Streamflow Characteristics for Selected Stations In and Near the Grand Mesa, Uncompahgre, and Gunnison National Forests, Southwestern Colorado

By Gerhard Kuhn

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CONVERSION FACTORS

Multiply	By	To obtain
acre	0.4047	square hectometer
acre-foot (acre-ft)	1,233	cubic meter
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
foot (ft)	0.3048	meter
inch	25.4	millimeter
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer

Degree Celsius (°C) may be converted to degree Fahrenheit (°F) by using the following equation:

°F = 9/5 (°C) + 32

Streamflow Characteristics for Selected Stations In and Near the Grand Mesa, Uncompahgre, and Gunnison National Forests, Southwestern Colorado

By Gerhard Kuhn

Abstract

The U.S Geological Survey, in cooperation with the Grand Mesa, Uncompahgre, and Gunnison National Forests, began a study in 2000 to develop selected streamflow characteristics for 60 streamflow-gaging stations in and near the Grand Mesa, Uncompahgre, and Gunnison National Forests. The study area is located in southwestern Colorado within the Gunnison River, Dolores River, and Plateau Creek Basins, which are tributaries of the Colorado River.

In addition to presenting the compiled daily, monthly, and annual discharge data for the 60 stations, the report presents tabular and graphical results for the following computed streamflow characteristics: (1) Instantaneous peak-flow frequency; (2) flow duration for daily mean discharges on an annual (water year) basis and on a monthly basis, and flow duration for the annual and monthly mean discharges; (3) low-flow and high-flow frequency of daily mean discharges for periods of 1, 3, 7, 15, 30, 60, 120, and 183 consecutive days; and (4) annual and monthly mean and median discharges for each year and month of record, and frequency of the annual and monthly mean and median discharges. All discharge data and results from the streamflow-characteristics analyses are presented in Microsoft Excel workbooks on the enclosed CD–ROM.

INTRODUCTION

The U.S. Department of Agriculture, Forest Service, manages more than 191 million acres of Federal land in 44 States, Puerto Rico, and the Virgin Islands; these lands possess resources and values of major economic, social, and environmental importance to the Nation. National Forests and Grasslands each have a Land and Resources Management Plan (LRMP) that is prepared in compliance with the National Forest Management Act of 1976 (U.S. Department of Agriculture, 2002c) and the National Environmental Policy Act of 1969 (U.S. Environmental Protection Agency, 2002). LRMPs typically need to be revised every 15 years (U.S. Department of Agriculture, 2002a, 2002b).

The LRMP for the Grand Mesa, Uncompahgre, and Gunnison National Forests in southwestern Colorado (fig. 1) was completed in 1983 and was revised substantially in 1991. Since completion of the 1983 LRMP, the areas in and adjacent to the Grand Mesa, Uncompahgre, and Gunnison National Forests (hereinafter, study area) have experienced increases in population and development of private land, increases in recreational use, and changes in the demand and use of natural resources. Additionally, there have been advances in scientific understanding of forest ecosystems (Robert L. Storch, U.S. Department of Agriculture, written commun., 2001). Because the LRMP has not been revised for a number of years and because of the changes in resource knowledge and use, the Grand Mesa, Uncompahgre, and Gunnison National Forests are in the process of revising their LRMP (Federal Register, 1999).

A number of water-resources issues have been identified in revising the LRMP for the study area. These issues include the following: (1) How do various activities in the forests affect water quality and quantity, soil resources, and riparian areas? (2) How can a revised management plan further the implementation of the National Clean Water Action Plan and

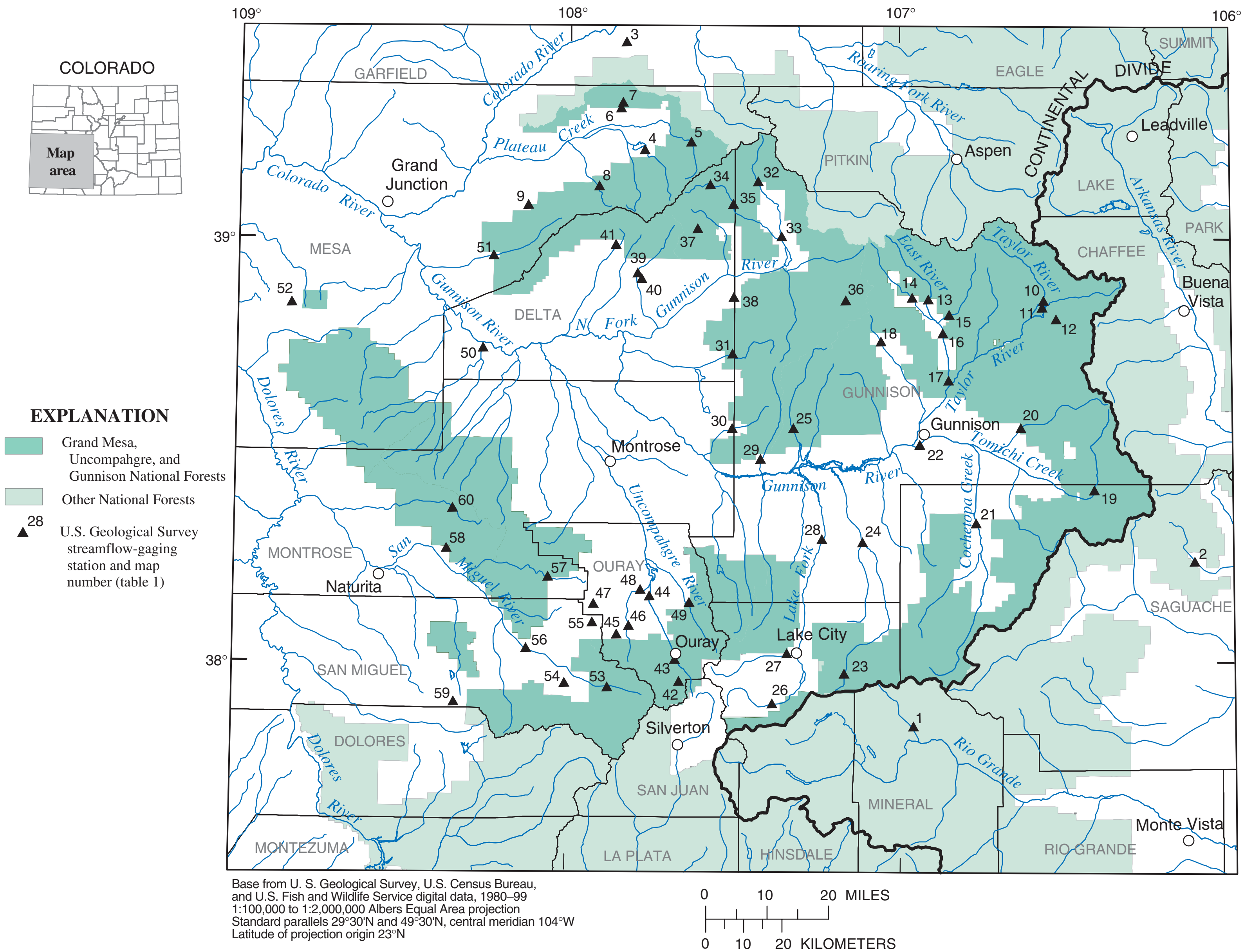

Figure 1. Selected streamflow-gaging stations in the Grand Mesa, Uncompahgre, and Gunnison National Forests study area.

Policy and the framework for developing and implementing Total Maximum Daily Loads (TMDLs) in forest and rangeland environments? (3) In which stream or lake systems is improved programmatic direction needed to ensure the viability of aquatic species or to restore dwindling populations? (4) How should surface-water uses, including types and levels of use on lakes and streams, be regulated to maintain quality of the recreation experiences and protect natural resources? (Federal Register, 1999).

To evaluate these and other water-related issues and to formulate management actions that result in the best management of water and water-related resources, managers for the Grand Mesa, Uncompahgre, and Gunnison National Forests have identified a need for (1) scientifically based streamflow data to support instream flow analysis that is acceptable to all interested parties and (2) an analysis of streamflow data in order to describe and understand the seasonal and annual variability. To provide the needed streamflow data and analysis, the U.S Geological Survey (USGS), in cooperation with the Grand Mesa, Uncompahgre, and Gunnison National Forests, began a study in 2000 to develop selected streamflow characteristics using historical discharge data for 60 streamflow-gaging stations (hereinafter, stations) in and near the study area. The study would result in an update for some streamflow characteristics previously compiled for some of the stations (Richter and others, 1984).

Purpose and Scope

The purpose of this report is to present streamflow characteristics for 60 stations (fig. 1, table 1) in tabular and graphical form. Specifically, this report presents the compiled daily, monthly, and annual mean discharge data for the 60 stations from the beginning of available daily discharge data through water year 2000 (table 2) and results for the following computed streamflow characteristics:

1. Instantaneous peak-flow frequency computed for 43 stations that had 10 or more complete years of record (table 2) using the log-Pearson type III (LP3) distribution. The results include the annual instantaneous peak discharges that have a 1.5- and 2.33-year recurrence interval along with the corresponding stages (gage heights) taken from the most recent or last rating curve in use. Stations 09145000 and 09174500 have less than 10 complete years of record (table 2) but were included in this analysis because, for station 09145000, peak discharge data were available for a few additional years other than the period of daily discharge record and, for station 09174500, the peak discharge for water year 1942 (partial record) was available, providing 10 instantaneous peaks; therefore, peak-flow frequency was computed for a total of 45 stations.
2. Flow duration computed for daily mean discharges on (a) an annual (water year) basis and (b) a monthly basis; these analyses were made for all 60 stations. Additional results include flow duration computed for annual and monthly mean discharges; these analyses were made for 28 stations with 18 or more years of record (table 2).
3. N-day low-flow and high-flow frequency computed for daily mean discharges using the LP3 distribution; these analyses were made for 1, 3, 7, 15, 30, 60, 120, and 183 consecutive days and for 43 stations that had 10 or more complete years of record (table 2).
4. Annual and monthly mean and median discharges for each year and month of record computed from the daily mean discharge data; these analyses were performed for all 60 stations (table 1). Additional analysis included frequency of the annual and monthly mean and median annual discharges computed for 43 stations that had 10 or more complete years of record (table 2) using the LP3 distribution. Because station 09174500 has 10 years of record for some months (table 2), frequency of the monthly mean and median discharges also were computed for those months.

The cooperative study with the Grand Mesa, Uncompahgre, and Gunnison National Forests required that results of the streamflow characteristics analyses be provided in digital (computerized) format; hence, all discharge data and results from the four study objectives are presented in Microsoft Excel workbooks (hereinafter, Excel files) on the enclosed CD–ROM. A brief description of the organization and content of the digital data are described in the subsequent sections of this report.

Table 1. Selected streamflow-gaging stations in and adjacent to the Grand Mesa, Uncompahgre, and Gunnison National Forests

[--, no data]

Map number (figure 1)	Station number	Station name[1]	Latitude (degrees, minutes, seconds)	Longitude (degrees, minutes, seconds)	Drainage area (square miles)	Station elevation (feet)	Annual mean discharge[2] (cubic feet per second)
1	08216500	Willow Creek at Creede	37 51 22	106 55 37	35.3	8,880	21.8
2	08224500	Kerber Creek at Ashley Ranch near Villa Grove	38 14 28	106 06 57	38.0	8,830	12.4
3	09092500	Beaver Creek near Rifle	39 28 19	107 49 55	7.90	6,685	4.65
4	09095800	Plateau Creek near Heiberger	39 13 03	107 46 26	18.6	8,016	9.12
5	09096800	Buzzard Creek below Owens Creek near Heiberger	39 14 10	107 38 00	49.7	8,206	25.2
6	09097500	Buzzard Creek near Collbran	39 19 30	107 50 29	143	6,955	46.6
7	09097600	Brush Creek near Collbran	39 19 30	107 50 30	9.57	8,183	6.78
8	09099500	Big Creek at upper station near Collbran	39 07 55	107 55 05	20.2	8,590	27.0
9	09104500	Mesa Creek near Mesa	39 05 11	108 07 34	6.79	7,400	11.8
10	09107000	Taylor River at Taylor Park	38 51 37	106 33 58	128	9,340	109
11	09107500	Texas Creek at Taylor Park	38 50 41	106 34 12	40.4	9,300	35.5
12	09108000	Willow Creek at Taylor Park	38 48 58	106 31 44	47.0	9,490	24.9
13	09110500	East River near Crested Butte	38 51 52	106 54 33	90.3	8,880	139
14	09111500	Slate River near Crested Butte	38 52 11	106 58 08	68.9	8,820	143
15	09112000	Cement Creek near Crested Butte	38 49 28	106 51 08	26.1	9,050	36.5
16	09112200	East River below Cement Creek near Crested Butte	38 47 03	106 52 13	238	8,440	336
17	09112500	East River at Almont	38 39 52	106 50 51	289	8,006	340
18	09113300	Ohio Creek at Baldwin	38 45 56	107 03 28	47.2	8,600	47.6
19	09115500	Tomichi Creek at Sargents	38 24 42	106 25 20	149	8,416	63.6
20	09118000	Quartz Creek near Ohio City	38 33 35	106 38 09	106	8,430	54.3
21	09118450	Cochetopa Creek below Rock Creek near Parlin	38 20 08	106 46 18	334	8,475	47.3
22	09119000	Tomichi Creek at Gunnison	38 31 18	106 56 25	1,061	7,629	175
23	09121500	Cebolla Creek near Lake City	37 58 52	107 10 05	25.2	10,200	14.4
24	09122000	Cebolla Creek at Powderhorn	38 17 29	107 06 50	340	8,000	102
25	09122500	Soap Creek near Sapinero	38 33 39	107 18 58	57.4	7,790	58.6
26	09123400	Lake Fork below Mill Gulch near Lake City	37 54 23	107 23 03	57.5	9,400	101
27	09124000	Henson Creek at Lake City	38 01 11	107 20 05	83.1	8,750	100
28	09124500	Lake Fork at Gateview	38 17 56	107 13 46	334	7,828	238
29	09125000	Curecanti Creek near Sapinero	38 29 16	107 24 52	35.0	7,867	32.3
30	09127500	Crystal Creek near Maher	38 33 07	107 30 20	42.2	8,070	28.2

Table 1. Selected streamflow-gaging stations in and adjacent to the Grand Mesa, Uncompahgre, and Gunnison National Forests—Continued

[--, no data]

Map number (figure 1)	Station number	Station name[1]	Latitude (degrees, minutes, seconds)	Longitude (degrees, minutes, seconds)	Drainage area (square miles)	Station elevation (feet)	Annual mean discharge[2] (cubic feet per second)
31	09128500	Smith Fork near Crawford	38 43 40	107 30 22	42.8	7,091	42.8
32	09129800	Clear Fork near Ragged Mountain	39 08 36	107 25 50	38.5	7,450	36.8
33	09130500	East Muddy Creek near Bardine	39 00 48	107 21 28	133	6,655	88.4
34	09130600	West Muddy Creek near Ragged Mountain	39 07 51	107 34 29	7.42	8,658	4.76
35	09131200	West Muddy Creek near Somerset	39 05 23	107 30 17	49.9	8,020	31.6
36	09132000	Ruby Anthracite Creek near Floresta	38 51 47	107 09 48	20.7	8,805	43.9
37	09132900	West Hubbard Creek near Paonia	39 01 56	107 36 47	2.34	9,640	3.54
38	09134000	Minnesota Creek near Paonia	38 52 13	107 30 06	41.5	6,200	23.4
39	09134500	Leroux Creek near Cedaredge	38 55 35	107 47 35	34.5	7,255	47.6
40	09134700	Cow Creek near Cedaredge	38 55 34	107 47 31	7.24	7,268	13.2
41	09143000	Surface Creek near Cedaredge	38 59 05	107 51 13	27.4	8,261	43.2
42	09144500	Red Mountain Creek near Ironton	37 57 46	107 39 44	18.1	9,586	30.9
43	09145000	Uncompahgre River at Ouray	38 01 09	107 40 32	42.0	7,800	90.5
44	09146200	Uncompahgre River near Ridgway	38 11 02	107 44 43	149	6,878	167
45	09146400	West Fork Dallas Creek near Ridgway	38 04 25	107 51 02	14.1	8,400	12.8
46	09146500	East Fork Dallas Creek near Ridgway	38 05 36	107 48 47	16.8	7,980	25.2
47	09146600	Pleasant Valley Creek near Noel	38 08 44	107 55 09	8.17	8,680	2.22
48	09147000	Dallas Creek near Ridgway	38 10 40	107 45 28	97.2	6,980	40.1
49	09147100	Cow Creek near Ridgway	38 08 58	107 38 39	45.4	7,620	61.0
50	09151500	Escalante Creek near Delta	38 45 24	108 15 34	209	4,810	60.4
51	09152000	Kannah Creek near Whitewater	38 57 42	108 13 47	61.9	6,060	30.9
52	09163570	Hay Press Creek above Fruita Reservoir No. 3 near Glade Park	38 51 03	108 46 56	.77	8,990	0.71
53	09171200	San Miguel River near Telluride	37 56 53	107 52 35	42.8	8,622	63.3
54	09172000	Fall Creek near Fall Creek	37 57 30	108 00 19	33.4	7,929	24.6
55	09172100	Leopard Creek at Noel	38 06 06	107 55 22	9.03	8,700	2.74
56	09172500	San Miguel River near Placerville	38 02 05	108 07 15	308	7,056	240
57	09173500	Horsefly Creek near Sams	38 12 14	108 03 25	28.8	8,330	9.19
58	09174500	Cottonwood Creek near Nucla	38 16 25	108 21 44	38.8	6,080	4.75
59	09174700	West Naturita Creek at upper station near Norwood	37 54 39	108 20 08	7.31	8,180	--
60	09176500	Tabeguache Creek near Nucla	38 22 08	108 20 42	16.9	8,010	11.2

[1]Not all streams mentioned in station names are shown in figure 1.

[2]Annual mean discharge is from beginning of record through end of record, or through water year 2000 (table 2) if station was active at beginning of water year 2001.

Table 2. Periods of daily mean discharge record for stations in and adjacent to the Grand Mesa, Uncompahgre, and Gunnison National Forests

[--, not computed]

Map number (figure 1)	Station number (table 1)	Time periods for which daily discharge data are available	Number of complete water years in each time period	Total number of complete water years
1	08216500	06/01/1951 to 09/30/1982	31	31
2	08224500	06/01/1923 to 09/30/1926;	3	--
		05/01/1936 to 09/30/1982;	46	--
		10/01/1998 to 09/30/2000	2	51
3	09092500	10/01/1952 to 09/30/1982	30	30
4	09095800	05/01/1958 to 09/30/1964	6	6
5	09096800	10/01/1955 to 09/30/1970	15	15
6	09097500	10/01/1921 to 09/30/1980	59	59
7	09097600	10/01/1955 to 09/30/1967	12	12
8	09099500	10/01/1945 to 09/30/1956	11	11
9	09104500	10/01/1940 to 09/30/1960	20	20
10	09107000	06/01/1929 to 09/30/1934;	5	--
		10/01/1987 to 09/30/2000	13	18
11	09107500	06/01/1929 to 09/30/1934;	5	--
		10/01/1987 to 09/30/1992	5	10
12	09108000	06/01/1929 to 09/30/1934	5	5
13	09110500	11/01/1939 to 09/30/1951	11	11
14	09111500	04/01/1940 to 09/30/1951;	11	--
		10/01/1993 to 09/30/2000	7	18
15	09112000	10/01/1910 to 12/31/1913;	3	--
		04/01/1940 to 09/30/1951	11	14
16	09112200	10/01/1963 to 09/30/1972;	9	--
		10/01/1979 to 09/30/1981;	2	--
		10/01/1993 to 09/30/2000	7	18
17	09112500	10/01/1910 to 09/30/1922;	12	--
		10/01/1934 to 09/30/2000	66	78
18	09113300	10/01/1958 to 09/30/1970	12	12
19	09115500	10/01/1916 to 09/30/1922;	6	--
		10/01/1937 to 09/30/1972;	35	--
		10/01/1992 to 09/30/2000	8	49
20	09118000	10/01/1937 to 09/30/1950;	13	--
		10/01/1959 to 09/30/1970	11	24
21	09118450	10/01/1981 to 09/30/2000	19	19
22	09119000	10/01/1937 to 09/30/2000	63	63
23	09121500	08/01/1946 to 09/30/1954	8	8
24	09122000	10/01/1937 to 09/30/1955	18	18
25	09122500	08/01/1955 to 09/30/1966	11	11
26	09123400	10/01/1981 to 09/30/1986	5	5
27	09124000	10/01/1917 to 09/30/1919;	2	--
		10/01/1931 to 09/30/1937	6	8
28	09124500	10/01/1937 to 09/30/2000	63	63
29	09125000	10/01/1945 to 09/30/1972	27	27
30	09127500	10/01/1945 to 09/30/1954;	9	--
		10/01/1960 to 09/30/1969	9	18
31	09128500	10/01/1935 to 09/30/1994	59	59

Table 2. Periods of daily mean discharge record for stations in and adjacent to the Grand Mesa, Uncompahgre, and Gunnison National Forests—Continued

[--, not computed]

Map number (figure 1)	Station number (table 1)	Time periods for which daily discharge data are available	Number of complete water years in each time period	Total number of complete water years
32	09129800	10/01/1965 to 09/30/1973	8	8
33	09130500	10/01/1934 to 09/30/1953	19	19
34	09130600	10/01/1955 to 09/30/1965	10	10
35	09131200	10/01/1961 to 09/30/1973	12	12
36	09132000	10/01/1938 to 09/30/1943; 10/01/1954 to 09/30/1958	5 4	-- 9
37	09132900	10/01/1960 to 09/30/1973	13	13
38	09134000	10/01/1936 to 09/30/1947; 10/01/1985 to 09/30/2000	11 15	-- 26
39	09134500	10/01/1936 to 09/30/1956; 10/01/1960 to 09/30/1969	20 9	-- 29
40	09134700	10/01/1960 to 09/30/1969	9	9
41	09143000	07/01/1939 to 10/31/1999; 04/01/2000 to 09/30/2000	60 0	-- 60
42	09144500	10/01/1947 to 12/31/1955	8	8
43	09145000	04/01/1916 to 09/30/1924	8	8
44	09146200	10/01/1958 to 09/30/2000	42	42
45	09146400	10/01/1955 to 09/30/1970	15	15
46	09146500	10/01/1947 to 09/30/1953; 10/01/1960 to 09/30/1970	6 10	-- 16
47	09146600	10/01/1955 to 09/30/1967	12	12
48	09147000	03/01/1922 to 09/30/1927; 10/01/1955 to 09/30/1971; 10/01/1979 to 09/30/2000	5 16 21	-- -- 42
49	09147100	10/01/1955 to 09/30/1973	18	18
50	09151500	05/01/1976 to 09/30/1989	13	13
51	09152000	10/01/1917 to 09/30/1921; 09/01/1922 to 09/30/1982	4 60	-- 64
52	09163570	10/01/1983 to 03/31/1988	4	4
53	09171200	10/01/1959 to 09/30/1965	6	6
54	09172000	08/01/1941 to 09/30/1959	18	18
55	09172100	10/01/1955 to 09/30/1963	8	8
56	09172500	10/01/1910 to 09/30/1912; 10/01/1930 to 09/30/1934; 04/01/1942 to 09/30/2000	2 4 58	-- -- 64
57	09173500	10/01/1942 to 09/30/1951	9	9
58	09174500	05/01/1942 to 09/30/1951	9	9
59	09174700	05/01/1975 to 07/31/1975; 04/01/1976 to 07/31/1976; 04/01/1977 to 07/31/1977; 04/01/1978 to 07/31/1978; 04/01/1979 to 07/31/1979; 04/01/1980 to 07/31/1980	0 0 0 0 0 0	-- -- -- -- -- 0
60	09176500	04/01/1946 to 09/30/1953	7	7

Description of Study Area

The study area is located in southwestern Colorado (fig. 1) within the Gunnison River, Dolores River, and Plateau Creek Basins, which are tributaries of the Colorado River. The study area comprises about 12,890 mi^2 within the three drainage basins; however, the area within the Grand Mesa, Uncompahgre, and Gunnison National Forests is only about 4,940 mi^2 (about 3,161,600 acres). The study area has highly diverse physical, climatologic, and hydrologic characteristics.

The study area is in the Southern Rocky Mountains and Colorado Plateaus physiographic provinces (Fenneman, 1931), and elevations range from about 4,600 ft at Grand Junction to about 14,000 ft at several mountain peaks near Lake City and Ouray. The large range in elevation and presence of numerous mountain ranges have a profound effect on precipitation, which ranges from about 8 inches per year at Grand Junction to about 40 inches per year in mountains along the Continental Divide (Colorado Climate Center, 1984). Differences in elevation also affect air temperature, which generally decreases about 5.4°F for every 1,000 ft increase in elevation; annual mean temperature is about 54°F at Grand Junction and decreases to about 33°F at Taylor Park (near stations 10 and 11 in fig. 1) (Chaney and others, 1987, p. 12).

Because of the increase in precipitation and decrease in temperature associated with the increase in elevation, most precipitation during the months of October through May is in the form of snow, especially in the higher mountainous areas. The winter precipitation results in accumulation of mountain snowpacks with 10 to 25 inches of water equivalent; melting of the snowpack during April through July results in about 50 to 80 percent of the annual streamflow (Kuhn and Nickless, 1994, p. 5). Precipitation from rainfall during summer usually does not result in substantial streamflow, even though a summer monsoon often is prevalent in the area; however, late-season rainfall from monsoonal precipitation during late September and early October in 1911 resulted in a record flood in parts of the Dolores River, San Juan River, and Rio Grande Basins (Clayton, 1912).

Acknowledgments

The author thanks John M. Almy and Warren Young, with the Grand Mesa, Uncompahgre, and Gunnison National Forests, for their assistance in providing the geographic information system (GIS) coverage of National Forest lands used in figure 1. Technical reviews of the report by Kirk A. Miller and Ryan F. Thompson, editorial review by Mary A. Kidd, preparation of the final manuscript by Alene J. Brogan, and preparation of figure 1 by Jean A. Dupree, all USGS, are greatly appreciated.

ORGANIZATION OF DISCHARGE AND STREAMFLOW CHARACTERISTICS DATA ON THE CD–ROM

Data on the CD–ROM are arranged in a directory structure based on the four report purposes (study objectives) described in the "Purpose and Scope" section of this report. The following schematic illustrates the data structure (directories are in bold type and files are in italic type):

U.S. Geological Survey OFR 02–471
- **Discharge.Data**
  - *discharge.08216500.xls*
  - . . . . .
  - *discharge.09176500.xls*
- **Objective.1 (Peak.Frequency)**
  - *pkfq.08216500.xls*
  - . . . . .
  - *pkfq.09174500.xls*
- **Objective.2 (Annual-Monthly.Daily-Duration)**
  - *flow-dur.08216500.xls*
  - . . . . .
  - *flow-dur.09176500.xls*
  - **Annual-Monthly.Mean.Flow-Duration**
    - *ann-mon.dur.08216500.xls*
    - . . . . .
    - *ann-mon.dur.09172500.xls*
- **Objective.3 (N-Day.Frequency)**
  - *N-Day-High.Frequency*
    - *nday-high.08216500.xls*
    - . . . . .
    - *nday-high.09176500.xls*

N-Day-Low.Frequency

nday-low.08216500.xls

. . . . .

nday-low.09176500.xls

Objective.4 (Annual-Monthly.Mean-Median)

mean_medn.08216500.xls

. . . . .

mean_medn.09176500.xls

Annual-Monthly.Mean-Frequency

ann-mon.mean-freq.08216500.xls

. . . . .

ann-mon.mean-freq.09174500.xls

Annual-Monthly.Median-Frequency

ann-mon.medn-freq.08216500.xls

. . . . .

ann-mon.medn-freq.09174500.xls

PDF.Hydrographs

(Obj-1) Peak.Freq

pkfq.08216500.pdf

. . . . .

pkfq.09174500.pdf

(Obj-2) Ann-Mon.Daily.Duration

dly-dur.all.08216500.pdf

. . . . .

dly-dur.all.09174500.pdf

(Obj-2) Ann-Mon.Mean.Dur

AM-mean-dur.all.08216500.pdf

. . . . .

AM-mean-dur.all.09172500.pdf

(Obj-3) N-Day.High-Low.Freq

n-day.freq.08216500.pdf

. . . . .

n-day.freq.09172500.pdf

(Obj-4) Ann-Mon.Mean.Freq

AM-mean-freq.all.08216500.pdf

. . . . .

AM-mean-freq.all.09174500.pdf

(Obj-4) Ann-Mon.Median.Freq

AM-medn-freq.all.08216500.pdf

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AM-medn-freq.all.09174500.pdf

ReadMe.txt

USGS_OFR.02–471.pdf

ar505enu.exe

All data are contained in the master directory "**U.S. Geological Survey OFR 92–471**" that contains subdirectories for (1) the daily, monthly, and annual discharge data; (2) each of the four streamflow characteristic objectives; and (3) Adobe portable document format for all the graphs of streamflow characteristics. In addition, the CD–ROM contains these additional files: (1) "ReadMe.txt" that provides an orientation to the contents of the CD–ROM; (2) "USGS_OFR.02–471.pdf" that contains the report text as a PDF file; and (3) "ar505.exe" that is the installation program for Adobe Acrobat Reader needed to view PDF files (for those users that do not have the program installed on their computer). In the directory schematic, only the first and last discharge data, streamflow characteristics data, and PDF files are listed—the line with the dots between the listed files (in italics) is intended to represent the many other files not listed in the schematic.

In the directories for each of the streamflow characteristics objectives, each Excel file (one file for each station for which a characteristic was computed) contains at least one worksheet with a data table listing the streamflow characteristic results and a graph showing the streamflow characteristic results; however, most Excel files have additional worksheets with additional data tables and graphs because multiple characteristics usually were computed. The computer programs used to derive the streamflow characteristics and graphs provided graphical output in the form of postscript files. The conversion filter used to import the postscript files into the Excel files resulted in a degraded image quality; therefore, PDF files, which have a higher image quality, are provided for each streamflow characteristic in the various subdirectories and files of the "**PDF.Hydrographs**" directory. A brief description of the streamflow characteristics data tables in the Excel files is presented in the next section of this report; no additional description of the PDF files is necessary.

DESCRIPTION OF STREAMFLOW CHARACTERISTICS DATA ON THE CD–ROM

A brief description of some data fields on the streamflow characteristics data tables in the Excel files is presented in the following report sections. The descriptions, however, are not intended to be an interpretation of the resulting output. No description of the daily, monthly, and annual discharges in the Excel files in the "**Discharge.Data**" directory is presented herein.

Objective 1—Peak Frequency

Frequency analysis of instantaneous peak discharge was made using the USGS computer program PEAKFQ (U.S. Geological Survey, 2002a). This program uses the LP3 distribution for analysis and incorporates all of the additional computational procedures described in the report "Guidelines for Determining Flood Flow Frequency" that commonly, and hereinafter, is referred to as "Bulletin 17B" (U.S. Interagency Advisory Committee on Water Data, 1982).

An example of the Excel data table for results of peak frequency computation is shown in table 3. The major components of the data table are as follows:

1. The station number and name.
2. A list of standard annual exceedance probabilities and recurrence intervals; the Bulletin 17B, systematic record, and "expected probability" estimated peak discharges for each listed exceedance probability and recurrence interval; and the 95-percent confidence limits for each Bulletin 17B peak discharge estimate. The Bulletin 17B estimated peak discharge estimates are the actual result of the analysis. The systematic record estimated peak discharges are included in the output from the PEAKFQ program for comparative purposes; the computations for the systematic record discharges are based on a simple LP3 frequency analysis without the computational enhancements described in Bulletin 17B (U.S. Interagency Advisory Committee on Water Data, 1982). The expected probability estimate discharge represents a measure of the central tendency of the spread between the confidence limits (U.S. Interagency Advisory Committee on Water Data, 1982, p. 24); additional discussion of expected probability estimate is presented in Appendix 11 of that publication (U.S. Interagency Advisory Committee on Water Data, 1982).
3. The estimated peak discharges for two additional annual exceedance probabilities and recurrence intervals, the 1.5-year and 2.33-year floods, together with the stage for the estimated discharges taken from the most recent or last discharge rating curve in use. Stage at a USGS gaging station is a measure of the stream surface elevation in reference to some arbitrary or predetermined datum (Rantz and others, 1982a, p. 23); therefore, stage may not necessarily be equivalent to the mean stream depth for a given discharge. (See Rantz and others [1982a, 1982b] for detailed discussion of stage measurement, rating curves, and computation of discharge.)
4. A summary of the input data that lists the number of peaks in the record, number of values not used in the analysis, and the generalized skew value.
5. The number of recorded peaks that were less than or greater than a listed high and low outlier criterion; the criteria are computed within the PEAKFQ program by using outlier computation techniques (U.S. Interagency Advisory Committee on Water Data, 1982, p. 17–18).
6. The computed parameters, in logarithmic units, for the LP3 distribution, for both the systematic record and for the Bulletin 17B methods.
7. A graph of the peak frequency analysis results is presented to the right of the Excel data table; an example is shown in figure 2.

The peak discharges for each year of record are listed in a second worksheet of the Excel file; an example is shown in table 4. The listing of the recorded peak discharges includes a column for peak discharge codes; however, there were none for the example selected. An explanation of the peak discharges codes is included in table 4. In the Excel files, the explanation for the peak discharge codes is not provided in each Excel file but rather in a separate file, *Peak_Q.Codes.xls*, in the **Objective.1 (Peak.Frequency)** directory of the CD–ROM.

Station 09097600 Brush Creek near Collbran was selected for the example (fig. 2) because it illustrates frequency analysis results for shorter time periods that commonly do not have recorded peak discharges at the smaller exceedance probabilities (higher recurrence intervals). Hence, careful judgment needs to be used in interpreting and applying the frequency analysis results; the range of the 95-percent confidence limits, which is considerable for station 09097600 at the smaller exceedances, needs to be considered in any application of the Bulletin 17B estimated discharges. For stations with longer periods of record, the range of the recorded peak discharges usually will be larger (closer to the range of estimated peak discharges in the frequency table), and the range of the 95-percent confidence limits usually will be smaller.

The PEAKFQ program normally does not use discharge values that have a peak discharge code of

Table 3. Example data table for results of peak frequency computation

Station 09097600 Brush Creek near Collbran

ANNUAL PEAKS FREQUENCY CURVE -- DISCHARGES AT SELECTED EXCEEDANCE PROBABILITIES

Annual exceedance probability	Recurrence interval (years)	For listed variable, estimated peak discharge, in cubic feet per second: Bulletin I7B estimate	Systematic record	Expected probability estimate	95-percent confidence limit for Bulletin I7B estimates: Lower	Upper
0.995	1.005	15.2	20.1	9.7	5.4	25.9
0.99	1.01	18.0	22.5	12.8	7.0	29.6
0.95	1.05	28.6	31.3	24.5	13.8	43.1
0.9	1.11	36.6	38.1	33.3	19.8	53.0
0.8	1.25	49.4	48.9	47.1	30.1	69.1
0.5	2	87.8	83.5	87.8	62.1	124.2
0.2	5	156.1	153.1	163.7	111.7	256.6
0.1	10	211.0	216.5	232.0	145.8	390.7
0.04	25	291.0	320.7	347.2	190.6	621.9
0.02	50	358.3	418.6	462.0	225.4	844.6
0.01	100	431.9	536.7	610.4	261.5	1,115.0
0.005	200	512.6	678.8	805.4	299.1	1,441.0
0.002	500	630.9	910.9	--	351.6	1,969.0
	Non-standard values					
0.667	1.5	65.4	(1.50-year flood)	Stage = 3.26 ft.	Rating table	
0.429	2.33	99.2	(2.33-year flood)	Stage = 3.50 ft.	date: 10/01/1962	

INPUT DATA SUMMARY

Number of peaks in record	=	12
Peaks not used in analysis	=	0
Systematic peaks in analysis	=	12
Historic peaks in analysis	=	0
Years of historic record	=	0
Generalized skew	=	–0.300
Standard error of generalized skew	=	0.550
Skew option	=	Weighted

	Number	Value
NO SYSTEMATIC PEAKS WERE BELOW GAGE BASE.	0	0.0
NO LOW OUTLIERS BELOW FLOOD BASE WERE DROPPED.	0	20.4
NO HIGH OUTLIERS OR HISTORIC PEAKS EXCEEDED HHBASE.	0	377.7

Values are in cubic feet per second

ANNUAL FREQUENCY CURVE PARAMETERS -- LOG-PEARSON TYPE III

	Logarithmic value: Mean	Standard deviation	Skew
Systematic record	1.944	0.297	0.446
Bulletin 17B estimate	1.944	0.297	0.005

Dashes anywhere in the above data indicate value not computed.

See the file "Peaks.explanation.xls" for Bulletin 17B reference and explanation of column

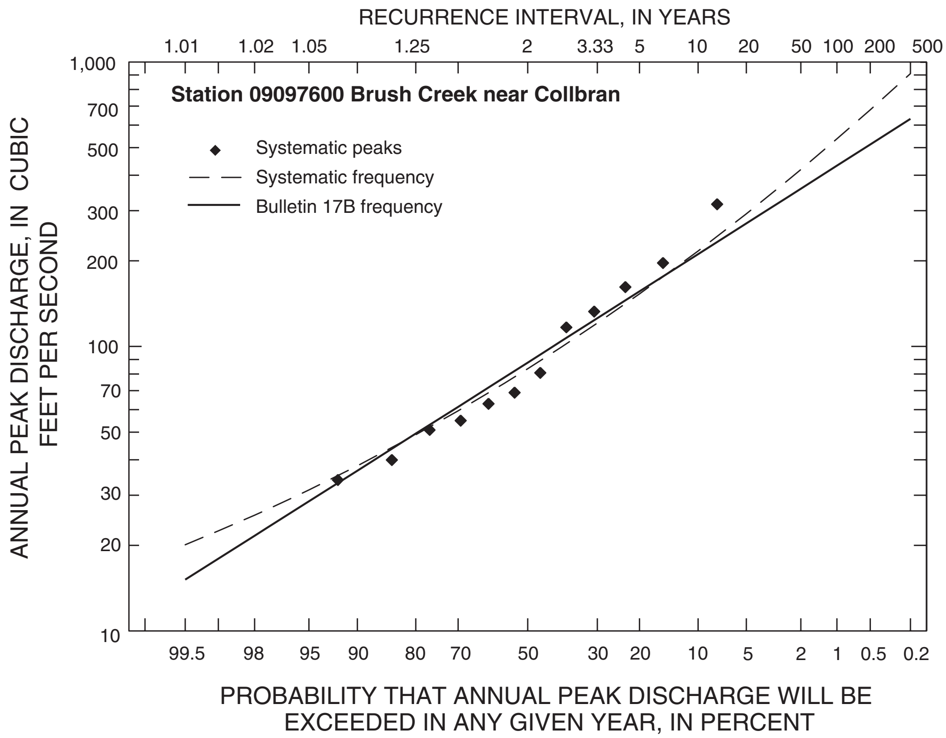

Figure 2. Example graph for results of peak frequency computation.

6 or 7 [table 4; *Peak_Q.Codes.xls* file in the **Objective.1 (Peak.Frequency)** directory of the CD–ROM]. However, peak discharge values with a peak discharge code of 6 or 7 were used in the analyses for this study because (1) peak discharge frequency analysis was needed for stations where discharge was affected by diversion or regulation (code 6) and (2) the peak discharges coded as historic (code 7) did not meet the criteria for historic peaks (U.S. Interagency Advisory Committee on Water Data, 1982; U.S. Geological Survey, 2002a [draft user manual]) even though the values were coded as being historic peaks. When using the frequency analysis results for stations where discharge is affected by diversion or regulation, the user needs to consider this fact in applying the results.

Objective 2—Duration of Daily Mean Discharges on an Annual and Monthly Basis

Flow durations for daily mean discharges were computed using the statistical analysis capabilities of the USGS National Water Information System (NWIS). Although most components of NWIS are accessible only by USGS personnel, some of the statistical procedures have been ported to software packages (such as PEAKFQ) that are available to the public. The public software program, SWSTAT (U.S. Geological Survey, 2002b), also could have been used to compute flow duration, but the use of the NWIS capability was more efficient given the number of stations and time periods in the analysis. Each Excel file for flow duration of daily mean discharge computed on an annual and monthly basis contains 13 worksheets: one worksheet for the annual computation and one worksheet for each month of the year. An example of a flow-duration data table is shown in table 5 and has the following components:

1. The station number and name.
2. A variable number of percentage values that indicate the percentage of time that a given discharge was equaled or exceeded.
3. The discharge values that correspond to the percentage values.
4. The type of discharge value; the NWIS software calculates a predetermined number of class intervals and computes percentage and discharge values for each class (the “Computed” type). Other percentage values (even values) are inter

Table 4. Example data table for peak discharge data

Station 09097600 Brush Creek near Collbran			
Annual instantaneous peak discharges for period of record			
Water year	**Date**	**Peak discharge, in cubic feet per second**	**Peak discharge code[1]**
1956	05/07/56	69.0	
1957	06/07/57	317.0	
1958	05/20/58	133.0	
1959	05/15/59	51.0	
1960	05/12/60	81.0	
1961	05/19/61	55.0	
1962	05/06/62	117.0	
1963	05/04/63	34.0	
1964	05/17/64	197.0	
1965	05/21/65	162.0	
1966	05/02/66	40.0	
1967	05/23/67	63.0	

[1]Station 09097600 Brush Creek near Collbran does not have any peak discharge codes. Meaning of peak discharge codes is as follows:

Code	**Peak discharge code explanation**
1	Discharge is a maximum daily mean.
2	Discharge is an estimate.
3	Discharge affected by dam failure.
5	Discharge affected by unknown degree of regulation or diversion.
6	Discharge affected by known degree of regulation or diversion.
7	Discharge is a historic peak.
B	Month or day of discharge is unknown or not exact.
E	Value is only maximum peak available for this year.

polated by the NWIS software from the computed values (the “Interpolated” type).

5. A graph for the flow-duration analysis is presented to the right of the Excel data table; an example graph is shown in figure 3.

The flow-duration graph (fig. 3) consists of three hydrographs: one hydrograph shows the entire range of the flow duration and usually has a logarithmic discharge scale; a second hydrograph shows the discharge range that was equaled or exceeded 0 to 30 percent of the time; and a third hydrograph shows the discharge range that was equaled or exceeded 30 to 100 percent of the time. The second and third hydrographs always have an arithmetic scale for discharge; when the range of discharge is small, which includes October–March, the first hydrograph usually has an arithmetic scale also. In some cases, the second hydrograph may not include discharges at the highest percentage values (0 to about 3 percent). Also, sometimes the flow-duration curve is not very smooth and may be poorly defined or truncated at one end. This usually is attributable to winter discharge that is not very variable and commonly is mostly estimated, or the period of record is relatively short (table 2). An example of winter-record flow duration is shown in figure 4.

Table 5. Example data table for results of annual and monthly flow-duration computation using daily mean discharges

Station 08216500 Willow Creek at Creede		
Annual flow-duration data for daily mean discharge		
Percentage of time discharge was equaled or exceeded	**Discharge, in cubic feet per second**	**Type of discharge value**
99.99	1.90	Computed
99.56	2.40	Computed
99.00	2.53	Interpolated
98.00	2.75	Interpolated
96.89	3.00	Computed
95.00	3.14	Interpolated
90.00	3.51	Interpolated
87.49	3.70	Computed
85.00	3.93	Interpolated
80.00	4.39	Interpolated
76.66	4.70	Computed
75.00	4.87	Interpolated
70.00	5.40	Interpolated
66.12	5.80	Computed
60.00	6.71	Interpolated
56.07	7.30	Computed
50.00	8.85	Interpolated
48.61	9.20	Computed
44.86	11.00	Computed
40.00	13.26	Interpolated
38.42	14.00	Computed
31.20	18.00	Computed
30.00	18.84	Interpolated
25.00	22.35	Interpolated
24.07	23.00	Computed
20.00	27.91	Interpolated
19.92	28.00	Computed
16.22	35.00	Computed
15.00	38.38	Interpolated
12.96	44.00	Computed
10.00	54.92	Interpolated
9.71	56.00	Computed
7.50	70.00	Computed
5.35	87.00	Computed
5.00	91.36	Interpolated
3.58	109.00	Computed
2.09	137.00	Computed
2.00	140.98	Interpolated
1.30	171.00	Computed
1.00	187.69	Interpolated
0.53	214.00	Computed
0.16	268.00	Computed
0.02	336.00	Computed

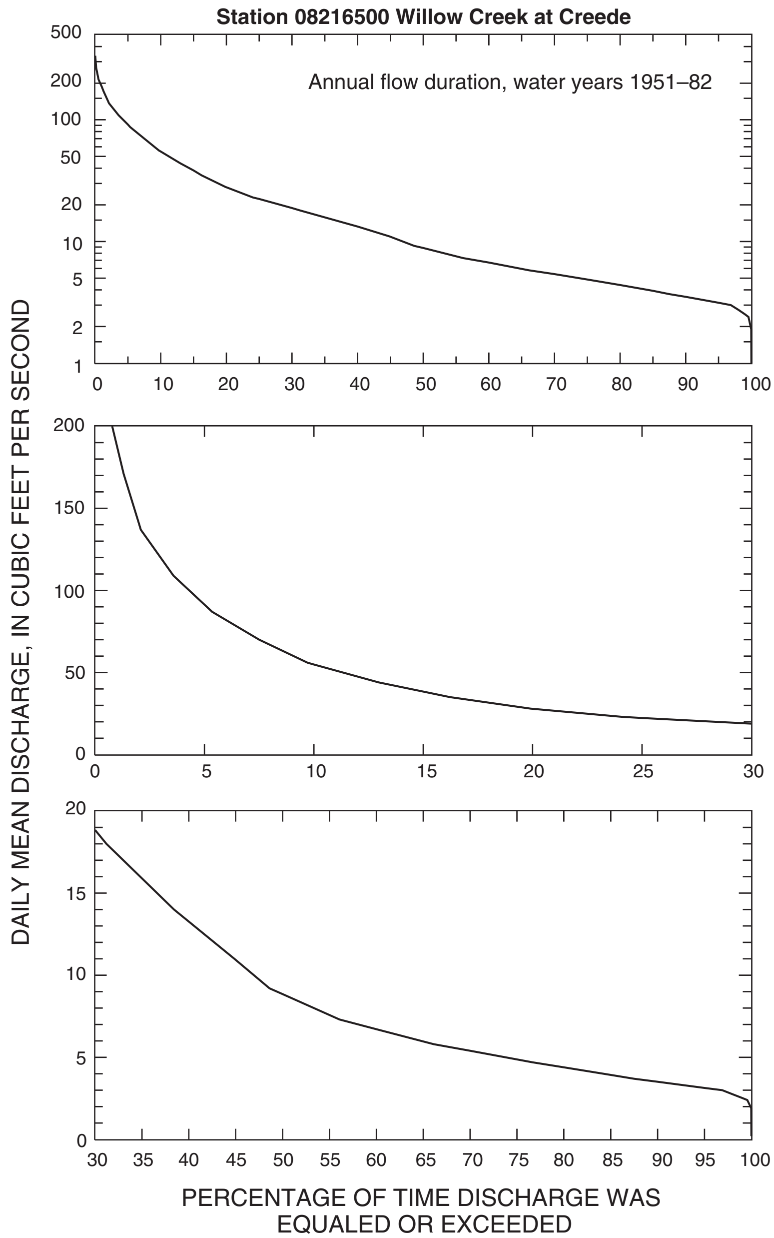

Figure 3. Example graph for results of annual and monthly flow-duration computation using daily mean discharges.

Duration of Annual and Monthly Mean Discharges

The proposal for this study (U.S. Geological Survey, written commun., August 2000) indicated that stations with 20 years or more of record would be used in the flow-duration analysis of annual and monthly mean discharges; however, nine additional stations with 18 or 19 years of record (table 2) were included in the analysis.

The flow-duration data for annual and monthly mean discharge were computed using the univariate procedure of the Statistical Analysis System (SAS) software (SAS Institute, Inc., 1990) because the NWIS and SWSTAT programs do not readily compute flow duration of annual and monthly mean discharges due to the small number of values available for analysis. Therefore, the data tables for results of computing flow duration of annual and monthly mean discharges are somewhat different from the data tables for results of computing flow duration from daily mean discharges; however, each Excel file also has 13 worksheets for the analyses on an annual and monthly basis, and each worksheet includes a data table and a graph of the results. An example of the data table is shown in table 6 and has the following components:

1. The station number and name.
2. A uniform number of percentage values that indicate the percentage of time that a given discharge was equaled or exceeded.
3. The annual or monthly mean discharge values, in cubic feet per second, that correspond to the percentage values.
4. An additional column of annual or monthly discharge values, in acre-feet.
5. A graph showing flow duration of annual or monthly mean discharge is presented to the right of the Excel data table; an example graph is shown in figure 5.

The graph of mean annual flow duration (fig. 5) has two y-axes, one for discharge in cubic feet per second and one for discharge in acre-feet. A slight flattening of the curve can be noted at each end; this is partly attributable to the small number of data points and to the smaller variability in annual and monthly mean discharge values. The Excel data tables for monthly mean discharge are nearly the same as those for the annual mean discharge (table 6); however, the graphs for flow duration of monthly mean discharge are somewhat different (fig. 6). In this case, two hydrographs are provided, one for monthly mean discharge in cubic feet per second and one for monthly discharge in acre-feet.

Objective 3—N-Day Frequency

Computation of the N-day (1, 3, 7, 15, 30, 60, 120, and 183 consecutive days) high- and low-flow frequency was a 2-step process using the SWSTAT program. First, the daily mean discharges for the period of record were input and the lowest and highest mean discharges for each N-day period in each year were computed; then, the yearly values of the N-day high- and low-flow were used in an LP3 frequency analysis.

There are two differences between the computations for N-day low flow and N-day high flow. First, the computations for high flow are made on a water year (October 1 through September 30) basis, whereas the computations for low flow are made on a climate year (April 1 through March 31) basis. Second, the high-flow frequency is expressed in terms of exceedance probability, whereas the low-flow frequency is expressed in terms of nonexceedance probability.

The first step of the analysis, computation of the highest and lowest mean discharges for each N-day period for each year, was completed for all stations except station 09174700 (table 2; seasonal record); however, the frequency analysis step was completed only for the 44 stations with 10 or more complete years of record (table 2). Because discharge records are obtained on a water year basis, the number of years of record available on a climate year basis usually will be 1 or 2 years less than the number of years available on a water year basis. Therefore, only 8 or 9 years of record were available for the low-flow frequency computation for some stations; these stations were included to be consistent with all stations used in the high-flow frequency computation. Careful judgment needs to be used in interpreting and applying the low-flow frequency results for stations with the shorter records.

N-Day High-Flow Frequency

The Excel files for the N-day high-flow frequency each contain nine worksheets. The first worksheet lists the highest mean discharge for each complete water year of record for each of the N-day periods and the rank of the N-day discharge (table 7).

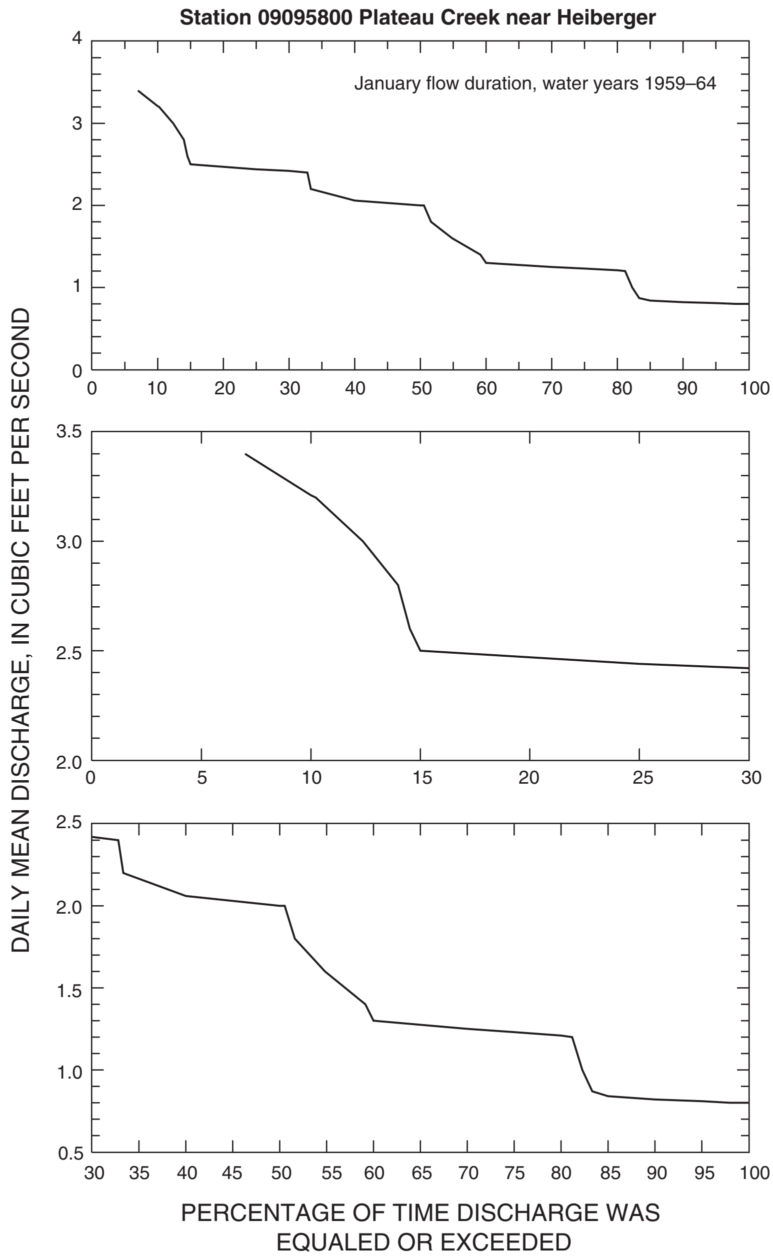

Figure 4. Example graph for results of monthly flow-duration computation during winter using daily mean discharges.

Table 6. Example data table for results of annual and monthly flow-duration computation using annual and monthly mean discharges

Station 08216500 Willow Creek at Creede		
Flow-duration data for mean annual discharge		
Percentage of time discharge was equaled or exceeded	**Mean annual discharge, in cubic feet per second**	**Annual discharge, in acre-feet**
99	7.71	5,580
98	7.71	5,580
97	7.71	5,580
95	10.30	7,460
90	12.10	8,780
85	12.50	9,050
80	13.60	9,850
75	14.40	10,400
70	14.90	10,800
65	15.70	11,400
60	16.70	12,100
55	17.10	12,400
50	19.50	14,200
45	21.30	15,500
40	23.90	17,400
35	26.90	19,500
30	27.30	19,800
25	30.70	22,200
20	31.50	22,900
15	32.40	23,500
10	34.20	24,800
5	37.60	27,200
3	39.70	28,700
2	39.70	28,700
1	39.70	28,700

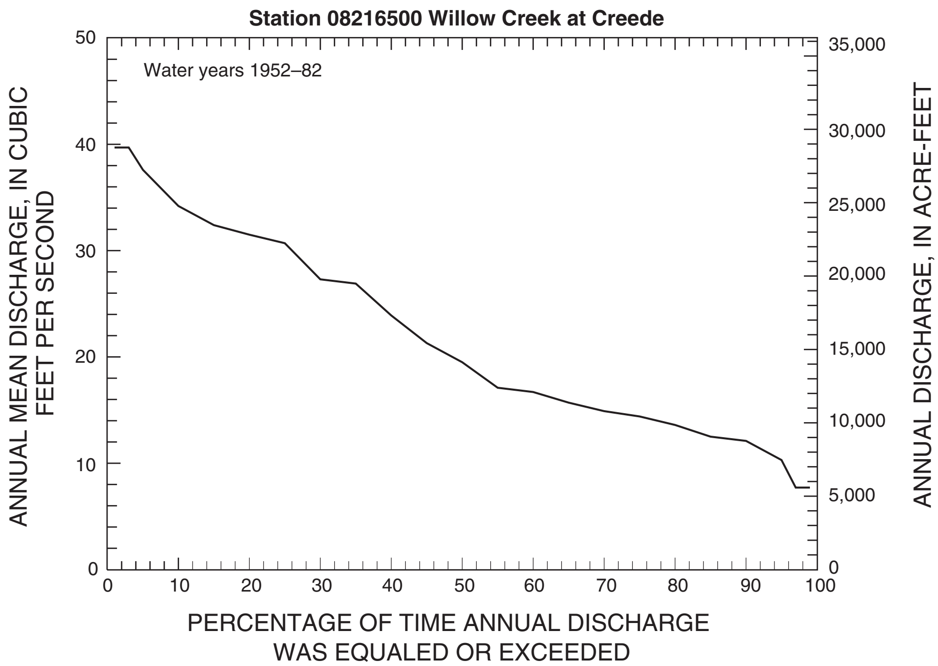

Figure 5. Example graph for results of annual flow-duration computation using annual mean discharges.

Eight additional worksheets present the high-flow frequency analysis results for each of the N-day periods; each of these eight worksheets has a data table (table 8) with the following components:

1. The station number and name and the number of days in the N-day period.
2. A list of standard annual exceedance probabilities and recurrence intervals and the estimated N-day high-flow discharge for each listed exceedance probability and recurrence interval.
3. The statistical variables for the computed LP3 distribution including the skew, mean, and standard deviation. For the N-day frequency analysis, the skew is equal to the station skew because the LP3 enhancements in Bulletin 17B, such as weighting the skew (U.S. Interagency Advisory Committee on Water Data, 1982), are not used in the N-day frequency computations.
4. The time period and number of values used in the analysis.
5. A graph showing the LP3 frequency curve is presented to the right of the Excel data table; an example graph is shown in figure 7.

N-Day Low-Flow Frequency

The Excel files for results of the N-day low-flow frequency analysis are practically identical to those for the high-flow frequency analysis. The first worksheet lists of the lowest mean discharge for each complete climate year of record for each of the N-day periods and the rank of the N-day discharge (table 9). Eight additional worksheets present the low-flow frequency analyses results for each of the N-day periods; each of these eight worksheets has a data table (table 10) with the following components:

1. The station number and name and the number of days in the N-day period.
2. A list of standard annual nonexceedance probabilities and recurrence intervals and the estimated N-day low-flow discharge for each listed non-exceedance probability and recurrence interval. [The additional columns that begin with “Adjusted” are described in the following paragraph.]
3. The statistical variables for the computed LP3 distribution including the skew, mean, and standard deviation. For the N-day frequency analysis, the skew is equal to the station skew because the LP3 enhancements in Bulletin 17B, such as weighting the skew (U.S. Interagency Advisory

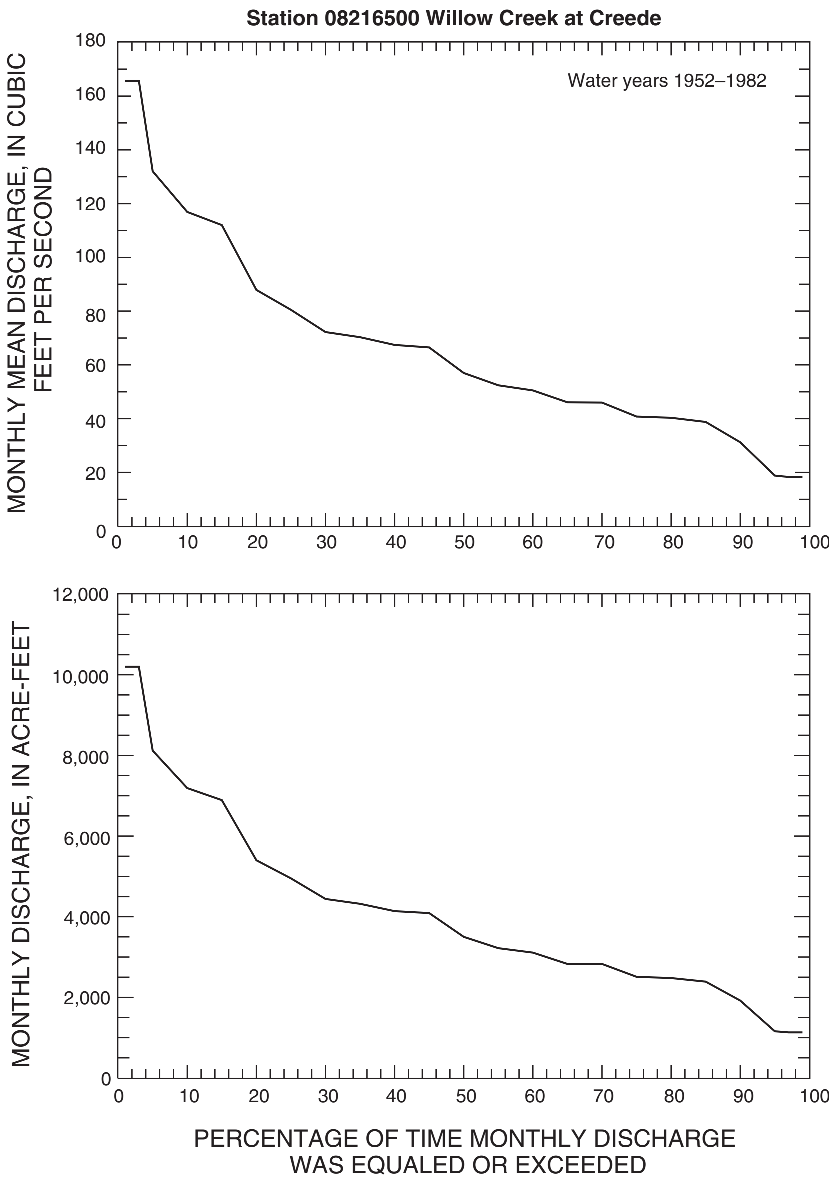

Figure 6. Example graph for results of monthly flow-duration computation using monthly mean discharges (month = May).

Table 7. Example data table for annual values of N-day high flow used in log-Pearson type-III frequency computations

Station 09096800 Buzzard Creek below Owens Creek near Heiberger

	Highest mean discharge, in cubic feet per second, and ranking for the following number of consecutive days for October to September (Water year)															
Water	1-Day high		3-Day high		7-Day high		15-Day high		30-Day high		60-Day high		120-Day high		183-Day high	
year	Discharge	Rank	Discharge	Rank	Discharge	Rank	Discharge	Rank	Discharge	Rank	Discharge	Rank	Discharge	Rank	Discharge	Rank
1956	171.00	12	165.00	11	146.00	11	106.00	12	91.40	12	67.90	12	38.30	12	25.80	12
1957	446.00	2	437.00	2	414.00	1	359.00	2	304.00	1	228.00	1	133.00	1	88.70	1
1958	435.00	4	363.00	4	329.00	4	313.00	4	288.00	2	195.00	3	101.00	4	67.80	5
1959	180.00	11	164.00	12	138.00	12	104.00	14	89.00	13	60.00	13	34.00	13	22.60	13
1960	275.00	8	260.00	8	226.00	8	169.00	10	136.00	10	103.00	9	54.90	9	36.30	10
1961	152.00	13	145.00	13	138.00	13	126.00	11	105.00	11	70.10	11	39.60	11	26.40	11
1962	440.00	3	432.00	3	401.00	3	318.00	3	268.00	4	221.00	2	132.00	2	88.10	2
1963	95.00	15	87.70	15	80.10	15	57.30	15	43.40	15	36.60	15	20.90	15	14.10	15
1964	328.00	7	319.00	7	308.00	6	274.00	6	196.00	7	123.00	8	65.50	8	43.70	8
1965	342.00	6	327.00	6	297.00	7	227.00	7	211.00	6	178.00	5	104.00	3	69.90	3
1966	200.00	10	195.00	10	191.00	10	170.00	9	137.00	9	94.00	10	54.80	10	37.00	9
1967	136.00	14	132.00	14	126.00	14	105.00	13	79.90	14	51.80	14	31.60	14	21.90	14
1968	388.00	5	339.00	5	316.00	5	294.00	5	242.00	5	167.00	6	89.90	6	60.40	6
1969	250.00	9	235.00	9	202.00	9	186.00	8	173.00	8	128.00	7	84.10	7	56.20	7
1970	448.00	1	440.00	1	402.00	2	360.00	1	280.00	3	187.00	4	100.00	5	68.60	4

Table 8. Example data table for results of N-day high-flow frequency computation

Station 09096800 Buzzard Creek below Owens Creek near Heiberger

Frequency analysis results for: 1-DAY HIGH FLOW

Log-Pearson Type III Statistics

Exceedance probability	Recurrence interval (years)	Discharge (cubic feet per second)
0.99	1.01	66.9
0.95	1.05	105.5
0.9	1.11	132.2
0.8	1.25	171.1
0.5	2	267.5
0.2	5	394.4
0.1	10	472.6
0.04	25	564.1
0.02	50	627.1
0.01	100	685.9
0.005	200	741.2

The following seven statistics are based on non-zero values:

Mean (logs)	2.409
Variance (logs)	0.047
Standard Deviation (logs)	0.218
Skewness (logs)	–0.493
Standard Error of Skewness (logs)	0.580
Serial Correlation Coefficient (logs)	–0.416
Coefficient of Variation (logs)	0.090

October 1 - start of season

September 30 - end of season

1956–1970 - time period

15 - non-zero values

0 - zero values

Table 9. Example data table for annual values of N-day low flow used in log-Pearson type-III frequency computation

Station 09096800 Buzzard Creek below Owens Creek near Heiberger

Climate year	Lowest mean discharge, in cubic feet per second, and ranking for the following number of consecutive days for April to March (Climate year)															
	1-Day low		3-Day low		7-Day low		15-Day low		30-Day low		60-Day low		120-Day low		183-Day low	
	Discharge	Rank	Discharge	Rank	Discharge	Rank	Discharge	Rank	Discharge	Rank	Discharge	Rank	Discharge	Rank	Discharge	Rank
1956	0.00	1	0.00	1	0.00	1	0.00	1	0.00	2	0.04	2	0.22	1	0.37	1
1957	1.60	14	1.67	14	1.81	13	1.89	13	2.06	13	3.14	14	3.78	13	4.04	12
1958	0.00	2	0.00	2	0.00	2	0.00	2	0.09	4	0.14	3	0.41	3	0.57	3
1959	0.00	3	0.00	3	0.06	9	0.14	9	0.18	5	0.36	6	0.67	4	0.72	4
1960	0.00	4	0.00	4	0.00	3	0.00	3	0.00	1	0.00	1	0.22	2	0.49	2
1961	0.00	5	0.00	5	0.00	4	0.00	4	0.04	3	0.27	4	3.28	11	3.69	11
1962	0.00	6	0.00	6	0.00	5	0.07	7	0.25	7	0.48	8	0.87	7	0.87	6
1963	0.00	7	0.00	7	0.00	6	0.05	6	0.26	8	0.45	7	0.72	5	0.86	5
1964	0.00	8	0.00	8	0.10	10	0.18	10	0.52	9	0.58	9	0.74	6	0.90	7
1965	1.50	13	1.60	13	2.23	14	2.53	14	2.72	14	3.04	13	3.52	12	4.76	13
1966	0.00	9	0.00	9	0.00	7	0.02	5	0.20	6	0.35	5	1.10	8	1.32	8
1967	0.00	10	0.00	10	0.00	8	0.11	8	0.80	11	1.43	11	1.55	9	1.64	9
1968	0.30	12	0.43	12	0.56	12	0.63	12	1.05	12	1.65	12	2.38	10	2.48	10
1969	0.00	11	0.17	11	0.29	11	0.55	11	0.64	10	1.09	10	4.95	14	5.07	14

NOTE: No 1-day, 3-day, or 7-day frequency analyses for this station because of too many zero values.

Table 10. Example data table for results of N-day low-flow frequency computation

Station 09096800 Buzzard Creek below Owens Creek near Heiberger

Frequency analysis results for: 30-DAY LOW FLOW

Log-Pearson Type III Statistics

Non-exceedance probability	Recurrence interval (years)	Discharge (cubic feet per second)	*Adjusted non-exceedance probability	*Adjusted recurrence interval (years)	*Adjusted discharge (cubic feet per second)
0.01	100	0.00	0.081	12.39	0.00
0.02	50	0.00	0.090	11.11	0.00
0.05	20	0.01	0.118	8.48	0.00
0.1	10	0.03	0.164	6.09	0.00
0.2	5	0.07	0.257	3.89	0.04
0.5	2	0.38	0.536	1.87	0.32
0.8	1.25	1.22	0.814	1.23	1.15
0.9	1.11	1.88	0.907	1.10	1.82
0.96	1.04	2.68	0.963	1.04	2.62
0.98	1.02	3.19	0.981	1.02	3.14
0.99	1.01	3.62	0.991	1.01	3.58

* An explanation of the adjusted values is provided in text of data report in the "Report.pdf" file in the "Data.Report" directory of this CD-ROM.

The following seven statistics are based on non-zero values:

Mean (logs)	–0.567
Variance (logs)	0.598
Standard Deviation (logs)	0.773
Skewness (logs)	–1.190
Standard Error of Skewness (logs)	0.616
Serial Correlation Coefficient (logs)	–0.250
Coefficient of Variation (logs)	–1.364

April 1–start of season
March 31–end of season
1957–1970 - time period
13 - non-zero values
1 - zero values

Committee on Water Data, 1982), are not used in the N-day frequency computations.

4. The time period and number of values used in the analysis.
5. A graph showing the LP3 frequency curve presented to the right of the Excel data table; an example graph is shown in figure 8.

There is one additional component in the data table for results of the N-day low-flow frequency analysis: The listing of the adjusted nonexceedance probabilities, recurrence intervals, and estimated N-day low-flow discharges (table 10). The additional data columns are listed only for a few stations and then only for the smaller N-day periods; the adjusted data values are needed because some of the recorded N-day discharge values are zero. The LP3 distribution cannot be computed for a data set with zero values; therefore, the zero values are removed from the data set for the frequency computation, and then the results are adjusted to account for the values that were excluded (U.S. Geological Survey, Office of Surface Water Technical Memorandum 70.07, dated September 1969

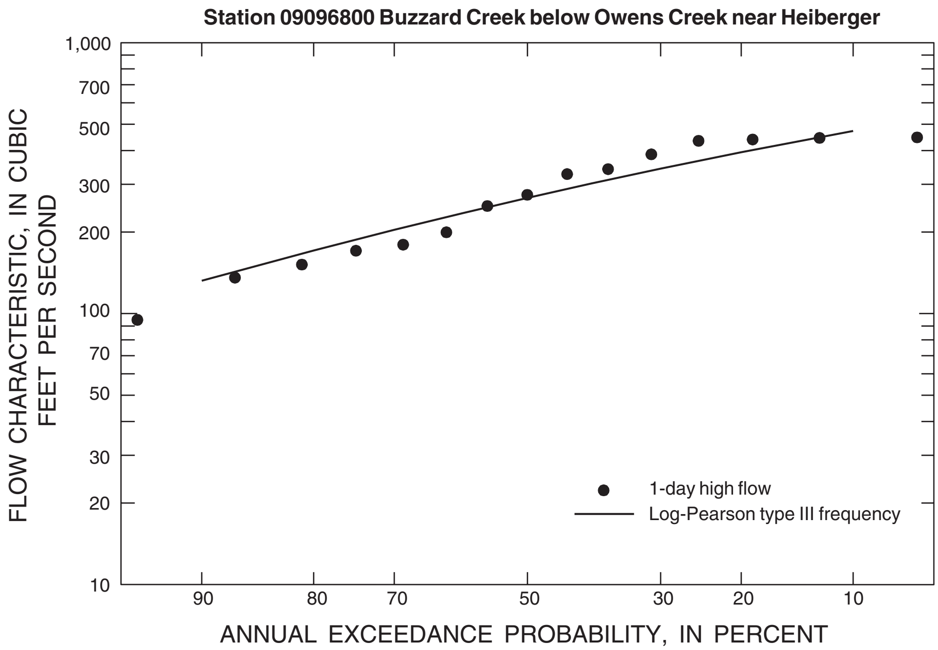

Figure 7. Example graph for results of N-day high-flow frequency computation.

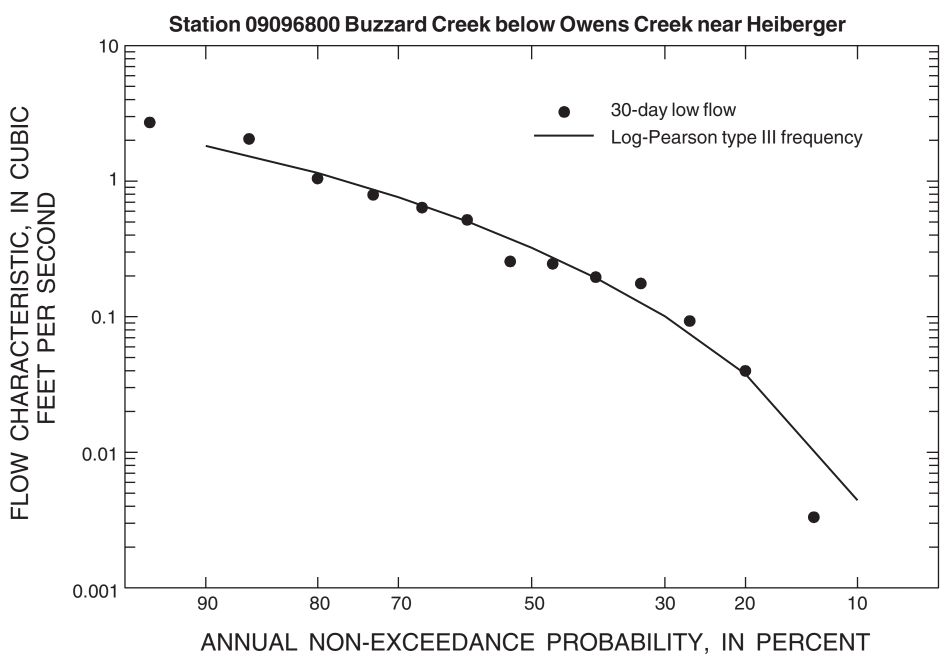

Figure 8. Example graph for results of N-day low-flow frequency computation.

Table 11. Example data table for results of annual and monthly mean discharge computation

Station 09113300 Ohio Creek at Baldwin

	Annual and Monthly Mean Discharges, in Cubic Feet Per Second												
Water year	**Annual**	**October**	**November**	**December**	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**
1959	35.87	11.48	10.55	12.00	11.00	10.00	8.94	23.57	139.58	142.83	31.35	19.95	8.07
1960	40.53	19.58	18.87	11.00	10.00	9.00	9.13	75.83	116.06	160.37	34.39	15.19	8.18
1961	35.01	12.26	10.40	10.00	10.00	8.54	9.45	30.73	151.45	113.47	18.38	16.81	27.40
1962	69.43	24.32	16.63	12.00	11.00	12.00	14.00	91.70	263.71	242.57	101.94	29.97	10.43
1963	21.24	9.66	7.50	5.50	5.00	5.54	9.87	37.20	100.10	38.07	7.55	15.69	11.99
1964	36.80	8.25	10.53	8.50	8.50	7.50	7.00	13.23	161.84	141.20	38.89	24.97	10.15
1965	78.73	9.74	8.00	9.00	9.00	10.00	9.84	41.03	229.61	316.87	203.97	53.10	40.90
1966	37.03	26.32	15.40	14.00	12.00	11.00	11.77	82.77	139.06	86.20	21.26	16.09	7.34
1967	41.85	11.75	11.08	11.16	7.82	8.54	22.81	58.50	127.23	154.03	38.68	24.84	25.20
1968	57.75	10.31	8.98	8.11	8.40	8.09	9.47	22.37	191.84	290.50	59.39	57.45	18.43
1969	56.05	11.24	13.03	9.54	7.26	7.06	7.30	93.69	256.90	144.40	69.00	26.61	23.50
1970	60.60	23.23	17.53	11.26	10.18	9.25	10.32	19.67	286.87	201.67	62.42	25.81	45.33
All years	47.57	14.85	12.38	10.17	9.18	8.88	10.83	49.19	180.35	169.35	57.27	27.21	19.74

Note: Mean value for all years is the mean of the annual or monthly values for individual years.

Table 12. Example data table for results of annual and monthly median discharge computation

Station 09113300 Ohio Creek at Baldwin

Water year	Annual and Monthly Median Discharges, in Cubic Feet Per Second												
	Annual	October	November	December	January	February	March	April	May	June	July	August	September
1959	12.00	11.00	11.00	12.00	11.00	10.00	8.80	18.50	128.00	144.00	22.00	16.00	7.10
1960	14.00	19.00	19.00	11.00	10.00	9.00	8.00	81.50	122.00	168.00	29.00	13.00	8.00
1961	13.00	12.00	10.00	10.00	10.00	9.00	9.00	21.00	148.00	114.00	15.00	16.00	25.00
1962	17.00	22.00	16.00	12.00	11.00	12.00	14.00	54.50	217.00	240.00	75.00	27.00	10.00
1963	9.00	9.40	7.50	5.50	5.00	5.00	5.00	35.00	101.00	36.50	7.80	15.00	12.00
1964	10.00	7.20	11.00	8.50	8.50	7.50	7.00	7.25	149.00	130.00	33.00	23.00	10.00
1965	11.00	10.00	8.00	9.00	9.00	10.00	10.00	13.00	195.00	312.50	220.00	51.00	37.00
1966	15.00	24.00	16.00	14.00	12.00	11.00	10.00	77.00	135.00	86.00	15.00	14.00	6.30
1967	18.00	11.00	11.00	9.00	8.00	8.50	20.00	55.00	114.00	145.50	38.00	20.00	22.00
1968	14.50	9.20	9.00	8.00	8.50	8.00	8.50	22.00	128.00	305.00	59.00	55.00	18.00
1969	15.00	11.00	13.00	9.80	7.20	7.10	7.40	57.50	254.00	130.00	65.00	26.00	24.00
1970	21.00	23.00	17.00	11.00	10.00	9.50	10.00	14.00	301.00	209.00	57.00	24.00	33.00
All years	14.25	11.00	11.00	9.90	9.50	9.00	8.90	28.50	141.50	144.75	35.50	21.50	15.00

Note: Median value for all years is the median of the annual or monthly values for individual years.

Table 13. Example data table for results of frequency computation using annual and monthly mean discharges

Station 09113300 Ohio Creek at Baldwin

Frequency-Curve Data for May Mean Discharge

Annual exceedance probability	Recurrence interval (years)	May mean discharge, in cubic feet per second
0.995	1.005	73.4
0.99	1.01	79.1
0.95	1.05	97.6
0.9	1.11	109.7
0.8	1.25	126.6
0.5	2	168.7
0.2	5	228.0
0.1	10	268.6
0.04	25	321.2
0.02	50	361.5
0.01	100	402.8
0.005	200	445.3

FREQUENCY CURVE PARAMETERS—LOG-PEARSON TYPE III

	Logarithmic value		
	Mean	Standard deviation	Skew
Systematic record	2.232	0.152	0.179

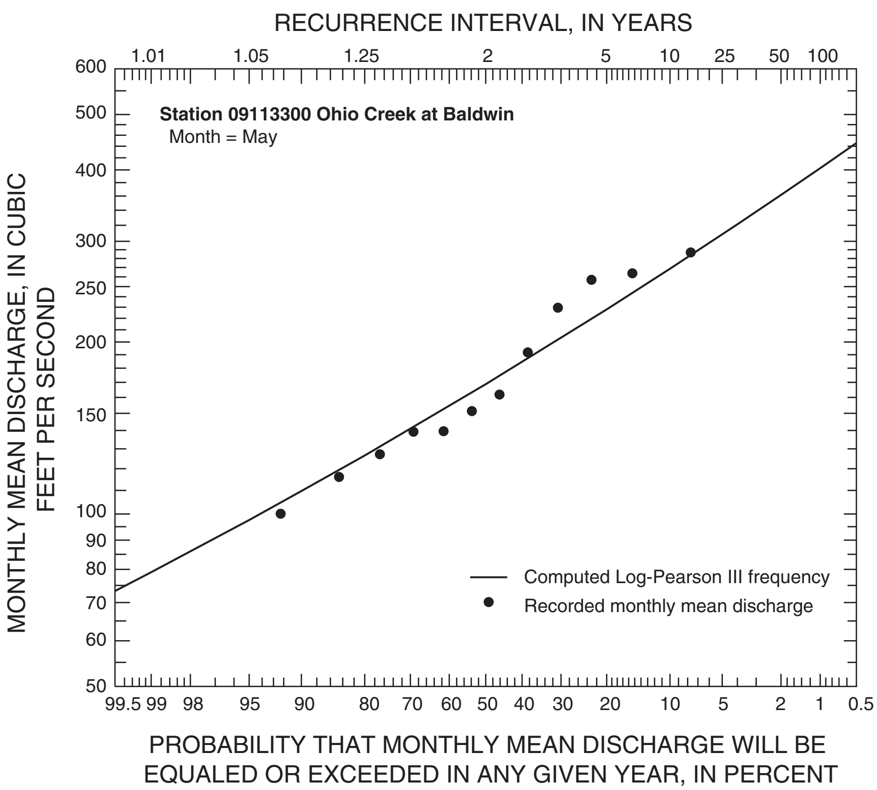

Figure 9. Example graph for results of frequency computation using annual and monthly mean discharges.

and accessed May 10, 2002, at URL http://water.usgs.gov/admin/memo/SW/sw70.07.html). The adjustment for zero discharges in the frequency analysis has the greatest effect on estimated discharges for the smallest nonexceedance probabilities (table 10).

Objective 4—Mean and Median Discharge on an Annual and Monthly Basis

The annual and monthly mean and median discharges also were computed from daily mean discharges by using the univariate procedure of the SAS software (SAS Institute, Inc., 1990). The statistics were computed only for years and months with complete daily discharge record. Examples of the data tables provided in the Excel files are shown in tables 11 and 12. The annual and monthly mean and median discharges for all years in the data tables (last row, tables 11 and 12) are the mean and median of the annual and monthly values for the individual years. In the case of mean, the annual and monthly means for all years are about equal to the annual and monthly means computed from daily mean discharges; however, in the case of median, the annual and monthly medians for all years usually are not about equal to the annual and monthly medians computed from daily mean discharges.

Frequency of Annual and Monthly Mean and Median Discharges

Frequency analysis of the annual and monthly mean and median discharges was completed using the PEAKFQ program with the options that enabled a simple LP3 frequency analysis without the enhancements described in Bulletin 17B (U.S. Interagency Advisory Committee on Water Data, 1982). The PEAKFQ program was used instead of the SWSTAT program because PEAKFQ provides a simpler method of data handling. Low-outlier criteria were used; the criteria were computed by the PEAKFQ program for each individual station based on the available input data.

Annual and Monthly Mean

Each Excel file showing results for flow duration of daily mean discharge computed on an annual and monthly basis contains 13 worksheets: one worksheet is for the annual computation and twelve worksheets are for each month of the year. An example of the data table for frequency computation of annual and monthly mean discharges is shown in table 13 and contains the following components:

1. The station number and name.
2. A list of standard annual exceedance probabilities and recurrence intervals and the estimated annual or monthly mean discharges for each listed exceedance probability and recurrence interval.
3. The computed parameters, in logarithmic units, for the LP3 distribution; these results exclude any low outliers.
4. A graph showing the LP3 frequency curve is presented to the right of the Excel data table; an example graph is shown in figure 9.

Annual and Monthly Median

Each Excel file showing results for flow duration of daily mean discharge computed on an annual and monthly basis contains 13 worksheets: One worksheet for the annual computation and one worksheet for each month of the year. An example of the data table for frequency computation of annual and monthly median discharges is shown in table 14 and contains the following components:

1. The station number and name.
2. A list of standard annual exceedance probabilities and recurrence intervals and the estimated annual or monthly median discharges for each listed exceedance probability and recurrence interval.
3. The computed parameters, in logarithmic units, for the LP3 distribution; these results exclude any low outliers.
4. A graph showing the LP3 frequency curve presented to the right of the Excel data table; an example graph is shown in figure 10.

The example for frequency of annual and monthly median discharge is intended to show the effect of low outliers in the analysis. When low outliers are removed from a data set, a conditional probability adjustment needs to be applied (U.S. Interagency Advisory Committee on Water Data, 1982, p. 17–19, Appendix 5); this adjustment is similar to the adjustment made to the N-day low-flow frequency when zero discharges were in the record. The resulting outputs from the PEAKFQ and SWSTAT programs, however, are somewhat different. The output data (table 14) and frequency curve (fig. 10) reflect the conditional probability adjustment.

Table 14. Example data table for results of frequency computation using annual and monthly median discharges

Station 09113300 Ohio Creek at Baldwin Frequency Curve Data for December Median Discharge		
Annual exceedance probability	**Recurrence interval (years)**	**December mean discharge, in cubic feet per second**
0.995	1.005	--
0.99	1.01	--
0.95	1.05	--
0.9	1.11	8.0
0.8	1.25	8.6
0.5	2	10.0
0.2	5	11.7
0.1	10	12.7
0.04	25	13.9
0.02	50	14.8
0.01	100	15.7
0.005	200	16.6

FREQUENCY CURVE PARAMETERS—LOG-PEARSON TYPE III

	Logarithmic value		
	Mean	**Standard deviation**	**Skew**
Systematic record	1.002	0.078	0.223

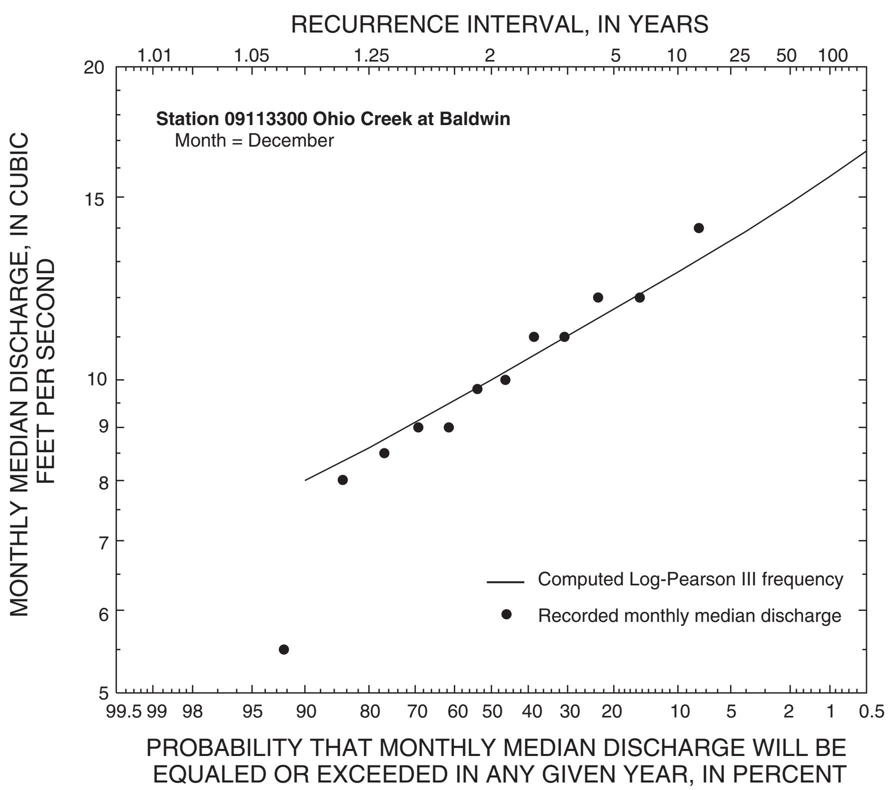

Figure 10. Example graph for results of frequency computation using annual and monthly median discharges.

SUMMARY

The Land and Resources Management Plan (LRMP) for the Grand Mesa, Uncompahgre, and Gunnison National Forests (study area) in Colorado was completed in 1983 and was substantially revised in 1991. Since completion of the 1983 LRMP, the study area has experienced increases in population growth and development of private land, increases in recreational use, and changes in the demand and use of natural resources. Because the LRMP has not been revised for a number of years and because of the changes in resource knowledge and use, the Grand Mesa, Uncompahgre, and Gunnison National Forests are in the process of revising their LRMP.

The Grand Mesa, Uncompahgre, and Gunnison National Forests managers have identified a need for (1) scientifically based streamflow data to support instream flow analysis that is acceptable to all interested parties and (2) an analysis of streamflow data in order to describe and understand the seasonal and annual variability. To provide the needed streamflow data and analysis, the U.S Geological Survey (USGS), in cooperation with the Grand Mesa, Uncompahgre, and Gunnison National Forests, began a study in 2000 to develop selected streamflow characteristics for streamflow-gaging stations in and near the study area.

The purpose of this report is to present the compiled daily, monthly, and annual mean discharge data for 60 stations from the beginning of available daily discharge data through water year 2000 and results for the following computed streamflow characteristics:

1. Instantaneous peak-flow frequency computed for 45 stations using the log-Pearson type III (LP3) distribution. The results include the annual instantaneous peak discharges that have a 1.5- and 2.33-year recurrence interval along with the corresponding stages (gage-heights) taken from the most recent or last rating curve in use.
2. Flow duration computed for daily mean discharges on (a) an annual (water year) basis and (b) a monthly basis; these analyses were made for all 60 stations. Additional results include flow duration computed for annual and monthly mean discharges for 28 stations.
3. N-day low-flow and high-flow frequency computed for daily mean discharges using the LP3 distribution; these analyses were made for 1, 3, 7, 15, 30, 60, 120, and 183 consecutive days and for 43 stations.
4. Annual and monthly mean and median discharges for each year and month of record computed from the daily mean discharge data; these analyses were performed for all 60 stations. In addition, results for frequency of the annual and monthly mean and median annual discharges computed for 43 stations using the LP3 distribution.

The study area is located in southwestern Colorado within the Gunnison River, Dolores River, and Plateau Creek Basins, which are tributaries of the Colorado River. The area comprises about 12,890 mi^2 within the three drainage basins; however, the area within the Grand Mesa, Uncompahgre, and Gunnison National Forests is only about 4,940 mi^2 (about 3,161,600 acres). Elevations range from about 4,600 ft at Grand Junction to about 14,000 ft at several mountain peaks near Lake City and Ouray. The large range in elevation and presence of numerous mountain ranges have a profound effect on precipitation, which ranges from about 8 inches per year at Grand Junction to about 40 inches per year in mountains along the Continental Divide. Winter precipitation results in accumulation of mountain snowpacks with 10 to 25 inches of water equivalent; melting of the snowpack during April through July results in about 50 to 80 percent of the annual streamflow.

The cooperative study with the Grand Mesa, Uncompahgre, and Gunnison National Forests required that results of the streamflow characteristics analyses be provided in digital (computerized) format; hence, all discharge data and results from the four study objectives are presented in Microsoft Excel workbooks (Excel files) on the enclosed CD-ROM. Data on the CD-ROM are arranged in a directory structure based on the four report purposes (study objectives).

REFERENCES

Chaney, T.H., Kuhn, Gerhard, Brooks, Tom, and others, 1987, Hydrology of Area 58, Northern Great Plains and Rocky Mountain coal provinces, Colorado and Utah: U.S. Geological Survey Water-Resources Investigations/Open-File Report 85–479, 103 p.

Clayton, B.S., 1912, The flood of October 5, 1911, in southwestern Colorado: Denver, Colorado State Engineer, Sixteenth Biennial Report, chap. XI, p. 127–129.

Colorado Climate Center, compiler, 1984, Colorado average annual precipitation, 1951–1980: Reston, Va., U.S. Geological Survey, 1 sheet, scale 1:500,000.

Federal Register, 1999, Revised land and resource management plan, Grand Mesa, Uncompahgre, and Gunnison National Forests, CO: Federal Register, September 28, 1999, v. 64, no. 187, p. 52266–52273.

Fenneman, N.M., 1931, Physiography of western United States: New York, McGraw-Hill, 534 p.

Kuhn, Gerhard, and Nickless, R.C., 1994, Use of frequency analysis and the extended streamflow prediction procedure to estimate evacuation dates for the joint-use pool of Pueblo Reservoir, Colorado: U.S. Geological Survey Water-Resources Investigations Report 94–4054, 46 p.

Rantz, S.E., and others, 1982a, Measurement and computation of streamflow–Volume 1, measurement of stage and discharge: U.S. Geological Survey Water-Supply Paper 2175, p. 1–284.

———1982b, Measurement and computation of streamflow—Volume 2, computation of discharge: U.S. Geological Survey Water-Supply Paper 2175, p. 285–631.

Richter, B.D., Kircher, J.E., Remmers, M.A., and Forst, B.A., 1984, Summary of basin and streamflow characteristics for selected basins in western Colorado and adjacent States: U.S. Geological Survey Open-File Report 84–137, 266 p.

SAS Institute, Inc., 1990, SAS procedures guide, version 6, third edition: Cary, N.C., SAS Institute Inc., 705 p.

U.S. Department of Agriculture, 2002a, About the NEPA/NFMA homepage: USDA Forest Service NEPA, NFMA and Appeals, accessed May 10, 2002, at URL http://www.fs.fed.us/forum/nepa/aboutnepanfma.html.

U.S. Department of Agriculture, 2002b, Forest planning on the Grand Mesa, Uncompahgre, and Gunnison National Forests: Grand Mesa, Uncompahgre and Gunnison National Forests homepage, accessed May 10, 2002, at URL http://www.fs.fed.us/r2/gmug/policy/plan_rev/index.shtml.

U.S. Department of Agriculture, 2002c, National Forest Management Act of 1976: Forest Service, accessed May 10, 2002, at URL http://www.fs.fed.us/forum/nepa/nfmalaw.html.

U.S. Environmental Protection Agency, 2002, National Environmental Policy Act: Office of Federal Activities, accessed May 10, 2002, at URL http://ceq.ch.doc.gov/nepa/regs/nepa/nepacquia.htm.

U.S. Geological Survey, 2002a, PEAKFQ—Flood-frequency analysis based on Bulletin 17B: U.S. Geological Survey Water Resources Applications Software, accessed May 13, 2002, at URL http://water.usgs.gov/software/peakfq.html.

U.S. Geological Survey, 2002b, SWSTAT—Surface-water statistics: U.S. Geological Survey Water Resources Applications Software, accessed May 13, 2002, at URL http://water.usgs.gov/software/swstat.html.

U.S. Interagency Advisory Committee on Water Data, 1982, Guidelines for determining flood flow frequency: Hydrology Subcommittee, Bulletin 17B, 28 p., 14 apps. [Available from the National Technical Information Service as report PB–86–157278/AS]