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Methods for Estimating the Magnitude and Frequency of Peak Streamflows for Unregulated Streams in Oklahoma Developed by Using Streamflow Data Through 2017

Scientific Investigations Report 2019–5143

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

Cover photograph. Looking downstream at the State Highway 74 bridge on Skeleton Creek near Lovell, Oklahoma, May 29, 2015. Photograph by Jason Lewis, U.S. Geological Survey.

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DAVID BERNHARDT, Secretary

U.S. Geological Survey
James F. Reilly II, Director

U.S. Geological Survey, Reston, Virginia: 2019

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Suggested citation:
Lewis, J.M., Hunter, S.L., and Labriola, L.G., 2019, Methods for estimating the magnitude and frequency of peak streamflows for unregulated streams in Oklahoma developed by using streamflow data through 2017: U.S. Geological Survey Scientific Investigations Report 2019–5143, 39 p., https://doi.org/10.3133/sir20195143.

Associated data for this publication:
Labriola, L.G., Smith, S.J., Hunter, S.L., and Lewis, J.M., 2019, Data release of basin characteristics, generalized skew map and peak-streamflow frequency estimates in Oklahoma: U.S Geological Survey data release, https://doi.org/10.5066/P9B99TQZ.

ISSN 2328-0328 (online)

Contents

Figures

Tables

Conversion Factors

U.S. customary units to International System of Units

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
acre	4,047	square meter (m^2)
acre	0.4047	hectare (ha)
square mile (mi^2)	2.590	square kilometer (km^2)
	Volume	
cubic mile (mi^3)	4.168	cubic kilometer (km^3)
acre-foot (acre-ft)	1,233	cubic meter (m^3)
acre-foot (acre-ft)	0.001233	cubic hectometer (hm^3)
	Flow rate	
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
cubic foot per second per square mile ($[ft^3/s]/mi^2$)	0.01093	cubic meter per second per square kilometer ($[m^3/s]/km^2$)
	Hydraulic gradient	
foot per mile (ft/mi)	0.1894	meter per kilometer (m/km)

Datum

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88).

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

Elevation, as used in this report, refers to distance above the vertical datum.

Supplemental information

Water year is the 12-month period October 1 through September 30, designated by the calendar year in which the water year ends.

Abbreviations

CONTDA	contributing drainage-basin area
CSL10_85fm	main-channel 10–85 slope
GIS	geographic information system
GLS	generalized least squares
IACWD	Interagency Advisory Committee on Water Data
LPIII	log-Pearson Type III standard frequency distribution
NRCS	Natural Resources Conservation Service (U.S. Department of Agriculture)
OLS	ordinary least squares
PRECIP	area-weighted mean-annual precipitation
R^2	coefficient of determination
USGS	U.S. Geological Survey
WLS	weighted least squares
WREG	weighted-multiple-linear regression

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Abstract

The U.S. Geological Survey (USGS), in cooperation with the Oklahoma Department of Transportation, updated peak-streamflow regression equations for estimating flows with annual exceedance probabilities from 50 to 0.2 percent for the State of Oklahoma. These regression equations incorporate basin characteristics to estimate peak-streamflow magnitude and frequency throughout the State by use of a generalized least-squares regression analysis. The most statistically significant independent variables required to estimate peak-streamflow magnitude and frequency for unregulated streams in Oklahoma are contributing drainage area, mean-annual precipitation, and main-channel slope. The regression equations are applicable for stream basins with drainage areas less than 2,510 square miles that are not affected by regulation. The standard model error ranged from 31.28 to 49.32 percent for the different annual exceedance probabilities that were computed.

Annual-maximum peak flows observed at 212 USGS streamgages through water year 2017 were used for the regression analysis, excluding the Oklahoma Panhandle region. The USGS StreamStats web application was used to obtain the independent variables required for the peak-streamflow regression equations. Limitations on the use of the regression equations and the reliability of regression estimates for natural unregulated streams are described. Log-Pearson Type III analysis information, basin and climate characteristics, and the peak-streamflow frequency estimates for the 212 streamgages in and near Oklahoma are provided in this report.

This report contains descriptions of the methods that can be used to estimate peak streamflows at ungaged sites by using estimates from streamgages on unregulated streams. For ungaged sites on urban streams and streams regulated by small floodwater-retarding structures, an adjustment of the statewide regression equations for natural unregulated streams can be used to estimate peak-streamflow magnitude and frequency.

Introduction

Estimates of the magnitude and frequency of floods are required for the safe and economical design of highway bridges, culverts, dams, levees, and other structures on or near streams. Flood-plain management programs and flood-insurance rates also are based on flood magnitude and frequency information. Estimates of the magnitude and frequency of flooding events, or peak streamflows, are commonly needed at ungaged sites with no streamflow data available. Regional regression equations can be used to estimate peak streamflows at ungaged sites.

The U.S. Department of Agriculture, Natural Resources Conservation Service (NRCS) has constructed several floodwater-retarding structures throughout Oklahoma that regulate flood peaks. Currently (2019), about 2,105 floodwater-retarding structures are in more than 120 stream basins in Oklahoma. On completion of the NRCS Watershed Protection and Flood Prevention Program (Tortorelli, 1997), about 2,500 floodwater-retarding structures will regulate flood peaks for about 8,500 square miles (mi^2) (about 12 percent) of the State. By design, floodwater-retarding structures decrease the magnitude of main-stem flood peaks and decrease the rate of runoff recession of single storms (Bergman and Huntzinger, 1981). Consideration of the flood peak modification capability of floodwater-retarding structures can result in more hydraulically efficient, cost-effective culvert or bridge designs along downstream segments of streams regulated by floodwater-retarding structures (Tortorelli, 1997).

The U.S. Geological Survey (USGS), in cooperation with the Oklahoma Department of Transportation, updated the regression equations for estimating peak-streamflow frequencies for Oklahoma streams with a drainage area less than 2,510 mi^2 as documented in Lewis (2010) and other reports (Tortorelli and Bergman, 1985; Tortorelli, 1997). The methods used in this report should provide more accurate estimates of peak streamflows for Oklahoma than these previous reports (Tortorelli and Bergman, 1985; Tortorelli, 1997; Lewis, 2010) because of the inclusion of several years of additional data. As in Lewis (2010), a combination of different regression methods were used, including generalized least-squares (GLS) regression methods. GLS methods were used because of their ability to compensate for cross-correlation of peak streamflow between streamgages and differences in historical record lengths (Veilleux, 2009).

Purpose and Scope

This report presents updated methods for estimating the magnitude and frequency of peak streamflows for the 50-, 20-, 10-, 4-, 2-, 1-, and 0.2-percent annual exceedance probability floods for ungaged sites on unregulated streams with drainage areas of less than 2,510 mi^2 in Oklahoma, excluding the Panhandle region. This report describes the methods that can be used to estimate peak-streamflow frequencies for streamgages on unregulated streams and nearby ungaged locations on the same stream. Methods used to adjust estimates for ungaged urban streams and streams regulated by floodwater-retarding structures also are presented. This report also provides peak-streamflow frequency analyses and basin characteristics for all streamgages used in the regression analysis.

Flood-streamflow records through the 2017 water year at 212 streamgages throughout Oklahoma and in nearby areas of Arkansas, Kansas, Missouri, and Texas were used to develop statewide peak-streamflow frequency estimate equations. Estimates of peak-streamflow frequency from the 212 streamgages were related to climatic and physiographic attributes, referred to as basin characteristics, by using multiple-linear regression. The regression equations derived from these analyses provide methods to estimate flood frequencies of unregulated streams.

This report provides methods to estimate peak streamflows for streams with drainage areas less than 2,510 mi^2. Peak-streamflow frequency for streams with greater than or equal to 2,510-mi^2 drainage areas can be estimated by using methods described in Sauer (1974a) and Lewis and Esralew (2009). The Oklahoma generalized skew map, a necessary element in the development of the peak-streamflow frequencies for the 212 streamgages, was updated by including streamflow information through 2017. In this report, methods are presented to estimate peak-streamflow frequencies at sites on urban streams (based on Sauer, 1974b) and streams regulated by floodwater-retarding structures (based on Tortorelli and Bergman, 1985).

The regression equations in this report supersede those in Lewis (2010) for estimating peak-streamflow frequencies in unregulated Oklahoma streams with drainage areas less than 2,510 mi^2. The current report updates the regression equations published in Lewis (2010) by (1) incorporating an additional 9 years of annual peak-streamflow data, with major peak streamflows recorded during water years 2015 and 2017; (2) incorporating additional streamgages that now have adequate numbers of years for frequency analysis; (3) removing selected streamgages included in Lewis (2010) that were determined to be affected by regulation or outside of the modified study area; (4) including the most up-to-date basin characteristics for each streamgage location determined by using a geographic information system (GIS); (5) using updated mean-annual precipitation data from 1971 to 2000 and an area-weighted mean of precipitation for the contributing drainage area, from which a point estimate of mean-annual precipitation was determined; (6) using Bulletin 17C methodologies to determine flood flow frequencies (England and others, 2019); and (7) featuring results from a GLS regression method shown to be better at handling cross-correlation and differing record lengths of peak streamflow at streamgages than other regression methods (Tasker and Stedinger, 1989).

Description of Study Area

The study area includes all of Oklahoma and parts of the neighboring States of Kansas, Missouri, Arkansas, and Texas (fig. 1). Oklahoma covers about 70,000 mi^2 and has a wide range of physiographic and climatic characteristics that contribute to streamflow variability. Based on methods in Esralew and Smith (2010), Oklahoma was divided into two regions, excluding the Panhandle region. Regression equations were developed in 2015 to estimate peak streamflows in the Panhandle region (Smith and others, 2015). Compared to eastern Oklahoma, western Oklahoma is characterized by flatter topography, less mean-annual precipitation, and smaller main-channel slopes. For these reasons, separate sets of regression equations were developed for western and eastern Oklahoma, referred to as region 1 and region 2, respectively (fig. 1).

General Description and Effects of Floodwater-Retarding Structures

This report includes an adjustment for the effects of small floodwater-retarding structures on peak streamflow because streamflow in many areas of Oklahoma is regulated by these structures. Floodwater-retarding structures built by the NRCS are used in stream basin protection and flood-prevention programs.

Floodwater-retarding structures generally consist of an earthen dam, a valved drain pipe, a drop inlet principal spillway, and an open-channel earthen emergency spillway (Moore, 1969). The principal spillway is ungated and automatically limits the rate at which water can flow from a reservoir. Most of the structures built in Oklahoma have release rates of 10 to 15 cubic feet per second per square mile ([ft^3/s]/mi^2). The space in a reservoir between the elevation of the principal spillway crest and the emergency spillway crest is used for floodwater detention.

Most floodwater-retarding structures in Oklahoma are designed to draw down the floodwater-retarding pool in 10 days or less (R.C. Riley, Natural Resources Conservation Service, written commun., 1984). The 10-day drawdown requirement serves two purposes. First, most vegetation in the floodwater-retarding pool will survive as much as 10 days of inundation without destroying the viability of the stand. Second, a 10-day drawdown period will substantially reduce any rapid runoff from repetitive storms (Tortorelli, 1997).

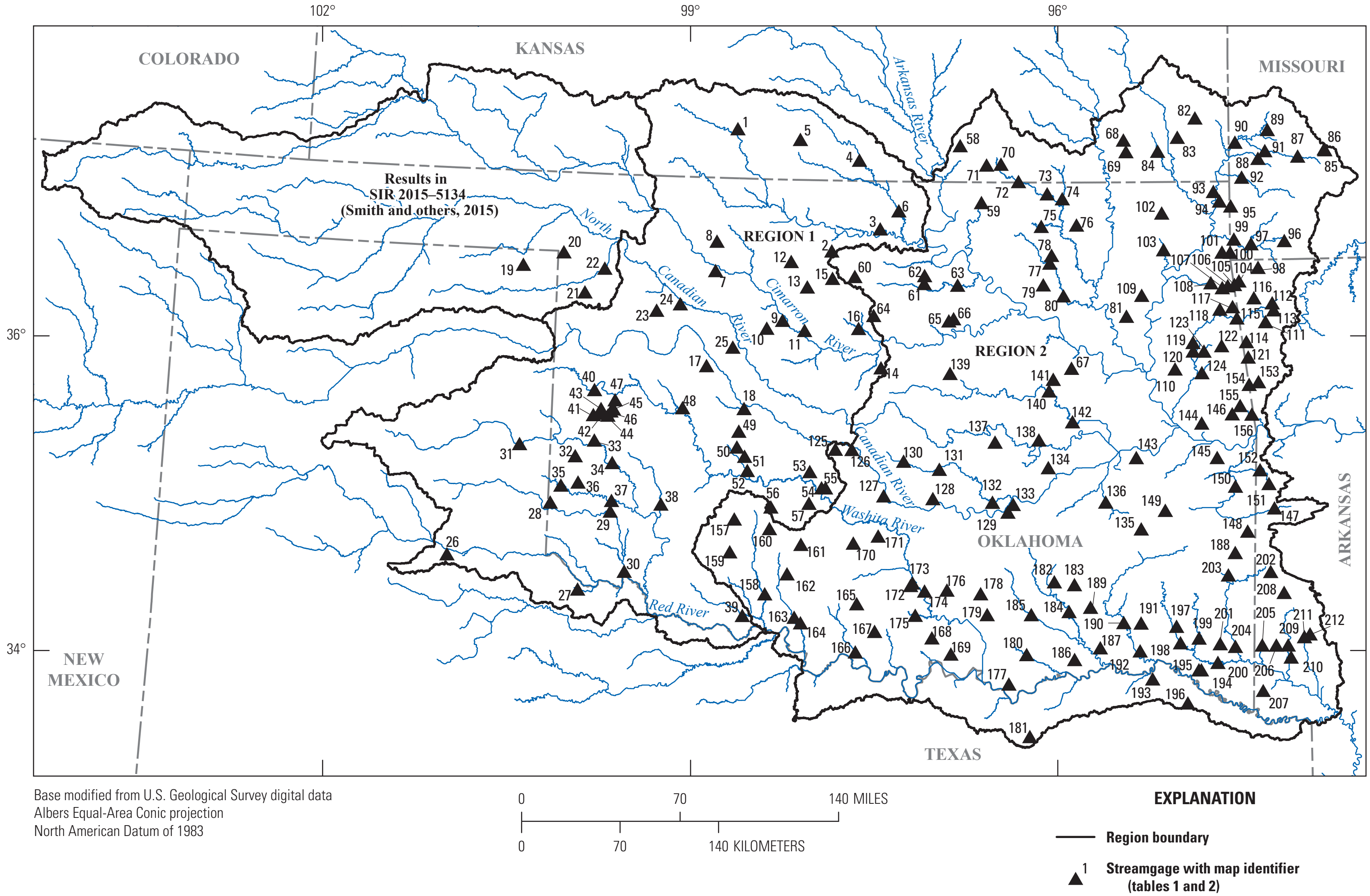


Figure 1. Locations of streamgages in and near Oklahoma used for flood-frequency analysis.

Floodwater-retarding structures have embankment heights ranging generally from 20 to 60 feet (ft) and drainage areas ranging generally from 1 to 20 mi^2 (Moore, 1969). Storage capacity is limited to 12,500 acre-feet (acre-ft) for floodwater detention and 25,000 acre-ft total for combined uses, including recreation, municipal and industrial water, and others (Tortorelli, 1997).

The emergency spillway design, including storage above the emergency crest and capacity of an emergency spillway, is affected by the size of the floodwater-retarding structure and the location of the structure in the basin. Design details may be found in the NRCS National Engineering Handbook, Section 4 (U.S. Soil Conservation Service, 1972).

Peak flood streamflow is when a system of upstream floodwater-retarding structures regulates upstream flow. This reduction in the peak streamflow is related to the percentage of the overall basin that is regulated by floodwater-retarding structures (Hartman and others, 1967; Moore, 1969; Moore and Coskun, 1970; DeCoursey, 1975; Schoof and others, 1980). The slope of the recession segment of the hydrograph will decrease as the number of floodwater-retarding structures with water flowing over the principal spillways increases. The change in slope of the hydrograph is commonly referred to as hydrograph attenuation (Montaldo and others, 2004).

Several factors substantially influence the effectiveness of the floodwater-retarding structures in attenuating peak flow on the main stem downstream from the floodwater-retarding structures (Hartman and others, 1967; Moore, 1969; Moore and Coskun, 1970; Schoof and others, 1980). These factors include precipitation distribution over the basin, the amount of water impounded by floodwater-retarding structures before the storm, and distribution of floodwater-retarding structures in the basin. Peak flows become increasingly attenuated as the proportion of precipitation falling on parts of a basin with floodwater-retarding structures increases. Floodwater-retarding structures are more effective at attenuating the flood peak if the structures are empty before the storm. Floodwater-retarding structures in the upper end of an elongated basin are less effective than those in a fan-shaped basin (Tortorelli, 1997). Floodwater-retarding structures act like temporary detention ponds; they provide controlled releases that can be scheduled, but rather release water passively regardless of downstream conditions. For these reasons, the streamflow downstream from some floodwater-retarding structures can be treated as unregulated. When necessary, adjustments can be applied before estimating the magnitude and frequency of peak streamflows downstream from certain floodwater-retarding structures as explained in the “Adjustment for Ungaged Sites on Streams Regulated by Floodwater-Retarding Structures” section of this report.

Data Development

Streamflow data from selected streamgages in Oklahoma and from nearby streamgages in adjacent States were compiled (USGS, 2018a). Next, basin characteristics were then calculated for each streamgage. The following sections describe these steps in detail.

Annual Peak Data

The first step in peak-streamflow frequency analysis is the compilation and review of all streamgages with peak-streamflow data. Streamgages selected for analysis (fig. 1) were in 8-digit hydrologic unit boundaries (based on the 8-digit hydrologic unit codes) that were in or were adjacent to the Oklahoma State boundary (NRCS, 2019). Review was done to eliminate discrepancies in peak-streamflow data for streamgages across State lines. Peak-streamflow data from streamgages with similar hydrologic characteristics in areas of Arkansas, Kansas, Missouri, and Texas that are near Oklahoma also were selected for regression analysis.

The flood-frequency analysis for streams that are not substantially regulated by dams and floodwater-retarding structures (hereinafter referred to as “unregulated streams”) and with a drainage area less than 2,510 mi^2 is based on annual peak-streamflow data systematically collected at 212 streamgages (table 1, in back of report). The data were grouped by water year, defined as the 12-month period from October 1 of a given year through September 30 of the following year. Data collected from streamgages through the 2017 water year were used for this report. Only data from those streamgages with at least 10 years of flood peak data were used in the analysis. The Interagency Advisory Committee on Water Data (IACWD) recommends at least 10 years of data for estimating the magnitude and frequency of peak streamflows (IACWD, 1982). All selected streamgages are on streams that are not substantially regulated by dams and floodwater-retarding structures. Substantial regulation is defined as a contributing drainage basin where 20 percent or more of the basin is upstream from dams and floodwater-retarding structures (Heimann and Tortorelli, 1988). All selected streamgages were evaluated for the possibility of redundancy, where a pair of streamgages on the same stream have similar upstream drainage sizes and are essentially providing the same peak-streamflow information (Gruber and Stedinger, 2008). The drainage area ratio method was used to determine if two streamgages were too similar to act as independent data points for developing a regional hydrologic model (Veilleux, 2009).

Basin Characteristics

Several basin characteristics were investigated for use as potential independent variables in the regression analysis. In this report, the basin characteristics (table 2) are the independent variables, and the resulting peak-streamflow frequency values are the dependent variables. Details regarding the basin characteristics listed in table 2 are available in the accompanying data release (Labriola and others, 2019).

Table 2. Basin characteristics investigated as possible independent variables for regressions used to estimate peak streamflows for unregulated streams.

[NED, National Elevation Dataset; NHD, National Hydrography Dataset; WBD, Watershed Boundary Dataset; PRISM, Parameter-Elevation Regressions on Independent Slopes Model; NCRS, Natural Resources Conservation Service; FWRS, floodwater-retarding structures; NOAA, National Oceanic and Atmospheric Administration]

Characteristic name	Units	Method	Source data
Contributing Drainage Area (CONTDA)	Square miles	ArcHydro method	NED 10-meter-resolution elevation data (https://viewer.nationalmap.gov/basic/, accessed August 2019), high-resolution NHD (http://nhd.usgs.gov/data.html, accessed August 2019), and WBD (http://www.ncgc.nrcs.usda.gov/products/datasets/watershed/, accessed August 2019)
Area-weighted mean annual precipitation 1971–2000 (PRECIP)	Inches	Area-weighted mean	PRISM (http://www.prism.oregonstate.edu/, accessed August 2019)
Main channel slope (CSL10_85_fm)	Feet per mile	ArcHydro method of computing stream slope from points 10 and 85 percent of the distance from the site to the basin divide, along the main channel	NED 10-meter-resolution elevation data (https://viewer.nationalmap.gov/basic/, accessed August 2019) and high-resolution NHD (http://nhd.usgs.gov/data.html, accessed August 2019)
Basin outlet horizontal coordinate	Meters	Point extract at outlet	NED 10-meter-resolution elevation data (https://viewer.nationalmap.gov/basic/, accessed August 2019) and high-resolution NHD (http://nhd.usgs.gov/data.html, accessed August 2019)
Basin outlet vertical coordinate	Meters	Point extract at outlet	NED 10-meter-resolution elevation data (https://viewer.nationalmap.gov/basic/, accessed August 2019) and high-resolution NHD (http://nhd.usgs.gov/data.html, accessed August 2019)
Elevation at Outlet	Feet	Point extract at outlet	NED 10-meter-resolution elevation data (https://viewer.nationalmap.gov/basic/, accessed August 2019) and high-resolution NHD (http://nhd.usgs.gov/data.html, accessed August 2019)
Mean annual precipitation 1961–90	Inches	Point extract at outlet	PRISM (http://www.prism.oregonstate.edu/, accessed August 2019)
Mean annual precipitation 1971–2000	Inches	Point extract at outlet	PRISM (http://www.prism.oregonstate.edu/, accessed August 2019)
Mean annual precipitation 1981–2010	Inches	Point extract at outlet	PRISM (http://www.prism.oregonstate.edu/, accessed August 2019)

Table 2. Basin characteristics investigated as possible independent variables for regressions used to estimate peak streamflows for unregulated streams.—Continued

[NED, National Elevation Dataset; NHD, National Hydrography Dataset; WBD, Watershed Boundary Dataset; PRISM, Parameter-Elevation Regressions on Independent Slopes Model; NCRS, Natural Resources Conservation Service; FWRS, floodwater-retarding structures; NOAA, National Oceanic and Atmospheric Administration]

Characteristic name	Units	Method	Source data
Mean February precipitation 1971–2000	Inches	Point extract at outlet	PRISM (http://www.prism.oregonstate.edu/, accessed August 2019)
Mean March precipitation 1971–2000	Inches	Point extract at outlet	PRISM (http://www.prism.oregonstate.edu/, accessed August 2019)
Mean April precipitation 1971–2000	Inches	Point extract at outlet	PRISM (http://www.prism.oregonstate.edu/, accessed August 2019)
Mean May precipitation 1971–2000	Inches	Point extract at outlet	PRISM (http://www.prism.oregonstate.edu/, accessed August 2019)
Mean June precipitation 1971–2000	Inches	Point extract at outlet	PRISM (http://www.prism.oregonstate.edu/, accessed August 2019)
Mean December precipitation 1971–2000	Inches	Point extract at outlet	PRISM (http://www.prism.oregonstate.edu/, accessed August 2019)
Mean June–October precipitation 1971–2000	Inches	Point extract at outlet	PRISM (http://www.prism.oregonstate.edu/, accessed August 2019)
Mean November–May precipitation 1971–2000	Inches	Point extract at outlet	PRISM (http://www.prism.oregonstate.edu/, accessed August 2019)
Elevation at 10 percent of the stream length starting from the outlet path slope using DEM	Feet	ArcHydro method	NED 10-meter-resolution elevation data (https://viewer.nationalmap.gov/basic/, accessed August 2019) and high-resolution NHD (http://nhd.usgs.gov/data.html, accessed August 2019)
Elevation at 85 percent of the stream length starting from the outlet path slope using DEM	Feet	ArcHydro method	NED 10-meter-resolution elevation data (https://viewer.nationalmap.gov/basic/, accessed August 2019) and high-resolution NHD (http://nhd.usgs.gov/data.html, accessed August 2019)

Table 2. Basin characteristics investigated as possible independent variables for regressions used to estimate peak streamflows for unregulated streams.—Continued

[NED, National Elevation Dataset; NHD, National Hydrography Dataset; WBD, Watershed Boundary Dataset; PRISM, Parameter-Elevation Regressions on Independent Slopes Model; NCRS, Natural Resources Conservation Service; FWRS, floodwater-retarding structures; NOAA, National Oceanic and Atmospheric Administration]

Characteristic name	Units	Method	Source data
Longest flowpath length	Feet	ArcHydro method	NED 10-meter-resolution elevation data (https://viewer.nationalmap.gov/basic/, accessed August 2019) and high-resolution NHD (http://nhd.usgs.gov/data.html, accessed August 2019)
NRCS FWRS—unregulated contributing drainage area	Square miles	ArcHydro method	NED 10-meter-resolution elevation data (https://viewer.nationalmap.gov/basic/, accessed August 2019), high-resolution NHD (http://nhd.usgs.gov/data.html, accessed August 2019), and WBD (http://www.ncgc.nrcs.usda.gov/products/datasets/watershed/, accessed August 2019)
Percentage NRCS FWRS—regulated contributing drainage area	Percent	ArcHydro method	NED 10-meter-resolution elevation data (https://viewer.nationalmap.gov/basic/, accessed August 2019), high-resolution NHD (http://nhd.usgs.gov/data.html, accessed August 2019), and WBD (http://www.ncgc.nrcs.usda.gov/products/datasets/watershed/, accessed August 2019)
Basin centroid horizontal coordinate	Meters	ArcHydro method	NED 10-meter-resolution elevation data (https://viewer.nationalmap.gov/basic/, accessed August 2019), high-resolution NHD (http://nhd.usgs.gov/data.html, accessed August 2019), and WBD (http://www.ncgc.nrcs.usda.gov/products/datasets/watershed/, accessed August 2019)
Basin centroid vertical coordinate	Meters	ArcHydro method	NED 10-meter-resolution elevation data (https://viewer.nationalmap.gov/basic/, accessed August 2019), high-resolution NHD (http://nhd.usgs.gov/data.html, accessed August 2019), and WBD (http://www.ncgc.nrcs.usda.gov/products/datasets/watershed/, accessed August 2019)
Basin perimeter	Miles	ArcHydro method	NED 10-meter-resolution elevation data (https://viewer.nationalmap.gov/basic/, accessed August 2019), high-resolution NHD (http://nhd.usgs.gov/data.html, accessed August 2019), and WBD (http://www.ncgc.nrcs.usda.gov/products/datasets/watershed/, accessed August 2019)
Basin shape factor	Dimensionless	ArcHydro method	NED 10-meter-resolution elevation data (https://viewer.nationalmap.gov/basic/, accessed August 2019), high-resolution NHD (http://nhd.usgs.gov/data.html, accessed August 2019), and WBD (http://www.ncgc.nrcs.usda.gov/products/datasets/watershed/, accessed August 2019)
Area-weighted mean basin slope	Percent	Area-weighted average	NED 10-meter-resolution elevation data (https://viewer.nationalmap.gov/basic/, accessed August 2019), high-resolution NHD (http://nhd.usgs.gov/data.html, accessed August 2019), and WBD (http://www.ncgc.nrcs.usda.gov/products/datasets/watershed/, accessed August 2019)
Area-weighted mean basin elevation	Feet	Area-weighted average	NED 10-meter-resolution elevation data (https://viewer.nationalmap.gov/basic/, accessed August 2019), high-resolution NHD (http://nhd.usgs.gov/data.html, accessed August 2019), and WBD (http://www.ncgc.nrcs.usda.gov/products/datasets/watershed/, accessed August 2019)

Table 2. Basin characteristics investigated as possible independent variables for regressions used to estimate peak streamflows for unregulated streams.—Continued

[NED, National Elevation Dataset; NHD, National Hydrography Dataset; WBD, Watershed Boundary Dataset; PRISM, Parameter-Elevation Regressions on Independent Slopes Model; NCRS, Natural Resources Conservation Service; FWRS, floodwater-retarding structures; NOAA, National Oceanic and Atmospheric Administration]

Characteristic name	Units	Method	Source data
Minimum basin elevation	Feet	ArcHydro method	NED 10-meter-resolution elevation data (https://viewer.nationalmap.gov/basic/, accessed August 2019), high-resolution NHD (http://nhd.usgs.gov/data.html, accessed August 2019), and WBD (http://www.ncgc.nrcs.usda.gov/products/datasets/watershed/, accessed August 2019)
Maximum basin elevation	Feet	ArcHydro method	NED 10-meter-resolution elevation data (https://viewer.nationalmap.gov/basic/, accessed August 2019), high-resolution NHD (http://nhd.usgs.gov/data.html, accessed August 2019), and WBD (http://www.ncgc.nrcs.usda.gov/products/datasets/watershed/, accessed August 2019)
Basin relief	Feet	ArcHydro method	NED 10-meter-resolution elevation data (https://viewer.nationalmap.gov/basic/, accessed August 2019), high-resolution NHD (http://nhd.usgs.gov/data.html, accessed August 2019), and WBD (http://www.ncgc.nrcs.usda.gov/products/datasets/watershed/, accessed August 2019)
Relative basin relief	Feet per mile	ArcHydro method	NED 10-meter-resolution elevation data (https://viewer.nationalmap.gov/basic/, accessed August 2019), high-resolution NHD (http://nhd.usgs.gov/data.html, accessed August 2019), and WBD (http://www.ncgc.nrcs.usda.gov/products/datasets/watershed/, accessed August 2019)
Soil permeability	Inches per hour	Area-weighted average	State Soil Geographic (STATSGO) Data (http://www.ncgc.nrcs.udsa.gov/products/datasets/statsgo/, accessed July 2008)
Area-weighted mean January precipitation 1981–2010	Inches	Area-weighted average	PRISM (http://www.prism.oregonstate.edu/, accessed August 2019)
Area-weighted mean February precipitation 1981–2010	Inches	Area-weighted average	PRISM (http://www.prism.oregonstate.edu/, accessed August 2019)
Area-weighted mean March precipitation 1981–2010	Inches	Area-weighted average	PRISM (http://www.prism.oregonstate.edu/, accessed August 2019)
Area-weighted mean April precipitation 1981–2010	Inches	Area-weighted average	PRISM (http://www.prism.oregonstate.edu/, accessed August 2019)
Area-weighted mean May precipitation 1981–2010	Inches	Area-weighted average	PRISM (http://www.prism.oregonstate.edu/, accessed August 2019)

Table 2. Basin characteristics investigated as possible independent variables for regressions used to estimate peak streamflows for unregulated streams.—Continued

[NED, National Elevation Dataset; NHD, National Hydrography Dataset; WBD, Watershed Boundary Dataset; PRISM, Parameter-Elevation Regressions on Independent Slopes Model; NCRS, Natural Resources Conservation Service; FWRS, floodwater-retarding structures; NOAA, National Oceanic and Atmospheric Administration]

Characteristic name	Units	Method	Source data
Area-weighted mean June precipitation 1981–2010	Inches	Area-weighted average	PRISM (http://www.prism.oregonstate.edu/, accessed August 2019)
Area-weighted mean July precipitation 1981–2010	Inches	Area-weighted average	PRISM (http://www.prism.oregonstate.edu/, accessed August 2019)
Area-weighted mean August precipitation 1981–2010	Inches	Area-weighted average	PRISM (http://www.prism.oregonstate.edu/, accessed August 2019)
Area-weighted mean September precipitation 1981–2010	Inches	Area-weighted average	PRISM (http://www.prism.oregonstate.edu/, accessed August 2019)
Area-weighted mean October precipitation 1981–2010	Inches	Area-weighted average	PRISM (http://www.prism.oregonstate.edu/, accessed August 2019)
Area-weighted mean November precipitation 1981–2010	Inches	Area-weighted average	PRISM (http://www.prism.oregonstate.edu/, accessed August 2019)
Area-weighted mean December precipitation 1981–2010	Inches	Area-weighted average	PRISM (http://www.prism.oregonstate.edu/, accessed August 2019)
Area-weighted mean June–October precipitation 1981–2010	Inches	Area-weighted average	PRISM (http://www.prism.oregonstate.edu/, accessed August 2019)
Area-weighted mean November–May precipitation 1981–2010	Inches	Area-weighted average	PRISM (http://www.prism.oregonstate.edu/, accessed August 2019)
Area-weighted maximum 24-hour precipitation in 100 years	Inches	Area-weighted average	NOAA Atlas 14 (https://hdsc.nws.noaa.gov/hdsc/pfds/, accessed August 2019) and Asquith, W.H., and Roussel, M.C., 2004, Atlas of depth-duration frequency of precipitation annual maxima for Texas: U.S. Geological Survey Scientific Investigations Report 2004–5041, 106 p.

Table 2. Basin characteristics investigated as possible independent variables for regressions used to estimate peak streamflows for unregulated streams.—Continued

[NED, National Elevation Dataset; NHD, National Hydrography Dataset; WBD, Watershed Boundary Dataset; PRISM, Parameter-Elevation Regressions on Independent Slopes Model; NCRS, Natural Resources Conservation Service; FWRS, floodwater-retarding structures; NOAA, National Oceanic and Atmospheric Administration]

Characteristic name	Units	Method	Source data
Area-weighted maximum 24-hour precipitation in 10 years	Inches	Area-weighted average	NOAA Atlas 14 (https://hdsc.nws.noaa.gov/hdsc/pfds/, accessed August 2019) and Asquith, W.H., and Roussel, M.C., 2004, Atlas of depth-duration frequency of precipitation annual maxima for Texas: U.S. Geological Survey Scientific Investigations Report 2004–5041, 106 p.
Area-weighted maximum 24-hour precipitation in 2 years	Inches	Area-weighted average	NOAA Atlas 14 (https://hdsc.nws.noaa.gov/hdsc/pfds/, accessed August 2019) and Asquith, W.H., and Roussel, M.C., 2004, Atlas of depth-duration frequency of precipitation annual maxima for Texas: U.S. Geological Survey Scientific Investigations Report 2004–5041, 106 p.
Canopy Cover 2001	Percent	Area-weighted average	National Land-Cover Dataset 2001, 30-meter resolution data layer from the Multi-Resolution Land Characteristics Consortium, accessed August 2019
Impervious Cover 2001	Percent	Area-weighted average	National Land-Cover Dataset 2001, 30-meter resolution data layer from the Multi-Resolution Land Characteristics Consortium, accessed August 2019
Canopy Cover 2011	Percent	Area-weighted average	National Land-Cover Dataset 2011, 30-meter resolution data layer from the Multi-Resolution Land Characteristics Consortium, accessed August 2019
Impervious Cover 2011	Percent	Area-weighted average	National Land-Cover Dataset 2011, 30-meter resolution data layer from the Multi-Resolution Land Characteristics Consortium, accessed August 2019
Shrub Cover 2011	Percent	Area-weighted average	National Land-Cover Dataset 2011, 30-meter resolution data layer from the Multi-Resolution Land Characteristics Consortium, accessed August 2019
Pasture Cover 2011	Percent	Area-weighted average	National Land-Cover Dataset 2011, 30-meter resolution data layer from the Multi-Resolution Land Characteristics Consortium, accessed August 2019

Basin characteristics were calculated for each streamgage by using GIS techniques and the USGS StreamStats application (Ries and others, 2004, 2008; Smith and Esralew, 2010) to ensure consistency and reproducibility. Regression equations and flow statistics at streamgages are integrated into the USGS StreamStats Web-based tool available at http://water.usgs.gov/osw/streamstats/index.html (USGS, 2016). StreamStats allows users to obtain flow statistics, basin characteristics, and other information for user-selected stream locations. The user can select a stream location on a GIS-based interactive map of Oklahoma, and StreamStats will delineate the drainage basin upstream from the selected location, compute basin characteristics, and compute flow statistics at the ungaged stream location by using regression estimates (Smith and Esralew, 2010).

Selection of the final characteristics were based on several factors, including ease of measurement of the characteristic, coefficient of determination (R^2), Mallow's *Cp* statistic (Helsel and Hirsch, 2002), multicollinearity, and statistical significance (p-value <0.05) of the independent variables. Multicollinearity among the independent variables was assessed by using the variance inflation factor which describes correlation among independent variables. Of the possible basin characteristics used in the regression analysis, contributing drainage-basin area (CONTDA), area-weighted mean-annual precipitation (PRECIP), and main-channel 10–85 slope (CSL10_85fm) were selected as the most appropriate independent variables for the regression analyses. The abbreviations CONTDA, PRECIP, and CSL10_85fm were selected to be consistent with StreamStats terminology. For region 1, CONTDA and PRECIP were the independent variables selected for the final regression equations. For region 2, CSL10_85fm and CONTDA were the independent variables selected for the final regression equations.

The CONTDA can be defined as a point on a stream to which all areas in the basin contribute runoff. The StreamStats application takes a user-defined outlet on a stream and delineates the drainage basin of the stream at that location. The basin outlet and delineated basin are used as the templates for estimating basin characteristics. The contributing drainage areas calculated by using StreamStats were compared to previously published drainage areas for those streams with streamgages. The drainage areas were within 2 percent of each other in 95 percent of cases.

Mean-annual precipitation proved to be an influential independent variable in past analyses (Sauer, 1974a; Thomas and Corley, 1977; Tortorelli and Bergman, 1985; Tortorelli, 1997). Mean-annual precipitation data over the drainage basin for the period 1971 to 2000 (PRISM Climate Group, 2008), computed by using an area-weighted method, were used to define mean-annual precipitation for a given streamgage.

The Oklahoma StreamStats application was used to compute 10–85 channel slope, which is defined as the difference in elevation between points at 10 and 85 percent of the stream length starting from the outlet and along the longest flow path (also referred to as main-channel length). StreamStats uses the USGS National Hydrography Dataset (USGS, 2008) to compute the longest flow path from, and StreamStats obtains the corresponding elevations from a digital elevation model from the USGS National Elevation Dataset (USGS, 2006). The automated slope computation procedures used in StreamStats are similar to the manual computation procedures used by Tortorelli (1997), but generally are more precise because the automated slope computations are performed exclusively on 1:24,000-scale data (S.J. Smith and R.A. Esralew, USGS, written commun., 2010); however, previous methods used slope computations at different scales. The computed slope is reported in units of feet per mile.

Estimates of Magnitude and Frequency of Peak Streamflows at Streamgages on Unregulated Streams

Flood magnitude and frequency can be estimated for a specific streamgage by analysis of annual peak streamflow at that streamgage. In the past, these estimates have been reported in terms of a T-year flood (for example, 100-year flood) based on the recurrence interval for that flood. The terminology associated with flood-frequency estimates has shifted away from the T-year recurrence interval flood to the P-percent chance exceedance flood (Holmes and Dinicola, 2010). T-year recurrence intervals with corresponding annual exceedance probabilities and P-percent chance exceedances are shown in table 3. Throughout the remaining sections of this report, the P-percent chance exceedance terminology will be used to describe peak-streamflow frequency estimates.

Table 3. T-year recurrence intervals with corresponding annual exceedance probabilities and P-percent chance exceedances for peak-streamflow frequency estimates.

T-year recurrence interval	Annual exceedance probability	P-percent chance exceedance
2	0.5	50
5	0.2	20
10	0.1	10
25	0.04	4
50	0.02	2
100	0.01	1
500	0.002	0.2

Peak-Streamflow Frequency

The IACWD provides a standard procedure for peak-streamflow frequency estimates, USGS Bulletin 17C, that involves a standard frequency distribution, the log-Pearson Type III (LPIII) (England and others, 2019). Systematically collected and historical peak streamflows are fit to the LPIII distribution. The asymmetry in the shape of the distribution is defined by a skew coefficient that is used in the estimate procedure. Estimates of the *P*-percent chance exceedance flows can be computed by the following equation:

$$\log Q_x = X + KS, \quad (1)$$

where

Q_x is the *P*-percent chance exceedance flow, in cubic feet per second;

X is the mean of the logarithms of the annual peak streamflows;

K is a factor based on the skew coefficient and the given percent chance exceedance, which can be obtained from appendix 3 in USGS Bulletin 17C (England and others, 2019); and

S is the standard deviation of the logarithms (base 10) of the annual peak streamflows, which is a measure of the degree of variation of the annual log of peak streamflow about the mean log peak streamflow.

Because of variation in the climatic and physiographic characteristics in Oklahoma and the nearby areas in Arkansas, Kansas, Missouri, and Texas, the LPIII distribution does not always adequately define a suitable distribution of peak-streamflow values (Tortorelli, 1997). To reduce errors in peak-streamflow frequency resulting from a poor LPIII fit, estimates of peak-streamflow frequency for the streamgages evaluated in this report were adjusted based on historical flood information (where available), low-outlier thresholds, skew coefficients, and IACWD guidelines.

The USGS computer program PEAKFQ (version 7.2) was used to compute flood-frequency estimates for the 212 streamgages on unregulated streams evaluated in this report. PEAKFQ automates many of the analytical procedures recommended in USGS Bulletin 17C (England and others, 2019). The PEAKFQ program and associated documentation can be downloaded online at http://water.usgs.gov/software/PeakFQ/ (USGS, 2018b). Peak-streamflow frequency estimates of the 50-, 20-, 10-, 4-, 2-, 1-, and 0.2-percent annual exceedance probabilities are listed for each streamgage evaluated during this study (table 1).

Weighted Skew

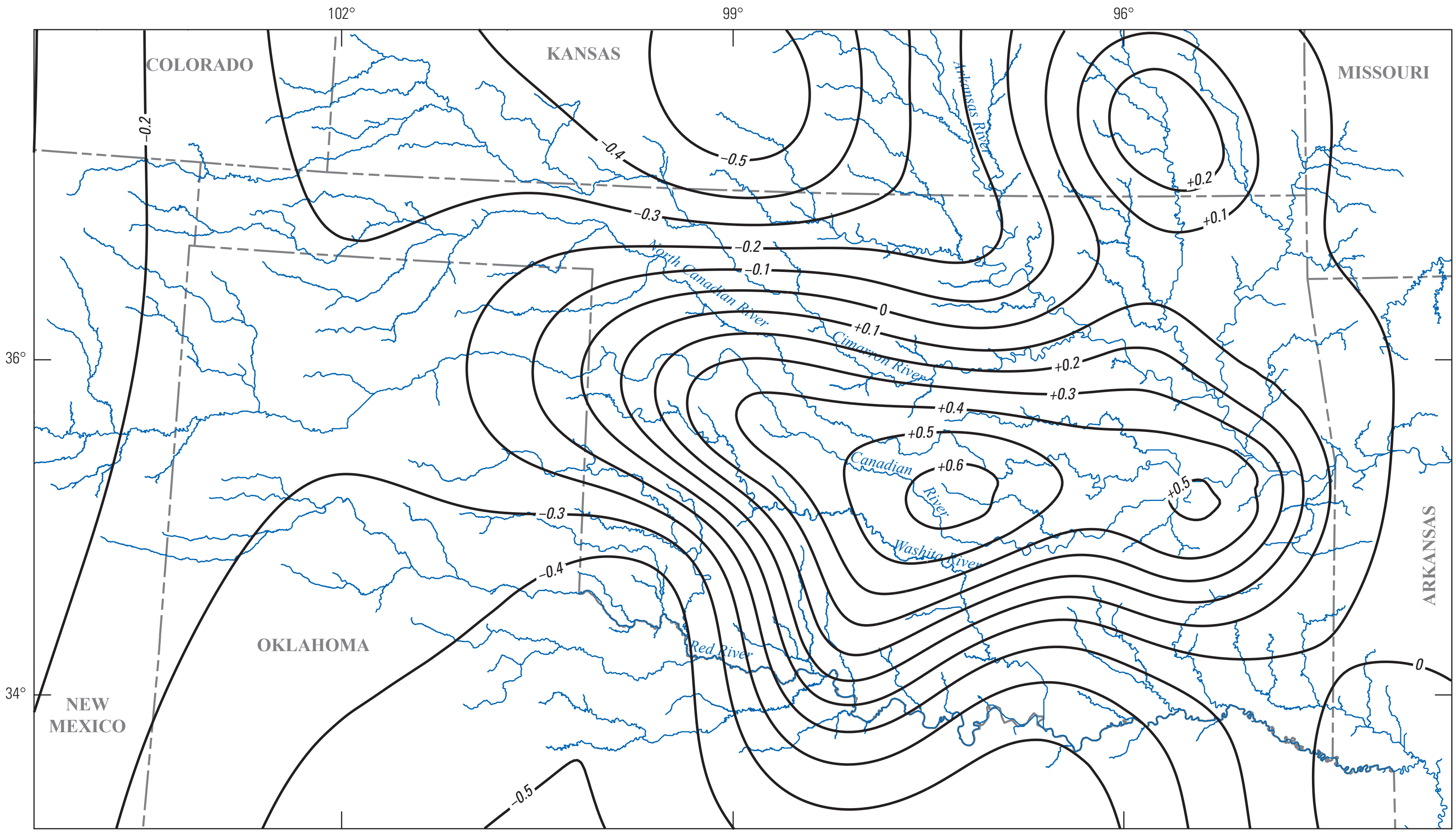
Determining skew coefficients is the next step in peak-streamflow frequency analyses. The skew coefficient measures the asymmetry of the probability distribution of a set of annual peak streamflows and is difficult to estimate reliably for streamgages with short periods of record. The IACWD therefore recommends applying a weighted skew coefficient to the LPIII distribution. This skew coefficient is calculated by weighting the skew coefficient computed from the peak-streamflow data at the streamgage (station skew) and a generalized skew coefficient representative of the surrounding area (fig. 2). The weighted skew coefficient is based on the inverse of the respective mean square errors for each of the two skew coefficients (IACWD, 1982).

The weighted skew coefficient generally is preferred for peak-streamflow frequency estimates. The station skew and weighted skew are listed in table 1 (back of report) for each streamgage. Weighted skew coefficients (station skews weighted with generalized skews for Oklahoma [fig. 2]) were used for all streamgages in this report. Development of the generalized skew map for Oklahoma is explained in the “Generalized Skew Analysis” section of this report.

Generalized Skew Analysis

A nationwide generalized skew map is provided in USGS Bulletin 17B (IACWD, 1982). However, a more refined generalized skew map was needed for Oklahoma instead of a map prepared at a national scale. Lewis and Esralew (2009) previously published generalized skew coefficients for Oklahoma that used adjusted station skew coefficients from streamgages with at least 20 years of peak-streamflow data, drainage basins greater than 10 mi^2 and less than 2,510 mi^2, and streamflow data through 2007.

Adjusted station skew coefficients from streamgages with at least 20 years of peak-streamflow data, drainage basins greater than 10 mi^2 and less than 2,510 mi^2, and streamflow data through 2017 were used to create an updated generalized skew map for Oklahoma (Labriola and others, 2019). The updated generalized skew map for Oklahoma was created by using station record skew values following methods detailed in Bulletin 17C (England and others, 2019) and by interpolating the values over the State of Oklahoma with a GIS. The revised skew map was created by using GIS “Topo to Raster” (Esri, 2018a) and “Contour” (Esri, 2018b) tools for interpolating and smoothing isolines. The interpolation and smoothing process was iterated four times, progressively refining the skew map by eliminating outlying skew values and skew contours. A generalized skew map with a mean square error of 0.148 was achieved for Oklahoma. This updated generalized skew map is available in the companion data release (Labriola and others, 2019) and shown in figure 2. The streamgages used to develop the Oklahoma generalized skew map are specified in table 1.



Base modified from U.S. Geological Survey digital data
Albers Equal-Area Conic projection
North American Datum of 1983

0 70 140 MILES
0 70 140 KILOMETERS

EXPLANATION

—+0.6— Line of equal generalized skew coefficient of logarithms of annual maximum streamflow, based on streamgage records through 2017 greater than or equal to 20 years in length. Basin drainage area between 10 and 2,510 square miles. Interval is 0.1.

Figure 2. Generalized skew coefficients of logarithms of annual maximum streamflow for Oklahoma streams with drainage areas between 10 and 2,510 square miles.

Estimates of Magnitude and Frequency of Peak Streamflows at Ungaged Sites on Unregulated Streams

Estimates of the magnitude and frequency of peak streamflows are commonly needed at ungaged sites. These estimates can be obtained by defining regression equations that relate peak streamflows of selected frequencies at streamgages to basin characteristics. Multiple-linear regression analysis (Helsel and Hirsch, 2002) was used to establish the statistical relations between one dependent variable (peak streamflow) and one or more independent variables (basin characteristics). The 50-, 20-, 10-, 4-, 2-, 1-, and 0.2-percent annual exceedance probability streamflows were used as dependent variables, and the selected basin characteristics were used as independent variables. Logarithmic transformations of the dependent and independent variables were used to increase the linearity between the dependent and independent variables. The general steps followed in this study to develop regression equations were:

1. Basin characteristics were evaluated to identify possible explanatory variables used in the regression equations.
2. Peak-streamflow annual exceedance probability streamflows and basin characteristics were log transformed to obtain better linear relations between the dependent variables and the independent variables.
3. Stepwise regression analysis was used to assess the most appropriate basin characteristics.
4. Preliminary multiple-linear regression models were formed by using ordinary least squares (OLS).
5. Residual plots were examined, and leverage and influence statistics were computed and plotted to identify data observations that may substantially affect regression results. Outliers were removed based on this procedure.
6. Iterations of steps 2–5 were completed for OLS regression models to reduce the number of independent variables.
7. Weighting procedures were developed.
8. Significance of coefficients in the weighted least-squares (WLS) regression model was checked along with residuals, and streamgages with large leverage and influence were identified.
9. From the same dataset, a GLS regression model was formed by using the USGS weighted-multiple-linear regression (WREG) program (Eng and others, 2009).

OLS regression analysis was performed on streamflow data from the 212 streamgages in order to determine if regression equations for separate hydrologic regions in the State was warranted. A similar check was performed on the GLS models. No geographic patterns were evident after the residuals (differences between estimated peak streamflow and measured peak streamflow) were examined. Separating the State into two regions did improve the regression models in region 2 (eastern Oklahoma).

Regression Analysis

Previous regression analysis of peak-streamflow frequency for Oklahoma (Tortorelli, 1997) used WLS procedures. Lewis (2010) used the GLS procedure but used Bulletin 17B methods to calculate the magnitude of peak frequencies; Bulletin 17B methods have been superseded by Bulletin 17C methods (England and others, 2019). In this report, the updated Bulletin 17C methods were used along with OLS, WLS, and GLS regression procedures. WLS regression was used to test the statistical significance ($p<0.05$) of possible independent variables (Ries and Dillow, 2006). The GLS method was then used to determine the final regression equations. Stedinger and Tasker (1985) showed that the GLS method can be used to assign weights to the streamgage data used in the regression analysis to adjust not only for differences in record length, as in WLS, but also for cross-correlation of the annual time series on which the peak-flow statistics for the streamgage data are based, and for spatial correlation among the streamgage data. Annual peak flows of basins are cross-correlated because a single storm can cause the annual peak in several basins. One advantage of using GLS is that it accounts for cross-correlation among basins.

GLS regression entails weighting each basin in accordance with the variance (time-sampling error) and spatial-correlation structure of the streamflow characteristic (annual peak streamflow among streamgages) (Lumia and others, 2006). The residual mean square error for ungaged sites is portioned into regression model error (error in assuming an incomplete regression form) and sampling error (time- and spatial-sampling errors). When using GLS, the variance of prediction (and the square root, the standard error of prediction) is the sum of the model error variance and an additional term. This additional term has been called a sampling error variance (of the coefficients) but is different from the time-sampling and spatial-sampling error.

The GLS regression analysis used in this report incorporated logarithmic (base 10) transformations of the streamflow (annual peak flows) and basin characteristics to obtain a constant variance of the residuals about the regression line and to make the relation between the dependent variable (peak flow) and independent variables (basin characteristics) acceptable for linear least-squares regression procedures. The multiple-regression equation based on logarithmic transformation of the variables has the following form:

$$\mathrm{Log}_{10} Y = b_0 + b_1 \log_{10} X_1 + \mathrm{b}_2 \log_{10} X_2 + \ldots\ldots + b_{\mathrm{n}} \log_{10} X_{\mathrm{n}}, \quad (2)$$

and the following form after taking the antilogarithms,

$$Y = 10^{b0}\,(X_1^{\,b1})\,(X_2^{\,b2})\ldots\ldots(X_n^{\,bn}) \qquad (3)$$

where

Y	= dependent variable (peak flow for selected exceedance),
b_0 to b_n	= regression model coefficient estimated by using GLS procedures, and
X_1 to X_n	= independent variables (basin characteristics).

The USGS WREG computer program, which applies OLS, WLS, and GLS regression methods, was used to estimate the regression parameters (Eng and others, 2009). The WREG program allows for selection between these three regression methods and for transformations on the dependent and independent variables. The multiple performance metrics from the WREG program were used to identify possible problem sites used in the regression. The residuals metric was used to show differences between estimated and measured flow at various flow magnitudes. Residuals randomly distributed around zero are preferred. The leverage metric was used to measure how distant the values of independent variables at one streamgage were from the centroid of values of the same variables at all other streamgages. The influence metric indicated whether a streamgage had a large influence on the estimated regression parameter values (Eng and others, 2009). Individual streamgages identified as having large influence and leverage were not arbitrarily removed because the streamgage may have been the only one in that particular area or because removal did not alter the regression. After examining the leverage and influence plots, the following streamgages were removed: in region 1, Willow Creek near Albert, Okla. (07325860) and in region 2, Bois D'Arc Creek near Randolph, Tex. (07332600) and Blue Beaver Creek near Cache, Okla. (07311200). Caution is needed when estimating peak streamflows in areas near these three streamgages because of water-use practices. Performance metrics for the 10-percent annual exceedance probability from the regression model for region 2 are shown in figure 3.

Regression Equations

Regression equations were developed for use in estimating peak streamflows associated with 50-, 20-, 10-, 4-, 2-, 1-, and 0.2-percent annual exceedance probabilities. Combinations of independent variables that did not have substantial leverage or influence were selected for inclusion in the final regression equations; multicollinearity also provided the lowest estimated error for each percent exceedance. Contributing drainage area, mean-annual precipitation, and stream slope were the most appropriate basin characteristics used to estimate peak-streamflow frequency on unregulated streams. The values for each of these three characteristics used in the

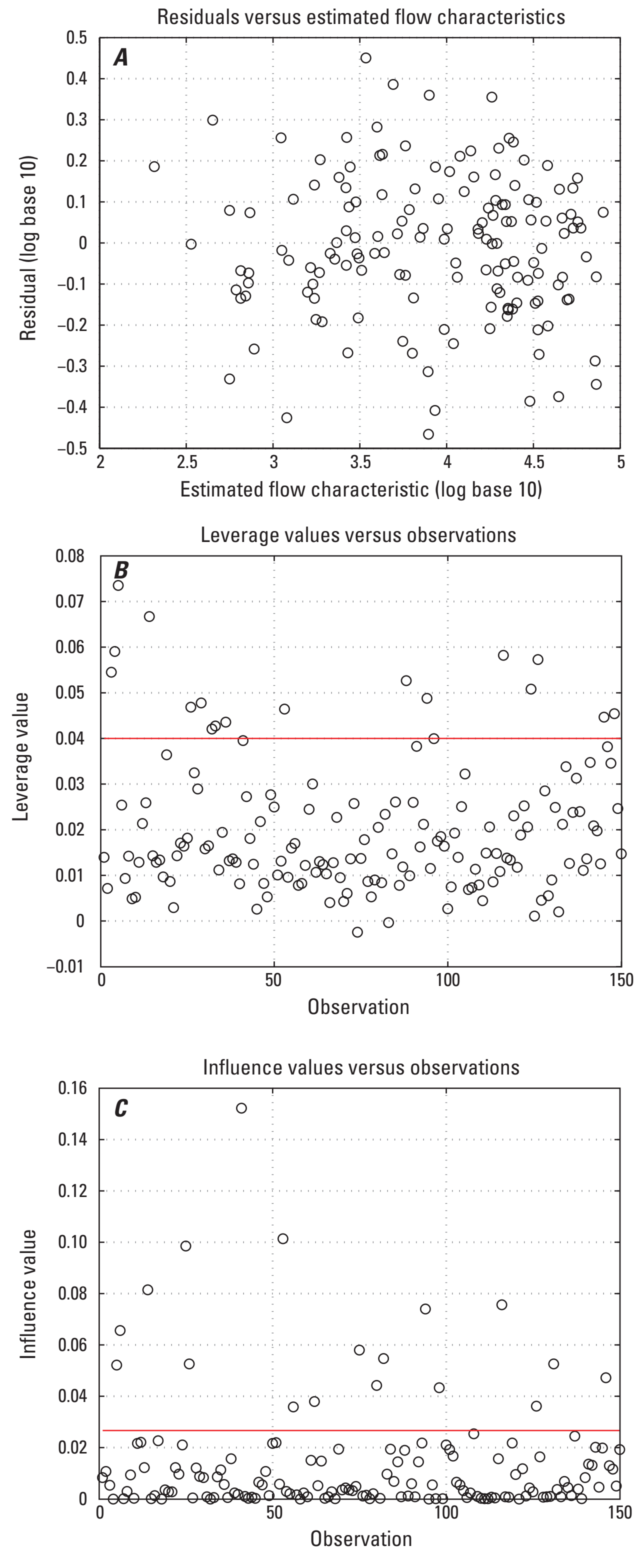


Figure 3. Weighted-multiple-linear regression (WREG) program performance metrics (*A*, residuals, *B*, leverage, and *C*, influence) for the 10-percent annual exceedance probability from the peak-streamflow regression model for eastern Oklahoma (region 2).

regression equations are listed in table 1 for each streamgage used in the analysis.

The following equations were developed for unregulated streams from the results of the GLS regression analysis in the WREG program and are listed according to percent chance exceedance.

Region 1

$$Q_{50\%} = 1.2\,(CONTDA)^{0.54}\,(PRECIP)^{1.44} \quad (4)$$

$$Q_{20\%} = 1.82\,(CONTDA)^{0.56}\,(PRECIP)^{1.55} \quad (5)$$

$$Q_{10\%} = 1.82\,(CONTDA)^{0.55}\,(PRECIP)^{1.68} \quad (6)$$

$$Q_{4\%} = 1.90\,(CONTDA)^{0.54}\,(PRECIP)^{1.81} \quad (7)$$

$$Q_{2\%} = 1.92\,(CONTDA)^{0.54}\,(PRECIP)^{1.91} \quad (8)$$

$$Q_{1\%} = 1.95\,(CONTDA)^{0.53}\,(PRECIP)^{1.98} \quad (9)$$

$$Q_{0.2\%} = 2.09\,(CONTDA)^{0.51}\,(PRECIP)^{2.13} \quad (10)$$

Region 2

$$Q_{50\%} = 61.6\,(CSL\_85fm)^{0.40}\,(CONTDA)^{0.75} \quad (11)$$

$$Q_{20\%} = 97.7\,(CSL\_85fm)^{0.44}\,(CONTDA)^{0.77} \quad (12)$$

$$Q_{10\%} = 126\,(CSL\_85fm)^{0.46}\,(CONTDA)^{0.78} \quad (13)$$

$$Q_{4\%} = 174\,(CSL\_85fm)^{0.47}\,(CONTDA)^{0.78} \quad (14)$$

$$Q_{2\%} = 204\,(CSL\_85fm)^{0.50}\,(CONTDA)^{0.79} \quad (15)$$

$$Q_{1\%} = 240\,(CSL\_85fm)^{0.50}\,(CONTDA)^{0.79} \quad (16)$$

$$Q_{0.2\%} = 363\,(CSL\_85fm)^{0.51}\,(CONTDA)^{0.80} \quad (17)$$

where

$Q_{50\%}$, $Q_{20\%}$,……, and $Q_{0.2\%}$ = the peak streamflows with annual exceedance probabilities of 50 percent, 20 percent, ……, and 0.2 percent, in cubic feet per second;

CONTDA = the contributing drainage area, in square miles;

PRECIP = the area-weighted precipitation from the period 1971–2000, in inches; and

CSL10_85fm = the main-channel slope, measured at the points that are 10 percent and 85 percent upstream from the streamgage or ungaged site, on the main-channel length between the study site and the drainage divide, in feet per mile.

Accuracy and Limitations

Regression equations are statistical models in which the results are inexact. Regression equations need to be applied within the limits of the data with the understanding that the results are best-fit estimates with associated variances. Residual errors in the model (differences between estimated and measured values) were examined to determine variables that optimized the accuracy of each regression equation, which depends on the model and sampling error. Regression-equation model errors are described by the standard model error. Sampling errors result from the limitations on the number of years of streamgage record, from the assumption that the streamgage record is representative of long-term streamflow, and from differences in hydrologic conditions. Although the use of GLS methodology allows for separation of the sampling error variance from the total mean square error of the residuals, the GLS methodology does not prevent this type of error.

Different forms of the coefficient of determination (R^2) are commonly used to assess the accuracy of a regression peak-flow estimate, the mean standard error of prediction, and the standard model error (Helsel and Hirsch, 2002). The adjusted R^2 measures the proportion of the variability in the dependent variable (site peak flow, $Q_{x(s)}$) that is accounted for by the independent variables (the basin characteristics, *CONTDA*, *PRECIP*, and *CSL10_85fm*). The larger the R^2, the better the fit of the model, with a value of 1.00 indicating that 100 percent of the variability in the dependent variable is accounted for by the independent variables (Helsel and Hirsch, 2002). Griffis and Stedinger (2007) state that R^2_{pseudo} is a more appropriate performance metric for WLS and GLS regressions compared to other forms of the coefficient of determination. R^2_{pseudo} is based on the variability in the dependent variable explained by the regression, after removing the effect of the time-sampling error (Eng and others, 2009). Table 4 lists all R^2_{pseudo} values for each of the percent chance exceedance peak streamflows.

The standard error of prediction is derived from the sum of the model error variance and the sampling error of the coefficients and is a measure of the expected accuracy of the regression estimates for the selected percent chance exceedances. The standard model error, which depends on the number and predictive power of the independent variables, measures the ability of these variables to estimate peak-streamflow frequency from the site records that were used to develop the equation. The WREG program reports mean

Table 4. Accuracy of peak streamflows estimated for unregulated streams in regions 1 and 2 in Oklahoma.

[R^2, coefficient of determination; S_p, mean standard error of prediction]

Percent chance exceedance	R^2_{pseudo}	S_p (percent)	Standard model error (percent)	Equivalent years of record
		Region 1		
50	92.08	42.99	41.90	2
20	94.74	34.09	32.97	5
10	95.18	32.52	31.28	8
4	92.18	41.34	39.56	9
2	93.72	37.48	35.93	11
1	92.86	40.34	38.65	12
0.2	89.33	51.20	49.32	12
		Region 2		
50	90.59	46.88	46.02	2
20	93.98	36.23	35.38	5
10	94.18	35.03	33.79	8
4	92.78	39.88	38.82	9
2	93.72	37.07	35.93	11
1	92.84	39.90	38.65	12
0.2	89.30	50.70	49.32	12

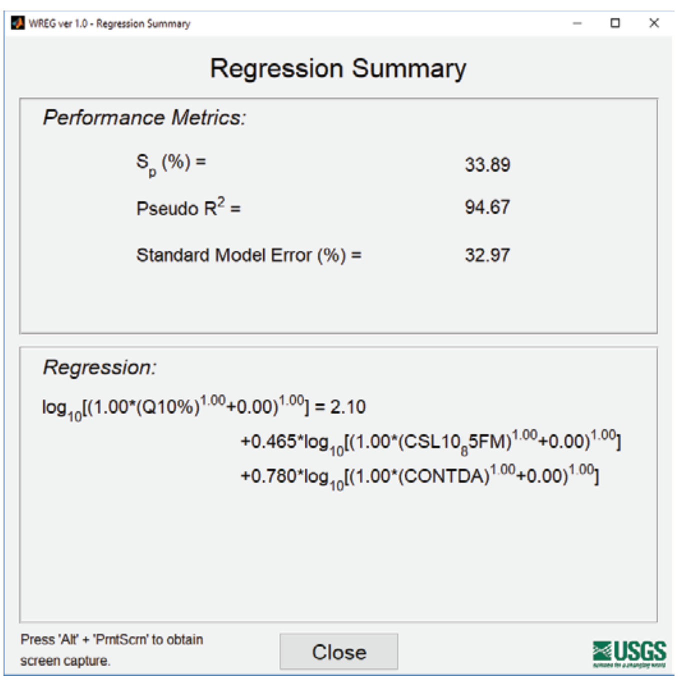


Figure 4. Weighted-multiple-linear regression (WREG) program output for the 10-percent annual exceedance probability for peak streamflows in eastern Oklahoma (region 2) from the generalized least-squares (GLS) regression model.

standard error of prediction (S_p), standard model error, and R^2_{pseudo} in the model output (fig. 4). For regions 1 and 2 in Oklahoma, the mean standard error of prediction ranges from 32.52 to 51.20 percent, and the standard model error ranges from 31.28 to 49.32 percent for the different annual exceedance probabilities that were computed (table 4).

Equivalent years of record, proposed by Hardison (1971), is another way of measuring the reliability of peak-streamflow regression equations. Equivalent years of record, which is an approximation, is the number of actual years of record needed to provide estimates equal in accuracy to those estimates computed by the regression equations. The accuracy of the regression equations for unregulated streams, expressed as equivalent years of record, is summarized in table 4.

The regression equations developed in this report are applicable to streams in Oklahoma with drainage areas less than 2,510 mi^2 that are not substantially affected by regulation. The equations are intended for use on unregulated streams in Oklahoma and should not be used outside the range of the independent variables used in the analysis:

CONTDA	Equal to or greater than 0.100 square mile	and less than or equal to 2,510 square miles
PRECIP	Equal to or greater than 16.6 inches	and less than or equal to 62.1 inches
CSL10_85fm	Equal to or greater than 1.98 foot per mile	and less than or equal to 342 feet per mile

The same cautions are applicable for estimating flows on streams regulated with floodwater-retarding structures as with unregulated drainage basin peak-streamflow estimates. The adjusted equations described in “Adjustment for Ungaged Sites on Urban Streams” can be used when the percent of regulated drainage area is not greater than 86 percent of the basin, which is the upper limit of the range of regulated data used to check the validity of the adjustment (Tortorelli and Bergman, 1985; Tortorelli, 1997). The adjusted equations are intended for use on parts of a basin with NRCS floodwater-retarding structures and not with any other floodwater-retarding structures. When the regulated drainage area is greater than 86 percent of the basin, the flow routing techniques in Chow and others (1988) may be used.

Application of Methods

This section presents methods for use of the regression equations to make a weighted peak-streamflow estimate for streamgage data on unregulated streams with a drainage area less than 2,510 mi^2 in Oklahoma and for use of this result to make an estimate for a nearby ungaged site on the same stream. For ungaged sites on urban streams and ungaged sites on streams regulated by floodwater-retarding structures, an adjustment of the statewide regression equations for unregulated streams can be used to estimate peak-streamflow frequency.

Peak-Streamflow Magnitude and Frequency Estimates for a Streamgage

The IACWD (1982) recommends that peak-streamflow frequency estimates for streamgage sites on unregulated streams are combinations of streamgage data and regression estimates. The estimates weighted by years of record are considered more reliable than either the regression estimate or streamgage data when making estimates of peak-streamflow frequency relations at gaged sites (Sauer, 1974a; Thomas and Corley, 1977). The equivalent years of record concept is used to combine streamgage estimates with regression estimates to obtain weighted estimates of peak streamflow at a gaged site.

The locations of the streamgages with unregulated periods of record used in the report are shown in figure 1. The map identifier can be used to obtain the streamgage's peak streamflow for percent chance exceedance, from table 1. The streamgages that have unregulated periods of record, but are now regulated, are noted in table 1. If the streamgage of interest is still on an unregulated stream, then the peak streamflow is used with the regression estimate $\mathbf{Q}_{x(r)}$ in a weighting procedure described by Sauer (1974a) and Thomas and Corley (1977):

$$\mathbf{Q}_{x(w)} = [\mathbf{Q}_{x(s)}(\mathbf{N}) + \mathbf{Q}_{x(r)}(\mathbf{E})] / (\mathbf{N} + \mathbf{E}) \qquad (18)$$

where

- $\mathbf{Q}_{x(w)}$ is the weighted estimate of peak streamflow, for percent chance exceedance **x**, in cubic feet per second;
- $\mathbf{Q}_{x(s)}$ is the estimate of peak streamflow for the streamgage, for percent chance exceedance **x** (table 1), in cubic feet per second;
- $\mathbf{Q}_{x(r)}$ is the regression estimate of peak streamflow, for percent chance exceedance **x** (equations 4–17), in cubic feet per second;
- **N** is number of actual years of record at the streamgage (table 1); and
- **E** is equivalent years of record for percent chance exceedance **x** (table 4).

Example

The following example illustrates how the method described is used to determine weighted peak-streamflow estimates for a streamgage on an unregulated stream. The example computation is for Kiamichi River near Big Cedar, Oklahoma (07335700), and the results are presented in table 5.

The column $\mathbf{Q}_{x(s)}$ in table 5 indicates the computed peak-streamflow frequency relations derived from the 52 years of record at streamgage 07335700 (site 188, table 1, fig. 1). The values in the column labeled $\mathbf{Q}_{x(r)}$ were estimated by using equations 11–17 and the following basin attributes (table 1):

CSL10_85fm = 54.87 feet per mile (ft/mi) and

CONTDA = 39.63 mi^2.

The $\mathbf{Q}_{x(r)}$ estimates computed from equations 11–17 are presented in table 5. The weighted estimates, $\mathbf{Q}_{x(w)}$, were computed from equation 18 by using the appropriate equivalent years of record from table 4.

Peak-Streamflow Magnitude and Frequency Estimates for an Ungaged Site near a Streamgage

The combined use of the regression equations and the streamgage data can yield an estimate of the peak-streamflow magnitude and frequency for ungaged sites near streamgages on the same stream. The following method is indicated for use if the ungaged site has a drainage area within 50 percent of the drainage area of the streamgage (Sauer, 1974a). The ratio, $\mathbf{R}_w$, represents the correction needed to adjust the regression estimate, $\mathbf{Q}_{x(r)}$, to the weighted estimate, $\mathbf{Q}_{x(w)}$, at the streamgage:

$$\mathbf{R}_{\mathbf{w}} = \frac{\mathbf{Q}_{\mathbf{x(w)}}}{\mathbf{Q}_{\mathbf{x(r)}}} \qquad (19)$$

where

- $\mathbf{Q}_{x(w)}$ is the weighted estimate of peak streamflow at the streamgage, for percent chance exceedance **x** (equation 18), in cubic feet per second, and

Table 5. Weighted peak-streamflow frequency estimates for Kiamichi River near Big Cedar, Oklahoma (07335700), eastern Oklahoma (region 2).

[ft^3/s, cubic feet per second]

Percent chance exceedance	$Q_{x(s)}$[1] (ft^3/s)	N[2] (years)	$Q_{x(r)}$[3] (ft^3/s)	E[4] (years)	$Q_{x(w)}$[5] (ft^3/s)
50	8,910	52	4,830	2	8,760
20	15,600	52	9,670	5	15,080
10	20,800	52	14,000	8	20,000
4	28,400	52	20,200	9	27,200
2	34,600	52	27,600	11	33,400
1	41,400	52	32,500	12	39,700
0.2	59,400	52	53,100	12	58,200

[1]Estimate of peak streamflow for the streamgage, for percent chance exceedance x, table 1.

[2]Number of available years of streamflow record at streamgage, table 1.

[3]Regression estimate of peak streamflow, for percent chance exceedance x, equations 11–17.

[4]Equivalent years of unregulated streamflow record for percent chance exceedance x, table 4.

[5]Weighted estimate of peak streamflow, for percent chance exceedance x, equation 18.

$\mathbf{Q}_{x(r)}$ is the regression estimate of peak streamflow at the streamgage, for percent chance exceedance **x** (equations 11–17), in cubic feet per second.

$\mathbf{R}_w$ is then used to determine the correction factor $\mathbf{R}_c$ for the ungaged site. The following equation from Sauer (1974a) gives the correction factor $\mathbf{R}_c$, for an ungaged site that is near a streamgage on the same stream,

$$\mathbf{R_c} = \mathbf{R_w} - \frac{\Delta \mathrm{CONTDA}}{0.5 CONTDA_g}\left(\mathbf{R_w} 1.00\right) \qquad (20)$$

where

ΔCONTDA is the difference between the drainage areas of the streamgage and the ungaged site, and

$CONTDA_g$ is the drainage area of the streamgage.

The regression estimate, $\mathbf{Q}_{x(r)}$, for the ungaged site is multiplied by the correction factor $\mathbf{R}_c$ to improve the estimate by using nearby streamgage data. If the drainage area of the ungaged site is within 50 percent of the streamgages, the peak-streamflow frequency estimate for the ungaged site can be calculated by interpolation of the weighted station peak streamflow, $\mathbf{Q}_{x(w)}$, for each streamgage. Interpolation is based on the drainage area. If the peak streamflows for the ungaged site are affected by urbanization, the peak streamflows need to be modified by methods given in the following section "Adjustment for Ungaged Sites on Urban Streams." If the drainage area of the ungaged site is 50 percent more than or less than that of the streamgage (that is, $\mathbf{\Delta CONTDA/CONTDA}_g$ is greater than 0.5), equation 11 is not used, and the regression equations 4–10 are used without adjustment.

Example

The following example illustrates how to adjust a weighted estimate calculated for a gaged site on an unregulated stream for an ungaged site on the same stream. Assume an estimate of the 1-percent chance exceedance flood is needed at an ungaged site upstream from streamgage 07335700 on the Kiamichi River (table 5). Assume the following hypothetical basin attributes for the ungaged site:

CSL10_85fm = 42.0 ft/mi

CONTDA = 20.5 mi^2

The following data and calculations are needed to estimate $Q_{1\%}$ at the ungaged site.

1. Streamgage site 07335700, Kiamichi River near Big Cedar

   $\mathbf{CONTDA}_g$ = 39.63 mi^2
   $\mathbf{Q}_{1\%(r)}$ = 32,500 cubic feet per second (ft^3/s), from equation 16, table 5
   $\mathbf{Q}_{1\%(w)}$ = 39,700 ft^3/s, from equation 18, table 5
   $\mathbf{R}_w = \mathbf{Q}_{1\%(w)} / \mathbf{Q}_{1\%(r)}$ = 1.22

2. Ungaged site on the Kiamichi River

   CONTDA = 20.5 mi^2
   $\mathbf{Q}_{1\%(r)}$ = 19,300 ft^3/s, from equation 16
   ΔCONTDA = 19.1 mi^2
   $\mathbf{\Delta CONTDA/CONTDA}_g$ = 0.48 (Because 0.48 is less than 0.5, $\mathbf{R}_c$ is computed from equation 18 and used to adjust $\mathbf{Q}_{1\%(r)}$.)

$$\mathbf{R_c} = 1.22 - \frac{19.1}{0.5\left(39.6\right)}\left(1.22 - 1.00\right) = 1.00$$

$\mathbf{Q}_{1\%} = \mathbf{Q}_{1\%(r)}\,(\mathbf{R}_c)$ = 19,300 (1.00) = 19,300 ft^3/s

The estimate of the 1-percent chance exceedance flood at the ungaged site on the Kiamichi River is a flow of 19,300 ft^3/s, after the regression estimate is adjusted for the data for gaging station 07335700.

Adjustment for Ungaged Sites on Urban Streams

The percentage of the basin that is impervious and the percentage of the basin served by storm sewers are required in addition to the variables needed for ungaged sites on unregulated streams to estimate flood magnitude and frequency for ungaged sites on urban streams. The percentage of the basin that is impervious can be determined from the StreamStats web application (USGS, 2016), aerial photographs, recent USGS topographic maps, or field surveys. The percentage of the basin served by storm sewers needs to be determined from the best available storm sewer and drainage map.

After the percentages of the area that is impervious and the area that is served by storm sewers are obtained, $\mathbf{R}_L$, the urban adjustment factor, is obtained from figure 5 (Leopold, 1968).

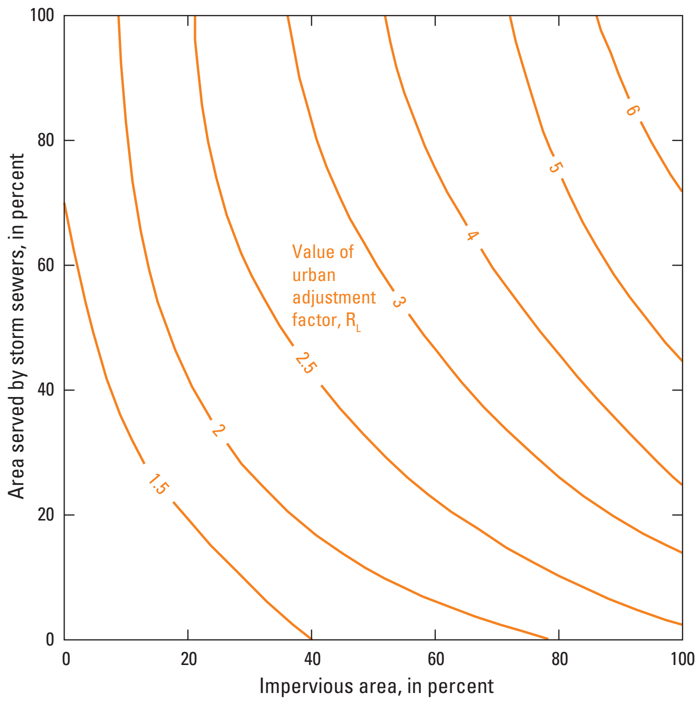


Figure 5. Relation of urban adjustment factor, R_L, to the percentage of the area that is impervious and the percentage of the area that is served by storm sewers (adapted from Leopold, 1968).

The urban adjustment factor, $\mathbf{R_L}$, is the ratio of the mean-annual flood in urban areas to that in rural areas. The following equations from Sauer (1974b) can be used to adjust estimates from equations 11–17 to urban areas:

$$Q50\%(u) = R_L\ Q50\%(r) \quad (21)$$

$$Q20\%(u) = 1.60\ (R_L-1)\ Q50\%(r) + 0.167\ (7-R_L)\ Q20\%(r) \quad (22)$$

$$Q10\%(u) = 1.87\ (R_L-1)\ Q50\%(r) + 0.167\ (7-R_L)\ Q10\%(r) \quad (23)$$

$$Q4\%(u) = 2.21\ (R_L-1)\ Q50\%(r) + 0.167\ (7-R_L)\ Q4\%(r) \quad (24)$$

$$Q2\%(u) = 2.46\ (R_L-1)\ Q50\%(r) + 0.167\ (7-R_L)\ Q2\%(r) \quad (25)$$

$$Q1\%(u) = 2.72\ (R_L-1)\ Q50\%(r) + 0.167\ (7-R_L)\ Q1\%(r) \quad (26)$$

$$Q0.2\%(u) = 3.30\ (R_L-1)\ Q50\%(r) + 0.167\ (7-R_L)\ Q0.2\%(r) \quad (27)$$

where

$\mathbf{Q_{x(u)}}$ = the adjusted regression estimate of peak flow for ungaged sites on urban streams, for percent chance exceedance x, in cubic feet per second,

$\mathbf{R_L}$ = urban adjustment factor (fig. 5), and

$\mathbf{Q_{x(r)}}$ = the regression estimate of peak flow for ungaged sites on unregulated streams, for percent chance exceedance x (equations 11–17), in cubic feet per second.

A nationwide seven-parameter urban adjustment equation set is presented in Jennings and others (1994). These equations may be compared to or used instead of the Oklahoma equations.

Example

This example shows how the 1-percent chance exceedance flood can be calculated for a hypothetical stream in an urban environment. The calculation is based on the basin being 50 percent impervious and that 65 percent of the basin is served by storm sewers. The 1-percent chance exceedance flood ($\mathbf{Q_{1\%(u)}}$) can be estimated for this hypothetical urban site with the following additional hypothetical basin attribute values:

CSL10_85fm = 11.5 ft/mi

CONTDA = 25.0 mi^2

$\mathbf{Q_{1\%(r)}}$ = 10,300 ft^3/s, from equation 16 (rural areas)

$\mathbf{Q_{50\%(r)}}$ = 1,830 ft^3/s, from equation 11 (rural areas)

$\mathbf{R_L}$ = 3 from figure 5

$\mathbf{Q_{1\%(u)}}$ = 16,800 ft^3/s, from equation 26 (urban areas)

The estimate of the 1-percent chance exceedance flood in urban areas for this ungaged watershed is a streamflow of 16,800 ft^3/s. This estimate is 63 percent more than the 1-percent chance exceedance flood for rural areas.

Adjustment for Ungaged Sites on Streams Regulated by Floodwater-Retarding Structures

An adjustment needs to be made when estimating peak-streamflow magnitude and frequency in basins regulated by floodwater-retarding structures. The regression estimate of peak streamflow for ungaged sites on regulated streams, or **Fx(r)**, for percent chance exceedance **x**, can be computed from equations 11–17 by substituting the drainage area of the unregulated part of the basin or drainage area downstream from the floodwater-retarding structures, **DAUNREG**, for

CONTDA. A complete discussion of the analysis can be found in Tortorelli and Bergman (1985). These authors indicated that the main-channel slope for the entire basin could be used to estimate a conservative result; this method will result in a larger peak streamflow than when using the main-channel slope downstream from floodwater-retarding structures only.

If floodwater-retarding structures regulate less than 86 percent of the basin, the following equations are used to adjust the regression estimate of peak streamflow of ungaged sites on unregulated streams:

$$F_{50\%(r)} = 1.2\,(DAUNREG)^{0.54}\,(PRECIP)^{1.44} \quad (28)$$

$$F_{20\%(r)} = 1.82\,(DAUNREG)^{0.56}\,(PRECIP)^{1.55} \quad (29)$$

$$F_{10\%(r)} = 1.82\,(DAUNREG)^{0.55}\,(PRECIP)^{1.68} \quad (30)$$

$$F_{4\%(r)} = 1.90\,(DAUNREG)^{0.54}\,(PRECIP)^{1.81} \quad (31)$$

$$F_{2\%(r)} = 1.92\,(DAUNREG)^{0.54}\,(PRECIP)^{1.91} \quad (32)$$

$$F_{1\%(r)} = 1.95\,(DAUNREG)^{0.53}\,(PRECIP)^{1.98} \quad (33)$$

$$F_{0.2\%(r)} = 2.09\,(DAUNREG)^{0.51}\,(PRECIP)^{2.13} \quad (34)$$

where

$\mathbf{F}_{x(r)}$ is the regression peak-streamflow estimate adjusted for floodwater-retarding structures, for percent chance exceedance **x**, in cubic feet per second;

DAUNREG is the contributing drainage area of the unregulated part of the basin or drainage area downstream from the floodwater-retarding structures, in square miles;

PRECIP is area-weighted precipitation of the drainage basin for the period 1971–2000, in inches.

The adjusted equations can be used when the percentage of regulated drainage area is not greater than 86 percent of the basin, which is the upper limit of the range of regulated data used to check the validity of the adjustment (Tortorelli and Bergman, 1985). When the percentage of regulated drainage area is greater than 86 percent of the basin, flow routing techniques, such as outlined in Chow and others (1988), may be used.

Example

This example illustrates how a peak-streamflow estimate is calculated for an ungaged site on a stream regulated by floodwater-retarding structures. An estimate of the $\boldsymbol{Q}_{1\%}$ is needed for this example on an ungaged site on Uncle Johns Creek (region 1) in Kingfisher County that is regulated by floodwater-retarding structures.

To obtain the regression flood-frequency estimate for an ungaged site on a stream regulated by floodwater-retarding structures, $\mathbf{F}_{1\%(r)}$, equation 33 is used. Equation 33 uses **DAUNREG**, the area of the drainage basin unregulated by floodwater-retarding structures, instead of **CONTDA**. The following data and calculations are needed to estimate $\boldsymbol{Q}_{1\%}$ for the ungaged site on a stream regulated by floodwater-retarding structures:

CONTDA = 155 mi^2

DAUNREG = 65.1 mi^2

PRECIP = 31.0 inches

The following information is required to obtain the needed peak-streamflow estimate: $\mathbf{F}_{1\%(r)}$ = 16,000 ft^3/s (from equation 33). Thus, the estimate of the 1-percent chance exceedance flood with 58 percent of the basin regulated by floodwater-retarding structures is a flow of 16,000 ft^3/s.

Summary

This report presents the results of a cooperative study by the U.S. Geological Survey (USGS) and the Oklahoma Department of Transportation to provide estimates of the magnitude and frequency of peak streamflows from updated regional regression equations for Oklahoma by using generalized least-squares regression methods. Annual-maximum peak flows observed at 212 streamgages through water year 2017 were used for the regression analysis, excluding the Oklahoma Panhandle region. The basin characteristics for each site were determined by using a geographic information system and the USGS web application StreamStats. The most statistically significant basin characteristics required to estimate peak-streamflow frequency for unregulated streams in Oklahoma were contributing drainage area, mean-annual precipitation, and main-channel slope. Multiple-regression analyses were used to define the relations between peak-streamflow frequency and basin characteristics. The resulting regression equations can be used to estimate peak streamflow and frequency of floods with selected annual exceedance probabilities ranging from 50 to 0.2 percent.

Regression equations for unregulated streams are applicable in Oklahoma basins with drainage areas less than 2,510 square miles that are not substantially affected by dams and floodwater-retarding structures. The mean standard error of prediction ranged from 32.52 to 51.20 percent, and the standard model error ranged from 31.28 to 49.32 percent for the different annual exceedance probabilities that were computed. This report also presents methods on estimating peak-streamflow magnitude and frequency for ungaged sites on streams with streamgages and for sites on urban streams and streams regulated by floodwater-retarding structures. Log-Pearson Type III analysis information, basin characteristics, and the peak-streamflow frequency estimates for 212 streamgages in and near Oklahoma are provided in this report.

Acknowledgments

The author thanks S. Jerrod Smith, U.S. Geological Survey, for providing technical assistance with computing basin attributes from StreamStats for the selected streamgages.

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Table 1

Table 1. Peak-streamflow frequency estimates and basin characteristics for selected streamgages with at least 10 years of annual

[LPIII, Log-Pearson Type III; EMA, expected moments algorithm; mi², square mile; ft/mi, foot per mile; reg, regional; wt, weighted; Trib., Tributary; nr, near;

Station number	Map identifier (fig. 1)	Station name	Region (fig. 1)	Available systematic record[1] (years)	Analysis information: Water years for peak discharges (systematic and historical) used	Analysis information: Historical record length[2] (years)
07148100	58	Grouse Creek near Dexter, Kans.[5]	2	30	1960–89	30
07148800	1	Medicine Lodge River Trib. nr Medicine Lodge, Kans.[5]	1	21	1957–77	21
07150580	2	Sand Creek Trib. near Kremlin, Okla.	1	12	1964–75	12
07150870	3	Salt Fork Arkansas River Trib. near Eddy, Okla.	1	22	1964–85	22
07151500	4	Chikaskia River near Corbin, Kans.[5]	1	68	1923–2017	95
07151600	5	Rush Creek near Harper, Kans.[5]	1	33	1957–89	33
07152000	6	Chikaskia River near Blackwell, Okla.[5]	1	82	1923–2017	95
07152360	59	Elm Creek near Foraker, Okla.	2	12	1964–75	12
07152520	60	Black Bear Creek Trib. near Garber, Okla.	2	12	1964–75	12
07152842	61	Subwatershed W-4 near Morrison, Okla.	2	22	1951–72	22
07152846	62	Subwatershed W-3 near Morrison, Okla.	2	25	1951–75	25
07153000	63	Black Bear Creek at Pawnee, Okla.[5, 6]	2	20	1908–62	55
07158020	7	Cimarron River Trib. near Lone Wolf, Okla.	1	12	1964–75	12
07158080	8	Sand Creek Trib. near Waynoka, Okla.	1	13	1951–75	25
07158180	9	Salt Creek Trib. near Okeene, Okla.	1	12	1964–75	12
07158400	10	Salt Creek near Okeene, Okla.	1	12	1962–79	18
07158500	11	Preacher Creek near Dover, Okla.	1	26	1952–84	33
07158550	12	Turkey Creek Trib. near Goltry, Okla.	1	19	1964–82	19
07159000	13	Turkey Creek near Drummond, Okla.[5]	1	27	1948–74	43
07159810	14	Watershed W-IV near Guthrie, Okla.	1	14	1942–55	14
07160350	15	Skeleton Creek at Enid, Okla.	1	21	1997–2017	21
07160500	16	Skeleton Creek near Lovell, Okla.[5]	1	60	1950–2017	68
07160550	64	West Beaver Creek near Orlando, Okla.	2	22	1964–85	22
07163000	65	Council Creek near Stillwater, Okla.[5]	2	60	1934–93	82
07163020	66	Corral Creek near Yale, Okla.	2	12	1964–75	12
07165550	67	Snake Creek near Bixby, Okla.	2	15	1962–76	15
07170700	68	Big Hill Creek near Cherryvale, Kans.[5]	2	23	1958–79	30
07170800	69	Mud Creek near Mound Valley, Kans.	2	34	1957–90	34
07171700	70	Spring Branch near Cedar Vale, Kans.	2	38	1957–94	38
07171800	71	Cedar Creek Trib. near Hooser, Kans.	2	34	1957–89	34
07172000	72	Caney River near Elgin, Kans.[5, 6]	2	26	1939–64	26
07173000	73	Caney River near Hulah, Okla.[6]	2	12	1926–50	25
07174200	74	L. Caney River blw Cotton Creek near Copan, Okla.[5, 6]	2	22	1959–79	22
07174600	75	Sand Creek at Okesa, Okla.[5]	2	34	1959–93	34
07174720	76	Hogshooter Creek Trib. near Bartlesville, Okla.	2	21	1965–85	21

peak-streamflow data from unregulated basins in and near Oklahoma.

L., Little; blw, below; Lk, Lake; Rv, River; Fk, Fork; SWS, subwatershed; ab, above; Ck, Creek]

Site number (fig. 1)	Basin characteristics: Skew coefficient for LPIII distribution[3]: EMA without reg skew	Basin characteristics: Skew coefficient for LPIII distribution[3]: EMA with reg skew	Basin characteristics: Contrib-uting drainage area (mi^2)	Basin characteristics: Area-wt mean annual pre-cipitation[4] (inch)	Basin characteristics: Stream slope (ft/mi)	Peak-streamflow frequency estimates: Peak streamflow for indicated percent chance exceedance (percent): 50	20	10	4	2	1	0.2
58	-0.310	-0.102	171.34	36.4	8.63	8,410	18,600	27,900	42,800	56,100	71,500	116,000
1	-0.730	-0.527	2.15	28.5	38.88	137	508	930	1,670	2,370	2,460	5,450
2	2.397	-0.117	7.13	34.0	14.76	474	1,290	2,140	3,650	5,130	6,940	12,600
3	0.039	-0.211	2.51	34.9	19.55	258	537	775	1,130	1,430	1,770	2,660
4	0.022	-0.249	812.58	30.5	7.67	9,790	19,000	26,400	36,900	45,500	54,700	78,100
5	-0.441	-0.398	11.78	31.0	20.10	1,170	2,320	3,220	4,450	5,420	6,420	8,840
6	-0.575	-0.258	1,873.05	31.8	6.58	21,600	40,400	54,900	75,200	91,500	109,000	152,000
59	0.809	-0.102	18.34	38.7	14.65	2,100	4,660	7,000	10,700	14,100	18,000	29,200
60	-0.712	-0.100	1.02	34.7	24.01	74.1	319	674	1,480	2,440	3,800	9,240
61	-0.310	-0.108	0.33	37.1	52.70	131	244	334	465	574	692	1,000
62	-0.401	-0.100	0.08	37.2	182.11	66.3	187	318	556	794	1,090	2,050
63	-0.258	-0.093	538.32	36.6	3.39	5,250	9,290	12,400	16,900	20,600	24,500	34,800
7	-0.478	-0.018	4.20	28.4	28.55	530	769	934	1,150	1,310	1,480	1,880
8	-0.196	-0.154	1.77	28.1	57.50	152	362	563	889	1,190	1,540	2,550
9	1.078	0.248	8.37	30.9	12.71	1,400	2,470	3,380	4,790	6,030	7,450	11,600
10	0.433	0.202	181.49	30.9	8.45	4,780	7,690	9,970	13,300	16,000	19,000	27,200
11	0.700	0.231	14.33	32.8	14.47	190	621	1,190	2,430	3,900	6,040	15,000
12	0.149	-0.061	4.82	31.8	15.13	349	1,000	1,730	3,080	4,460	6,210	12,000
13	0.009	0.011	254.76	32.4	4.31	2,720	7,560	12,900	22,900	33,200	46,300	91,000
14	-0.097	0.311	0.15	36.0	132.65	29.6	79.6	138	256	386	564	1,250
15	0.133	-0.030	69.95	34.0	12.63	3,380	5,200	6,500	8,240	9,590	11,000	14,500
16	0.156	0.158	412.05	33.6	5.67	5,770	14,500	23,800	41,000	58,600	81,100	159,100
64	-0.541	0.043	13.58	35.0	19.56	845	2,200	3,640	6,240	8,870	12,200	23,200
65	0.264	0.100	30.03	38.4	13.88	2,280	4,890	7,360	11,400	15,300	19,900	34,000
66	-0.327	0.052	3.01	38.5	45.65	596	912	1,150	1,460	1,720	1,980	2,650
67	0.067	0.297	47.69	42.7	9.45	3,220	5,760	7,940	11,400	14,400	18,000	28,600
68	1.307	0.297	36.84	43.1	8.80	3,550	6,900	9,980	15,000	19,800	25,500	43,300
69	0.303	0.246	4.40	44.2	27.39	1,200	2,160	2,980	4,260	5,400	6,700	10,600
70	-0.234	-0.026	3.08	37.9	42.41	1,070	1,820	2,400	3,220	3,890	4,610	6,490
71	-0.040	-0.059	0.51	37.6	153.63	167	311	429	602	749	910	1,340
72	0.466	0.023	428.50	37.7	7.02	17,100	27,000	34,300	44,400	52,500	61,000	82,700
73	-0.402	0.058	710.78	38.2	5.45	14,700	27,600	38,500	55,200	69,700	86,000	132,000
74	0.024	0.082	503.37	40.0	4.92	6,680	12,800	18,200	26,500	33,800	42,200	66,500
75	-0.821	-0.059	137.83	40.3	9.68	7,830	13,200	17,300	19,200	27,700	32,600	45,200
76	0.225	0.079	0.78	40.6	65.71	344	502	613	762	878	998	1,297

Table 1. Peak-streamflow frequency estimates and basin characteristics for selected streamgages with at least 10 years of annual

[LPIII, Log-Pearson Type III; EMA, expected moments algorithm; mi^2, square mile; ft/mi, foot per mile; reg, regional; wt, weighted; Trib., Tributary; nr, near;

Station number	Map identifier (fig. 1)	Station name	Region (fig. 1)	Available systematic record[1] (years)	Analysis information	
					Water years for peak discharges (systematic and historical) used	Histori-cal record length[2] (years)
07176500	77	Bird Creek at Avant, Okla.[5, 6]	2	31	1946–76	31
07176800	78	Candy Creek near Wolco, Okla.	2	12	1970–81	12
07177000	79	Hominy Creek near Skiatook, Okla.[5, 6]	2	38	1943–80	38
07177500	80	Bird Creek near Sperry, Okla.[5, 6]	2	46	1939–84	46
07178640	81	Bull Creek near Inola, Okla.	2	11	1965–75	11
07183800	82	Limestone Creek near Beulah, Kans.[5]	2	33	1957–89	33
07184000	83	Lightning Creek near McCune, Kans.[5]	2	67	1938–2017	80
07184500	84	Labette Creek near Oswego, Kans.[5]	2	42	1935–2015	81
07185500	85	Stahl Creek near Miller, Mo.[5]	2	34	1951–84	34
07185600	86	South Fork Stahl Creek near Miller, Mo.	2	28	1951–79	29
07185700	87	Spring River at LaRussell, Mo.[5]	2	35	1957–2017	61
07185765	88	Spring River at Carthage, Mo.	2	29	1967–2017	51
07185900	89	O’Possum Creek at Jasper, Mo.	2	23	1955–77	23
07186000	90	Spring River near Waco, Mo.[5]	2	95	1923–2017	95
07186400	91	Center Creek near Carterville, Mo.[5]	2	30	1962–91	30
07187000	92	Shoal Creek above Joplin, Mo.[5]	2	94	1924–2017	94
07188000	93	Spring River near Quapaw, Okla.[5]	2	78	1940–2017	78
07188140	94	Flint Branch near Peoria, Okla.	2	22	1964–85	22
07188500	95	Lost Creek at Seneca, Mo.[5]	2	27	1949–75	27
07188653	96	Big Sugar Creek near Powell, Mo.	2	17	2001–2017	17
07188885	97	Indian Creek near Lanagan, Mo.	2	18	2000–2017	18
07188900	98	Butler Creek Trib. near Gravette, Ark.	2	21	1961–81	21
07189000	99	Elk River near Tiff City, Mo.[5]	2	78	1940–2017	78
07189540	100	Cave Springs Branch near South West City, Mo.	2	20	1998–2017	20
07189542	101	Honey Creek near South West City, Mo.	2	20	1998–2017	20
07190600	102	Big Cabin Creek near Pyramid Corners, Okla.	2	15	1964–80	17
07191000	103	Big Cabin Creek near Big Cabin, Okla.[5]	2	77	1941–2017	83
07191160	104	Spavinaw Creek near Maysville, Ark.[5]	2	15	2002–17	16
07191179	105	Spavinaw Creek near Cherokee City, Ark.[5]	2	15	2002–17	16
07191220	106	Spavinaw Creek near Sycamore, Okla.[5]	2	58	1960–2017	58
071912213	107	Spavinaw Creek near Colcord, Okla.[5]	2	16	2002–17	16
07191222	108	Beaty Creek near Jay, Okla.[5]	2	19	1999–2017	19
07192000	109	Pryor Creek near Pryor, Okla.[5]	2	21	1943–63	21
07194515	110	Mill Creek near Park Hill, Okla.	2	20	1965–84	20
07194800	111	Illinois River at Savoy, Ark.	2	22	1980–2017	38

peak-streamflow data from unregulated basins in and near Oklahoma.—Continued

L., Little; blw, below; Lk, Lake; Rv, River; Fk, Fork; SWS, subwatershed; ab, above; Ck, Creek]

Site number (fig. 1)	Basin characteristics					Peak-streamflow frequency estimates						
	Skew coefficient for LPIII distribution[3]		Contrib-uting drainage area (mi^2)	Area-wt mean annual pre-cipitation[4] (inch)	Stream slope (ft/mi)	Peak streamflow for indicated percent chance exceedance (percent)						
	EMA without reg skew	EMA with reg skew				50	20	10	4	2	1	0.2
77	0.012	0.040	368.55	41.5	6.05	12,400	19,000	23,800	30,200	35,400	40,700	54,300
78	0.200	0.042	31.35	41.1	15.15	5,990	7,760	8,900	10,300	11,300	12,400	14,700
79	0.343	0.106	340.11	40.9	4.50	8,360	13,100	16,600	21,500	25,500	29,700	40,700
80	0.634	0.176	906.98	41.1	4.09	14,700	26,200	35,900	50,600	63,400	78,000	120,000
81	0.404	0.124	10.83	43.6	13.30	1,040	1,290	1,460	1,660	1,800	1,950	2,280
82	-0.513	0.004	13.27	45.1	15.78	3,020	6,480	9,660	14,800	19,500	24,900	41,200
83	0.171	0.123	195.94	44.8	3.43	7,090	15,300	23,100	36,200	48,600	63,400	110,000
84	0.473	0.196	213.21	43.0	3.71	8,020	12,600	16,100	21,100	25,200	29,600	41,600
85	-1.151	-0.310	4.02	44.9	27.03	660	1,030	1,270	1,590	1,820	2,040	2,560
86	-0.231	-0.296	0.96	45.0	45.10	202	409	577	820	1,020	1,230	1,780
87	0.114	-0.270	305.59	45.1	6.04	6,790	13,100	18,100	25,200	30,900	37,000	52,300
88	-0.616	-0.304	447.81	45.1	5.18	10,900	20,800	28,500	39,200	47,700	56,600	78,800
89	-0.332	-0.302	9.82	45.1	11.37	1,190	1,870	2,330	2,910	3,340	3,770	4,750
90	-0.077	-0.262	1,158.12	45.1	2.51	20,000	37,000	50,200	68,600	83,300	98,700	137,000
91	0.526	-0.230	228.93	45.1	7.75	5,700	11,200	15,600	21,900	27,200	32,800	47,400
92	0.113	-0.201	427.45	45.6	5.83	7,720	16,000	23,100	33,700	42,700	52,600	79,200
93	-0.082	0.001	2,515.63	45.2	2.07	36,900	68,500	94,700	134,000	167,000	204,000	306,000
94	0.483	0.053	4.88	44.4	34.84	780	1,480	2,070	2,980	3,780	4,680	7,230
95	0.285	-0.250	40.75	45.1	22.60	934	3,230	5,980	11,200	16,600	23,400	45,600
96	-0.405	-0.306	141.78	46.5	14.46	6,920	16,800	25,900	40,100	52,600	66,500	105,000
97	0.534	-0.283	238.37	45.3	9.35	9,430	16,200	21,100	27,700	32,700	37,900	50,300
98	-1.038	-0.176	0.99	46.9	128.02	117	286	450	719	966	1,250	2,100
99	-0.870	-0.320	850.68	45.9	6.81	20,900	44,800	64,800	94,200	119,000	145,000	213,000
100	-0.024	-0.280	8.00	45.7	28.52	879	1,940	2,860	4,240	5,420	6,720	10,200
101	-0.014	-0.279	48.64	46.1	23.25	1,970	5,910	10,100	17,600	24,700	33,300	59,400
102	0.909	0.093	71.06	43.9	9.61	4,820	8,200	10,900	14,800	18,100	21,700	31,400
103	-0.215	-0.016	450.31	44.1	4.45	16,400	28,400	37,900	51,500	62,700	74,800	107,000
104	-0.350	-0.176	88.80	47.2	17.53	2,220	7,490	13,800	26,000	38,700	55,100	110,000
105	-0.332	-0.175	103.48	47.2	16.11	2,480	8,230	15,100	28,200	41,800	59,200	118,000
106	-0.297	0.007	131.55	47.2	14.18	4,450	9,920	15,100	23,600	31,600	41,000	69,600
107	-0.401	-0.004	162.42	47.3	13.10	4,200	7,980	26,400	51,700	78,900	118,000	260,000
108	0.015	0.024	59.12	46.8	18.88	6,340	13,200	19,400	29,200	38,200	48,600	79,200
109	0.199	0.079	227.41	43.5	3.71	4,990	11,500	18,000	29,200	39,900	53,000	95,000
110	0.150	0.155	2.10	47.0	99.43	419	844	1,230	1,860	2,440	3,130	5,210
111	0.099	-0.159	167.44	48.1	13.37	12,300	27,400	41,200	62,900	82,200	104,000	166,000

Table 1. Peak-streamflow frequency estimates and basin characteristics for selected streamgages with at least 10 years of annual

[LPIII, Log-Pearson Type III; EMA, expected moments algorithm; mi^2, square mile; ft/mi, foot per mile; reg, regional; wt, weighted; Trib., Tributary; nr, near;

Station number	Map identifier (fig. 1)	Station name	Region (fig. 1)	Available systematic record[1] (years)	Analysis information: Water years for peak discharges (systematic and historical) used	Analysis information: Histori-cal record length[2] (years)
07195000	112	Osage Creek near Elm Springs, Ark.[5]	2	30	1950–79	30
07195200	113	Brush Creek Trib. near Tontitown, Ark.	2	21	1959–79	21
07195450	114	Ballard Creek at Summers, Ark.	2	24	1963–86	24
07195500	115	Illinois River near Watts, Okla.[5]	2	62	1956–2017	62
07195800	116	Flint Creek at Springtown, Ark.[5]	2	57	1961–2017	57
07195865	117	Sager Creek near West Siloam Springs, Okla.	2	21	1997–2017	21
07196000	118	Flint Creek near Kansas, Okla.[5]	2	53	1956–2017	62
07196380	119	Steely Hollow near Tahlequah, Okla.	2	11	1965–75	11
07196500	120	Illinois River near Tahlequah, Okla.[5]	2	83	1935–2017	102
07196900	121	Baron Fork at Dutch Mills, Ark.[5]	2	52	1958–2017	60
07196973	122	Peacheater Creek at Christie, Okla.	2	10	1994–2003	10
07197000	123	Baron Fork at Eldon, Okla.[5]	2	70	1948–2017	70
07197360	124	Caney Creek near Barber, Okla.	2	20	1998–2017	20
07228290	17	Rough Creek near Thomas, Okla.	1	22	1964–85	22
07228450	18	Deer Creek Trib. near Hydro, Okla.	1	12	1964–75	12
07228930	125	Worley Creek near Tuttle, Okla.	2	15	1965–85	21
07228960	126	Canadian River Trib. near Newcastle, Okla.	2	11	1965–75	11
07229300	127	Walnut Creek near Purcell, Okla.	2	30	1966–2017	52
07229420	128	Julian Creek Trib. near Asher, Okla.	2	21	1964–84	21
07229430	129	Arbeca Creek near Allen, Okla.	2	11	1964–74	11
07230000	130	Little River blw Lk Thunderbird near Norman, Okla.[6]	2	13	1953–64	13
07230500	131	Little River near Tecumseh, Okla.[5, 6]	2	22	1944–65	34
07231000	132	Little River near Sasakwa, Okla.[6]	2	20	1939–61	27
07231320	133	Leader Creek Trib. near Atwood, Okla.	2	22	1964–85	22
07231560	134	Middle Creek near Carson, Okla.	2	11	1964–74	11
07231950	135	Pine Creek near Higgins, Okla.	2	22	1964–85	22
07232000	136	Gaines Creek near Krebs, Okla.[5]	2	21	1938–62	26
07234150	19	White Woman Creek Trib. near Darrouzett, Tex.	1	20	1966–2016	51
07234290	20	Clear Creek Trib. near Catesby, Okla.	1	20	1966–85	20
07235700	21	Little Wolf Creek Trib. near Gage, Okla.	1	11	1964–74	11
07236000	22	Wolf Creek near Fargo, Okla.	1	16	1943–58	16
07237750	23	Cottonwood Creek near Vici, Okla.	1	21	1964–84	21
07237800	24	Bent Creek near Seiling, Okla.	1	19	1967–85	19
07239050	25	North Canadian River Trib. near Eagle City, Okla.	1	12	1964–75	12
07241880	137	Sand Creek near Cromwell, Okla.	2	22	1964–85	22

peak-streamflow data from unregulated basins in and near Oklahoma.—Continued

L., Little; blw, below; Lk, Lake; Rv, River; Fk, Fork; SWS, subwatershed; ab, above; Ck, Creek]

Site number (fig. 1)	Basin characteristics					Peak-streamflow frequency estimates						
	Skew coefficient for LPIII distribution[3]		Contrib-uting drainage area (mi²)	Area-wt mean annual pre-cipitation[4] (inch)	Stream slope (ft/mi)	Peak streamflow for indicated percent chance exceedance (percent)						
	EMA without reg skew	EMA with reg skew				50	20	10	4	2	1	0.2
112	-0.429	-0.185	129.96	47.0	15.78	4,870	10,500	15,400	22,900	29,400	36,600	56,600
113	-0.674	-0.175	0.38	46.8	127.96	85.3	180	262	387	495	615	944
114	-1.267	-0.178	14.31	49.0	43.10	2,070	3,640	4,840	6,490	7,810	9,200	12,700
115	-0.034	0.016	629.77	47.5	6.60	19,300	37,600	53,400	77,600	98,800	123,000	191,000
116	0.004	-0.150	14.72	47.6	38.23	768	1,990	3,230	5,330	7,320	9,700	16,900
117	-0.480	0.002	19.11	47.9	22.45	1,900	3,340	4,490	6,150	7,540	9,050	13,100
118	-0.300	-0.020	115.59	47.8	15.33	3,990	10,800	18,200	31,700	45,300	62,400	119,000
119	-0.292	0.066	3.84	47.8	78.25	500	1,730	3,350	6,810	10,800	16,400	38,500
120	-0.033	-0.150	950.25	47.6	4.54	20,600	41,200	58,500	84,200	106,000	130,000	195,000
121	-1.066	-0.179	41.09	50.2	39.03	8,660	13,400	16,800	21,100	24,400	27,700	35,600
122	0.141	0.057	24.85	48.7	32.83	1,580	2,240	2,690	3,270	3,720	4,180	5,290
123	-0.466	0.020	311.58	49.4	10.28	15,200	29,300	41,400	59,800	75,900	94,100	148,000
124	0.074	0.114	90.21	49.0	21.92	5,440	8,580	11,000	14,300	17,000	19,900	27,400
17	-1.258	-0.511	10.19	29.8	39.26	720	2,460	4,340	7,550	10,500	13,900	23,200
18	0.518	0.444	2.32	31.1	62.25	299	536	747	1,090	1,400	2,230	2,960
125	-0.995	0.521	11.22	35.2	17.11	1,180	2,070	2,870	4,180	5,390	6,850	11,400
126	-0.244	0.554	3.27	36.1	44.15	686	1,160	1,570	2,230	2,840	3,550	5,770
127	0.148	0.568	202.13	36.7	6.61	7,930	16,100	24,300	39,000	54,000	73,400	142,000
128	0.443	0.537	2.30	39.4	27.35	392	743	1,080	1,650	2,210	2,900	5,220
129	-0.584	0.297	2.12	42.4	30.67	553	1,270	2,010	3,360	4,740	6,510	12,600
130	1.353	0.646	257.09	38.1	6.15	5,260	10,100	14,800	23,100	31,400	42,100	79,100
131	1.231	0.610	462.50	38.3	5.54	9,280	17,000	24,300	36,600	48,600	63,600	113,000
132	-0.300	0.339	888.35	39.2	3.30	12,100	23,800	34,800	53,300	70,900	92,400	161,000
133	0.216	0.354	0.73	42.1	75.47	294	589	872	1,350	1,820	2,380	4,240
134	0.280	0.462	7.34	43.8	27.16	1,590	2,970	4,250	6,380	8,420	10,900	18,900
135	-0.374	0.298	10.83	51.2	48.66	3,860	8,020	12,000	18,900	25,600	33,800	60,600
136	0.681	0.480	585.08	47.9	3.07	12,400	24,000	34,900	53,700	71,900	94,600	170,000
19	-0.539	-0.164	4.10	23.4	16.30	143	360	573	930	1,260	1,650	2,820
20	0.206	-0.132	8.56	23.6	34.18	128	452	856	1,700	2,550	3,710	7,840
21	-1.346	-0.021	17.53	24.5	17.90	400	1,540	3,110	6,550	10,600	16,300	38,900
22	-0.018	-0.050	1,473.01	23.7	6.54	3,450	9,280	15,500	26,600	37,600	51,300	95,800
23	-0.640	0.134	11.65	27.6	40.31	422	971	1,520	2,470	3,400	4,550	8,300
24	0.076	0.152	129.00	27.4	9.77	223	4,240	6,010	8,780	11,300	14,200	22,600
25	0.351	0.344	0.55	30.0	90.87	88	218	364	644	944	1,350	2,850
137	-0.283	-0.020	9.52	41.3	24.37	1,400	2,200	2,780	3,570	4,200	4,850	6,500

Table 1. Peak-streamflow frequency estimates and basin characteristics for selected streamgages with at least 10 years of annual

[LPIII, Log-Pearson Type III; EMA, expected moments algorithm; mi², square mile; ft/mi, foot per mile; reg, regional; wt, weighted; Trib., Tributary; nr, near;

Station number	Map identifier (fig. 1)	Station name	Region (fig. 1)	Available systematic record[1] (years)	Analysis information	
					Water years for peak discharges (systematic and historical) used	Histori-cal record length[2] (years)
07242160	138	Alabama Creek near Weleetka, Okla.	2	19	1965–85	19
07243000	139	Dry Creek near Kendrick, Okla.[5]	2	39	1956–94	39
07243500	140	Deep Fork near Beggs, Okla.[5, 6]	2	29	1939–67	29
07243550	141	Adams Creek near Beggs, Okla.	2	20	1965–84	20
07244000	142	Deep Fork near Dewar, Okla.	2	18	1908–55	47
07244790	143	Brooken Creek near Enterprise, Okla.	2	11	1964–74	11
07245500	144	Sallisaw Creek near Sallisaw, Okla.[5, 6]	2	22	1941–63	22
07246610	145	Pecan Creek near Spiro, Okla.	2	12	1965–76	12
07246630	146	Big Black Fox Creek near Long, Okla.	2	21	1964–84	21
07247000	147	Poteau River at Cauthron, Ark.[5, 6]	2	34	1939–72	34
07247250	148	Black Fork below Big Creek near Page, Okla.	2	25	1993–2017	25
07247500	149	Fourche Maline near Red Oak, Okla.[5, 6]	2	25	1939–63	25
07249000	150	Poteau River at Poteau, Okla.	2	12	1923–45	23
07249300	151	James Fork near Midland, Ark.	2	20	1963–82	20
07249400	152	James Fork near Hackett, Ark.[5]	2	60	1958–2017	60
07249500	153	Cove Creek near Lee Creek, Ark.[5]	2	55	1950–2004	55
07249650	154	Mountain Fork near Evansville, Ark.	2	20	1962–81	20
07249920	155	Little Lee Creek near Nicut, Okla.	2	17	2001–2017	17
07249985	156	Lee Creek near Short, Okla.	2	68	1931–2017	87
07299300	26	Little Red Rv nr Turkey, Tex.	1	14	1968–81	14
07299670	27	Groesbeck Creek at S.H. 6 near Quannah, Tex.[5]	1	56	1962–2017	56
07300150	28	Bear Creek near Vinson, Okla.	1	22	1964–85	22
07300500	29	Salt Fork Red River at Magnum, Okla.[5]	1	80	1938–2017	80
07301110	30	Salt Fork Red River near Elmer, Okla.	1	38	1980–2017	38
07301300	31	North Fork Red River near Shamrock, Tex.	1	54	1964–2017	54
07301455	32	Turkey Creek near Erick, Okla.	1	17	1964–85	22
07301480	33	Short Creek near Sayre, Okla.	1	22	1964–85	22
07301500	34	North Fork Red River near Carter, Okla.[5]	1	32	1904–62	59
07303400	35	Elm Fork of North Fork Red River near Carl, Okla.[5]	1	43	1960–2017	58
07303450	36	Deer Creek near Plainview, Okla.	1	12	1964–75	12
07303500	37	Elm Fork of North Fk Red River near Magnum, Okla.[5]	1	72	1905–76	72
07304500	38	Elk Creek near Hobart, Okla.	1	20	1905–65	61
07309480	157	Canyon Creek near Medicine Park, Okla.	2	11	1964–75	11
07311000	158	East Cache Creek near Walters, Okla.[6]	2	22	1939–60	22
07311200	159	Blue Beaver Creek near Cache, Okla.	2	39	1965–2003	39

peak-streamflow data from unregulated basins in and near Oklahoma.—Continued

L., Little; blw, below; Lk, Lake; Rv, River; Fk, Fork; SWS, subwatershed; ab, above; Ck, Creek]

Site number (fig. 1)	Basin characteristics					Peak-streamflow frequency estimates						
	Skew coefficient for LPIII distribution[3]		Contrib-uting drainage area (mi²)	Area-wt mean annual pre-cipitation[4] (inch)	Stream slope (ft/mi)	Peak streamflow for indicated percent chance exceedance (percent)						
	EMA without reg skew	EMA with reg skew				50	20	10	4	2	1	0.2
138	-0.122	0.085	16.21	42.7	19.12	2,200	3,330	4,150	5,272	6,160	7,100	9,480
139	0.141	0.145	68.37	38.4	13.76	3,950	7,000	9,530	13,300	16,600	20,300	30,800
140	0.322	0.372	2,004.26	39.3	2.41	9,390	22,600	37,000	64,400	93,600	132,000	276,000
141	-0.168	0.313	5.69	41.9	37.72	1,090	2,020	2,840	4,160	5,380	6,805	11,200
142	0.233	0.434	2,295.99	39.8	1.98	10,100	21,500	33,000	53,600	74,400	101,000	194,000
143	-0.418	0.461	5.95	46.9	34.94	1,760	3,320	4,790	7,260	9,630	12,500	22,000
144	0.111	-0.156	181.11	49.4	13.25	13,200	28,800	42,700	64,300	83,300	105,000	165,000
145	-0.095	0.234	0.92	47.5	44.53	260	405	516	673	803	945	1,330
146	-0.961	0.059	5.51	48.4	55.79	783	1,460	2,040	2,910	3,670	4,530	6,950
147	-0.299	-0.177	203.56	52.2	8.89	10,900	18,900	24,900	33,100	39,600	46,500	63,600
148	-0.621	0.000	94.32	59.9	41.19	12,800	24,300	34,100	48,800	61,600	76,000	116,000
149	0.089	0.344	120.35	49.9	14.67	6,320	13,900	21,600	35,300	49,200	66,800	128,000
150	-0.122	0.124	1,250.72	51.8	2.82	25,800	50,600	72,500	107,000	139,000	175,000	283,000
151	0.038	0.048	43.81	52.4	52.27	5,150	11,000	16,400	25,300	33,400	43,000	72,100
152	-0.111	-0.163	146.67	49.4	16.24	7,080	12,000	15,700	20,800	24,700	28,900	39,300
153	-0.147	-0.168	34.84	51.9	34.00	4,950	10,600	15,500	23,100	29,700	37,000	57,400
154	-0.408	0.180	8.40	52.1	128.70	1,270	2,460	3,430	4,840	6,020	7,290	10,600
155	0.012	0.092	101.84	49.8	21.62	7,760	14,100	19,400	27,500	34,400	42,200	64,200
156	-0.244	0.022	434.09	50.3	15.73	24,700	44,800	61,100	85,300	106,000	129,000	191,000
26	1.292	-0.363	147.54	22.0	23.59	2,910	3,300	3,510	3,730	3,880	4,010	4,260
27	-0.504	-0.481	320.00	25.7	7.10	2,010	5,260	8,170	12,600	16,300	20,300	30,500
28	-0.788	-0.367	7.18	25.9	38.79	600	1,690	2,780	4,580	6,210	8,080	13,400
29	-0.738	-0.394	1,319.45	25.0	11.66	8,120	20,900	32,900	51,700	68,100	86,200	135,000
30	0.426	-0.352	1,847.90	26.3	9.77	5,510	12,400	18,400	27,300	34,800	42,900	64,000
31	-0.421	-0.236	816.73	23.5	10.36	3,240	7,140	10,600	15,800	20,300	25,300	39,000
32	-0.759	-0.208	21.87	26.1	17.30	964	1,880	2,620	3,690	4,580	5,530	8,020
33	0.271	-0.059	9.28	26.3	31.62	446	935	1,370	2,050	2,660	3,350	5,340
34	-0.338	-0.163	2,072.51	24.6	9.57	9,710	17,800	24,100	33,100	40,400	48,200	68,400
35	-0.238	-0.299	437.96	24.8	15.76	3,180	9,240	15,600	26,400	36,700	48,800	84,500
36	-0.669	-0.302	26.78	26.8	25.58	902	1,730	2,380	3,280	4,010	4,770	6,660
37	-0.548	-0.330	846.33	26.2	10.87	7,450	16,000	23,200	33,700	42,400	51,800	76,000
38	0.984	-0.176	549.28	28.7	6.33	4,030	6,750	8,740	11,400	13,500	15,700	21,100
157	0.888	0.140	3.39	32.8	56.74	1,220	1,690	2,020	2,440	2,770	3,100	3,920
158	-0.204	0.130	693.50	32.9	5.07	7,400	13,500	18,700	26,700	33,600	41,500	64,000
159	0.083	0.040	24.67	32.6	35.58	1,670	3,650	5,520	8,600	11,500	14,900	25,200

Table 1. Peak-streamflow frequency estimates and basin characteristics for selected streamgages with at least 10 years of annual

[LPIII, Log-Pearson Type III; EMA, expected moments algorithm; mi^2, square mile; ft/mi, foot per mile; reg, regional; wt, weighted; Trib., Tributary; nr, near;

Station number	Map identifier (fig. 1)	Station name	Region (fig. 1)	Available systematic record[1] (years)	Analysis information: Water years for peak discharges (systematic and historical) used	Analysis information: Historical record length[2] (years)
07311500	39	Deep Red Creek near Randlett, Okla.[5]	1	68	1950–2017	68
07312850	160	Nine Mile Beaver Creek near Elgin, Okla.	2	22	1964–85	22
07312950	161	Little Beaver Creek near Marlow, Okla.	2	12	1964–75	12
07313000	162	Little Beaver Creek near Duncan, Okla.	2	15	1949–63	15
07313500	163	Beaver Creek near Waurika, Okla.[5, 6]	2	24	1951–76	26
07313600	164	Cow Creek near Waurika, Okla.	2	20	1955–85	31
07315680	165	Cottonwood Creek Trib. near Loco, Okla.	2	22	1964–85	22
07315700	166	Mud Creek near Courtney, Okla.[5]	2	57	1961–2017	61
07315880	167	Demijohn Creek near Wilson, Okla.	2	10	1964–73	10
07316130	168	Wilson Creek Trib. near McMillan, Okla.	2	11	1965–75	11
07316140	169	Brier Creek near Powell, Okla.	2	21	1965–85	21
07316500	40	Washita River near Cheyenne, Okla.[5, 6]	1	23	1934–60	27
07317500	41	Sandstone Creek SWS 16A near Cheyenne, Okla.[6, 7]	1	21	1952–73	21
07318500	42	Sandstone Creek SWS 14 near Cheyenne, Okla.[6, 7]	1	12	1954–73	20
07319000	43	Sandstone Creek SWS 17 near Cheyenne, Okla.[6, 7]	1	21	1953–73	21
07320000	44	Sandstone Creek SWS 10A near Elk City, Okla.[6, 7]	1	19	1954–72	21
07321500	45	Sandstone Creek SWS 3 near Elk City, Okla.[6, 7]	1	14	1955–73	19
07322000	46	Sandstone Creek SWS 9 near Elk City, Okla.[6, 7]	1	18	1952–73	22
07324000	47	Sandstone Creek SWS 1 near Cheyenne, Okla.[6, 7]	1	18	1952–73	22
07325000	48	Washita River near Clinton, Okla.[5, 6]	1	27	1934–60	27
07325840	49	Lake Creek near Sickles, Okla.	1	12	2006–17	12
07325850	50	Lake Creek near Eakly, Okla.	1	22	1970–2017	48
07325860	51	Willow Creek near Albert, Okla.	1	19	1972–2017	46
07326000	52	Cobb Creek near Fort Cobb, Okla.[6]	1	19	1937–58	22
07327150	53	Salt Creek near Chickasha, Okla.	1	11	1967–77	11
07327420	54	West Bitter Creek near Tabler, Okla.	1	15	1963–77	15
07327440	55	East Bitter Creek near Tabler, Okla.[6]	1	10	1964–73	10
073274406	56	Little Washita River ab SCS Pond No 26 nr Cyril, Okla.	1	19	1995–2013	19
07327490	57	Little Washita River near Ninnekah, Okla.[5, 6]	1	22	1947–73	27
07329000	170	Rush Creek at Purdy, Okla.[6]	2	15	1940–54	15
07329500	171	Rush Creek near Maysville, Okla.[6]	2	11	1954–64	11
07329780	172	Honey Creek below Turner Falls near Davis, Okla.[5]	2	13	2005–2017	13
07329810	173	Honey Creek near Davis, Okla.	2	22	1964–85	22
07329900	174	Rock Creek at Dougherty, Okla.[6]	2	11	1956–66	11
07330500	175	Caddo Creek near Ardmore, Okla.	2	14	1937–50	14

peak-streamflow data from unregulated basins in and near Oklahoma.—Continued

L., Little; blw, below; Lk, Lake; Rv, River; Fk, Fork; SWS, subwatershed; ab, above; Ck, Creek]

Site number (fig. 1)	Basin characteristics					Peak-streamflow frequency estimates						
	Skew coefficient for LPIII distribution[3]		Contrib-uting drainage area (mi²)	Area-wt mean annual pre-cipitation[4] (inch)	Stream slope (ft/mi)	Peak streamflow for indicated percent chance exceedance (percent)						
	EMA without reg skew	EMA with reg skew				50	20	10	4	2	1	0.2
39	-0.232	-0.042	604.08	30.8	5.92	7,200	17,000	26,500	42,600	57,600	75,600	131,000
160	-0.606	0.265	6.36	33.9	39.94	639	1,750	3,060	5,660	8,530	12,400	27,400
161	0.238	0.377	34.86	35.6	22.38	800	2,000	3,350	5,780	8,830	12,700	27,300
162	-0.270	0.276	156.58	35.4	9.11	14,500	28,400	41,200	62,300	82,000	106,000	180,000
163	0.598	0.207	564.36	34.6	3.98	4,470	12,000	20,700	37,500	55,600	79,700	169,000
164	-0.738	0.132	192.66	35.3	6.32	2,560	7,220	12,600	23,100	34,300	49,300	104,000
165	-0.419	0.118	1.81	36.3	56.06	486	1,080	1,670	2,660	3,610	4,760	8,430
166	-0.239	-0.078	574.41	35.1	3.89	5,990	16,800	28,500	49,800	71,200	98,000	185,000
167	-0.949	-0.044	6.44	36.9	30.34	1,890	2,170	2,330	2,510	2,640	2,750	3,010
168	-0.327	0.140	2.95	40.3	43.67	765	1,110	1,350	1,680	1,940	2,200	2,880
169	0.200	-0.201	11.99	42.2	25.65	2,990	5,560	7,590	10,500	12,800	15,300	21,700
40	0.122	0.105	762.59	24.2	8.96	5,600	15,700	27,300	49,700	73,500	105,000	218,000
41	0.337	0.036	9.68	25.8	45.39	453	1,070	1,690	2,750	3,770	5,020	8,960
42	-0.052	0.054	1.01	26.7	116.64	265	629	994	1,620	2,240	2,990	5,390
43	0.662	0.090	11.11	26.0	51.32	1,110	2,220	3,230	4,820	6,270	7,960	13,000
44	-0.445	0.057	2.79	27.0	75.30	698	1,170	1,530	2,050	2,480	2,950	4,190
45	0.032	0.103	0.65	27.4	107.51	338	710	1,060	1,620	2,140	2,770	4,670
46	-0.197	0.065	3.36	27.4	60.09	863	1,580	2,170	3,060	3,820	5,640	7,070
47	-0.318	0.125	5.39	27.5	46.93	1,000	2,410	3,860	6,440	9,000	12,200	22,900
48	0.678	0.389	1,948.58	28.9	6.79	7,800	18,400	29,800	51,300	74,100	104,000	215,000
49	-0.026	0.402	19.14	31.4	31.50	862	1,210	1,470	1,820	2,100	2,410	3,210
50	-0.299	0.348	52.46	31.6	15.90	911	2,750	5,100	10,200	16,200	25,000	62,100
51	0.559	0.371	28.19	32.0	27.43	504	1,630	3,170	6,680	11,000	17,600	47,000
52	0.948	0.366	310.72	31.4	7.23	4,420	10,700	17,700	31,000	45,300	64,300	135,000
53	0.089	0.497	23.79	34.1	13.17	688	1,610	2,630	4,610	6,750	9,650	20,700
54	-0.792	0.510	59.70	34.0	10.89	2,170	2,840	3,320	3,960	4,480	5,020	6,400
55	-0.582	0.497	35.38	34.6	12.23	1,680	2,970	4,120	6,000	7,740	9,830	16,400
56	-0.182	0.320	3.65	33.4	37.74	348	965	1,700	3,210	4,920	7,280	16,600
57	0.626	0.488	207.96	34.4	8.53	3,320	7,780	12,700	22,200	32,600	46,600	99,700
170	0.244	0.431	139.68	36.6	9.97	9,970	16,100	21,100	28,700	35,300	42,900	64,800
171	-0.310	0.387	201.75	36.9	8.78	6,070	12,800	19,400	31,100	42,800	57,600	108,000
172	0.083	0.095	16.43	39.5	27.25	1,420	3,430	5,490	9,140	12,700	17,200	32,000
173	-0.294	0.093	18.75	39.6	41.48	1,940	4,580	7,260	11,900	16,500	22,100	40,400
174	0.095	0.047	136.76	41.2	13.71	4,560	10,700	16,900	27,400	37,600	50,000	89,300
175	-0.743	-0.068	296.30	38.0	5.81	8,130	15,600	21,900	31,200	39,200	48,000	72,200

Table 1. Peak-streamflow frequency estimates and basin characteristics for selected streamgages with at least 10 years of annual

[LPIII, Log-Pearson Type III; EMA, expected moments algorithm; mi², square mile; ft/mi, foot per mile; reg, regional; wt, weighted; Trib., Tributary; nr, near;

Station number	Map identifier (fig. 1)	Station name	Region (fig. 1)	Available systematic record[1] (years)	Analysis information: Water years for peak discharges (systematic and historical) used	Analysis information: Historical record length[2] (years)
07331200	176	Mill Creek near Mill Creek, Okla.	2	11	2007–17	11
07332070	177	Rock Creek near Achille, Okla.	2	10	1965–74	10
07332390	178	Blue River near Connerville, Okla.[5]	2	14	2004–17	14
07332400	179	Blue River at Milburn, Okla.	2	22	1966–87	22
07332500	180	Blue River near Blue, Okla.[5]	2	81	1937–2017	81
07332600	181	Bois D'Arc Ck nr Randolph, Tex.[5]	2	23	1963–85	23
07333500	182	Chickasaw Creek near Stringtown, Okla.	2	20	1956–75	20
07333800	183	McGee Creek near Stringtown, Okla.	2	20	1956–75	20
07334000	184	Muddy Boggy Creek near Farris, Okla.[5, 6]	2	49	1938–86	49
07335000	185	Clear Boggy Creek near Caney, Okla.[5, 6]	2	20	1938–60	23
07335310	186	Rock Creek near Boswell, Okla.	2	21	1965–85	21
07335320	187	Bokchito Creek near Soper, Okla.	2	11	1964–75	11
07335700	188	Kiamichi River near Big Cedar, Okla.	2	52	1966–2017	52
07336000	189	Tenmile Creek near Miller, Okla.	2	29	1956–84	29
07336500	190	Kiamichi River near Belzoni, Okla.[5]	2	47	1926–72	57
07336520	191	Frazier Creek near Oleta, Okla.	2	22	1964–85	22
07336710	192	Rock Creek near Sawyer, Okla.	2	11	1964–74	11
07336750	193	Little Pine Creek near Kanawha, Tex.	2	12	1969–80	12
07336780	194	Perry Creek near Idabel, Okla.	2	10	1964–73	10
07336785	195	Bokchito Creek near Garvin, Okla.	2	12	1965–76	12
07336800	196	Pecan Creek near Clarksville, Tex.	2	16	1962–77	16
07337220	197	Big Branch near Ringold, Okla.	2	11	1964–74	11
07337500	198	Little River near Wright City, Okla.[5, 6]	2	26	1930–68	39
07337900	199	Glover River near Glover, Okla.[5]	2	57	1961–2017	57
07338500	200	Little River blw Lukfata Creek near Idabel, Okla.[5, 6]	2	39	1930–68	39
07338520	201	Yanubbee Creek near Broken Bow, Okla.	2	22	1964–85	22
07338700	202	Twomile Creek near Hatfield, Ark.	2	21	1963–83	21
07338780	203	Mountain Fork Trib. near Smithville, Okla.	2	20	1965–84	20
07339000	204	Mountain Fork near Eagletown, Okla.[5, 6]	2	39	1915–68	54
07339500	205	Rolling Fork near DeQueen, Ark.[5, 6]	2	25	1947–73	27
07339800	206	Pepper Creek near DeQueen, Ark.	2	26	1961–86	26
07340200	207	West Flat Creek near Foreman, Ark.	2	20	1962–83	22
07340300	208	Cossatot River near Vandervoort, Ark.[5]	2	50	1961–2016	56
07340500	209	Cossatot River near DeQueen, Ark.[5, 6]	2	37	1938–74	37
07340530	210	Mill Slough Trib. near Locksburg, Ark.	2	24	1963–86	24

peak-streamflow data from unregulated basins in and near Oklahoma.—Continued

L., Little; blw, below; Lk, Lake; Rv, River; Fk, Fork; SWS, subwatershed; ab, above; Ck, Creek]

Site number (fig. 1)	Basin characteristics					Peak-streamflow frequency estimates						
	Skew coefficient for LPIII distribution[3]		Contrib-uting drainage area (mi²)	Area-wt mean annual pre-cipitation[4] (inch)	Stream slope (ft/mi)	Peak streamflow for indicated percent chance exceedance (percent)						
	EMA without reg skew	EMA with reg skew				50	20	10	4	2	1	0.2
176	-0.117	0.000	46.74	41.7	11.32	2,120	3,120	3,810	4,720	5,420	6,140	7,910
177	0.587	-0.241	0.71	43.5	27.10	416	693	892	1,160	1,360	1,570	2,060
178	-0.867	-0.093	162.41	42.1	7.29	4,290	9,590	14,500	22,300	29,400	37,700	61,600
179	-0.426	-0.154	203.19	42.3	10.26	9,120	18,600	26,600	38,700	49,100	60,500	91,700
180	0.070	-0.159	477.45	43.5	6.98	9,560	17,700	24,100	33,300	40,900	49,000	70,000
181	-0.287	-0.308	72.09	43.3	8.38	8,920	12,400	14,500	17,000	18,800	20,500	24,200
182	-0.234	0.034	32.62	45.5	25.40	7,530	10,900	13,200	16,200	18,500	20,900	26,700
183	-0.677	0.031	88.76	47.4	6.11	6,720	8,660	9,900	11,400	12,500	13,600	16,200
184	-0.121	0.065	1,088.92	45.0	3.18	19,200	29,600	37,000	46,800	54,300	62,100	81,400
185	-0.084	-0.109	713.37	43.4	3.37	15,200	29,900	42,300	60,900	76,700	94,200	142,000
186	-0.685	-0.205	1.01	46.0	33.38	253	429	558	732	869	1,010	1,360
187	0.565	-0.109	17.48	47.1	15.75	4,000	5,000	5,560	6,250	6,730	7,190	8,210
188	-0.523	-0.023	39.63	62.1	54.87	8,910	15,600	20,800	28,400	34,600	41,400	59,400
189	0.272	0.006	68.31	48.1	12.21	3,600	5,150	6,210	7,580	8,610	9,690	12,300
190	-0.160	-0.047	1,415.94	51.3	3.35	34,100	49,000	59,000	72,000	81,700	91,600	115,000
191	-0.184	-0.031	18.54	50.8	25.34	2,470	4,560	6,260	8,780	10,900	13,200	19,600
192	0.156	-0.068	3.33	49.4	33.06	796	1,170	1,430	1,760	2,010	2,270	2,890
193	-0.142	-0.102	75.27	48.8	5.24	6,160	12,600	18,200	26,700	34,100	42,400	65,500
194	1.020	-0.010	7.60	51.1	22.72	2,210	3,040	3,580	4,270	4,780	5,300	6,510
195	1.028	-0.020	2.89	51.1	22.67	780	991	1,120	1,280	1,390	1,500	1,760
196	-0.422	-0.085	98.91	49.2	4.30	3,990	8,020	11,500	16,700	21,300	26,400	40,500
197	0.385	0.004	1.99	52.2	72.35	449	856	1,200	1,720	2,170	2,680	4,090
198	-0.042	-0.035	648.22	53.9	9.74	30,500	49,700	64,000	84,000	100,000	117,000	160,000
199	0.057	-0.008	320.28	55.3	13.52	28,000	45,700	59,000	77,400	92,300	108,000	149,000
200	-0.055	-0.027	1,228.14	53.9	5.67	27,500	46,000	60,200	80,000	96,100	113,000	158,000
201	-0.394	-0.044	9.03	53.8	42.27	1,750	3,100	4,160	5,690	6,960	8,330	12,000
202	0.394	-0.146	16.22	60.0	44.03	2,060	3,580	4,740	6,340	7,630	8,990	12,400
203	0.505	-0.143	0.65	56.1	69.96	260	360	477	640	772	910	1,260
204	-0.498	-0.062	799.80	57.3	6.82	36,700	62,200	81,600	109,000	131,000	154,000	215,000
205	0.448	-0.141	183.37	56.4	17.52	16,400	31,800	44,400	62,800	78,400	95,300	140,000
206	-0.503	-0.186	6.27	55.9	41.72	985	2,410	3,780	6,020	8,060	10,400	17,400
207	-0.607	-0.186	10.65	50.8	10.62	1,550	2,650	3,470	4,590	5,480	6,400	8,690
208	-0.383	-0.187	89.10	62.0	28.54	15,200	26,000	33,900	44,700	53,200	62,000	83,800
209	0.225	-0.141	361.22	58.7	15.46	28,800	47,100	60,400	78,400	92,500	107,000	143,000
210	-0.351	-0.179	0.69	54.7	55.83	186	345	472	652	799	957	1,360

Table 1. Peak-streamflow frequency estimates and basin characteristics for selected streamgages with at least 10 years of annual

[LPIII, Log-Pearson Type III; EMA, expected moments algorithm; mi^2, square mile; ft/mi, foot per mile; reg, regional; wt, weighted; Trib., Tributary; nr, near;

Station number	Map identifier (fig. 1)	Station name	Region (fig. 1)	Available systematic record[1] (years)	Analysis information	
					Water years for peak discharges (systematic and historical) used	Histori-cal record length[2] (years)
07341000	211	Saline River near Dierks, Ark.[5, 6]	2	34	1920–72	53
07341100	212	Rock Creek near Dierks, Ark.	2	23	1961–83	23

[1]Available systematic record reflects number of annual peak streamflows from natural basins (U.S. Geological Survey, 2018a). Many stations became regulated during the period of operation. Regulated annual peak streamflows not included in peak-streamflow frequency analysis.

[2]Historical record length reflects that known as of 2018 water year.

[3]Reflects weighting adjusted station skew with skew value from Oklahoma generalized skew map (fig. 2).

[4]Values at station location derived from geographic information system using gridded mean-annual precipitation based on 1971–2000 data.

[5]Station used in construction of Oklahoma generalized skew map (fig. 2).

[6]Station has an unregulated period of record used in the analysis, but now is regulated.

[7]Streamflow data computed from inflow to floodwater-retarding structure.

peak-streamflow data from unregulated basins in and near Oklahoma.—Continued

L., Little; blw, below; Lk, Lake; Rv, River; Fk, Fork; SWS, subwatershed; ab, above; Ck, Creek]

Site number (fig. 1)	Basin characteristics					Peak-streamflow frequency estimates						
	Skew coefficient for LPIII distribution[3]		Contrib-uting drainage area (mi^2)	Area-wt mean annual pre-cipitation[4] (inch)	Stream slope (ft/mi)	Peak streamflow for indicated percent chance exceedance (percent)						
	EMA without reg skew	EMA with reg skew				50	20	10	4	2	1	0.2
211	0.045	-0.156	120.21	59.1	20.90	10,200	19,500	27,000	37,900	47,000	56,900	82,900
212	-0.550	-0.187	9.39	56.9	41.95	2,010	4,490	6,720	10,200	13,300	16,800	26,500

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Publishing support provided byLafayette Publishing Service Center

Lewis and others—**Methods for Estimating the Magnitude and Frequency of Peak Streamflows for Unregulated Streams in Oklahoma**—Scientific Investigations Report 2019–5143

ISSN 2328-0328 (online)
https://doi.org/10.3133/sir20195143