

January 24, 2003

MEMORANDUM

TO: Hoh River Geomorphology Investigation Team
Attention: Jennifer Bountry, P.E. and Timothy Randle, P.E., D-8540

FROM: John F. England, Jr., P.H., P.E., Hydraulic Engineer
Technical Service Center
Flood Hydrology Group, D-8530

SUBJECT: Flood Frequency, Flow Duration and Precipitation Analyses - Hoh River
Geomorphology Investigation

The attached final report summarizes flood frequency, flow duration and precipitation estimates within the Hoh River Watershed, Washington. The report finalizes preliminary draft estimates that were made in February 2000. The primary basis for the flood frequency and flow duration estimates are U.S. Geological Survey peak discharge and mean daily flow records. National Weather Service records, obtained from the Western Regional Climate Center, were used to compute precipitation statistics. The data and results presented in the report are appropriate for detailed hydraulic and geomorphic studies and analyses.

This report has been prepared by John F. England, Jr. and has been reviewed by Robert E. Swain, in accordance with Technical Service Center Peer Review guidelines.

If you have any questions about the contents of this report, please contact John England by phone at (303) 445-2541 or email at jengland@do.usbr.gov.

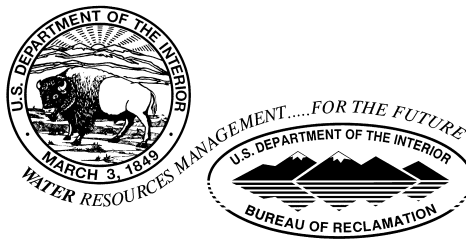
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TECHNICAL SERVICE CENTER
Denver, Colorado

**FLOOD FREQUENCY, FLOW DURATION AND PRECIPITATION
ANALYSES**

**HOH RIVER GEOMORPHOLOGY INVESTIGATION
OLYMPIC PENINSULA, WASHINGTON**

U.S. Department of the Interior
Bureau of Reclamation



JANUARY 2003

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Prepared by

John F. England, Jr., P.H., P.E.
Hydraulic Engineer

Flood Hydrology Group, D-8530
Technical Service Center
Denver, Colorado

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**Flood Frequency, Flow Duration And Precipitation Analyses
Hoh River Geomorphology Investigation
Olympic Peninsula, Washington**

PREPARED BY:

John F. England, Jr., P.H., P.E.
Hydraulic Engineer
Flood Hydrology Group (D-8530)

DATE: _____

**PEER
REVIEWED BY:**

Robert E. Swain, P.E.
Technical Specialist-Flood Hydrology
Flood Hydrology Group (D-8530)

DATE: _____

1.00 INTRODUCTION

This report summarizes flood frequency, flow duration and precipitation estimates for the Hoh River at Highway 101 (river mile 14.8) near Forks, Washington. These estimates were completed as part of the Hoh River Geomorphology Investigation. The primary basis for the flood frequency and flow duration estimates are U.S. Geological Survey peak discharge and mean daily flow records. National Weather Service records were used to compute precipitation statistics. Streamflow and precipitation gages used in the study are shown in Figure 1. The data and results presented herein are appropriate for detailed hydraulic and geomorphic studies and analyses.

Three analysis techniques were utilized for the Hoh River geomorphology investigation: (1) frequency analysis of flood peak discharge estimates at a site; (2) mean daily flow-duration estimates; and (3) computing precipitation statistics. In the context of the Hoh River geomorphology investigation, peak flow frequency estimates can be used for estimating stream bed shear stress and stream power (e.g., Costa and O'Connor, 1995). Flow-duration curves can be used to infer median river flow in a "typical" or "hypothetical" year, determine instream flow requirements for habitat (e.g., Milhous et al., 1990). Precipitation statistics can be used to understand the distribution and magnitude of precipitation in different seasons and years.

2.00 STREAMFLOW AND PRECIPITATION DATA

The U.S. Geological Survey has been collecting streamflow data in Washington and the Olympic Peninsula since the late 1800s. Washington streamflow records prior to 1951 are summarized in Parker and Lee (1923), Grover and Parker (1940), and USGS (1955). Since that time, records have been summarized in Water-Supply Papers and are now listed in annual Water Resources Data reports (e.g., Wiggins et al., 1998). Streamflow data used in this study were obtained directly from the USGS National Water Information System (NWIS) Database. These data were cross-checked with those published in USGS Water-Data Reports and Water-Supply Papers, including: USGS (1937, 1955, 1971), and Wiggins et al. (1998).

Currently, the only active gaging station in the Hoh River basin, with data published by the USGS, is the Hoh River at U.S. Highway 101 near Forks (Wiggins et al., 1998). This gage accounts for approximately 85 percent of the total Hoh River drainage basin area, which is approximately 299 mi² at the mouth (Lum, 1986 p. 3). Streamflow data from this station were used in flood frequency and flow duration analyses. In addition, the peak discharge data from a discontinued gage on the Hoh River near Forks (Table 1), located slightly upstream of the active gage, were combined with the Highway 101 gage to estimate peak discharge exceedance probabilities. The locations of the two gages are shown in Figure 1. The largest floods recorded at these two stations are listed in Table 2. Because of the difference in drainage area, records from the Forks gage were adjusted to the Highway 101 gage using equation (1) (e.g., Sumioka et al., 1998) with the exponent derived from overlapping records from 1960 to 1964 at the two gages (Appendix A).

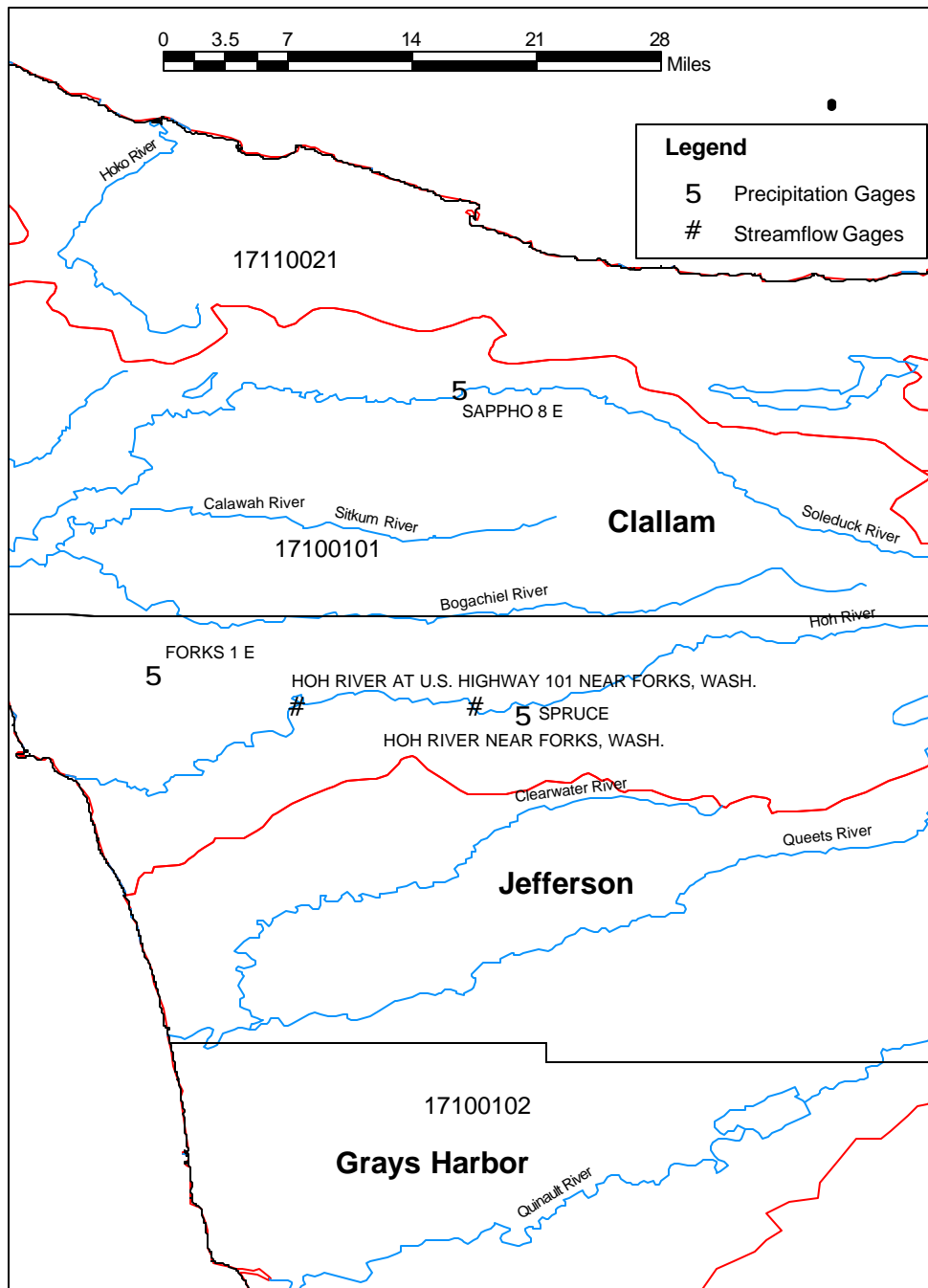


Figure 1: Location of streamflow gaging stations and precipitation gages analyzed in the study.

$$Q_{Highway101} = Q_{Forks} \left(\frac{A_{Highway101}}{A_{Forks}} \right)^{0.815} \quad (1)$$

Table 1: U.S. Geological Survey streamflow gaging stations analyzed in this study

USGS Gaging Station No.	Station Name	Drainage Area	Lat.	Long.	Gage Elevation (feet, NGVD)	Hydrologic Unit Code	Period of Record (Water Years)	Years Analyzed (length)
12041000	Hoh River near Forks (Spruce), WA	208 mi ²	47°48'25"	124°06'20"	320	17100101	1927-1964	1927-1960 (34)
12041200	Hoh River at U.S. Highway 101 near Forks, WA	253 mi ²	47°48'25"	124°14'59"	163.64	17100101	1961-2001	1961-2001 (41)

Table 2: Largest floods at U.S. Geological Survey streamflow gaging stations analyzed in this study

USGS Gaging Station No.	Station Name	Period of Record (Water Years)	Largest Peak Discharge and Date	Second Largest Peak Discharge and Date	Third Largest Peak Discharge and Date
12041000	Hoh River near Forks (Spruce), WA	1927-1960	38,700 ft ³ /s 11/26/1949	36,100 ft ³ /s 11/05/1934	33,600 ft ³ /s 11/03/1955
12041000	Hoh River at U.S. Highway 101 near Forks, WA	1961-2001	54,500 ft ³ /s 11/24/1990	51,600 ft ³ /s 12/17/1979	51,100 ft ³ /s 12/26/1980

Historical information obtained directly from USGS (1937, 1955) was used to supplement peak discharge estimates and extend record lengths back to 1891 for peak flow frequency estimation. The gaging station observer noted that the November 5, 1934 flood stage and discharge was higher than any other time since 1891 based on his past 43 years of residence and local observations of the stream (USGS, 1937 p. 24). A higher stage and discharge than the November 1934 peak was recorded on November 26, 1949. According to USGS records, the November 1949 flood is the maximum stage known since at least 1891 (USGS, 1955 p. 55). This statement means that since water year 1891, flood stages and discharges not recorded by any gages are lower in magnitude than the November 1949 flood. No large flood occurred in 1891 of comparable magnitude to 1949, and there is no additional historical information to document any large floods (or lack of large floods) occurred prior to 1891. The November 1949 flood was used to incorporate a historical period to 1891 in the flood frequency analysis. The historical and combined gage records consist of 75 years of peak flows and 37 years with unknown peak flows less than 45,400 ft³/s. A combined peak flow time series for the two sites is shown in Figure 2.

Precipitation records used in this study were obtained from the National Climatic Data Center (NCDC) Climate Database records. These records were obtained on compact discs from Hydrosphere Corporation, and from the Western Regional Climate Center at the Desert Research Institute (<http://www.wrcc.dri.edu/CLIMATEDATA.html>). Gages that are within the National Weather Service (NWS) Cooperative Network were analyzed. The data are located in the NWS climatic division WA-01 Western Olympic Coastal. Data from three stations were analyzed as part of this study (Table 3); the locations of these gages are shown in Figure 1. These were the only stations closest to the Hoh River basin that had at least 10 years of precipitation data. One station (Spruce) is located within the Hoh River basin.

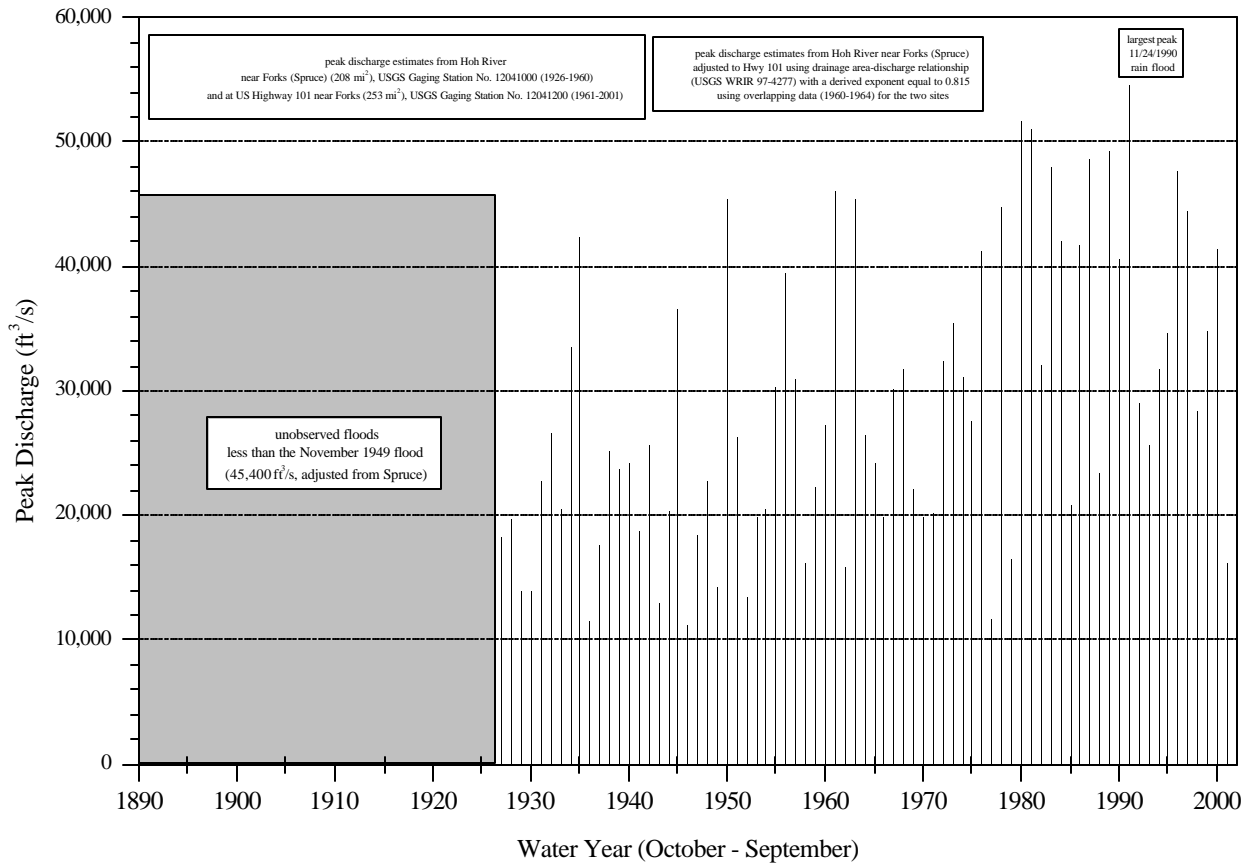


Figure 2: Combined peak discharge time series for the Hoh River at U.S. Highway 101 near Forks, WA.

Table 3: NWS cooperative network precipitation gaging stations analyzed in this study

COOP No.	Division No.	Station Name	Lat	Long	Elev. (ft, NGVD)	Period of Record	Years Analyzed (length)
2914	WA-01	Forks 1E	47°57'00"	124°22'00"	350	1931-present	1931-2001 (71)
7319	WA-01	Sapho 8E	48°04'00"	124°07'00"	760	1948-1997	1953-1996 (44)
7987	WA-01	Spruce	47°48'00"	124°04'00"	370	1931-1980	1931-1980 (50)

3.00 FLOOD FREQUENCY ESTIMATES

Flood frequency estimates were made for peak discharge. The data were assumed to follow a log-Pearson Type III (LP-III) distribution. The method of moments was used to estimate the LP-III parameters for peak discharge estimates using Expected Moments Algorithm (EMA) techniques (Cohn et al., 1997; England, 1999). The EMA procedure is an alternate method to IACWD (1982) for utilizing historical peak discharge information. Cohn et al. (1997) and England (1998) showed that the EMA estimator is an improvement over IACWD historical procedures. In the absence of historical information, EMA is identical to the Bulletin 17B parameter estimation (Cohn et al., 1997). Confidence intervals were estimated using the approach in Cohn et al. (2001). Because the record length was relatively long (111 years), no regional skew weighting was performed and an at-site estimate of the station skewness coefficient was used.

As discussed above, peak discharge data utilized to estimate flood frequency consist of annual peaks and historical data shown in Figure 2. A peak discharge frequency curve was constructed for flows on the Hoh River at Highway 101 (Figure 3) based on the 75 years of peak discharge and 37 years of censored data presented above. The data are sufficient to define flood frequency relations to the 1 in 100 annual exceedance probability (100-year flood); the model and confidence intervals are tentatively extrapolated to 1 in 200. The EMA LP-III final parameters (\log_{10}) are: 4.412 (mean); 0.174 (standard deviation); and -0.217 (skew coefficient). The LP-III model mean flow estimate is 25,900 ft³/s. Peak discharge flood frequency relations are summarized in Table 4. From these results, a peak flow estimate for the 1.5-year flood is 22,000 ft³/s, with a 95-percent probability that on average the true value of the 1.5-year peak is between 20,200 and 23,900 ft³/s. The mean peak flow is slightly smaller than the median peak flow estimate (50%) presented in Table 4 because the flood frequency distribution is skewed (Figure 3). Model input and output is attached as Appendix B.

The flood frequency results indicate that the two largest floods recorded since 1927 (November 1990 and December 1979) have an exceedance probability less than about 1 in 50. The estimated frequency curve starts to depart from the trend of the data for exceedance probabilities less than 0.05 (20-year flood). Based on the peak discharge frequency relation, there is a 95 percent chance that flows with an annual exceedance probability of 1 in 100 are less than about 74,300 ft³/s. These estimates are less than those presented in Sumioka et al. (1998) for extreme floods. For the 100-year flood (exceedance probability 0.01), Sumioka et al.'s weighted peak discharge estimate was 71,500 ft³/s; 95 percent confidence intervals were 60,500 ft³/s and 90,100 ft³/s (Sumioka et al. 1998, p. 37).

Table 4: Peak discharge frequency estimates for the Hoh River at U.S. Highway 101 near Forks, WA

Annual Exceedance Probability (%)	Return Period (years)	Peak Discharge (ft ³ /s)		
		LP-III Model Estimate	5% Confidence Limit	95% Confidence Limit
75	1.33	19,900	18,100	21,700
66.7	1.5	22,000	20,200	23,900
50	2	26,200	24,200	28,400
20	5	36,400	33,700	39,300
10	10	42,800	39,500	46,700
4	25	50,600	46,300	57,200
2	50	56,200	50,600	65,600
1	100	61,700	54,400	74,300
0.5	200	67,000	57,700	83,500

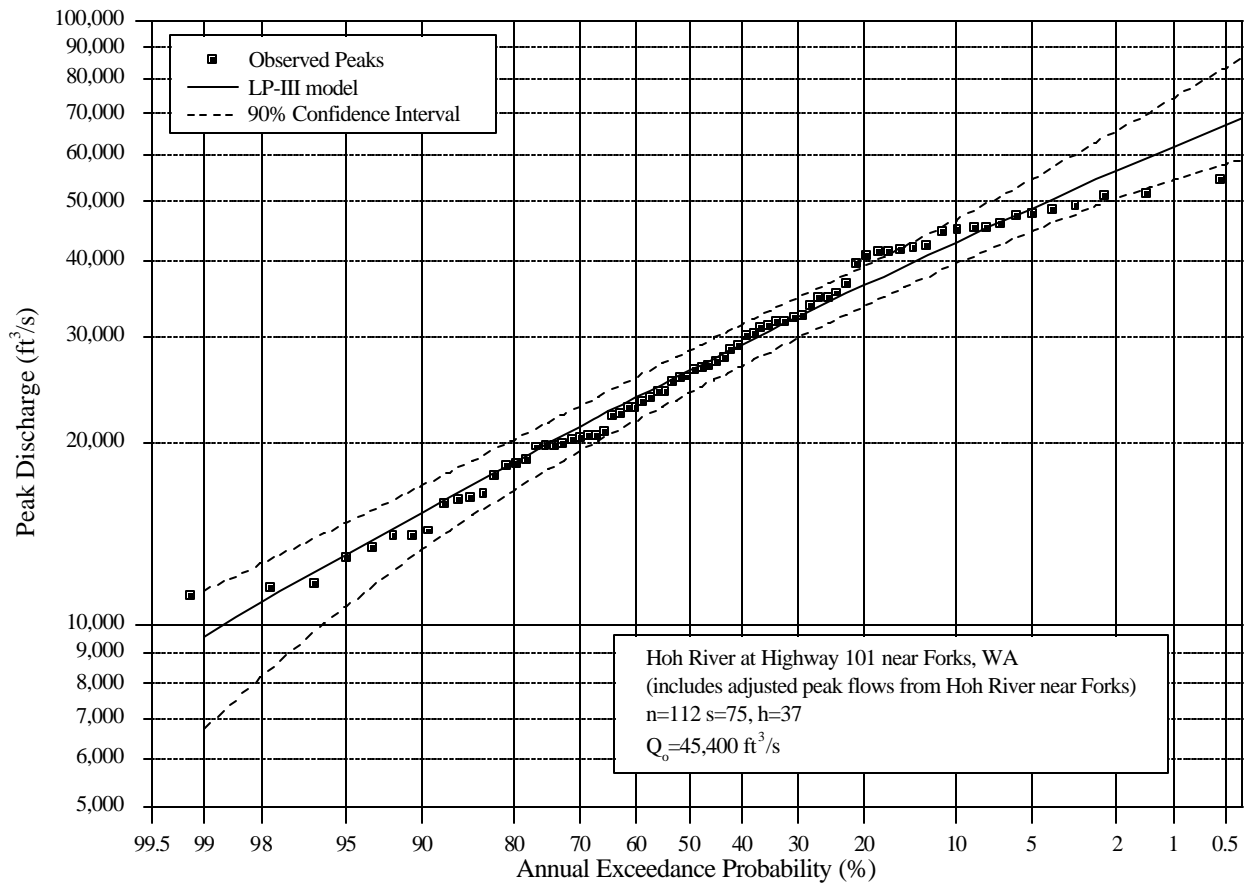


Figure 3: Annual peak discharge frequency curve for the Hoh River at U.S. Highway 101 near Forks, WA.

The geomorphic and hydraulic reaches of interest are along the Hoh River. Flood frequency estimates made for the Hoh River at Highway 101 (Table 4) can be transferred to other locations on the Hoh River main channel with similar characteristics using equation 2 (Sumioka et al., 1998) with the exponent in this equation presented for Region 1 which includes the Hoh River. If the drainage area at the ungaged site is between 50 and 150% of the drainage area at Highway 101 (253 mi²), the flood frequency estimates in Table 4 can be applied to sites on the Hoh River with drainage areas ranging from 126.5 to 299 mi² using equation 2.

$$Q_{Ungaged} = Q_{Highway101} \left(\frac{A_{Ungaged}}{A_{Highway101}} \right)^{0.92} \quad (2)$$

If flood frequency estimates are needed for other locations within the watershed that have differing characteristics than near Forks, and/or for sites with drainage areas outside this range, it is recommended that the regional regression equations for ungaged sites within Region 1 (Sumioka et al., 1998 p. 89) be used. In those equations the major factors are drainage area and mean annual precipitation. Approximate mean annual precipitation estimates for the watershed are presented in Section 5.00 of this report. It is recommended that the computer program National Flood Frequency (NFF) version 3.0 (Ries and Crouse, 2002) be used to make these estimates as needed.

4.00 FLOW DURATION ESTIMATES

Mosley and McKerchar (1993, p. 8.27) provide a definition for flow duration: “A flow-duration curve (FDC) plots cumulative frequency of discharge, that is, discharge as a function of the percentage of time that the discharge is exceeded. It is not a probability curve, because discharge is correlated between successive time intervals, and discharge characteristics are dependent on the season of the year.” Searcy (1959) and Vogel and Fennessey (1994) describe the theory and methods to construct flow-duration curves (FDCs). Flow-duration curve applications are presented and reviewed by Searcy (1959) and Vogel and Fennessey (1995).

Two types of simple FDCs were constructed using the Hoh River at Highway 101 gage: period-of-record FDCs and seasonal FDCs. The period-of-record FDC was constructed using flow data for the entire period of record that the gaging station has been in operation (1961-2001). The seasonal FDC was constructed from all the data from the period of record for a particular season or month. Three seasonal FDCs were estimated: for the November-April winter season, for the May-June spring season, and for the July through October summer season. In addition, an FDC was estimated for each month. These period-of-record and seasonal FDCs are dependent on the period used. In a strict sense, the flow-duration curve applies only to the period (1961-2001) for which data were used to develop the curve (Searcy, 1959 p. 2). The data from the Forks gage were not transferred to the Highway 101 location because there is no simple way to transfer mean daily flow estimates for all days and seasons.

The cumulative distribution function (CDF) of the FDC was estimated directly via techniques outlined in Vogel and Fennessey (1994). The period-of-record FDC was estimated using three steps:

1. separate out the s mean daily flows for each season and year i of the n years of record ($i = 1, \dots, n$);
2. combine the s seasonal flows for each year i into a single series (ns) and rank the entire seasonal mean daily flow $q(j)$ series ($j = 1, \dots, ns$), from largest to smallest magnitude; and
3. utilize a plotting position (equation 1) to estimate the percentage of time $p(j)$ a particular flow $q(j)$ was equaled or exceeded.

$$p(j) = \left(\frac{j}{ns + 1} \right) 100; \quad j = 1, \dots, ns \quad (1)$$

Note that $q(1)$ is the largest observation and $q(ns)$ is the smallest mean daily streamflow observation. Likewise, $p(1)$ and $p(ns)$ are the smallest and largest percent exceedances, respectively. For the period of record analysis, one can just rank all the data directly.

Streamflow seasonality for the Hoh River is shown in Figure 4. Overall, mean daily streamflow on the Hoh River is slightly bimodal. Winter floods produce larger peaks, maximum mean and median daily flows. However, median flows are nearly as high during the late spring (June) snowmelt runoff period.

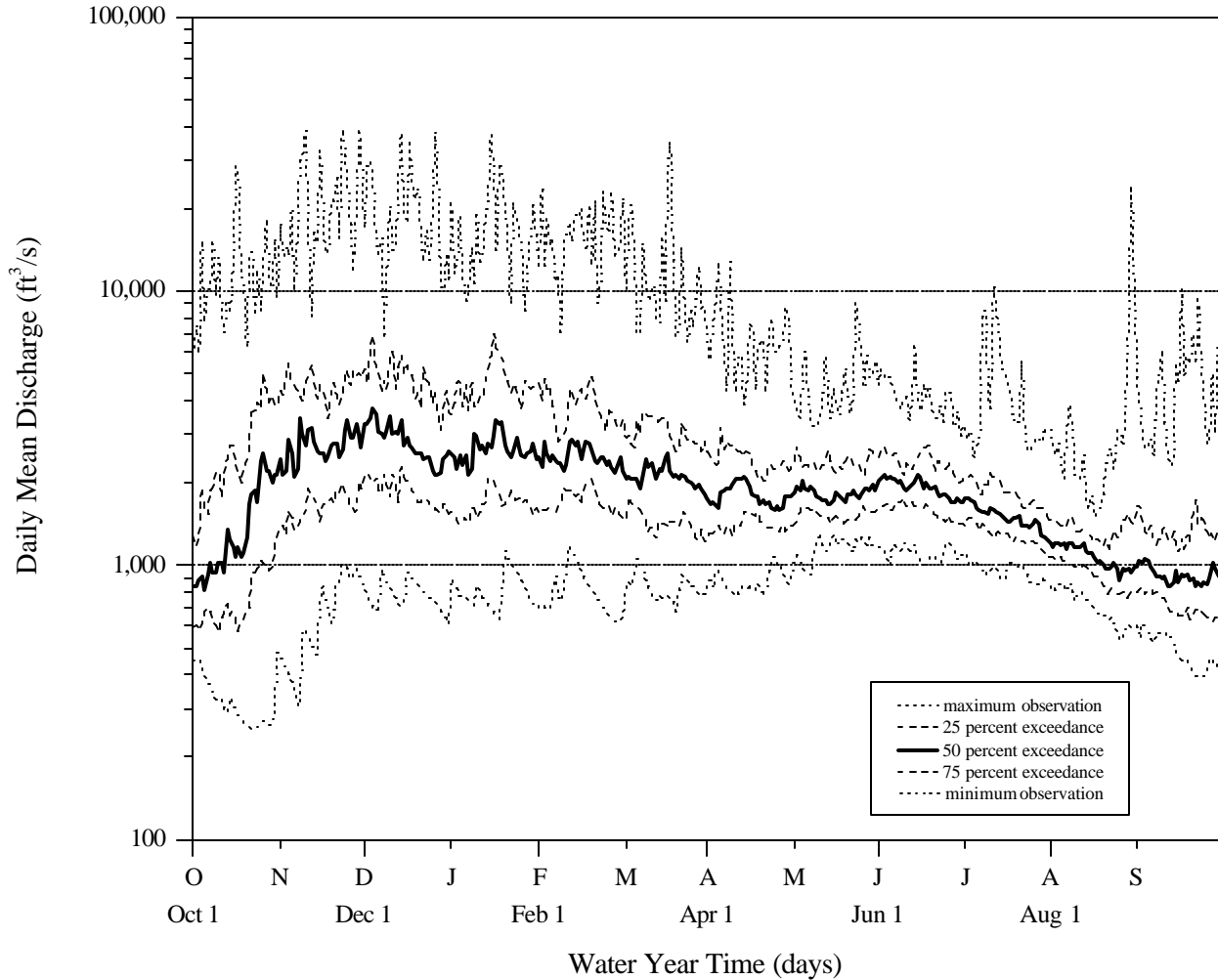


Figure 4: Mean daily flow duration hydrograph for the Hoh River at U.S. Highway 101 near Forks, water years 1961-2001.

Flow-duration curves were made for period-of-record annual, seasonal and monthly FDCs. The period-of-record annual FDC (Figure 5) shows that mean daily flows are greater than about 1,260 ft³/s 75 percent of the time. The median flow (50 percent) is 1,810 ft³/s for the water year. Mean daily flows for the November-April season are nearly always greater than the two other selected seasons, except for the lower flow periods that are dominated by relatively higher flows in May and June. In addition, daily flows during the July-October season are usually lower than flows in any other season for a given percentile (Figure 5), except that the highest flows for this season are larger than the spring runoff. Specific FDC percentiles of daily mean discharge for the year and each of the three seasons are summarized in Table 5. Mean daily flow statistics for individual months are attached as Appendix C.

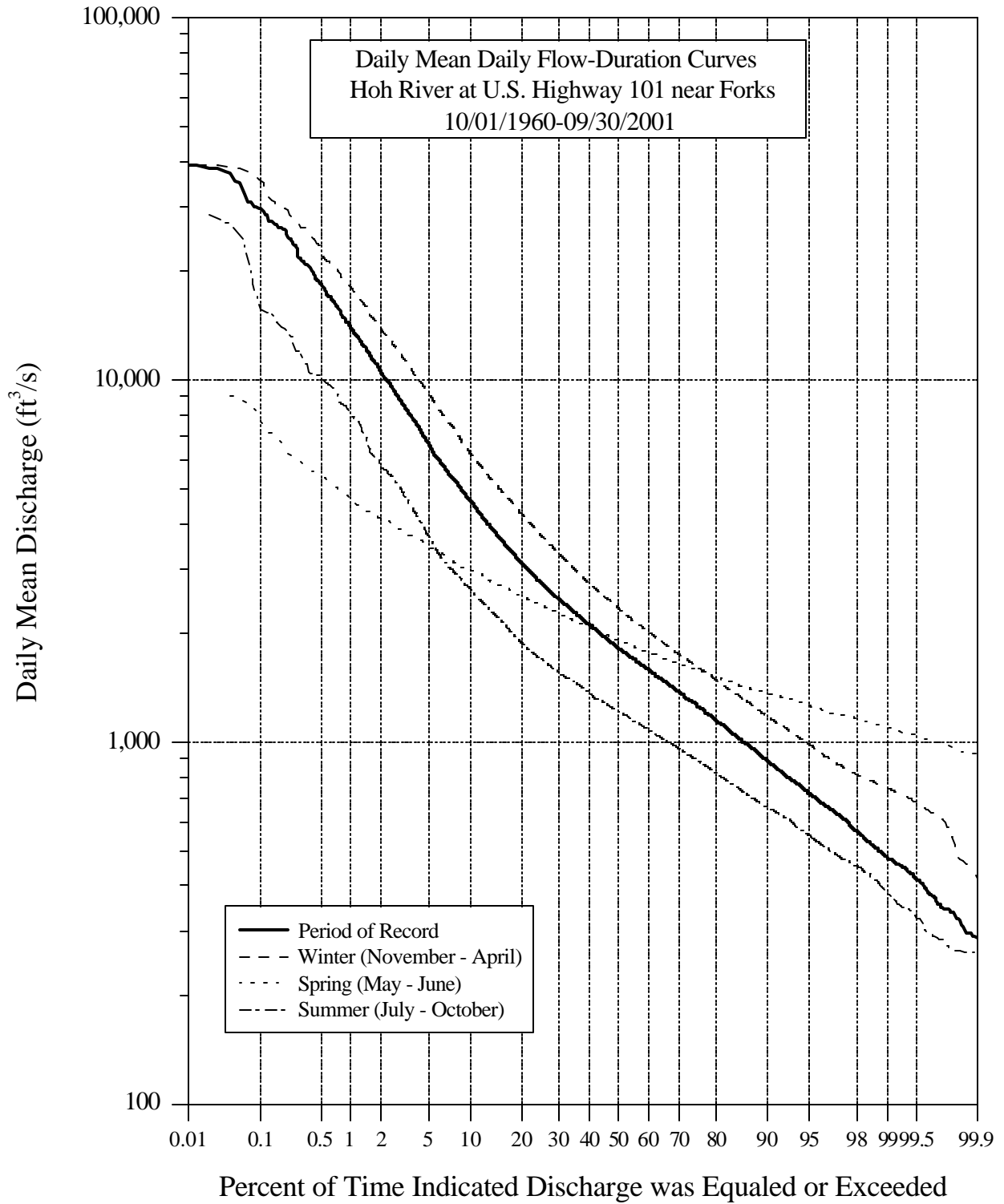


Figure 5: Period of record and seasonal mean daily flow duration curves for the Hoh River at U.S. Highway 101 near Forks, water years 1961-2001.

Table 5: Period of record and seasonal mean daily flow duration statistics for the Hoh River at U.S. Highway 101 near Forks, water years 1961-2001

parameter	Annual	Season		
	Period of Record	November-April	May-June	July-October
number of samples	14,975	7,431	2,501	5,043
mean (ft ³ /s)	2,533.72	3,340.15	2,079.12	1,570.89
standard deviation (ft ³ /s)	2,659.45	3,348.89	749.06	1,487.18
coefficient of variation	1.050	1.003	0.360	0.947
skewness coefficient	5.080	4.154	2.167	6.215
lag-1 serial correlation coefficient	0.750	0.721	0.798	0.719
minimum observation (ft ³ /s)	252	307	876	252
99.99 percent exceedance (ft ³ /s)	252	228	219	127
99.94 percent exceedance (ft ³ /s)	264	388	903	256
99.7 percent exceedance (ft ³ /s)	360	624	999	288
99 percent exceedance (ft ³ /s)	476	741	1,090	380
96.75 percent exceedance (ft ³ /s)	645	892	1,200	495
90 percent exceedance (ft ³ /s)	889	1,180	1,370	660
80 percent exceedance (ft ³ /s)	1,140	1,480	1,510	819
75 percent exceedance (ft ³ /s)	1,260	1,610	1,580	889
70 percent exceedance (ft ³ /s)	1,370	1,740	1,640	957
60 percent exceedance (ft ³ /s)	1,590	2,010	1,770	1,080
50 percent exceedance (ft ³ /s)	1,810	2,330	1,900	1,210
40 percent exceedance (ft ³ /s)	2,100	2,740	2,070	1,360
30 percent exceedance (ft ³ /s)	2,500	3,320	2,280	1,560
25 percent exceedance (ft ³ /s)	2,750	3,730	2,390	1,700
20 percent exceedance (ft ³ /s)	3,120	4,260	2,520	1,880
10 percent exceedance (ft ³ /s)	4,630	6,240	2,970	2,640
3.25 percent exceedance (ft ³ /s)	8,350	11,300	3,770	4,710
1 percent exceedance (ft ³ /s)	14,100	18,200	4,670	8,160
0.3 percent exceedance (ft ³ /s)	21,410	26,200	5,940	11,920
0.06 percent exceedance (ft ³ /s)	32,630	38,020	8,740	24,040
0.01 percent exceedance (ft ³ /s)	39,000	29,450	3,640	16,010
maximum observation (ft ³ /s)	39,000	39,000	9,050	28,600

5.00 PRECIPITATION ESTIMATES

Annual precipitation in the region is subdivided into the same three seasons used in the flow-duration analysis: winter (November through April), spring (May through June) and summer/fall (July through October). Annual and seasonal statistics for the three stations (locations shown in Figure 1) are listed in Table 6. On a seasonal basis, the majority of precipitation occurs in the November through April winter period (Table 6); this corresponds to the occurrence of widespread winter precipitation and flooding. The driest period is during the spring, when snowmelt is a dominant source of runoff for the Hoh River. The annual and seasonal precipitation at the three sites are shown in Figures 6 through 8. A 5-year moving average is used to smooth the data. The NWS typical data selection standard to estimate monthly and annual precipitation statistics is to discount the month and year if more than five days are missing. In order to significantly extend the number of years of data available for statistics, a relatively liberal criterion was used to select the data. In general, if more than two or more months were missing, that year and season was excluded from the analysis. Thus, the estimates presented in Table 6 and Figures 6 through 8 are approximate. For the three sites, Spruce, located near the discontinued Forks streamflow gage, has the highest annual and winter mean precipitation. The Sappho gage, located in the Soleduck River basin and north of the Hoh River basin, is the driest of the three locations examined in this study.

Table 6: Annual and seasonal precipitation statistics for the three NWS Cooperative stations

Station Name	COOP No.	Years Analyzed	Elev. (ft, NGVD)	Mean (inches)				Standard Deviation (inches)				Coefficient of Variation			
				Annual	Winter	Spring	Summer/Fall	Annual	Winter	Spring	Summer/Fall	Annual	Winter	Spring	Summer/Fall
Forks 1E	2914	1931-2001 (71)	350	117.71	87.41	8.87	21.42	19.94	17.76	3.55	6.19	0.17	0.20	0.40	0.29
Sappho 8E	7319	1953-1996 (44)	760	93.51	69.80	6.43	17.29	17.14	14.99	2.88	5.67	0.18	0.21	0.45	0.33
Spruce	7987	1931-1980 (50)	370	125.36	93.68	9.05	22.62	19.80	16.99	3.42	6.97	0.16	0.18	0.38	0.31

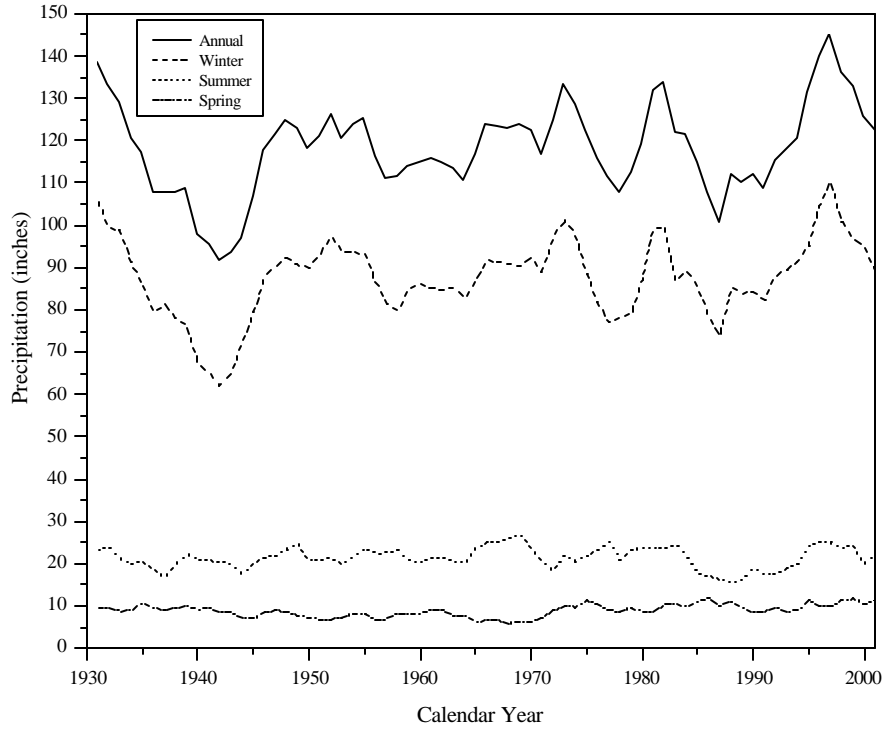


Figure 6: Annual and seasonal precipitation at Forks 1E. Data are smoothed using a 5-year moving average.

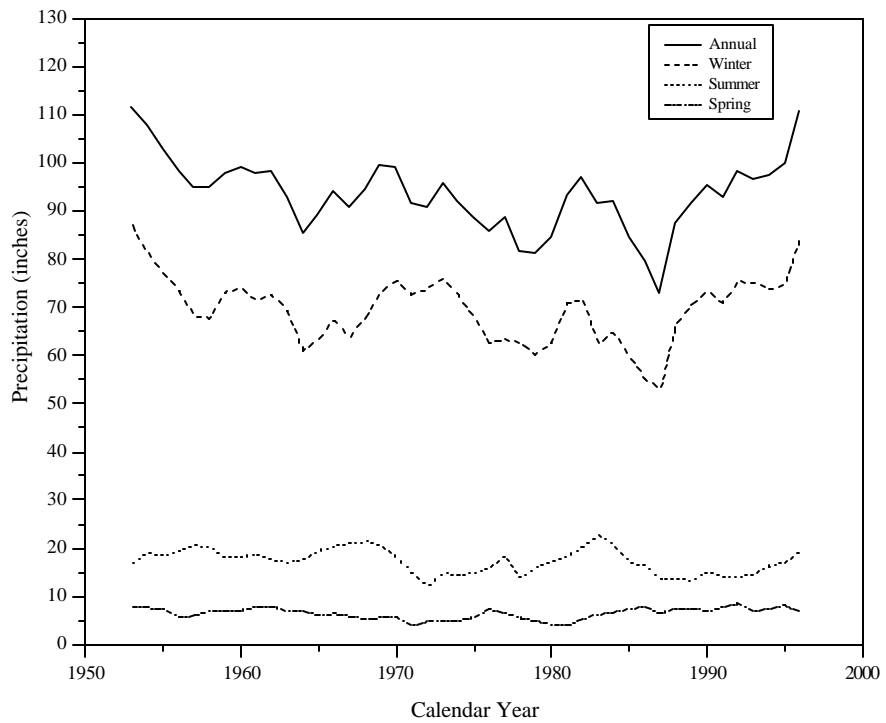


Figure 7: Annual and seasonal precipitation at Sappho 8E. Data are smoothed using a 5-year moving average.



Figure 8: Annual and seasonal precipitation at Spruce. Data are smoothed using a 5-year moving average.

6.00 CONCLUSIONS

1. The log-Pearson Type III distribution was fit to annual peak discharge estimates at the Hoh River gaging station using the Expected Moments Algorithm and available historical information. The results indicated that the distribution adequately fit the data. Peak discharge probability estimates indicate the 2-year flood is approximately 26,200 ft³/s and the 100-year flood ranges between 54,400 and 74,300 ft³/s.
2. A period-of-record FDC for the water year indicated that mean daily flows are typically greater than about 1,260 ft³/s for 75 percent of the time. The median flow (50 percent) is 1,810 ft³/s for the water year. Mean daily flows for the November-April winter season are nearly always greater than any other season. The snowmelt runoff occurs in the May through June season; flows in this season were typically lower than the winter season.
3. Annual mean precipitation ranged from 93.5 to 125.4 inches at three locations. The majority of precipitation occurs in the November through April period, which contributes to the occurrence of winter floods on the Hoh River.

This report was peer reviewed by Robert E. Swain, Technical Specialist, Flood Hydrology Group (D-8530). If you have any questions regarding the contents of this report, please contact John England at 303-445-2541 (jengland@do.usbr.gov).

7.00 REFERENCES

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APPENDIX A

PEAK DISCHARGE DATA TRANSFER

Hoh River Peak Discharge Transfer from near Spruce to Highway 101

Q2, A2- Spruce transfer to Hwy101

near Spruce						at 101						
base Q		12000	area (mi ²)	208		base Q		16000	area (mi ²)	253		
Type	Station	Date	Discharge	GageAtPeak	Q/A	Type	Station	Date	Discharge	GageAtPeak	Q/A	Power Exponent
3	12041000	1/15/1961	28800	16.9	138.4615	3	12041200	1/15/1961	46000	17.74	181.8182	2.391
4	12041000	11/17/1960	15500	11.47	74.51923	4	12041200	11/17/1960	16600	10.58	65.61265	0.350
4	12041000	12/12/1960	17000	12.15	81.73077	4	12041200	12/12/1960	19700	11.56	77.86561	0.753
4	12041000	1/10/1961	17900	12.51	86.05769	4	12041200	1/10/1961	24400	12.86	96.44269	1.582
4	12041000	2/21/1961	19200	13.04	92.30769	4	12041200	2/21/1961	25700	13.21	101.581	1.489
3	12041000	1/3/1962	13600	10.66	65.38462	3	12041200	1/3/1962	15900	10.36	62.84585	0.798
3	12041000	11/19/1962	38700	18.8	186.0577	3	12041200	11/20/1962	45400	17.64	179.4466	0.815
4	12041000	11/25/1962	20000	12.66	96.15385	4	12041200	11/25/1962	20700	11.84	81.81818	0.176
4	12041000	12/15/1962	16700	11.47	80.28846	4	12041200	12/15/1962	18200	11.08	71.93676	0.439
4	12041000	2/4/1963	24000	14.03	115.3846	4	12041200	2/4/1963	26800	13.51	105.9289	0.563
3	12041000	10/21/1963	21200	13.11	101.9231	3	12041200	10/21/1963	26500	13.42	104.7431	1.139
4	12041000	11/26/1963	14500	10.7	69.71154	4	12041200	11/26/1963	17800	10.98	70.35573	1.047
4	12041000	12/23/1963	13000	10.13	62.5	4	12041200	12/23/1963	19700	11.57	77.86561	2.122
											mean	1.051
											std dev	0.677
											med	0.815

APPENDIX B

FLOOD FREQUENCY INPUT/OUTPUT

```

*****
*   EXPECTED MOMENTS ALGORITHM PROGRAM EMA   *
*   COMPUTES EXCEEDENCE PROBABILITIES AND   *
*   RETURN PERIOD ESTIMATES VIA PLOTTING POSITIONS, *
*   *
*   AND COMPUTES MOMENTS, PARAMETERS, AND QUANTILES *
*   ASSUMING A P-III DISTRIBUTION           *
*   FOR HISTORICAL, PALEOHYDROLOGIC       *
*   AND SYSTEMATIC PEAK FLOW DATA         *
*   *
*   USBR VERSION **BETA** 1.0              *
*   VERSION DATE: 07-06-1999              *
*****

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EMA Program Input File Name is: hoh-pk-em3.in
 EMA Program Output File Name is: hoh-pk-em3.out
 EMA Program Spreadsheet File Name is: hoh-pk-em3.ss

EMA Run Date is 1/24/2003
 EMA Run Time is 2:59:42:01 pm

Hoh River at Hwy 101 (combined with Spruce), WA 1926-1998
 Historical Information to 1891 from USGS WSP 792

INPUT AND CALCULATED CONSTANTS

Number of User-Input Bounds is: 1

Bound	nh	neprim	tl	tu	nn	kk	kt	pe
1	36	0	0.00	45400.00	111	10	0	0.090090
Alpha	ns	ne	nqt	nfb_sum	kk_sum	n_qmax		
.400	75	10	75	76	10	111		

User has selected the Cunnane plotting position
 for estimating exceedance probabilities and relative goodness-of-fit

User has selected log-Pearson Type III distribution
 (Base 10 logarithms)

rskew	rwgt	bias	tol	log
0.000	0.000	1.0	0.1E-05	1

run mode	conf	lim	type
1		1	

Input no. of discharges to estimate exceed. prob 2

Input Discharge Values
 45400.00
 54500.00

INPUT YEAR AND DISCHARGE VALUES FOR PLOTTING

Year	Discharge	tl	tu
1927	18300.00	18300.00	18300.00
1928	19700.00	19700.00	19700.00
1929	14000.00	14000.00	14000.00
1930	14000.00	14000.00	14000.00
1931	22800.00	22800.00	22800.00
1932	26700.00	26700.00	26700.00
1933	20600.00	20600.00	20600.00
1934	33600.00	33600.00	33600.00
1935	42300.00	42300.00	42300.00

1936	11500.00	11500.00	11500.00
1937	17600.00	17600.00	17600.00
1938	25200.00	25200.00	25200.00
1939	23700.00	23700.00	23700.00
1940	24300.00	24300.00	24300.00
1941	18800.00	18800.00	18800.00
1942	25600.00	25600.00	25600.00
1943	12900.00	12900.00	12900.00
1944	20400.00	20400.00	20400.00
1945	36600.00	36600.00	36600.00
1946	11200.00	11200.00	11200.00
1947	18400.00	18400.00	18400.00
1948	22800.00	22800.00	22800.00
1949	14300.00	14300.00	14300.00
1950	45400.00	45400.00	45400.00
1951	26300.00	26300.00	26300.00
1952	13400.00	13400.00	13400.00
1953	19800.00	19800.00	19800.00
1954	20600.00	20600.00	20600.00
1955	30300.00	30300.00	30300.00
1956	39400.00	39400.00	39400.00
1957	31000.00	31000.00	31000.00
1958	16200.00	16200.00	16200.00
1959	22300.00	22300.00	22300.00
1960	27200.00	27200.00	27200.00
1961	46000.00	46000.00	46000.00
1962	15900.00	15900.00	15900.00
1963	45400.00	45400.00	45400.00
1964	26500.00	26500.00	26500.00
1965	24300.00	24300.00	24300.00
1966	19900.00	19900.00	19900.00
1967	30100.00	30100.00	30100.00
1968	31700.00	31700.00	31700.00
1969	22200.00	22200.00	22200.00
1970	19800.00	19800.00	19800.00
1971	20200.00	20200.00	20200.00
1972	32400.00	32400.00	32400.00
1973	35400.00	35400.00	35400.00
1974	31200.00	31200.00	31200.00
1975	27600.00	27600.00	27600.00
1976	41200.00	41200.00	41200.00
1977	11700.00	11700.00	11700.00
1978	44800.00	44800.00	44800.00
1979	16500.00	16500.00	16500.00
1980	51600.00	51600.00	51600.00
1981	51100.00	51100.00	51100.00
1982	32100.00	32100.00	32100.00
1983	47900.00	47900.00	47900.00
1984	42000.00	42000.00	42000.00
1985	20900.00	20900.00	20900.00
1986	41700.00	41700.00	41700.00
1987	48600.00	48600.00	48600.00
1988	23400.00	23400.00	23400.00
1989	49300.00	49300.00	49300.00
1990	40600.00	40600.00	40600.00
1991	54500.00	54500.00	54500.00
1992	29000.00	29000.00	29000.00
1993	25700.00	25700.00	25700.00
1994	31700.00	31700.00	31700.00
1995	34600.00	34600.00	34600.00
1996	47600.00	47600.00	47600.00
1997	44500.00	44500.00	44500.00
1998	28400.00	28400.00	28400.00
1999	34800.00	34800.00	34800.00
2000	41400.00	41400.00	41400.00
2001	16100.00	16100.00	16100.00

SORTED DISCHARGE VALUES, CALCULATED EXCEEDANCE PROBABILITIES
AND RETURN PERIOD ESTIMATES

i	Year	Discharge	Exceed. Prob. P (%)	Rt. Per. T
1	1991	54500.00	0.5299	188.7000
2	1980	51600.00	1.4132	70.7625
3	1981	51100.00	2.2964	43.5462
4	1989	49300.00	3.1797	31.4500
5	1987	48600.00	4.0629	24.6130
6	1983	47900.00	4.9461	20.2179
7	1996	47600.00	5.8294	17.1545
8	1961	46000.00	6.7126	14.8974
9	1963	45400.00	7.5958	13.1651
10	1950	45400.00	8.4791	11.7938
11	1978	44800.00	9.8463	10.1560
12	1997	44500.00	11.2419	8.8953
13	1935	42300.00	12.6375	7.9130
14	1984	42000.00	14.0331	7.1260
15	1986	41700.00	15.4286	6.4815
16	2000	41400.00	16.8242	5.9438
17	1976	41200.00	18.2198	5.4885
18	1990	40600.00	19.6153	5.0981
19	1956	39400.00	21.0109	4.7594
20	1945	36600.00	22.4065	4.4630
21	1973	35400.00	23.8020	4.2013
22	1999	34800.00	25.1976	3.9686
23	1995	34600.00	26.5932	3.7604
24	1934	33600.00	27.9887	3.5729
25	1972	32400.00	29.3843	3.4032
26	1982	32100.00	30.7799	3.2489
27	1994	31700.00	32.1754	3.1080
28	1968	31700.00	33.5710	2.9788
29	1974	31200.00	34.9666	2.8599
30	1957	31000.00	36.3621	2.7501
31	1955	30300.00	37.7577	2.6485
32	1967	30100.00	39.1533	2.5541
33	1992	29000.00	40.5488	2.4662
34	1998	28400.00	41.9444	2.3841
35	1975	27600.00	43.3400	2.3073
36	1960	27200.00	44.7355	2.2354
37	1932	26700.00	46.1311	2.1677
38	1964	26500.00	47.5267	2.1041
39	1951	26300.00	48.9222	2.0441
40	1993	25700.00	50.3178	1.9874
41	1942	25600.00	51.7134	1.9337
42	1938	25200.00	53.1089	1.8829
43	1965	24300.00	54.5045	1.8347
44	1940	24300.00	55.9001	1.7889
45	1939	23700.00	57.2956	1.7453
46	1988	23400.00	58.6912	1.7038
47	1948	22800.00	60.0868	1.6643
48	1931	22800.00	61.4823	1.6265
49	1959	22300.00	62.8779	1.5904
50	1969	22200.00	64.2735	1.5559
51	1985	20900.00	65.6690	1.5228
52	1954	20600.00	67.0646	1.4911
53	1933	20600.00	68.4602	1.4607
54	1944	20400.00	69.8557	1.4315
55	1971	20200.00	71.2513	1.4035
56	1966	19900.00	72.6469	1.3765
57	1970	19800.00	74.0424	1.3506
58	1953	19800.00	75.4380	1.3256
59	1928	19700.00	76.8336	1.3015
60	1941	18800.00	78.2291	1.2783
61	1947	18400.00	79.6247	1.2559
62	1927	18300.00	81.0203	1.2343
63	1937	17600.00	82.4159	1.2134
64	1979	16500.00	83.8114	1.1932
65	1958	16200.00	85.2070	1.1736
66	2001	16100.00	86.6026	1.1547
67	1962	15900.00	87.9981	1.1364
68	1949	14300.00	89.3937	1.1186
69	1930	14000.00	90.7893	1.1015
70	1929	14000.00	92.1848	1.0848

71	1952	13400.00	93.5804	1.0686
72	1943	12900.00	94.9760	1.0529
73	1977	11700.00	96.3715	1.0377
74	1936	11500.00	97.7671	1.0228
75	1946	11200.00	99.1627	1.0084

Initial EMA Calculated Moments

Mean	Variance	Skew
4.424833	0.032895	-0.171783

Number of Iterations for EMA Convergence is: 24

EMA CALCULATED MOMENTS
(Log-10 Moments)

Mean	Variance	Std. Dev	Skew
4.412807	0.030332	0.174162	-0.217348

The user chose rskew = 0.000 and rwgt = 0.0
The EMA Moments reflect this regional skew adjustment

FINAL PIII/LP-III PARAMETERS

Location	Shape	Scale
(Tau)	(Alpha)	(Beta)
6.015412	84.673675	-0.018927

QUANTILES OF THE LOG-PEARSON TYPE III DISTRIBUTION

i	Q	EXCEED PROB P (%)	T
1	9551.08	99.00000	1.010
2	10274.60	98.50000	1.015
3	10843.41	98.00000	1.020
4	11321.36	97.50000	1.026
5	12453.18	96.00000	1.042
6	13061.32	95.00000	1.053
7	15344.43	90.00000	1.111
8	16247.77	87.50000	1.143
9	17067.98	85.00000	1.176
10	17830.41	82.50000	1.212
11	18551.09	80.00000	1.250
12	19240.94	77.50000	1.290
13	19907.88	75.00000	1.333
14	20557.89	72.50000	1.379
15	21195.75	70.00000	1.429
16	21825.37	67.50000	1.481
17	22034.00	66.66670	1.500
18	22450.11	65.00000	1.538
19	23072.91	62.50000	1.600
20	23696.50	60.00000	1.667
21	24323.41	57.50000	1.739
22	24956.12	55.00000	1.818
23	25597.12	52.50000	1.905
24	26248.95	50.00000	2.000
25	26914.30	47.50000	2.105
26	27596.08	45.00000	2.222
27	28297.51	42.50000	2.353
28	29022.17	40.00000	2.500
29	29774.23	37.50000	2.667
30	30558.54	35.00000	2.857
31	31380.87	32.50000	3.077
32	32248.26	30.00000	3.333
33	33169.45	27.50000	3.636
34	34155.49	25.00000	4.000
35	35220.84	22.50000	4.444
36	36384.82	20.00000	5.000

37	37674.36	17.50000	5.714
38	39128.55	15.00000	6.667
39	40807.57	12.50000	8.000
40	42811.49	10.00000	10.000
41	45326.44	7.50000	13.333
42	48766.45	5.00000	20.000
43	50617.24	4.00000	25.000
44	54436.92	2.50000	40.000
45	56219.00	2.00000	50.000
46	59414.47	1.33334	75.000
47	61653.03	1.00000	100.000
48	66967.10	0.50000	200.000
49	73858.96	0.20000	500.000
50	78997.59	0.10000	1000.000
51	84087.11	0.05000	2000.000
52	90756.18	0.02000	5000.000
53	95765.73	0.01000	10000.000

RELATIVE GOODNESS-OF-FIT

i	Exceed. Prob	Q Observed	Q Estimated	Relative Difference
1	0.0052994	54500.00	66524.99	0.2206
2	0.0141318	51600.00	58959.22	0.1426
3	0.0229641	51100.00	55117.44	0.0786
4	0.0317965	49300.00	52494.73	0.0648
5	0.0406289	48600.00	50488.71	0.0389
6	0.0494612	47900.00	48856.94	0.0200
7	0.0582936	47600.00	47477.05	-0.0026
8	0.0671259	46000.00	46278.51	0.0061
9	0.0759583	45400.00	45216.88	-0.0040
10	0.0847907	45400.00	44262.33	-0.0251
11	0.0984635	44800.00	42948.70	-0.0413
12	0.1124192	44500.00	41766.64	-0.0614
13	0.1263748	42300.00	40707.96	-0.0376
14	0.1403305	42000.00	39746.99	-0.0536
15	0.1542862	41700.00	38865.29	-0.0680
16	0.1682419	41400.00	38049.19	-0.0809
17	0.1821975	41200.00	37288.24	-0.0949
18	0.1961532	40600.00	36574.27	-0.0992
19	0.2101089	39400.00	35900.77	-0.0888
20	0.2240646	36600.00	35262.47	-0.0365
21	0.2380202	35400.00	34655.05	-0.0210
22	0.2519759	34800.00	34074.89	-0.0208
23	0.2659316	34600.00	33518.95	-0.0312
24	0.2798872	33600.00	32984.65	-0.0183
25	0.2938429	32400.00	32469.76	0.0022
26	0.3077986	32100.00	31972.36	-0.0040
27	0.3217543	31700.00	31490.77	-0.0066
28	0.3357099	31700.00	31023.51	-0.0213
29	0.3496656	31200.00	30569.27	-0.0202
30	0.3636213	31000.00	30126.89	-0.0282
31	0.3775770	30300.00	29695.31	-0.0200
32	0.3915326	30100.00	29273.60	-0.0275
33	0.4054883	29000.00	28860.89	-0.0048
34	0.4194440	28400.00	28456.41	0.0020
35	0.4333997	27600.00	28059.43	0.0166
36	0.4473553	27200.00	27669.30	0.0173
37	0.4613110	26700.00	27285.39	0.0219
38	0.4752667	26500.00	26907.12	0.0154
39	0.4892224	26300.00	26533.96	0.0089
40	0.5031780	25700.00	26165.39	0.0181
41	0.5171337	25600.00	25800.92	0.0078
42	0.5310894	25200.00	25440.09	0.0095
43	0.5450450	24300.00	25082.43	0.0322
44	0.5590007	24300.00	24727.50	0.0176
45	0.5729564	23700.00	24374.88	0.0285
46	0.5869121	23400.00	24024.12	0.0267
47	0.6008677	22800.00	23674.81	0.0384
48	0.6148234	22800.00	23326.51	0.0231
49	0.6287791	22300.00	22978.78	0.0304

50	0.6427348	22200.00	22631.17	0.0194
51	0.6566904	20900.00	22283.22	0.0662
52	0.6706461	20600.00	21934.43	0.0648
53	0.6846018	20600.00	21584.30	0.0478
54	0.6985575	20400.00	21232.27	0.0408
55	0.7125131	20200.00	20877.74	0.0336
56	0.7264688	19900.00	20520.08	0.0312
57	0.7404245	19800.00	20158.56	0.0181
58	0.7543801	19800.00	19792.40	-0.0004
59	0.7683358	19700.00	19420.69	-0.0142
60	0.7822915	18800.00	19042.42	0.0129
61	0.7962472	18400.00	18656.39	0.0139
62	0.8102028	18300.00	18261.23	-0.0021
63	0.8241585	17600.00	17855.27	0.0145
64	0.8381142	16500.00	17436.53	0.0568
65	0.8520699	16200.00	17002.53	0.0495
66	0.8660255	16100.00	16550.18	0.0280
67	0.8799812	15900.00	16075.46	0.0110
68	0.8939369	14300.00	15573.08	0.0890
69	0.9078926	14000.00	15035.69	0.0740
70	0.9218482	14000.00	14452.76	0.0323
71	0.9358039	13400.00	13808.12	0.0305
72	0.9497596	12900.00	13074.97	0.0136
73	0.9637152	11700.00	12202.87	0.0430
74	0.9776709	11500.00	11075.06	-0.0370
75	0.9916266	11200.00	9259.46	-0.1733

GOODNESS-OF-FIT

Via Average Relative Deviations (ARD) and Mean Squared Deviations (MSD)

Number of observations: 75
 Number of observations that exceed any threshold/bound: 10

All Observations

ARD MSD
 0.0377 0.0029

Maximum Observed

ARD_Q1 MSD_Q1
 0.2206 0.0487

Above-Threshold Values

ARD_QK MSD_QK
 0.0603 0.0082

NON-EXCEEDANCE PROBABILITY TEST FOR LARGEST OBSERVATION

n_Qmax	Q_max	cdf	Ret. Per.	p*
111	54500.00	0.975196	40.316	0.062

p* is within acceptable range (0.05, 0.95)

Probability Plot Correlation Statistic
 for Observations below all Thresholds/Bounds is 0.9946

ESTIMATED EXCEEDANCE PROBABILITIES FROM FITTED DISTRIBUTION

i	Input Q	Exceed Prob P (%)	T
1	45400.00	7.43628	13.448
2	54500.00	2.48043	40.316

Total EMA Program Run time: 0.010 seconds

CONFIDENCE INTERVAL ESTIMATES

i	EXCEED PROB P (%)	T,Q	STD_DEV (Q)	CI_LOW	CI_HIGH
1	.99	1.010	9548.50	1.15	6725.06, 11384.76
2	.98	1.015	10272.72	1.13	7543.26, 12065.82
3	.98	1.020	10842.00	1.12	8193.98, 12604.46
4	.97	1.026	11320.32	1.12	8744.04, 13059.57
5	.96	1.042	12452.86	1.10	10050.75, 14147.29
6	.95	1.053	13061.31	1.09	10750.89, 14737.87
7	.90	1.111	15345.18	1.07	13326.17, 16993.84
8	.87	1.143	16248.66	1.07	14310.68, 17902.64
9	.85	1.176	17068.92	1.06	15185.22, 18735.27
10	.82	1.212	17831.36	1.06	15982.09, 19515.37
11	.80	1.250	18552.00	1.06	16722.15, 20257.94
12	.77	1.290	19241.79	1.06	17419.87, 20973.27
13	.75	1.333	19908.62	1.06	18085.75, 21668.78
14	.72	1.379	20558.52	1.05	18727.75, 22350.10
15	.70	1.429	21196.24	1.05	19352.10, 23021.67
16	.67	1.481	21825.71	1.05	19963.83, 23687.11
17	.66	1.500	22034.28	1.05	20165.66, 23908.10
18	.65	1.538	22450.28	1.05	20567.11, 24349.52
19	.62	1.600	23072.90	1.05	21165.52, 25011.60
20	.60	1.667	23696.30	1.05	21762.22, 25675.84
21	.57	1.739	24323.00	1.05	22360.09, 26344.59
22	.55	1.818	24955.50	1.05	22961.81, 27020.14
23	.52	1.905	25596.27	1.05	23570.00, 27704.85
24	.50	2.000	26247.87	1.05	24187.25, 28401.15
25	.47	2.105	26912.99	1.05	24816.23, 29111.67
26	.45	2.222	27594.52	1.05	25459.77, 29839.31
27	.42	2.353	28295.69	1.05	26120.89, 30587.35
28	.40	2.500	29020.10	1.05	26802.97, 31359.60
29	.37	2.667	29771.89	1.05	27509.83, 32160.53
30	.35	2.857	30555.93	1.05	28245.87, 32995.54
31	.32	3.077	31378.00	1.05	29016.31, 33871.30
32	.30	3.333	32245.12	1.05	29827.43, 34796.15
33	.27	3.636	33166.04	1.05	30686.97, 35780.86
34	.25	4.000	34151.84	1.05	31604.72, 36839.59
35	.22	4.444	35216.95	1.05	32593.36, 37991.56
36	.20	5.000	36380.73	1.05	33669.85, 39263.58
37	.17	5.714	37670.11	1.05	34857.66, 40694.54
38	.15	6.667	39124.22	1.05	36190.69, 42343.25
39	.12	8.000	40803.29	1.05	37720.40, 44303.59
40	.10	10.000	42807.49	1.05	39530.20, 46736.12
41	.07	13.333	45323.17	1.05	41767.84, 49944.03
42	.05	20.000	48764.93	1.06	44737.31, 54603.24
43	.04	25.000	50617.05	1.06	46276.80, 57226.29
44	.02	40.000	54440.45	1.07	49300.55, 62866.02
45	.02	50.000	56224.72	1.08	50636.76, 65596.33
46	.01	75.000	59424.90	1.09	52914.28, 70650.56
47	.01	100.000	61667.38	1.09	54423.79, 74320.92
48	.00	200.000	66992.94	1.11	57735.28, 83468.11
49	.00	500.000	73904.53	1.14	61526.79, 96342.93
50	.00	1000.000	79061.65	1.16	64032.01, 106760.12
51	.00	2000.000	84172.82	1.18	66276.04, 117828.35
52	.00	5000.000	90875.47	1.22	68899.52, 133546.11
53	.00	10000.000	95914.28	1.24	70661.75, 146353.69

APPENDIX C

**MONTHLY FLOW DURATION
ESTIMATES**

STATFLUV Program Input File Name is: hoh-jan.txt
STATFLUV Program Output File Name is: hoh-jan.out

ESTIMATED SAMPLE STATISTICS (UNBIASED ESTIMATES)

SAMPLE SIZE = 1271
SAMPLE MEAN = 3750.006
SAMPLE MEDIAN = 2610.000
STANDARD DEVIATION = 3552.168
COEFFICIENT OF VARIATION = 0.9472
SKEWNESS COEFFICIENT = 3.2802
KURTOSIS COEFFICIENT = 18.8856
LAG-1 SERIAL CORR. COEFF.= 0.6839

SELECTED QUANTILES FOR BOXPLOT CONSTRUCTION

PERCENTILE	QUARTILE
p min	638.0000
p .0001	81.1536
p .0006	486.9216
p .0030	693.3200
p .0100	751.4400
p .0325	869.4000
p .1000	1240.0000
p .2000	1554.0000
p .2500	1700.0000
p .3000	1876.0000
p .4000	2210.0000
p .5000	2610.0000
p .6000	3150.0000
p .7000	3870.0000
p .7500	4350.0000
p .8000	4952.0000
p .9000	7630.0000
p .9675	12800.0000
p .9900	18928.0000
p .9970	26936.8000
p .9994	28314.7200
p .9999	4719.1200
p max	37100.0000

STATFLUV Program Input File Name is: hoh-feb.txt
STATFLUV Program Output File Name is: hoh-feb.out

ESTIMATED SAMPLE STATISTICS (UNBIASED ESTIMATES)

SAMPLE SIZE = 1158
SAMPLE MEAN = 3389.066
SAMPLE MEDIAN = 2470.000
STANDARD DEVIATION = 3057.626
COEFFICIENT OF VARIATION = 0.9022
SKEWNESS COEFFICIENT = 3.1121
KURTOSIS COEFFICIENT = 15.0883
LAG-1 SERIAL CORR. COEFF.= 0.7465

SELECTED QUANTILES FOR BOXPLOT CONSTRUCTION

PERCENTILE	QUARTILE
p min	621.0000
p .0001	71.9739
p .0006	431.8434
p .0030	661.4940
p .0100	731.7200
p .0325	959.3400

p .1000	1268.0000
p .2000	1560.0000
p .2500	1690.0000
p .3000	1820.0000
p .4000	2130.0000
p .5000	2470.0000
p .6000	2840.0000
p .7000	3400.0000
p .7500	3780.0000
p .8000	4250.0000
p .9000	6187.0000
p .9675	11799.7500
p .9900	17328.0000
p .9970	22189.1000
p .9994	19226.4000
p .9999	9954.4000
p max	24100.0000

STATFLUV Program Input File Name is: hoh-march.txt
 STATFLUV Program Output File Name is: hoh-march.out

ESTIMATED SAMPLE STATISTICS (UNBIASED ESTIMATES)

SAMPLE SIZE	=	1271
SAMPLE MEAN	=	2667.548
SAMPLE MEDIAN	=	2100.000
STANDARD DEVIATION	=	2302.637
COEFFICIENT OF VARIATION	=	0.8632
SKEWNESS COEFFICIENT	=	5.5928
KURTOSIS COEFFICIENT	=	55.3946
LAG-1 SERIAL CORR. COEFF.	=	0.7365

SELECTED QUANTILES FOR BOXPLOT CONSTRUCTION

PERCENTILE	QUANTILE
p min	632.0000
p .0001	80.3904
p .0006	482.3424
p .0030	720.8000
p .0100	780.0000
p .0325	899.3400
p .1000	1110.0000
p .2000	1370.0000
p .2500	1490.0000
p .3000	1620.0000
p .4000	1878.0000
p .5000	2100.0000
p .6000	2390.0000
p .7000	2774.0000
p .7500	3000.0000
p .8000	3400.0000
p .9000	4628.0000
p .9675	7140.0000
p .9900	12468.0000
p .9970	20920.8000
p .9994	26712.0000
p .9999	4452.0000
p max	35000.0000

STATFLUV Program Input File Name is: hoh-april.txt
 STATFLUV Program Output File Name is: hoh-april.out

ESTIMATED SAMPLE STATISTICS (UNBIASED ESTIMATES)

SAMPLE SIZE	=	1230
SAMPLE MEAN	=	2101.600
SAMPLE MEDIAN	=	1810.000

STANDARD DEVIATION = 1201.730
 COEFFICIENT OF VARIATION = 0.5718
 SKEWNESS COEFFICIENT = 3.2655
 KURTOSIS COEFFICIENT = 20.1395
 LAG-1 SERIAL CORR. COEFF.= 0.7244

SELECTED QUANTILES FOR BOXPLOT CONSTRUCTION

PERCENTILE	QUARTILE
p min	767.0000
p .0001	94.4177
p .0006	566.5062
p .0030	794.8510
p .0100	820.0000
p .0325	914.0300
p .1000	1130.0000
p .2000	1340.0000
p .2500	1400.0000
p .3000	1500.0000
p .4000	1650.0000
p .5000	1810.0000
p .6000	1980.0000
p .7000	2220.0000
p .7500	2382.5000
p .8000	2570.0000
p .9000	3240.0000
p .9675	4989.9250
p .9900	7501.4000
p .9970	8877.4500
p .9994	11615.9160
p .9999	7885.9860
p max	13200.0000

STATFLUV Program Input File Name is: hoh-may.txt
 STATFLUV Program Output File Name is: hoh-may.out

ESTIMATED SAMPLE STATISTICS (UNBIASED ESTIMATES)

SAMPLE SIZE = 1271
 SAMPLE MEAN = 2052.354
 SAMPLE MEDIAN = 1860.000
 STANDARD DEVIATION = 771.628
 COEFFICIENT OF VARIATION = 0.3760
 SKEWNESS COEFFICIENT = 2.4766
 KURTOSIS COEFFICIENT = 14.3081
 LAG-1 SERIAL CORR. COEFF.= 0.7469

SELECTED QUANTILES FOR BOXPLOT CONSTRUCTION

PERCENTILE	QUARTILE
p min	876.0000
p .0001	111.4272
p .0006	668.5632
p .0030	938.1600
p .0100	1097.2000
p .0325	1210.0000
p .1000	1360.0000
p .2000	1490.0000
p .2500	1550.0000
p .3000	1610.0000
p .4000	1730.0000
p .5000	1860.0000
p .6000	2030.0000
p .7000	2230.0000
p .7500	2340.0000
p .8000	2480.0000
p .9000	2940.0000

p .9675	3796.4000
p .9900	5168.0000
p .9970	6244.5600
p .9994	6906.9600
p .9999	1151.1600
p max	9050.0000

STATFLUV Program Input File Name is: hoh-june.txt
 STATFLUV Program Output File Name is: hoh-june.out

ESTIMATED SAMPLE STATISTICS (UNBIASED ESTIMATES)

SAMPLE SIZE	=	1230
SAMPLE MEAN	=	2106.770
SAMPLE MEDIAN	=	1945.000
STANDARD DEVIATION	=	724.282
COEFFICIENT OF VARIATION	=	0.3438
SKEWNESS COEFFICIENT	=	1.8011
KURTOSIS COEFFICIENT	=	9.9426
LAG-1 SERIAL CORR. COEFF.=		0.8128

SELECTED QUANTILES FOR BOXPLOT CONSTRUCTION

PERCENTILE	QUARTILE
p min	997.0000
p .0001	122.7307
p .0006	736.3842
p .0030	1020.0000
p .0100	1076.2000
p .0325	1190.0000
p .1000	1380.0000
p .2000	1550.0000
p .2500	1610.0000
p .3000	1683.0000
p .4000	1804.0000
p .5000	1945.0000
p .6000	2100.0000
p .7000	2307.0000
p .7500	2440.0000
p .8000	2570.0000
p .9000	3010.0000
p .9675	3769.9250
p .9900	4520.7000
p .9970	5252.8900
p .9994	7222.3320
p .9999	4378.7220
p max	8430.0000

STATFLUV Program Input File Name is: hoh-july.txt
 STATFLUV Program Output File Name is: hoh-july.out

ESTIMATED SAMPLE STATISTICS (UNBIASED ESTIMATES)

SAMPLE SIZE	=	1271
SAMPLE MEAN	=	1704.952
SAMPLE MEDIAN	=	1530.000
STANDARD DEVIATION	=	763.009
COEFFICIENT OF VARIATION	=	0.4475
SKEWNESS COEFFICIENT	=	4.5853
KURTOSIS COEFFICIENT	=	38.4105
LAG-1 SERIAL CORR. COEFF.=		0.8196

SELECTED QUANTILES FOR BOXPLOT CONSTRUCTION

PERCENTILE	QUARTILE
p min	855.0000
p .0001	108.7560

p .0006	652.5360
p .0030	866.8960
p .0100	907.9200
p .0325	1003.4000
p .1000	1130.0000
p .2000	1230.0000
p .2500	1280.0000
p .3000	1320.0000
p .4000	1430.0000
p .5000	1530.0000
p .6000	1630.0000
p .7000	1770.0000
p .7500	1880.0000
p .8000	2040.0000
p .9000	2488.0000
p .9675	3096.6000
p .9900	4569.2000
p .9970	8304.1600
p .9994	7860.9600
p .9999	1310.1600
p max	10300.0000

STATFLUV Program Input File Name is: hoh-aug.txt
 STATFLUV Program Output File Name is: hoh-aug.out

ESTIMATED SAMPLE STATISTICS (UNBIASED ESTIMATES)

SAMPLE SIZE	=	1271
SAMPLE MEAN	=	1265.761
SAMPLE MEDIAN	=	1120.000
STANDARD DEVIATION	=	885.476
COEFFICIENT OF VARIATION	=	0.6996
SKEWNESS COEFFICIENT	=	15.5248
KURTOSIS COEFFICIENT	=	369.6133
LAG-1 SERIAL CORR. COEFF.	=	0.6158

SELECTED QUANTILES FOR BOXPLOT CONSTRUCTION

PERCENTILE	QUANTILE
p min	535.0000
p .0001	68.0520
p .0006	408.3120
p .0030	579.7920
p .0100	616.1600
p .0325	670.3400
p .1000	796.2000
p .2000	897.4000
p .2500	939.0000
p .3000	973.0000
p .4000	1050.0000
p .5000	1120.0000
p .6000	1210.0000
p .7000	1310.0000
p .7500	1380.0000
p .8000	1470.0000
p .9000	1780.0000
p .9675	2446.6000
p .9900	3253.6000
p .9970	6536.0800
p .9994	18469.4400
p .9999	3078.2400
p max	24200.0000

STATFLUV Program Input File Name is: hoh-sep.txt
 STATFLUV Program Output File Name is: hoh-sep.out

ESTIMATED SAMPLE STATISTICS (UNBIASED ESTIMATES)

SAMPLE SIZE	=	1230
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SAMPLE MEAN = 1165.941
 SAMPLE MEDIAN = 937.500
 STANDARD DEVIATION = 834.894
 COEFFICIENT OF VARIATION = 0.7161
 SKEWNESS COEFFICIENT = 4.2069
 KURTOSIS COEFFICIENT = 31.1709
 LAG-1 SERIAL CORR. COEFF.= 0.6985

SELECTED QUANTILES FOR BOXPLOT CONSTRUCTION

PERCENTILE	QUARTILE
p min	387.0000
p .0001	47.6397
p .0006	285.8382
p .0030	396.6930
p .0100	440.2400
p .0325	494.0150
p .1000	597.0000
p .2000	682.0000
p .2500	723.0000
p .3000	762.0000
p .4000	848.0000
p .5000	937.5000
p .6000	1040.0000
p .7000	1170.0000
p .7500	1270.0000
p .8000	1420.0000
p .9000	1950.0000
p .9675	2979.9250
p .9900	5037.6000
p .9970	6907.6300
p .9994	8174.1500
p .9999	3404.0250
p max	10200.0000

STATFLUV Program Input File Name is: hoh-oct.txt
 STATFLUV Program Output File Name is: hoh-oct.out

ESTIMATED SAMPLE STATISTICS (UNBIASED ESTIMATES)

SAMPLE SIZE = 1271
 SAMPLE MEAN = 2133.821
 SAMPLE MEDIAN = 1200.000
 STANDARD DEVIATION = 2480.457
 COEFFICIENT OF VARIATION = 1.1624
 SKEWNESS COEFFICIENT = 3.7269
 KURTOSIS COEFFICIENT = 26.4189
 LAG-1 SERIAL CORR. COEFF.= 0.6827

SELECTED QUANTILES FOR BOXPLOT CONSTRUCTION

PERCENTILE	QUARTILE
p min	252.0000
p .0001	32.0544
p .0006	192.3264
p .0030	258.4480
p .0100	280.7600
p .0325	356.7000
p .1000	500.0000
p .2000	650.0000
p .2500	724.0000
p .3000	790.6000
p .4000	961.0000
p .5000	1200.0000
p .6000	1620.0000
p .7000	2254.0000
p .7500	2570.0000

p .8000 3106.0000
 p .9000 4878.0000
 p .9675 8242.8000
 p .9900 12000.0000
 p .9970 16096.8000
 p .9994 21827.5200
 p .9999 3637.9200
 p max 28600.0000

STATFLUV Program Input File Name is: hoh-nov.txt
 STATFLUV Program Output File Name is: hoh-nov.out

ESTIMATED SAMPLE STATISTICS (UNBIASED ESTIMATES)

SAMPLE SIZE = 1230
 SAMPLE MEAN = 3952.887
 SAMPLE MEDIAN = 2730.000
 STANDARD DEVIATION = 4258.337
 COEFFICIENT OF VARIATION = 1.0773
 SKEWNESS COEFFICIENT = 3.8963
 KURTOSIS COEFFICIENT = 24.0587
 LAG-1 SERIAL CORR. COEFF.= 0.6726

SELECTED QUANTILES FOR BOXPLOT CONSTRUCTION

PERCENTILE	QUANTILE
p min	307.0000
p .0001	37.7917
p .0006	226.7502
p .0030	367.5620
p .0100	478.8900
p .0325	780.0000
p .1000	1070.0000
p .2000	1432.0000
p .2500	1650.0000
p .3000	1840.0000
p .4000	2270.0000
p .5000	2730.0000
p .6000	3346.0000
p .7000	4100.0000
p .7500	4590.0000
p .8000	5208.0000
p .9000	7599.0000
p .9675	14098.5000
p .9900	24983.0000
p .9970	34411.3000
p .9994	30967.1780
p .9999	12052.8630
p max	39000.0000

STATFLUV Program Input File Name is: hoh-dec.txt
 STATFLUV Program Output File Name is: hoh-dec.out

ESTIMATED SAMPLE STATISTICS (UNBIASED ESTIMATES)

SAMPLE SIZE = 1271
 SAMPLE MEAN = 4163.960
 SAMPLE MEDIAN = 2830.000
 STANDARD DEVIATION = 4132.570
 COEFFICIENT OF VARIATION = 0.9925
 SKEWNESS COEFFICIENT = 3.4959
 KURTOSIS COEFFICIENT = 20.0638
 LAG-1 SERIAL CORR. COEFF.= 0.6642

SELECTED QUANTILES FOR BOXPLOT CONSTRUCTION

PERCENTILE	QUANTILE
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p min	612.0000
p .0001	77.8464
p .0006	467.0784
p .0030	676.5040
p .0100	740.7200
p .0325	1063.4000
p .1000	1450.0000
p .2000	1730.0000
p .2500	1870.0000
p .3000	2016.0000
p .4000	2390.0000
p .5000	2830.0000
p .6000	3390.0000
p .7000	4134.0000
p .7500	4730.0000
p .8000	5468.0000
p .9000	8358.0000
p .9675	13466.0000
p .9900	23996.0000
p .9970	30848.8000
p .9994	29230.5600
p .9999	4871.7600
p max	38300.0000