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SEMP Historical Meteorology Evaluation for the Area Near Fort Benning, GA: 1999 – 2001

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Background

The Strategic Environmental Research and Development Program (SERDP) has initiated a project focused on addressing science and technology requirements for ecosystem management of Department of Defense (DoD) military installations. This project, entitled the SERDP Ecosystem Management Project (SEMP), involves several research projects that are focused on the land management needs and goals of Fort Benning, GA. The goals of SEMP are to: (1) provide knowledge, tools and techniques to enhance sustainable mission use and stewardship of military installations, and (2) contribute to understanding and enhancing the ecological role of military installations within their ecoregions.

The two major components of SEMP are: (1) the creation of long-term monitoring site(s) on DoD lands to observe trends over time, and (2) the establishment of research projects aimed at gaining a better understanding of the roles of DoD military mission activities and land management practices at various spatial (from plot to managed unit to installation-wide to regional and ecoregional) and temporal scales.

Five research efforts, and a long-term monitoring program, have been underway at Fort Benning, beginning in fiscal year (FY) 1999. They focus on identifying ecosystem change indicators and on understanding disturbance within the ecosystem; especially disturbances resulting from military mission activities and land management practices. Research teams from Oak Ridge National Laboratory, University of Florida, University of Georgia's Savannah River Research Laboratory, the Corps of Engineers Engineer Research and Development Center, and several other universities are working at Fort Benning, collaborating on strategies for selection of research sites, sharing common review forums, and contributing data into a common data repository.

During the 1999 and 2000 research seasons, a significant drought occurred. During the 2001 research season, a moderate drought occurred. At its worst, no water flowed in 9 out of 10 streams where SEMP water quality instruments had been installed. Since unusually dry seasons occurred during two of the three data collecting opportunities, the SERDP Science Advisory Board (SAB), in 2001, raised the question, "Are the data being collected representative of the local ecosystem?" A project designed to answer this question was budgeted in FY02 and initiated in October 2002.

A good deal of data had been collected in the first three seasons of the 10-year SEMP monitoring program, and this represented a majority of the data for several of the projects. Yet this was during a period that can be characterized as significantly more arid than normal.

Objectives

1. Determine how aberrant the weather (temperature, precipitation, and stream flow) was during the first three SEMP data collection seasons (1999-2001 – the Study Years), and
2. Suggest the possible effect that using the data from these years might have on the validity of SEMP-developed ecosystem models that propose to use the Study Years data as validation.

Temperature

Air temperature is a basic climatic parameter. A summary for the West Central section of Georgia (see Appendix A for coverage) for Temperature for the period beginning in 1895 and continuing to 2003* is presented in Figure 1 (p 8). For the Study Years, the average monthly temperatures were 50.5, 51.0, and 52.3 °F. These temperatures are 3.4, 3.9, and 5.2 degrees above the long-term average of 47.1 °F. These values are significantly above the average, showing a 3-year trend higher with the last 2 years above the first Root Mean Square (RMS) of the average temperature. They also may represent a portion of a larger trend (lasting 10 years) of above average temperatures that began roughly in the middle to late 1980s and has continued at the higher level since then. The Study Years are also unusual in that their averages were noticeably above the 10-year moving average (roughly 49.5 °F by +0.9, +1.4, and +1.7 degrees for 1999, 2000, and 2001, respectively). Therefore, all 3 years can be characterized as warm in a warm period. Following further along this line of thought, times of warmer and colder weather have occurred in lengths of roughly 16.5 years:

- Pre-1900 to 1915 {>15 years} cooler,
- 1915 to 1935 {20 years} warmer,
- 1936 to 1944 {marginally or indistinctively 8 years) cooler,

* Dataset compiled by Desert Research Institute Climate Center, www.wrcc.dri.edu/spi/divplot/map.html (no longer available)

- 1945-1962 {17 years} warmer,
- 1963-1984 {21 years} cooler.

The years 1999, 2000, and 2001 seem to represent the mature section of one of the warm phases.

We wished to ensure that the values from the Weather Service Office (WSO) location are representative of Fort Benning. To do this, we plotted (Figure 2, p 9) the 2000 WSO averages* against the average of the SEMP values for our Meteorology Station 1[†] (located in roughly central Fort Benning; see Appendix C). The two values closely coincide with each other, so the regional averages appear to well represent Fort Benning parameters.

Precipitation

Precipitation is another major climatic concern (Appendix A). A graph[‡] similar to that for temperature, and covering the same region (Figure 3, p 10), shows rainfall values of 38.6, 38.8, and 42.9 inches for 1999, 2000, 2001, respectively. The average of these data is 50.1 inches with an RMS of 7.5 inches. Thus, the Study Years 1999 and 2000 were much drier than average, the driest since 1954 when the last major drought in Georgia is recognized[§]. The year 2001 is also classed as a dry year. The years immediately preceding our Study Years tended to be wetter than usual, so the contrast in the minds of local individuals might be enhanced. The Study Years are not astoundingly unusual; single drought years of about 1 RMS have occurred 20 times previously. Significantly more extreme events have occurred in 1954 (dry) and 1929 (wet). In addition, 3 note-worthy drought years in a row (1895 to 1897) have occurred previously. Of these 3, 1 year was greater than and 2 years near the RMS value.) This suggests that even extended drought is within a normal pattern.

Stages in precipitation are more difficult to define than for temperature. Those that might be recognized are:

- 1900-1915 {15 years} dry,
- 1940-1950 {10 years} wet,
- 1960-1980 {20 years} wet,
- 1981-1989 {9 years} dry, and
- 1990-1997 {7 years} wet.

The average length for these stages is 12.2 years. Neither the stage length nor the years of a stage for precipitation coordinate with those for temperature. Therefore, precipitation and temperature stages appear to be independent. Finally, if the Study Years represent a part of a stage, they are only the initial part of a stage. If they do not represent a part of a stage, then they represent only random climate

* http://cirrus.dnr.state.sc.us/cgi-bin/sercc/cliMAIN.pl?ga2166

[†] http://sempdata.wes.army.mil/ SEMP values are taken every 30 minutes. Some months do not have complete data. January and February data are not available.

[‡] These data are called the Standardized Precipitation Index (SPI), a probability index that considers only precipitation. The SPI is based on the probability of recording a given amount of precipitation, and the probabilities are standardized so that an index of zero indicates the median precipitation amount (half of the historical precipitation amounts are below the median, and half are above the median). The index is negative for drought, and positive for wet conditions. As the dry or wet conditions become more severe, the index becomes more negative or positive. From: http://lwf.ncdc.noaa.gov/oa/climate/research/prelim/drought/spi.html

[§] Telephone conversation 13 May 2003 with Pam Knox, Assistant Georgia State Climatologist, Driftmier Engineering Center, University of Georgia, Athens, GA, 706-542-6067.

fluctuation. More recent and supplemental data* are presented in Figure 4 (p 11).

In Figure 4, an increasing precipitation deficit occurs from October 1998 to about June 2000. From July 2000 to June 2001, roughly average precipitation occurred. From July 2001 to April 2002 another deficit period took place. Average precipitation was experienced from May 2002 to January 2003.

We wish to know how unusual the Study Period is. From the WSO data (see Appendix C for location) for Columbus, we can compare the study period with the more than 50 years of data available (beginning in 1948 — Appendix B) (Figure 5, p 11).

From this figure, most of 1999-2001 has been a period of below average precipitation. To see if there was any difference between these data and those on Fort Benning, readings from one of the most central Meteorological Stations† for the year 2000 were summed by month and also displayed in Figure 4. It is apparent from Figure 4 that the WSO Columbus data well represent those taken in the middle of the installation (the light blue boxes vs. the smaller, darker blue boxes, respectively; in fact, one often overlaps the other).

The same data in Figure 4 were reformatted to show the degree of difference from the mean value for each month during the study period (Figure 5, p 11).

Table 1 can be derived from Figure 6 (p 12). The table shows that:

1. Most of 1999 was a deficit year at -0.81SD — nearly one standard deviation (except for October, which was normal). Thus, if 1SD represents 65% of the variation, a year like 1999 is still within roughly two-thirds of all years observed. (In fact, from Figure 2, previous severe years occurred in 1955 and 1905.)
2. Most of 2000 was a deficit year at -0.48SD — nearly one-half standard deviation (although several months were roughly normal).
3. Most of 2001 was a deficit year at -0.43SD — nearly as dry as the previous year, in spite of a huge positive peak in March.

Year	Average SD
1999	-0.811
2000	-0.485
2001	-0.433

Table 1: Standard deviations for the Study Years

As previously mentioned, this is unusual for the 50-year record for the Columbus Airport data, but over the longer period shown in Figure 3, it is characteristic. To better represent the climate, we further examine the longer period of available data from the West Central section of Georgia. In this exercise, the precipitation data are divided into nine "5-inch bins" covering the range of data from 30 inches as a low to 75 inches as a high. From this we can find the

* From the Southeast Regional Climate Center: http://water.dnr.state.sc.us/water/climate/sercc/products/cumulative_graphs/cumulative_map.html (no longer available).

† All data available for SEMP Meteorological Station #1; data from the SEMP Data Repository for Climate for the year 2000. http://sempdata.wes.army.mil/. The installation itself does not collect this type of data.

frequency of occurrence of precipitation amounts in each bin (Table 2).

Table 2: Frequency of Precipitation Ranges

Bin No.	Bin Range	Count of Bin	Bin % Total	Cumulative Count
1	30-35	2	2	2
2	35-40	6	6	8
3	40-45	21	19	29
4	45-50	27	25	56
5	50-55	26	24	82
6	55-60	14	13	96
7	60-65	9	8	105
8	65-70	2	2	107
9	70-75	1	1	108

The years 1999 and 2000 (with 38.62 and 38.86 inches of precipitation, respectively) both fall in the 35-40 inches range (Bin Range 2 in Figure 7, p 12). Bin Range 2 can be expected to occur 5.5% of the time. Year 2001 (with 42.87 inches of precipitation) falls in the 40-45 inches range (Bin Range 3 in Figure 7), which can be expected to occur 19.4% of the time. Interestingly, none of these years fell into the lowest precipitation range. In regards to the occurrence of the Study Years being consecutive, similar low levels of precipitation previously occurred in 1896 and 1897 at 40.88 inches (falling into bin 2, which occurs 5.5% of the time) and 43.52 inches (falling in bin 3, which occurs 19.4% of the time). This coordinates directly with the official estimation that a drought like that during the Study Years occurs once every 50 to 100 years*.

* Knox, op cit.

Stream Flow

The third parameter investigated was stream flow. The U.S. Geological Survey (USGS) has two stream monitoring stations near Fort Benning from which we might draw useful conclusions on the character of the climate during the Study Years. Monthly flow data for the Chattahoochee River is available beginning with 1929 (nearly 71 years of monthly averages are available), and for Upatoi Creek the record begins in 1968 (with about 34 years of monthly averages). A graph of the raw flow values by month was not informative because there was so much variation. To better interpret the flow data, the monthly averages were compared with the actual values for the Study Years (where they are available) for the Chattahoochee River (Figure 8, p 13) and Upatoi Creek† (Figure 9, p 13).

Comparing the Study Years with the average conditions for the USGS stations on the Chattahoochee (data for 1929-2000) and Upatoi Creek (data for 1968-2001), it can be seen that, although the absolute volumes are different, in both graphs the highest annual flow period centers on March of each year. The June to November segment corresponds to a steady, low flow period. From the Upatoi Creek data, flows for 2001 roughly reflect the average situation. Even in 1999 and 2000, the low flow period is not very different from

† Similar to the 2000 Benning curve in Figure 4, a review of the data available from the SEMP Data Repository for Hydrography was made to determine if there was any difference between these data and those on Fort Benning itself. Although the hydrography data have fields for flow rate and water level, no cross-section area is available, so it is not possible to compute flow from the SEMP hydrography data.

normal, particularly in Upatoi Creek. For both stations, however, 1999 and 2000 were well below average. This is almost entirely explained by the fact that the period of high flow for 1999 and 2000 were significantly lower than even a standard deviation. For both graphs, the peak flow period for 1999 and 2000 is barely distinguishable from the average low flow. This is a critical issue, since the yearly water flow budget (the sum of the area under the curves) is determined in the February to May period. For 1999 and 2000, the water flow budget was minimal at this important period.

The degree of deviation from the average flow rates for the rest of the year is presented in Figure 10 (p 14). It shows the variations to be strongly and consistently negative. The year 2000 is the consistently most low flow aberrant year, although 1999 is at times more aberrant. The March value for 1999 is 2.6SD away from the average for that month. Most significantly, the greatest negative deviation is in the most critical months for both years. There have been 10 occurrences of a greater standard deviation in 33 years, though March 1999 is at the 97th percentile.

Conclusions

Precipitation has been more than one sigma below average for all three initial collection seasons. On time scales in the range of decades to a century, one sigma is not beyond the nature of the climate in the area. However, the first years of SEMP data gathering have captured a noteworthy dry period — one end of the spectrum.

For a program covering a temporal horizon of 25-30 years, it would appear this dry period is an expected, although an unusually extended, part of the variation in the system. However, the currently acquired SEMP data do not represent a full normal distribution.

From the data reviewed in this study, climatic variations may occur in temporal scales greater than 25-35 years. So the minimum scheduled SEMP temporal scale (10 years) may not be enough time to capture the full range of natural variability.

Where data were available (from the SEMP Data Repository), the values and trends were highly coincident when compared to the outside sources used here. There is every reason to believe that the regional data well represent Fort Benning weather characteristics.

The three Study Years appear to represent the drought portion of normal variation (i.e., it reaches, but does not significantly exceed, normal extremes). Ecosystems respond to forcing agents. A drought as a forcing agent is similar to forest fire as a forcing agent. In both cases, although they occur infrequently, they are nevertheless integral to the definition of an ecosystem. Researchers may actually consider themselves fortunate to have captured within their data one of the important events of the region's ecology. Similarly, the low stream flow rates observed (a reflection of low precipitation) are also ecosystem forcing events that help to define the limits of what a system can endure and how the system sustains itself.

Recommendations

1. Recognize in models being developed that the data collected thus far are likely to represent the drought portion of normal variation.
2. Data to test the variation resulting from an ecosystem model cannot be represented using solely data collected during the period 1999-2001.
3. To adequately capture the full range of expected fluctuation, the period of long-term data collection should be at least 25-35 years.

Although it is beyond the scope of this study, another question rises, "In the first 3 years of SEMP, efforts were focused on selecting environmental parameters to evaluate conditions over the longer life of the project. To what extent has the selection of these parameters been affected by the drought and what is the validity of the selected parameters in normal, let alone, extremely wet years?" As a logical next step then, an evaluation of the sensitivity of the SEMP parameters to climate variation needs to be carried out.

Point of Contact

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Greenland David, Multiyear Variation of Temperature and Precipitation In The Coastal States of the Southeastern United States, Southeastern Geographer, Volume XXXXI, Number 1, May 2001, pp 36-52.

Southeast Regional Climate Center, Columbus WSO Airport, GA (092166), Period of Record Monthly Climate Summary, Period of Record: 7/ 1/1948 to 12/31/2001: http://cirrus.dnr.state.sc.us/cgi-bin/sercc/cliMAIN.pl?ga2166

Southeast Regional Climate Center, Precipitation Accumulation and Departures from Normal in the Southeast at: http://water.dnr.state.sc.us/water/climate/sercc/products/cumulative_graphs/cumulative_map.html

United States Geologic Survey: *Monthly Streamflow Statistics for the Nation*, at: http://waterdata.usgs.gov/nwis/monthly

Figures

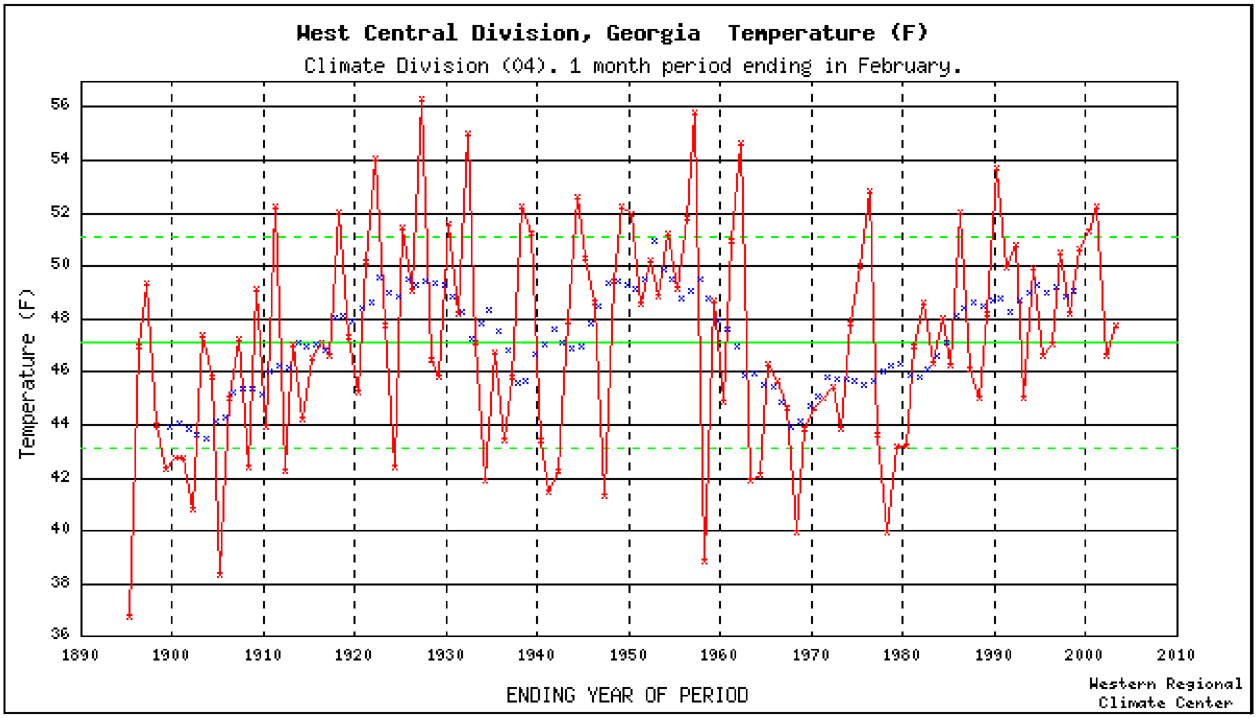

Figure 1. Temperature for the West Central section of Georgia.

Red - 1-month period

blue - 10 year running mean

green - average (solid), ± sigma (dashed)

Average Temperature 1-Month Period Ending in Month 2

YEARS: 1890 - 2010	
AVERAGE	47.121
SIGMA (RMS)	3.991
COEFF OF VAR	0.085
SKEWNESS	-0.060
MEDIAN	47.000
MAXIMUM VALUE	56.300
MINIMUM VALUE	36.700
NUMBER OBS	109.

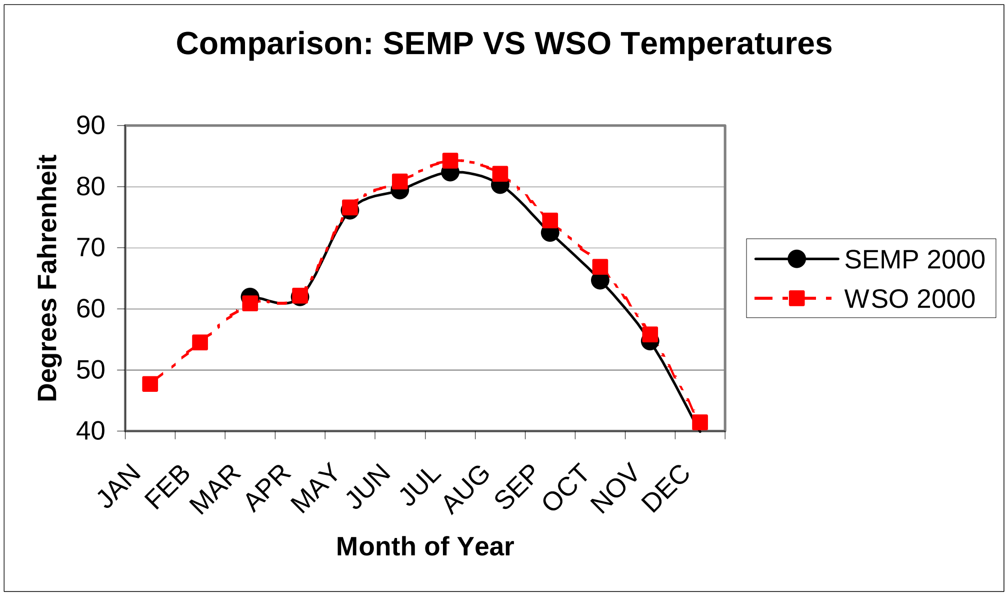

Figure 2. Comparison of SEMP and WSO monthly temperature averages.

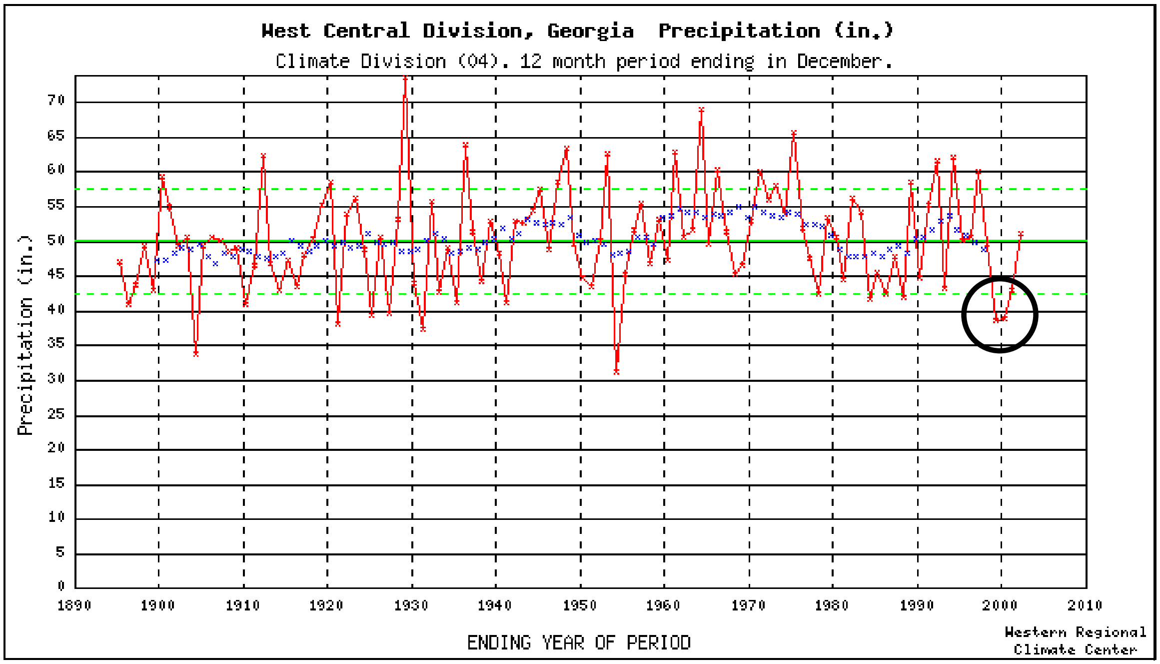

Figure 3: Precipitation for the West Central section of Georgia.

Red - 12-month period

blue - 10 year running mean

green - average (solid), ± sigma (dashed)

Total Precipitation 12-Month Period Ending in Month 12

YEARS: 1890 - 2010

AVERAGE	50.077
SIGMA (RMS)	7.496
COEFF OF VAR	0.150
SKEWNESS	0.335
MEDIAN	49.775
MAXIMUM VALUE	73.540
MINIMUM VALUE	31.030
NUMBER OBS	108.

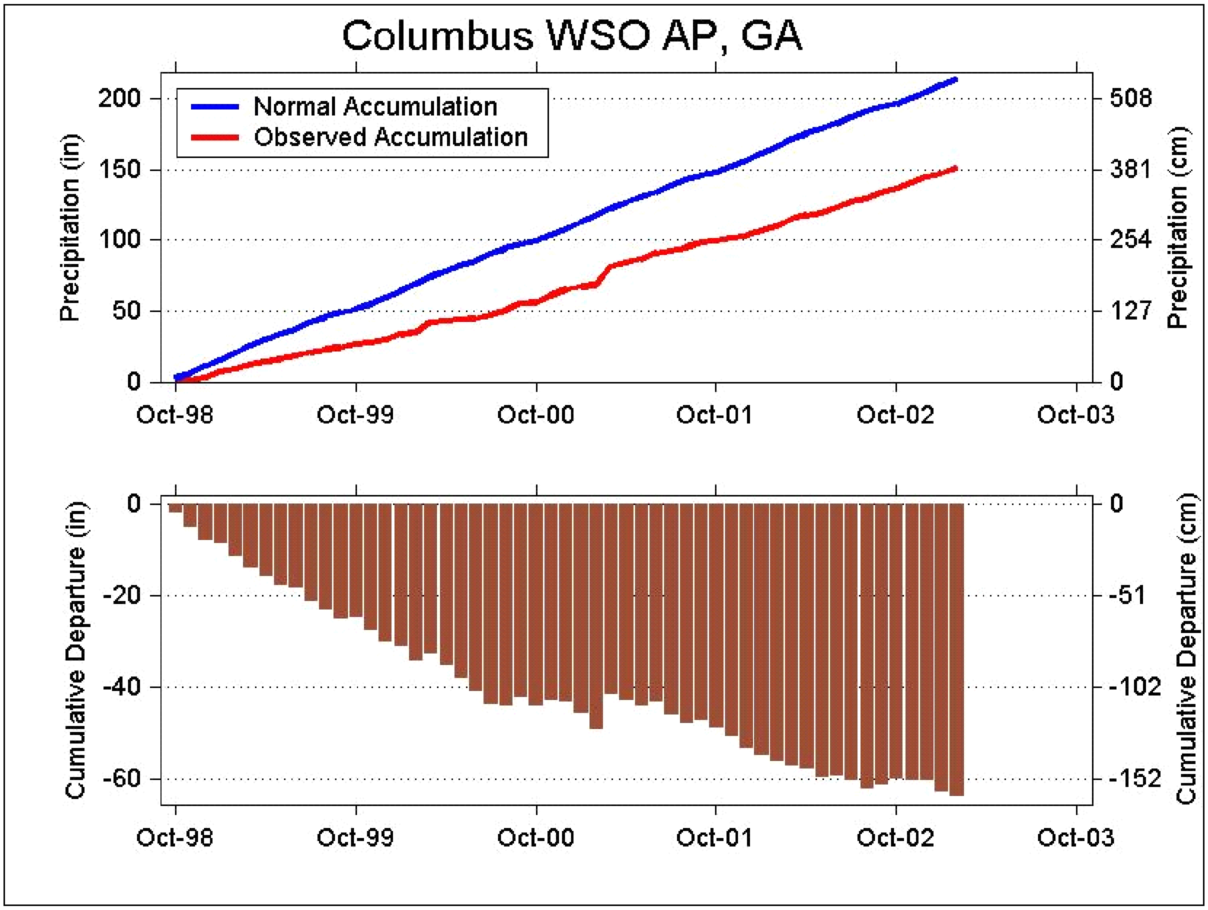

Figure 4. Precipitation at Columbus GA Airport and cumulative departure from October 1998.

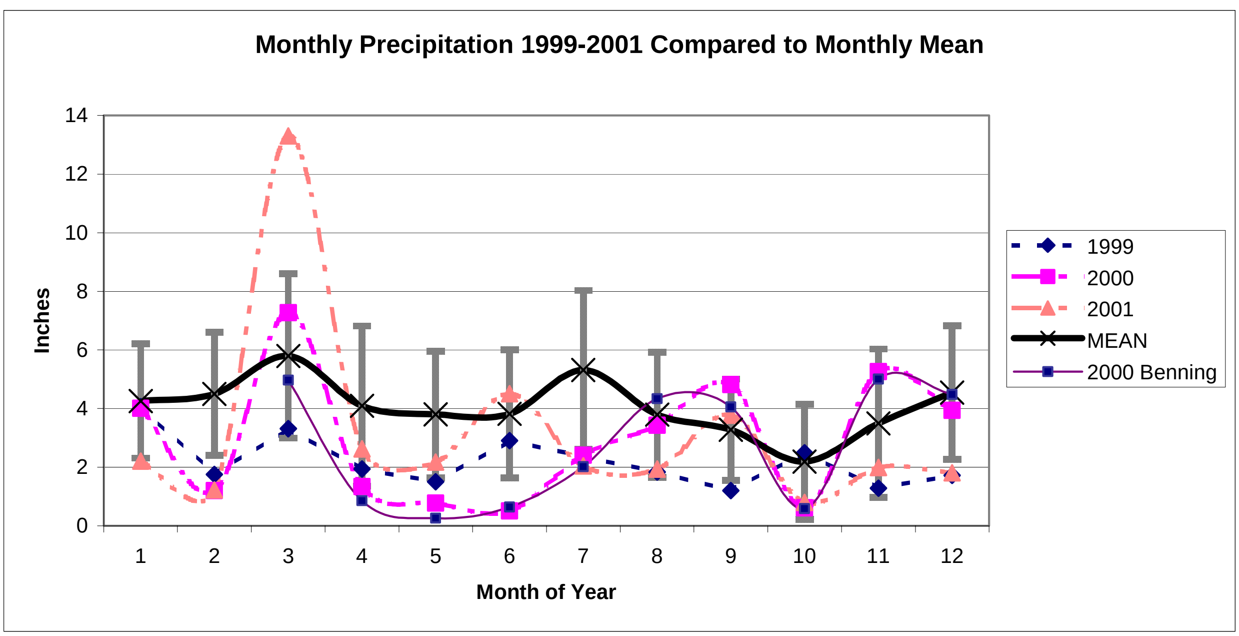

Figure 5. Average monthly precipitation compared to the Study Years.

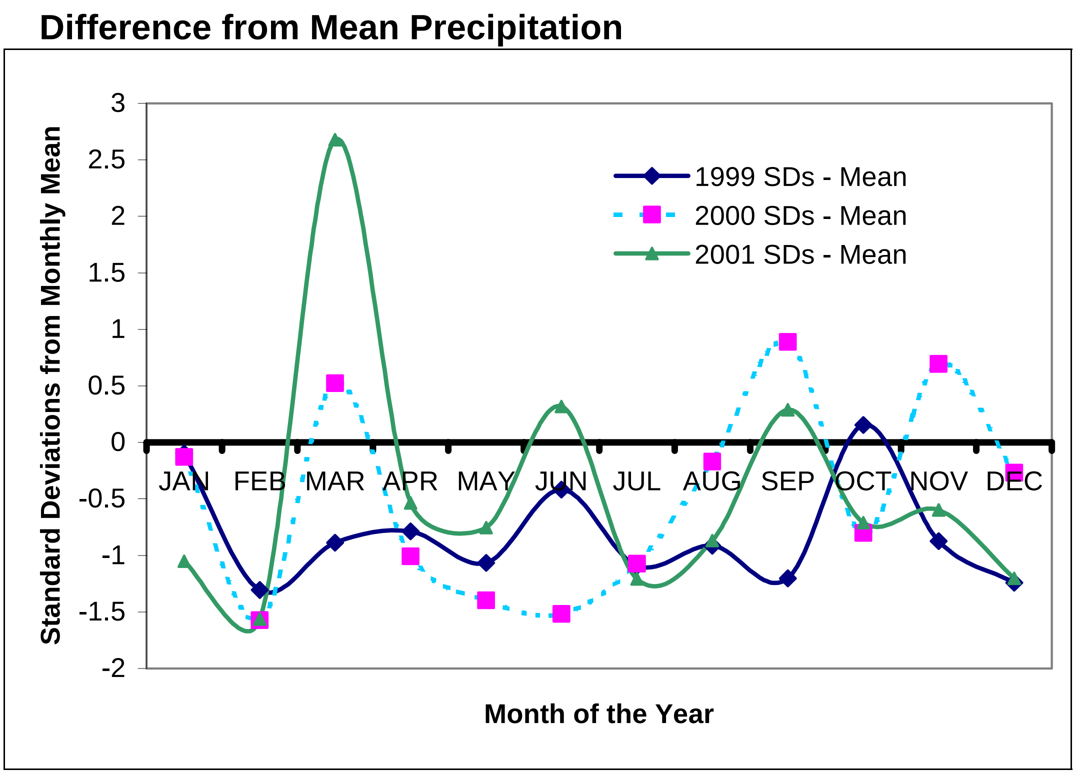

Figure 6. Precipitation difference from the mean value for each month during the study period.

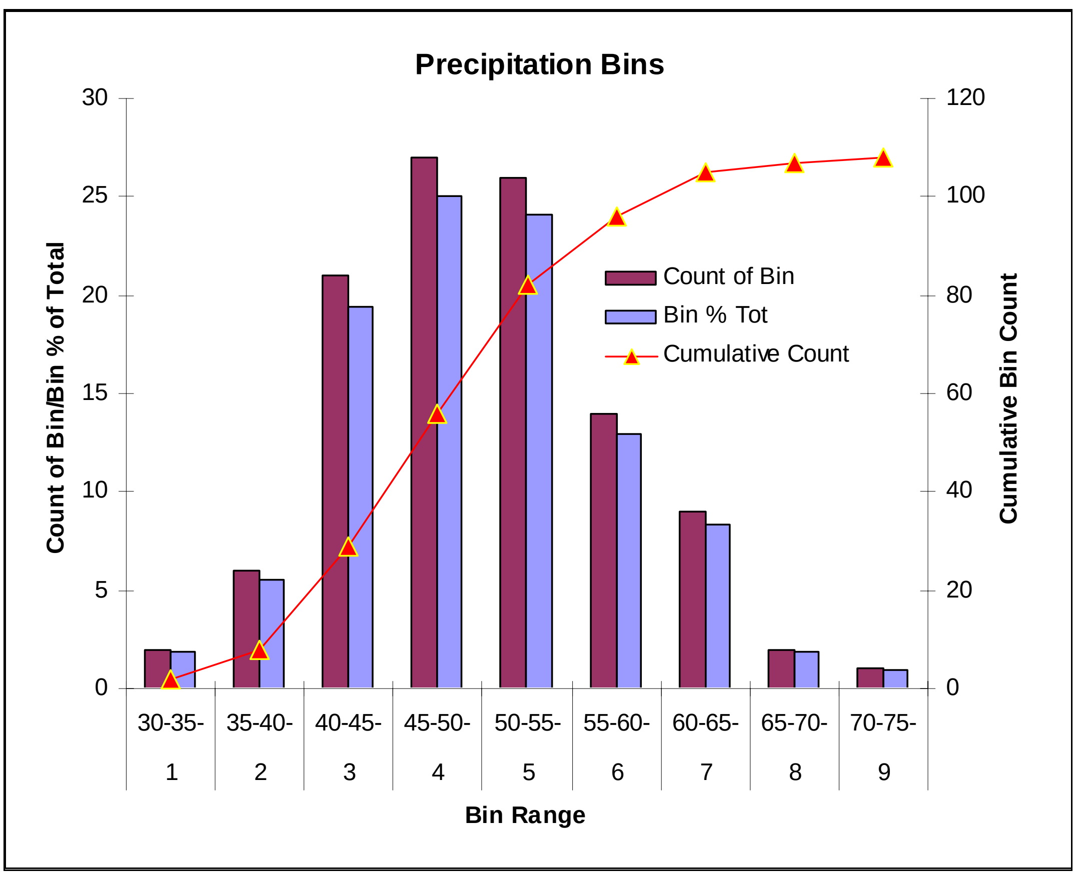

Figure 7. Frequency of precipitation ranges.

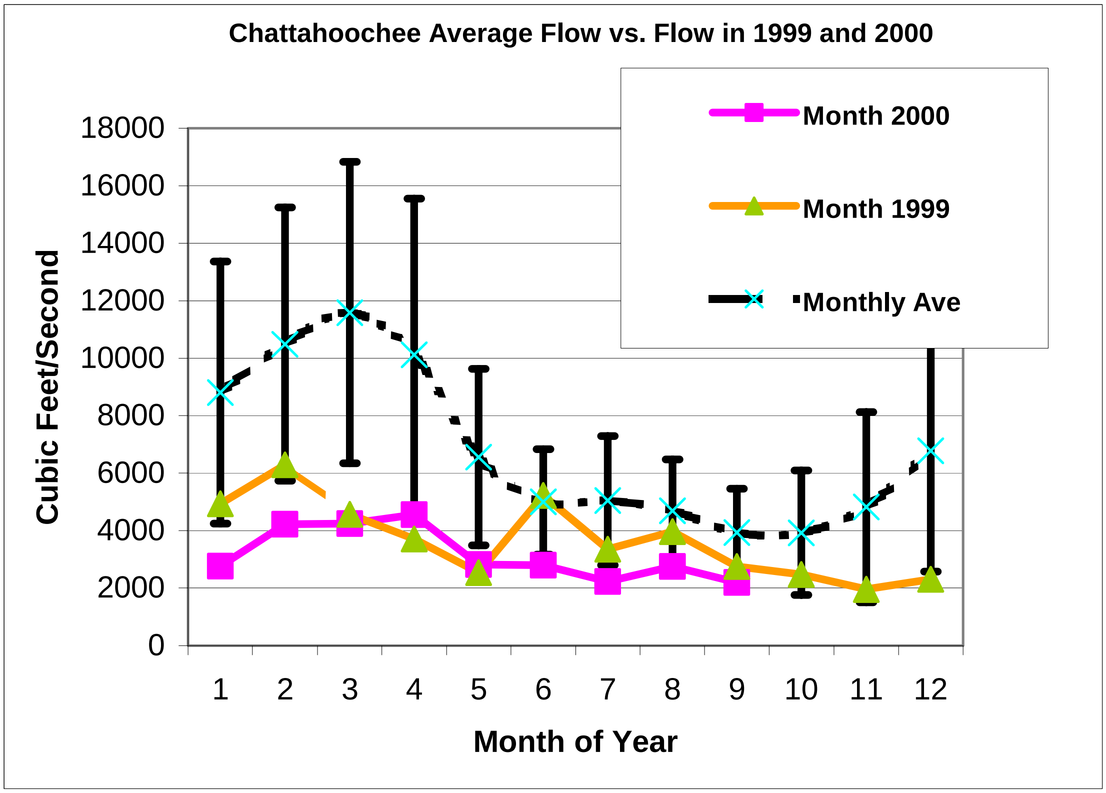

Figure 8. Study Years flow rates compared with average rates for Chattahoochee River.

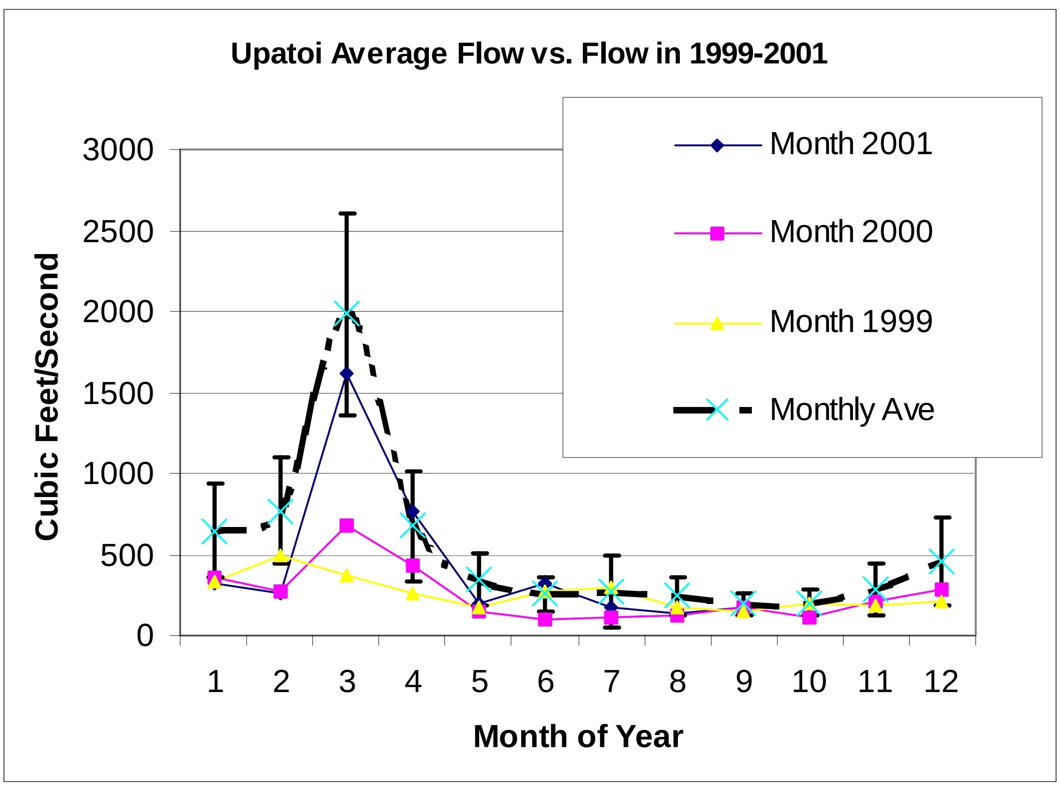

Figure 9. Study Years flow rates compared with average rates for Upatoi Creek.

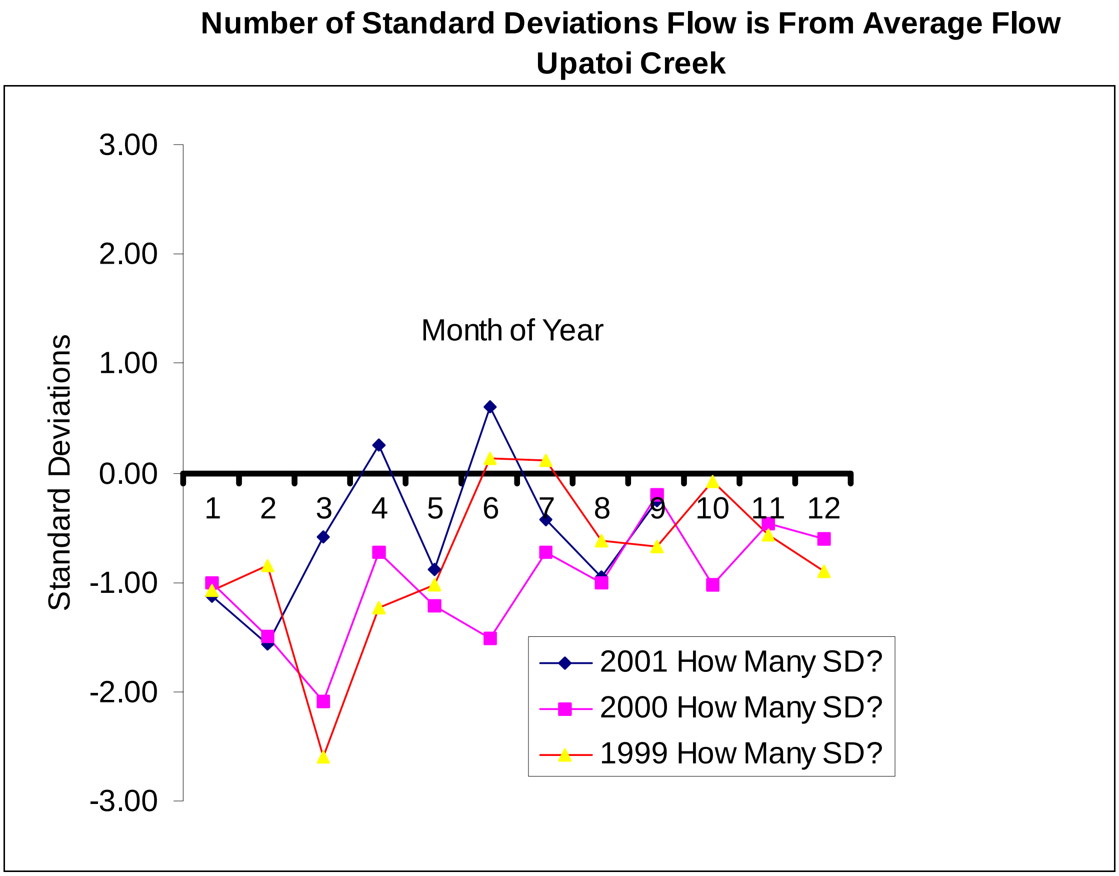

Figure 10. Difference from average flow in Upatoi Creek in standard deviations for the Study Years.

Appendix A: Data for West Central Section of Georgia for Precipitation

Area of coverage:
Includes Haralson, Carroll, Douglas, Henry, Fayette, Coweta, Heard, Spalding, Meriwether, Troup, Lamar, Pike, Upson, Talbot, Harris, Taylor, Muscogee, Marion, Chattahoochee, Macon, and Schley counties in Georgia. See Figure A1.

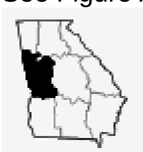

Figure A1: Darkened area is the extent of the West Central Georgia Division.

Year	Precipitation (Inches)
Average	50.1
1895	46.830
1896	40.880
1897	43.520
1898	49.150
1899	42.910
1900	59.170
1901	54.870
1902	49.270
1903	50.500
1904	33.690
1905	49.260
1906	50.570
1907	49.970
1908	48.430
1909	49.120
1910	40.820
1911	46.510
1912	62.350
1913	46.640
1914	42.770
1915	47.110
1916	43.280
1917	48.040
1918	50.180
1919	55.230
1920	58.560
1921	37.990
1922	53.830
1923	56.040
1924	48.800
1925	39.310
1926	50.650
1927	39.590
1928	53.140
1929	73.540
1930	44.000
1931	37.280
1932	55.650
1933	42.490
1934	49.050
1935	41.170
1936	63.680
1937	51.270
1938	44.210
1939	52.780
1940	48.190
1941	41.190
1942	52.940
1943	52.620
1944	54.320
1945	57.440
1946	48.780
1947	58.390
1948	63.160
1949	49.460
1950	44.620
1951	43.430
1952	50.020
1953	62.530
1954	31.030
1955	45.140
1956	51.570
1957	55.340
1958	46.660
1959	53.170
1960	47.120
1961	62.670
1962	50.630
1963	51.600
1964	68.890
1965	49.400
1966	60.340
1967	51.270
1968	45.100
1969	46.330
1970	52.790
1971	60.050
1972	55.850
1973	57.810
1974	53.840
1975	65.650
1976	51.770
1977	47.380
1978	42.360
1979	53.260
1980	50.440
1981	44.470
1982	56.070
1983	54.070
1984	41.680
1985	45.450
1986	42.410
1987	47.590
1988	41.760
1989	58.560
1990	44.760
1991	55.070
1992	61.400
1993	43.000
1994	61.900
1995	49.990
1996	50.560
1997	59.950
1998	49.580
1999	38.620
2000	38.860
2001	42.870
2002	51.010

The stations included in the divisional averages are those that have long-term means calculated in the publication “Climatological Data” and also give departures from average. Many are non-airport stations. To derive the composite value, simple arithmetic averages of all stations are used. Typically this is a couple to a few dozen sites.

Appendix B: WSO Data for Columbus (rainfall in inches/time unit)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
1948	4.26	4.5	5.8	4.09	3.8	3.82	9.88	5.66	3.3	1.52	12.45	4.75	37.56
1949	2.87	7.79	3.86	8.12	3.03	3.32	10.41	4.31	3.14	2.83	1.34	3.84	54.86
1950	2.09	3.06	6.58	2.87	4.09	4.33	6.2	5.77	1.6	1.49	0.81	5.47	44.36
1951	2.06	1.22	3.72	3.66	1.58	5.43	3.99	5.37	6.94	1.24	2.52	5.65	43.38
1952	3.75	4.85	12.53	2.24	7.03	3.14	1.83	6.39	3.39	0.31	2.02	7.26	54.74
1953	4.75	6.6	1.9	11.67	4.36	4.9	6.09	1	5.98	0.3	2.11	9.39	59.05
1954	0.87	2.33	4.42	2.08	2.26	1.56	6.14	2.3	0.45	0.89	3.65	3.28	30.23
1955	4.93	4.02	2.08	4.34	6.21	1.29	12.15	2.08	0.42	1.73	2.58	0.43	42.26
1956	1.43	6.02	5.59	2.36	0.78	2.71	6.41	0.96	6.59	1.33	0.31	9.29	43.78
1957	3.05	1.97	4.24	6.19	7.63	4.29	1.74	2.61	3.88	1.05	8.62	1.91	47.18
1958	2.75	3.81	7.69	4.49	2.12	4.96	5.77	3.39	2.2	1.11	1.61	3.4	43.3
1959	3.87	6.16	8.12	1.41	8.45	6.16	5.01	4.17	3.31	6.59	0.89	2.29	56.43
1960	6.37	4.87	7.22	5.9	2.12	2.2	3.42	5.59	2.83	1.13	1.06	2.19	44.9
1961	2.34	9.41	6.54	5.36	3.93	4.32	4.53	4.96	1.17	0.02	1.11	7.29	50.98
1962	5.94	4.74	8.5	5.58	0.22	2.59	7.51	2.82	3.24	1.44	4.13	2.69	49.4
1963	6.24	3.25	2.69	2.53	1.17	4.3	3.2	3.04	3.04	0	4.8	4.88	39.14
1964	7.01	5.37	5.56	11.38	3.63	3.91	9.57	5.18	4.8	8.09	2.08	6.64	73.22
1965	2.79	5.46	6.06	1.07	2.54	7.91	5.48	1.88	5.81	2.99	2.13	2.75	46.87
1966	7.87	8.45	7.3	2.76	7.87	4.54	5.1	7.16	3.46	4.7	3.98	6.74	69.93
1967	3.48	3.34	1.4	0.86	6.62	10.83	3.81	5.06	3.84	3.23	2.86	4.9	50.23
1968	1.78	1.54	4.38	2.58	4.73	1.8	3.02	3.64	2.57	0.85	4.34	4.88	36.11
1969	1.22	4.13	4.49	8.3	6.02	2.81	6.55	2.93	6.32	0.31	0.79	5.09	48.96
1970	4.59	4.22	6.85	2.91	4.24	5.35	6.36	2.91	2.94	4.47	2.48	6.89	54.21
1971	5.33	7.13	9.16	3.27	4.42	4.22	13.24	5.11	4.96	0.26	2.41	4.96	64.47
1972	6.1	3.92	5.01	1.07	3.31	7.74	7.75	1.04	2.47	2.31	4.36	9.38	54.46
1973	6.03	4.55	9.82	5.95	4.53	4.42	3.64	6.97	2.23	1.16	3.37	7.14	59.81
1974	7.5	3.98	2.13	5.85	7.54	2.87	5.26	5.2	4.87	0.55	3.88	5.15	54.78
1975	6.64	7.56	7.32	6.66	4.78	3.94	7.87	4.11	2.85	5.42	2.67	3.54	63.36
1976	3.64	1.59	7.88	2.7	3.75	6.88	2.73	3.71	4.97	5.06	4.94	3.87	51.72
1977	4.15	2.02	7.92	1.73	3.49	3.46	3.79	10.07	3.54	2.15	6.12	3.56	52
1978	8.35	1.77	4.43	4.32	6.46	2.44	5.14	3.97	0.72	0.02	2.91	3.01	43.54
1979	6.91	7.84	2.72	10.69	4.59	1.24	4.12	2.5	5.5	1.47	4.52	2.52	54.62
1980	3.98	3.53	11.2	5.13	6.9	2.69	3.22	4.49	2.32	1.92	1.77	1.66	48.81
1981	1.27	7.72	4.2	6.88	1.45	3.05	5.4	2.93	2.62	1.9	1.18	8.94	47.54
1982	4.22	4.88	2.17	8.42	4.19	2.46	5.73	2.4	1.12	2	5.29	8.74	51.62
1983	3.95	5.75	7.37	4.48	2.02	5.05	3.57	3.16	6.01	1.82	5.07	7.02	55.27
1984	3.6	3.22	5.96	2.16	4.42	1.96	7.5	3.5	0.22	0.42	2.47	2.69	38.12
1985	3.84	6.21	1.38	1.9	4.86	2.03	4.53	3.28	0.98	2.85	2.94	4.85	39.65
1986	1.45	4.67	8.78	0.1	2.55	0.83	3.15	3.37	3.62	3.94	9.85	2.65	44.96
1987	5.47	7.69	4.38	0.62	6.25	9.19	4.31	1.82	2.31	0.37	3.22	2.9	48.53
1988	6.72	2.73	3.35	4.64	1.61	0.94	4.91	0.8	4.25	1.52	3.63	3.72	38.82
1989	0.72	2.64	4.88	6.51	2.42	7.34	11.58	2.27	3.68	2.46	5.11	7.31	56.92
1990	4.45	6.31	9.4	2.64	4.45	1.05	3.58	1.68	0.54	3	1.64	2.76	41.5
1991	7.46	1.94	7.86	4.32	7	3.9	3.79	10.11	2.38	0.58	4.7	3.34	57.38

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
1992	6.65	5.07	4.72	2.59	0.8	2.76	8.28	9.15	2.79	2.46	11.63	3.95	60.85
1993	4.12	3.52	8.06	2.21	2.04	0.74	3.41	4.32	0.97	3.72	4.92	4.01	42.04
1994	4.36	4.73	6.24	1.61	2.84	5.07	7.98	3.43	3.46	5.41	2.08	2.08	49.29
1995	3.91	6.05	2.68	1.32	1.51	3.46	2.34	2.24	3.7	8.41	3.75	5.45	44.82
1996	5.28	3.83	6.55	4.81	2.37	2.33	3.06	2.94	5.41	2.17	2.17	2.8	43.72
1997	4.16	6.29	1.86	5.84	4.65	5.99	4.4	1.73	2.25	2.77	4.26	6.72	50.92
1998	3.21	4.43	4.5	3.62	1.09	3.75	2.07	1.85	5.25	0.54	0.88	1.59	32.78
1999	4.07	1.76	3.31	1.94	1.5	2.91	2.36	1.84	1.2	2.49	1.29	1.72	26.39
2000	4.01	1.2	7.27	1.34	0.78	0.51	2.41	3.43	4.82	0.62	5.26	3.94	35.59
2001	2.21	1.22	13.3	2.63	2.17	4.51	2.05	1.94	3.78	0.8	1.99	1.81	38.41

Note: Data for stream flows are too extensive to be included in further appendices, but current values can be obtained at http://waterdata.usgs.gov/nwis/monthly.

Appendix C: Location of Sites Mentioned in This Technical Note