

Hydrology Report for Fountain Creek, El Paso County, CO



Prepared for:

FEMA, Region VIII

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December, 2009

Revised April, 2010

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1. Engineer Certification

Michael Baker Jr. Inc. (Baker) performed the hydrologic study for Fountain Creek, located in El Paso County, Colorado. The work was authorized by the Federal Emergency Management Agency (FEMA) Region VIII Office under contract HSFEHQ-04-D-0025. The work consisted of performing a hydrologic analysis at several U.S. Geological Survey (USGS) gaging stations along Fountain Creek. I am a registered professional engineer in the State of Colorado and have affixed my professional seal to this study below.



Colin McKernan P.E. # 39067

2. Introduction

2.1 Background

Baker was contracted by FEMA Region VIII to prepare a hydrologic analysis for Fountain Creek at seven USGS gage locations along Fountain Creek within El Paso and Pueblo counties. The purpose of this hydrology report is to document the methodology and calculations used to develop the 10-, 2-, 1-, and 0.2-percent-annual-chance-exceedance hydrologic peak flows for Fountain Creek. These peak flows will eventually be used for updating the effective Special Flood Hazard Areas within El Paso and Pueblo Counties, which will be used in the county-wide Digital Flood Insurance Rate Map conversion. A project location vicinity map is presented in Figure 1.

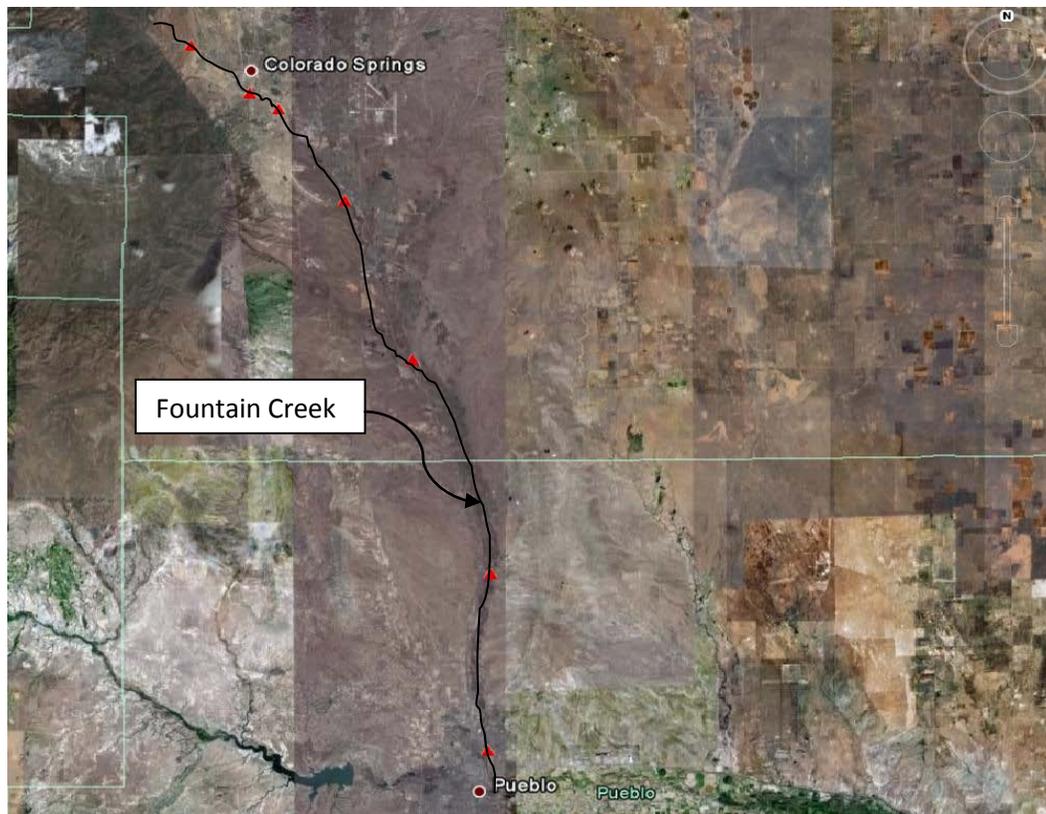


Figure 1. Location map

Discharges along Fountain Creek were originally established for the Flood Insurance Study (FIS) from a Log-Pearson Type III analysis utilizing available historic and systematic gage data. The years of record used for this FIS evaluation extended from 1893 through 1970.

Similarly to the methodology utilized for the FIS, discharges along Fountain Creek in this report have been computed through a statistical analysis of the available gage data. Peak

flow magnitude and frequency have been determined by using the USGS PeakFQ Windows Version 5.2 statistical flood-frequency analyses tool. Systematic records for this analysis were developed from the gage data at seven locations along Fountain Creek, extending from Colorado Springs, CO, to Pueblo, CO. The following stream gages have been included as part of the statistical analysis:

USGS Gage 07106500 – Fountain Creek at Pueblo, CO: This USGS gage is located at the upstream side of the U.S. Highway 50 bridge at Pueblo, approximately 2.6 miles upstream from the mouth. The reported drainage basin area for this gage is 926 square miles and is at an elevation of 4,705 feet referenced to the National Geodetic Vertical Datum of 1929 (NGVD 29). The gage has 68 years of peak stream flow values dating from January 1922 to September 1925; October 1940 to September 1965; and February 1971 to September 2008.

USGS Gage 07106300 – Fountain Creek near Pinon, CO: This USGS gage is located at the downstream side of new Pinon Road bridge, 0.6 mile southeast of Pinon, and approximately 1.8 miles upstream from Steele Hollow Creek. The reported drainage basin area for this gage is 865 square miles and is at an elevation of 4,990 feet NGVD 29. The gage has 35 years of peak stream flow values dating from April 1973 to September 2008.

USGS Gage 07106000 – Fountain Creek near Fountain, CO: This USGS gage is located at the downstream side of Old Pueblo Road bridge, 180 feet downstream from the Denver & Rio Grande Railroad bridge, 0.9 miles downstream of Little Fountain Creek, and 5.6 miles south of Fountain, CO. The reported drainage basin area for this gage is 681 square miles and is at an elevation of 5,355 feet NGVD 29). The gage has 41 years of peak stream flow values dating from October 1938 to February 1940; March 1940 to September 1954; and July 1985 to September 2008.

USGS Gage 07105800 – Fountain Creek near Security, CO: This USGS gage is located approximately 20 feet downstream from Carson Road bridge at Security, 0.9 miles southwest of South Security School, 3.5 miles northeast of Fountain, and 5.5 miles upstream from Jimmy Camp Creek. The reported drainage basin area for this gage is 495 square miles and is at an elevation of 5,640 feet NGVD 29. The gage has 44 years of peak stream flow values dating from October 1964 to September 2008.

USGS Gage 07105530 – Fountain Creek below Janitell Road below Colorado Springs, CO: This USGS gage is located at the downstream side of the Janitell Road bridge, 0.1 miles downstream from Spring Creek, and 2.4 miles southeast of the courthouse in Colorado Springs. The reported drainage basin area for this gage is 413 square miles and is at an elevation of 5,840 feet NGVD 29). The gage has 19 years of peak stream flow values dating from October 1989 to September 2008.

USGS Gage 07105500 – Fountain Creek at Colorado Springs, CO: This USGS gage is located approximately 10 feet downstream from Cheyenne Creek, 31 feet upstream from the Nevada Avenue bridge at Colorado Springs, and 1.3 miles downstream from Monument Creek. The reported drainage basin area for this gage is 392 square miles and is at an elevation of 5,900 feet NGVD 29). The gage has 33 years of peak stream flow values dating from January 1976 to September 2008.

USGS Gage 07103700 – Fountain Creek near Colorado Springs, CO: This USGS gage is located approximately 200 feet upstream from the diversion to City of Colorado Springs, 0.5 miles east of the U.S. Highway 24 bridge, 1.0 miles downstream of Sutherland Creek, and 3.3 miles northwest of the courthouse in Colorado Springs, CO. The reported drainage basin area for this gage is 103 square miles and is at an elevation of 6,110 feet NGVD 29). The gage has 51 years of peak stream flow values dating from April 1958 to September 2008.

As requested by FEMA Region VIII, the 10-, 2-, 1-, and 0.2-percent-annual-chance-exceedance hydrologic peak flows for Fountain Creek have also been determined by utilizing the latest USGS regional regression equations for Colorado as documented in SIR 2009-5136. Furthermore, peak flows for additional design points that fall in between gage locations were determined using drainage area transfer methods as outlined in the USGS WRIR 99-4190.

3. Hydrologic Analysis

3.1 Flood Frequency Analysis

The 10-, 2-, 1-, and 0.2-percent-annual-chance-exceedance peak flow rates were developed using the USGS PeakFQ Windows software. This program calculates peak discharges based on Bulletin 17B Guidelines for flood flow analysis. Historic record adjustment in accordance with Appendix 6 of Bulletin 17B has been made at each gage to account for historic peaks along Fountain Creek. Historical data were obtained from the gage peak-flow file in some cases (Pueblo and Fountain), as well as a paleohydrologic analysis for the 1935 and 1965 flood events on Fountain Creek. The historic record adjustment was made to include the historic peak values and to extend the flood record period. To further develop a conservative estimation of the peak flow rates, the generalized skew coefficient from Plate 1 in Bulletin 17B was estimated to be zero.

As part of the statistical analysis, the incorporation of the historic period adjustments and generalized skew adjustments has been documented to highlight the change in slope on the estimated frequency curve.

3.1.1 FOUNTAIN CREEK AT PUEBLO

At this location the systematic record included a historic peak value of 35,000 cubic feet per second (cfs) (1935), which was based on a slope-area measurement of peak flow with the gage height unknown. The USGS peak flow file also included a value of 47,000 cfs (1965), which was developed from the USGS paleohydrologic analysis. Records obtained from the USGS show that the estimated range of the 1965 flood was from 47,000 to 65,000 cfs. For use in this study, the published value included within the peak flow file, 47,000 cfs, was used in the flood frequency analysis. The systematic record was modified to extend the period of record from 68 years of data to the historic record of 88 years (1921 to 2008). Two low outliers were censored from the data set – 204 cfs in 1959 and 324 cfs in 1943. As a conservative estimate of the generalized skew coefficient for the Fountain Creek gage stations, a value of zero was assumed. The resulting estimated frequency curves for Fountain Creek at Pueblo can be seen in Figure 2.

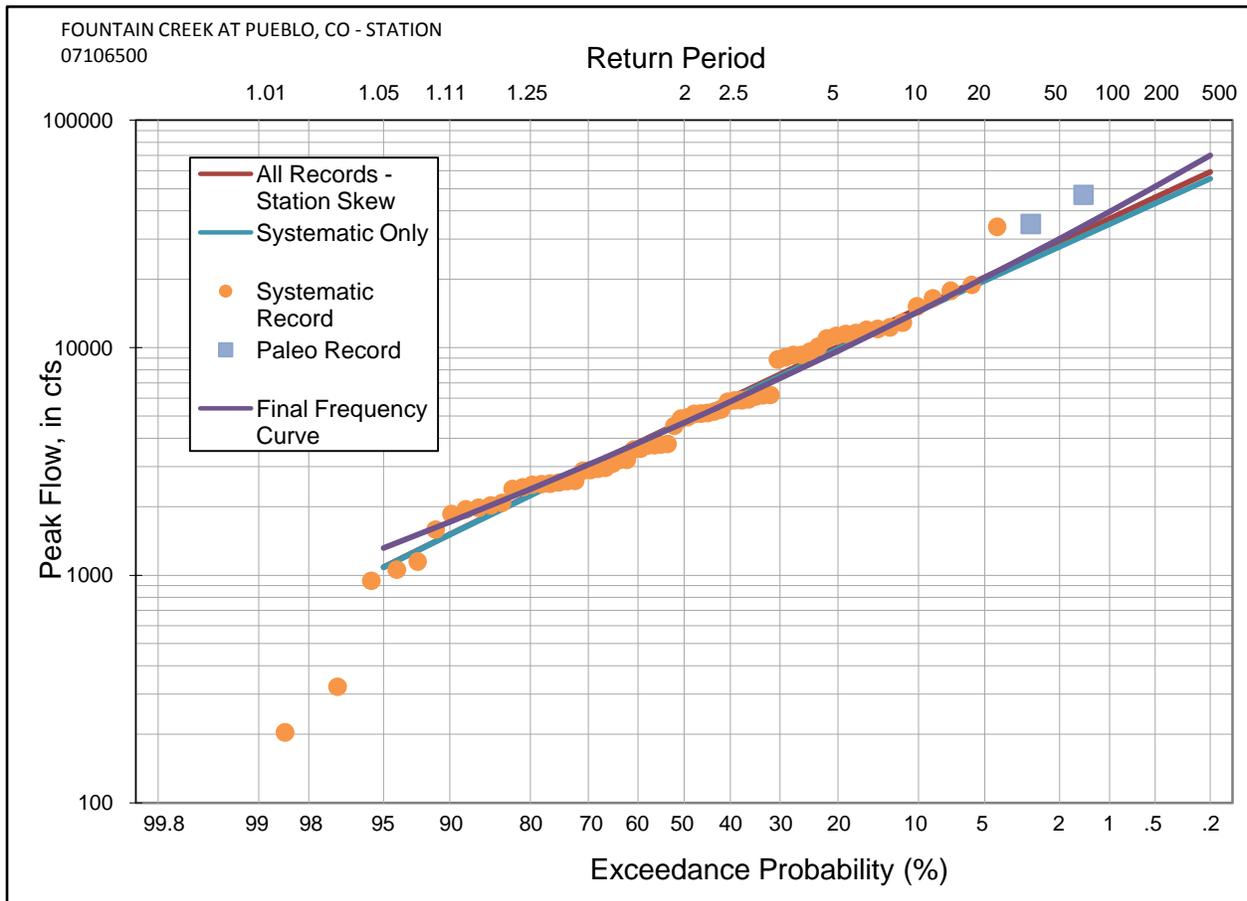


Figure 2: Calculated frequency curves for Fountain Creek at Pueblo, CO

3.1.2 Fountain Creek Near Pinon

At this location, the systematic record included 36 years of peak flow data. The systematic record was modified to include a peak flow value of 53,000 cfs (1965), which was developed from the USGS paleohydrologic analysis. Records obtained from the USGS show that the estimated range of the 1965 flood was from 47,000 to 60,000 cfs. For use in this study, the average value of the 1965 flood event estimate, 53,000 cfs, was used in the flood frequency analysis. Two other major floods occurred at the gaging station downstream at Pueblo in June 1921 (34,000 cfs) and May 1935 (35,000 cfs). In order to get consistent results for the gaging station near Pinon, the 1921 and 1935 floods were estimated. The 1935 flood was observed to be 25,000 cfs upstream at Security (495 square miles) and 35,000 cfs downstream at Pueblo (926 square miles). A straight line interpolation on log-log paper gives 33,700 cfs for the gaging station near Pinon (865 square miles). The 1921 flood of 34,000 cfs was only observed at the Pueblo station. Using this value and a drainage area ratio to the 0.5 power gives an estimate of 32,900 cfs for the gaging station near Pinon. The systematic record was also modified to extend the period of record to the historic record of 88 years (1921 to 2008). As a conservative estimate of the generalized skew coefficient for the Fountain Creek gage stations, a value of zero was assumed. The resulting estimated frequency curves for Fountain Creek at Pinon can be seen in Figure 3.

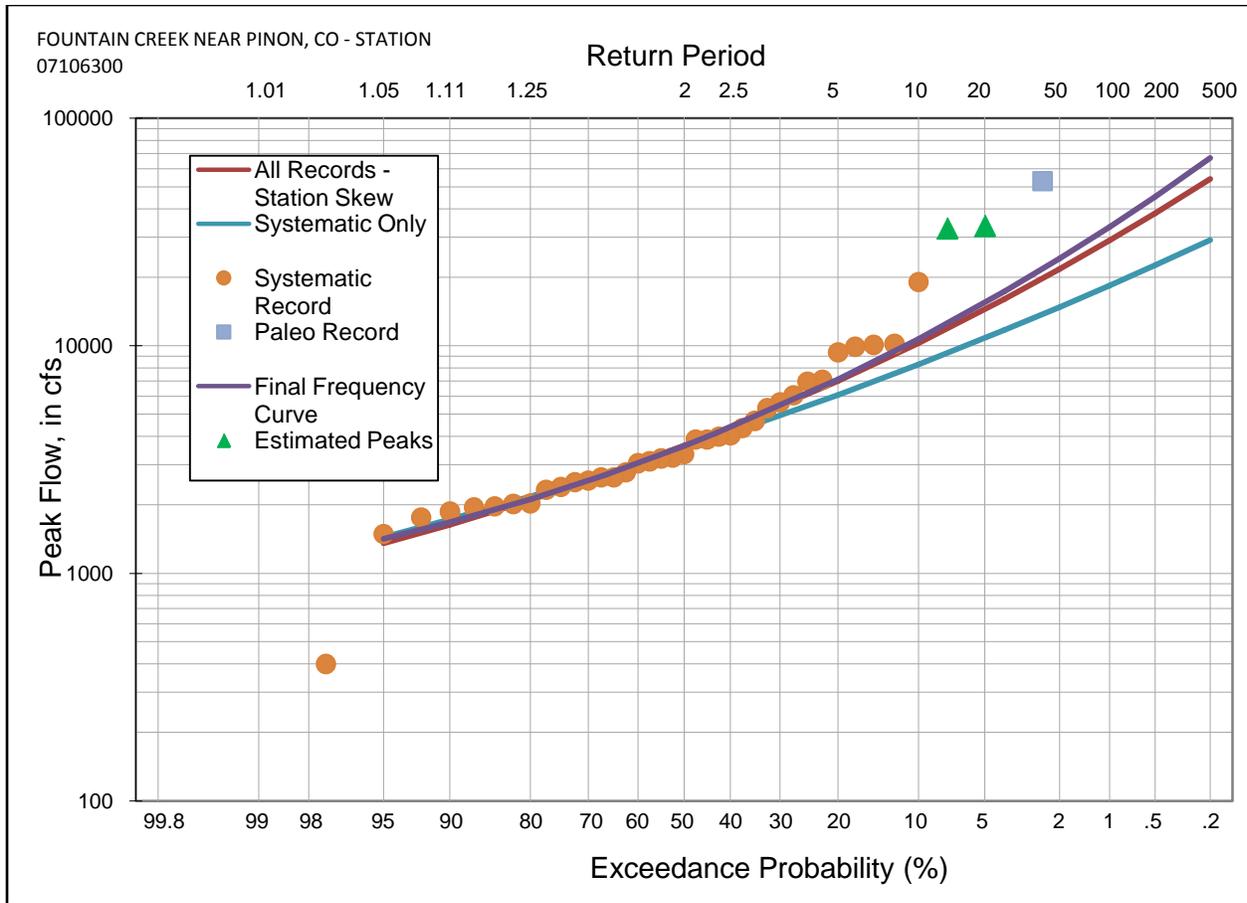


Figure 3: Calculated frequency curves for Fountain Creek near Pinon, CO

3.1.3 Fountain Creek Near Fountain

At this location, the systematic record included only one historic peak value of 3,480 cfs (1955). The systematic record was modified to include a peak flow value of 108,500 cfs (1965), which was developed from the average estimated flood values of 95,000 to 122,000 cfs from the USGS paleohydrologic analysis. The systematic record was modified to extend the period of record from 41 years of data to the historic record of 70 years (1939 to 2008). It was noted that the resulting frequency curve with the extended historic record and peak flow data was not a good fit. Using Bulletin 17B guidelines, a high outlier threshold was utilized to adjust the curve. As a conservative estimate of the generalized skew coefficient for the Fountain Creek gage stations, a value of zero was assumed. The resulting estimated frequency curves for Fountain Creek near Fountain can be seen in Figure 4.

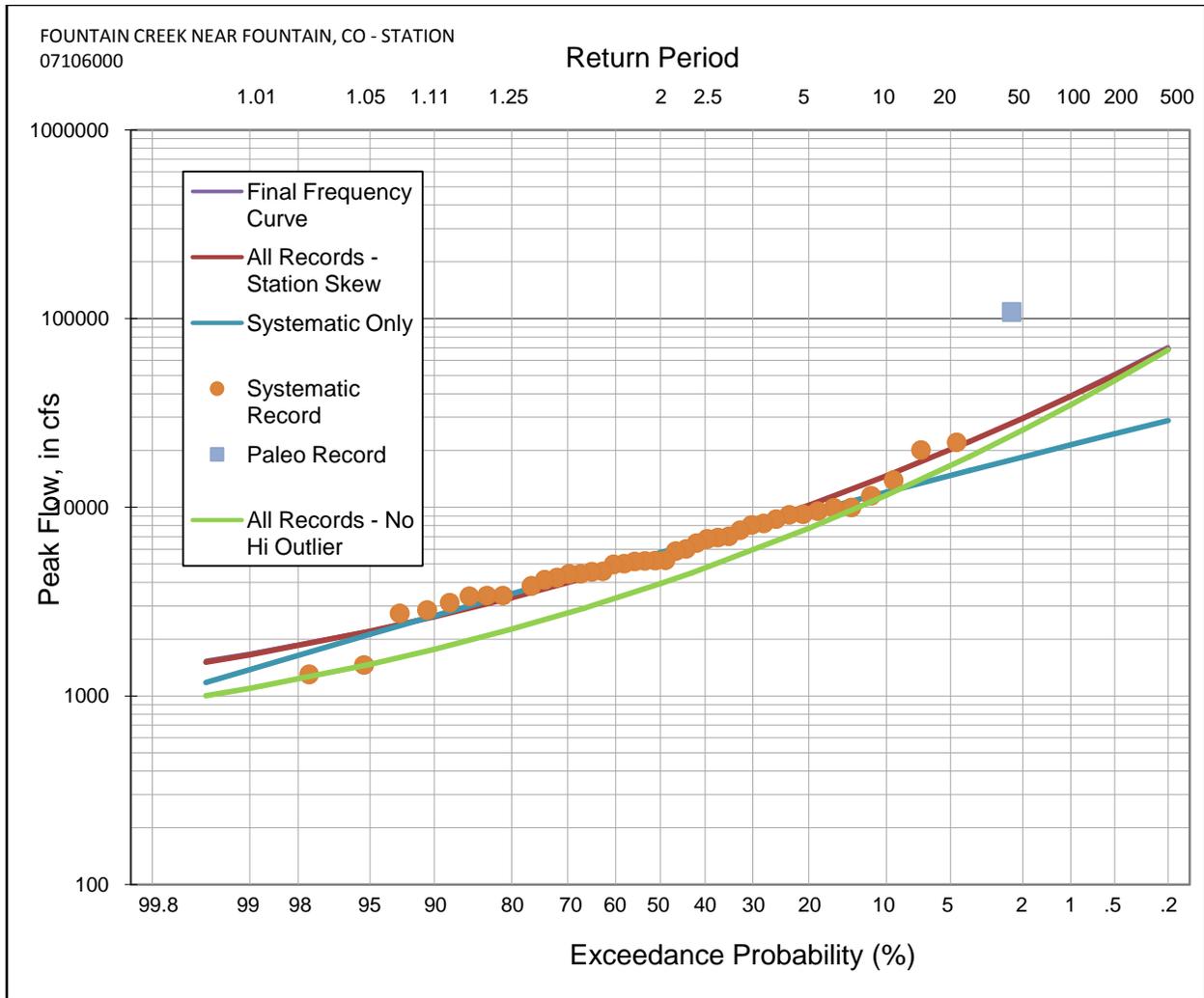


Figure 4: Calculated frequency curves for Fountain Creek near Fountain, CO

3.1.4 Fountain Creek at Security

At this location, the systematic record included 44 years of peak flow data. The systematic record was modified to include the peak flow value of 30,500 cfs (1935) and 25,000 (1965), which were developed from the USGS paleohydrologic analysis. Records obtained from the USGS show that the estimated range of the 1935 flood was from 27,000 to 34,000 cfs. For use in this study, the average value of the 1935 flood event estimate, 30,500 cfs, was used in the flood frequency analysis. The low outlier threshold was adjusted to censor the 1970 peak of 625 cfs. By censoring the 1970 peak, the weighted skew becomes 0.171 and more consistent with other stations on Fountain Creek. The systematic record was also modified to extend the period of record to the historic record of 74 years (1935 to 2008). As a conservative estimate of the generalized skew coefficient for the Fountain Creek gage stations a value of zero was assumed. The resulting estimated frequency curves for Fountain Creek at Security can be seen in Figure 5.

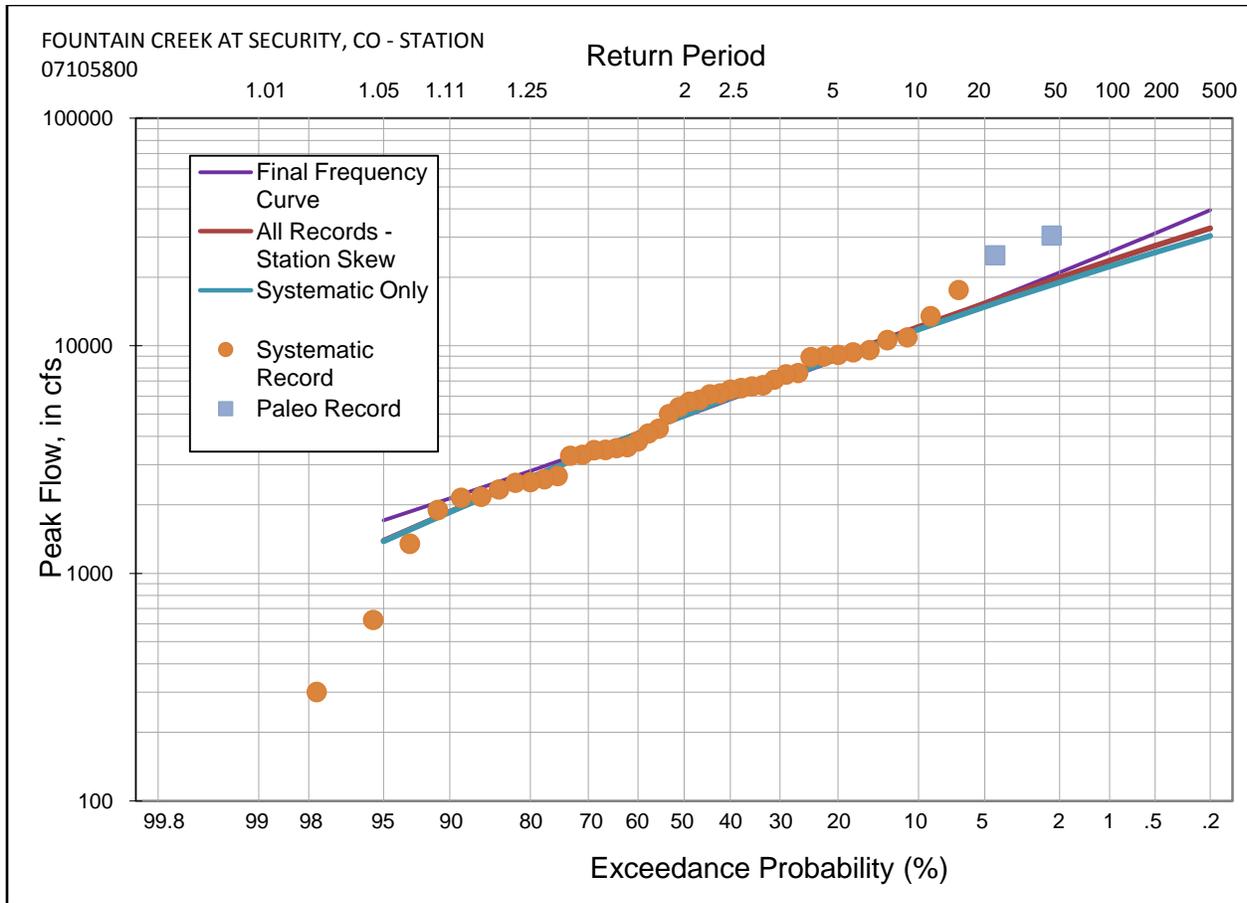


Figure 5: Calculated frequency curves for Fountain Creek at Security, CO

3.1.5 Fountain Creek Below Janitell

At this location, the systematic record included 19 years of peak flow data. The systematic record was modified to include the peak flow value of 32,750 cfs (1935) and 21,000 (1965), which were developed from the USGS paleohydrologic analysis. Records obtained from the USGS show that the estimated range of the 1935 flood was from 30,000 to 35,500 cfs, and 19,000 to 23,000 cfs for the 1965 flood. For use in this study, the average value of the flood event estimate, 32,570 cfs for 1935 and 21,000 cfs for 1965, was used in the flood frequency analysis. The systematic record was also modified to extend the period of record to the historic record of 74 years (1935 to 2008). As a conservative estimate of the generalized skew coefficient for the Fountain Creek gage stations, a value of zero was assumed. The resulting estimated frequency curves for Fountain Creek below Janitell can be seen in Figure 6.

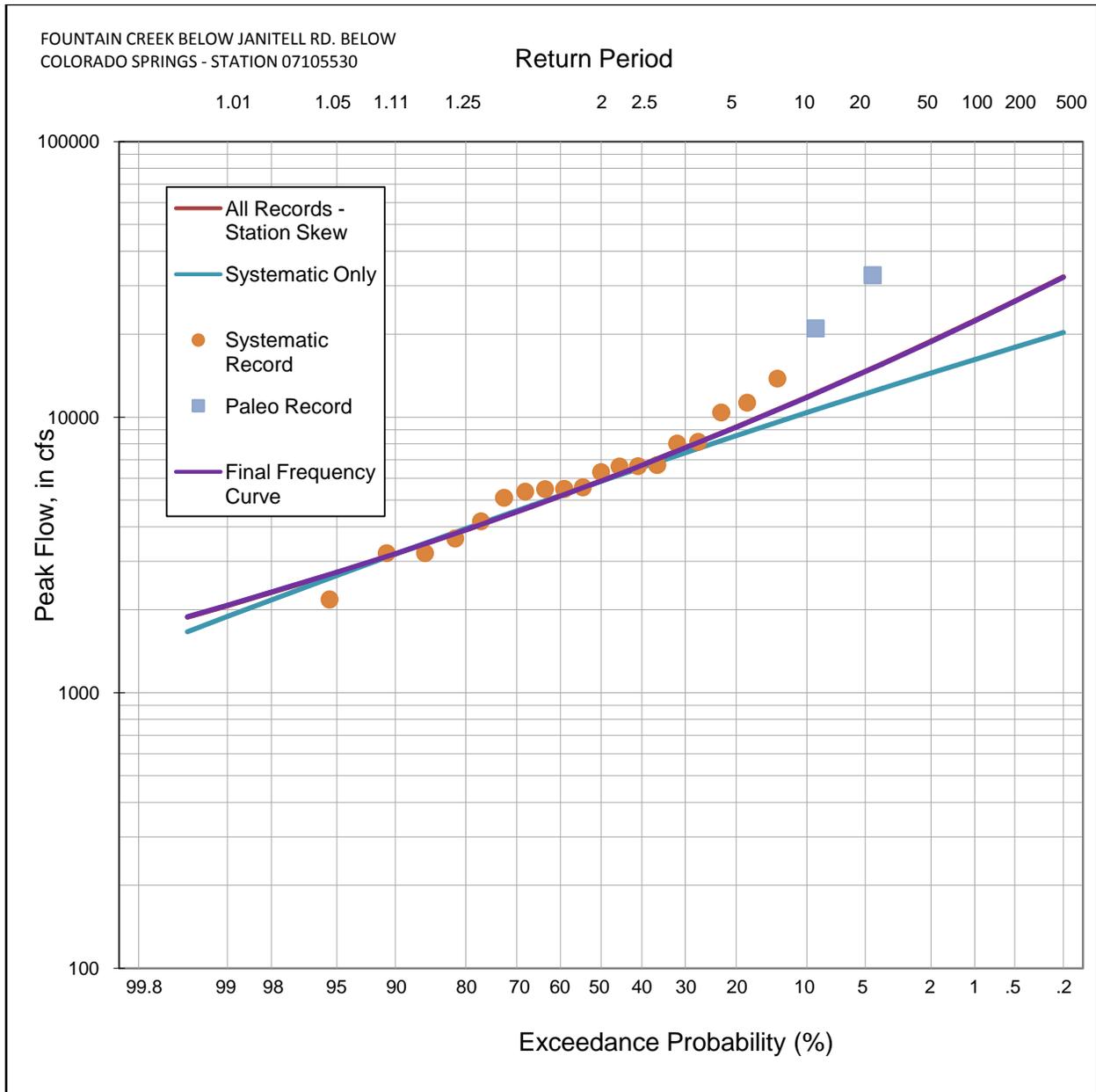


Figure 6: Calculated frequency curves for Fountain Creek Below Janitell Road, Below Colorado Springs, CO.

3.1.6 Fountain Creek At Colorado Springs

At this location the systematic record included 33 years of peak flow data. The systematic record was modified to include the peak flow value of 35,500 cfs (1935) and 13,500 (1965), which were developed from the USGS paleohydrologic analysis. Records obtained from the USGS show that the estimated range of the 1935 flood was from 33,000 to 38,000 cfs, and 12,000 to 15,500 cfs for the 1965 flood. For use in this study, the average value of the flood

event estimate, 35,500 cfs for 1935 and 13,500 cfs for 1965, was used in the flood frequency analysis. The systematic record was also modified to extend the period of record to the historic record of 74 years (1935 to 2008). As a conservative estimate of the generalized skew coefficient for the Fountain Creek gage stations, a value of zero was assumed. The resulting estimated frequency curves for Fountain Creek at Colorado Springs can be seen in Figure 7.

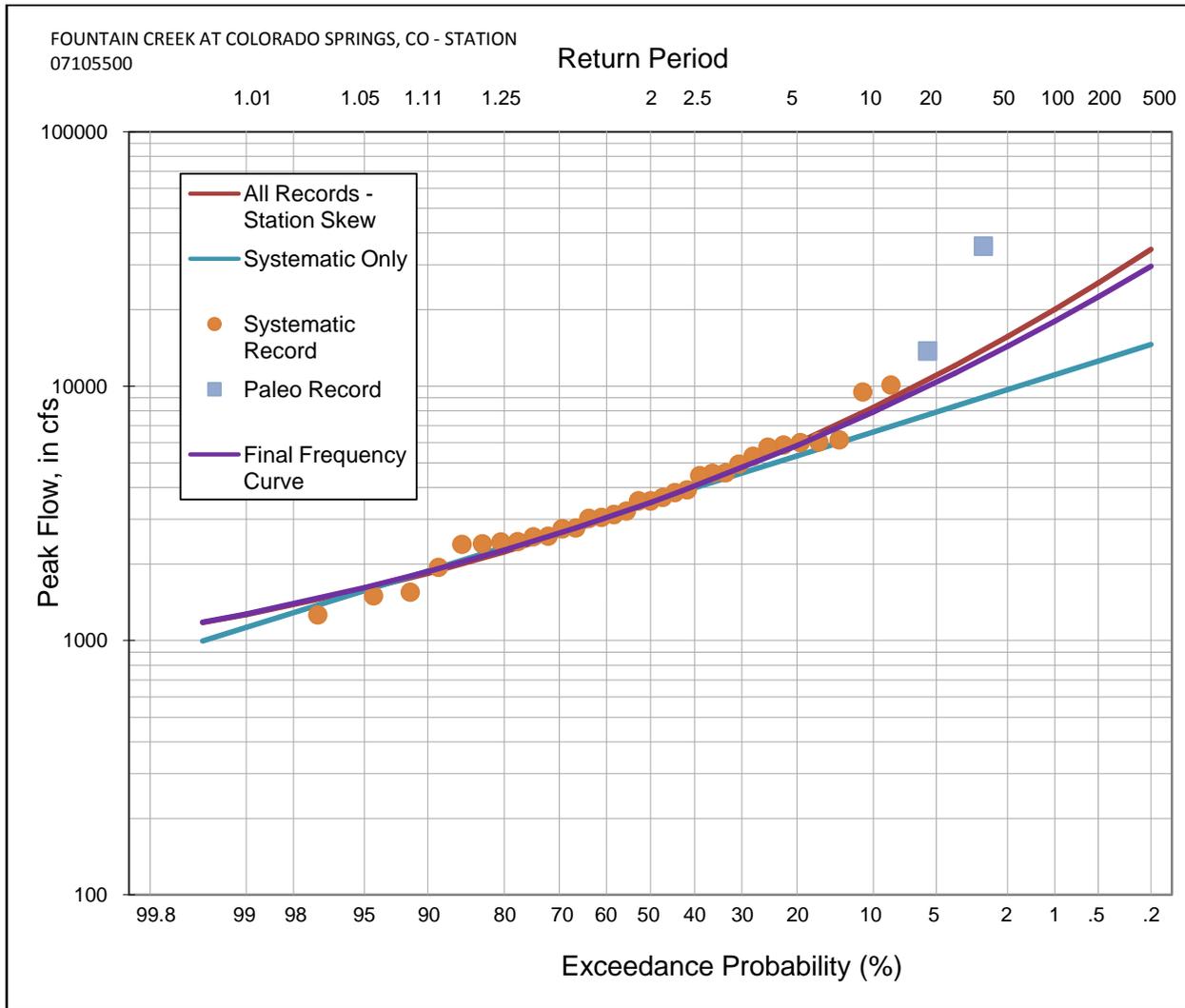


Figure 7: Calculated frequency curves for Fountain Creek at Colorado Springs, CO.

3.1.7 Fountain Creek Near Colorado Springs

At this location, the systematic record included 51 years of peak flow data. The systematic record was modified to include a peak flow value of 3,700 cfs (1935), which was developed from the USGS paleohydrologic analysis. Records obtained from the USGS show that the estimated range of the 1935 flood was from 3,300 to 4,100 cfs. For use in this study, the average value of the 1935 flood event estimate, 3,700 cfs, was used in the flood frequency analysis. The

systematic record was also modified to extend the period of record to the historic record of 74 years (1935 to 2008). As a conservative estimate of the generalized skew coefficient for the Fountain Creek gage stations, a value of zero was assumed. The resulting estimated frequency curves for Fountain Creek near Colorado Springs can be seen in Figure 8.

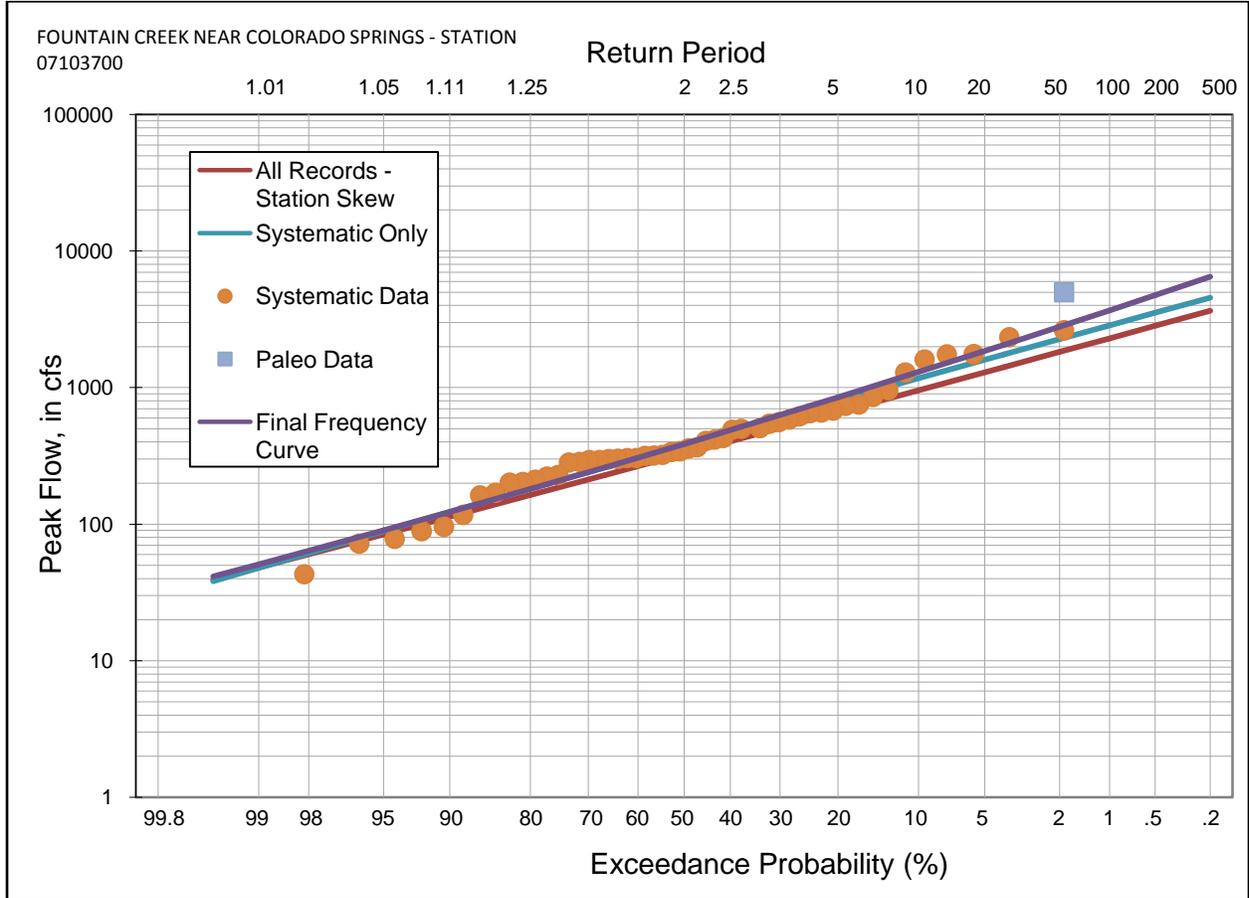


Figure 8: Calculated frequency curves for Fountain Creek near Colorado Springs, CO

The results of the flood frequency analysis for the gage locations along Fountain Creek can be seen in Table 1.

USGS Stream Gage	Drainage Area (Square Miles)	10%-Annual-Chance- Exceedance Peak Flow (cfs)	2%-Annual-Chance- Exceedance Peak Flow (cfs)	1%-Annual- Chance- Exceedance Peak Flow (cfs)	0.2%-Annual- Chance-Exceedance Peak Flow (cfs)
Fountain Creek near Colorado Springs, CO 07103700	103	1,300	2,800	3,700	6,500
Fountain Creek at Colorado Springs, CO 07105500	392	7,900	14,300	18,000	29,400
Fountain Creek at Janitell, CO 07105530	413	11,800	18,800	22,400	32,200
Fountain Creek at Security, CO 07105800	495	11,900	21,000	25,800	39,500
Fountain Creek at Fountain, CO 07106000	681	14,700	29,900	39,400	71,300
Fountain Creek near Pinon, CO 07106300	849	10,700	24,200	33,300	66,800
Fountain Creek near Pueblo, CO 07106500	926	14,400	30,200	39,600	70,000

Table 1: Flood Frequency Results for Fountain Creek

3.2 Regional Regression Analysis

For the sake of comparison to the flood frequency analysis, USGS regional regression equations were utilized at each gage location in order to determine the 10-, 2-, 1-, and 0.2-percent-annual-chance-exceedance hydrologic peak flows for Fountain Creek. The regional regression equations from SIR 2009-5136 have been prepared for Colorado in five hydrologic regions. Based on Figure 1 within SIR 2009-5136, the gaging locations studied in this hydrologic analysis fall within the Plains Region of Colorado. The regional regression equations for the Plains hydrologic region are as follows:

$$\begin{aligned}Q_{10} &= 10^{0.85} A^{0.59} P^{2.15} \\Q_{50} &= 10^{0.85} A^{0.62} P^{2.79} \\Q_{100} &= 10^{0.88} A^{0.63} P^{2.98} \\Q_{500} &= 10^{0.81} A^{0.64} P^{3.59}\end{aligned}$$

where Q is the peak discharge in cfs at each recurrence interval; A is the drainage basin area in square miles; and P is the 6-hour, 100-year precipitation in inches. The drainage basin area used was based on the USGS published value for each gaging station. The 6-hour, 100-year precipitation value for each location was determined using the National Oceanic and Atmospheric Administration (NOAA) Atlas 2 Precipitation-Frequency Atlas of the Western United States. In order to accurately determine the precipitation value, the USGS published Latitude and Longitude value for each gage site was input into the NOAA online precipitation frequency database where the values ranged from 3.45 to 3.59 inches.

The results of the regional regression equation analysis for the gage locations along Fountain Creek can be seen in Table 2. Overall, with the exception of the upstream Colorado Springs gage, the regional regression results can be seen to be significantly lower than those determined by the flood frequency analysis.

USGS Stream Gage	Drainage Area (Square Miles)	10%-Annual-Chance-Exceedance Peak Flow (cfs)	2%-Annual-Chance-Exceedance Peak Flow (cfs)	1%-Annual-Chance-Exceedance Peak Flow (cfs)	0.2%-Annual-Chance-Exceedance Peak Flow (cfs)
Fountain Creek near Colorado Springs, CO 07103700	103	1,622	4,163	5,931	11,373
Fountain Creek at Colorado Springs, CO 07105500	392	3,745	10,152	14,721	29,006
Fountain Creek at Janitell, CO 07105530	413	3,862	10,486	15,214	29,991
Fountain Creek at Security, CO 07105800	495	4,272	11,641	16,911	33,342
Fountain Creek at Fountain, CO 07106000	681	5,065	13,858	20,163	39,677
Fountain Creek near Pinon, CO 07106300	849	5,492	14,909	21,647	42,100
Fountain Creek near Pueblo, CO 07106500	926	5,710	15,482	22,473	43,591

Table 2: Regional Regression Equation Results for Fountain Creek

3.3 Intermediate Design Points

As requested by FEMA Region VIII, peak discharges were determined for intermediate design points along Fountain Creek for use in the El Paso County, CO, FIS. Using the methodology outlined in WRIR 99-4190, the peak discharges for sites near gaging stations on the same stream are estimated using the following drainage-area ratio:

$$Q_{T(u)} = Q_{T(g)} \left(\frac{A_u}{A_g} \right)^x$$

where $Q_{T(u)}$ is the peak discharge, in cfs, at the ungaged site for T-year recurrence interval; $Q_{T(g)}$ is the weighted peak discharge, in cfs, at the gaged site for the T-year recurrence interval; A_u is the drainage area, in square miles, at the ungaged site; A_g is the drainage area, in square miles, at the gaged site; and x is the average exponent drainage area for the Plains flood region (0.40).

The intermediate design points along Fountain Creek have an estimated drainage basin area ranging between 5.5 to 795 square miles. As discussed in WRIR 99-4190, the drainage-area ratio equation is applicable to design points at ungaged sites between 50 and 150 percent of the drainage area of the gaged sites. The range of drainage basin areas for the gage sites along Fountain Creek are 103 to 926 square miles, which sets the range of application for the ungaged sites at 51.5 to 1,389 square miles. For those intermediate design points outside of the range, the estimated peak discharges have been determined by using the drainage-area ratio equation for the lower end of the range, or 51.5 square miles.

The results of the drainage-area transfer analysis for the intermediate design points along Fountain Creek can be seen in Table 3.

Design Point	Drainage Area (Square Miles)	10-review-Annual- Chance Exceedance Peak Flow (cfs)	2-review-Annual- Chance Exceedance Peak Flow (cfs)	1-percent-Annual- Chance Exceedance Peak Flow (cfs)	0.2-percent-Annual- Chance Exceedance Peak Flow (cfs)
JUF030	5.5	985	2,122	2,804	4,926
JUF040	11.7				
JUF050	16.9				
JUF125	34.9				
JUF130	34.9				
JUF140	37.8				
JUF150	41.9				
JUF160	43.4				
JUF250	65.9	1,087	2,342	3,095	5,437
JUF260	68.5	1,104	2,378	3,143	5,521
JUF270	69.8	1,113	2,396	3,167	5,563
JUF350	91.1	1,238	2,666	3,523	6,189
JUF360	91.9	1,242	2,675	3,535	6,210
JUF400	100.2	1,286	2,769	3,659	6,429
JUF410	103.4	1,302	2,804	3,706	6,510
JUF470	116.2	1,364	2,938	3,883	6,821

Design Point	Drainage Area (Square Miles)	10-percent-Annual- Chance Exceedance Peak Flow	2-percent-Annual- Chance Exceedance Peak Flow	1-percent-Annual- Chance Exceedance Peak Flow	0.2-percent-Annual- Chance Exceedance Peak Flow
WFtn 1	118.7	1,376	2,963	3,916	6,880
JFC240	415	11,823	18,836	22,443	32,262
JFC260	485	11,803	20,829	25,590	39,179
JFC270	505	11,996	21,169	26,007	39,817
JFC280	514	12,081	21,319	26,192	40,100
JFC290	538	12,303	21,712	26,674	40,838
JFC310	611	14,076	28,630	37,727	68,273
JFC330	672	14,622	29,741	39,191	70,922
JFC340	677	14,665	29,830	39,307	71,132
JFC360	712	14,964	30,437	40,108	72,581
JFC380	773	10,306	23,309	32,074	64,341
JFC400	795	10,422	23,572	32,436	65,067

4. Summary of Discharges

A flood frequency analysis for Fountain Creek at seven gage locations was performed using Bulletin 17B procedures. The systematic data set was augmented by historic data available from the USGS paleohydrologic analysis. The results of the regional regression equation analysis were not used because the computed values were well outside of the 68-percent confidence interval of the gaged data, as shown in Figure 9 below. The results of the hydrologic analysis for Fountain Creek can be seen in Table 4.

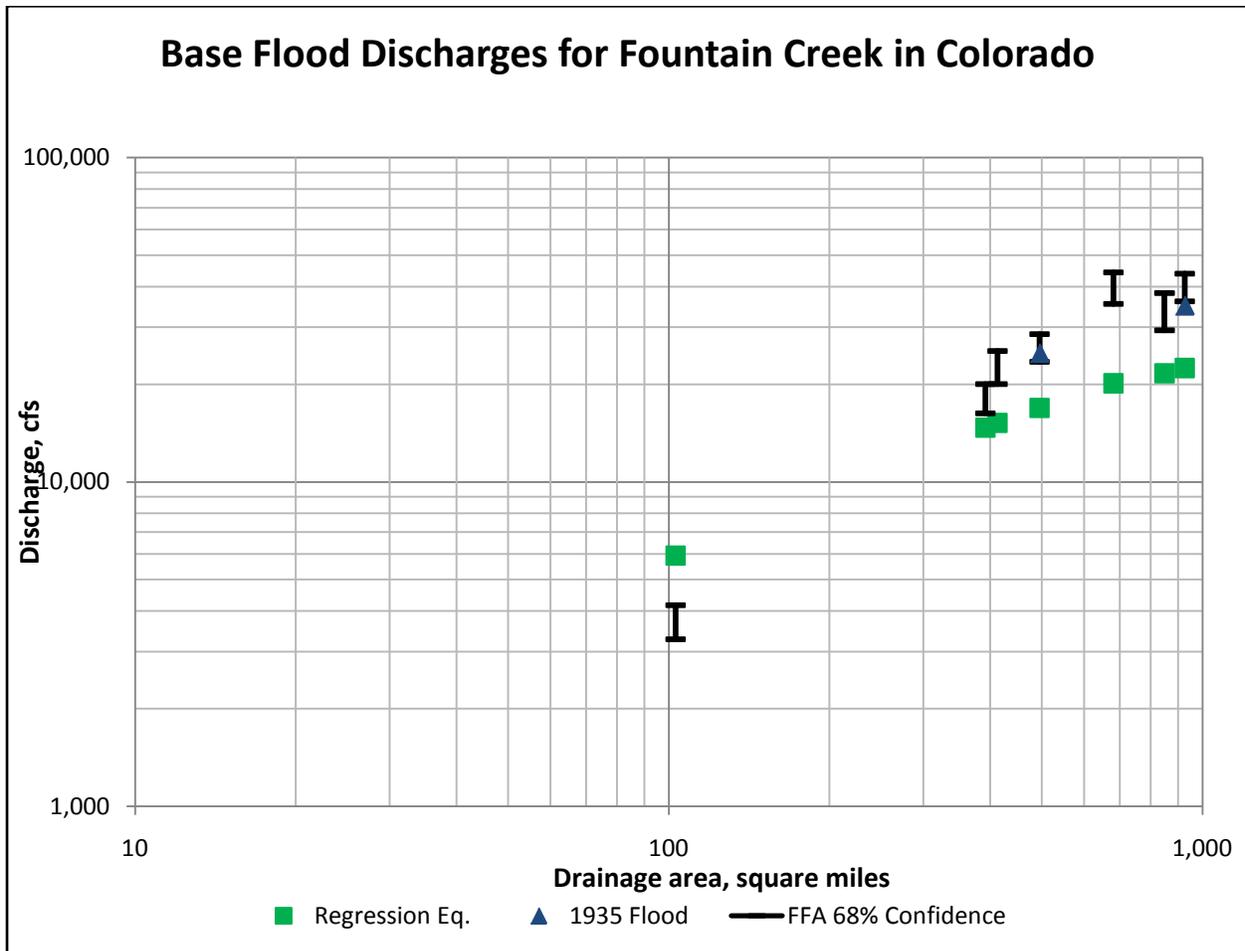


Figure 9: Comparison of Regression Equation and Flood Frequency Results for Fountain Creek

USGS Stream Gage	Drainage Area (Square Miles)	10-percent-Annual- Chance-Exceedance Peak Flow	2-percent-Annual- Chance-Exceedance Peak Flow	1-percent-Annual- Chance- Exceedance Peak Flow	0.2-percent-Annual- Chance-Exceedance Peak Flow
Fountain Creek near Colorado Springs, CO 07103700	103	1,300	2,800	3,700	6,500
Fountain Creek at Colorado Springs, CO 07105500	392	7,900	14,300	18,000	29,400
Fountain Creek at Janitell, CO 07105530	413	11,800	18,800	22,400	32,200
Fountain Creek at Security, CO 07105800	495	11,900	21,000	25,800	39,500
Fountain Creek at Fountain, CO 07106000	681	14,700	29,900	39,400	71,300
Fountain Creek near Pinon, CO 07106300	849	10,700	24,200	33,300	66,800
Fountain Creek near Pueblo, CO 07106500	926	14,400	30,200	39,600	70,000

Table 4: Summary of Discharges for Fountain Creek

5. References

PKFQWIN Version 5.2.0, Flood Frequency Analysis Based on Bulletin 17B, U.S. Geological Survey, November 2007.

Memorandum on Paleohydrologic Analysis for Fountain Creek, Robert Jarrett, U.S. Geological Survey, December 18, 2009.

Fountain Creek El Paso, Pueblo, and Teller Counties, Colorado, Hydrologic Watershed Analysis, U.S. Army Corps of Engineers, April 2004.

NOAA Atlas 2 Precipitation-Frequency Atlas of the Western United States Volume III – Colorado, NOAA, 1973.

Analysis of the Magnitude and Frequency of Floods in Colorado, Water-Resources Investigations Report 99-4190, U.S. Geological Survey, 2000.

Regional Regression Equations for Estimation of Natural Streamflow Statistics in Colorado, Scientific Investigations Report 2009-5136, U.S. Geological Survey, 2009.

6. Appendix

1
 Program PeakFq U. S. GEOLOGICAL SURVEY Seq.000.000
 Ver. 5.2 Annual peak flow frequency analysis Run Date /
 Time
 11/01/2007 following Bulletin 17-B Guidelines 04/02/2010
 14:27

--- PROCESSING OPTIONS ---

Plot option = Graphics device
 Basin char output = None
 Print option = Yes
 Debug print = No
 Input peaks listing = Long
 Input peaks format = WATSTORE peak file

Input files used:

peaks (ascii) - C:\DOCUMENTS AND
 SETTINGS\CMCKERNAN\DESKTOP\HYDROLOGY\FOUNTAINCRK_FINAL.TXT
 specifications - PKFQWPSF.TMP

Output file(s):

main - C:\DOCUMENTS AND
 SETTINGS\CMCKERNAN\DESKTOP\HYDROLOGY\FOUNTAINCRK_FINAL_68.PRT

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.001.001
 Ver. 5.2 Annual peak flow frequency analysis Run Date /
 Time
 11/01/2007 following Bulletin 17-B Guidelines 04/02/2010
 14:27

Station - 07106500 FOUNTAIN CREEK AT PUEBLO, CO.

I N P U T D A T A S U M M A R Y

Number of peaks in record = 68
 Peaks not used in analysis = 0
 Systematic peaks in analysis = 67
 Historic peaks in analysis = 1
 Years of historic record = 88
 Generalized skew = 0.000
 Standard error = 0.550
 Mean Square error = 0.303
 Skew option = WEIGHTED
 Gage base discharge = 0.0
 User supplied high outlier threshold = 33900.0
 User supplied low outlier criterion = 400.0
 Plotting position parameter = 0.00

***** NOTICE -- Preliminary machine computations. *****
 ***** User responsible for assessment and interpretation. *****

WCF134I-NO SYSTEMATIC PEAKS WERE BELOW GAGE BASE. 0.0
 *WCF191I-USER LOW-OUTLIER CRITERION SUPERSEDES 17B. 400.0 296.8
 WCF198I-LOW OUTLIERS BELOW FLOOD BASE WERE DROPPED. 2 400.0
 *WCF161I-USER HIGH OUTLIER CRITERION REPLACES 17B. 33900.0 51306.6
 WCF165I-HIGH OUTLIERS AND HISTORIC PEAKS ABOVE HHBASE. 2 1 33900.0

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.001.002
 Ver. 5.2 Annual peak flow frequency analysis Run Date /
 Time 11/01/2007 following Bulletin 17-B Guidelines 04/02/2010
 14:27

Station - 07106500 FOUNTAIN CREEK AT PUEBLO, CO.

ANNUAL FREQUENCY CURVE PARAMETERS -- LOG-PEARSON TYPE III

	FLOOD BASE		LOGARITHMIC		
	DISCHARGE	EXCEEDANCE PROBABILITY	MEAN	STANDARD DEVIATION	SKEW
SYSTEMATIC RECORD	0.0	1.0000	3.6590	0.4124	-0.456
BULL.17B ESTIMATE	400.0	0.9703	3.6861	0.3616	0.268

ANNUAL FREQUENCY CURVE -- DISCHARGES AT SELECTED EXCEEDANCE PROBABILITIES

ANNUAL LIMITS	EXCEEDANCE PROBABILITY	BULL.17B ESTIMATE	SYSTEMATIC RECORD	'EXPECTED 68-PCT CONFIDENCE FOR BULL. 17B			
				PROBABILITY'	ESTIMATE	LOWER	UPPER
	0.9950	--	264.0	--	--	--	--
	0.9900	--	366.6	--	--	--	--
	0.9500	1319.0	854.2	1285.0	1225.0	1413.0	1413.0
	0.9000	1715.0	1302.0	1687.0	1607.0	1825.0	1825.0
	0.8000	2388.0	2109.0	2367.0	2256.0	2522.0	2522.0
	0.6667	3294.0	3225.0	3282.0	3131.0	3461.0	3461.0
	0.5000	4678.0	4901.0	4678.0	4460.0	4905.0	4905.0
	0.4292	5430.0	5782.0	5438.0	5178.0	5697.0	5697.0
	0.2000	9657.0	10280.0	9758.0	9149.0	10220.0	10220.0
	0.1000	14410.0	14570.0	14720.0	13530.0	15410.0	15410.0
	0.0400	22450.0	20540.0	23360.0	20810.0	24350.0	24350.0
	0.0200	30170.0	25250.0	31940.0	27710.0	33060.0	33060.0
	0.0100	39610.0	30120.0	42780.0	36040.0	43830.0	43830.0
	0.0050	51070.0	35110.0	56440.0	46070.0	57060.0	57060.0
	0.0020	69960.0	41860.0	80040.0	62410.0	79130.0	79130.0

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.001.003

Ver. 5.2
 Time
 11/01/2007
 14:27

Annual peak flow frequency analysis
 following Bulletin 17-B Guidelines

Run Date /
 04/02/2010

Station - 07106500 FOUNTAIN CREEK AT PUEBLO, CO.

I N P U T D A T A L I S T I N G

WATER YEAR	DISCHARGE	CODES	WATER YEAR	DISCHARGE	CODES
-1935	35000.0	H	1975	5360.0	
1921	34000.0		1976	5870.0	
1922	5140.0		1977	5120.0	
1924	12000.0		1978	1860.0	
1925	2500.0		1979	946.0	
1941	1150.0		1980	15200.0	
1942	11000.0		1981	3600.0	
1943	324.0		1982	9080.0	
1944	12900.0		1983	2940.0	
1945	17800.0		1984	5940.0	
1946	16500.0		1985	4950.0	
1947	5880.0		1986	2590.0	
1948	9290.0		1987	2600.0	
1949	1590.0		1988	1980.0	
1950	9600.0		1989	1060.0	
1951	11600.0		1990	3780.0	
1952	5170.0		1991	3220.0	
1953	3730.0		1992	2440.0	
1954	5800.0		1993	2880.0	
1955	11500.0		1994	12300.0	
1956	5250.0		1995	11300.0	
1957	6180.0		1996	12100.0	
1958	3750.0		1997	10100.0	
1959	204.0		1998	3100.0	
1960	2530.0		1999	18900.0	
1961	6200.0		2000	2080.0	
1962	2520.0		2001	1950.0	
1963	8880.0		2002	2400.0	
1964	6110.0		2003	3580.0	
1965	47000.0		2004	4880.0	
1971	2030.0		2005	2900.0	
1972	3220.0		2006	9310.0	
1973	2970.0		2007	3720.0	
1974	2560.0		2008	4540.0	

Explanation of peak discharge qualification codes

PeakFQ CODE	NWIS CODE	DEFINITION
D	3	Dam failure, non-recurrent flow anomaly
G	8	Discharge greater than stated value
X	3+8	Both of the above

L 4 Discharge less than stated value
 K 6 OR C Known effect of regulation or urbanization
 H 7 Historic peak

- Minus-flagged discharge -- Not used in computation
 -8888.0 -- No discharge value given
- Minus-flagged water year -- Historic peak used in computation

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.001.004
 Ver. 5.2 Annual peak flow frequency analysis Run Date /
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Station - 07106500 FOUNTAIN CREEK AT PUEBLO, CO.

EMPIRICAL FREQUENCY CURVES -- WEIBULL PLOTTING POSITIONS

WATER YEAR	RANKED DISCHARGE	SYSTEMATIC RECORD	BULL.17B ESTIMATE
1965	47000.0	0.0147	0.0112
-1935	35000.0	--	0.0225
1921	34000.0	0.0294	0.0337
1999	18900.0	0.0441	0.0467
1945	17800.0	0.0588	0.0614
1946	16500.0	0.0735	0.0761
1980	15200.0	0.0882	0.0908
1944	12900.0	0.1029	0.1054
1994	12300.0	0.1176	0.1201
1996	12100.0	0.1324	0.1348
1924	12000.0	0.1471	0.1495
1951	11600.0	0.1618	0.1642
1955	11500.0	0.1765	0.1789
1995	11300.0	0.1912	0.1936
1942	11000.0	0.2059	0.2083
1997	10100.0	0.2206	0.2230
1950	9600.0	0.2353	0.2377
2006	9310.0	0.2500	0.2524
1948	9290.0	0.2647	0.2671
1982	9080.0	0.2794	0.2818
1963	8880.0	0.2941	0.2965
1961	6200.0	0.3088	0.3111
1957	6180.0	0.3235	0.3258
1964	6110.0	0.3382	0.3405
1984	5940.0	0.3529	0.3552
1947	5880.0	0.3676	0.3699
1976	5870.0	0.3824	0.3846
1954	5800.0	0.3971	0.3993
1975	5360.0	0.4118	0.4140
1956	5250.0	0.4265	0.4287

1952	5170.0	0.4412	0.4434
1922	5140.0	0.4559	0.4581
1977	5120.0	0.4706	0.4728
1985	4950.0	0.4853	0.4875
2004	4880.0	0.5000	0.5022
2008	4540.0	0.5147	0.5169
1990	3780.0	0.5294	0.5315
1958	3750.0	0.5441	0.5462
1953	3730.0	0.5588	0.5609
2007	3720.0	0.5735	0.5756
1981	3600.0	0.5882	0.5903
2003	3580.0	0.6029	0.6050
1972	3220.0	0.6176	0.6197
1991	3220.0	0.6324	0.6344
1998	3100.0	0.6471	0.6491
1973	2970.0	0.6618	0.6638
1983	2940.0	0.6765	0.6785
2005	2900.0	0.6912	0.6932
1993	2880.0	0.7059	0.7079
1987	2600.0	0.7206	0.7226
1986	2590.0	0.7353	0.7373
1974	2560.0	0.7500	0.7519
1960	2530.0	0.7647	0.7666
1962	2520.0	0.7794	0.7813
1925	2500.0	0.7941	0.7960
1992	2440.0	0.8088	0.8107
2002	2400.0	0.8235	0.8254
2000	2080.0	0.8382	0.8401
1971	2030.0	0.8529	0.8548
1988	1980.0	0.8676	0.8695
2001	1950.0	0.8824	0.8842
1978	1860.0	0.8971	0.8989
1949	1590.0	0.9118	0.9136
1941	1150.0	0.9265	0.9283
1989	1060.0	0.9412	0.9430
1979	946.0	0.9559	0.9576
1943	324.0	0.9706	0.9723
1959	204.0	0.9853	0.9870

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Program PeakFq	U. S. GEOLOGICAL SURVEY	Seq.002.001
Ver. 5.2	Annual peak flow frequency analysis	Run Date /
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Station - 07106300 FOUNTAIN CREEK NEAR PINON, CO

I N P U T D A T A S U M M A R Y

Number of peaks in record	=	39
Peaks not used in analysis	=	0
Systematic peaks in analysis	=	36
Historic peaks in analysis	=	3
Years of historic record	=	88

```

Generalized skew          = 0.000
Standard error           = 0.550
Mean Square error        = 0.303
Skew option              = WEIGHTED
Gage base discharge      = 0.0
User supplied high outlier threshold = --
User supplied low outlier criterion = --
Plotting position parameter = 0.00

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***** NOTICE -- Preliminary machine computations. *****
***** User responsible for assessment and interpretation. *****

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WCF134I-NO SYSTEMATIC PEAKS WERE BELOW GAGE BASE.          0.0
WCF198I-LOW OUTLIERS BELOW FLOOD BASE WERE DROPPED.      1    550.2
WCF165I-HIGH OUTLIERS AND HISTORIC PEAKS ABOVE HHBASE.  0  3    22583.7

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Program PeakFq          U. S. GEOLOGICAL SURVEY          Seq.002.002
Ver. 5.2                Annual peak flow frequency analysis  Run Date /
Time                   following Bulletin 17-B Guidelines  04/02/2010
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Station - 07106300 FOUNTAIN CREEK NEAR PINON, CO

ANNUAL FREQUENCY CURVE PARAMETERS -- LOG-PEARSON TYPE III

	FLOOD BASE		LOGARITHMIC		
	DISCHARGE	EXCEEDANCE PROBABILITY	MEAN	STANDARD DEVIATION	SKEW
SYSTEMATIC RECORD	0.0	1.0000	3.5489	0.3063	-0.215
BULL.17B ESTIMATE	550.2	0.9732	3.6009	0.3212	0.768

ANNUAL FREQUENCY CURVE -- DISCHARGES AT SELECTED EXCEEDANCE PROBABILITIES

ANNUAL LIMITS EXCEEDANCE ESTIMATES PROBABILITY	BULL.17B ESTIMATE	SYSTEMATIC RECORD	'EXPECTED PROBABILITY' ESTIMATE	68-PCT CONFIDENCE FOR BULL. 17B	
				LOWER	UPPER
0.9950	--	499.1	--	--	--
0.9900	--	614.2	--	--	--
0.9500	1417.0	1064.0	1376.0	1301.0	1532.0
0.9000	1677.0	1412.0	1642.0	1551.0	1804.0
0.8000	2117.0	1972.0	2091.0	1975.0	2261.0
0.6667	2712.0	2668.0	2696.0	2547.0	2881.0
0.5000	3632.0	3629.0	3632.0	3427.0	3848.0
0.4292	4141.0	4112.0	4152.0	3909.0	4388.0

0.2000	7119.0	6446.0	7259.0	6675.0	7620.0
0.1000	10710.0	8584.0	11170.0	9918.0	11640.0
0.0400	17310.0	11530.0	18830.0	15730.0	19230.0
0.0200	24210.0	13870.0	27460.0	21670.0	27350.0
0.0100	33310.0	16320.0	39750.0	29380.0	38260.0
0.0050	45250.0	18880.0	57380.0	39330.0	52850.0
0.0020	66840.0	22430.0	93240.0	56990.0	79770.0

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Program PeakFq U. S. GEOLOGICAL SURVEY Seq.002.003
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Station - 07106300 FOUNTAIN CREEK NEAR PINON, CO

I N P U T D A T A L I S T I N G

WATER YEAR	DISCHARGE	CODES	WATER YEAR	DISCHARGE	CODES
-1921	32900.0	H	1990	3990.0	
-1935	33700.0	H	1991	3880.0	
-1965	53000.0	H	1992	1950.0	
1973	1970.0		1993	3050.0	
1974	400.0		1994	7090.0	
1975	1870.0		1995	9910.0	
1976	4680.0		1996	3200.0	
1977	3880.0		1997	10100.0	
1978	2640.0		1998	3340.0	
1979	2640.0		1999	19100.0	
1980	10200.0		2000	2330.0	
1981	4350.0		2001	2400.0	
1982	9360.0		2002	2520.0	
1983	2020.0		2003	3230.0	
1984	1760.0		2004	5320.0	
1985	6960.0		2005	4040.0	
1986	2030.0		2006	6070.0	
1987	2780.0		2007	3110.0	
1988	2560.0		2008	5650.0	
1989	1490.0				

Explanation of peak discharge qualification codes

PeakFQ CODE	NWIS CODE	DEFINITION
D	3	Dam failure, non-recurrent flow anomaly
G	8	Discharge greater than stated value
X	3+8	Both of the above
L	4	Discharge less than stated value
K	6 OR C	Known effect of regulation or urbanization
H	7	Historic peak

- Minus-flagged discharge -- Not used in computation
-8888.0 -- No discharge value given
- Minus-flagged water year -- Historic peak used in computation

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.002.004
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Station - 07106300 FOUNTAIN CREEK NEAR PINON, CO

EMPIRICAL FREQUENCY CURVES -- WEIBULL PLOTTING POSITIONS

WATER YEAR	RANKED DISCHARGE	SYSTEMATIC RECORD	BULL.17B ESTIMATE
-1965	53000.0	--	0.0112
-1935	33700.0	--	0.0225
-1921	32900.0	--	0.0337
1999	19100.0	0.0270	0.0526
1980	10200.0	0.0541	0.0791
1997	10100.0	0.0811	0.1056
1995	9910.0	0.1081	0.1322
1982	9360.0	0.1351	0.1587
1994	7090.0	0.1622	0.1852
1985	6960.0	0.1892	0.2118
2006	6070.0	0.2162	0.2383
2008	5650.0	0.2432	0.2648
2004	5320.0	0.2703	0.2914
1976	4680.0	0.2973	0.3179
1981	4350.0	0.3243	0.3444
2005	4040.0	0.3514	0.3709
1990	3990.0	0.3784	0.3975
1977	3880.0	0.4054	0.4240
1991	3880.0	0.4324	0.4505
1998	3340.0	0.4595	0.4771
2003	3230.0	0.4865	0.5036
1996	3200.0	0.5135	0.5301
2007	3110.0	0.5405	0.5566
1993	3050.0	0.5676	0.5832
1987	2780.0	0.5946	0.6097
1978	2640.0	0.6216	0.6362
1979	2640.0	0.6486	0.6628
1988	2560.0	0.6757	0.6893
2002	2520.0	0.7027	0.7158
2001	2400.0	0.7297	0.7424
2000	2330.0	0.7568	0.7689
1986	2030.0	0.7838	0.7954
1983	2020.0	0.8108	0.8219

1973	1970.0	0.8378	0.8485
1992	1950.0	0.8649	0.8750
1975	1870.0	0.8919	0.9015
1984	1760.0	0.9189	0.9281
1989	1490.0	0.9459	0.9546
1974	400.0	0.9730	0.9811

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Program PeakFq      U. S. GEOLOGICAL SURVEY      Seq.003.001
Ver. 5.2           Annual peak flow frequency analysis  Run Date /
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14:27

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Station - 07106000 FOUNTAIN CREEK NEAR FOUNTAIN, CO.

I N P U T D A T A S U M M A R Y

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Number of peaks in record      =      42
Peaks not used in analysis     =       1
Systematic peaks in analysis   =      40
Historic peaks in analysis     =       1
Years of historic record      =      70
Generalized skew               =     0.000
    Standard error             =     0.550
    Mean Square error         =     0.303
Skew option                    =  WEIGHTED
Gage base discharge            =       0.0
User supplied high outlier threshold =  27692.0
User supplied low outlier criterion =  --
Plotting position parameter    =       0.00

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***** NOTICE -- Preliminary machine computations. *****
***** User responsible for assessment and interpretation. *****

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**WCF109W-PEAKS WITH MINUS-FLAGGED DISCHARGES WERE BYPASSED.      1
**WCF113W-NUMBER OF SYSTEMATIC PEAKS HAS BEEN REDUCED TO NSYS =  40
WCF134I-NO SYSTEMATIC PEAKS WERE BELOW GAGE BASE.                  0.0
WCF195I-NO LOW OUTLIERS WERE DETECTED BELOW CRITERION.            1171.7
*WCF161I-USER HIGH OUTLIER CRITERION REPLACES 17B.                27692.0  27691.9
WCF165I-HIGH OUTLIERS AND HISTORIC PEAKS ABOVE HHBASE.           0  1  27692.0
WCF002J-CALCS COMPLETED. RETURN CODE = 2

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Program PeakFq      U. S. GEOLOGICAL SURVEY      Seq.003.002
Ver. 5.2           Annual peak flow frequency analysis  Run Date /
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Station - 07106000 FOUNTAIN CREEK NEAR FOUNTAIN, CO.

ANNUAL FREQUENCY CURVE PARAMETERS -- LOG-PEARSON TYPE III

	FLOOD BASE		LOGARITHMIC		
	DISCHARGE	EXCEEDANCE PROBABILITY	MEAN	STANDARD DEVIATION	SKEW
SYSTEMATIC RECORD	0.0	1.0000	3.7556	0.2561	-0.109
BULL.17B ESTIMATE	0.0	1.0000	3.7739	0.2955	0.635

ANNUAL FREQUENCY CURVE -- DISCHARGES AT SELECTED EXCEEDANCE PROBABILITIES

ANNUAL LIMITS	EXCEEDANCE PROBABILITY	BULL.17B ESTIMATE	SYSTEMATIC RECORD	'EXPECTED	68-PCT CONFIDENCE	
				PROBABILITY'	LOWER	UPPER
	0.9950	1539.0	1175.0	1457.0	1405.0	1674.0
	0.9900	1682.0	1379.0	1605.0	1542.0	1823.0
	0.9500	2221.0	2122.0	2162.0	2060.0	2382.0
	0.9000	2636.0	2658.0	2586.0	2461.0	2810.0
	0.8000	3316.0	3480.0	3280.0	3120.0	3512.0
	0.6667	4205.0	4458.0	4184.0	3981.0	4432.0
	0.5000	5531.0	5757.0	5531.0	5258.0	5816.0
	0.4292	6244.0	6393.0	6258.0	5938.0	6568.0
	0.2000	10210.0	9383.0	10370.0	9653.0	10840.0
	0.1000	14690.0	12040.0	15180.0	13740.0	15790.0
	0.0400	22370.0	15640.0	23890.0	20600.0	24490.0
	0.0200	29920.0	18470.0	32970.0	27210.0	33200.0
	0.0100	39370.0	21420.0	45070.0	35370.0	44280.0
	0.0050	51150.0	24490.0	61250.0	45420.0	58300.0
	0.0020	71250.0	28770.0	91510.0	62300.0	82620.0

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.003.003
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Station - 07106000 FOUNTAIN CREEK NEAR FOUNTAIN, CO.

I N P U T D A T A L I S T I N G

WATER YEAR	DISCHARGE	CODES	WATER YEAR	DISCHARGE	CODES
-1965	108500.0	H	1988	4550.0	
1939	1300.0		1989	2740.0	
1940	22100.0		1990	5200.0	
1941	9940.0		1991	4440.0	

1942	4430.0		1992	2850.0
1943	3400.0		1993	5860.0
1944	3120.0		1994	6920.0
1945	13900.0		1995	9120.0
1946	9550.0		1996	4130.0
1947	7560.0		1997	11500.0
1948	9190.0		1998	4980.0
1949	5160.0		1999	20100.0
1950	3380.0		2000	5220.0
1951	4580.0		2001	6460.0
1952	5240.0		2002	3830.0
1953	1460.0		2003	8060.0
1954	6800.0		2004	8660.0
1955	-3480.0	H	2005	9970.0
1985	7020.0		2006	6010.0
1986	3400.0		2007	5020.0
1987	4240.0		2008	8220.0

Explanation of peak discharge qualification codes

PeakFQ CODE	NWIS CODE	DEFINITION
D	3	Dam failure, non-recurrent flow anomaly
G	8	Discharge greater than stated value
X	3+8	Both of the above
L	4	Discharge less than stated value
K	6 OR C	Known effect of regulation or urbanization
H	7	Historic peak
- Minus-flagged discharge -- Not used in computation		
-8888.0 -- No discharge value given		
- Minus-flagged water year -- Historic peak used in computation		

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.003.004
 Ver. 5.2 Annual peak flow frequency analysis Run Date /
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Station - 07106000 FOUNTAIN CREEK NEAR FOUNTAIN, CO.

EMPIRICAL FREQUENCY CURVES -- WEIBULL PLOTTING POSITIONS

WATER YEAR	RANKED DISCHARGE	SYSTEMATIC RECORD	BULL.17B ESTIMATE
-1965	108500.0	--	0.0141
1940	22100.0	0.0244	0.0333
1999	20100.0	0.0488	0.0576

1945	13900.0	0.0732	0.0819
1997	11500.0	0.0976	0.1062
2005	9970.0	0.1220	0.1305
1941	9940.0	0.1463	0.1548
1946	9550.0	0.1707	0.1790
1948	9190.0	0.1951	0.2033
1995	9120.0	0.2195	0.2276
2004	8660.0	0.2439	0.2519
2008	8220.0	0.2683	0.2762
2003	8060.0	0.2927	0.3005
1947	7560.0	0.3171	0.3248
1985	7020.0	0.3415	0.3491
1994	6920.0	0.3659	0.3734
1954	6800.0	0.3902	0.3977
2001	6460.0	0.4146	0.4220
2006	6010.0	0.4390	0.4463
1993	5860.0	0.4634	0.4706
1952	5240.0	0.4878	0.4949
2000	5220.0	0.5122	0.5192
1990	5200.0	0.5366	0.5435
1949	5160.0	0.5610	0.5678
2007	5020.0	0.5854	0.5921
1998	4980.0	0.6098	0.6164
1951	4580.0	0.6341	0.6407
1988	4550.0	0.6585	0.6650
1991	4440.0	0.6829	0.6893
1942	4430.0	0.7073	0.7136
1987	4240.0	0.7317	0.7379
1996	4130.0	0.7561	0.7621
2002	3830.0	0.7805	0.7864
1943	3400.0	0.8049	0.8107
1986	3400.0	0.8293	0.8350
1950	3380.0	0.8537	0.8593
1944	3120.0	0.8780	0.8836
1992	2850.0	0.9024	0.9079
1989	2740.0	0.9268	0.9322
1953	1460.0	0.9512	0.9565
1939	1300.0	0.9756	0.9808
1955	-3480.0	--	--

1

Program PeakFq	U. S. GEOLOGICAL SURVEY	Seq.004.001
Ver. 5.2	Annual peak flow frequency analysis	Run Date /
Time		
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Station - 07105800 FOUNTAIN CREEK AT SECURITY, CO

I N P U T D A T A S U M M A R Y

Number of peaks in record	=	45
Peaks not used in analysis	=	1
Systematic peaks in analysis	=	42
Historic peaks in analysis	=	2

```

Years of historic record      =      74
Generalized skew              =      0.000
    Standard error            =      0.550
    Mean Square error         =      0.303
Skew option                   =    WEIGHTED
Gage base discharge           =      0.0
User supplied high outlier threshold = 24000.0
User supplied low outlier criterion =    700.0
Plotting position parameter   =      0.00

```

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***** NOTICE -- Preliminary machine computations. *****
***** User responsible for assessment and interpretation. *****

```

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**WCF109W-PEAKS WITH MINUS-FLAGGED DISCHARGES WERE BYPASSED.      1
**WCF113W-NUMBER OF SYSTEMATIC PEAKS HAS BEEN REDUCED TO NSYS =  42
WCF134I-NO SYSTEMATIC PEAKS WERE BELOW GAGE BASE.                  0.0
*WCF191I-USER LOW-OUTLIER CRITERION SUPERSEDES 17B.              700.0   526.4
WCF198I-LOW OUTLIERS BELOW FLOOD BASE WERE DROPPED.              2       700.0
*WCF161I-USER HIGH OUTLIER CRITERION REPLACES 17B.              24000.0  24520.8
WCF165I-HIGH OUTLIERS AND HISTORIC PEAKS ABOVE HHBASE.          0 2    24000.0
WCF002J-CALCS COMPLETED. RETURN CODE = 2

```

1

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Program PeakFq              U. S. GEOLOGICAL SURVEY              Seq.004.002
Ver. 5.2                    Annual peak flow frequency analysis      Run Date /
Time                          following Bulletin 17-B Guidelines    04/02/2010
11/01/2007
14:27

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Station - 07105800 FOUNTAIN CREEK AT SECURITY, CO

ANNUAL FREQUENCY CURVE PARAMETERS -- LOG-PEARSON TYPE III

	FLOOD BASE		LOGARITHMIC		
	DISCHARGE	EXCEEDANCE PROBABILITY	MEAN	STANDARD DEVIATION	SKEW
SYSTEMATIC RECORD	0.0	1.0000	3.6448	0.3420	-1.184
BULL.17B ESTIMATE	700.0	0.9537	3.6975	0.2912	0.171

ANNUAL FREQUENCY CURVE -- DISCHARGES AT SELECTED EXCEEDANCE PROBABILITIES

ANNUAL LIMITS EXCEEDANCE ESTIMATES PROBABILITY	BULL.17B ESTIMATE	SYSTEMATIC RECORD	'EXPECTED 68-PCT CONFIDENCE PROBABILITY' FOR BULL. 17B		
			ESTIMATE	LOWER	UPPER
0.9950	--	249.7	--	--	--
0.9900	--	372.4	--	--	--

0.9500	1711.0	982.6	1651.0	1585.0	1836.0
0.9000	2138.0	1536.0	2090.0	1999.0	2278.0
0.8000	2821.0	2475.0	2787.0	2661.0	2981.0
0.6667	3677.0	3638.0	3659.0	3492.0	3866.0
0.5000	4889.0	5137.0	4889.0	4658.0	5132.0
0.4292	5513.0	5826.0	5524.0	5253.0	5790.0
0.2000	8707.0	8582.0	8823.0	8242.0	9226.0
0.1000	11900.0	10410.0	12220.0	11170.0	12750.0
0.0400	16750.0	12180.0	17590.0	15520.0	18190.0
0.0200	20980.0	13170.0	22500.0	19270.0	23020.0
0.0100	25780.0	13940.0	28330.0	23480.0	28550.0
0.0050	31200.0	14540.0	35250.0	28180.0	34880.0
0.0020	39460.0	15140.0	46480.0	35280.0	44620.0

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.004.003
 Ver. 5.2 Annual peak flow frequency analysis Run Date /
 Time following Bulletin 17-B Guidelines 04/02/2010
 11/01/2007
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Station - 07105800 FOUNTAIN CREEK AT SECURITY, CO

I N P U T D A T A L I S T I N G

WATER YEAR	DISCHARGE	CODES	WATER YEAR	DISCHARGE	CODES
-1935	30500.0	H	1987	3480.0	
-1965	25000.0	H	1988	3320.0	
1966	-8888.0		1989	2500.0	
1967	1350.0		1990	5790.0	
1968	2520.0		1991	5020.0	
1969	2170.0		1992	3490.0	
1970	625.0		1993	8930.0	
1971	301.0		1994	9370.0	
1972	6520.0		1995	7490.0	
1973	2340.0		1996	4120.0	
1974	2150.0		1997	10600.0	
1975	1900.0		1998	3550.0	
1976	7590.0		1999	17600.0	
1977	5380.0		2000	4320.0	
1978	9000.0		2001	6420.0	
1979	2680.0		2002	6120.0	
1980	9120.0		2003	7100.0	
1981	6640.0		2004	9570.0	
1982	6710.0		2005	13500.0	
1983	3290.0		2006	5690.0	
1984	2590.0		2007	6180.0	
1985	3800.0		2008	10900.0	
1986	3590.0				

Explanation of peak discharge qualification codes

PeakFQ CODE	NWIS CODE	DEFINITION
D	3	Dam failure, non-recurrent flow anomaly
G	8	Discharge greater than stated value
X	3+8	Both of the above
L	4	Discharge less than stated value
K	6 OR C	Known effect of regulation or urbanization
H	7	Historic peak
- Minus-flagged discharge -- Not used in computation		
-8888.0 -- No discharge value given		
- Minus-flagged water year -- Historic peak used in computation		

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.004.004
 Ver. 5.2 Annual peak flow frequency analysis Run Date /
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Station - 07105800 FOUNTAIN CREEK AT SECURITY, CO

EMPIRICAL FREQUENCY CURVES -- WEIBULL PLOTTING POSITIONS

WATER YEAR	RANKED DISCHARGE	SYSTEMATIC RECORD	BULL.17B ESTIMATE
-1935	30500.0	--	0.0133
-1965	25000.0	--	0.0267
1999	17600.0	0.0233	0.0448
2005	13500.0	0.0465	0.0676
2008	10900.0	0.0698	0.0905
1997	10600.0	0.0930	0.1133
2004	9570.0	0.1163	0.1362
1994	9370.0	0.1395	0.1590
1980	9120.0	0.1628	0.1819
1978	9000.0	0.1860	0.2048
1993	8930.0	0.2093	0.2276
1976	7590.0	0.2326	0.2505
1995	7490.0	0.2558	0.2733
2003	7100.0	0.2791	0.2962
1982	6710.0	0.3023	0.3190
1981	6640.0	0.3256	0.3419
1972	6520.0	0.3488	0.3648
2001	6420.0	0.3721	0.3876
2007	6180.0	0.3953	0.4105
2002	6120.0	0.4186	0.4333
1990	5790.0	0.4419	0.4562
2006	5690.0	0.4651	0.4790
1977	5380.0	0.4884	0.5019
1991	5020.0	0.5116	0.5248

2000	4320.0	0.5349	0.5476
1996	4120.0	0.5581	0.5705
1985	3800.0	0.5814	0.5933
1986	3590.0	0.6047	0.6162
1998	3550.0	0.6279	0.6390
1992	3490.0	0.6512	0.6619
1987	3480.0	0.6744	0.6848
1988	3320.0	0.6977	0.7076
1983	3290.0	0.7209	0.7305
1979	2680.0	0.7442	0.7533
1984	2590.0	0.7674	0.7762
1968	2520.0	0.7907	0.7990
1989	2500.0	0.8140	0.8219
1973	2340.0	0.8372	0.8448
1969	2170.0	0.8605	0.8676
1974	2150.0	0.8837	0.8905
1975	1900.0	0.9070	0.9133
1967	1350.0	0.9302	0.9362
1970	625.0	0.9535	0.9590
1971	301.0	0.9767	0.9819
1966	-8888.0	--	--

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.005.001
 Ver. 5.2 Annual peak flow frequency analysis Run Date /
 Time
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Station - 07105530 FOUNTAIN CR BLW JANITELL RD BLW COLO. SPRINGS, C

I N P U T D A T A S U M M A R Y

Number of peaks in record	=	21
Peaks not used in analysis	=	0
Systematic peaks in analysis	=	19
Historic peaks in analysis	=	2
Years of historic record	=	74
Generalized skew	=	0.000
Standard error	=	0.550
Mean Square error	=	0.303
Skew option	=	WEIGHTED
Gage base discharge	=	0.0
User supplied high outlier threshold	=	--
User supplied low outlier criterion	=	--
Plotting position parameter	=	0.00

***** NOTICE -- Preliminary machine computations. *****
 ***** User responsible for assessment and interpretation. *****

WCF134I-NO SYSTEMATIC PEAKS WERE BELOW GAGE BASE.	0.0
WCF195I-NO LOW OUTLIERS WERE DETECTED BELOW CRITERION.	1947.1
WCF165I-HIGH OUTLIERS AND HISTORIC PEAKS ABOVE HHBASE.	0 2 17221.2

**WCF171W-NUMBER HI-OUT/HIST PKS EXCEEDS 10PCT OF SYS PKS. 2 19
 WCF002J-CALCS COMPLETED. RETURN CODE = 2

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.005.002
 Ver. 5.2 Annual peak flow frequency analysis Run Date /
 Time
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Station - 07105530 FOUNTAIN CR BLW JANITELL RD BLW COLO. SPRINGS, C

ANNUAL FREQUENCY CURVE PARAMETERS -- LOG-PEARSON TYPE III

	FLOOD BASE		LOGARITHMIC		
	DISCHARGE	EXCEEDANCE PROBABILITY	MEAN	STANDARD DEVIATION	SKEW
SYSTEMATIC RECORD	0.0	1.0000	3.7627	0.2005	-0.154
BULL.17B ESTIMATE	0.0	1.0000	3.7805	0.2220	0.326

ANNUAL FREQUENCY CURVE -- DISCHARGES AT SELECTED EXCEEDANCE PROBABILITIES

ANNUAL LIMITS EXCEEDANCE ESTIMATES PROBABILITY	BULL.17B ESTIMATE	SYSTEMATIC RECORD	'EXPECTED	68-PCT CONFIDENCE	
			PROBABILITY'	FOR BULL. 17B	LOWER
0.9950	1890.0	1650.0	1647.0	1688.0	2087.0
0.9900	2078.0	1878.0	1860.0	1868.0	2282.0
0.9500	2735.0	2657.0	2586.0	2506.0	2957.0
0.9000	3198.0	3182.0	3083.0	2958.0	3430.0
0.8000	3899.0	3942.0	3823.0	3645.0	4149.0
0.6667	4737.0	4793.0	4696.0	4463.0	5013.0
0.5000	5867.0	5860.0	5867.0	5552.0	6198.0
0.4292	6430.0	6360.0	6453.0	6087.0	6797.0
0.2000	9182.0	8566.0	9402.0	8634.0	9814.0
0.1000	11790.0	10380.0	12380.0	10970.0	12780.0
0.0400	15590.0	12670.0	17130.0	14290.0	17200.0
0.0200	18800.0	14380.0	21580.0	17050.0	21020.0
0.0100	22350.0	16080.0	27060.0	20060.0	25320.0
0.0050	26290.0	17790.0	33870.0	23350.0	30150.0
0.0020	32180.0	20070.0	45670.0	28200.0	37470.0

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.005.003
 Ver. 5.2 Annual peak flow frequency analysis Run Date /
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Station - 07105530 FOUNTAIN CR BLW JANITELL RD BLW COLO. SPRINGS, C

I N P U T D A T A L I S T I N G

WATER YEAR	DISCHARGE	CODES	WATER YEAR	DISCHARGE	CODES
-1935	32750.0	H	1999	13800.0	
-1965	21000.0	H	2000	3630.0	
1990	5480.0		2001	6710.0	
1991	3210.0		2002	5570.0	
1992	2180.0		2003	6320.0	
1993	8140.0		2004	10400.0	
1994	11300.0		2005	8030.0	
1995	6630.0		2006	6640.0	
1996	4190.0		2007	5370.0	
1997	5100.0		2008	5490.0	
1998	3210.0				

Explanation of peak discharge qualification codes

PeakFQ CODE	NWIS CODE	DEFINITION
D	3	Dam failure, non-recurrent flow anomaly
G	8	Discharge greater than stated value
X	3+8	Both of the above
L	4	Discharge less than stated value
K	6 OR C	Known effect of regulation or urbanization
H	7	Historic peak
- Minus-flagged discharge -- Not used in computation		
-8888.0 -- No discharge value given		
- Minus-flagged water year -- Historic peak used in computation		

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.005.004
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Station - 07105530 FOUNTAIN CR BLW JANITELL RD BLW COLO. SPRINGS, C

EMPIRICAL FREQUENCY CURVES -- WEIBULL PLOTTING POSITIONS

WATER YEAR	RANKED DISCHARGE	SYSTEMATIC RECORD	BULL.17B ESTIMATE
---------------	---------------------	----------------------	----------------------

-1935	32750.0	--	0.0133
-1965	21000.0	--	0.0267
1999	13800.0	0.0500	0.0586
1994	11300.0	0.1000	0.1091
2004	10400.0	0.1500	0.1596
1993	8140.0	0.2000	0.2102
2005	8030.0	0.2500	0.2607
2001	6710.0	0.3000	0.3112
2006	6640.0	0.3500	0.3618
1995	6630.0	0.4000	0.4123
2003	6320.0	0.4500	0.4628
2002	5570.0	0.5000	0.5133
2008	5490.0	0.5500	0.5639
1990	5480.0	0.6000	0.6144
2007	5370.0	0.6500	0.6649
1997	5100.0	0.7000	0.7154
1996	4190.0	0.7500	0.7660
2000	3630.0	0.8000	0.8165
1991	3210.0	0.8500	0.8670
1998	3210.0	0.9000	0.9175
1992	2180.0	0.9500	0.9681

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.006.001
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Station - 07105500 FOUNTAIN CREEK AT COLORADO SPRINGS, CO

I N P U T D A T A S U M M A R Y

Number of peaks in record	=	35
Peaks not used in analysis	=	0
Systematic peaks in analysis	=	33
Historic peaks in analysis	=	2
Years of historic record	=	74
Generalized skew	=	0.000
Standard error	=	0.550
Mean Square error	=	0.303
Skew option	=	WEIGHTED
Gage base discharge	=	0.0
User supplied high outlier threshold	=	--
User supplied low outlier criterion	=	--
Plotting position parameter	=	0.00

***** NOTICE -- Preliminary machine computations. *****
 ***** User responsible for assessment and interpretation. *****

WCF134I-NO SYSTEMATIC PEAKS WERE BELOW GAGE BASE.	0.0
WCF195I-NO LOW OUTLIERS WERE DETECTED BELOW CRITERION.	978.7
WCF165I-HIGH OUTLIERS AND HISTORIC PEAKS ABOVE HHBASE.	0 2 12657.5

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.006.002
 Ver. 5.2 Annual peak flow frequency analysis Run Date /
 Time following Bulletin 17-B Guidelines 04/02/2010
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Station - 07105500 FOUNTAIN CREEK AT COLORADO SPRINGS, CO

ANNUAL FREQUENCY CURVE PARAMETERS -- LOG-PEARSON TYPE III

	FLOOD BASE		LOGARITHMIC		
	DISCHARGE	EXCEEDANCE PROBABILITY	MEAN	STANDARD DEVIATION	SKEW
SYSTEMATIC RECORD	0.0	1.0000	3.5465	0.2135	0.073
BULL.17B ESTIMATE	0.0	1.0000	3.5680	0.2482	0.618

ANNUAL FREQUENCY CURVE -- DISCHARGES AT SELECTED EXCEEDANCE PROBABILITIES

ANNUAL LIMITS EXCEEDANCE ESTIMATES PROBABILITY	BULL.17B ESTIMATE	SYSTEMATIC RECORD	'EXPECTED	68-PCT CONFIDENCE		
			PROBABILITY'	FOR BULL. 17B	LOWER	UPPER
			ESTIMATE			
0.9950	1179.0	1026.0	1113.0	1083.0	1275.0	
0.9900	1273.0	1152.0	1211.0	1173.0	1371.0	
0.9500	1613.0	1584.0	1568.0	1504.0	1721.0	
0.9000	1866.0	1882.0	1830.0	1750.0	1979.0	
0.8000	2266.0	2324.0	2241.0	2142.0	2389.0	
0.6667	2769.0	2834.0	2755.0	2633.0	2907.0	
0.5000	3488.0	3499.0	3488.0	3328.0	3654.0	
0.4292	3862.0	3820.0	3871.0	3687.0	4047.0	
0.2000	5834.0	5313.0	5928.0	5538.0	6165.0	
0.1000	7904.0	6632.0	8176.0	7430.0	8452.0	
0.0400	11230.0	8424.0	12000.0	10410.0	12210.0	
0.0200	14310.0	9844.0	15800.0	13110.0	15760.0	
0.0100	17980.0	11340.0	20650.0	16290.0	20050.0	
0.0050	22350.0	12910.0	26880.0	20040.0	25240.0	
0.0020	29440.0	15130.0	38060.0	26030.0	33770.0	

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.006.003
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Station - 07105500 FOUNTAIN CREEK AT COLORADO SPRINGS, CO

I N P U T D A T A L I S T I N G

WATER YEAR	DISCHARGE	CODES	WATER YEAR	DISCHARGE	CODES
-1935	35500.0	H	1992	1940.0	
-1965	13500.0	H	1993	5750.0	
1976	1550.0		1994	10100.0	
1977	2400.0		1995	4560.0	
1978	6000.0		1996	2570.0	
1979	3130.0		1997	4550.0	
1980	3230.0		1998	2750.0	
1981	3650.0		1999	9490.0	
1982	3050.0		2000	1500.0	
1983	2440.0		2001	6040.0	
1984	2560.0		2002	4940.0	
1985	4450.0		2003	3540.0	
1986	1260.0		2004	6150.0	
1987	2770.0		2005	5870.0	
1988	3020.0		2006	3540.0	
1989	2390.0		2007	2450.0	
1990	5300.0		2008	3820.0	
1991	3910.0				

Explanation of peak discharge qualification codes

PeakFQ CODE	NWIS CODE	DEFINITION
D	3	Dam failure, non-recurrent flow anomaly
G	8	Discharge greater than stated value
X	3+8	Both of the above
L	4	Discharge less than stated value
K	6 OR C	Known effect of regulation or urbanization
H	7	Historic peak
- Minus-flagged discharge -- Not used in computation		
-8888.0 -- No discharge value given		
- Minus-flagged water year -- Historic peak used in computation		

1

Program PeakFq	U. S. GEOLOGICAL SURVEY	Seq.006.004
Ver. 5.2	Annual peak flow frequency analysis	Run Date /
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Station - 07105500 FOUNTAIN CREEK AT COLORADO SPRINGS, CO

EMPIRICAL FREQUENCY CURVES -- WEIBULL PLOTTING POSITIONS

WATER YEAR	RANKED DISCHARGE	SYSTEMATIC RECORD	BULL.17B ESTIMATE
-1935	35500.0	--	0.0133
-1965	13500.0	--	0.0267
1994	10100.0	0.0294	0.0479
1999	9490.0	0.0588	0.0770
2004	6150.0	0.0882	0.1061
2001	6040.0	0.1176	0.1352
1978	6000.0	0.1471	0.1642
2005	5870.0	0.1765	0.1933
1993	5750.0	0.2059	0.2224
1990	5300.0	0.2353	0.2515
2002	4940.0	0.2647	0.2806
1995	4560.0	0.2941	0.3097
1997	4550.0	0.3235	0.3388
1985	4450.0	0.3529	0.3679
1991	3910.0	0.3824	0.3970
2008	3820.0	0.4118	0.4261
1981	3650.0	0.4412	0.4552
2003	3540.0	0.4706	0.4842
2006	3540.0	0.5000	0.5133
1980	3230.0	0.5294	0.5424
1979	3130.0	0.5588	0.5715
1982	3050.0	0.5882	0.6006
1988	3020.0	0.6176	0.6297
1987	2770.0	0.6471	0.6588
1998	2750.0	0.6765	0.6879
1996	2570.0	0.7059	0.7170
1984	2560.0	0.7353	0.7461
2007	2450.0	0.7647	0.7752
1983	2440.0	0.7941	0.8042
1977	2400.0	0.8235	0.8333
1989	2390.0	0.8529	0.8624
1992	1940.0	0.8824	0.8915
1976	1550.0	0.9118	0.9206
2000	1500.0	0.9412	0.9497
1986	1260.0	0.9706	0.9788

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.007.001
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Station - 07103700 FOUNTAIN CREEK NEAR COLORADO SPRINGS, CO.

I N P U T D A T A S U M M A R Y

Number of peaks in record = 52
 Peaks not used in analysis = 0
 Systematic peaks in analysis = 51

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Historic peaks in analysis      =      1
Years of historic record      =      74
Generalized skew              =      0.000
    Standard error            =      0.550
    Mean Square error         =      0.303
Skew option                   =      WEIGHTED
Gage base discharge           =      0.0
User supplied high outlier threshold =  --
User supplied low outlier criterion =  --
Plotting position parameter    =      0.00

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***** NOTICE -- Preliminary machine computations. *****
***** User responsible for assessment and interpretation. *****

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WCF134I-NO SYSTEMATIC PEAKS WERE BELOW GAGE BASE.          0.0
WCF195I-NO LOW OUTLIERS WERE DETECTED BELOW CRITERION.    33.2
WCF165I-HIGH OUTLIERS AND HISTORIC PEAKS ABOVE HHBASE.  0  1  4374.8

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1

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Program PeakFq          U. S. GEOLOGICAL SURVEY          Seq.007.002
Ver. 5.2                Annual peak flow frequency analysis  Run Date /
Time                                                            11/01/2007
11/01/2007              following Bulletin 17-B Guidelines  04/02/2010
14:27

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Station - 07103700 FOUNTAIN CREEK NEAR COLORADO SPRINGS, CO.

ANNUAL FREQUENCY CURVE PARAMETERS -- LOG-PEARSON TYPE III

	FLOOD BASE		LOGARITHMIC		
	DISCHARGE	EXCEEDANCE PROBABILITY	MEAN	STANDARD DEVIATION	SKEW
SYSTEMATIC RECORD	0.0	1.0000	2.5812	0.3819	-0.025
BULL.17B ESTIMATE	0.0	1.0000	2.5964	0.3998	0.134

ANNUAL FREQUENCY CURVE -- DISCHARGES AT SELECTED EXCEEDANCE PROBABILITIES

ANNUAL LIMITS EXCEEDANCE ESTIMATES PROBABILITY	BULL.17B ESTIMATE	SYSTEMATIC RECORD	'EXPECTED	68-PCT CONFIDENCE	
			PROBABILITY'	FOR BULL. 17B	LOWER
0.9950	41.4	38.8	37.3	36.5	46.5
0.9900	50.8	48.5	46.8	45.2	56.6
0.9500	90.0	89.2	86.4	81.9	98.4
0.9000	123.0	123.3	119.9	113.1	133.1
0.8000	180.9	182.1	178.5	168.3	193.8
0.6667	261.2	261.9	259.7	244.9	278.0

0.5000	386.7	382.7	386.7	364.1	410.8
0.4292	456.0	447.7	457.0	429.3	484.7
0.2000	851.1	800.1	863.7	794.7	914.5
0.1000	1301.0	1174.0	1339.0	1201.0	1416.0
0.0400	2063.0	1764.0	2177.0	1877.0	2284.0
0.0200	2792.0	2293.0	3015.0	2513.0	3129.0
0.0100	3679.0	2901.0	4077.0	3277.0	4171.0
0.0050	4748.0	3597.0	5421.0	4187.0	5443.0
0.0020	6492.0	4664.0	7749.0	5654.0	7546.0

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.007.003
 Ver. 5.2 Annual peak flow frequency analysis Run Date /
 Time
 11/01/2007 following Bulletin 17-B Guidelines 04/02/2010
 14:27

Station - 07103700 FOUNTAIN CREEK NEAR COLORADO SPRINGS, CO.

I N P U T D A T A L I S T I N G

WATER YEAR	DISCHARGE	CODES	WATER YEAR	DISCHARGE	CODES
-1935	5000.0	H	1983	286.0	
1958	752.0		1984	305.0	
1959	584.0		1985	229.0	
1960	89.0		1986	72.0	
1961	955.0		1987	202.0	
1962	366.0		1988	163.0	
1963	428.0		1989	170.0	
1964	2630.0		1990	318.0	
1965	359.0		1991	2340.0	
1966	317.0		1992	299.0	
1967	544.0		1993	78.0	
1968	301.0		1994	736.0	
1969	295.0		1995	1760.0	
1970	616.0		1996	657.0	
1971	96.0		1997	1610.0	
1972	223.0		1998	1290.0	
1973	283.0		1999	1750.0	
1974	500.0		2000	117.0	
1975	492.0		2001	204.0	
1976	408.0		2002	43.0	
1977	560.0		2003	211.0	
1978	342.0		2004	680.0	
1979	416.0		2005	295.0	
1980	338.0		2006	853.0	
1981	650.0		2007	505.0	
1982	305.0		2008	322.0	

Explanation of peak discharge qualification codes

PeakFQ NWIS

CODE	CODE	DEFINITION
D	3	Dam failure, non-recurrent flow anomaly
G	8	Discharge greater than stated value
X	3+8	Both of the above
L	4	Discharge less than stated value
K	6 OR C	Known effect of regulation or urbanization
H	7	Historic peak

- Minus-flagged discharge -- Not used in computation
-8888.0 -- No discharge value given

- Minus-flagged water year -- Historic peak used in computation

1

Program PeakFq	U. S. GEOLOGICAL SURVEY	Seq.007.004
Ver. 5.2	Annual peak flow frequency analysis	Run Date /
Time		
11/01/2007	following Bulletin 17-B Guidelines	04/02/2010
14:27		

Station - 07103700 FOUNTAIN CREEK NEAR COLORADO SPRINGS, CO.

EMPIRICAL FREQUENCY CURVES -- WEIBULL PLOTTING POSITIONS

WATER YEAR	RANKED DISCHARGE	SYSTEMATIC RECORD	BULL.17B ESTIMATE
-1935	5000.0	--	0.0133
1964	2630.0	0.0192	0.0295
1991	2340.0	0.0385	0.0486
1995	1760.0	0.0577	0.0677
1999	1750.0	0.0769	0.0868
1997	1610.0	0.0962	0.1059
1998	1290.0	0.1154	0.1250
1961	955.0	0.1346	0.1441
2006	853.0	0.1538	0.1631
1958	752.0	0.1731	0.1822
1994	736.0	0.1923	0.2013
2004	680.0	0.2115	0.2204
1996	657.0	0.2308	0.2395
1981	650.0	0.2500	0.2586
1970	616.0	0.2692	0.2776
1959	584.0	0.2885	0.2967
1977	560.0	0.3077	0.3158
1967	544.0	0.3269	0.3349
2007	505.0	0.3462	0.3540
1974	500.0	0.3654	0.3731
1975	492.0	0.3846	0.3922
1963	428.0	0.4038	0.4112
1979	416.0	0.4231	0.4303
1976	408.0	0.4423	0.4494
1962	366.0	0.4615	0.4685

1965	359.0	0.4808	0.4876
1978	342.0	0.5000	0.5067
1980	338.0	0.5192	0.5258
2008	322.0	0.5385	0.5448
1990	318.0	0.5577	0.5639
1966	317.0	0.5769	0.5830
1982	305.0	0.5962	0.6021
1984	305.0	0.6154	0.6212
1968	301.0	0.6346	0.6403
1992	299.0	0.6538	0.6593
1969	295.0	0.6731	0.6784
2005	295.0	0.6923	0.6975
1983	286.0	0.7115	0.7166
1973	283.0	0.7308	0.7357
1985	229.0	0.7500	0.7548
1972	223.0	0.7692	0.7739
2003	211.0	0.7885	0.7929
2001	204.0	0.8077	0.8120
1987	202.0	0.8269	0.8311
1989	170.0	0.8462	0.8502
1988	163.0	0.8654	0.8693
2000	117.0	0.8846	0.8884
1971	96.0	0.9038	0.9075
1960	89.0	0.9231	0.9265
1993	78.0	0.9423	0.9456
1986	72.0	0.9615	0.9647
2002	43.0	0.9808	0.9838

1

End PeakFQ analysis.

Stations processed	:	7
Number of errors	:	0
Stations skipped	:	0
Station years	:	302

Data records may have been ignored for the stations listed below.
 (Card type must be Y, Z, N, H, I, 2, 3, 4, or *.)
 (2, 4, and * records are ignored.)

Precipitation Frequency Data Output

NOAA Atlas 2
Colorado 38.85471°N 104.878°W
Site-specific Estimates

Map	Precipitation (inches)	Precipitation Intensity (in/hr)
2-year 6-hour	1.70	0.28
2-year 24-hour	2.15	0.09
100- year 6- hour	3.51	0.59
100- year 24-hour	4.55	0.19

FOUNTAIN CREEK NEAR
COLORADO SPRINGS, CO
07163700

Hydrometeorological Design Studies Center - NOAA/National Weather Service
1325 East-West Highway - Silver Spring, MD 20910 - (301) 713-1669
Wed Mar 31 13:33:06 2010

Precipitation Frequency Data Output

NOAA Atlas 2
Colorado 38.81638°N 104.8228°W
Site-specific Estimates

Map	Precipitation (inches)	Precipitation Intensity (in/hr)
2-year 6-hour	1.73	0.29
2-year 24-hour	2.18	0.09
100-year 6-hour	3.59	0.60
100-year 24-hour	4.56	0.19

FOUNTAIN CREEK AT COLORADO
SPRINGS, CO

07105500

Hydrometeorological Design Studies Center - NOAA/National Weather Service
1325 East-West Highway - Silver Spring, MD 20910 - (301) 713-1669
Wed Mar 31 13:31:12 2010

Precipitation Frequency Data Output

NOAA Atlas 2
Colorado 38.80305°N 104.7958°W
Site-specific Estimates

Map	Precipitation (inches)	Precipitation Intensity (in/hr)
2-year 6-hour	1.75	0.29
2-year 24-hour	2.18	0.09
100- year 6- hour	3.59	0.60
100- year 24-hour	4.55	0.19

FOUNTAIN CREEK BELOW JANITELL RD.
BELOW COLORADO SPRINGS, CO

07105530

Hydrometeorological Design Studies Center - NOAA/National Weather Service
1325 East-West Highway - Silver Spring, MD 20910 - (301) 713-1669
Wed Mar 31 13:29:13 2010

Precipitation Frequency Data Output

NOAA Atlas 2
Colorado 38.72944°N 104.7339°W
Site-specific Estimates

Map	Precipitation (inches)	Precipitation Intensity (in/hr)
2-year 6-hour	1.76	0.29
2-year 24-hour	2.18	0.09
100- year 6- hour	3.58	0.60
100- year 24-hour	4.54	0.19

FOUNTAIN CREEK AT SECURITY, CO
07105800

Hydrometeorological Design Studies Center - NOAA/National Weather Service
1325 East-West Highway - Silver Spring, MD 20910 - (301) 713-1669
Wed Mar 31 13:26:32 2010

Precipitation Frequency Data Output

NOAA Atlas 2
Colorado 38.60167°N 104.6702°W
Site-specific Estimates

Map	Precipitation (inches)	Precipitation Intensity (in/hr)
2-year 6-hour	1.72	0.29
2-year 24-hour	2.13	0.09
100- year 6- hour	3.55	0.59
100- year 24-hour	4.52	0.19

FOUNTAIN CREEK NEAR FOUNTAIN, CO
07106000

Hydrometeorological Design Studies Center - NOAA/National Weather Service
1325 East-West Highway - Silver Spring, MD 20910 - (301) 713-1669
Wed Mar 31 13:24:45 2010

Precipitation Frequency Data Output

NOAA Atlas 2
 Colorado 38.43972°N 104.5936°W
Site-specific Estimates

Map	Precipitation (inches)	Precipitation Intensity (in/hr)
2-year 6-hour	1.64	0.27
2-year 24-hour	2.05	0.09
100- year 6- hour	3.47	0.58
100- year 24-hour	4.43	0.18

FOUNTAIN CREEK NEAR PINON, CO
 07106300

Hydrometeorological Design Studies Center - NOAA/National Weather Service
 1325 East-West Highway - Silver Spring, MD 20910 - (301) 713-1669
 Wed Mar 31 13:22:57 2010

Precipitation Frequency Data Output

NOAA Atlas 2
Colorado 38.28778°N 104.6011°W
Site-specific Estimates

Map	Precipitation (inches)	Precipitation Intensity (in/hr)
2-year 6-hour	1.62	0.27
2-year 24-hour	2.03	0.08
100- year 6- hour	3.45	0.58
100- year 24-hour	4.39	0.18

FOUNTAIN CREEK AT PUEBLO, CO
07106500

Hydrometeorological Design Studies Center - NOAA/National Weather Service
1325 East-West Highway - Silver Spring, MD 20910 - (301) 713-1669
Wed Mar 31 13:20:30 2010

Prepared in cooperation with the Colorado Water Conservation Board
and the Colorado Department of Transportation

Regional Regression Equations for Estimation of Natural Streamflow Statistics in Colorado

Scientific Investigations Report 2009–5136

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

U.S. Department of the Interior
KEN SALAZAR, Secretary

U.S. Geological Survey
Suzette M. Kimball, Acting Director

U.S. Geological Survey, Reston, Virginia: 2009

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Suggested citation:

Capesius, J.P., and Stephens, V.C., 2009, Regional regression equations for estimation of natural streamflow statistics in Colorado: U.S. Geological Survey Scientific Investigations Report 2009–5136, 46 p.

Library of Congress Cataloging-in-Publication Data

Capesius, Joseph P.

Regional regression equations for estimation of natural streamflow statistics in Colorado / by Joseph P. Capesius and Verlin C. Stephens
p. cm. -- (Scientific investigations report ; 2009-5136)

"Prepared in cooperation with the Colorado Water Conservation Board and the Colorado Department of Transportation."

Includes bibliographic references.

ISBN 978-1-4113-2562-3

1. Stream measurements--Colorado. 2. Streamflow--Colorado. 3. Regression analysis. I. Stephens, Verlin C. II. Geological Survey (U.S.) III. Colorado Water Conservation Board. IV. Colorado Dept. of Transportation. V. Title. VI. Series: Scientific investigations report ; 2009-5136.

GB1225.C6C36 2009

551.48'309788021--dc22

2009039729

2 Regional Regression Equations for Estimation of Natural Streamflow Statistics in Colorado

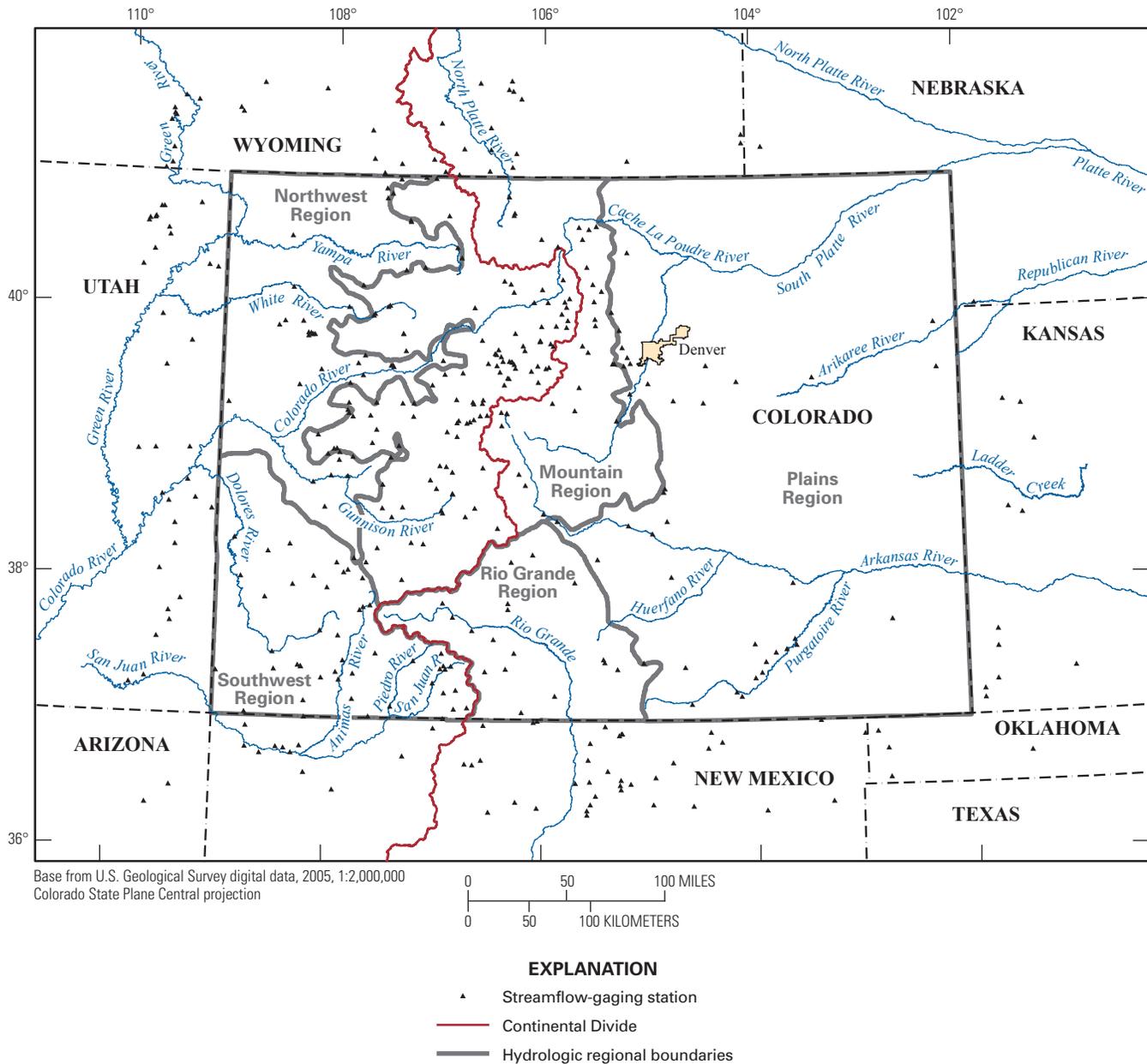


Figure 1. Boundaries of hydrologic regions and locations of streamflow gaging stations in Colorado and adjacent States.

Q_{10th} , Q_{25th} , Q_{50th} , Q_{75th} , and Q_{90th} , indicate the percentage of days that a given daily-mean streamflow is exceeded. For example, a 10-percent flow-duration value (Q_{10th}) is calculated as the daily-mean streamflow at a given station that is exceeded 10 percent of the time or 10 percent of the days. Finally, this report also describes some limitations associated with the equations, which includes an assessment of prediction errors and assessment of equation applicability for ungaged sites.

The study area of equation applicability is limited to Colorado, even though the study area was extended to include stations within a 50-mile boundary or buffer surrounding Colorado. The study area was extended 50 miles beyond the Colorado for the sole purpose of equation development.

The regional equations for peak-streamflow estimation were developed using annual peak-streamflow data collected through water year 2006 (October 1, 2005, through September 30, 2006). The remaining equations, with the exception of the 7-day, T -year minimum streamflow equations, were developed with data through water year 2007. The 7-day, T -year minimum streamflow equations were developed with data collected through climate year 2007 (April 1, 2006, through March 31, 2007). The choice of climate year in lieu of water year explicitly was made because the climate year designation splits the daily-mean streamflow record at a time (spring) in which streamflows for a given station generally are larger than at the water year (autumn) or even calendar year transition.

Regression Equation Response Variables	
Variable	Variable definition
Q_T	T -year peak streamflow, in cubic feet per second
${}_7Q_T^{\min}$	7-day, T -year minimum streamflow, in cubic feet per second
${}_7Q_T^{\max}$	7-day, T -year maximum streamflow, in cubic feet per second
Q_{ann}	Annual-mean streamflow, in cubic feet per second
Q_{month}	Monthly-mean streamflow by abbreviation, in cubic feet per second
$Q_{\#th}$	Daily-mean streamflow as exceedance probability as percent, in cubic feet per second
Regression Equation Predictor Variables	
Variable	Variable definition
A	Drainage area, in square miles
A_{7500}	Percentage of A above 7,500 feet of elevation plus 1
E	Mean elevation of watershed, in feet
P	Mean annual precipitation, in inches
${}_6P_{100}$	6-hour, 100-year precipitation, in inches
S	Mean watershed slope, in percent
Regression Equation Diagnostics for GLS and WLS Regression Equations	
Diagnostic	Diagnostic Definition
SEP	Standard error of prediction (WLS and GLS), in percent
$\text{adj}R^2$	$100 \times$ adjusted R-squared (WLS only), dimensionless
$\text{pseudo}R^2$	$100 \times$ pseudo R-squared (GLS only), dimensionless
SME	Standard model error (GLS only), in percent
$\sqrt{\quad}$	Mark that qualifies (see text) the reliability of regression residuals

Figure 2. Summary of variables and regression diagnostics for regional equations. GLS, Generalized Least Squares; WLS, Weighted Least Squares.

Weighted Least-Squares Regression

The regionalized regression equations for computing the annual-and monthly-mean streamflow equations and the equations for the flow-duration curve were developed using WLS regression. For the regional regression analysis reported here, WLS regression was preferred over GLS regression because GLS regression was specifically developed for use with T -year type streamflow statistics and is difficult to extend to other streamflow statistics. The weights used for the WLS regression for the annual-mean and monthly-mean equations are based on the variance of the logarithms of the observed values. Specifically, stations with lesser variance received greater weighting. The weights for flow-duration equations are based on length of available record in years. The equations for estimating monthly- and annual-mean streamflows and flow-duration curves for four of the five hydrologic regions are listed in figures 3–7. Equations

were not developed for the Plains hydrologic region for reasons outlined in section “Selection of Stations for Other Streamflow Statistics.”

The figures also provide appropriate WLS-regression diagnostics for each equation. These include the standard error of prediction and the adjusted R-squared statistic. Each equation is statistically significant with a p-value less than 0.01. Readers are directed to standard texts on regression such as Helsel and Hirsch (2002) or Montgomery and others (2001) for details. Similar to the GLS-regression equations, the ranges of the predictor variables also are listed in the figures.

Discussion of Selection of Variables

The six selected basin and climatic characteristics were examined as predictor variables for the regression equations reported in figures 3–7. Regression-equation development is an inherently iterative process, and the modeler must

Peak Streamflow Equations for Plains Hydrologic Region

Generalized least-squares (GLS) regression, 69 stations

Approximate range of predictor variables

A : 0.5–2,930 square miles and ${}_6P_{100}$: 2.4–5.1 inches

$Q_2 = 10^{1.26} A^{0.52} {}_6P_{100}^{0.35}$	√	$SEP = 183,$	$pseudoR^2 = 40,$	$SME = 174,$
$Q_5 = 10^{0.94} A^{0.57} {}_6P_{100}^{1.64}$	√	$SEP = 142,$	$pseudoR^2 = 54,$	$SME = 134,$
$Q_{10} = 10^{0.85} A^{0.59} {}_6P_{100}^{2.15}$	√	$SEP = 136,$	$pseudoR^2 = 58,$	$SME = 128,$
$Q_{25} = 10^{0.84} A^{0.61} {}_6P_{100}^{2.57}$	√	$SEP = 137,$	$pseudoR^2 = 62,$	$SME = 128,$
$Q_{50} = 10^{0.85} A^{0.62} {}_6P_{100}^{2.79}$	√	$SEP = 139,$	$pseudoR^2 = 64,$	$SME = 129,$
$Q_{100} = 10^{0.88} A^{0.63} {}_6P_{100}^{2.98}$	√	$SEP = 141,$	$pseudoR^2 = 65,$	$SME = 131,$
$Q_{200} = 10^{0.95} A^{0.63} {}_6P_{100}^{3.37}$	√	$SEP = 160,$	$pseudoR^2 = 65,$	$SME = 147,$ and
$Q_{500} = 10^{0.81} A^{0.64} {}_6P_{100}^{3.59}$	√	$SEP = 141,$	$pseudoR^2 = 70,$	$SME = 128.$

Summary of Variables, Units, and Regression Diagnostics is shown in figure 2.

Figure 7. Regional regression equations for the Plains hydrologic region.

Summary

The U.S. Geological Survey (USGS), in cooperation with the Colorado Water Conservation Board and the Colorado Department of Transportation, developed regional regression equations for estimation of various streamflow statistics that are representative of natural streamflow conditions in Colorado. Accurate estimates of various streamflow statistics are important for water-resource management, stream-related structural design, stream-hazard identification, and water-quality management. Streamflow statistics routinely are needed for sites in ungaged watersheds (ungaged sites) that lack nearby streamflow-gaging stations (stations) from which streamflow statistics could be directly computed. Regional regression equations are a common tool used to estimate streamflow statistics at ungaged sites across the Nation and Colorado.

Regional regression equations are based on statistical relations between (1) streamflow statistics of interest computed from applicable records of the stations and (2) basin and climatic characteristics, for which data are typically readily available. The use of regional equations generally represents a reliable and cost-effective means for estimating streamflow statistics at ungaged sites, along with expressions of predictive uncertainty.

The purpose of this report is to present regional regression equations by hydrologic region for estimation of streamflow statistics for naturally flowing streams in Colorado. The equations were developed using the statistical relations between streamflow statistics (response variables) and basin and climatic characteristics (predictor variables).

For each of five hydrologic regions in Colorado, peak-streamflow equations that are based on peak-streamflow data from selected stations are presented for the 2-, 5-, 10-, 25-, 50-,

100-, 200- and 500-year instantaneous-peak streamflows (peak streamflow). For four of the five hydrologic regions, minimum and maximum 7-day streamflow (7-day, T -year) equations based on daily-mean streamflow data from selected stations are presented for 7-day minimum 2-, 10-, and 50-year streamflows, as well as for 7-day maximum 2-, 10-, and 50-year streamflows. Other equations presented for the same four hydrologic regions include those for estimation of annual- and monthly-mean streamflow and streamflow-duration statistics for exceedances of 10, 25, 50, 75, and 90 percent. The streamflow-duration statistics collectively are referred to as the “flow-duration curve.” The flow-duration values, presented in this report as Q_{10th} , Q_{25th} , Q_{50th} , Q_{75th} , and Q_{90th} , indicate the percentage of days that a given daily-mean streamflow is exceeded. For example, a 10-percent flow-duration value (Q_{10th}) is calculated as the daily-mean streamflow at a given station that is exceeded 10 percent of the time or 10 percent of the days. Finally, this report also describes some limitations associated with the equations, including an assessment of prediction errors and assessment of equation applicability for ungaged sites.

The regional equations for peak-streamflow estimation were developed using annual peak-streamflow data collected through water year 2006 (October 1, 2005, through September 30, 2006). The remaining equations, with the exception of the 7-day, T -year minimum streamflow equations, were developed using data through water year 2007. The 7-day, T -year minimum streamflow equations were developed using data collected through climate year 2007 (April 1, 2006, through March 31, 2007).

The study was limited to the use of several selected basin and climatic characteristics including drainage area; mean watershed elevation; mean watershed slope; percentage of drainage area above 7,500 feet of elevation; mean annual precipitation; and 6-hour, 100-year precipitation.

**Prepared in cooperation with the
Colorado Department of Transportation
and the Bureau of Land Management**

Analysis of the Magnitude and Frequency of Floods in Colorado

Water-Resources Investigations Report 99–4190

Analysis of the Magnitude and Frequency of Floods in Colorado

By J.E. Vaill

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 99-4190

Prepared in cooperation with the
COLORADO DEPARTMENT OF TRANSPORTATION
and the BUREAU OF LAND MANAGEMENT

Denver, Colorado
2000

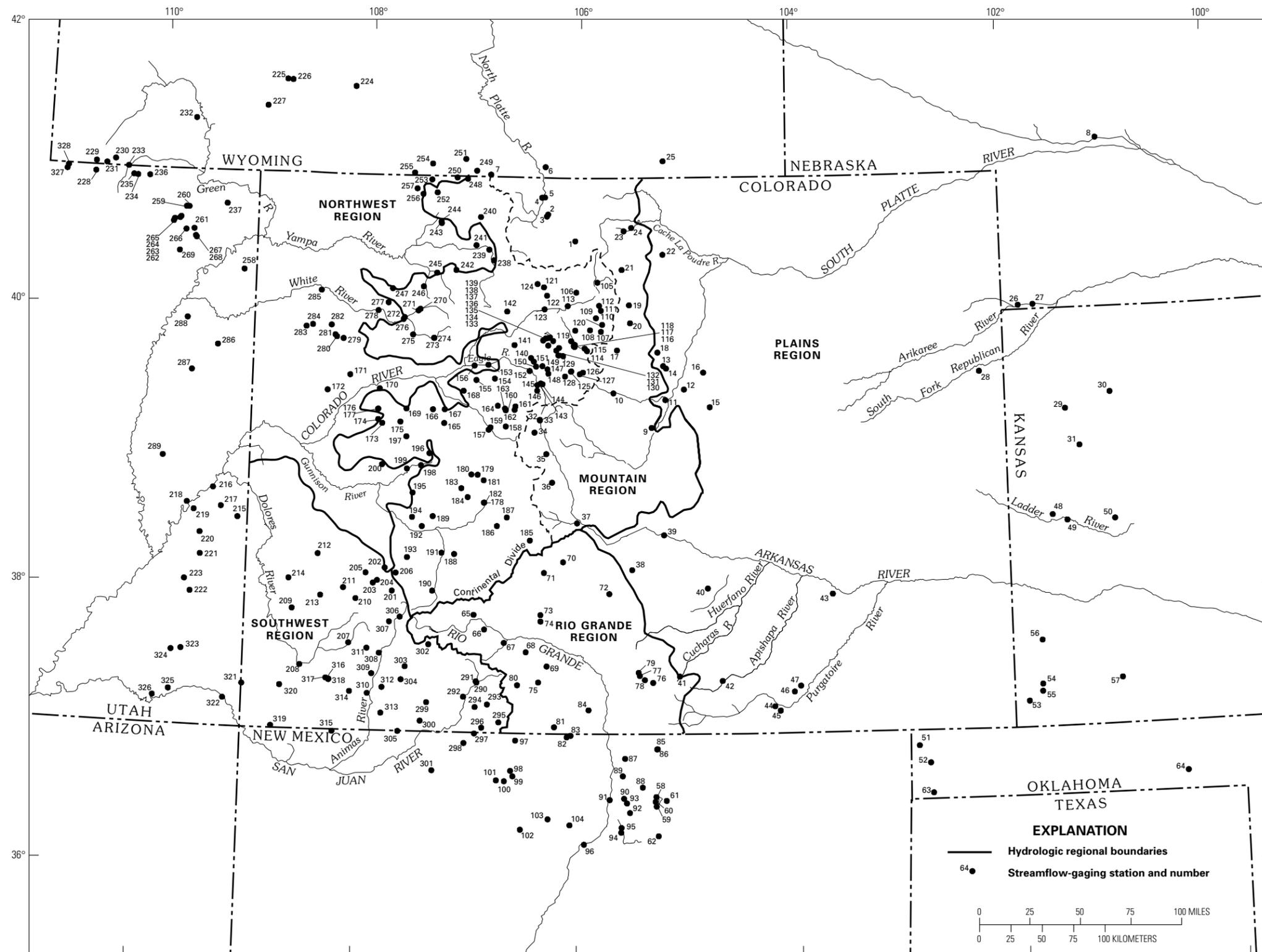


Figure 1. Boundaries of hydrologic regions and location of streamflow-gaging stations in Colorado and adjacent States.

interval of interest is selected, a weighted estimate of the peak discharge can be computed for a site using the regression equation for the appropriate region and the peak-discharge value from the flood-frequency curve.

Weighted estimates are used for unregulated streams to reduce the time-sampling error that may occur in a station flood-frequency estimate. This time-sampling error is associated with the length of record for a gaging station. A station with a short period of record may have a large time-sampling error because its record may not be representative of the actual flood history of the site based on a large number of years. The observed period of record has the possibility of falling within a wet or dry climatic cycle. The weighted estimate of flood frequency should be a better indicator of the true value because the regression estimate is an average of the flood histories of many gaging stations over a long period of time (Thomas and Lindskov, 1983).

Table 2. Basin characteristics and the range of values used in the analysis

Basin characteristics	Range of values
Drainage-basin area, in square miles	5.5 to 988.0
Mean annual precipitation, in inches	7.0 to 49.0
Mean drainage-basin elevation, in feet	2,805 to 12,200
Mean drainage-basin slope, in foot per foot	0.081 to 0.562

Sites near Gaging Stations on the Same Stream

Peak discharges for sites near gaging stations on the same stream can be estimated by using a ratio of drainage area for the sites near the ungaged sites and the gaged sites. This method is considered to be reliable when the drainage-area ratio is between about 0.5 and 1.5 and when the two sites have similar drainage-basin and climatic characteristics. If the sites of interest have similar basin and climatic characteristics and meet the drainage-area-ratio requirement, peak discharges can be computed by the following equation:

$$Q_{T(u)} = Q_{T(g)}(A_u/A_g)^x, \quad (3)$$

where

- $Q_{T(u)}$ is the peak discharge, in cubic feet per second, at the ungaged site for T-year recurrence interval;
- $Q_{T(g)}$ is the weighted peak discharge, in cubic feet per second, at the gaged site for T-year recurrence interval;
- A_u is the drainage area, in square miles, at the ungaged site;
- A_g is the drainage area, in square miles, at the gaged site; and
- x is the average exponent for drainage area for each flood region as follows:

Flood region	Exponent
Mountains	0.69
Rio Grande	0.88
Southwest	0.71
Northwest	0.64
Plains	0.40

The following is an example calculation to determine the 100-year peak discharge for an ungaged site near a gaged site on the same stream in the mountain region. The drainage area at the ungaged site is given as 350 mi² and at the gaged site is 450 mi². The weighted discharge for the 100-year peak at the gaged site is given as 11,500 ft³/s.

1. Check that the drainage area ratio A_u/A_g is between 0.5 and 1.5. That ratio is as follows:

$$A_u/A_g = 350/450 = 0.78$$

which meets the ratio requirement.

2. Compute the discharge at the ungaged site using the specified values in equation 3:

$$Q_{100(u)} = 11,500(350/450)^{0.69} = 9,670 \text{ ft}^3/\text{s}.$$

Ungaged Sites

Peak discharges at ungaged sites can be computed using the appropriate regional equation shown in table 1. For sites on streams that cross regional boundaries, results from more than one of the regional equations need to be weighted as described below.