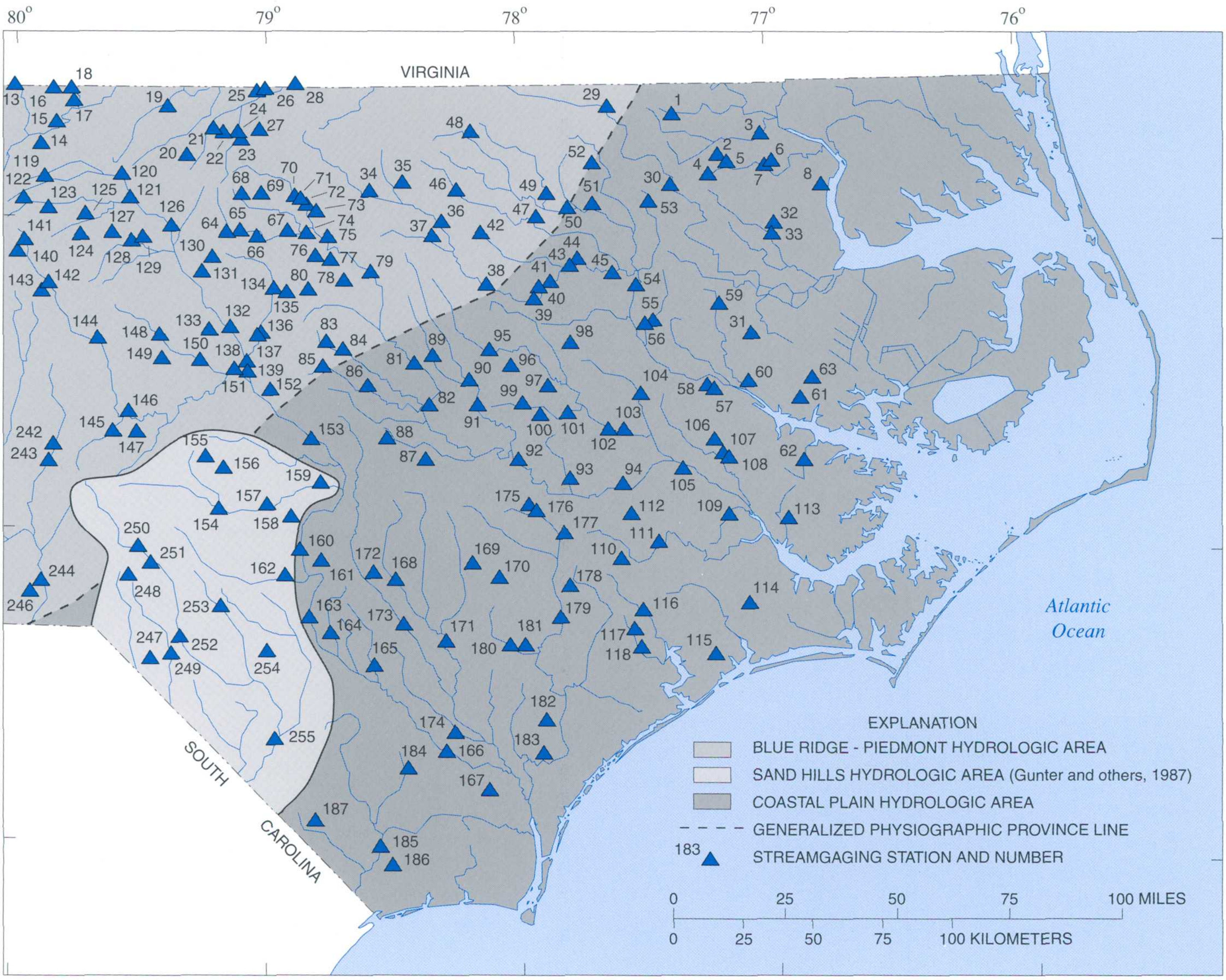


Figure 1. Locations of gaged rural sites in North Carolina.



80°
79°
78°
77°
76°
36°
35°
34°
VIRGINIA
SOUTH CAROLINA
Atlantic Ocean
EXPLANATION
BLUE RIDGE - PIEDMONT HYDROLOGIC AREA
SAND HILLS HYDROLOGIC AREA (Gunter and others, 1987)
COASTAL PLAIN HYDROLOGIC AREA
GENERALIZED PHYSIOGRAPHIC PROVINCE LINE
183 STREAMGAGING STATION AND NUMBER
0 25 50 75 100 MILES
0 25 50 75 100 KILOMETERS

office staff in collecting, processing, and storing the peak-flow data necessary for the completion of this report.

BASIN CHARACTERISTICS

The annual peak-flow data that were used in this study were collected at gages in rural basins from all areas of the State, representing the wide range of physical and climatic conditions that occur in North Carolina. Eight parameters that characterize the size, shape, relief, and climate of rural basins in North Carolina were computed and compiled for each site used in the study. Physical basin characteristics include drainage area (DA), channel length (L), channel slope (CSLOPE), basin slope (BSLOPE), and basin shape (SHAPE) (table 3). The primary climatic characteristics relevant to flood frequency in each basin are the intensity, duration, and amount of storm rainfall, as well as other meteorologic inputs that control evaporation and transpiration. Lichty and Liscum (1978) suggested the use of a regional climate factor, CF_t, where t = 2-, 25-, and 100-year recurrence intervals, that integrates long-term rainfall and pan evaporation information and represents the effect of these climatic influences on flood frequency. In this study, a refined version of CF_t, as developed and described by Lichty and Karlinger (1990), was used to characterize climatic effects of flood frequency. Climate factors, CF_t, for each site were computed by using a computer algorithm that used the maps of climate factor isolines presented in Lichty and Karlinger (1990) and the latitude and longitude of a site to interpolate values for the three climate factors, CF_2, CF_{25}, and CF_{100}.

The hydrologic area for each site was determined by examining drainage boundary maps. The appropriate integer value for each site was then assigned to the region variable (REG) (table 3).

Other than drainage area, the physical basin characteristics selected for use in this study were not readily available for most of the basins in the study. In previous studies, drainage area was the primary explanatory variable; thus, there was no prior need to measure or compute the other characteristics. As a result, the other physical basin characteristics had to be computed and compiled. Because of the large number of sites involved and the need for consistent, unbiased methodology in making measurements and computations, a geographic information system (GIS) was used to compute the required physical basin characteristics.

Table 3. Basin characteristics that were used in the North Carolina flood-frequency regionalization study

[mi^2, square mile; mi, mile; ft/mi, foot per mile; ----, a dimensionless characteristic]

Basin characteristic	Unit of measure	Definition
	Physical characteristics	
DA	mi^2	Drainage area, measured area contained within basin divides.
L	mi	Channel length, measured from gage site upstream along main channel to basin divide.
CSLOPE	ft/mi	Channel slope, computed between points at 10- and 85-percent of the length, measured from the gage site.
BSLOPE	ft/mi	Basin slope, mean value of slope measured along several flow paths from basin divide to channel.
SHAPE	----	Shape, computed by dividing drainage area by the square of channel length (DA/L^2).
	Climatic characteristics	
CF_2	----	2-year recurrence interval climate factor
CF_{25}	----	25-year recurrence interval climate factor
CF_{100}	----	100-year recurrence interval climate factor
	Regional identifiers	
BRP	----	1, if site is in Blue Ridge-Piedmont; 0, if not.
CP	----	1, if site is in Coastal Plain; 0, if not.
SH	----	1, if site is in Sand Hills; 0, if not.
REG	----	1, if site is in Blue Ridge-Piedmont; 2, if site is in Coastal Plain; 3, if site is in Sand Hills.

In order to use GIS to develop basin characteristics, a digital elevation model (DEM) was created by combining individual data sets. These data sets included the U.S. Environmental Protection Agency River File 3 (McKay and others, 1994), USGS digital line graph contour lines (U.S. Geological Survey, 1989), and the National Oceanic and Atmospheric Administration shoreline data set (National Oceanic and Atmospheric Administration, 1999). Known drainage basin boundaries were overlain onto the DEM, and a combination of computer and visual interpolation techniques were used to define boundaries between the 366 gage sites and the known drainage boundaries.

Once the DEM was constructed and basin boundaries were delineated for all sites, a set of computer algorithms was developed to automatically compute drainage area, L, CSLOPE, BSLOPE, and SHAPE. Although GIS-computed drainage area was computed, the values used for DA were the drainage areas compiled from site records that were hand-computed and checked when the sites were established. The percent difference between GIS-computed drainage area and DA was automatically computed and used to verify the delineation of basin boundaries and the automated computations. Sites with greater than 10-percent difference between the computed drainage area and DA were flagged and re-examined. Errors in boundary delineation were corrected by comparing USGS 7.5-minute topographic maps with the original hand-delineated basin boundary and by using manual techniques to match the GIS basin boundary to the original. After adjusting basin boundaries, basin characteristics were recomputed and rechecked until satisfactory results were obtained. Several sites with drainage areas less than about 1 square mile (mi^2) did not meet the criteria of less that 10-percent difference between computed drainage area and DA because the resolution of the GIS data and computational methods were about one-tenth of a square mile. These sites were examined manually to determine if the automated delineation of basin boundaries was consistent with the hand-drawn boundaries; if not, the boundaries were adjusted accordingly and basin characteristics were recomputed.

ESTIMATION OF FLOOD MAGNITUDE AND FREQUENCY AT GAGED SITES

Flood-frequency estimates for a given stream site are typically presented as a set of exceedance probabilities or, alternatively, recurrence intervals along with the associated discharges. Exceedance probability is defined as the probability of exceeding a specified discharge in a 1-year period and is expressed as decimal fractions less than 1.0 or as percentages less than 100. A discharge with an exceedance probability of 0.10 has a 10-percent chance of being exceeded in any given year. Recurrence interval is defined as the number of years, on average, during which the specified discharge is expected to be exceeded one time and is expressed as number of years. A discharge with a 10-year recurrence interval is one that, on average, will be exceeded once every 10 years. Recurrence interval and exceedance probability are the mathematical inverses of one another; thus, a discharge with an exceedance probability of 0.10 has a recurrence interval of 1/0.10 or 10 years. Conversely, a discharge with a recurrence interval of 10 years has an exceedance probability of one-tenth or 0.10. It is important to remember that recurrence intervals, regardless of length, always refer to the average number of occurrences over a long period of time; for example, a 10-year flood discharge is one that might occur about 10 times in a 100-year period, rather than exactly once every 10 years.

Flood-frequency estimates for gaged sites are computed by fitting the series of annual peak flows to some known statistical distribution. For the purposes of this study, estimates of flood-flow frequency are computed by fitting the logarithms (base 10) of the annual peak flows to a log-Pearson Type III distribution, following the guidelines and using the computational methods described in Bulletin 17B of the Hydrology Subcommittee of the Interagency Advisory Committee on Water Data (1982). The equation for fitting the log-Pearson Type III distribution to an observed series of annual peak flows is as follows:

$$LogQ_t = \bar{X} + KS, \qquad (1)$$

where

- Q_t is the t-year recurrence interval discharge in cubic feet per second,
- $\bar{X}$ is the mean of the log-transformed annual peak flows,
- K is a factor dependent on recurrence interval and the skew coefficient of the log-transformed annual peak flows, and
- S is the standard deviation of the log-transformed annual peak flows.

Values for K for a wide range of recurrence intervals and skew coefficients are published in Appendix 3 of Bulletin 17B (Hydrology Subcommittee of the Interagency Advisory Committee on Water Data, 1982).

Fitting the log-Pearson Type III distribution to the general case of a long, well-distributed series of annual peak flows is fairly straightforward. Often, however, a series of peak flows may include low or high outliers, which are extremely low or high peak flows that depart significantly from the trend in the data. The gage record also may frequently include information about maximum peak flows that occurred outside of the period of regularly collected, or systematic, record. Such peak flows, known as historic peaks, are often the maximum peak flows known to have occurred during an extended period of time, longer than the period of collected record. The interpretation of outliers and historic peak information in the fitting process can greatly affect the final flood-frequency estimate. Bulletin 17B (Hydrology Subcommittee of the Interagency Advisory Committee on Water Data, 1982) provides guidelines for detecting and interpreting these data points and provides computational methods for making appropriate corrections to the distribution to account for their presence. In some cases, high or low outliers are excluded from the record, so that the number of systematic peaks may not be equal to the number of years in the period of record.

Statistical measures, such as mean, standard deviation, or skew coefficient, can be described in terms of the sample or computed measure and the population or true measure. In terms of annual peak flows, the period of collected record can be thought of as a sample, or small portion, of the entire record, or population. Statistical measures computed from the sample record are estimates of what the measure would be if the entire population were known and used to compute the given measure. The accuracy of these estimates depends on the nature of the specific measure and the given sample of the population.

Skew coefficient measures the symmetry of the distribution of a set of peak flows about the median of the distribution. A peak-flow distribution with the mean equal to the median is said to have zero skew. A positively skewed distribution has a mean that exceeds the median typically as a result of one or more extremely high peak flows. A negatively skewed distribution has a mean that is less than the median typically because of one or more extremely low peak flows.

The computed skew coefficient for the peak-flow record of a given station is very sensitive to extreme events; therefore, the sample skew coefficient for short records may not provide an accurate estimate of the population skew. This is problematic because the *K*-factor in equation 1 for a given recurrence interval is dependent only on skew coefficient; therefore, an inaccurate skew coefficient will result in a flood-frequency estimate that is not representative of the true, or population, value.

A more accurate estimate of skew coefficient at a site can be obtained by using a weighted average of the sample skew coefficient estimate with a generalized, or regional, skew coefficient. A generalized skew coefficient is obtained by combining skew estimates from nearby, similar sites. A nationwide generalized skew study was conducted for the study documented in Bulletin 17B (Hydrology Subcommittee of the Interagency Advisory Committee on Water Data, 1982). Skew coefficients for long-term gage sites from all over the Nation were computed and used to produce a map of isolines of generalized skew. Gunter and others (1987) used this nationwide generalized skew in their flood-frequency computations. In addition, the USGS in North Carolina has computed other unpublished flood-frequency estimates by using the nationwide generalized skew.

During preliminary computations of flood-frequency estimates for inclusion in the regression analyses, a number of inconsistencies were noted between the computed values of sample skew coefficients at long-term gaging sites in North Carolina and the values obtained from the national generalized skew study. Inconsistencies at long-term sites are of concern because if generalized skew coefficients for a region are accurate estimates of the population skew, then the computed values of sample skew at long-term sites should approach the generalized values. Instead, it was noted that while sample skew coefficients at long-term North Carolina sites were somewhat consistent among themselves, they did not agree with the generalized values obtained from the nationwide generalized skew study. This anecdotal evidence, when considered along with the age and lack of resolution of the national study, was deemed sufficient cause to develop new generalized skew estimates for rural gaging sites in North Carolina.

Bulletin 17B (Hydrology Subcommittee of the Interagency Advisory Committee on Water Data, 1982) describes three methods for performing generalized skew studies using skew coefficients computed from long-term gaging stations—(1) plot computed skew coefficients on a map and construct skew isolines, (2) use regression techniques to develop a skew prediction equation that would relate station skew coefficients to some set of basin characteristics, or (3) use the arithmetic mean of computed skew coefficients from long-term sites in the area. For the purposes of this report, a modification of the second method initially was decided to be the most likely method to produce satisfactory results. However, rather than using ordinary least-squares regression, a weighted least-squares regression technique was used to determine the relation between the sample skew coefficient and selected basin characteristics. Sample skew estimates were weighted according to their respective record length; sites with long records were assigned greater weight than those with short records. The use of this regression technique in this study made it possible for data from all 347 sites with unregulated flows to be used in developing the estimate.

Multiple regression analysis, using ordinary least-squares regression, was used to determine the best set of basin characteristics to use as explanatory, or independent, variables in the weighted least-squares predictive model. Initial analyses were somewhat disappointing; no combination of basin characteristics accounted for a significant amount of the variance in computed skew. Lacking any significant statewide relationship between sample skew and basin characteristics, three location variables—BRP, CP, and SH, one for each of the three hydrologic areas, Blue Ridge-Piedmont, Coastal Plain, and Sand Hills—were added to the analysis. For a given site, the location variable representing the region of the site was set at 1, and the other two location variables were set at 0 (table 3). When these variables were added to the multiple regression analysis, results were only marginally better. None of the exploratory multiple regression models yielded significant relations between sample skew and the basin characteristics.

Given the lack of satisfactory results in this attempt to develop predictive equations relating skew to a set of basin characteristics, it was decided to apply a modified version of the second method in Bulletin 17B (Hydrology Subcommittee of the Interagency Advisory Committee on Water Data, 1982). A regional regression prediction equation was developed using weighted least-squares regression (Tasker and Stedinger, 1986). Weights were assigned, according to record length, to the computed skews for each site. Because the only statistically significant explanatory variable in the regression analysis was an indicator variable for the Sand Hills hydrologic area, the regression equation predicts one value for all sites in the Sand Hills area and another value for all sites in the remaining hydrologic areas. These predictions are essentially a weighted average of the sites in each of the two areas and, therefore, can be considered a modified version of the third method as well. The two weighted regional average skew values, along with the standard error of prediction and the mean square error of prediction associated with each estimate (table 4), were determined by the methods described in Tasker and Stedinger (1986).

Table 4. Generalized skew coefficient and associated mean square error for rural North Carolina gaging sites

Hydrologic area	Generalized skew coefficient	Standard error	Mean square error
Blue Ridge-Piedmont and Coastal Plain	0.195	0.194	0.038
Sand Hills	0.252	0.250	0.062

As described previously, a weighted skew coefficient is used in order to improve the accuracy of the skew coefficient used to fit peak-flow records to a log-Pearson Type III distribution. The weighted skew coefficient for a given site is computed as the weighted average of the generalized skew coefficient and the site's computed skew coefficient, with weights assigned according to the mean square error of each component skew value. Flood-frequency estimates for all sites with unregulated flow records were computed by using the weighted skew method. Flood-frequency estimates for sites with regulated flow record were computed by fitting the recorded regulated peak flows to the log-Pearson Type III distribution. Computed sample skew coefficients for the regulated flow record were used because regulated peak-flow records typically are not representative of regional or generalized conditions. Although flood-frequency estimates for regulated sites are presented in this report, more detailed, site-specific analyses of flood frequency at many regulated sites are available from the U.S. Army Corps of Engineers.

ESTIMATION OF FLOOD MAGNITUDE AND FREQUENCY AT UNGAGED SITES

Two regional analyses were used to develop methods for estimating flood discharges for ungaged rural basins in North Carolina. The first analysis, a traditional regional regression, required the use of generalized least-squares regression to define a set of predictive equations that relate peak discharges for the 2-, 5-, 10-, 25-, 50-, 100-, 200-, and 500-year recurrence intervals to selected basin characteristics for unregulated rural basins in each of three hydrologic areas of North Carolina (fig. 1). The second analysis, the region-of-influence method, required the development of a computer application to derive, for any given ungaged rural site in the Blue Ridge-Piedmont or Coastal Plain hydrologic areas, unique predictive relations between the 2-, 5-, 10-, 25-, 50-, 100-, 200-, and 500-year recurrence interval discharges and selected basin characteristics. Just as in the traditional regional regression, generalized least-squares regression is used to develop these predictive relations; however, in the region-of-influence analysis, regression techniques are applied to only a selected subset of gaged sites, rather than the entire data base of gaged sites.

Regional Regression Analysis

Ordinary least-squares regression with flood discharge as the dependent variable was used in exploratory analyses to determine the best regression models for all combinations of the eight basin characteristics that were used as explanatory variables. An additional goal of the exploratory analysis was to determine if the subdivision of the State into three hydrologic areas is supported by current data.

Initially, the regionalization scheme used by Gunter and others (1987), which divided the State into the Blue Ridge-Piedmont, Coastal Plain, and Sand Hills hydrologic areas, was assumed to still be valid. Multiple regression analysis, using Mallow's Cp (Stedinger and Tasker, 1985), adjusted coefficient of determination, and hydrologic judgment as criteria, resulted in one-variable and two-variable models relating flood discharge to basin characteristics for each of the three hydrologic areas. The most significant one-variable models for all three regions included drainage area only. The most significant two-variable models included drainage area and the 25-year climate factor for the Blue Ridge-Piedmont and Sand Hills hydrologic areas; while the best two-variable models for Coastal Plain sites consisted of drainage area and channel length.

The validity of the regionalization scheme was examined by performing additional ordinary least-squares regression analyses by using the two-variable models determined previously and comparing the coefficients and intercepts for each region's model to those for the rest of the State. In each case, the coefficients and intercepts for each region's model differed from those of the model using the remaining sites in the State. Additionally, a further test was conducted by introducing the location variable (table 3) for each region into the regression model. Each of these variables was set either at 1, if the site was in a particular region, or 0, if not. A five-variable ordinary least-squares regression model, including all available sites and using (1) drainage area, (2) climate factor, (3) location variable, (4) the product of the location variable with drainage area, and (5) the product of the location variable with climate factor as explanatory variables, was constructed for each recurrence interval discharge in each of the three hydrologic area. For a given region's model, a significant coefficient for the location variable indicates a difference in the intercept between sites in that region and sites in the rest of the State; a significant coefficient for either of the terms that are products of a location variable and another variable indicates a difference in the coefficients of the basin characteristic in that term between sites in that region and the rest of the State. In this particular test, a 95-percent confidence level was defined as significant. All three regional models had significant coefficients for at least one of the location variables or location variable product terms. Given the results of these regression tests, the regionalization scheme used by Gunter and others (1987) was accepted.

Ordinary least-squares regression is an appropriate and efficient regression model for use when flow estimates that are used as response variables are independent of each other (no correlation exists between pairs of sites) and when the reliability and variability of flow estimates that are used as response variables are approximately equal. The flow estimates that were used in this regression were generated from peak-flow records at gaging stations in all parts of North Carolina with periods of record ranging from

10 to 101 years. Records from gaging stations on the same stream within the same basin or even in adjacent basins may be highly correlated because the peak flows resulted from the same rainfall events, similar antecedent conditions, and similar basin characteristics. However, records from other sites, in basins remote from each other, have varying degrees of correlation. In general, correlation between pairs of sites can be described as a function of distance between sites. Additionally, the reliability of flow estimates that were used as response variables in this regression is, in general, a function of record length and, as such, cannot be considered equal for all sites in the regression. Variability of the flow estimates, characterized by the standard deviation of the peak-flow record that was used to compute the flow estimate, depends in large part on characteristics of the basin and also cannot be considered equal for all sites used in the regression. For these reasons, ordinary least-squares regression was used only as an exploratory technique in this analysis to identify the best potential regression models and to evaluate the proposed regionalization scheme. The final regression equations were developed by using generalized least-squares regression techniques.

Generalized least-squares regression, as described by Stedinger and Tasker (1985), is a regression technique that takes into account the correlation between, as well as differences in the variability and reliability of, the flow estimates used as dependent, or response, variables. These factors are accounted for in generalized least-squares regression by assigning different weights to each observation of the response variable used in the regression, based on its contribution to the total variance of the sample-flow statistic used as the response variable. In contrast, ordinary least-squares regression assumes equal reliability and variability in flow estimates at all sites and no cross-correlation between flow records at all sites, so that each flow estimate has equal variance and is assigned equal weight in the regression.

The use of generalized least-squares regression techniques to model the relations between peak discharges and basin characteristics of North Carolina rural basins requires estimates of the cross-correlation coefficients and standard deviation of the peak-flow records that were used to compute peak discharges for the selected recurrence intervals. For each of the three hydrologic areas, a scatter-plot of sample correlation coefficients versus distance between sites was constructed for site pairs with long periods (at least 30 years) of concurrent record. A graphical 'best-fit' line to these points was used to define the relation between cross-correlation coefficient and distance between sites. This relation was then used to populate a cross-correlation matrix for the sites contained in each area. Variability of each peak-flow estimate is measured by the standard deviation of the peak-flow record used to compute that estimate. For each hydrologic area, a generalized least-squares regression of the sample standard deviations against drainage area was used to obtain estimates of the standard deviations of the peak-flow records at each site. These regression estimates of the standard deviations were used to assign weights to flow estimates because they are independent of the sample standard deviation estimates used to compute the flow estimate. Finally, length of record at each peak-flow site was used as a direct measure of the relative reliability of the flow estimates computed from those records.

Generalized least-squares regression was used to evaluate the 1- and 2-variable models suggested by preliminary ordinary least-squares regression for each of the three hydrologic areas in North Carolina. The final regression models in all of the regions relate peak discharge to drainage area for each recurrence interval (table 5). The 2-variable model for each region was tested by using generalized least-squares regression, and in each case, the addition of a second variable did not substantially improve the predictive ability of the model.

Table 5. North Carolina rural flood-frequency equations

[DA, drainage area, in square miles. Result will be in cubic feet per second]

Rural flood recurrence interval (years)	Hydrologic area		
	Blue Ridge-Piedmont	Coastal Plain	Sand Hills
2	135 DA $^{0.702}$	64.7 DA $^{0.673}$	33.5 DA $^{0.712}$
5	242 DA $^{0.677}$	129 DA $^{0.635}$	55.5 DA $^{0.701}$
10	334 DA $^{0.662}$	188 DA $^{0.615}$	72.9 DA $^{0.697}$
25	476 DA $^{0.645}$	281 DA $^{0.593}$	98.1 DA $^{0.693}$
50	602 DA $^{0.635}$	367 DA $^{0.579}$	120 DA $^{0.691}$
100	745 DA $^{0.625}$	468 DA $^{0.566}$	143 DA $^{0.688}$
200	908 DA $^{0.616}$	586 DA $^{0.554}$	170 DA $^{0.686}$
500	1,160 DA $^{0.605}$	773 DA $^{0.539}$	210 DA $^{0.684}$

Uncertainty in a flow estimate that was predicted for an ungaged site by using the regression equations can be measured by the standard error of prediction, S_p, which is computed as the square root of the mean square error of prediction, MSEp. The MSEp is the sum of two components—the mean square error resulting from the model, γ^2, and the sampling mean square error, $MSE_{s,i}$, which results from estimating model parameters from samples of the population. The mean square model error, γ^2, is a characteristic of the model and is a constant for all sites. The mean square sample error, $MSE_{s,i}$, for a given site, however, depends on the values of the explanatory variables (DA) used to develop the flow estimate at that site. The standard error of prediction for a site, i, is computed as:

$$S_{p,i} = (\gamma^2 + MSE_{s,i})^{\frac{1}{2}} \quad , \qquad (2)$$

and, therefore, varies from site to site. If the values of the explanatory variables for the gage sites used in the regression are assumed to be a representative sample of all sites in the region, then the average accuracy of prediction for the regression model can be determined by computing the average standard error of prediction:

$$S_p = \left\{ \gamma^2 + \frac{1}{n} \sum_{i=1}^{n} MSE_{s,i} \right\}^{\frac{1}{2}} \quad . \qquad (3)$$

The standard error of the model ($SE_{(model)}$) can be converted from log (base 10) units to percent error by using the transformation formula,

$$\%SE_{(model)} = 100(10^{2.3026(\gamma^2)} - 1)^{\frac{1}{2}} \quad . \qquad (4)$$

Similarly, the average standard error of prediction can be transformed from log (base 10) units to percent error by substituting $S_p^{\ 2}$ for γ^2 in equation 4. Computation of $S_{p,i}$ for a given ungaged site, i, involves fairly complex matrix algebra. Computational procedures and the required matrices are provided in the Appendix.

The standard errors of the model, which measure how well the regression model fits the data used to construct it, ranged from about 34 percent to just over 57 percent. This error term is comparable to errors often cited and referred to as 'model error' or 'standard error of estimate' in earlier studies in which ordinary least-squares regression was used to develop predictive equations. The average standard errors of prediction, which provide a better overall measure of a model's predictive ability, ranged from about 36 percent to about 65 percent (table 6). Another measure of predictive ability is equivalent years of record (Hardison, 1971). Equivalent years of record are the number of years of peak-flow record needed to provide an estimate by using log-Pearson Type III techniques that would be equal in accuracy to an estimate made by using regional methods (table 6).

Table 6. Average predictive errors, in percent, and equivalent years of record associated with North Carolina rural flood-frequency equations

Rural flood recurrence interval (years)	Hydrologic area					
	Blue Ridge-Piedmont		Coastal Plain		Sand Hills	
	Average error of prediction	Equivalent years of record	Average error of prediction	Equivalent years of record	Average error of prediction	Equivalent years of record
2	41.2	2.0	37.9	2.9	38.4	2.1
5	41.2	3.0	35.9	4.9	42.6	2.7
10	42.0	4.1	36.3	6.7	45.6	3.4
25	43.6	5.4	38.0	8.8	49.8	4.2
50	45.9	6.4	39.8	10.1	53.1	4.6
100	47.0	7.2	42.0	11.1	56.6	5.0
200	48.9	7.9	44.2	11.9	60.2	5.4
500	51.6	8.7	47.3	12.7	65.1	5.7

Region-of-Influence Analysis

The region-of-influence method (Tasker and Slade, 1994) estimates flood discharges at ungaged basins by deriving, for a given ungaged rural site, regression relations between the flood discharges and basin characteristics of a unique subset of gaged sites. This unique subset of gaged sites for a given ungaged site, first suggested by Acreman and Wiltshire (1987), was described by Burn (1990a, b) as the region of influence for an ungaged site, hence the name of the method. The unique subset of gaged sites is defined as the N 'nearest' gages to the ungaged site, where distance between sites i and j is defined by the Euclidean distance metric:

$$d_{ij} = \left(\sum_{k=1}^{p} \left(\frac{x_{ik} - x_{jk}}{sd(X_k)} \right)^2 \right)^{\frac{1}{2}} , \qquad (5)$$

where

d_{ij} is the distance between sites i and j in terms of basin characteristics,

p is the number of basin characteristics used to calculate d_{ij},

X_k is the kth basin characteristic,

$sd(X_k)$ is the sample standard deviation for X_k, and

x_{ik} is the value of X_k at the ith site.

This distance metric is directly analogous to the more familiar equation for distance, D, between two points, (x_1, y_1) and (x_2, y_2) in a 2-dimensional rectangular coordinate system:

$$D = [(x_2 - x_1)^2 + (y_2 - y_1)^2]^{\frac{1}{2}} , \qquad (6)$$

where the only difference is the use of sample standard deviation to standardize the different basin characteristics and the slight notational difference of using an additional subscript k rather than changing variable symbols (x, y).

The distances, d_{ij}'s, between a given ungaged site and all the gaged sites are computed and ranked; the N gaging stations with the smallest d_{ij} compose the region of influence for that gaging station. Once determined, generalized least-squares regression techniques are used to develop the unique predictive relations between flood discharge and basin characteristics and estimates of the selected recurrence interval discharge at the ungaged site computed.

The number, p, and identity of the basin characteristics that are used to compute d_{ij} and the number of gaged sites, N, that compose the region of influence are specific to a given set of flood-discharge estimates and basin characteristics. In order to adapt the region-of-influence method to that data set, these parameters must be determined. In addition to these parameters, the set of basin characteristics also must be chosen for use as explanatory variables in the generalized least-squares regression models developed for each region. There is a subtle but important distinction between the two sets of basin characteristics—the first is used to define a region of influence; the second serves as variables in the unique predictive equations that are developed for that region of influence. These two sets of characteristics need not be identical but are in some cases. In other cases, such as in North Carolina, the set of characteristics used as variables is a subset of the set of characteristics used to define the region of influence.

Selection of the number of gaged sites, N, and the number and identity of the basin characteristics that will define the region of influence for North Carolina was done by trial and error, using a computed root mean square error (RMSE) as the criterion. RMSE was computed by removing one site at a time from the data base and using the remaining sites to compute an estimate of the flow characteristic. Once completed for every site, the RMSE was computed as the square root of the arithmetic mean of the differences between the estimated and computed values at each site. The results of the exploratory multiple regression analyses performed as part of the traditional regional regression analysis were used to provide some insight in selecting initial sets of basin characteristics. The strong evidence for using separate hydrologic areas in the traditional regression analysis led to the decision to restrict a site's region of influence to its hydrologic area. As a result, 15 sites in the Sand Hills region (fig. 1) were not enough to support a valid region-of-influence analysis. For any ungaged site identified as a Sand Hills site, the same set of 15 sites would compose the region of influence, and the unique predictive equation developed would be the same equation developed by using traditional regional regression techniques, as described in previous sections of this report.

Combinations of defining variables that were tested include DA and CF_{25}; DA and REG; DA, CF_{25}, and REG; and DA, CF_{25}, L, and REG. Each set of defining variables was tested by using values of 25, 30, and 35 for N. For all variable combinations, N = 30 provided the best results; and the combination of variables that minimized RMSE for all recurrence intervals was DA, CF_{25}, and REG. For these initial tests, DA and CF_{25} were used as explanatory variables in the unique regression relations. Subsequent testing, after the defining variables and N were determined, indicated that CF_{25} was not significant as an explanatory variable. As a result, only DA is used as an explanatory variable in the final version of the region-of-influence method.

After determining the best combination of variables to define the region of influence and the optimal value for N, the computer application for the region of influence was completed. Equation 5 is used to determine the region of influence for an ungaged site, given the required input variables. Unique predictive equations for the ungaged site are then developed, using a generalized least-squares regression of the sites within the region of influence, and the predicted flood-discharge estimates are computed. In addition, because generalized least-squares regression was used to develop the predictive equations, $S_{p,i}$, the site-specific standard error of prediction is computed for each estimated recurrence interval discharge.

Comparison of Results

Application of the regional regression equations requires one less variable than application of the region-of-influence method. However, the additional variable, latitude and longitude of the ungaged site, is simple to determine, so that the variable requirements of the methods are nearly equal. The regional regression equations are easily evaluated manually, the region-of-influence method, however, is computationally intensive but is made simpler by the use of a computer application that performs the complex computations.

The average RMSE was computed for each area and recurrence interval (table 7), providing a measure of the predictive ability of the model or method. Average RMSE was computed as the square root of the arithmetic mean of the differences between the flood-frequency estimate determined using the log-Pearson Type III and the flood-frequency estimate computed using either the regression equations or the region-of-influence method. RMSE for the region-of-influence method is slightly less than for the traditional regression equations in all cases. A site-specific comparison of predictive error also is possible by using $S_{p,i}$. As discussed previously, the region-of-influence method reports the site-specific standard error of prediction, $S_{p,i}$. The $S_{p,i}$ is not typically computed when evaluating the traditional regression equations manually because of the complexity of the computations involved. Automation of the equations eliminates this concern, and the $S_{p,i}$ is reported along with the flood-discharge estimate for any given site, allowing for comparison of predictive results on a site-by-site basis.

Table 7. Root mean square error, in percent, for the regional regression and region-of-influence methods, presented by hydrologic area and recurrence interval

[n.a., not applicable]

Recurrence interval	Hydrologic area					
	Blue Ridge-Piedmont		Coastal Plain		Sand Hills	
	Regional regression	Region of influence	Regional regression	Region of influence	Regional regression	Region of influence
2	43.9	42.9	39.3	34.4	40.9	n.a.
5	45.4	43.3	38.6	34.6	46.1	n.a.
10	47.4	44.7	40.5	37.1	50.3	n.a.
25	50.7	47.3	44.4	41.7	55.9	n.a.
50	53.4	49.5	47.9	45.6	60.3	n.a.
100	56.2	51.9	51.6	49.7	64.7	n.a.
200	59.2	54.4	55.7	53.9	69.3	n.a.
500	63.1	57.9	61.1	59.6	75.4	n.a.

In general, little difference was found in the ease of application or in average predictive abilities between the regional regression equations and the region-of-influence method. The region-of-influence method is a new technique and is still being improved. As a result, the region-of-influence method is considered a secondary or alternative method of determining flood-frequency estimates for ungaged rural sites in North Carolina.

Use of Computer Software

As part of the study described by this report, a computer software package was developed that computes (1) estimates of flood-frequency discharges using the region-of-influence method at ungaged rural sites in the Blue Ridge-Piedmont or Coastal Plain hydrologic areas of North Carolina, (2) estimates of flood-frequency discharges using the regional regression equations for ungaged rural sites in each of the three hydrologic areas of North Carolina, and (3) the associated site-specific errors of prediction, $S_{p,i}$, for each method. The complexity of the computations required for the region-of-influence method requires the use of the software for practical application of the method. The regional regression equations can be evaluated manually, but the software allows for easy evaluation of the complex computation of the $S_{p,i}$ for the regional regression method.

The computer software package includes an executable program file and four supporting data files. All five files are required for execution of the computer software. The software package and instructions for down loading, installation, and execution of the program currently are available at the North Carolina District home page on the World Wide Web at URL <http://nc.water.usgs.gov/reports/wri014207>.

APPLICATION OF METHODS

The methods presented in this report can be used to estimate the 2-, 5-, 10-, 25-, 50-, 100-, 200-, and 500-year recurrence interval flood discharges at gaged and ungaged, unregulated, rural sites in North Carolina. Use of either the regional regression equations or the region-of-influence method requires estimates of the input variables. To apply these methods, first locate the ungaged site on a map and identify in which hydrologic area the site is located. An estimate of the latitude and longitude of the site is required for the region-of-influence method. Next, delineate the drainage boundaries of the ungaged site and measure the drainage area contained within those boundaries. The corresponding regression equations (table 5) can then be applied to determine an estimate of the flood discharges for the recurrence interval of interest. Alternatively, the region-of-influence computer application can be initiated; it will query the user for an output file name, an identifier for the site of interest, the hydrologic area for the site, the drainage area of the site, and the latitude and longitude of the site. With this information, the computer application computes the climate factor, defines a region of influence, and produces the desired flood-discharge estimates, along with the standard error of prediction, $S_{p,i}$, specific to the ungaged site.

The computer application contains the regression equations and can be used to apply either method. Use of the computer application to evaluate the regression equation provides an automated computation of $S_{p,i}$ for the regression equations as well as for the region-of-influence method. If evaluated manually, $S_{p,i}$ can be computed only by using the rather complex computational procedures described previously and outlined in detail in the Appendix. Although average standard errors of prediction (table 6) give an idea of the relative accuracy of the methods; $S_{p,i}$ is the more precise measure of the accuracy of a specific prediction.

Flood-frequency estimates at gaged sites and ungaged sites on the same stream as a gaged site can be improved by combining the estimate determined by regional methods with the estimate determined by fitting the log-Pearson Type III distribution to the peak-flow record at the gaged site. At a gaged site, the best estimate of flood frequency can be determined by

$$Q_t(w) = \frac{Q_t(g)N + Q_t(r)EY}{N + EY}, \quad (7)$$

where

$Q_t(w)$ is the weighted discharge for recurrence interval t;

$Q_t(g)$ is the discharge for recurrence interval t determined using peak-flow record from the gaged site;

$Q_t(r)$ is the discharge for recurrence interval t determined using regional methods;

N is the number of systematic peaks in the gaged sites record; and

EY is the equivalent years of record from table 6.

Flood estimates at an ungaged site that is on the same stream as a gaged site can be determined by using a combination of the regional estimate and the log-Pearson Type III estimate from the nearby gaged site. In order to make the appropriate adjustment, first compute the ratio,

$$R = \frac{Q_t(w)}{Q_t(r)}, \qquad (8)$$

for the gaged site by using $Q_t(w)$ and $Q_t(r)$ as defined in the preceding paragraph. Next, a correction factor, R', is computed as follows:

$$R' = R - \frac{\Delta DA(R-1)}{0.5DA_g}, \qquad (9)$$

where ΔDA is the absolute value of the difference between the drainage areas of the gaged and ungaged sites, and DA_g is the drainage area of the gaged site. If $\Delta DA/DA_g$ is less than 0.5, then the corrected discharge for the ungaged site, Q_t(corr), can be computed by multiplying the correction factor, R', by the regional estimate for the ungaged site, $Q_t(r)$. If $\Delta DA/DA_g$ is greater than 0.5, use the results of the regional methods without correction.

At times, flood-frequency estimates may be desired for an ungaged site that is between two gaged sites on the same stream. In this case, select the gaged site for which $\Delta DA/DA_g$ is less than 0.5, compute R', and apply as described above. If $\Delta DA/DA_g$ is less than 0.5 for both gaged sites, compute R' for each. If both correction factors are greater than 1.0, use the larger R'; if both correction factors are less than 1.0, use the smaller R'. If one correction factor is greater than 1.0 and the other smaller than 1.0, an average of the two correction factors should be used.

If the drainage basin for an ungaged site lies within more than one hydrologic area, the computed discharge should be adjusted according to the proportion of the total drainage area that lies within each hydrologic area. The adjusted discharge can be determined by the equation:

$$Q_t(\text{adjusted}) = Q_t(HA1)x\frac{DA_1}{DA_{\text{total}}} + Q_t(HA2)x\frac{DA_2}{DA_{\text{total}}}, \qquad (10)$$

where Q_t(adjusted) is the adjusted discharge for the t-year recurrence interval; $Q_t(HA1)$ and $Q_t(HA2)$ are the discharges computed as if the entire drainage area were within the hydrologic areas, $HA1$ and $HA2$; DA_1 and DA_2 are portions of the total drainage area found in the respective hydrologic drainage areas; and DA_{total} is the total drainage area.

SUMMARY

Accurate and reliable estimates of the magnitude and frequency of floods are critical for such activities as bridge design, flood-plain delineation and management, water-supply management, and management of water-control structures, among others. Recognizing the need for accurate estimates of flood frequency at ungaged rural basins, the U.S. Geological Survey, in cooperation with the North Carolina Department of Transportation, conducted a study to further define the relation between flood discharges of selected recurrence intervals and selected physical and climatic characteristics of rural North Carolina basins. This study includes the development of two methods for regionalizing, or extending in space, flood-frequency estimates at gaged sites. In the first method, traditional regional regression analysis, a generalized least-squares regression analysis is used to develop a set of predictive equations for each of three hydrologic areas in North Carolina—the Blue Ridge-Piedmont, the Coastal Plain, and the Sand Hills. In the second method, the region-of-influence method, flood-frequency estimates for ungaged sites are predicted interactively, based on data from a subset of gaged sites with basin characteristics similar to those of the ungaged site. This report documents the development of both methods, using a data base of flood-discharge estimates and basin characteristics for 317 rural North Carolina gaged sites.

An initial set of 366 gaged sites was determined to have some annual peak-flow record; basin characteristics data were computed and compiled for all of these sites by using a GIS. While the development of the basin characteristics was ongoing, flow records were examined to determine which sites had flows that were affected by regulation or channelization. Of the 366 original sites, 19 sites had only regulated record and 27 sites had periods of unregulated flow record prior to regulation. After basin characteristics were developed and flow records were examined, preliminary computations of flood-frequency estimates

were begun. Results of these preliminary computations indicated the need for a generalized skew study for North Carolina basins to replace outdated generalized skews that were based on a nationwide study. After the generalized skew study, flood-frequency estimates for all sites with 10 or more years of record were computed. Flood-frequency estimates were computed for 317 rural, unregulated sites and for 42 rural, regulated sites. The sites with regulated record were excluded from further analysis.

Basin characteristics data and flood-frequency estimates for the 317 rural, unregulated sites were merged to form the data base that was used to develop the regional regression equations and the region-of-influence method. Of the 317 total sites, 222 were located in the Blue Ridge-Piedmont hydrologic area, 80 were located in the Coastal Plain hydrologic area, and 15 were located in the Sand Hills hydrologic area. Preliminary multiple regression analyses, using ordinary least-squares regression, were conducted to confirm the validity of the regionalization scheme and to identify the best combination of explanatory variables for inclusion in the generalized least-squares analysis.

Generalized least-squares analysis was used to develop a set of equations for each region that relates the 2-, 5-, 10-, 25-, 50-, 100-, 200-, and 500-year recurrence interval flood discharges to drainage area. Model error and error of prediction for the equations ranged from about 40 percent for the lower recurrence interval equations to more than 50 percent, with two equations for the Sand Hills indicating more than 60 percent.

The region-of-influence method was adapted to the available flood-frequency and basin characteristics data for North Carolina. The drainage area, hydrologic area, and latitude and longitude of an ungaged site in either the Blue Ridge-Piedmont or Coastal Plain hydrologic areas of North Carolina are required to predict the 2-, 5-, 10-, 25-, 50-, 100-, 200-, and 500-year recurrence interval flood discharges for a specified ungaged site. The Sand Hills hydrologic area did not have a sufficient number of sites to apply the region-of-influence method. Because of the complexity of the computations involved in the region-of-influence method, a computer application is required for the practical use of the method.

A brief comparison of the regional regression and region-of-influence methods, based on ease of application and RMSE of prediction, resulted in neither method being clearly superior. Both require hydrologic area and drainage area as input variables; the region-of-influence method additionally requires latitude and longitude, but these coordinates are fairly simple to determine. The RMSE were, in general, lower for the region-of-influence method, but only slightly. The region-of-influence method is newly developed and still being refined. As a result, the regional regression equations are considered to be the primary method of estimating magnitude and frequency of floods for rural ungaged sites in North Carolina. The region-of-influence method can be considered an alternative method.

A computer application is available that automates the complex computations required by the region-of-influence method. This computer application includes the option to compute flood-frequency estimates using the predictive equations developed by the traditional regional regression analysis. The computer application also computes site-specific error of prediction for each method.

REFERENCES

Acreman, M.C., and Wiltshire, S.E., 1987, Identification of regions for regional flood frequency analysis [abs.], EOS, v. 68, no. 44.

Burn, D.H., 1990a, An appraisal of the "region of influence" approach to flood frequency analysis: Hydrological Sciences Journal, v. 35, no. 24, p. 149–165.

———1990b, Evaluation of regional flood frequency analysis with a region of influence approach: Water Resources Research, v. 26, no. 10, p. 2257–2265.

Gunter, H.C., Mason, R.R., and Stamey, T.C., 1987, Magnitude and frequency of floods in rural and urban basins of North Carolina: U.S. Geological Survey Water-Resources Investigations Report 87–4096, 52 p.

Hardison, C.H., 1971, Prediction error of regression estimates of streamflow characteristics at ungaged sites: U.S. Geological Survey Professional Paper 750–C, p. C228–C236.

Hodge, S.A., and Tasker, G.D., 1995, Magnitude and frequency of floods in Arkansas: U.S. Geological Survey Water-Resources Investigations Report 95–4224, 52 p.

Hydrology Subcommittee of the Interagency Advisory Committee on Water Data, 1982, Guidelines for determining flood frequency: U.S. Geological Survey Bulletin 17B, Office of Water Data Collection, Reston, Va., 183 p.

Lichty, R.W., and Karlinger, M.R., 1990, Climate factor for small-basin flood frequency: American Water Resources Association, Water Resources Bulletin, v. 26, no. 4, p. 577–586.

Lichty, R.W., and Liscum, F., 1978, A rainfall-runoff modeling procedure for improving estimates of T-year annual floods for small drainage basins: U.S. Geological Survey Water-Resources Investigations 78–7, 44 p.

McKay, L., Hanson, S., Horn, R., Dulaney, R., Cahoon, A., Olsen, M., and Dewald, T., 1994, The U.S. EPA Reach File Version 3.0 Alpha Release (RF3-Alpha) Technical Reference: U.S. Environmental Protection Agency, Washington, D.C.

National Oceanic and Atmospheric Administration, 1999, NOAA's medium resolution digital vector shoreline, accessed March 17, 1999, at URL http://seaserver.nos.noaa.gov/projects/shoreline.html.

Stedinger, J.R., and Tasker, G.D., 1985, Regional hydrologic analysis 1—Ordinary, weighted, and generalized least square compared: American Geophysical Union, Water-Resources Research, v. 21, no. 9, p. 1421–1432.

Tasker, G.D., and Slade, R.M., 1994, An interactive regional regression approach to estimating flood quantiles, *in* Fontane, D.G., and Tuvel, H.N., eds., Proceedings of the Twenty-First Annual Conference, Water policy and management, solving the problems, May 23–26, 1994: Denver, Colo., Denver Society of American Society of Civil Engineers, p. 782–785.

Tasker, G.D., and Stedinger, J.R., 1986, Regional skew with weighted LS regression: Journal of Water Resources Planning and Management, v. 112, no. 2, p. 225–237.

——— 1989, An operational GLS model for hydrologic regression: Journal of Hydrology, v. 111, p. 361–375.

U.S. Geological Survey, 1989, Digital line graphs from 1:100,000-scale maps, National Mapping Program Technical Instructions Data Users Guide 2, 88 p.

Table 1. Map identification numbers and descriptions of gaged rural sites in North Carolina with annual peak-flow record

[nc, flood-frequency estimates were not computed because the site has less than 10 years of peak-flow record; *, duplicate map identification and station number for sites having separate period of regulated or channelized flows; r, site excluded from regional analysis because flows were affected by regulation or channelization]

Map identification number (fig. 1)	Station number	Station name	Latitude	Longitude	Period of analysis	Number of systematic peaks
1	02053110	Wildcat Swamp near Jackson	36°25'48"	77°22'24"	1953–1971	19
2	02053170	Cutawhiskie Creek near Woodland	36°17'54"	77°11'58"	1953–1971	19
3	02053200	Potecasi Creek near Union	36°22'14"	77°01'36"	1929–1996	39
4[nc]	02053400	Ahoskie Creek near Rich Square	36°14'52"	77°14'12"	1965–1973	9
5[nc]	02053450	Ahoskie Creek at Mintons Store	36°16'46"	77°09'28"	1965–1973	9
6	02053500	Ahoskie Creek at Ahoskie	36°16'48"	77°00'00"	1940–1963	13
6*[r]	02053500*	Ahoskie Creek at Ahoskie (channelized period)	36°16'48"	77°00'00"	1964–1996	33
7	02053510	Ahoskie Creek tributary at Poortown	36°16'29"	77°00'38"	1964–1973	10
8	02053550	Chinkapin Creek near Colerain	36°11'52"	76°47'14"	1953–1971	19
9	02068500	Dan River near Francisco	36°30'53"	80°18'11"	1916–1938	13
9*[r]	02068500*	Dan River near Francisco (regulated period)	36°30'53"	80°18'11"	1939–1996	54
10	02068610	Hog Rock Creek near Moores Springs	36°23'53"	80°19'46"	1955–1971	15
11	02068660	Little Snow Creek near Lawsonville	36°27'54"	80°10'28"	1954–1971	18
12	02069030	Belews Creek near Kernersville	36°12'20"	80°04'25"	1954–1971	17
13	02070500	Mayo River near Price	36°32'05"	79°59'30"	1930–1996	45
14	02070810	Jacobs Creek near Wentworth	36°20'54"	79°53'14"	1954–1973	18
15	02071000	Dan River near Wentworth	36°24'45"	79°49'35"	1908–1996	57
16	02071410	Matrimony Creek near Leaksville	36°31'39"	79°50'08"	1958–1973	15
17[nc]	02071500	Dan River at Leaksville	36°29'00"	79°46'00"	1930–1949	9
18	02074000	Smith River at Eden	36°31'31"	79°45'57"	1940–1949	10
18*[r]	02074000*	Smith River at Eden (regulated period)	36°31'31"	79°45'57"	1950–1996	47
19	02075160	Moon Creek near Yanceyville	36°28'13"	79°23'00"	1954–1989	21
20	02075230	South Country Line Creek near Hightowers	36°19'29"	79°18'20"	1954–1976	23
21	02077200	Hyco Creek near Leasburg	36°23'57"	79°11'50"	1965–1996	30
22	02077210	Kilgore Creek tributary near Leasburg	36°22'38"	79°09'57"	1954–1971	13
23	02077240	Double Creek near Roseville	36°21'44"	79°05'48"	1965–1982	16
24	02077250	South Hyco Creek near Roseville	36°23'09"	79°06'26"	1967–1980	14
25[r, nc]	02077300	Hyco River at McGehees Mill	36°31'02"	79°01'42"	1965–1973	9
26[r]	02077303	Hyco River below Afterbay Dam near McGehees Mill	36°31'24"	78°59'48"	1974–1996	23
27	02077310	Storys Creek near Roxboro	36°23'48"	79°01'14"	1954–1971	18
28[r]	02077670	Mayo Creek near Bethel Hill	36°32'26"	78°52'21"	1978–1996	19
29	02080500	Roanoke River at Roanoke Rapids	36°27'37"	77°38'04"	1878–1949	38
29*[r]	02080500*	Roanoke River at Roanoke Rapids (regulated period)	36°27'37"	77°38'04"	1956–1996	41
30	02081000	Roanoke River near Scotland Neck	36°12'34"	77°23'03"	1940–1949	10
31	02081060	Smithwick Creek tributary near Williamston	35°43'51"	77°04'42"	1953–1971	19

Table 1. Map identification numbers and descriptions of gaged rural sites in North Carolina with annual peak-flow record—Continued

[nc, flood-frequency estimates were not computed because the site has less than 10 years of peak-flow record; *, duplicate map identification and station number for sites having separate period of regulated or channelized flows; r, site excluded from regional analysis because flows were affected by regulation or channelization]

Map identification number (fig. 1)	Station number	Station name	Latitude	Longitude	Period of analysis	Number of systematic peaks
32	02081110	White Oak Swamp near Windsor	36°04'46"	76°58'36"	1953–1971	14
33[nc]	0208111310	Cashie River at Secondary Road 1257 near Windsor	36°02'51"	76°59'07"	1988–1996	9
34	02081500	Tar River near Tar River	36°11'41"	78°35'00"	1940–1996	57
35	02081710	Long Creek at Kittrell	36°13'30"	78°27'15"	1954–1976	20
36	02081747	Tar River at U.S. 401 at Louisburg	36°05'34"	78°17'48"	1964–1996	33
37	02081800	Cedar Creek near Louisburg	36°03'14"	78°20'24"	1935–1975	22
38[nc]	02081935	Tar River at Spring Hope	35°55'42"	78°08'53"	1967–1971	5
39	02082000	Tar River near Nashville	35°50'57"	77°55'51"	1919–1970	42
40	02082500	Sapony Creek near Nashville	35°53'10"	77°54'40"	1951–1970	20
41[r]	02082506	Tar River below Tar River Reservoir near Rocky Mount	35°53'58"	77°51'57"	1973–1996	24
42	02082540	Wildcat Branch near Mapleville	36°03'29"	78°08'39"	1953–1976	11
43[r]	02082585	Tar River at NC97 at Rocky Mount	35°57'15"	77°47'15"	1977–1996	20
44	02082610	Tar River near Rocky Mount	35°58'38"	77°45'35"	1964–1973	10
45	02082630	Harts Mill Run near Tarboro	35°55'40"	77°37'10"	1953–1971	18
46[nc]	02082731	Devils Cradle Creek near Alert at Secondary Road 1412	36°12'03"	78°14'19"	1993–1996	4
47	02082770	Swift Creek at Hilliardston	36°06'42"	77°55'16"	1924–1996	33
48	02082835	Fishing Creek near Warrenton	36°23'00"	78°10'54"	1954–1976	22
49	02082950	Little Fishing Creek near White Oak	36°11'08"	77°52'34"	1960–1996	37
50[nc]	02082955	Fishing Creek near Glenview	36°08'44"	77°50'31"	1967–1971	5
51	02083000	Fishing Creek near Enfield	36°09'03"	77°41'35"	1915–1996	82
52	02083090	Beaverdam Swamp near Heathsville	36°16'49"	77°41'48"	1953–1971	19
53	02083410	Deep Creek near Scotland Neck	36°09'26"	77°28'24"	1953–1973	21
54	02083500	Tar River at Tarboro	35°53'38"	77°32'00"	1897–1996	95
55	02083800	Conetoe Creek near Bethel	35°46'33"	77°27'45"	1957–1996	40
56[nc]	02083833	Conetoe Creek (tributary 3) near Penny Hill	35°46'00"	77°29'26"	1993–1996	4
57[nc]	02084160	Chicod Creek at Secondary Road 1760 near Simpson	35°33'47"	77°13'43"	1976–1981	6
57*[r]	02084160*	Chicod Creek at Secondary Road 1760 near Simpson (channelized period)	35°33'47"	77°13'43"	1982–1996	11
58[nc]	02084164	Juniper Branch at Secondary Road 1766 near Simpson	35°33'55"	77°14'43"	1976–1978	3
58*[r,nc]	02084164*	Juniper Branch at Secondary Road 1766 near Simpson (channelized period)	35°33'55"	77°14'43"	1979–1986	8
59	02084240	Collie Swamp near Everetts	35°49'34"	77°12'03"	1953–1976	24
60	02084500	Herring Run near Washington	35°34'03"	77°01'09"	1946–1980	30
61	02084520	Upper Goose Creek near Yeatsville	35°31'25"	76°53'23"	1953–1973	21
62	02084540	Durham Creek at Edward	35°19'25"	76°52'26"	1966–1992	27
63	02084570	Acre Swamp near Pinetown	35°35'02"	76°50'23"	1953–1969	17
64[nc]	02084909	Sevenmile Creek near Efland	36°03'56"	79°08'39"	1988–1996	9

Table 1. Map identification numbers and descriptions of gaged rural sites in North Carolina with annual peak-flow record—Continued

[nc, flood-frequency estimates were not computed because the site has less than 10 years of peak-flow record; *, duplicate map identification and station number for sites having separate period of regulated or channelized flows; r, site excluded from regional analysis because flows were affected by regulation or channelization]

Map identification number (fig. 1)	Station number	Station name	Latitude	Longitude	Period of analysis	Number of systematic peaks
65	02085000	Eno River at Hillsborough	36°04'18"	79°05'49"	1928–1996	54
66	02085020	Stony Creek tributary near Hillsboro	36°03'01"	79°02'14"	1953–1971	19
67	02085070	Eno River near Durham	36°04'20"	78°54'30"	1964–1996	33
68	02085190	North Fork Little River tributary near Rougemont	36°11'41"	79°00'52"	1954–1976	23
69	0208521324	Little River at Secondary Road 1461 near Orange Factory	36°08'30"	78°55'10"	1962–1996	35
70	02085500	Flat River at Bahama	36°10'57"	78°52'44"	1926–1996	71
71	02086000	Dial Creek near Bahama	36°10'36"	78°51'24"	1926–1991	47
72[r]	02086500	Flat River at Dam near Bahama	36°08'55"	78°49'43"	1928–1993	48
73	02086624	Knap Of Reeds Creek near Butner	36°07'40"	78°48'55"	1983–1995	13
74[nc]	02086849	Ellerbe Creek near Gorman	36°03'33"	78°49'58"	1983–1994	8
75	02087000	Neuse River near Northside	36°02'54"	78°44'59"	1928–1980	53
76	0208700780	Little Lick Creek above Secondary Road 1814 near Oak Grove	35°59'11"	78°47'58"	1983–1995	13
77	02087030	Lick Creek near Durham	35°58'50"	78°44'19"	1954–1971	18
78	02087140	Lower Barton Creek tributary near Raleigh	35°54'44"	78°40'55"	1954–1971	18
79	02087183	Neuse River near Falls	35°56'25"	78°34'56"	1945–1980	21
79*[r]	02087183*	Neuse River near Falls (regulated period)	35°56'25"	78°34'56"	1981–1996	16
80	02087240	Stirrup Iron Creek tributary near Nelson	35°53'06"	78°49'37"	1952–1973	20
81	02087500	Neuse River near Clayton	35°38'50"	78°24'22"	1919–1980	53
81*[r]	02087500*	Neuse River near Clayton (regulated period)	35°38'50"	78°24'22"	1981–1996	16
82	02087570	Neuse River at Smithfield	35°30'46"	78°21'00"	1908–1980	48
82*[r]	02087570*	Neuse River at Smithfield (regulated period)	35°30'46"	78°21'00"	1981–1990	10
83	02087580	Swift Creek near Apex	35°43'00"	78°45'00"	1954–1971	18
84[nc]	0208758850	Swift Creek near McCullars Crossroads	35°41'33"	78°41'34"	1992–1996	5
85	02087910	Middle Creek near Holly Springs	35°39'28"	78°48'06"	1954–1971	18
86	02088000	Middle Creek near Clayton	35°34'10"	78°35'30"	1940–1996	56
87	02088140	Stone Creek near Newton Grove	35°20'24"	78°21'54"	1953–1971	19
88	02088210	Hannah Creek near Benson	35°23'36"	78°31'48"	1953–1971	19
89	02088420	Long Branch near Selma	35°38'11"	78°15'06"	1953–1971	19
90	02088470	Little River near Kenly	35°35'20"	78°11'18"	1965–1989	25
91	02088500	Little River near Princeton	35°30'40"	78°09'38"	1919–1996	66
92	02089000	Neuse River near Goldsboro	35°20'14"	77°59'51"	1930–1980	51
92*[r]	02089000*	Neuse River near Goldsboro (regulated period)	35°20'14"	77°59'51"	1984–1996	13
93[nc]	0208925200	Bear Creek at Mays Store	35°16'28"	77°47'40"	1988–1996	9
94	02089500	Neuse River at Kinston	35°15'29"	77°35'09"	1919–1980	53
94*[r]	02089500*	Neuse River at Kinston (regulated period)	35°15'29"	77°35'09"	1981–1996	16

Table 1. Map identification numbers and descriptions of gaged rural sites in North Carolina with annual peak-flow record—Continued

[nc, flood-frequency estimates were not computed because the site has less than 10 years of peak-flow record; *, duplicate map identification and station number for sites having separate period of regulated or channelized flows; r, site excluded from regional analysis because flows were affected by regulation or channelization]

Map identification number (fig. 1)	Station number	Station name	Latitude	Longitude	Period of analysis	Number of systematic peaks
95	02090380	Contentnea Creek near Lucama	35°41'29"	78°06'38"	1965–1976	12
95*[r]	02090380*	Contentnea Creek near Lucama (regulated period)	35°41'29"	78°06'38"	1977–1996	20
96	02090560	Lee Swamp tributary near Lucama	35°38'21"	78°01'37"	1953–1971	19
97	02090625	Turner Swamp near Eureka	35°34'14"	77°52'47"	1969–1987	19
98	02090780	Whiteoak Swamp tributary near Wilson	35°42'24"	77°47'11"	1953–1971	19
99	02090960	Nahunta Swamp near Pikeville	35°30'40"	77°58'56"	1953–1973	19
100[nc]	0209096970	Moccasin Run near Patetown	35°28'46"	77°54'37"	1989–1996	8
101	02091000	Nahunta Swamp near Shine	35°29'20"	77°48'22"	1955–1996	42
102	02091430	Shepherd Run near Snow Hill	35°26'06"	77°38'42"	1953–1971	19
103	02091500	Contentnea Creek at Hookerton	35°25'44"	77°34'59"	1928–1996	68
104	02091700	Little Contentnea Creek near Farmville	35°32'40"	77°30'41"	1957–1987	31
105	02091810	Halfmoon Creek near Fort Barnwell	35°17'58"	77°21'14"	1953–1975	12
106	02091970	Creeping Swamp near Vanceboro	35°23'30"	77°13'46"	1972–1985	14
107	02092000	Swift Creek near Vanceboro	35°20'42"	77°11'45"	1909–1989	39
108	02092020	Palmetto Swamp near Vanceboro	35°20'18"	77°10'16"	1953–1976	24
109	02092120	Bachelor Creek near New Bern	35°10'24"	77°06'14"	1953–1971	19
110	02092290	Rattlesnake Branch near Comfort	35°00'31"	77°35'50"	1953–1971	19
111	02092500	Trent River near Trenton	35°03'54"	77°27'24"	1928–1996	45
112	02092520	Vine Swamp near Kinston	35°09'29"	77°33'16"	1953–1971	19
113	02092620	Upper Broad Creek tributary near Grantsboro	35°08'06"	76°56'31"	1953–1973	21
114	02092720	White Oak River at Belgrade	34°53'30"	77°14'02"	1953–1973	21
115	02092780	Bell Swamp near Hubert	34°42'04"	77°14'01"	1953–1970	18
116	02093000	New River near Gum Branch	34°50'56"	77°31'11"	1908–1996	33
117	02093040	Southwest Creek tributary near Jacksonville	34°47'18"	77°33'08"	1954–1973	19
118	02093070	Southwest Creek near Jacksonville	34°43'56"	77°32'02"	1953–1973	20
119	02093290	Haw River near Summerfield	36°14'32"	79°52'20"	1954–1971	18
120	02093500	Haw River near Benaja	36°15'06"	79°33'55"	1916–1971	43
121[nc]	02093549	Haw River at Altamahaw	36°10'43"	79°30'09"	1968–1973	6
122	02093800	Reedy Fork near Oak Ridge	36°10'22"	79°57'12"	1956–1996	41
123	02094000	Horsepen Creek at Battle Ground	36°08'34"	79°51'40"	1926–1959	30
124	02095000	South Buffalo Creek near Greensboro	36°03'36"	79°43'33"	1929–1958	29
125	02095500	North Buffalo Creek near Greensboro	36°07'13"	79°42'30"	1929–1990	62
126	02096500	Haw River at Haw River	36°05'13"	79°22'02"	1929–1996	68
127	02096660	Rock Creek near Whitsett	36°04'49"	78°47'45"	1954–1971	17
128	02096700	Big Alamance Creek near Elon College	36°02'21"	79°31'29"	1945–1980	23

Table 1. Map identification numbers and descriptions of gaged rural sites in North Carolina with annual peak-flow record—Continued

[nc, flood-frequency estimates were not computed because the site has less than 10 years of peak-flow record; *, duplicate map identification and station number for sites having separate period of regulated or channelized flows; r, site excluded from regional analysis because flows were affected by regulation or channelization]

Map identification number (fig. 1)	Station number	Station name	Latitude	Longitude	Period of analysis	Number of systematic peaks
129	02096740	Gun Branch near Alamance	36°02'58"	79°28'35"	1954–1973	19
130[nc]	02096846	Cane Creek near Orange Grove	35°59'13"	79°12'23"	1989–1996	8
131	02096850	Cane Creek near Teer	35°56'34"	79°14'46"	1960–1973	14
132	02096960	Haw River near Bynum	35°45'48"	79°08'02"	1908–1996	69
133	02097010	Robeson Creek near Pittsboro	35°43'29"	79°12'33"	1954–1976	23
134	02097314	New Hope Creek near Blands	35°53'05"	78°57'58"	1983–1996	14
135	0209741955	Northeast Creek at Secondary Road 1100 near Genlee	35°52'20"	78°54'49"	1983–1996	12
136	02097910	White Oak Creek near Wilsonville	35°44'47"	79°00'44"	1954–1971	18
137	02098000	New Hope River near Pittsboro	35°44'12"	79°01'36"	1908–1973	24
138[r]	02098198	Haw River below B. Everett Jordan Dam near Moncure	35°39'11"	79°04'03"	1980–1992	13
139[nc]	02098200	Haw River near Haywood	35°39'01"	79°03'59"	1966–1972	7
140	02098500	West Fork Deep River near High Point	36°00'15"	79°58'42"	1924–1966	42
141	02099000	East Fork Deep River near High Point	36°02'15"	79°56'46"	1929–1994	66
142	02099500	Deep River near Randleman	35°54'06"	79°51'05"	1929–1996	66
143[nc]	02100000	Muddy Creek near Archdale	35°52'35"	79°52'43"	1935–1941	7
144	02100500	Deep River at Ramseur	35°43'34"	79°39'20"	1901–1996	73
145	02101000	Bear Creek at Robbins	35°26'03"	79°35'39"	1940–1971	32
146	02101030	Falls Creek near Bennett	35°33'20"	79°29'56"	1954–1973	20
147	02101480	Sugar Creek near Tramway	35°25'28"	79°14'50"	1954–1973	20
148[nc]	0210166029	Rocky River near Crutchfield Crossroads	35°48'25"	79°31'41"	1988–1996	9
149	02101800	Tick Creek near Mount Vernon Springs	35°39'37"	79°24'08"	1959–1996	26
150	02101890	Bear Creek near Goldston	35°37'33"	79°17'54"	1952–1971	19
151	02102000	Deep River at Moncure	35°37'38"	79°06'58"	1931–1996	66
152[nc]	02102192	Buckhorn Creek near Corinth	35°33'34"	78°58'25"	1973–1980	8
152*[r]	02102192*	Buckhorn Creek near Corinth (regulated period)	35°33'34"	78°58'25"	1981–1996	16
153	02102500	Cape Fear River at Lillington	35°24'22"	78°48'48"	1924–1980	57
153*[r]	02102500*	Cape Fear River at Lillington (regulated period)	35°24'22"	78°48'48"	1981–1996	16
154	02102908	Flat Creek near Inverness	35°10'54"	79°10'40"	1969–1996	28
155	02102910	Dunhams Creek tributary near Carthage	35°18'41"	79°22'53"	1954–1971	18
156	02102930	Crane Creek near Vass	35°17'53"	79°16'19"	1954–1971	18
157	02103000	Little River at Manchester	35°11'38"	78°59'14"	1939–1950	11
158	02103390	South Prong Anderson Creek near Lillington	35°15'31"	78°55'27"	1953–1971	19
159	02103500	Little River at Linden	35°15'46"	78°46'35"	1928–1971	44
160	02104000	Cape Fear River at Fayetteville	35°02'49"	78°51'36"	1889–1976	71
161	02104080	Reese Creek near Fayetteville	35°04'49"	78°47'45"	1953–1971	17

Table 1. Map identification numbers and descriptions of gaged rural sites in North Carolina with annual peak-flow record—Continued

[nc, flood-frequency estimates were not computed because the site has less than 10 years of peak-flow record; *, duplicate map identification and station number for sites having separate period of regulated or channelized flows; r, site excluded from regional analysis because flows were affected by regulation or channelization]

Map identification number (fig. 1)	Station number	Station name	Latitude	Longitude	Period of analysis	Number of systematic peaks
162	02104500	Rockfish Creek near Hope Mills	34°57'57"	78°55'04"	1939–1954	16
163	02105500	Cape Fear River at William O. Huske Lock near Tarheel	34°50'05"	78°49'27"	1938–1980	36
163*r	02105500*	Cape Fear River at William O. Huske Lock near Tarheel (regulated period)	34°50'05"	78°49'27"	1981–1996	15
164	02105570	Browns Creek near Elizabethtown	34°36'32"	78°36'57"	1953–1973	18
165	02105630	Turnbull Creek near Elizabethtown	34°41'32"	78°35'02"	1949–1971	19
166	02105769	Cape Fear River at Lock 1 near Kelly	34°24'15"	78°17'38"	1970–1980	11
166*r	02105769*	Cape Fear River at Lock 1 near Kelly (regulated period)	34°24'15"	78°17'38"	1981–1996	16
167	02105900	Hood Creek near Leland	34°16'43"	78°07'34"	1953–1996	24
168	02106000	Little Coharie Creek near Roseboro	34°57'13"	78°29'17"	1924–1991	41
169	02106240	Turkey Creek near Turkey	35°00'11"	78°11'06"	1953–1973	18
170	02106410	Stewarts Creek tributary near Warsaw	34°57'25"	78°04'42"	1955–1971	16
171	02106500	Black River near Tomahawk	34°45'17"	78°17'21"	1928–1996	45
172	02106910	Big Swamp near Roseboro	34°58'38"	78°34'07"	1953–1973	20
173	02107000	South River near Parkersburg	34°48'45"	78°27'26"	1952–1986	35
174	02107500	Colly Creek near Kelly	34°27'48"	78°15'26"	1908–1971	21
175	02107590	Northeast Cape Fear River tributary near Mount Olive	35°11'06"	77°57'34"	1954–1971	18
176	02107600	Northeast Cape Fear River near Seven Springs	35°10'20"	77°55'56"	1959–1975	17
177	02107620	Mathews Creek near Pink Hill	35°05'49"	77°49'10"	1953–1976	16
178	02107980	Limestone Creek near Beulaville	34°45'48"	77°48'15"	1953–1971	19
179	02108000	Northeast Cape Fear River near Chinquapin	34°49'40"	77°50'00"	1941–1996	56
180	02108500	Rockfish Creek near Wallace	34°44'32"	78°02'22"	1955–1981	27
181	02108548	Little Rockfish Creek at Wallace	34°44'02"	77°58'03"	1977–1992	16
182	02108610	Pike Creek near Burgaw	34°30'00"	77°53'58"	1953–1971	18
183	02108630	Turkey Creek near Castle Hayne	34°23'47"	77°54'48"	1953–1971	19
184	02108960	Buckhead Branch near Bolton	34°20'52"	78°26'19"	1953–1971	19
185	02109500	Waccamaw River at Freeland	34°05'43"	78°32'55"	1940–1996	57
186	02109640	Wet Ash Swamp near Ash	34°02'17"	78°30'14"	1953–1971	18
187	02110020	Mill Branch near Tabor City	34°10'59"	78°48'08"	1953–1971	18
188	02111000	Yadkin River at Patterson	35°59'29"	81°33'30"	1940–1996	56
189	02111180	Elk Creek at Elkville	36°04'16"	81°24'13"	1940–1996	31
190	02111340	South Prong Lewis Fork Creek near North Wilkesboro	36°11'23"	81°24'40"	1955–1971	16
191	02111500	Reddies River at North Wilkesboro	36°10'29"	81°10'09"	1940–1995	55
192	02112000	Yadkin River at Wilkesboro	36°09'09"	81°08'45"	1904–1961	48
192*r	02112000*	Yadkin River at Wilkesboro (regulated period)	36°09'09"	81°08'45"	1962–1996	35
193	02112120	Roaring River near Roaring River	36°14'59"	81°02'39"	1916–1996	32

Table 1. Map identification numbers and descriptions of gaged rural sites in North Carolina with annual peak-flow record—Continued

[nc, flood-frequency estimates were not computed because the site has less than 10 years of peak-flow record; *, duplicate map identification and station number for sites having separate period of regulated or channelized flows; r, site excluded from regional analysis because flows were affected by regulation or channelization]

Map identification number (fig. 1)	Station number	Station name	Latitude	Longitude	Period of analysis	Number of systematic peaks
194	02112247	Elkin River at Elkin	36°15'12"	80°51'45"	1971–1980	10
195[r]	02112250	Yadkin River at Elkin	36°14'30"	80°50'49"	1965–1995	31
196	02112360	Mitchell River near State Road	36°18'42"	80°48'26"	1940–1996	32
197	02112410	Fisher River near Bottom	36°26'35"	80°46'12"	1954–1971	16
198	02112500	Fisher River near Dobson	36°23'05"	80°40'20"	1922–1933	12
199	02113000	Fisher River near Copeland	36°21'26"	80°41'10"	1922–1996	74
200[r]	02113500	Yadkin River at Siloam	35°16'55"	80°33'46"	1977–1987	11
201	02113850	Ararat River at Ararat	36°24'16"	80°33'43"	1947–1996	32
202	02114010	Ararat River at Dam near Pilot Mountain	36°22'00"	80°33'00"	1938–1968	16
203	02114450	Little Yadkin River at Dalton	36°17'56"	80°25'53"	1961–1996	36
204[r]	02115360	Yadkin River at Enon	36°07'55"	80°26'39"	1965–1996	32
205	02115500	Forbush Creek near Yadkinville	36°08'13"	80°33'09"	1941–1971	31
206	02115520	Logan Creek near Smithtown	36°12'50"	80°33'32"	1954–1971	18
207	02115540	South Deep Creek near Yadkinville	36°08'00"	80°46'00"	1954–1966	13
208[nc]	02115730	Mill Creek near Stanleyville	36°10'49"	80°16'19"	1965–1972	6
209[nc]	02115740	Mill Creek near Oldtown	36°09'06"	80°19'03"	1965–1972	6
210[nc]	02115810	Little Creek near Clemmons	36°02'19"	80°20'46"	1965–1972	6
211	02115830	Smith Creek near Kernersville	36°06'19"	80°06'19"	1954–1971	18
212	02115856	Salem Creek near Atwood	36°02'10"	80°18'35"	1972–1982	11
213	02115860	Muddy Creek near Muddy Creek	36°00'01"	80°20'25"	1965–1991	19
214	02115900	South Fork Muddy Creek near Clemmons	36°00'22"	80°18'07"	1965–1991	19
215	02116500	Yadkin River at Yadkin College	35°51'23"	80°23'14"	1916–1961	33
215*[r]	02116500*	Yadkin River at Yadkin College (regulated period)	35°51'23"	80°23'14"	1962–1996	35
216	02117030	Humpy Creek near Fork	35°51'17"	80°26'24"	1969–1983	15
217	02117410	McClelland Creek near Statesville	35°57'04"	80°56'46"	1954–1976	22
218	02117500	Rocky Creek at Turnersburg	35°54'23"	80°48'34"	1941–1971	31
219	02118000	South Yadkin River near Mocksville	35°50'41"	80°39'34"	1930–1996	58
220	02118500	Hunting Creek near Harmony	36°00'00"	80°44'44"	1952–1996	45
221	02119000	South Yadkin River at Cooleemee	35°48'10"	80°33'22"	1916–1965	37
222[r]	02119400	Third Creek near Stony Point	35°52'04"	81°04'00"	1957–1969	13
223	02120500	Third Creek at Cleveland	35°45'00"	80°41'00"	1916–1954	14
223*[r]	02120500*	Third Creek at Cleveland (regulated period)	35°45'00"	80°41'00"	1955–1971	17
224	02120780	Second Creek near Barber	35°43'05"	80°35'45"	1980–1996	17
225	02120820	Deal Branch near Salisbury	35°44'43"	80°30'25"	1954–1971	15
226	02121000	Yadkin River near Salisbury	35°43'30"	80°23'50"	1896–1927	30

Table 1. Map identification numbers and descriptions of gaged rural sites in North Carolina with annual peak-flow record—Continued

[nc, flood-frequency estimates were not computed because the site has less than 10 years of peak-flow record; *, duplicate map identification and station number for sites having separate period of regulated or channelized flows; r, site excluded from regional analysis because flows were affected by regulation or channelization]

Map identification number (fig. 1)	Station number	Station name	Latitude	Longitude	Period of analysis	Number of systematic peaks
227	02121180	North Potts Creek at Linwood	35°45'28"	80°19'24"	1980–1990	11
228	02121500	Abbotts Creek at Lexington	35°48'23"	80°14'05"	1941–1995	23
229	02121940	Flat Swamp Creek near Lexington	35°43'59"	80°06'37"	1954–1971	18
230[nc]	02122500	Yadkin River at High Rock	35°35'46"	80°13'59"	1916–1927	8
230*[r]	02122500*	Yadkin River at High Rock (regulated period)	35°35'46"	80°13'59"	1942–1961	19
231	02122560	Cabin Creek near Jackson Hill	35°34'57"	80°09'12"	1954–1971	17
232	02122720	Beaverdam Creek tributary near Denton	35°31'57"	80°05'04"	1954–1971	18
233	02123500	Uwharrie River near Eldorado	35°25'47"	80°01'05"	1928–1971	32
234	02123567	Dutchmans Creek near Uwharrie	35°22'05"	80°01'49"	1982–1995	12
235	02124060	North Prong Clarke Creek near Huntersville	35°25'13"	80°47'54"	1954–1973	20
236	02124130	Mallard Creek near Charlotte	35°19'05"	80°44'16"	1954–1971	18
237	02125000	Big Bear Creek near Richfield	35°20'02"	80°20'09"	1955–1996	42
238	02125410	Chinkapin Creek near Monroe	35°02'48"	80°29'33"	1953–1971	18
239	02126000	Rocky River near Norwood	35°08'54"	80°10'33"	1908–1996	67
240	02127000	Brown Creek near Polkton	35°02'10"	80°08'42"	1908–1971	36
241	02127390	Palmetto Branch at Ansonville	35°06'03"	80°07'11"	1953–1971	17
242	02128000	Little River near Star	35°23'11"	79°49'56"	1955–1996	41
243	02128260	Cheek Creek near Pekin	35°12'37"	79°50'49"	1954–1971	18
244[r]	02129000	Pee Dee River near Rockingham	34°56'46"	79°52'11"	1928–1996	69
245	02129440	South Fork Jones Creek near Morven	34°53'51"	80°00'24"	1954–1971	18
246	02129530	Little Creek tributary near Pee Dee	34°55'07"	79°54'38"	1955–1971	11
247	02132230	Bridge Creek tributary at Johns	34°42'12"	79°26'34"	1953–1973	18
248[nc]	0213228795	Jordan Creek near Silver Hill	34°58'12"	79°31'35"	1985–1993	9
249	02132320	Big Shoe Heel Creek near Laurinburg	34°45'01"	79°23'12"	1987–1996	10
250	02133500	Drowning Creek near Hoffman	35°03'38"	79°29'39"	1940–1996	57
251	02133590	Beaverdam Creek near Aberdeen	35°00'42"	79°26'50"	1953–1971	18
252	02133624	Lumber River near Maxton	34°46'22"	79°19'55"	1987–1996	10
253	02133960	Raft Swamp near Red Springs	34°52'16"	79°10'12"	1953–1971	15
254	02134380	Tenmile Swamp near Lumberton	34°43'34"	78°59'31"	1953–1973	18
255	02134500	Lumber River at Boardman	34°26'32"	78°57'38"	1901–1996	67
256	02137000	Mill Creek at Old Fort	35°37'59"	82°11'14"	1940–1975	15
257	02137727	Catawba River near Pleasant Gardens	35°41'09"	82°03'40"	1981–1996	16
258	02138000	Catawba River near Marion	35°42'26"	82°02'00"	1916–1981	40
259	02138500	Linville River near Nebo	35°47'41"	81°53'25"	1916–1996	74
260	02138680	White Branch near Marion	35°38'46"	81°55'18"	1955–1971	14

Table 1. Map identification numbers and descriptions of gaged rural sites in North Carolina with annual peak-flow record—Continued

[nc, flood-frequency estimates were not computed because the site has less than 10 years of peak-flow record; *, duplicate map identification and station number for sites having separate period of regulated or channelized flows; r, site excluded from regional analysis because flows were affected by regulation or channelization]

Map identification number (fig. 1)	Station number	Station name	Latitude	Longitude	Period of analysis	Number of systematic peaks
261	02140980	Carroll Creek near Collettsville	35°53'21"	81°44'18"	1955–1971	17
262	02140991	Johns River at Arneys Store	35°50'01"	81°42'43"	1986–1996	11
263	02141130	Zacks Fork Creek near Lenoir	35°55'32"	81°31'13"	1967–1976	10
264	02141890	Duck Creek near Taylorsville	35°53'34"	81°18'09"	1954–1971	18
265	02142000	Lower Little River near All Healing Springs	35°56'44"	81°14'13"	1954–1995	42
266	02142480	Hagan Creek near Catawba	35°40'20"	81°08'12"	1954–1971	15
267[r]	02142500	Catawba River at Catawba	35°43'00"	81°03'59"	1936–1962	30
268	0214253830	Norwood Creek near Troutman	35°40'48"	80°56'44"	1984–1996	13
269	02142900	Long Creek near Paw Creek	35°19'42"	80°54'35"	1966–1996	31
270	02143000	Henry Fork near Henry River	35°41'03"	81°24'10"	1916–1996	59
271	02143040	Jacob Fork at Ramsey	35°35'26"	81°34'02"	1962–1996	35
272	02143310	Lithia Inn Branch near Lincolnton	35°27'47"	81°13'27"	1954–1971	14
273	02143500	Indian Creek near Laboratory	35°25'20"	81°15'52"	1916–1996	45
274	02144000	Long Creek near Bessemer City	35°18'23"	81°14'05"	1954–1996	43
275	02145000	South Fork Catawba River at Lowell	35°17'10"	81°06'00"	1940–1996	42
276	02146890	East Fork Twelve Mile Creek near Waxhaw	34°57'46"	80°42'40"	1954–1972	18
277	02146900	Twelve Mile Creek near Waxhaw	34°57'08"	80°45'21"	1949–1996	36
278[r]	02148500	Broad River near Chimney Rock	35°25'29"	82°10'54"	1928–1958	31
279	02149000	Cove Creek near Lake Lure	35°25'24"	82°06'42"	1916–1996	45
280	02150420	Camp Creek near Rutherfordton	35°27'47"	81°54'29"	1955–1971	17
281	02151000	Second Broad River at Cliffside	35°14'08"	81°45'57"	1926–1996	71
282	02151500	Broad River near Boiling Springs	35°12'39"	81°41'52"	1926–1996	70
283	02152100	First Broad River near Casar	35°29'35"	81°40'56"	1960–1996	36
284	02152420	Big Knob Creek near Fallston	35°29'34"	81°32'25"	1953–1971	18
285	02152500	First Broad River near Lawndale	35°22'50"	81°32'40"	1916–1980	41
286	02152610	Sugar Branch near Boiling Springs	35°15'00"	81°37'15"	1954–1987	34
287	03160610	Old Field Creek near West Jefferson	36°21'29"	81°31'46"	1955–1971	17
288	03161000	South Fork New River near Jefferson	36°23'35"	81°24'26"	1916–1996	69
289	03162110	Buffalo Creek at Warrensville	36°27'22"	81°30'51"	1940–1971	17
290	03162500	North Fork New River at Crumpler	36°31'04"	81°23'18"	1878–1966	39
291	03162880	Vile Creek near Sparta	36°30'39"	81°06'16"	1955–1971	17
292	03439000	French Broad River at Rosman	35°08'32"	82°49'28"	1908–1996	62
293	03439500	French Broad at Calvert	35°08'55"	82°47'57"	1916–1955	31
294	03440000	Catheys Creek near Brevard	35°12'40"	82°47'00"	1945–1996	21
295	03441000	Davidson River near Brevard	35°16'23"	82°42'21"	1876–1996	73

Table 1. Map identification numbers and descriptions of gaged rural sites in North Carolina with annual peak-flow record—Continued

[nc, flood-frequency estimates were not computed because the site has less than 10 years of peak-flow record; *, duplicate map identification and station number for sites having separate period of regulated or channelized flows; r, site excluded from regional analysis because flows were affected by regulation or channelization]

Map identification number (fig. 1)	Station number	Station name	Latitude	Longitude	Period of analysis	Number of systematic peaks
296	03441440	Little River above High Falls near Cedar Mountain	35°11'32"	82°36'49"	1963–1990	28
297	03441500	Little River near Penrose	35°13'23"	82°38'07"	1916–1973	13
298	03442000	Crab Creek near Penrose	35°14'02"	82°36'39"	1916–1965	13
299	03443000	French Broad River at Blantyre	35°17'56"	82°37'26"	1875–1996	76
300	03444000	Boylston Creek near Horseshoe	35°22'10"	82°33'50"	1943–1973	13
301	03444500	South Fork Mills River at The Pink Beds	35°21'59"	82°44'20"	1927–1973	31
302	03446000	Mills River near Mills River	35°23'55"	82°35'42"	1876–1996	64
303	03446410	Laurel Branch near Edneyville	35°22'15"	82°24'10"	1955–1970	12
304	03446500	Clear Creek near Hendersonville	35°21'14"	82°26'40"	1910–1965	10
305	03447000	Mud Creek at Naples	35°22'52"	82°29'54"	1916–1955	17
306	03447500	Cane Creek at Fletcher	35°26'08"	82°29'23"	1916–1973	18
307	03448000	French Broad River at Bent Creek	35°30'07"	82°35'33"	1916–1986	52
308	03448500	Hominy Creek at Candler	35°32'28"	82°40'35"	1940–1978	35
309[nc]	0344894205	North Fork Swannanoa River near Walkertown	35°41'07"	82°19'58"	1990–1996	7
310	03449000	North Fork Swannanoa River near Black Mountain	35°39'11"	82°21'04"	1926–1952	27
310*[r,nc]	03449000*	North Fork Swannanoa River near Black Mountain (regulated period)	35°39'11"	82°21'04"	1953–1957	5
311	03450000	Beetree Creek near Swannanoa	35°39'11"	82°24'20"	1927–1996	61
312	03451000	Swannanoa River at Biltmore	35°34'06"	82°32'42"	1791–1979	51
312*[r]	03451000*	Swannanoa River at Biltmore (regulated period)	35°34'06"	82°32'42"	1980–1996	17
313	03451500	French Broad River at Asheville	35°36'33"	82°34'43"	1896–1996	101
314	03452000	Sandymush Creek near Alexander	35°43'49"	82°40'11"	1940–1955	13
315	03453000	Ivy Creek near Marshall	35°46'10"	82°37'16"	1876–1996	42
316	03453500	French Broad River at Marshall	35°47'10"	82°39'39"	1916–1996	54
317	03453880	Brush Creek at Walnut	35°50'40"	82°44'30"	1954–1971	17
318	03454000	Big Laurel Creek near Stackhouse	35°55'12"	82°45'42"	1935–1978	39
319	03454500	French Broad River at Hot Springs	35°53'23"	82°49'16"	1796–1978	15
320	03455500	West Fork Pigeon River above Lake Logan near Hazelwood	35°23'46"	82°56'17"	1955–1996	42
321[r,nc]	0345577330	West Fork Pigeon River near Retreat	35°25'36"	82°55'12"	1989–1996	8
322[r]	03456100	West Fork Pigeon River at Bethel	35°27'48"	82°54'00"	1955–1996	41
323	03456500	East Fork Pigeon River near Canton	35°27'42"	82°52'13"	1955–1996	42
324	03456991	Pigeon River near Canton	35°31'19"	82°50'53"	1810–1996	71
325	03457500	Allen Creek near Hazelwood	35°25'49"	83°00'30"	1950–1973	24
326[nc]	03458500	Pigeon River nr Crabtree	35°34'37"	82°57'07"	1922–1930	9
327	03459000	Jonathan Creek near Cove Creek	35°37'21"	83°00'25"	1931–1973	43
328	03459500	Pigeon River near Hepco	35°38'05"	82°59'21"	1876–1996	69

Table 1. Map identification numbers and descriptions of gaged rural sites in North Carolina with annual peak-flow record—Continued

[nc, flood-frequency estimates were not computed because the site has less than 10 years of peak-flow record; *, duplicate map identification and station number for sites having separate period of regulated or channelized flows; r, site excluded from regional analysis because flows were affected by regulation or channelization]

Map identification number (fig. 1)	Station number	Station name	Latitude	Longitude	Period of analysis	Number of systematic peaks
329	03460000	Cataloochee Creek near Cataloochee	35°40'02"	83°04'22"	1935–1996	52
330	03461910	North Toe River at Newland	36°05'01"	81°55'45"	1955–1973	19
331	03462000	North Toe River at Altapass	35°53'59"	82°01'50"	1935–1978	24
332	03463300	South Toe River near Celo	35°49'53"	82°11'04"	1958–1996	39
333	03463500	South Toe River at Newdale	35°54'22"	82°11'19"	1916–1978	18
334	03463910	Phipps Creek near Burnsville	35°54'40"	82°22'10"	1957–1973	14
335	03464000	Cane River near Sioux	36°00'52"	82°19'40"	1893–1978	38
336	03464500	Nolichucky River at Poplar	36°04'29"	82°20'41"	1926–1978	30
337	03478910	Cove Creek at Sherwood	36°15'50"	81°47'03"	1940–1972	18
338	03479000	Watauga River near Sugar Grove	36°14'18"	81°49'22"	1916–1996	57
339	03480540	Peavine Branch near Banner Elk	36°10'20"	81°54'42"	1953–1972	11
340	03481000	Elk River near Elk Park	36°11'01"	81°57'45"	1935–1978	21
341	03500000	Little Tennessee River near Prentiss	35°08'59"	83°22'47"	1899–1996	52
342	03500240	Cartoogechaye Creek near Franklin	35°09'31"	83°23'40"	1949–1996	35
343[r]	03500500	Cullasaja River at Highlands	35°04'14"	83°13'57"	1928–1971	44
344	03501000	Cullasaja River at Cullasaja	35°09'59"	83°19'25"	1908–1976	52
345	03501760	Coon Creek near Franklin	35°14'04"	83°20'28"	1957–1973	17
346	03502000	Little Tennessee River at Iotla	35°13'59"	82°23'32"	1899–1949	17
347	03503000	Little Tennessee River at Needmore	35°20'11"	83°31'37"	1899–1996	51
348	03504000	Nantahala River near Rainbow Springs	35°07'37"	83°37'09"	1940–1996	57
349[r]	03505500	Nantahala River at Nantahala	35°17'55"	83°39'21"	1943–1982	39
350	03506500	Nantahala River at Almond	35°22'32"	83°33'59"	1923–1941	17
351	03507000	Little Tennessee River at Judson	35°24'30"	83°33'26"	1897–1944	48
352[nc]	03508000	Tuckasegee River at Tuckasegee	35°16'55"	83°07'37"	1840–1940	6
352*[r]	03508000*	Tuckasegee River at Tuckasegee (regulated period)	35°16'55"	83°07'37"	1941–1976	37
353	03509000	Scott Creek above Sylva	35°23'02"	83°12'51"	1929–1995	48
354	03510500	Tuckasegee River At Dillsboro	35°22'00"	83°15'37"	1928–1940	13
354*[r]	03510500*	Tuckasegee River at Dillsboro (regulated period)	35°22'00"	83°15'37"	1941–1982	43
355	03511000	Oconaluftee River at Cherokee	35°29'04"	83°18'56"	1867–1949	28
356	03512000	Oconaluftee River at Birdtown	35°27'41"	83°21'13"	1946–1996	48
357	03513000	Tuckasegee River at Bryson City	35°25'40"	83°26'51"	1898–1940	43
357*[r]	03513000*	Tuckasegee River at Bryson City (regulated period)	35°25'40"	83°26'51"	1941–1995	55
358	03513410	Jenkins Branch tributary at Bryson City	35°24'50"	83°27'20"	1957–1971	13
359	03513500	Noland Creek near Bryson City	35°29'05"	83°30'15"	1936–1971	36
360	03514000	Hazel Creek at Proctor	35°28'38"	83°42'58"	1943–1952	10

Table 1. Map identification numbers and descriptions of gaged rural sites in North Carolina with annual peak-flow record—Continued

[nc, flood-frequency estimates were not computed because the site has less than 10 years of peak-flow record; *, duplicate map identification and station number for sites having separate period of regulated or channelized flows; r, site excluded from regional analysis because flows were affected by regulation or channelization]

Map identification number (fig. 1)	Station number	Station name	Latitude	Longitude	Period of analysis	Number of systematic peaks
361[nc]	03515000	Little Tennessee River at Fontana Dam	35°26'45"	83°48'20"	1939–1944	6
361*[r]	03515000*	Little Tennessee River at Fontana Dam (regulated period)	35°26'45"	83°48'20"	1945–1954	10
362	03516000	Snowbird Creek near Robbinsville	35°18'40"	83°51'35"	1943–1952	10
363	03546000	Shooting Creek near Hayesville	35°01'29"	83°42'27"	1923–1955	13
364[r]	03547000	Hiwassee River below Chatuge Dam near Hayesville	35°01'45"	83°47'45"	1943–1974	32
365	03548500	Hiwassee River above Murphy	35°04'49"	84°00'10"	1897–1941	44
365*[r]	03548500*	Hiwassee River above Murphy (regulated period)	35°04'49"	84°00'10"	1942–1996	55
366	03550000	Valley River at Tomotla	35°08'20"	83°58'50"	1898–1996	86

Table 2. Recurrence interval discharges and basin characteristics for gaged rural sites in North Carolina

[Q, recurrence interval flood discharge for years indicated; DA, drainage area; L, channel length; CSLOPE, channel slope; BSLOPE, basin slope; SHAPE, basin shape; CF, climate factor for recurrence interval years indicated; REG, region: 1, if site is in Blue Ridge-Piedmont; 2, if site is in Coastal Plain; 3, if site is in Sand Hills; nc, flood-frequency estimates were not computed because the site has less than 10 years of peak-flow record; *, duplicate map identification number for sites having separate periods of regulated or channelized flows; r, site excluded from regional analysis because flows were affected by regulation or channelization; n.a., data not available]

Map identification number (fig. 1)	Q_2	Q_5	Q_{10}	Q_{25}	Q_{50}	Q_{100}	Q_{200}	Q_{500}	DA (mi^2)	L (mi)	CSLOPE (ft/mi)	BSLOPE (ft/mi)	SHAPE (DA/L^2)	CF_2	CF_{25}	CF_{100}	REG
1	51.7	99.7	142	210	271	343	426	557	0.7	1.17	8.61	4.33	0.53	2.24	2.89	3.08	2
2	334	643	914	1340	1720	2160	2660	3440	11.8	5.84	2.93	13.25	.33	2.25	2.90	3.09	2
3	1950	2950	3690	4720	5550	6430	7370	8720	225	30.86	3.18	16.19	.23	2.26	2.90	3.10	2
4[nc]	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	3.7	2.65	2.38	4.10	.58	2.25	2.90	3.09	2
5[nc]	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	24.0	8.03	2.18	9.79	.34	2.26	2.90	3.09	2
6	818	1380	1830	2500	3070	3700	4390	5440	63.3	18.55	2.34	8.23	.18	2.26	2.90	3.10	2
6*[r]	963	1340	1630	2070	2440	2860	3330	4040	63.3	18.55	2.34	8.23	.18	2.26	2.90	3.10	2
7	209	253	280	313	337	361	384	415	2.6	3.07	7.12	2.28	.25	2.26	2.90	3.10	2
8	220	426	612	912	1190	1520	1900	2510	8.9	4.96	6.71	1.53	.35	2.31	2.94	3.14	1
9	4600	7600	10000	13600	16700	20100	24000	29800	129	46.52	51.21	211.90	.06	2.07	2.77	2.95	1
9*[r]	4210	7370	9940	13700	17000	20600	24600	30500	129	46.52	51.21	211.90	.06	2.07	2.77	2.95	1
10	128	186	227	284	329	377	427	499	.3	1.96	393.39	225.04	.33	2.08	2.78	2.95	1
11	617	945	1190	1540	1820	2120	2450	2920	5.4	5.21	53.24	154.08	.20	2.08	2.77	2.95	1
12	879	1510	2030	2810	3500	4280	5160	6510	14.9	6.25	18.65	87.83	.37	2.11	2.80	2.97	1
13	7020	11800	15700	21600	26700	32600	39100	49200	242	36.02	21.01	145.96	.20	2.10	2.79	2.97	1
14	878	1550	2130	3020	3810	4730	5770	7390	16.2	7.98	40.33	137.37	.26	2.11	2.80	2.97	1
15	18300	25500	30400	36600	41300	46100	51000	57600	1053	97.48	23.62	148.17	.11	2.10	2.80	2.97	1
16	960	1640	2200	3030	3730	4520	5410	6730	12.0	9.17	30.50	138.34	.14	2.10	2.79	2.97	1
17[nc]	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	1150	116.76	20.23	154.63	.09	2.10	2.79	2.97	1
18	15000	24300	31600	42200	51100	61000	71900	88000	538	77.81	10.76	194.65	.09	2.10	2.79	2.97	1
18*[r]	10300	15300	19000	24100	28200	32500	37000	43500	538	77.81	10.76	194.65	.09	2.10	2.79	2.97	1
19	821	1640	2390	3590	4700	6010	7540	9960	29.9	8.97	20.81	117.88	.41	2.11	2.80	2.98	1
20	907	1380	1740	2240	2660	3120	3610	4340	7.1	4.32	40.20	103.92	.35	2.12	2.80	2.98	1
21	1870	3710	5370	8010	10400	13200	16500	21600	45.9	14.66	13.59	118.79	.22	2.12	2.80	2.98	1
22	44.2	77.6	106	149	188	232	282	359	.2	.39	19.18	66.32	.66	2.12	2.80	2.98	1
23	724	1270	1720	2410	3010	3700	4480	5670	7.5	4.39	53.25	94.67	.39	2.12	2.80	2.98	1
24	1960	3680	5190	7570	9720	12200	15100	19600	56.5	14.40	13.70	104.89	.27	2.12	2.80	2.98	1
25[r, nc]	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	191	30.26	6.66	108.97	.22	2.11	2.80	2.98	1
26[r]	4450	8400	10900	13700	15600	17100	18500	20100	202	32.72	6.28	108.48	.19	2.14	2.82	3.01	1
27	173	260	322	408	475	547	622	727	2.0	2.60	38.00	100.05	.28	2.16	2.83	3.01	1
28[r]	385	1010	1700	3030	4430	6280	8690	13000	53.5	16.06	13.21	108.45	.21	2.14	2.82	3.01	1
29	77200	105000	125000	151000	172000	194000	217000	249000	8386	280.12	4.03	159.83	.11	2.22	2.87	3.06	1
29*[r]	22800	29400	35100	43900	51600	60500	70800	87000	8386	280.12	4.03	159.83	.11	2.22	2.87	3.06	1
30	51400	78200	99000	129000	154000	181000	212000	257000	8671	311.75	3.83	155.40	.09	2.25	2.89	3.09	2
31	70.7	148	220	340	452	585	744	1000	.9	1.17	18.78	10.29	.38	2.29	2.92	3.12	2

Table 2. Recurrence interval discharges and basin characteristics for gaged rural sites in North Carolina—Continued

[Q, recurrence interval flood discharge for years indicated; DA, drainage area; L, channel length; CSLOPE, channel slope; BSLOPE, basin slope; SHAPE, basin shape; CF, climate factor for recurrence interval years indicated; REG, region: 1, if site is in Blue Ridge-Piedmont; 2, if site is in Coastal Plain; 3, if site is in Sand Hills; nc, flood-frequency estimates were not computed because the site has less than 10 years of peak-flow record; *, duplicate map identification number for sites having separate periods of regulated or channelized flows; r, site excluded from regional analysis because flows were affected by regulation or channelization; n.a., data not available]

Map identification number (fig. 1)	Q_2	Q_5	Q_{10}	Q_{25}	Q_{50}	Q_{100}	Q_{200}	Q_{500}	DA (mi^2)	L (mi)	CSLOPE (ft/mi)	BSLOPE (ft/mi)	SHAPE (DA/L^2)	CF_2	CF_{25}	CF_{100}	REG
32	637	1010	1290	1700	2030	2400	2810	3400	17.1	6.76	5.83	9.42	0.42	2.27	2.91	3.10	2
33[nc]	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	108	24.98	2.45	9.75	.19	2.36	2.98	3.16	2
34	5040	8190	10600	14000	16800	19800	23100	27800	167	30.12	11.33	77.62	.18	2.17	2.84	3.02	1
35	348	685	997	1510	1990	2570	3270	4390	3.3	5.41	35.92	104.99	.22	2.18	2.84	3.02	1
36	5920	9130	11500	14900	17600	20500	23600	28100	427	52.26	7.45	93.14	.16	2.19	2.85	3.03	1
37	1190	1990	2610	3500	4240	5050	5940	7230	47.8	14.33	14.77	93.74	.23	2.19	2.85	3.03	1
38[nc]	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	660	76.62	4.14	90.51	.11	2.21	2.87	3.05	1
39	6690	9690	11900	15000	17400	20000	22800	26900	701	87.60	4.17	88.94	.09	2.25	2.90	3.09	1
40	913	1630	2220	3120	3900	4790	5790	7300	64.8	19.85	4.83	44.34	.17	2.25	2.90	3.09	1
41[r]	7530	10000	11200	12400	13100	13700	14100	14600	777	95.12	3.81	84.58	.09	2.25	2.90	3.09	2
42	56.2	115	170	261	347	450	572	769	.3	.53	98.69	39.08	.76	2.20	2.86	3.04	2
43[r]	8570	11300	12400	13400	13900	14300	14500	14800	925	102.35	3.42	80.30	.09	2.25	2.90	3.09	2
44	7700	10100	11700	13800	15300	16900	18500	20700	930	104.89	3.71	79.30	.09	2.25	2.90	3.09	2
45	266	399	498	635	746	865	993	1180	8.6	5.49	10.82	37.10	.29	2.26	2.90	3.09	2
46[nc]	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	13.4	7.79	24.43	81.63	.22	2.18	2.85	3.03	2
47	1820	3000	3930	5280	6430	7690	9090	11200	166	40.80	5.81	87.37	.10	2.24	2.89	3.08	2
48	1150	2170	3080	4540	5860	7420	9250	12100	45.0	11.36	11.65	85.77	.36	2.17	2.84	3.02	2
49	2410	3980	5250	7160	8810	10700	12800	15900	177	30.93	6.85	76.60	.19	2.24	2.89	3.08	2
50[nc]	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	440	53.86	3.65	82.13	.16	2.24	2.89	3.08	2
51	4590	7460	9720	13000	15700	18700	22000	26900	526	57.85	3.97	77.03	.16	2.24	2.89	3.08	2
52	210	422	619	946	1250	1630	2070	2790	9.4	5.22	15.08	36.16	.37	2.23	2.88	3.07	2
53	386	808	1210	1890	2540	3330	4290	5850	11.7	5.95	4.60	10.38	.36	2.25	2.89	3.09	2
54	13900	20300	24900	31200	36300	41700	47500	55700	2183	148.95	2.63	66.04	.10	2.26	2.90	3.09	2
55	819	1250	1570	2000	2350	2710	3100	3650	78.1	16.59	2.14	8.86	.26	2.27	2.91	3.10	2
56[nc]	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	11.0	9.76	2.24	3.45	.13	2.26	2.91	3.10	2
57[nc]	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	45.0	10.82	3.64	12.34	.38	2.32	2.94	3.12	2
57*[r]	1460	2260	2690	3110	3370	3570	3740	3920	45.0	10.82	3.64	12.34	.38	2.32	2.94	3.12	2
58[nc]	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	7.5	4.90	9.66	13.23	.34	2.32	2.94	3.12	2
58*[r,nc]	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	7.5	4.90	9.66	13.23	.34	2.32	2.94	3.12	2
59	671	1160	1570	2190	2720	3320	4000	5020	29.0	9.75	3.43	16.82	.33	2.28	2.91	3.11	2
60	244	397	517	687	828	982	1150	1390	9.6	4.76	8.21	8.18	.43	2.32	2.95	3.14	2
61	103	192	269	388	494	615	754	968	1.5	2.37	5.55	3.21	.29	2.32	2.95	3.14	2
62	443	750	1000	1380	1710	2090	2510	3150	26.0	9.15	2.07	16.80	.28	2.37	2.98	3.17	2
63	623	1150	1610	2330	2980	3720	4580	5920	32.2	7.85	3.90	5.16	.53	2.32	2.95	3.14	2
64[nc]	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	14.1	6.11	26.95	79.86	.38	2.15	2.82	2.99	1

Table 2. Recurrence interval discharges and basin characteristics for gaged rural sites in North Carolina—Continued

[Q, recurrence interval flood discharge for years indicated; DA, drainage area; L, channel length; CSLOPE, channel slope; BSLOPE, basin slope; SHAPE, basin shape; CF, climate factor for recurrence interval years indicated; REG, region: 1, if site is in Blue Ridge-Piedmont; 2, if site is in Coastal Plain; 3, if site is in Sand Hills; nc, flood-frequency estimates were not computed because the site has less than 10 years of peak-flow record; *, duplicate map identification number for sites having separate periods of regulated or channelized flows; r, site excluded from regional analysis because flows were affected by regulation or channelization; n.a., data not available]

Map identification number (fig. 1)	Q_2	Q_5	Q_{10}	Q_{25}	Q_{50}	Q_{100}	Q_{200}	Q_{500}	DA (mi^2)	L (mi)	CSLOPE (ft/mi)	BSLOPE (ft/mi)	SHAPE (DA/L^2)	CF_2	CF_{25}	CF_{100}	REG
65	2770	4340	5550	7270	8680	10200	11900	14300	66.0	15.62	11.78	81.54	0.27	2.17	2.84	3.01	1
66	87.2	165	232	339	434	545	673	872	.8	1.11	126.53	135.53	.72	2.17	2.84	3.01	1
67	4840	8500	11400	15800	19400	23400	27800	34400	141	33.53	11.00	92.00	.13	2.17	2.84	3.01	1
68	156	273	371	519	649	796	962	1220	1.0	1.34	39.06	63.54	.52	2.17	2.84	3.01	1
69	3470	6180	8410	11700	14600	17800	21400	26700	78.2	18.92	15.26	76.96	.22	2.17	2.84	3.01	1
70	6820	10800	13800	18000	21400	25100	29100	34800	149	24.50	12.08	79.98	.25	2.17	2.84	3.01	1
71	337	606	835	1190	1510	1870	2280	2930	4.8	5.13	31.73	112.77	.18	2.17	2.84	3.01	1
72[r]	6650	10200	12400	15000	16800	18400	19900	21700	168	29.13	11.83	82.17	.20	2.17	2.84	3.01	1
73	2210	3980	5470	7750	9770	12100	14700	18700	43.0	14.25	17.05	85.63	.21	2.17	2.84	3.02	1
74[nc]	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	21.9	12.15	14.29	84.86	.15	2.17	2.84	3.01	1
75	8500	13200	16900	22100	26500	31200	36400	44000	535	47.55	9.18	83.44	.24	2.18	2.84	3.02	1
76	868	1330	1670	2140	2520	2920	3350	3960	10.1	5.01	16.67	91.21	.40	2.18	2.84	3.02	1
77	696	827	908	1000	1070	1140	1210	1300	13.8	7.04	15.49	100.58	.28	2.18	2.84	3.02	1
78	109	195	267	377	472	581	704	891	.7	1.06	98.62	100.04	.60	2.18	2.85	3.02	1
79	6960	9670	11600	14300	16400	18600	21000	24400	771	64.87	7.08	87.30	.18	2.19	2.85	3.03	1
79*[r]	4820	5900	6620	7540	8230	8930	9640	10600	771	64.87	7.08	87.30	.18	2.19	2.85	3.03	1
80	49.4	85.2	115	159	197	240	289	363	.3	.73	75.75	111.31	.48	2.18	2.84	3.02	1
81	9710	13200	15700	18900	21400	23900	26600	30300	1150	94.85	4.90	87.62	.13	2.25	2.88	3.05	1
81*[r]	7090	10000	12300	15600	18300	21300	24600	29600	1150	94.85	4.90	87.62	.13	2.25	2.88	3.05	1
82	8810	11400	13300	15600	17500	19300	21300	24000	1206	108.53	4.37	86.24	.10	2.26	2.88	3.05	1
82*[r]	7630	10300	11700	13000	13700	14300	14700	15200	1206	108.53	4.37	86.24	.10	2.26	2.88	3.05	1
83	1390	2100	2630	3370	3970	4610	5300	6280	19.5	7.18	21.38	89.93	.37	2.23	2.87	3.03	1
84[nc]	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	35.8	11.55	13.54	89.20	.27	2.24	2.87	3.04	1
85	535	980	1360	1960	2490	3100	3800	4890	8.2	6.53	23.77	82.99	.19	2.23	2.87	3.03	1
86	1410	2620	3670	5310	6790	8510	10500	13600	83.5	22.16	9.08	81.46	.17	2.25	2.88	3.04	1
87	575	1120	1610	2430	3180	4090	5160	6890	27.9	9.77	11.67	46.15	.29	2.26	2.88	3.05	2
88	139	296	449	711	965	1280	1660	2300	2.6	3.45	34.25	80.30	.23	2.26	2.88	3.04	2
89	487	1030	1530	2370	3160	4100	5230	7040	7.6	5.36	21.29	45.76	.27	2.25	2.89	3.06	2
90	1630	2620	3390	4500	5420	6430	7530	9150	191	39.18	5.87	56.06	.12	2.25	2.89	3.06	2
91	2320	3500	4350	5500	6410	7360	8350	9740	232	49.28	5.32	50.49	.09	2.26	2.89	3.06	2
92	12700	18300	22500	28200	32700	37600	42800	50200	2399	169.34	2.78	68.54	.08	2.31	2.93	3.09	2
92*[r]	10200	15700	19700	25100	29500	34000	38900	45700	2399	169.34	2.78	68.54	.08	2.31	2.93	3.09	2
93[nc]	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	57.7	15.33	4.61	19.67	.25	2.32	2.93	3.10	2
94	13500	19800	24400	30800	35900	41300	47200	55500	2692	203.19	2.10	63.32	.07	2.33	2.94	3.11	2
94*[r]	10800	15700	18900	22800	25500	28200	30900	34200	2692	203.19	2.10	63.32	.07	2.33	2.94	3.11	2

Table 2. Recurrence interval discharges and basin characteristics for gaged rural sites in North Carolina—Continued

[Q, recurrence interval flood discharge for years indicated; DA, drainage area; L, channel length; CSLOPE, channel slope; BSLOPE, basin slope; SHAPE, basin shape; CF, climate factor for recurrence interval years indicated; REG, region: 1, if site is in Blue Ridge-Piedmont; 2, if site is in Coastal Plain; 3, if site is in Sand Hills; nc, flood-frequency estimates were not computed because the site has less than 10 years of peak-flow record; *, duplicate map identification number for sites having separate periods of regulated or channelized flows; r, site excluded from regional analysis because flows were affected by regulation or channelization; n.a., data not available]

Map identification number (fig. 1)	Q_2	Q_5	Q_{10}	Q_{25}	Q_{50}	Q_{100}	Q_{200}	Q_{500}	DA (mi^2)	L (mi)	CSLOPE (ft/mi)	BSLOPE (ft/mi)	SHAPE (DA/L^2)	CF_2	CF_{25}	CF_{100}	REG
95	1760	2860	3740	5010	6080	7260	8570	10500	161	28.02	6.14	55.52	0.20	2.25	2.90	3.09	2
95*[r]	2160	3250	3900	4620	5090	5520	5900	6350	161	28.02	6.14	55.52	.20	2.25	2.90	3.09	2
96	171	293	392	538	662	799	952	1180	2.8	3.74	11.87	30.38	.21	2.28	2.91	3.09	2
97	121	252	376	584	782	1020	1310	1780	2.1	2.12	15.71	20.07	.43	2.29	2.92	3.10	2
98	126	258	381	584	774	1000	1270	1710	2.6	2.51	17.67	8.17	.44	2.29	2.92	3.10	2
99	386	656	879	1220	1510	1840	2210	2790	18.6	10.51	7.48	38.55	.16	2.30	2.92	3.09	2
100[nc]	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	1.9	3.15	13.58	10.80	.23	2.30	2.92	3.10	2
101	1090	1740	2250	3000	3620	4310	5060	6190	80.4	22.82	4.03	28.29	.15	2.33	2.95	3.13	2
102	70	125	191	301	407	535	688	937	1.5	2.11	43.56	39.01	.34	2.32	2.93	3.10	2
103	4000	6410	8220	10800	12800	15000	17400	20800	733	71.80	2.84	35.09	.14	2.32	2.93	3.11	2
104	1420	2150	2690	3450	4060	4730	5440	6480	93.3	18.49	3.08	17.46	.28	2.32	2.93	3.11	2
105	340	711	1060	1650	2200	2870	3670	4970	4.9	3.71	7.90	21.89	.35	2.33	2.94	3.11	2
106	501	1000	1460	2210	2900	3730	4710	6290	27.0	8.46	5.17	11.26	.41	2.33	2.94	3.12	2
107	1930	3090	3990	5250	6290	7420	8640	10400	182	27.24	2.11	9.57	.25	2.33	2.94	3.12	2
108	517	1140	1760	2830	3870	5140	6710	9300	24.0	6.29	3.48	16.11	.57	2.33	2.94	3.12	2
109	869	1590	2220	3220	4120	5170	6390	8310	33.6	8.56	2.56	6.86	.51	2.34	2.95	3.12	2
110	217	390	539	772	982	1220	1500	1940	2.5	3.23	5.47	11.12	.44	2.34	2.94	3.11	2
111	1760	2910	3830	5180	6340	7640	9080	11300	168	32.46	2.04	17.33	.16	2.34	2.94	3.11	2
112	230	435	613	892	1140	1430	1770	2290	6.3	3.77	11.66	7.75	.46	2.33	2.94	3.11	2
113	141	367	620	1110	1630	2330	3240	4890	3.3	3.60	5.93	2.05	.28	2.39	2.99	3.17	2
114	606	1300	1990	3190	4360	5810	7610	10600	53.3	15.10	2.22	5.60	.26	2.36	2.96	3.13	2
115	122	263	403	645	883	1180	1540	2150	4.9	2.55	10.28	15.94	.71	2.40	2.99	3.15	2
116	1570	2760	3750	5260	6590	8090	9800	12400	94	15.74	4.07	24.27	.33	2.35	2.95	3.11	2
117	109	214	308	455	588	743	921	1200	1.0	1.21	31.68	22.23	.38	2.35	2.95	3.11	2
118	769	1570	2320	3580	4760	6190	7910	10700	26.9	10.28	6.16	22.31	.25	2.40	2.97	3.11	2
119	469	758	982	1300	1560	1850	2160	2620	26.3	12.57	10.60	85.79	.17	2.11	2.80	2.97	1
120	1670	3020	4180	6020	7670	9590	11800	15300	168	32.93	6.66	89.48	.16	2.12	2.80	2.98	1
121[nc]	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	188	42.64	5.17	90.27	.10	2.12	2.81	2.98	1
122	899	1630	2240	3150	3940	4820	5800	7280	20.6	9.17	19.56	88.69	.25	2.11	2.80	2.97	1
123	662	1130	1520	2120	2640	3240	3930	4980	15.9	7.48	21.30	81.00	.29	2.12	2.80	2.98	1
124	1660	2900	3950	5580	7030	8700	10600	13600	33.6	13.47	12.21	74.59	.19	2.12	2.80	2.98	1
125	2110	3600	4830	6690	8320	10200	12200	15400	37.1	12.83	12.47	73.20	.23	2.12	2.80	2.98	1
126	11500	18200	23300	30600	36500	42900	49800	59800	606	52.96	6.84	85.86	.22	2.14	2.81	2.98	1
127	1260	2330	3250	4680	5950	7410	9090	11700	14.6	6.27	21.48	86.92	.37	2.17	2.84	3.02	1
128	3740	5340	6460	7920	9050	10200	11400	13100	116	20.29	12.27	88.54	.28	2.13	2.81	2.98	1

Table 2. Recurrence interval discharges and basin characteristics for gaged rural sites in North Carolina—Continued

[Q, recurrence interval flood discharge for years indicated; DA, drainage area; L, channel length; CSLOPE, channel slope; BSLOPE, basin slope; SHAPE, basin shape; CF, climate factor for recurrence interval years indicated; REG, region: 1, if site is in Blue Ridge-Piedmont; 2, if site is in Coastal Plain; 3, if site is in Sand Hills; nc, flood-frequency estimates were not computed because the site has less than 10 years of peak-flow record; *, duplicate map identification number for sites having separate periods of regulated or channelized flows; r, site excluded from regional analysis because flows were affected by regulation or channelization; n.a., data not available]

Map identification number (fig. 1)	Q_2	Q_5	Q_{10}	Q_{25}	Q_{50}	Q_{100}	Q_{200}	Q_{500}	DA (mi^2)	L (mi)	CSLOPE (ft/mi)	BSLOPE (ft/mi)	SHAPE (DA/L^2)	CF_2	CF_{25}	CF_{100}	REG
129	221	566	945	1660	2410	3390	4650	6880	5.0	4.16	22.72	65.39	0.22	2.13	2.81	2.98	1
130[nc]	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	7.5	4.66	25.70	94.32	.35	2.18	2.83	2.99	1
131	1820	2860	3650	4760	5670	6650	7710	9240	33.7	9.75	18.51	93.90	.35	2.18	2.83	2.99	1
132	25000	36600	45000	56300	65300	74800	84800	99000	1275	82.36	6.20	85.28	.19	2.21	2.85	3.01	1
133	175	313	428	602	755	927	1120	1420	1.1	1.93	40.95	95.44	.41	2.19	2.83	3.00	1
134	2370	4060	5380	7250	8790	10400	12200	14800	75.9	21.38	18.18	93.48	.17	2.21	2.85	3.01	1
135	1300	2260	3060	4270	5330	6540	7900	9990	21.1	8.79	11.61	78.16	.27	2.21	2.85	3.02	1
136	828	1250	1550	1980	2330	2690	3090	3650	23.6	11.69	16.49	90.08	.19	2.22	2.86	3.02	1
137	3880	5610	6850	8500	9800	11200	12600	14600	285	34.81	11.44	91.08	.23	2.22	2.86	3.02	1
138[r]	14800	17000	17600	18000	18200	18200	18300	18300	1689	91.01	6.68	87.29	.20	2.22	2.86	3.02	1
139[nc]	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	1689	91.01	6.68	87.29	.20	.00	.22	.86	1
140	1590	2590	3390	4570	5580	6690	7930	9790	32.1	9.71	15.85	66.01	.34	2.16	2.82	2.99	1
141	1660	2770	3630	4860	5890	7000	8210	9960	14.8	6.54	18.72	79.92	.34	2.12	2.80	2.98	1
142	4760	7290	9170	11800	13900	16200	18600	22100	125	23.34	10.90	83.89	.23	2.17	2.82	2.99	1
143[nc]	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	16.7	9.61	19.55	79.42	.18	2.17	2.82	2.99	1
144	12100	17400	21200	26400	30600	35100	39700	46400	349	45.45	8.79	94.27	.17	2.18	2.83	3.00	1
145	6400	11700	16400	23900	30700	38700	48000	62700	137	18.60	17.28	90.65	.40	2.20	2.84	3.01	1
146	521	860	1130	1520	1850	2220	2620	3230	3.0	2.38	36.12	70.12	.48	2.19	2.84	3.00	1
147	143	266	371	533	675	838	1020	1310	.9	1.60	68.37	91.52	.32	2.24	2.87	3.03	1
148[nc]	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	7.4	6.09	22.99	69.92	.21	2.18	2.83	3.00	1
149	1090	2050	2870	4160	5300	6620	8140	10500	15.5	8.06	24.42	85.61	.24	2.19	2.83	3.00	1
150	2920	4480	5650	7310	8660	10100	11700	14000	43.2	16.66	9.64	61.78	.15	2.19	2.83	3.00	1
151	21800	29600	35200	42500	48300	54300	60600	69500	1434	115.73	5.50	91.10	.11	2.23	2.86	3.02	1
152[nc]	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	76.3	15.61	9.64	103.60	.31	2.23	2.87	3.03	1
152*[r]	746	1470	2170	3380	4570	6070	7930	11100	76.3	15.61	9.64	103.60	.31	2.23	2.87	3.03	1
153	42100	57300	68000	82300	93500	105000	118000	135000	3464	119.72	6.22	93.60	.24	2.25	2.87	3.04	1
153*[r]	28700	36300	41100	46700	50800	54700	58600	63600	3464	119.72	6.22	93.60	.24	2.25	2.87	3.04	1
154	146	229	293	385	462	546	638	772	7.6	5.87	42.55	86.78	.22	2.25	2.87	3.03	3
155	90.9	168	236	347	449	571	715	945	2.2	2.10	63.92	88.21	.48	2.21	2.84	3.01	3
156	863	1490	2000	2770	3420	4160	4980	6220	32.4	11.10	17.11	86.34	.27	2.24	2.87	3.03	3
157	2760	3700	4340	5190	5850	6530	7250	8230	348	40.74	7.27	84.77	.21	2.25	2.87	3.03	3
158	120	199	262	356	436	527	628	781	7.6	4.37	17.00	77.76	.39	2.25	2.87	3.04	3
159	3570	5540	7100	9370	11300	13400	15800	19300	459	57.53	5.33	80.68	.14	2.26	2.88	3.04	3
160	46000	63400	75700	92000	105000	118000	132000	151000	4395	156.35	5.15	89.44	.18	2.26	2.88	3.04	2
161	175	319	442	634	806	1000	1230	1590	7.9	4.81	7.27	23.11	.43	2.26	2.88	3.04	2

Table 2. Recurrence interval discharges and basin characteristics for gaged rural sites in North Carolina—Continued

[Q, recurrence interval flood discharge for years indicated; DA, drainage area; L, channel length; CSLOPE, channel slope; BSLOPE, basin slope; SHAPE, basin shape; CF, climate factor for recurrence interval years indicated; REG, region: 1, if site is in Blue Ridge-Piedmont; 2, if site is in Coastal Plain; 3, if site is in Sand Hills; nc, flood-frequency estimates were not computed because the site has less than 10 years of peak-flow record; *, duplicate map identification number for sites having separate periods of regulated or channelized flows; r, site excluded from regional analysis because flows were affected by regulation or channelization; n.a., data not available]

Map identification number (fig. 1)	Q_2	Q_5	Q_{10}	Q_{25}	Q_{50}	Q_{100}	Q_{200}	Q_{500}	DA (mi^2)	L (mi)	CSLOPE (ft/mi)	BSLOPE (ft/mi)	SHAPE (DA/L^2)	CF_2	CF_{25}	CF_{100}	REG
162	2090	3600	4870	6790	8480	10400	12600	15900	292	39.33	5.14	66.05	0.18	2.29	2.89	3.05	3
163	36500	45500	51200	58300	63500	68600	73800	80600	4852	176.67	4.67	86.19	.16	2.30	2.90	3.05	2
163*[r]	28500	33500	36200	39100	41000	42700	44200	46100	4852	176.67	4.67	86.19	.16	2.30	2.90	3.05	2
164	147	385	654	1170	1730	2480	3460	5230	14.1	7.56	12.15	24.86	.30	2.31	2.90	3.05	2
165	490	1000	1490	2310	3100	4060	5210	7120	60.1	19.22	3.19	11.61	.16	2.32	2.90	3.05	2
166	32500	47400	58200	72900	84600	96900	110000	128000	5255	229.76	3.55	81.22	.10	2.38	2.95	3.09	2
166*[r]	25100	33900	39800	47400	53100	58800	64700	72600	5255	229.76	3.55	81.22	.10	2.38	2.95	3.09	2
167	657	1200	1660	2360	2970	3660	4440	5630	21.6	7.51	8.09	12.90	.38	2.39	2.95	3.09	2
168	861	1480	1990	2760	3420	4170	5010	6290	92.8	24.69	4.25	22.86	.16	2.29	2.89	3.04	2
169	395	764	1090	1600	2050	2580	3190	4130	15.7	5.78	6.99	19.12	.45	2.33	2.92	3.07	2
170	56.9	96.8	129	178	219	265	317	395	.5	.86	8.83	41.15	.58	2.33	2.92	3.07	2
171	4140	6860	9050	12300	15000	18100	21500	26700	676	52.96	2.15	31.48	.24	2.33	2.91	3.05	2
172	555	1110	1640	2510	3330	4330	5540	7510	32.3	11.64	7.19	23.35	.25	2.28	2.89	3.04	2
173	1970	2990	3740	4790	5630	6530	7500	8880	379	65.20	2.72	25.51	.09	2.32	2.90	3.05	2
174	488	732	912	1160	1360	1580	1810	2140	103	29.39	1.79	6.03	.12	2.38	2.95	3.09	2
175	31.2	68.7	105	166	224	295	379	517	.6	1.41	31.94	10.32	.33	2.32	2.93	3.09	2
176	940	1590	2110	2880	3530	4260	5060	6270	47.5	10.83	5.65	18.88	.41	2.32	2.93	3.09	2
177	139	310	482	788	1090	1470	1950	2760	8.6	4.84	19.02	36.42	.36	2.33	2.93	3.10	2
178	1070	2100	3040	4570	5980	7660	9640	12800	49.7	15.46	4.84	24.90	.22	2.38	2.95	3.09	2
179	4810	7600	9780	12900	15600	18400	21600	26300	599	47.76	2.47	26.63	.27	2.34	2.93	3.09	2
180	1510	2600	3490	4820	5980	7270	8720	10900	69.3	13.50	5.64	26.50	.37	2.37	2.94	3.08	2
181	280	345	386	436	472	508	543	589	7.8	5.35	4.79	12.77	.29	2.38	2.94	3.08	2
182	129	331	550	953	1370	1900	2570	3720	1.1	1.27	3.71	.81	.70	2.39	2.95	3.10	2
183	326	731	1140	1870	2600	3520	4670	6630	10.2	4.40	6.96	7.38	.49	2.40	2.96	3.10	2
184	411	700	936	1290	1590	1920	2300	2870	15.3	4.35	5.03	6.70	.75	2.32	2.91	3.06	2
185	3870	6090	7780	10100	12100	14200	16400	19600	680	38.60	.87	7.67	.47	2.33	2.92	3.07	2
186	416	796	1130	1660	2140	2700	3350	4370	16.0	5.02	4.36	.72	.66	2.35	2.93	3.08	2
187	150	323	489	772	1040	1370	1770	2420	3.8	3.57	9.32	17.28	.30	2.32	2.91	3.06	1
188	1380	2730	4000	6120	8150	10600	13600	18500	28.8	15.93	89.91	323.81	.12	2.15	2.78	2.94	1
189	4070	8150	11900	18100	23900	30800	39000	52300	48.1	20.64	48.76	314.89	.12	2.14	2.78	2.95	1
190	456	768	1020	1400	1730	2100	2520	3150	11.0	6.66	386.26	325.50	.26	2.11	2.77	2.95	1
191	3640	6000	7830	10500	12700	15000	17600	21400	89.2	20.61	32.65	265.44	.20	2.13	2.79	2.96	1
192	12700	20900	27600	37800	46700	56800	68300	85800	504	48.21	21.29	243.78	.22	2.13	2.79	2.96	1
192*[r]	7340	9530	11000	12700	14100	15400	16700	18500	504	48.21	21.29	243.78	.22	2.13	2.79	2.96	1
193	6280	12000	17000	24700	31500	39300	48200	61800	128	20.23	33.91	254.90	.31	2.09	2.77	2.95	1

Table 2. Recurrence interval discharges and basin characteristics for gaged rural sites in North Carolina—Continued

[Q, recurrence interval flood discharge for years indicated; DA, drainage area; L, channel length; CSLOPE, channel slope; BSLOPE, basin slope; SHAPE, basin shape; CF, climate factor for recurrence interval years indicated; REG, region: 1, if site is in Blue Ridge-Piedmont; 2, if site is in Coastal Plain; 3, if site is in Sand Hills; nc, flood-frequency estimates were not computed because the site has less than 10 years of peak-flow record; *, duplicate map identification number for sites having separate periods of regulated or channelized flows; r, site excluded from regional analysis because flows were affected by regulation or channelization; n.a., data not available]

Map identification number (fig. 1)	Q_2	Q_5	Q_{10}	Q_{25}	Q_{50}	Q_{100}	Q_{200}	Q_{500}	DA (mi^2)	L (mi)	CSLOPE (ft/mi)	BSLOPE (ft/mi)	SHAPE (DA/L^2)	CF_2	CF_{25}	CF_{100}	REG
194	3250	4640	5630	6960	8010	9110	10300	11900	35.5	14.74	32.24	168.32	0.16	2.08	2.77	2.95	1
195[r]	16200	21900	25000	28300	30400	32200	33800	35700	869	70.50	12.10	218.10	.17	2.08	2.77	2.95	1
196	3270	5300	6850	9020	10800	12700	14700	17600	78.8	22.18	31.52	281.93	.16	2.08	2.77	2.95	1
197	1800	2650	3260	4090	4750	5440	6180	7220	44.7	15.33	27.18	257.85	.21	2.08	2.77	2.95	1
198	4710	6530	7810	9490	10800	12100	13500	15500	109	27.61	14.56	202.20	.15	2.08	2.77	2.95	1
199	5450	9070	12000	16500	20300	24700	29600	37000	128	30.68	13.23	198.38	.13	2.08	2.77	2.95	1
200[r]	28000	35300	39200	43300	45800	48100	50100	52500	1226	93.13	6.98	208.67	.14	2.20	2.82	2.99	1
201	6730	11200	14800	20000	24300	29100	34300	42000	231	28.32	19.16	173.69	.29	2.08	2.77	2.95	1
202	7760	13200	17500	23700	28800	34300	40400	49200	287	31.47	17.57	165.49	.29	2.08	2.77	2.95	1
203	3240	5400	7100	9550	11600	13800	16300	19900	42.8	13.55	22.17	145.31	.25	2.09	2.78	2.95	1
204[r]	39200	53100	59000	63800	66100	67700	68800	69800	1694	110.42	5.25	193.78	.14	2.10	2.78	2.96	1
205	1150	1700	2100	2650	3090	3560	4050	4760	22.1	11.48	21.49	105.01	.17	2.09	2.78	2.96	1
206	217	357	467	625	756	898	1050	1280	.9	1.13	85.26	88.49	.64	2.09	2.78	2.95	1
207	1570	2900	4040	5830	7430	9270	11400	14700	19.5	8.29	38.11	134.61	.26	2.14	2.80	2.97	1
208[nc]	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	10.2	6.32	28.92	66.74	.28	2.10	2.79	2.97	1
209[nc]	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	27.8	10.14	19.34	69.36	.27	2.10	2.79	2.97	1
210[nc]	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	6.8	6.67	31.49	60.00	.16	2.12	2.80	2.98	1
211	208	398	570	850	1110	1420	1780	2360	2.2	1.69	47.86	66.44	.73	2.12	2.80	2.98	1
212	2660	3280	3680	4160	4510	4860	5200	5650	65.6	16.39	13.47	86.79	.24	2.12	2.80	2.98	1
213	4210	7040	9300	12600	15400	18500	21900	27000	186	25.82	10.45	90.93	.27	2.13	2.80	2.98	1
214	1250	1950	2470	3210	3820	4460	5160	6170	42.9	14.12	15.63	92.00	.21	2.12	2.80	2.98	1
215	30200	43600	53500	67200	78300	90100	103000	121000	2280	149.50	4.38	169.42	.10	2.15	2.80	2.98	1
215*[r]	32700	46400	54600	64100	70700	76700	82400	89400	2280	149.50	4.38	169.42	.10	2.15	2.80	2.98	1
216	93.2	180	258	382	494	625	778	1020	1.0	1.60	56.18	100.24	.40	2.15	2.80	2.98	1
217	227	316	378	458	520	583	648	737	1.6	2.80	78.01	132.30	.19	2.15	2.80	2.97	1
218	2660	4240	5450	7140	8520	10000	11600	13900	101	34.64	18.90	138.79	.08	2.15	2.80	2.97	1
219	4060	6610	8570	11300	13600	16100	18700	22500	306	48.80	11.36	120.89	.13	2.15	2.80	2.98	1
220	5080	7620	9450	11900	13900	16000	18100	21200	155	30.06	13.21	148.05	.17	2.15	2.80	2.97	1
221	6940	10200	12500	15900	18500	21400	24500	29000	569	56.83	10.23	125.33	.17	2.16	2.80	2.98	1
222[r]	63.2	68.3	70.9	73.6	75.3	76.9	78.2	79.9	4.8	4.56	29.75	52.42	.23	2.15	2.80	2.97	1
223	1430	2080	2550	3200	3710	4260	4830	5650	87.4	33.20	11.75	91.45	.08	2.16	2.80	2.98	1
223*[r]	1490	1830	2050	2310	2490	2680	2860	3100	87.4	33.20	11.75	91.45	.08	2.16	2.80	2.98	1
224	2750	4040	4980	6300	7360	8490	9710	11500	118	16.59	12.07	96.08	.43	2.16	2.81	2.98	1
225	560	1040	1440	2070	2620	3260	3980	5090	3.9	3.17	28.98	99.43	.36	2.16	2.81	2.98	1
226	53300	79500	98500	124000	145000	166000	189000	221000	3450	170.84	3.90	170.74	.12	2.16	2.81	2.98	1

Table 2. Recurrence interval discharges and basin characteristics for gaged rural sites in North Carolina—Continued

[Q, recurrence interval flood discharge for years indicated; DA, drainage area; L, channel length; CSLOPE, channel slope; BSLOPE, basin slope; SHAPE, basin shape; CF, climate factor for recurrence interval years indicated; REG, region: 1, if site is in Blue Ridge-Piedmont; 2, if site is in Coastal Plain; 3, if site is in Sand Hills; nc, flood-frequency estimates were not computed because the site has less than 10 years of peak-flow record; *, duplicate map identification number for sites having separate periods of regulated or channelized flows; r, site excluded from regional analysis because flows were affected by regulation or channelization; n.a., data not available]

Map identification number (fig. 1)	Q_2	Q_5	Q_{10}	Q_{25}	Q_{50}	Q_{100}	Q_{200}	Q_{500}	DA (mi^2)	L (mi)	CSLOPE (ft/mi)	BSLOPE (ft/mi)	SHAPE (DA/L^2)	CF_2	CF_{25}	CF_{100}	REG
227	566	934	1230	1650	2010	2400	2840	3480	9.6	5.98	17.12	96.67	0.27	2.15	2.81	2.98	1
228	4640	6540	7870	9640	11000	12400	13900	16000	174	29.85	9.77	97.43	.20	2.17	2.82	2.99	1
229	449	685	862	1110	1310	1530	1760	2100	6.6	6.14	16.73	89.50	.17	2.17	2.82	3.00	1
230^nc	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	4000	186.48	3.43	160.97	.11	2.18	2.83	3.00	1
230*^r	41300	51800	58000	65200	70200	74900	79400	85000	4000	186.48	3.43	160.97	.11	2.18	2.83	3.00	1
231	852	955	1020	1090	1130	1180	1220	1280	13.7	6.59	21.96	86.01	.31	2.19	2.83	3.00	1
232	397	715	990	1420	1800	2250	2760	3570	2.9	2.80	45.36	113.22	.37	2.19	2.83	3.00	1
233	7730	10500	12500	15100	17000	19100	21200	24200	342	51.53	6.63	131.78	.13	2.19	2.83	3.00	1
234	425	719	959	1320	1630	1970	2360	2940	3.4	4.41	72.33	173.68	.18	2.20	2.83	3.00	1
235	571	1080	1520	2230	2880	3630	4510	5890	3.6	3.55	35.95	95.22	.28	2.18	2.81	2.98	1
236	1670	2420	2960	3700	4290	4920	5580	6520	20.7	7.02	29.69	93.64	.42	2.18	2.81	2.99	1
237	4630	7020	8770	11100	13000	15000	17100	20000	55.6	14.09	21.06	90.60	.28	2.20	2.83	3.00	1
238	1400	2320	3040	4090	4970	5930	6990	8540	8.5	5.26	27.59	55.44	.28	2.22	2.83	3.00	1
239	33200	47300	56800	69100	78400	87900	97500	111000	1372	81.80	5.70	84.63	.21	2.23	2.85	3.01	1
240	2190	4120	5850	8630	11200	14200	17800	23600	110	26.68	7.72	83.54	.16	2.24	2.85	3.01	1
241	176	284	367	486	584	690	806	975	.9	1.06	89.92	65.70	.73	2.24	2.85	3.01	1
242	4490	6350	7650	9360	10700	12000	13500	15400	106	29.55	12.14	108.15	.12	2.20	2.84	3.00	1
243	1030	1750	2350	3270	4070	4970	6000	7570	15.4	9.24	47.53	142.49	.18	2.20	2.84	3.01	1
244^r	73500	106000	132000	170000	202000	237000	276000	335000	6863	255.33	4.59	134.56	.11	2.25	2.86	3.02	1
245	845	1220	1480	1850	2140	2440	2760	3210	16.7	5.91	33.41	75.65	.47	2.24	2.86	3.02	1
246	16.8	28.7	38.6	53.4	66.2	80.7	97.1	122	.1	1.03	114.65	86.40	.14	2.25	2.86	3.02	1
247	107	195	272	393	502	630	778	1010	6.2	5.46	11.97	23.56	.19	2.26	2.87	3.03	3
248^nc	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	.1	.37	119.76	58.22	1.45	2.25	2.86	3.03	3
249	363	528	646	806	932	1060	1200	1400	83.3	20.22	7.30	40.58	.20	2.29	2.89	3.04	3
250	1350	2430	3400	4990	6460	8230	10300	13800	183	26.23	10.26	76.68	.27	2.23	2.85	3.02	3
251	77	116	144	184	215	248	284	334	4.7	4.32	33.83	66.99	.24	2.25	2.86	3.03	3
252	1450	2200	2760	3530	4160	4830	5560	6600	365	64.79	4.11	63.07	.09	2.29	2.89	3.04	3
253	467	648	774	942	1070	1210	1350	1550	39.8	14.30	7.65	24.83	.21	2.28	2.88	3.04	3
254	232	345	428	541	633	729	832	979	16.1	6.85	3.83	7.32	.36	2.30	2.89	3.05	3
255	4890	7610	9660	12500	14900	17400	20100	24000	1228	130.44	2.09	27.34	.07	2.31	2.90	3.05	3
256	1120	1810	2370	3200	3920	4710	5610	6950	20.7	8.95	268.53	407.99	.26	2.19	2.78	2.94	1
257	6270	9440	11800	14900	17500	20200	23000	27100	127	20.20	67.00	299.40	.31	2.18	2.78	2.94	1
258	7050	12500	17200	24600	31300	39200	48300	62700	172	23.12	52.06	299.74	.32	2.18	2.78	2.94	1
259	4580	8750	12500	18600	24200	30900	38700	51300	66.7	34.93	86.54	285.37	.05	2.17	2.78	2.94	1
260	57.3	93.4	122	163	197	234	275	336	0.5	1.07	526.60	243.48	.48	2.18	2.78	2.95	1

Table 2. Recurrence interval discharges and basin characteristics for gaged rural sites in North Carolina—Continued

[Q, recurrence interval flood discharge for years indicated; DA, drainage area; L, channel length; CSLOPE, channel slope; BSLOPE, basin slope; SHAPE, basin shape; CF, climate factor for recurrence interval years indicated; REG, region: 1, if site is in Blue Ridge-Piedmont; 2, if site is in Coastal Plain; 3, if site is in Sand Hills; nc, flood-frequency estimates were not computed because the site has less than 10 years of peak-flow record; *, duplicate map identification number for sites having separate periods of regulated or channelized flows; r, site excluded from regional analysis because flows were affected by regulation or channelization; n.a., data not available]

Map identification number (fig. 1)	Q_2	Q_5	Q_{10}	Q_{25}	Q_{50}	Q_{100}	Q_{200}	Q_{500}	DA (mi^2)	L (mi)	CSLOPE (ft/mi)	BSLOPE (ft/mi)	SHAPE (DA/L^2)	CF_2	CF_{25}	CF_{100}	REG
261	229	420	585	840	1070	1330	1630	2100	2.4	3.09	572.66	225.03	0.23	2.16	2.78	2.94	1
262	11900	21200	29000	41000	51600	63600	77400	98500	201	34.09	20.52	277.87	.17	2.17	2.78	2.95	1
263	449	776	1040	1440	1790	2170	2600	3250	9.1	6.71	31.80	227.46	.19	2.16	2.78	2.95	1
264	945	1560	2040	2760	3370	4040	4790	5910	18.4	9.83	44.78	189.99	.19	2.15	2.79	2.97	1
265	1520	2660	3610	5020	6240	7610	9140	11400	28.2	8.08	47.94	173.16	.43	2.15	2.79	2.97	1
266	853	1430	1900	2590	3190	3850	4600	5720	7.8	4.30	54.76	63.08	.44	2.17	2.80	2.97	1
267r	20500	39400	58400	92700	128000	174000	233000	338000	1535	99.51	5.45	174.39	.16	2.16	2.80	2.97	1
268	568	1010	1380	1940	2420	2970	3590	4540	7.2	4.34	31.23	139.86	.35	2.16	2.80	2.98	1
269	1330	2040	2590	3360	4010	4700	5460	6570	16.4	7.16	19.53	80.95	.31	2.18	2.81	2.98	1
270	5020	8550	11400	15600	19100	23100	27500	34000	83.2	30.41	35.01	165.65	.09	2.17	2.80	2.97	1
271	2280	3550	4510	5860	6960	8160	9450	11300	25.7	8.74	112.47	223.96	.33	2.18	2.79	2.95	1
272	199	413	615	952	1270	1660	2120	2880	1.0	1.49	81.90	43.94	.46	2.18	2.80	2.98	1
273	2100	3600	4840	6700	8330	10200	12200	15400	69.2	21.98	15.60	72.28	.14	2.18	2.80	2.98	1
274	1400	2350	3140	4310	5320	6470	7760	9730	31.8	10.79	20.61	79.15	.26	2.19	2.81	2.98	1
275	9490	14300	17900	22800	26700	30900	35400	41800	628	76.32	9.82	88.95	.11	2.18	2.81	2.98	1
276	2370	3200	3780	4540	5130	5740	6380	7260	41.8	9.79	12.37	65.58	.43	2.23	2.83	2.99	1
277	3130	4720	5910	7560	8900	10300	11900	14100	76.5	13.19	9.34	75.36	.44	2.23	2.83	2.99	1
278r	3020	7990	13100	22100	30900	41500	54300	74900	97.0	21.78	96.11	394.11	.20	2.19	2.78	2.94	1
279	3040	4760	6030	7760	9140	10600	12100	14300	79.0	19.99	22.73	295.91	.20	2.19	2.78	2.95	1
280	598	967	1250	1650	1980	2340	2730	3290	13.0	8.05	40.64	280.73	.20	2.19	2.79	2.95	1
281	4860	7620	9700	12600	15000	17600	20300	24300	220	42.35	15.04	212.62	.12	2.23	2.81	2.97	1
282	16900	25900	32500	41800	49300	57200	65800	78000	875	64.54	27.19	223.48	.21	2.23	2.81	2.97	1
283	3070	4900	6290	8230	9820	11500	13400	16000	60.5	20.27	25.87	305.26	.15	2.19	2.79	2.96	1
284	1070	1680	2150	2820	3380	3990	4660	5640	16.4	7.85	50.61	91.82	.25	2.19	2.79	2.96	1
285	6990	10200	12700	16100	18900	21900	25200	29900	200	40.97	13.36	212.84	.12	2.21	2.80	2.97	1
286	348	601	805	1100	1360	1640	1940	2400	1.4	2.29	72.02	100.64	.30	2.22	2.81	2.97	1
287	104	148	179	221	254	289	326	378	2.4	1.98	159.21	286.39	.58	2.10	2.76	2.93	1
288	5060	8850	12100	17300	21900	27300	33600	43500	205	66.19	10.53	314.07	.05	2.09	2.76	2.93	1
289	1160	1920	2550	3480	4290	5200	6230	7790	21.8	8.58	74.20	430.02	.29	2.09	2.75	2.92	1
290	5860	9590	12700	17400	21500	26100	31500	39700	277	41.20	19.42	386.04	.16	2.09	2.75	2.92	1
291	168	276	363	492	603	726	865	1070	2.1	2.32	219.54	266.66	.38	2.07	2.77	2.94	1
292	4150	6150	7610	9610	11200	12900	14700	17300	67.9	14.21	67.39	407.60	.34	2.27	2.80	2.95	1
293	4680	7170	9060	11700	13900	16300	18800	22500	103	19.57	79.36	373.79	.27	2.26	2.80	2.95	1
294	698	1250	1710	2420	3030	3730	4530	5740	11.7	4.85	205.76	446.05	.49	2.26	2.80	2.95	1
295	2760	4310	5460	7050	8320	9680	11100	13200	40.4	13.36	131.60	502.95	.22	2.25	2.80	2.95	1

Table 2. Recurrence interval discharges and basin characteristics for gaged rural sites in North Carolina—Continued

[Q, recurrence interval flood discharge for years indicated; DA, drainage area; L, channel length; CSLOPE, channel slope; BSLOPE, basin slope; SHAPE, basin shape; CF, climate factor for recurrence interval years indicated; REG, region: 1, if site is in Blue Ridge-Piedmont; 2, if site is in Coastal Plain; 3, if site is in Sand Hills; nc, flood-frequency estimates were not computed because the site has less than 10 years of peak-flow record; *, duplicate map identification number for sites having separate periods of regulated or channelized flows; r, site excluded from regional analysis because flows were affected by regulation or channelization; n.a., data not available]

Map identification number (fig. 1)	Q_2	Q_5	Q_{10}	Q_{25}	Q_{50}	Q_{100}	Q_{200}	Q_{500}	DA (mi^2)	L (mi)	CSLOPE (ft/mi)	BSLOPE (ft/mi)	SHAPE (DA/L^2)	CF_2	CF_{25}	CF_{100}	REG
296	1510	2430	3140	4170	5020	5960	6980	8490	26.8	11.33	37.09	239.70	0.21	2.24	2.80	2.96	1
297	1680	2540	3160	4000	4670	5370	6100	7130	41.4	13.96	44.43	242.70	.22	2.24	2.80	2.96	1
298	556	935	1250	1710	2120	2580	3100	3890	10.9	4.91	338.78	285.36	.44	2.24	2.80	2.96	1
299	6970	10900	14000	18500	22300	26600	31300	38300	296	36.20	3.88	343.47	.23	2.24	2.80	2.95	1
300	479	715	893	1140	1350	1570	1820	2170	14.8	11.44	50.40	263.91	.11	2.23	2.79	2.95	1
301	658	1120	1500	2080	2590	3170	3820	4820	10.0	4.78	179.84	387.36	.45	2.25	2.79	2.95	1
302	2490	3840	4880	6360	7600	8940	10400	12600	66.7	27.47	50.49	440.37	.09	2.23	2.78	2.94	1
303	80.1	109	129	154	174	194	215	243	.6	.88	436.52	199.55	.72	2.24	2.80	2.96	1
304	1450	2420	3200	4360	5360	6480	7730	9630	42.2	13.01	24.24	226.31	.25	2.24	2.80	2.96	1
305	3220	6340	9240	14100	18600	24200	30900	41800	109	15.41	10.25	187.68	.46	2.23	2.79	2.95	1
306	1790	2920	3840	5230	6440	7800	9360	11700	63.1	15.97	28.17	307.71	.25	2.23	2.79	2.95	1
307	10700	15300	18700	23300	26900	30700	34700	40400	676	61.46	2.71	300.03	.18	2.23	2.78	2.94	1
308	2030	3610	4990	7170	9160	11500	14200	18500	79.8	13.83	57.53	415.17	.42	2.22	2.78	2.93	1
309[nc]	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	14.5	4.76	503.19	641.91	.66	2.19	2.78	2.94	1
310	1780	3100	4230	5990	7550	9360	11400	14700	23.8	7.84	282.05	600.92	.39	2.19	2.78	2.94	1
310*[r,nc]	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	23.8	7.84	282.05	600.92	.39	2.19	2.78	2.94	1
311	247	427	575	794	983	1190	1430	1790	5.5	3.89	574.31	591.79	.36	2.19	2.78	2.94	1
312	3020	5220	7130	10100	12800	16000	19700	25600	130	23.03	21.11	426.04	.24	2.21	2.78	2.94	1
312*[r]	2900	4940	6670	9370	11800	14600	17800	22900	130	23.03	21.11	426.04	.24	2.21	2.78	2.94	1
313	14900	22000	27300	34600	40700	47100	54100	64200	945	72.49	2.59	320.73	.18	2.20	2.78	2.94	1
314	2050	3080	3850	4930	5810	6750	7770	9250	79.5	19.44	34.12	403.22	.21	2.21	2.77	2.92	1
315	4080	6670	8740	11800	14300	17200	20300	25000	158	24.08	47.85	440.28	.27	2.21	2.77	2.92	1
316	19800	30400	37900	48000	55900	64100	72600	84500	1332	90.72	4.09	337.83	.16	2.21	2.77	2.92	1
317	626	942	1170	1490	1740	2010	2300	2700	8.0	5.34	142.20	400.62	.27	2.20	2.77	2.92	1
318	3350	5410	7020	9340	11300	13400	15700	19100	126	28.76	72.67	508.25	.15	2.20	2.76	2.92	1
319	23300	37000	48000	64000	77700	92900	110000	135000	1567	106.96	6.30	358.29	.14	2.20	2.77	2.92	1
320	4100	5830	7050	8690	9970	11300	12700	14600	27.6	10.24	259.95	565.57	.26	2.26	2.80	2.95	1
321[r,nc]	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	33.5	12.63	213.40	568.89	.21	2.26	2.79	2.95	1
322[r]	4400	6590	8210	10500	12300	14200	16300	19300	58.4	17.24	172.62	565.25	.19	2.25	2.79	2.95	1
323	4320	6990	9070	12100	14600	17300	20200	24600	51.5	19.40	155.96	569.36	.14	2.25	2.79	2.95	1
324	7690	11800	15000	19500	23300	27400	31800	38400	130	24.00	125.34	533.76	.22	2.22	2.77	2.93	1
325	761	1110	1370	1720	2010	2310	2630	3090	14.4	5.16	556.54	589.19	.54	2.26	2.80	2.95	1
326[nc]	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	243	35.84	79.37	478.74	.19	2.21	2.77	2.92	1
327	1930	2710	3250	3960	4510	5070	5660	6470	65.3	17.58	74.41	510.37	.21	2.21	2.77	2.92	1
328	11200	16900	21200	27000	31700	36800	42200	49800	350	42.50	51.32	482.01	.19	2.21	2.77	2.92	1

Table 2. Recurrence interval discharges and basin characteristics for gaged rural sites in North Carolina—Continued

[Q, recurrence interval flood discharge for years indicated; DA, drainage area; L, channel length; CSLOPE, channel slope; BSLOPE, basin slope; SHAPE, basin shape; CF, climate factor for recurrence interval years indicated; REG, region: 1, if site is in Blue Ridge-Piedmont; 2, if site is in Coastal Plain; 3, if site is in Sand Hills; nc, flood-frequency estimates were not computed because the site has less than 10 years of peak-flow record; *, duplicate map identification number for sites having separate periods of regulated or channelized flows; r, site excluded from regional analysis because flows were affected by regulation or channelization; n.a., data not available]

Map identification number (fig. 1)	Q_2	Q_5	Q_{10}	Q_{25}	Q_{50}	Q_{100}	Q_{200}	Q_{500}	DA (mi^2)	L (mi)	CSLOPE (ft/mi)	BSLOPE (ft/mi)	SHAPE (DA/L^2)	CF_2	CF_{25}	CF_{100}	REG
329	1910	2980	3770	4850	5720	6640	7620	9000	49.2	10.68	183.96	530.96	0.43	2.21	2.77	2.92	1
330	368	430	468	513	546	578	609	650	9.2	4.90	127.36	313.06	.39	2.16	2.77	2.94	1
331	2840	4540	5880	7860	9540	11400	13500	16600	104	37.92	34.80	410.63	.07	2.17	2.78	2.94	1
332	5400	9260	12500	17300	21600	26400	31900	40300	43.3	14.34	158.20	520.68	.21	2.18	2.78	2.94	1
333	5550	9390	12600	17400	21700	26500	32000	40400	60.8	27.05	50.38	484.24	.08	2.17	2.77	2.94	1
334	145	224	283	367	436	510	590	707	1.6	3.08	519.11	405.77	.17	2.17	2.77	2.93	1
335	4950	9080	12800	18800	24300	30900	38600	51100	157	39.09	34.98	531.07	.10	2.17	2.77	2.93	1
336	16000	26300	34600	47000	57600	69600	83100	104000	608	73.77	23.71	452.57	.11	2.17	2.77	2.93	1
337	1050	2040	2940	4390	5730	7330	9200	12200	23.1	9.70	118.81	398.27	.25	2.15	2.77	2.94	1
338	5940	10500	14300	20200	25400	31400	38300	48900	92.1	19.38	84.54	376.69	.24	2.15	2.77	2.94	1
339	15.7	23.5	29.2	37	43.3	50	57.1	67.3	.5	1.72	997.21	415.55	.18	2.16	2.77	2.94	1
340	2260	3750	4970	6830	8450	10300	12400	15600	42.0	11.66	104.61	406.56	.31	2.16	2.77	2.93	1
341	3340	5170	6580	8580	10200	12000	14000	16900	140	25.26	6.86	375.26	.23	2.28	2.80	2.95	1
342	1960	2870	3530	4420	5140	5890	6690	7830	57.1	16.11	31.33	436.73	.22	2.28	2.80	2.95	1
343[r]	975	1600	2160	3070	3920	4950	6200	8250	14.9	7.41	98.65	246.33	.26	2.28	2.81	2.95	1
344	2900	4580	5930	7900	9590	11500	13600	16700	86.5	20.22	123.81	435.46	.21	2.28	2.80	2.95	1
345	124	256	375	568	746	954	1200	1580	1.6	2.64	491.80	467.80	.25	2.27	2.80	2.95	1
346	6160	8870	10800	13500	15700	18000	20400	23900	323	34.17	5.76	394.79	.28	2.24	2.80	2.96	1
347	9490	13500	16300	20000	22800	25700	28600	32700	436	52.12	6.48	408.05	.16	2.27	2.80	2.94	1
348	2500	3450	4090	4940	5590	6250	6940	7880	51.9	16.68	63.83	456.46	.19	2.28	2.80	2.95	1
349[r]	2800	4370	5530	7120	8390	9740	11200	13200	144	38.21	40.37	464.09	.10	2.27	2.80	2.95	1
350	5120	7330	8910	11000	12700	14500	16400	19000	174	49.80	42.39	475.41	.07	2.27	2.79	2.94	1
351	13600	21400	27400	36000	43100	50800	59200	71500	664	63.31	8.43	430.10	.17	2.27	2.79	2.94	1
352[nc]	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	143	21.61	112.60	411.88	.31	2.27	2.80	2.95	1
352*[r]	3990	6940	9190	12300	14800	17500	20300	24300	143	21.61	112.60	411.88	.31	2.27	2.80	2.95	1
353	1470	2070	2490	3050	3480	3930	4400	5040	51.0	15.75	167.42	520.46	.21	2.27	2.80	2.95	1
354	6780	9790	12100	15200	17800	20700	23700	28200	347	37.92	56.29	464.22	.24	2.27	2.80	2.95	1
354*[r]	7470	11800	15000	19300	22700	26200	29900	35000	347	37.92	56.29	464.22	.24	2.27	2.80	2.95	1
355	5370	7370	8720	10500	11800	13200	14600	16500	131	22.52	106.56	613.81	.26	2.27	2.80	2.94	1
356	8720	11500	13300	15600	17400	19100	20900	23300	184	26.94	85.10	589.97	.25	2.27	2.80	2.94	1
357	16900	26600	33800	43800	51700	60200	69200	81900	655	57.17	37.57	502.95	.20	2.27	2.79	2.94	1
357*[r]	16600	23100	27200	32200	35800	39300	42700	47200	655	57.17	37.57	502.95	.20	2.27	2.79	2.94	1
358	19.7	36.8	51.8	75.5	97	122	151	198	.5	1.78	595.52	474.30	.20	2.27	2.80	2.94	1
359	944	1290	1530	1840	2090	2340	2590	2950	13.8	8.53	346.36	601.47	.19	2.27	2.79	2.94	1
360	2310	3640	4660	6120	7330	8640	10100	12200	44.4	12.93	173.28	606.86	.26	2.26	2.79	2.93	1

Table 2. Recurrence interval discharges and basin characteristics for gaged rural sites in North Carolina—Continued

[Q, recurrence interval flood discharge for years indicated; DA, drainage area; L, channel length; CSLOPE, channel slope; BSLOPE, basin slope; SHAPE, basin shape; CF, climate factor for recurrence interval years indicated; REG, region: 1, if site is in Blue Ridge-Piedmont; 2, if site is in Coastal Plain; 3, if site is in Sand Hills; nc, flood-frequency estimates were not computed because the site has less than 10 years of peak-flow record; *, duplicate map identification number for sites having separate periods of regulated or channelized flows; r, site excluded from regional analysis because flows were affected by regulation or channelization; n.a., data not available]

Map identification number (fig. 1)	Q_2	Q_5	Q_{10}	Q_{25}	Q_{50}	Q_{100}	Q_{200}	Q_{500}	DA (mi^2)	L (mi)	CSLOPE (ft/mi)	BSLOPE (ft/mi)	SHAPE (DA/L^2)	CF_2	CF_{25}	CF_{100}	REG
361[nc]	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	1571	85.95	21.06	472.39	0.21	2.28	2.79	2.94	1
361*[r]	10800	17500	22400	29100	34500	40100	46100	54400	1571	85.95	21.06	472.39	.21	2.28	2.79	2.94	1
362	2920	4140	5020	6200	7140	8130	9180	10700	42.0	19.16	86.51	480.21	.11	2.29	2.80	2.95	1
363	1440	2410	3200	4380	5400	6550	7830	9780	37.6	7.91	150.30	474.21	.61	2.29	2.81	2.96	1
364[r]	1640	2090	2470	3070	3600	4220	4940	6070	190	26.23	50.04	384.09	.28	2.29	2.81	2.96	1
365	11300	15800	18800	22800	25800	28900	32100	36500	406	47.41	15.70	368.28	.18	2.31	2.81	2.96	1
365*[r]	8960	12600	14800	17400	19200	20800	22400	24300	406	47.41	15.70	368.28	.18	2.31	2.81	2.96	1
366	4190	6510	8320	10900	13000	15400	18000	21800	104	22.63	50.23	435.97	.20	2.31	2.81	2.95	1

APPENDIX

The value of the mean square error (MSE_s) at a specific site can be estimated as follows: Denote the column vector of n logarithms of observed peak-discharge characteristics at n sites in a region by Y. For example,

$$Y = \begin{bmatrix} \log Q_{50,\,1} \\ \log Q_{50,\,2} \\ \text{""} \\ \log Q_{50,\,n} \end{bmatrix},$$

in which, $Q_{50,i}$, represents the observed 50-year peak at the ith gaging station in the region. Further, let X represent a (n by p) matrix of p-1 basin characteristics augmented by a column of ones at n gaging stations and B represent a column vector of p regression coefficients.

For example,

$$X = \begin{bmatrix} 1 & \log(DA_1) & \log(IA_1) & \log(RQ50_1) \\ 1 & \log(DA_2) & \log(IA_2) & \log(RQ50_2) \\ & \text{""} & \text{""} & \text{""} \\ 1 & \log(DA_n) & \log(IA_n) & \log(RQ50_n) \end{bmatrix} \text{ and } B = \begin{bmatrix} a \\ b_1 \\ b_2 \\ b_4 \end{bmatrix}.$$

The linear model can be written as

$$Y=XB.$$

The mean square sampling error, $MSE_{s,0}$, for an ungaged site with basin characteristics given by the row vector x_0=[1 log (DA_0) log (IA_0) log ($RQ50_0$)], for example, is calculated as

$$MSE_{s,0} = x_0 \{X^T \Lambda^{-1} X\}^{-1} x_0^T,$$

in which Λ is the (n by n) covariance matrix associated with Y. The diagonal elements of Λ are model error variance, γ^2, plus the time-sampling error for each site i (i=1,2,3,...n), which is estimated as a function of a regional estimate of the standard deviation of annual peaks at site i, the recurrence interval of the dependent variable and the number of years of record at site i. The off-diagonal elements of Λ are the sample covariance of the estimated t-year peaks at sites i and j. These off-diagonal elements are estimated as a function of a regional estimate of the standard deviation of annual peaks at sites i and j, the recurrence interval of the dependent variable and the number of concurrent years of record at sites i and j (Tasker and Stedinger, 1989). The (p by p) matrix $\{X^T \Lambda^{-1} X\}^{-1}$ for each equation is given in Appendix table 1. The mean square error of a prediction, in log (base 10) units, at specific ungaged sites can be estimated as

$$MSE_{p,0} = (\gamma^2 + MSE_{s,0}).$$

The standard error of a prediction, $SE_{\text{prediction}}$, in percent, can be calculated as

$$SE_{\text{prediction}} = 100\{e^{5.302 \times (MSEp,\,0)} - 1\}^{0.5}.$$

Appendix Table 1. Matrix $\{X^T \Lambda^{-1} X\}^{-1}$ for the equations in table 5 (p. 11)

[These matrices can be used to compute the standard error of prediction and prediction intervals as explained in the text. Numbers are given in scientific notation, for example, 0.43958E–01 = 0.43958 x 10^{-1} = 0.043958]

Hydrologic area					
Blue Ridge-Piedmont		Coastal Plain		Sand Hills	
2-year recurrence interval					
0.14072E–02	–0.49612E–03	0.31893E–02	–0.98276E–03	0.10200E–01	–0.44648E–02
–0.49612E–03	0.24350E–03	–0.98276E–03	0.43777E–03	–0.44648E–02	0.25105E–02
5-year recurrence interval					
0.16431E–02	–0.55517E–03	0.37147E–02	–0.10840E–02	0.12971E–01	–0.56042E–02
–0.55517E–03	0.26322E–03	–0.10840E–02	0.45031E–03	–0.56042E–02	0.31270E–02
10-year recurrence interval					
0.18985E–02	–0.62424E–03	0.43917E–02	–0.12495E–02	0.15456E–01	–0.65943E–02
–0.62424E–03	0.28912E–03	–0.12495E–02	0.50084E–03	–0.65943E–02	0.36522E–02
25-year recurrence interval					
0.22833E–02	–0.73140E–03	0.54496E–02	–0.15204E–02	0.19118E–01	–0.80470E–02
–0.73140E–03	0.33094E–03	–0.15204E–02	0.59196E–03	–0.80470E–02	0.44209E–02
50-year recurrence interval					
0.25999E–02	–0.82124E–03	0.63333E–02	–0.17517E–02	0.22136E–01	–0.92451E–02
–0.82124E–03	0.36687E–03	–0.17517E–02	0.67303E–03	–0.92451E–02	0.50554E–02
100-year recurrence interval					
0.29342E–02	–0.91725E–03	0.72726E–02	–0.20005E–02	0.25348E–01	–0.10523E–01
–0.91725E–03	0.40581E–03	–0.20005E–02	0.76200E–03	–0.10523E–01	0.57330E–02
200-year recurrence interval					
0.32839E–02	–0.10186E–02	0.82596E–02	–0.22640E–02	0.28740E–01	–0.11875E–01
–0.10186E–02	0.44737E–03	–0.22640E–02	0.85763E–03	–0.11875E–01	0.64516E–02
500-year recurrence interval					
0.37671E–02	–0.11600E–02	0.96272E–02	–0.26319E–02	0.33482E–01	–0.13772E–01
–0.11600E–02	0.50586E–03	–0.26319E–02	0.99272E–03	–0.13772E–01	0.74616E–02

☆ U.S. GOVERNMENT PRINTING OFFICE: 2001 — 673-476 / 58012 Region No. 8

USGS Pope, Tasker, and Robbins Estimating the Magnitude and Frequency of Floods in Rural Basins of North Carolina—Revised USGS WRIR 01-4207