Appendix C

Apalachicola-Chattahoochee-Flint (ACF) Basin Detailed Analysis

Appendix C - Apalachicola-Chattahoochee-Flint Basin Detailed Analysis

1 ACF BASIN

1.1 DESCRIPTION OF BASIN

Streams of the Apalachicola-Chattahoochee-Flint Rivers (ACF) Basin begin as small Appalachian springs in the Blue Ridge Mountains of North Georgia. The spring waters flow for over 400 miles until the Chattahoochee River combines with the Flint River, forming the Apalachicola River at the Georgia, Florida border. From the confluence the Apalachicola flows an additional 108 miles to the Gulf of Mexico. The ACF Basin extends about 385 miles from northeast Georgia to the Gulf of Mexico. The total drainage area of the ACF Basin is approximately 19,600 square miles.

The largest metropolitan area in the basin is Atlanta, Georgia, located in the northern section. Progressing downstream are the Cities of Columbus, Georgia and Phenix City, Alabama. Albany, Georgia is located in the eastern portion of the basin. At the Gulf of Mexico is the City of Apalachicola, Florida. Features are shown in Figure C-1.

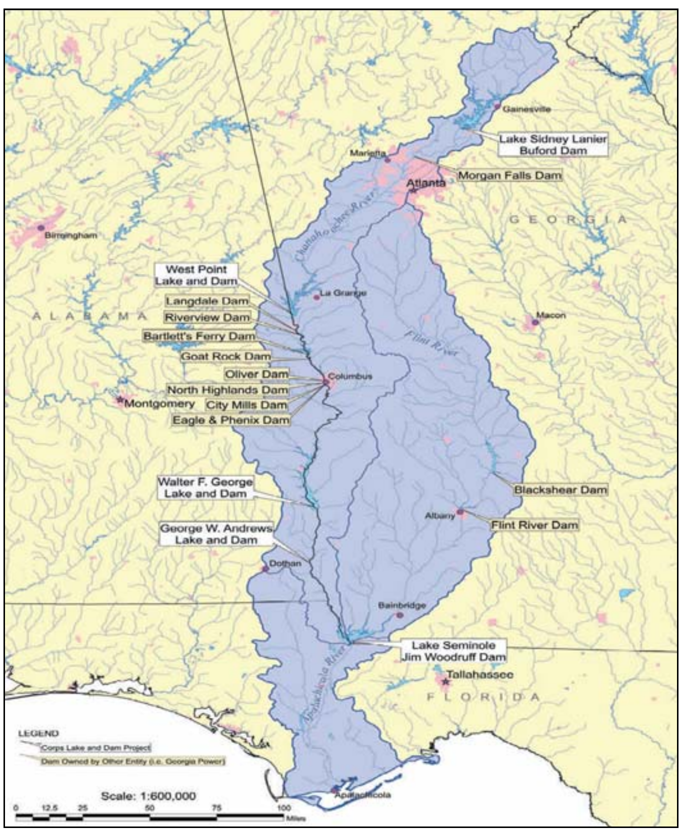

Figure C-1. ACF Basin

1.1.1 Physical Description

Chattahoochee Tributaries. The headwaters of the ACF System commence with spring-fed streams feeding Chattahoochee tributaries in northern Georgia mountains. The mountain slopes are steep, with rapid runoff during rainstorms. One of the most upstream tributaries is the Chestatee River that flows into Lake Lanier. In contrast to the mainstream of the Chattahoochee River, many tributaries remain free flowing. Flows in forested tributary basins and those in Metropolitan Atlanta retain similar runoff patterns. They have higher sustained flows during winter months, and relatively quick responses to storm events throughout the year. However, sharper peaks in the hydrographs of urban streams such as Peachtree Creek reflect the influence of impervious land cover in the urbanized parts of the basin.

Chattahoochee River. The Chattahoochee River has a drainage area of 8,770 square miles. The headwaters rise as cold-water mountain streams in the Blue Ridge Province at altitudes above 3,000 feet. From its beginning the river flows 430 miles to its confluence with the Flint River. The Chattahoochee River derives its name from Creek Indian words meaning painted rock. This river is one of the most heavily used water resources in Georgia.

Through most of its length, flows in the Chattahoochee River are controlled by hydroelectric plants releasing water for production of hydropower. These hydroelectric plants use peaking operations to augment power supply during peak periods of electric demand. Daily fluctuations below some reservoirs can be dramatic. Fluctuations are usually more pronounced during low flow periods when hydropower releases often cause daily fluctuations of several feet.

The Chattahoochee River includes five federal projects operated by the Corps of Engineers: Buford Dam (Lake Lanier), West Point Dam, Walter F. George Lock and Dam (Lake Eufaula), and George W. Andrews Lock and Dam. Of these, Lake Sidney Lanier (Buford Dam), West Point Lake, and Lake Eufaula (Walter F. George Dam) provide most water storage available to regulate flows in the basin. Lake Sidney Lanier alone provides 65 percent of conservation storage, although only five percent of the ACF River Basin drains into the lake. In addition, West Point Lake and Lake Walter F. George provide 18 and 14 percent, respectively, of the basin's conservation storage. Lake Seminole has some storage to regulate weekly flows, and the Georgia Power Lake at Morgan Falls provides daily regulation.

Georgia Power Company operates seven projects on the Chattahoochee River. One is north of Atlanta, Georgia and the remaining six are located along the Fall Line near Columbus, Georgia. These projects are Morgan Falls Dam, Langdale Dam, Riverview Dam, Bartletts Ferry Dam, Goat Rock Dam, Oliver Dam and North Highlands Dam.

The Chattahoochee River Basin also includes City Mills Dam owned by City Mills, and Eagle and Phenix Mills Dam owned by Uptown Columbus Inc. City Mills Dam is currently inoperative. Eagle and Phenix Mills Dam has an operable turbine with an expired Federal Energy Regulatory Commission (FERC) license. Habersham Mill Dam is located in the headwaters above Buford Dam.

Flint River. The Flint River Basin (8,460 square miles) includes Crisp County Dam and Lake (also known as Warwick or Blackshear Lake), and Albany Dam (also known as the Flint River Dam) that impounds Lake Worth. The river begins as a spring or groundwater seep underneath the runways of Hartsfield-Jackson International Airport. The flow is channeled off the airport by large drainage pipes. From the airport it meanders 350 miles in a basin that is approximately 212 miles in length. It has 220 miles of unimpeded flow, making it one of only 40 rivers in the U.S. with open flows of 200 miles or more of near natural stream. The Flint River remains relatively undeveloped, and for much of its length the river is free flowing.

Apalachicola River. The Flint River empties into Lake Seminole near Bainbridge, Georgia, where it joins the Chattahoochee River at the Florida state line near the Jim Woodruff Dam to form the Apalachicola River. The Apalachicola River Basin (2,370 square miles) includes Jim Woodruff Lock and Dam (Lake Seminole), which is operated by the Corps of Engineers. The river lies completely within the Coastal Plain and is 108 miles in length. The Apalachicola River then flows south across northwest Florida from the Georgia border to Apalachicola Bay in Florida.

1.1.2 Climate

The chief factors that control the climate of the ACF Basin are its geographical position in the southern end of the Temperate Zone, its proximity to the Gulf of Mexico and South Atlantic Ocean, and its range in altitude from almost sea level at the southern end to over 3,000 feet in the Blue Ridge Mountains to the north. The proximity of the warm South Atlantic and the semitropical Gulf of Mexico ensures a warm, moist climate. Extreme temperatures range from near 110 degrees in the summer to values near zero in the winter. Severe cold weather rarely lasts longer than a few days. The summers, while warm, are usually not oppressive. In the southern end of the basin the average maximum January temperature is 60 degrees and the average minimum January temperature is 37 degrees.

The maximum average July temperature is 91 degrees; in the southern end of the basin the corresponding minimum values value is 70 degrees. The frost-free season varies in length from about 200 days in the northern valleys to about 250 days in the southern part of the basin. Precipitation is mostly in the form of rain, but some snow falls in the mountainous northern region on an average of twice a year.

1.1.3 Precipitation

The entire ACF Watershed lies in a region which ordinarily receives an abundance of precipitation. The watershed receives a large amount of rainfall and it is well-distributed throughout the year. Winter and spring are the wettest periods and early fall, the driest. Light snow is not unusual in the northern part of the watershed, but constitutes only a very small fraction of the annual precipitation and has little effect on runoff. Intense flood producing storms occur mostly in the winter and spring. They are usually of the frontal-type, formed by the meeting of warm moist air masses from the Gulf of Mexico colliding with the cold, drier masses from the northern regions, and may cause heavy precipitation over large areas. The storms that occur in summer or early fall are usually of the thunderstorm type with high intensities over smaller areas. Tropical disturbances and hurricanes can occur producing high intensities of rainfall over large areas.

1.1.4 Storms and Floods

Major flood-producing storms over the ACF Watershed are usually of the frontal type, occurring in the winter and spring and lasting from 2 to 4 days, with their effect on the basin depending on their magnitude and orientation. The axes of the frontal-type storms generally cut across the long, narrow basin. Frequently a flood in the lower reaches is not accompanied by a flood in the upper reaches and vice versa. Occasionally, a summer storm of the hurricane type, such as the storms of July 1916 and July 1994, will cause major floods over practically the entire basin. However, summer storms are usually of the thunderstorm type with high intensities over small areas producing serious local floods. With normal runoff conditions, from 5 to 6 inches of intense rainfall are required to produce widespread flooding, but on many of the minor tributaries 3 to 4 inches are sufficient to produce local floods.

Principal Storms. During most years there are one or more flooding events within the ACF Basin. However on occasion there are significant storms that produce widespread flooding or unusually high river stages.

1.1.5 Runoff Characteristics

Within the ACF Basin rainfall occurs throughout the year but is less abundant during the August through November time frame. The amount of this rainfall that actually contributes to streamflow varies much more than the rainfall. Several factors such as plant growth and the seasonal rainfall patterns contribute to the volume of runoff.

Tables C-1, C-2, and C-3 present the average monthly runoff for the basin. These tables divide the basin at Atlanta, and Columbus, Georgia and Blountstown, Florida to show the different percentages of runoff verses rainfall for the various sections. The mountainous areas exhibit flashier runoff characteristics and somewhat higher percentages of runoff. Figures C-2, C-3, and C-4 present the same information in graphical form.

Table C-1. Basin Rainfall and Runoff above Atlanta

AVERAGE MONTHLY RUNOFF IN ACF BASIN MEASURED AT ATLANTA, GEORGIA												
MONTH	JAN	FEB	MAR	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
AVG MONTHLY FLOW (CFS) AT ATLANTA	3,455	3,887	4,353	3,749	2,913	2,350	2,108	1,891	1,603	1,621	1,947	2,598
AVG RUNOFF IN INCHES	2.75	2.79	3.46	2.88	2.32	1.81	1.68	1.50	1.23	1.29	1.50	2.07
AVG RAINFALL IN INCHES	4.83	4.95	5.66	4.09	3.61	4.75	5.78	4.83	3.83	2.50	3.36	4.25
PERCENT OF RAINFALL AS RUNOFF	57%	56%	61%	71%	64%	38%	29%	31%	32%	51%	45%	49%

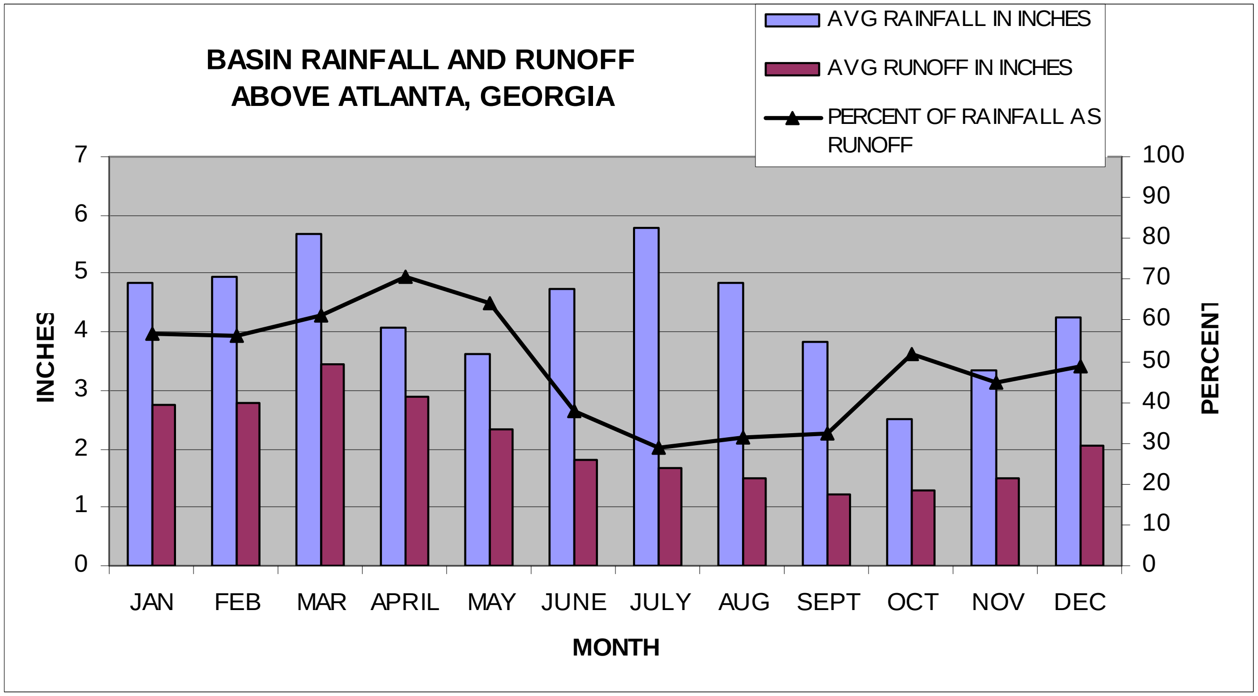

Figure C-2. Basin Rainfall and Runoff above Atlanta, Georgia

Table C-2. Basin Rainfall and Runoff between Columbus and Atlanta

AVERAGE MONTHLY RUNOFF IN ACF BASIN MEASURED AT COLUMBUS, GEORGIA												
MONTH	JAN	FEB	MAR	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
AVG MONTHLY FLOW (CFS) BETWEEN ATLANTA AND COLUMBUS	5,567	6,736	7,905	6,495	4,276	3,145	3,144	2,443	2,013	2,096	3,025	4,117
AVG RUNOFF IN INCHES	1.99	2.18	2.83	2.25	1.53	1.09	1.13	0.87	0.70	0.75	1.05	1.47
AVG RAINFALL IN INCHES	4.91	4.99	5.91	4.54	3.94	4.07	5.35	4.10	3.54	2.72	3.71	4.76
PERCENT OF RAINFALL AS RUNOFF	41%	44%	48%	50%	39%	27%	21%	21%	20%	28%	28%	31%

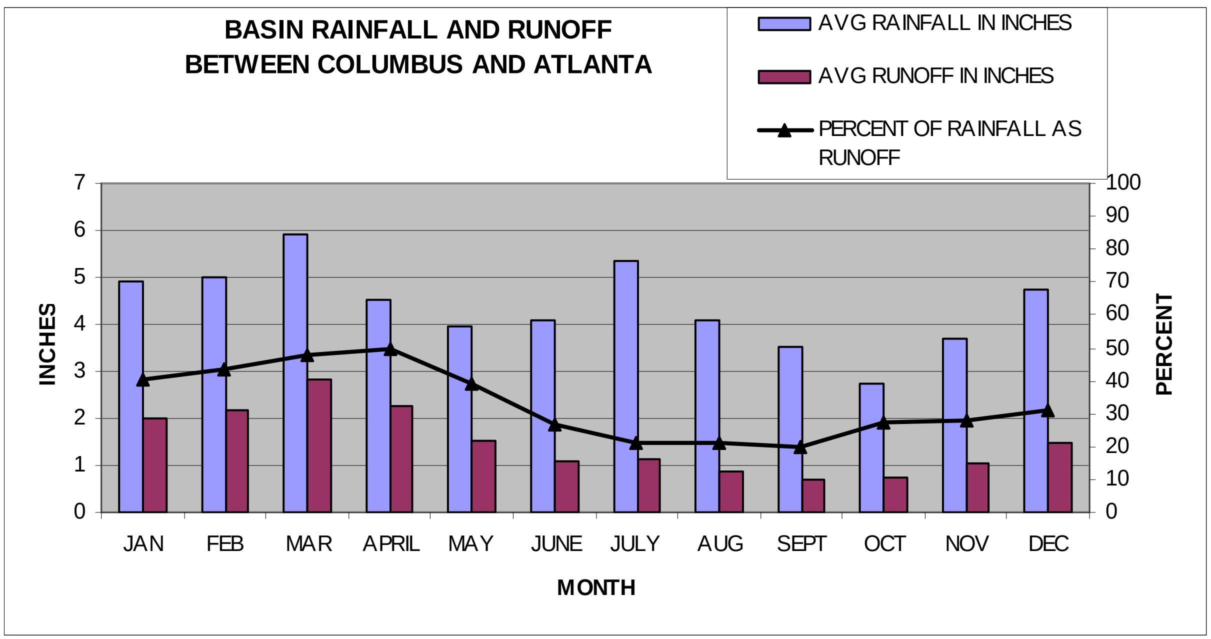

Figure C-3. Basin Rainfall and Runoff between Columbus and Atlanta, Georgia

Table C-3. Basin Rainfall and Runoff between Blountstown, FL and Columbus, GA

AVERAGE MONTHLY RUNOFF IN ACF BASIN MEASURED AT BLOUNTSTOWN, FLORIDA												
MONTHLY	JAN	FEB	MAR	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
AVG MONTHLY FLOW (CFS) BETWEEN COLUMBUS AND BLOUNTSTOWN	11,431	17,699	22,125	31,014	27,991	17,760	12,803	14,140	11,684	8,684	7,571	6,983
AVG RUNOFF IN INCHES AT BLOUNTSTOWN, FLORIDA	1.02	1.43	1.97	2.68	2.50	1.53	1.14	1.26	1.01	0.77	0.65	0.62
AVG RAINFALL IN INCHES	4.83	4.95	5.66	4.09	3.61	4.75	5.78	4.83	3.83	2.50	3.36	4.25
PERCENT OF RAINFALL AS RUNOFF	21%	29%	35%	65%	69%	32%	20%	26%	26%	31%	19%	15%

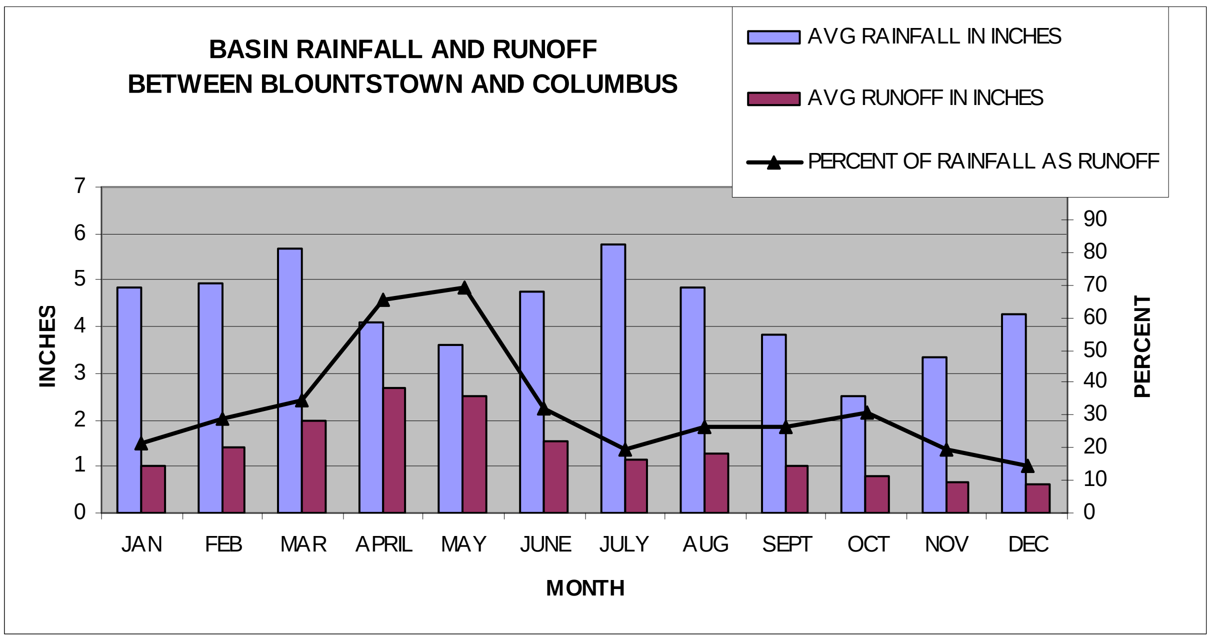

Figure C-4. Basin Rainfall and Runoff between Blountstown, FL and Columbus, GA

1.2 RESERVOIRS

1.2.1 Reservoir Storage

There are five (5) federally owned reservoir projects within the ACF Basin. These are Buford Dam (Lake Lanier), West Point Dam, Walter F. George Lock and Dam (Lake Eufaula), George W. Andrews Lock and Dam, and Jim Woodruff Lock and Dam (Lake Seminole). These projects were built and are operated by the Corps of Engineers, Mobile District Office. As mentioned above, Lake Sidney Lanier alone provides 63 percent of conservation storage, although only five percent of the ACF River Basin drains into the lake. In addition, West Point Lake and Lake Walter F. George provide 18 and 14 percent, respectively, of the basin's conservation storage. The conservation storages by reservoir are shown in Table C-4 and graphically in Figure C-5 below.

Table C-4. ACF Basin Conservation Storage by Project

Project	Conservation Storage (ac-ft)	Percentage
Lake Lanier	1,087,600	63%
West Point	306,127	18%
Walter F. George	244,400	14%
George Andrews	8,200	1%
Lake Seminole	66,847	4%
Total	**1,713,174**	

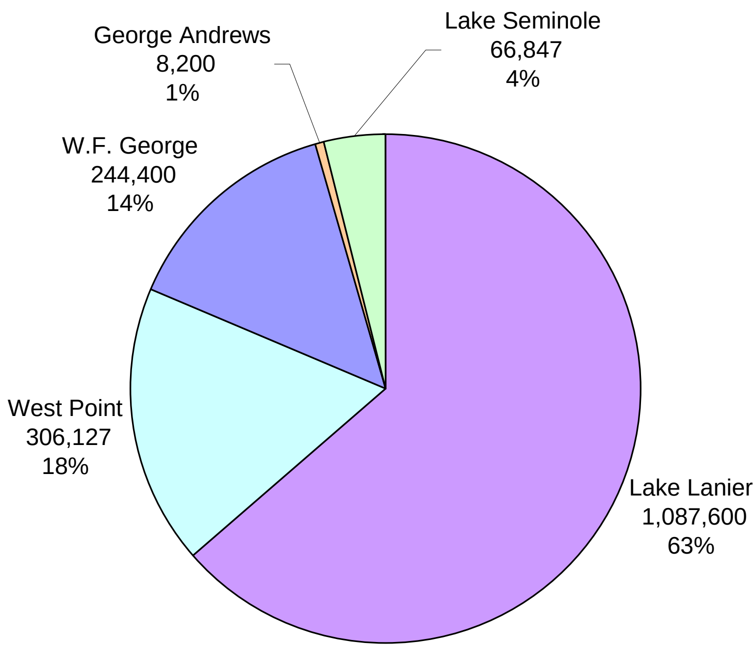

Figure C-5. ACF Basin Federal Reservoir Conservation Storage Percent by Acre-Feet

1.2.2 Reservoirs Selected for Yield

The only federal projects with significant storage are Buford Dam (Lake Lanier), West Point Dam, and Walter F. George Lock and Dam (Lake Eufaula). These three projects in the basin account for 95 percent of the total basin conservation storage. Therefore, yield analyses were done only on these three projects. These analyses are presented separately.

1.3 BUFORD DAM (LAKE SIDNEY LANIER)

Buford Dam (Lake Lanier) is the uppermost project in the basin. The site is located 50 miles northeast of central Atlanta, Georgia on the Chattahoochee River, 348.3 river miles above the Apalachicola River or 456 river miles from the Gulf Coast. Above Buford Dam, the Chattahoochee River Basin has a length of 52 miles, and an average width of 20 miles, with extreme widths ranging from a maximum of 36 miles in the headwater area to a minimum of 12 miles in the vicinity of the dam site. The drainage area above the dam is 1,040 square miles. The project was completed in June 1957.

Buford Dam is a multiple-purpose project with major project purposes including flood control, navigation, hydroelectric power, recreation, fish and wildlife development and water quality. An aerial photo of the main dam is shown on Figure C-6.

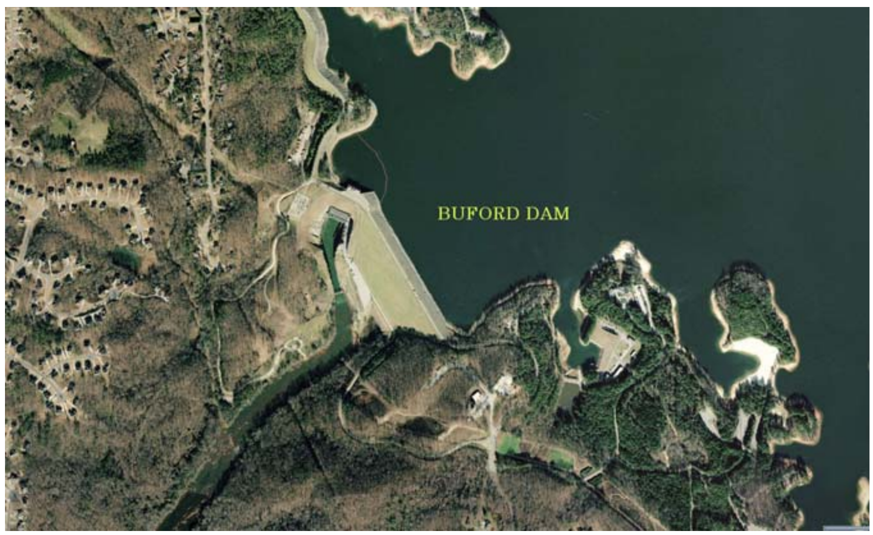

Figure C-6. Buford Dam

1.3.1 Drainage area

The Chattahoochee River and its upstream tributaries originate in the Blue Ridge Mountains of northern Georgia, near the western tip of South Carolina. The upper reaches of the basin streams are characterized by the steep slopes of mountain streams. The upper Chattahoochee River (157 square miles) is joined by the Soque River (166 square miles) about 60 miles northeast of Atlanta, Georgia and 11 miles upstream of the limits of the pool at elevation 1071 feet. The Chestatee River, a major tributary, formerly flowed into the Chattahoochee River above the dam site but now forms an arm of Lake Sidney Lanier, as shown on Figure C-7. Presently the Chattahoochee and Chestatee Rivers have drainage areas of 565 and 304 square miles and there is a drainage area of 115 square miles into the lake below their junction. The Chattahoochee and Chestatee Rivers comprise 84 percent of the dam site drainage, the reservoir pool comprises five percent and the remaining area is composed of minor streams which drain directly into the pool. The drainage area is shown on the following Figure C-7.

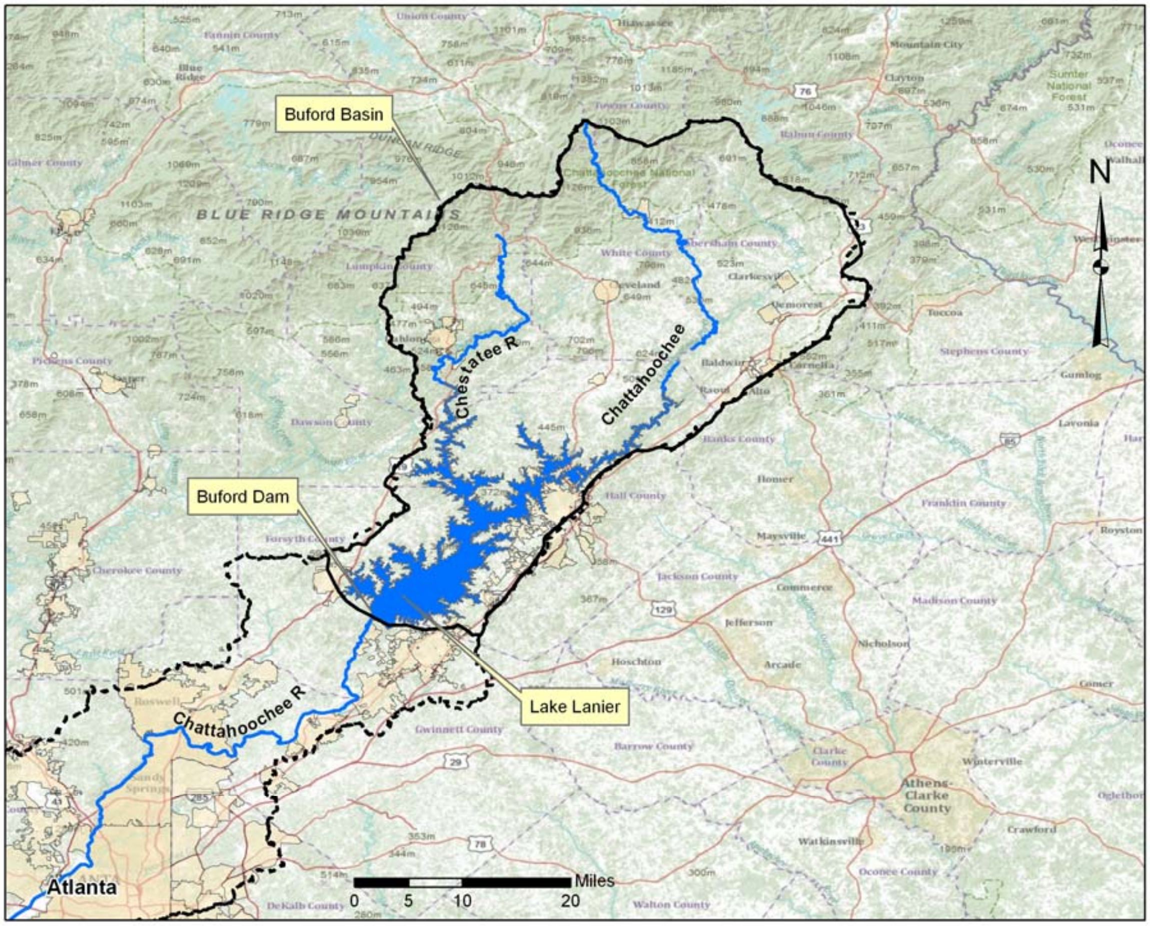

Figure C-7. Buford Basin Map

The drainage area is shown in relation to the rest of the basin in the following Figure C-8. This figure shows the local, or incremental area between projects. These areas will be used in the yield computations to determine local flows at the downstream project, rather than the whole basin above the project. For the Buford project, however, there is no upstream project, so the total area above Buford is used in the yield computations.

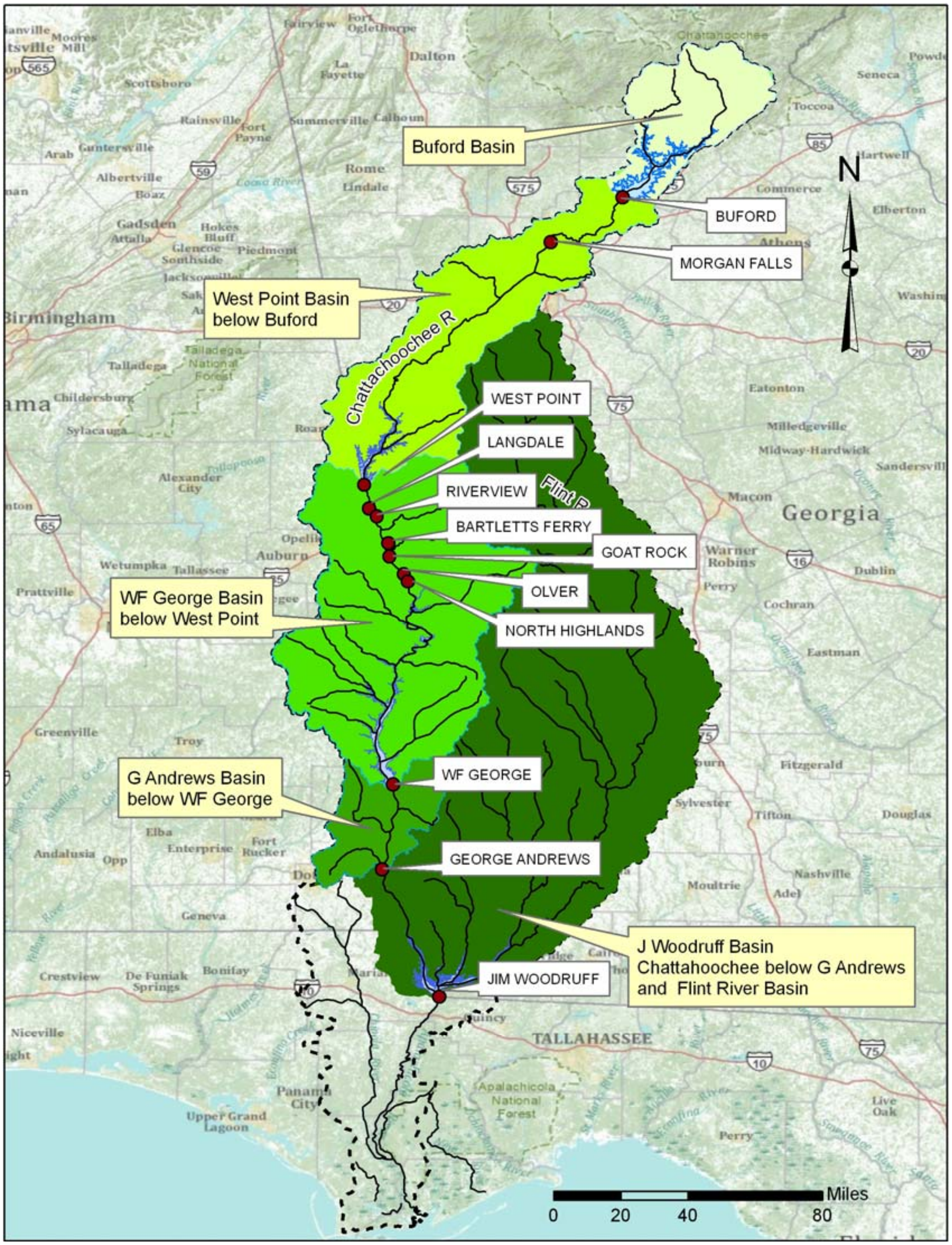

Figure C-8. Incremental Drainage Basin Map for Federal Projects on the ACF

1.3.2 Features

The project consists of an earth dam supplemented by earth saddle dikes and an unpaved chute spillway, an 86,000 kW power plant and appurtenances, and a reservoir extending about 44 miles up the Chattahoochee River and about 19 miles up the Chestatee River at full conservation pool. The main dam and reservoir are described below.

1.3.2.1 Dam

The main dam, 1,630 feet long and 192 feet high at maximum section, is an earth-fill structure with a rock section on the upstream side. The crest at elevation 1106 feet is 40 feet wide.

1.3.2.2 Reservoir

The reservoir has a total storage capacity of 2,554,000 acre-feet at full flood control pool, elevation 1085 feet, and covers an area of 47,182 acres. At full conservation pool, elevation 1071 feet, the reservoir covers 38,542 acres and has a total storage capacity of 1,955,200 acre-feet; at minimum conservation pool, elevation 1035 feet, the area covered is 22,442 acres with storage capacity of 867,600 acre-feet. Area-capacity curves are shown on Figure C-9 and Table C-5. Conservation storage varies seasonally from 1,049,400 acre-feet to 1,087,600 acre-feet between a minimum elevation of 1035 feet and a top of conservation pool elevation varying from 1070 to 1071 feet. However, another purpose of the project is flood control and a storage of 637,000 acre-feet between elevation 1070 and elevation 1085 feet has been reserved for the detention storage of flood water. The yield analysis will be based on the conservation storage as described above.

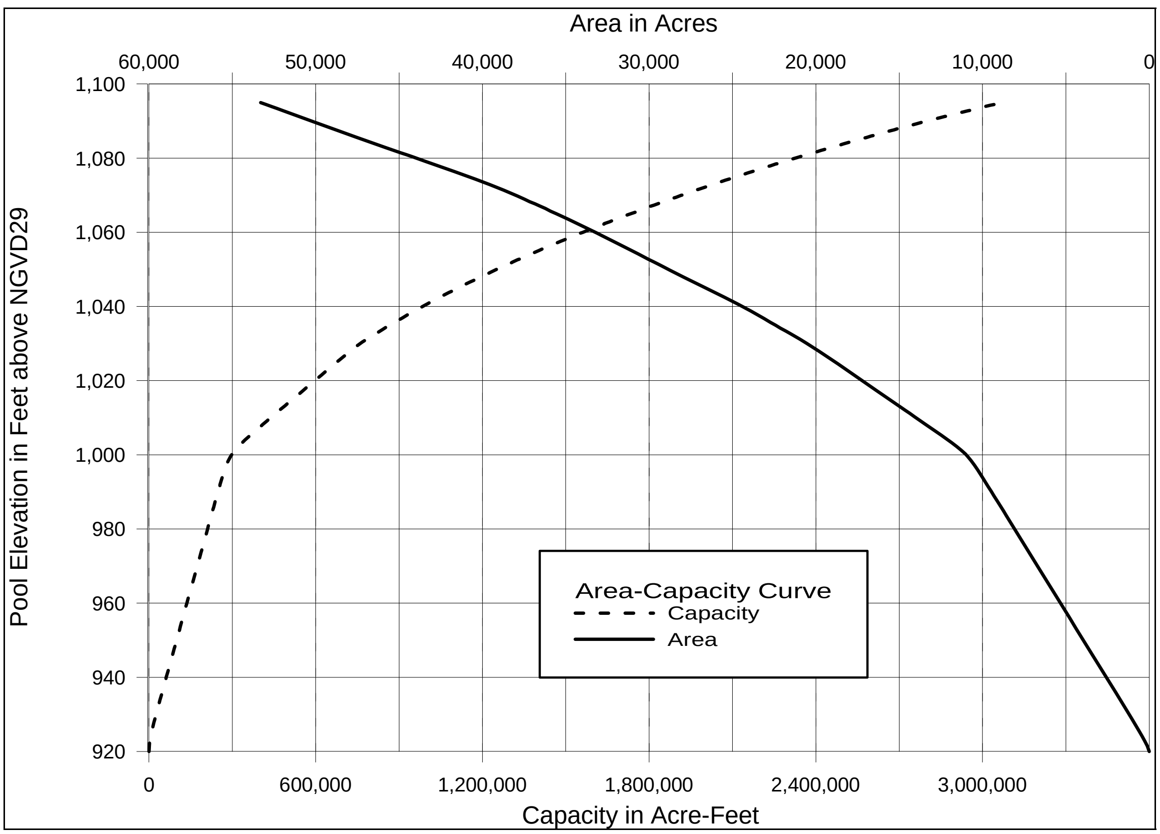

Figure C-9. Buford Area – Capacity Curves

Table C-5. Buford Reservoir Area and Capacity Data

Pool Elev	Total Area	Total Storage
(ft NGVD 29)	(ac)	(ac-ft)
920	0	0
940	1,090	5,000
960	3,100	37,000
980	6,450	121,000
1000	10,984	296,500
1010	13,819	420,200
1020	16,912	574,000
1030	20,508	760,100
1031	20,894	781,000
1032	21,281	802,000
1033	21,668	823,600
1034	22,055	845,600
* 1035	22,442	867,600
1036	22,829	890,300
1037	23,217	913,300
1038	23,609	936,500
1039	24,008	960,500
1040	24,416	984,500
1041	24,833	1,009,300
1042	25,257	1,034,300
1043	25,701	1,059,900
1044	26,159	1,085,900
1045	26,619	1,112,200
1046	27,079	1,139,200
1047	27,535	1,166,300
1048	27,983	1,194,300
1049	28,432	1,222,300
1050	28,861	1,250,900
1051	29,291	1,279,900
1052	29,721	1,309,500
1053	30,153	1,339,500
1054	30,587	1,369,800
1055	31,023	1,400,800
1056	31,461	1,431,800

Pool Elev	Total Area	Total Storage
(ft NGVD 29)	(ac)	(ac-ft)
1057	31,901	1,463,800
1058	32,343	1,495,800
1059	32,789	1,528,200
1060	33,238	1,56,1200
1061	33,690	1,594,700
1062	34,147	1,628,700
1063	34,610	1,663,000
1064	35,079	1,698,000
1065	35,555	1,733,100
1066	36,036	1,769,100
1067	36,522	1,805,200
1068	37,015	1,842,200
1069	37,515	1,879,200
** 1070	38,024	1,917,000
*** 1071	38,542	1,955,200
1072	39,078	1,994,200
1073	39,638	2,033,600
1074	40,226	2,073,600
1075	40,833	2,114,000
1076	41,458	2,155,000
1077	42,086	2,196,900
1078	42,716	2,239,300
1079	43,348	2,282,300
1080	43,982	2,326,000
1081	44,618	2,370,300
1082	45,256	2,415,300
1083	45,896	2,460,800
1084	46,538	2,507,000
1085	47,182	2,554,000
1090	50,250	2,800,000
1095	53,300	3,070,000
1100	56,500	3,330,000
1110	62,900	3,850,000

* Bottom of Conservation Pool
** Top of Winter Conservation Pool
*** Top of Summer Conservation Pool

1.3.3 Top of Conservation Pool

The top of conservation pool varies during the year from elevation 1070 to 1071 feet. Whenever surplus water is available the criteria is to hold the pool at elevation 1071 from 1 May through 1 October, then decrease to 1070 feet by 1 December, then hold 1070 feet unti1 15 April, and then increase to 1071 feet by 1 May. Figure C-10 presents the guide curve to be used. A constant top-of conservation pool level at elevation 1070 feet had been used until 1976. In February 1976 the extra storage was approved by the Division Engineer. A plot of the top of the conservation pool is shown on the following Figure C-10.

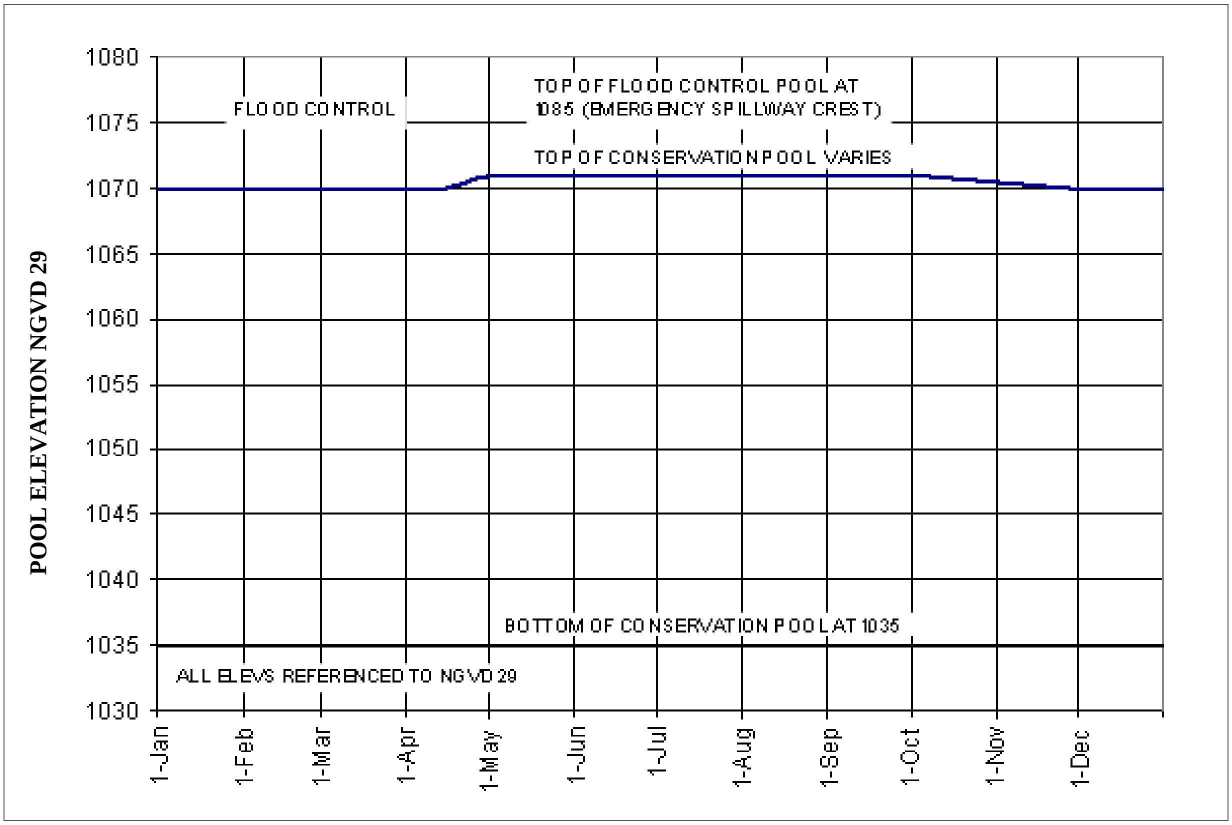

Figure C-10. Top and Bottom of Buford Conservation Pool

The storage for the yield analysis will be based on the storage in the conservation pool from elevation 1071 (or 1070 depending on the time of year) to 1035.

1.3.4 Regulation Plan

Normally the Buford project is operated as a peaking plant for the production of hydroelectric power and during off-peak periods maintains a continuous flow of approximately 650 cfs. Releases from Buford are re-regulated by Georgia Power Company’s Morgan Falls Reservoir to insure the City of Atlanta has sufficient flow for water supply and wastewater assimilation. In addition, increased flows during low flow periods are utilized by Corps of Engineers projects at West Point, Walter F. George, and Jim Woodruff for hydropower, to aid navigation and meet the flow requirements of the Jim Woodruff Revised Interim Operating Plan (RIOP).

1.3.5 Surface Water Inflows

Observed daily inflow, outflow (discharge), and pool elevation data for the period of record starting in Jan 1958, just as the pool was filling through the present (Oct 2009) are available. The data are presented in the following Figure C-11.

1.3.6 Unimpaired Flow

The existing unimpaired flow data set was updated through 2008 for use in the yield analysis. The daily data was smoothed using 3-, 5-, or 7-day averaging to eliminate small negative values. Although this averaging affects the peak values, the volume is the same and the yield computations were done on the smoothed data. A plot of this smoothed unimpaired daily flow averaged over each year for the period of record 1939 – 2008 is shown in Figure C-12. Daily flows for critical drought periods are plotted in more detail in Figures C-13 – C-17.

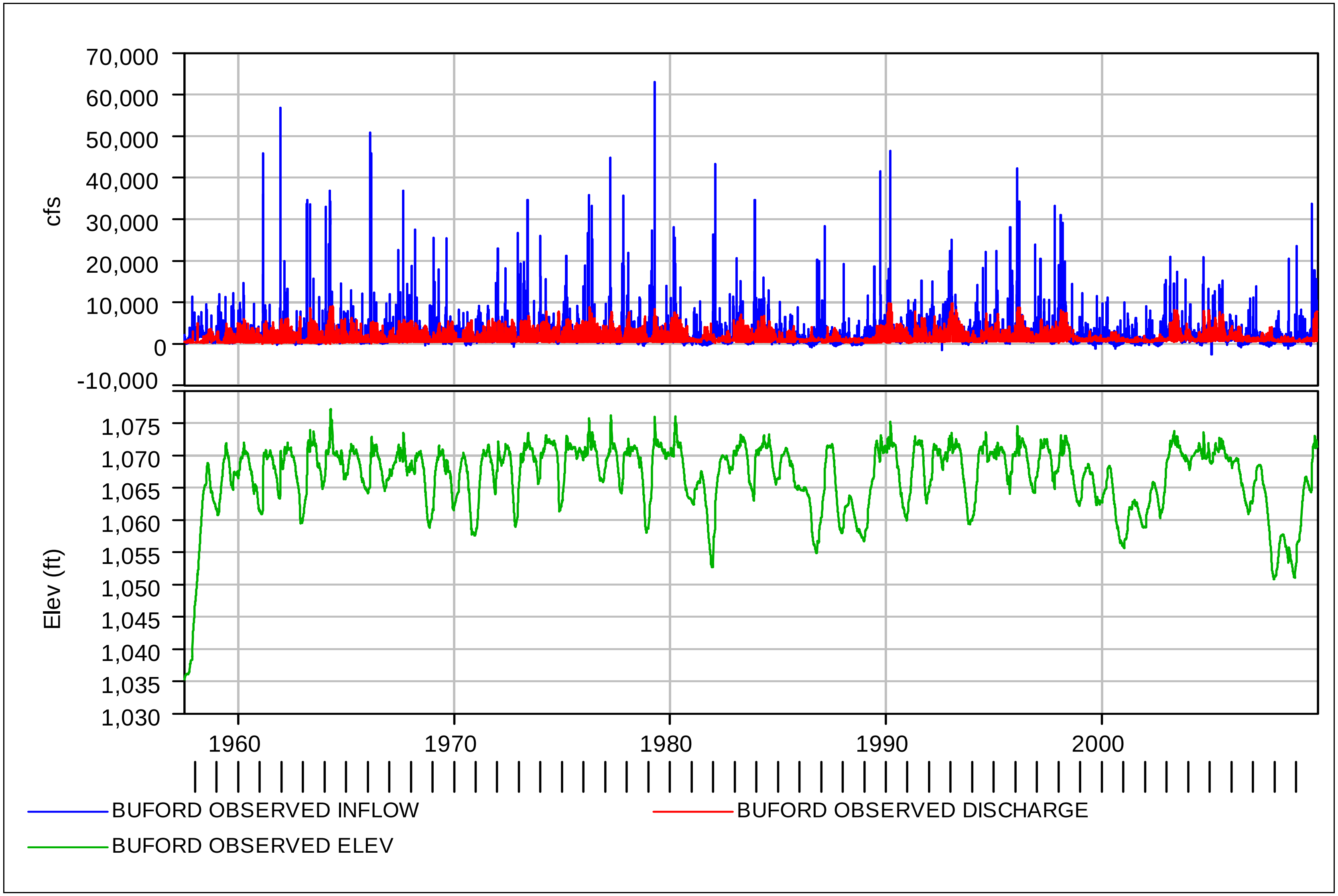

Figure C-11. Buford Inflow-Outflow-Pool Elevation (Jul 1957-Dec 2009)

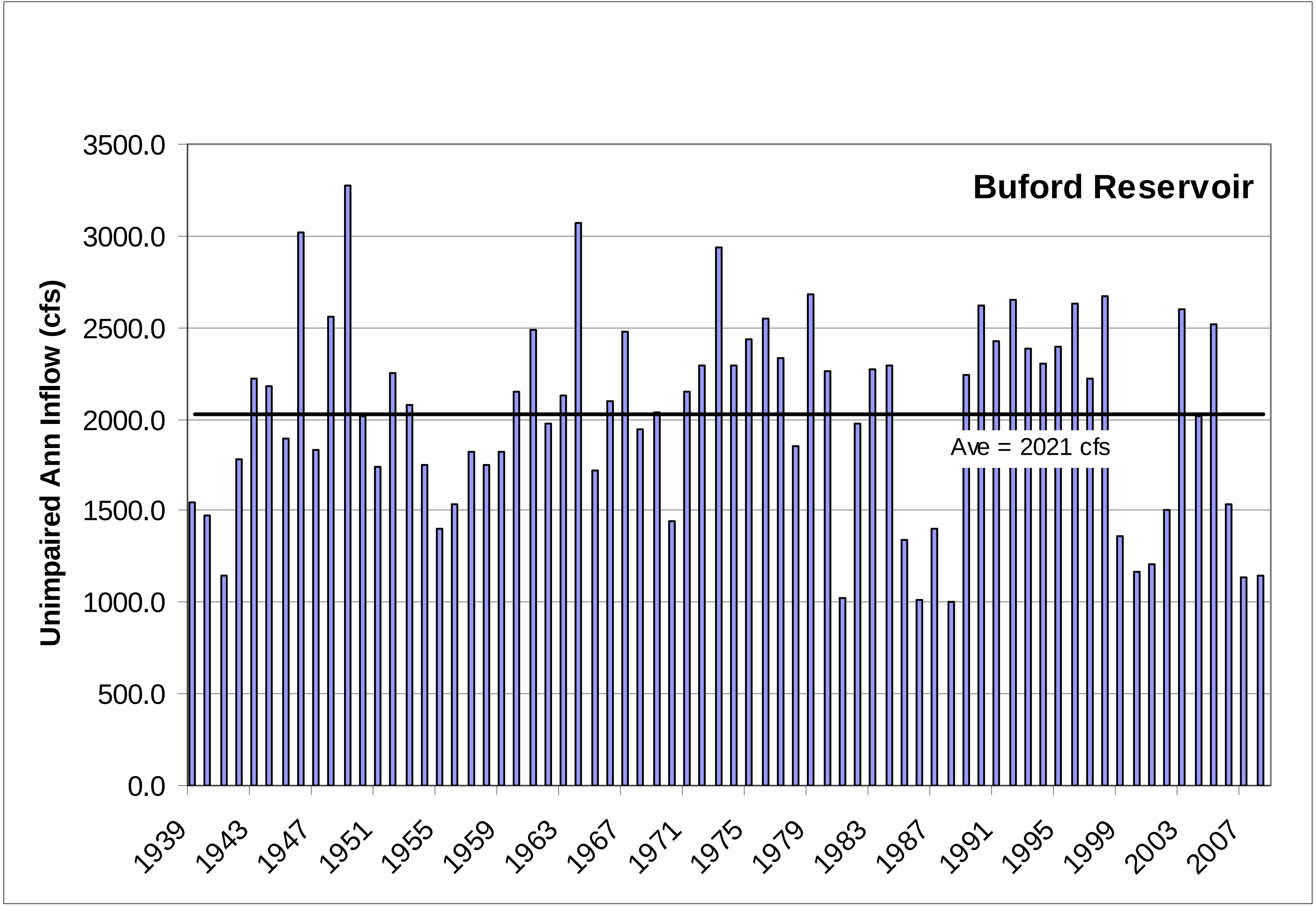

Figure C-12. Buford Unimpaired Annual Inflow Jan 1939 to Dec 2008

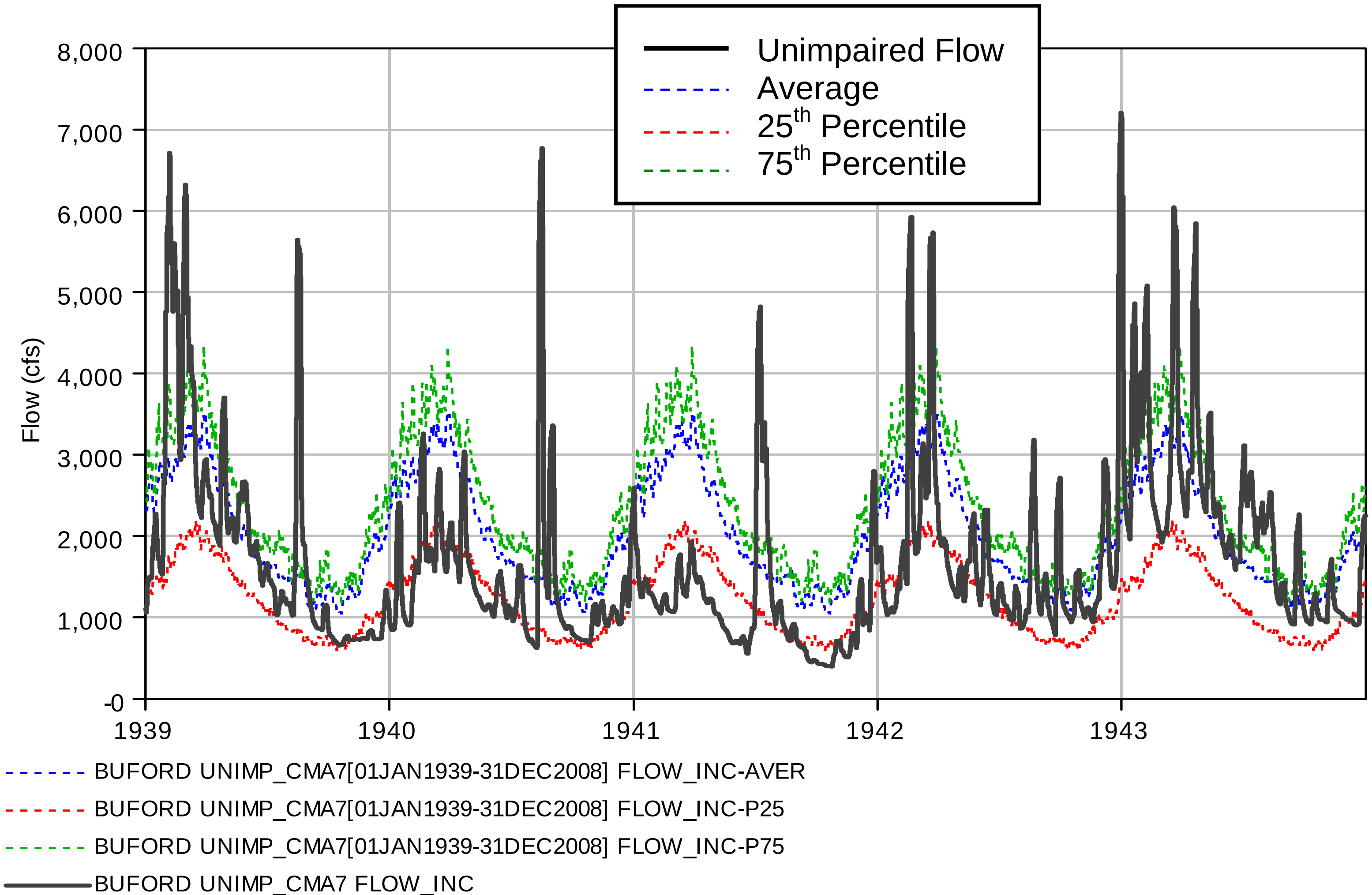

Figure C-13. Buford Unimpaired Inflow – 1940's Drought

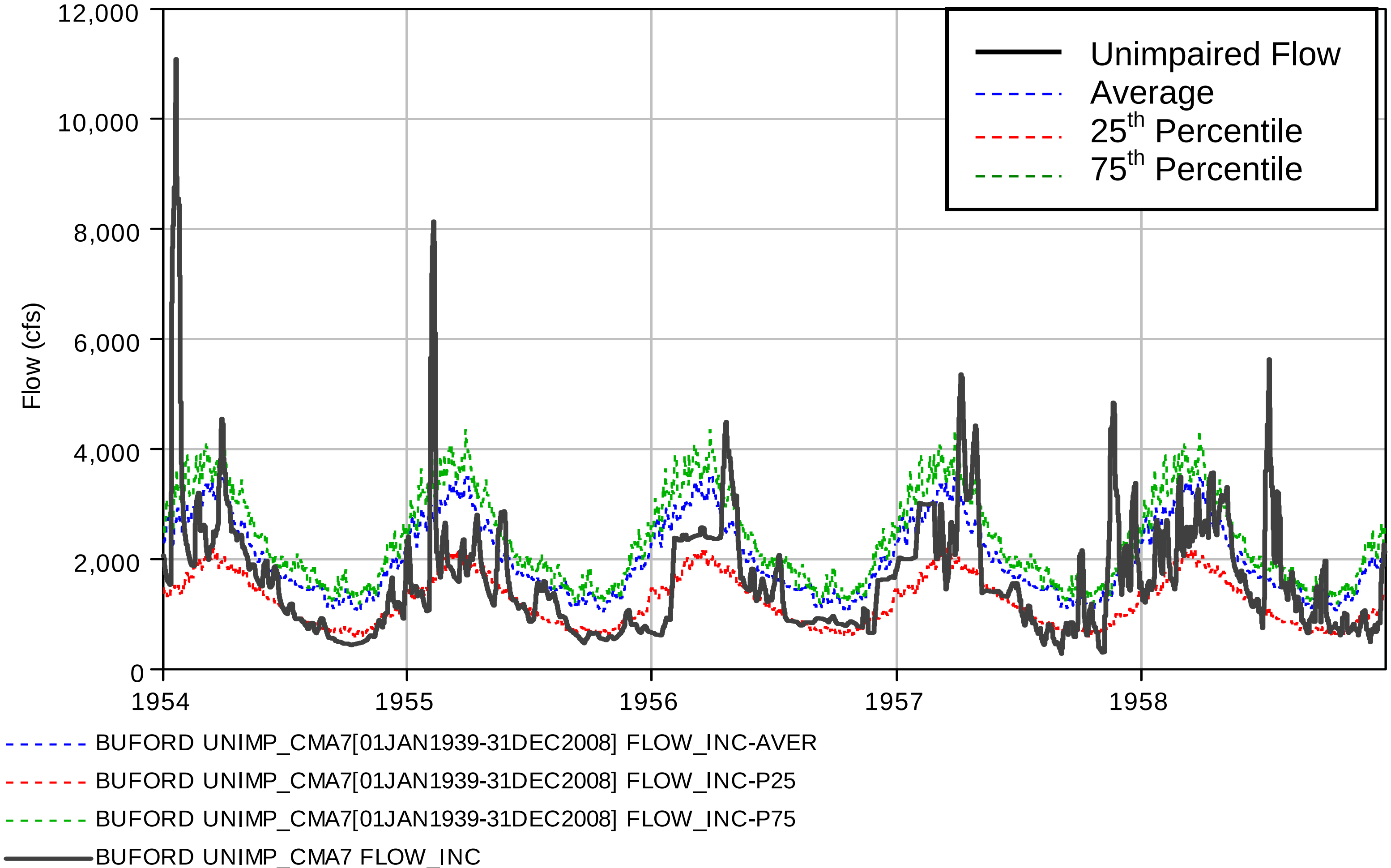

Figure C-14. Buford Unimpaired Inflow – 1950's Drought

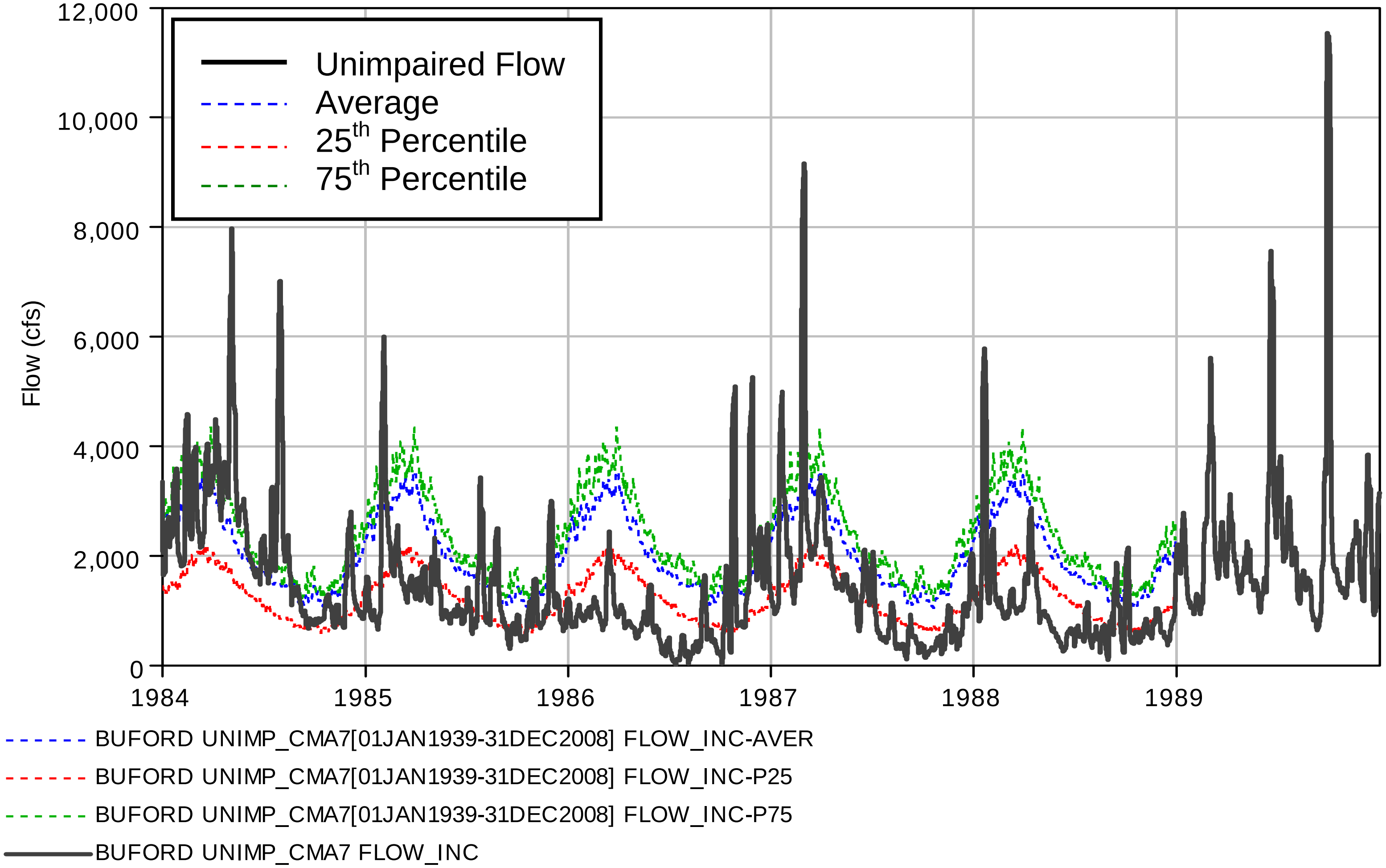

Figure C-15. Buford Unimpaired Inflow – 1980's Drought

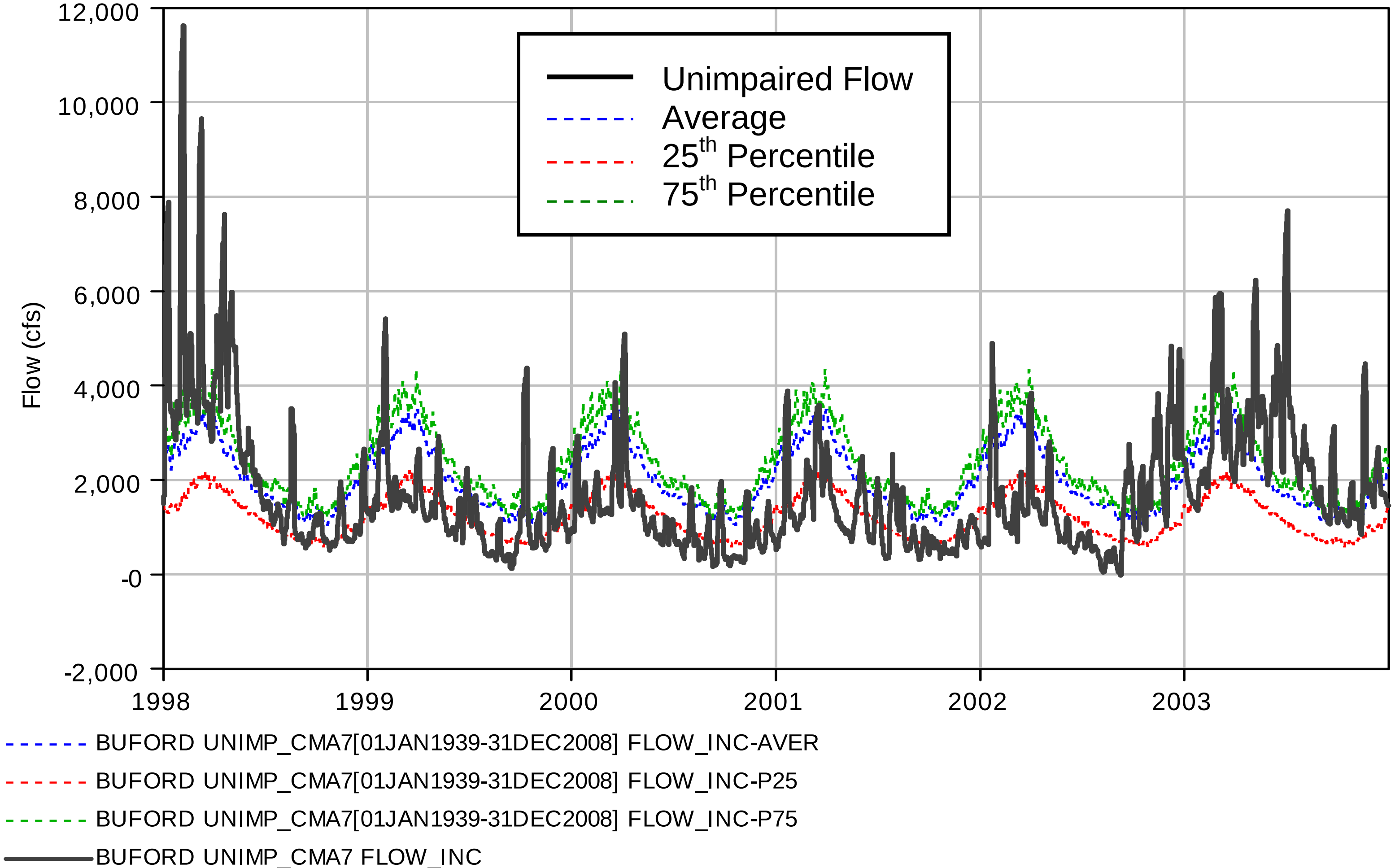

Figure C-16. Buford Unimpaired Inflow – 2000 Drought

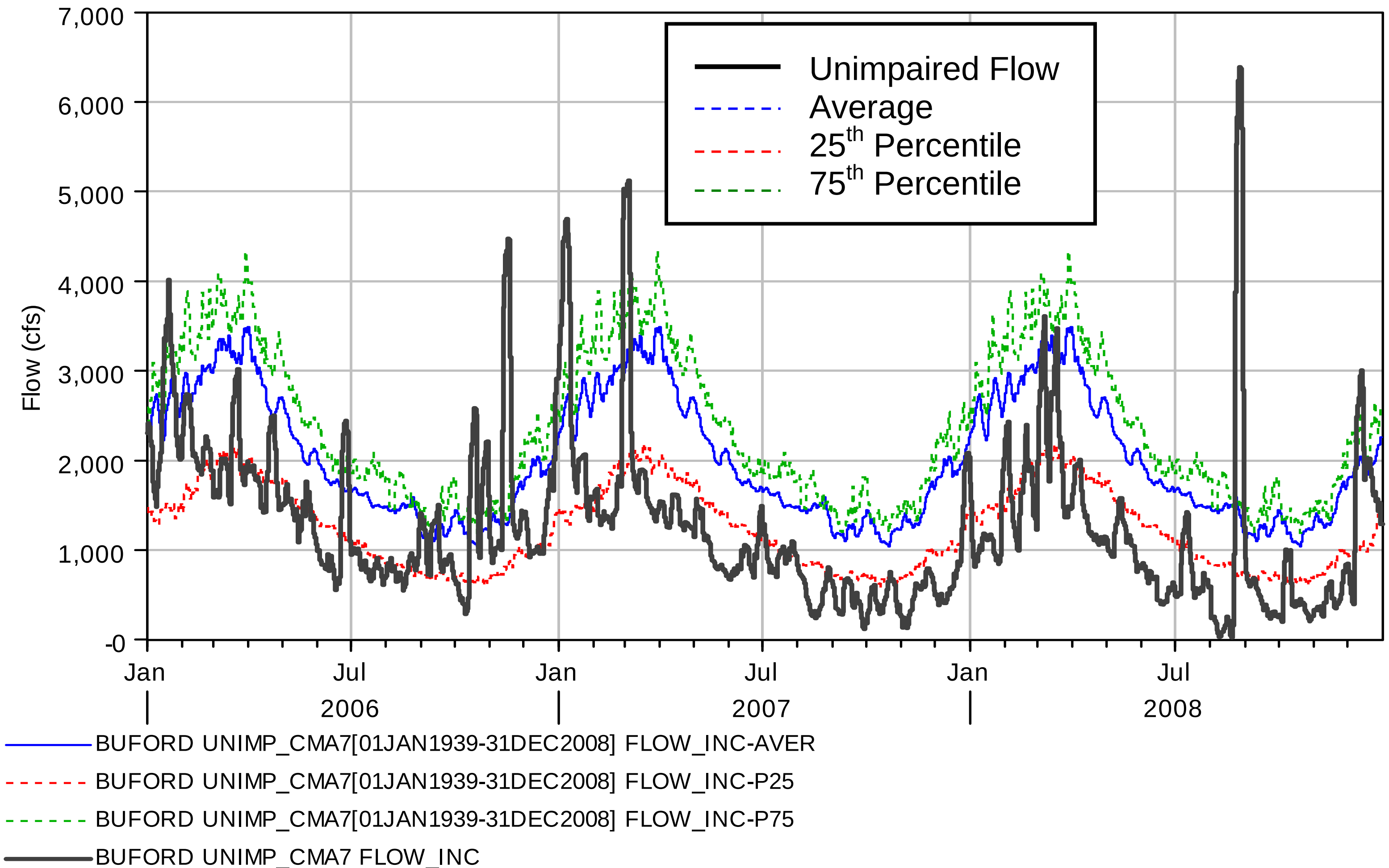

Figure C-17. Buford Unimpaired Inflow – 2007 Drought

1.4 WEST POINT DAM (WEST POINT LAKE)

West Point Dam is located on the Chattahoochee River at mile 201.4 above the mouth and 3.2 miles north of West Point, Georgia. It is 146.9 river miles below Buford Dam, and 126.2 miles above Walter F. George Lock and Dam. The project was completed in May 1975.

West Point Dam is a multiple-purpose project with major project purposes including flood control, hydroelectric power, navigation, recreation, fish and wildlife development and water quality. An aerial photo of the dam is shown in Figure C-18.

Figure C-18. West Point Dam

1.4.1 Drainage Area

The drainage area above the dam is 3,440 square miles. The area is shown on the following Figure C-19.

The operation of Buford Dam reduces peak stages about 10 feet to essentially non-damage stages at Morgan Falls Dam and for several miles downstream. The river bottoms are subject to some overbank flow during the infrequent floods at Vinings and in the northwest suburbs of Atlanta near Bolton. Between Bolton and West Point, a distance of about 100 river miles, there is no urban development in the floodplain.

The Town of Franklin, 37 miles above West Point, is on high ground well above the flood zone. However, the effect of Buford Dam on floods decreases progressively downstream so that at West Point, peak stages are only slightly reduced. The Cities of West Point and Columbus, Georgia, and Lanett, Langdale, Riverview and Phenix City, Alabama, are all subject to flooding. Bankfull channel capacities downstream are 40,000 cfs at West Point and 32,000 cfs at Columbus. The West Point project provides a maximum flood storage of 391,000 acre-feet including the 221,000 acre-feet between elevations 628 and 635 available on a seasonal basis, and the 170,300 acre-feet between elevations 635 and 641 for induced surcharge operations.

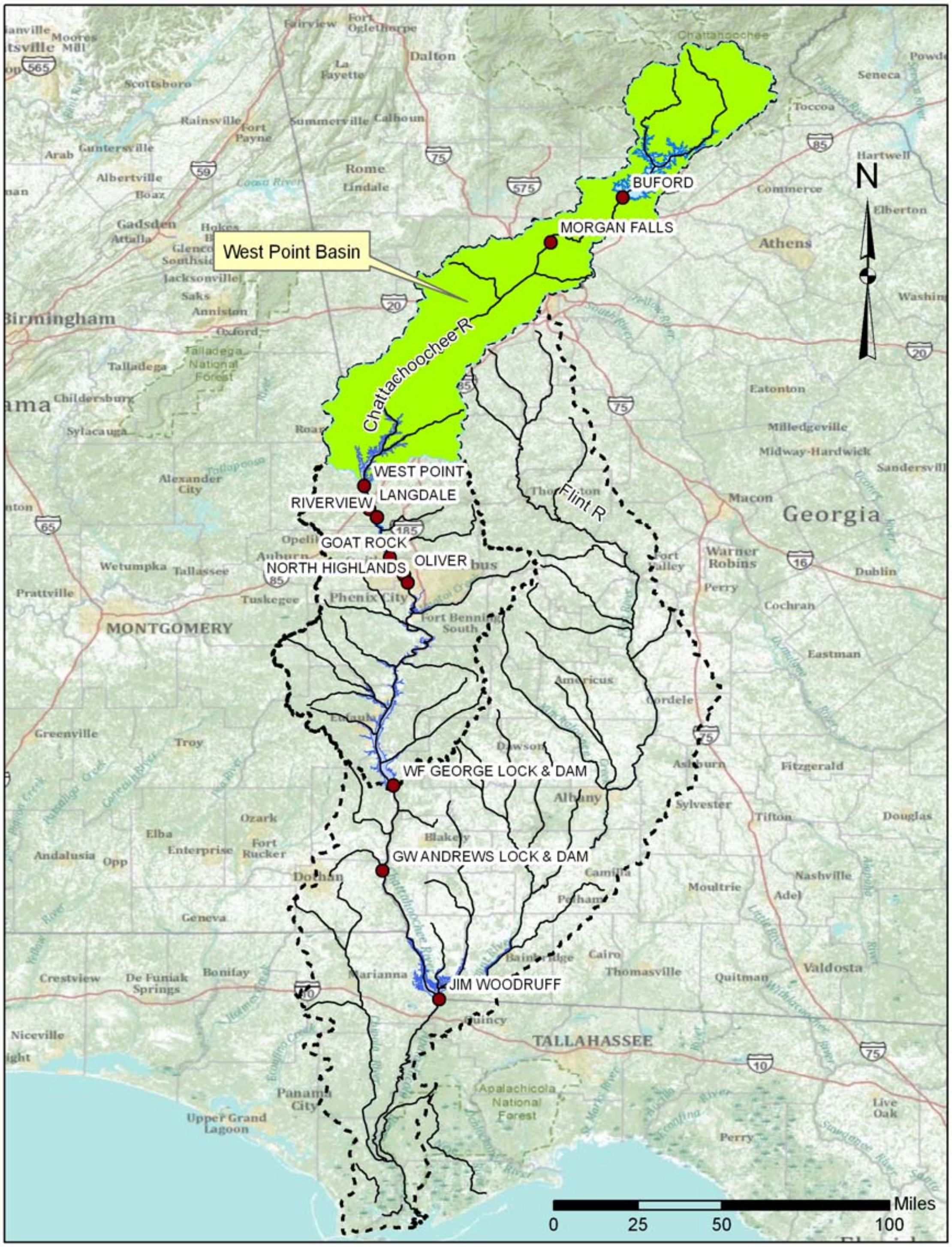

Figure C-19. West Point Basin Map

For the single reservoir yield analysis in this report, only the area below Buford will be used for local inflow to West Point. This drainage area is the difference in the Buford and West Point drainage areas and is equal to 2,400 square miles. This West Point Basin below Buford area is shown in the following Figure C-20.

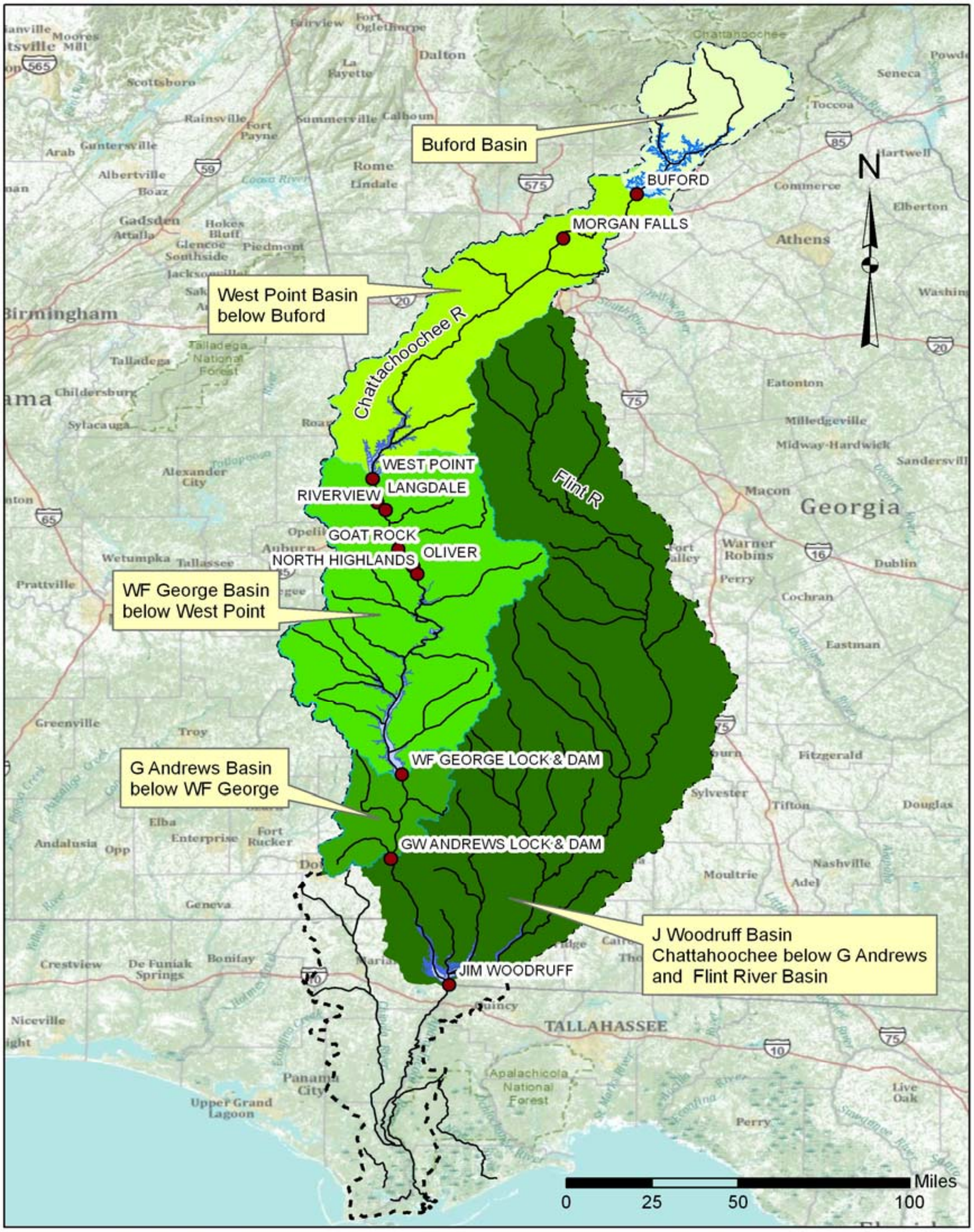

Figure C-20. Incremental Drainage Basin Map for Federal Projects on the ACF

1.4.2 Features

The West Point Dam is a concrete gravity type structure with rolled earthfill embankments joining the high ground on the east and west sides of the river. The total length of the concrete dam and earth embankments is 7,250 feet. At the top of the structures, elevation 652 feet above mean sea level, the length of the concrete portion of the dam is 896 feet. The principal structures that make up the concrete dam are an intake-powerhouse structure, a non-overflow section, a gated spillway located in the main river channel, and a left embankment retaining wall which supports the earth embankment on the east abutment.

1.4.2.1 Non-Overflow Section

The non-overflow section is 185 feet long and forms the tie between the earth embankment on the west side of the river and the powerhouse intake section. The length of the non-overflow is determined by the clearance required between the terminal cone slopes and the powerhouse intake.

1.4.2.2 Spillway Section

The spillway section is a gravity type ogee section 350 feet long with crest at elevation 597. The spillway contains six tainter gates, each 50 feet wide and 41 feet high, between 10-foot thick piers supported on the overflow section.

1.4.2.3 Powerhouse and Intake

The powerhouse and intake structure are integrated into a reinforced concrete unit which acts as a part of the dam. The structure is 321 feet in length and consists of five monoliths located between the spillway and non-overflow section. The intake structure provides waterway openings for three main generating units (two to be installed initially and one for a future unit) and one small generating unit to provide continuous minimum flow releases. The main turbines are propeller type with concrete semi-spiral cases. The small was selected to give maximum efficiency while discharging 675 cfs at any head.

1.4.2.4 Reservoir

The reservoir has a total storage capacity of 774,800 acre-feet at full flood control pool, elevation 641 feet, and covers an area of 31,800 acres. At full conservation pool, elevation 635 feet, the reservoir covers 25,900 acres and has a total storage capacity of 604,500 acre-feet; at minimum conservation pool, elevation 620 feet, the area covered is 15,500 acres with storage capacity of 298,400 acre-feet. Area-capacity curves are shown on Table C-6 and Figure C-21. Conservation storage varies seasonally from 143,900 acre-feet to 306,100 acre-feet between a minimum elevation of 620 feet and a top of conservation pool elevation varying from 628 to 635 feet. Although the top of the flood control pool is 641 feet, only the conservation pool will be used in the yield analysis.

Table C-6. West Point Reservoir Area and Capacity

Pool Elev (ft NGVD 29)	Total Area (ac)	Total Storage (ac-ft)
*620	15,512	298,396
621	16,100	314,202
622	16,702	330,602
623	17,318	347,612
624	17,949	365,245
625	18,593	383,515
626	19,252	402,437
627	19,926	422,025
**628	20,615	442,295
629	21,318	463,260
630	22,037	484,937
631	22,771	507,340
632	23,520	530,485
633	24,286	554,387
634	25,067	579,062
***635	25,864	604,527
636	26,677	630,796
637	27,507	657,887
638	28,353	685,816
639	29,216	714,600
640	30,096	744,254
****641	30,993	774,798
642	31,907	806,246
643	32,838	838,618
644	33,788	871,930
645	34,755	906,200

* Minimum power pool
** Top of power pool - December through April
*** Top of power pool - June through October
**** Top of flood control pool

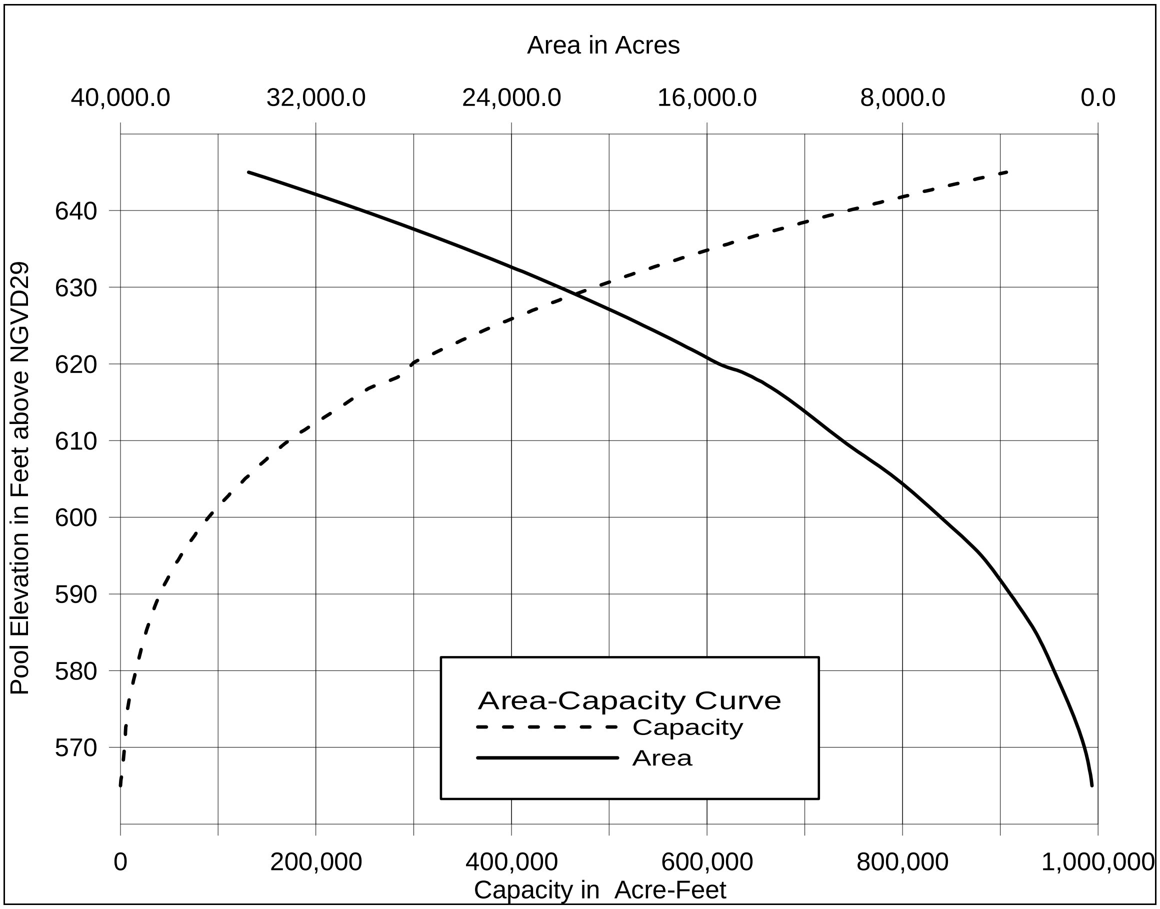

Figure C-21. West Point Area – Capacity Curves

1.4.3 Top of Conservation Pool

The top of conservation pool varies during the year from elevation 628 to 635 feet. Whenever surplus water is available the criteria is to hold the pool at elevation 635 from 1 June through 1 November, then decrease to 628 feet by 15 December, then hold 628 feet unti1 15 February, and then increase to 635 feet by 1 June, as shown in Figure C-22.

1.4.4 Regulation Plan

Normally the West Point project will be operated as a peaking plant for the production of hydroelectric power and during off-peak periods will maintain a continuous flow of 675 cfs. During low-water periods such regulation will provide increased flow downstream for navigation, water supply, water quality requirements and other purposes.

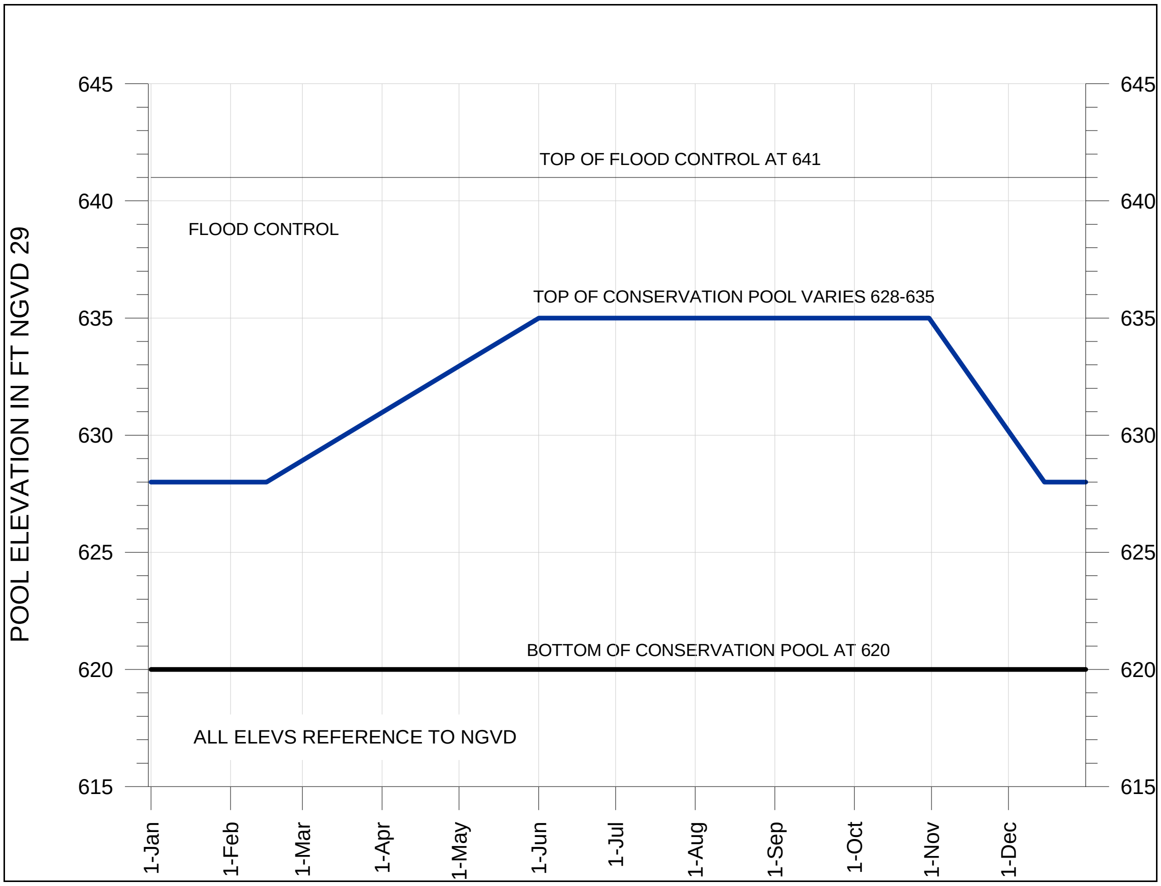

Figure C-22. Top and Bottom of West Point Conservation Pool

The storage for the yield analysis will be based on the storage in the conservation pool from elevation 635 (or 628 depending on the time of year) to 620.

1.4.5 Surface Water Inflows

Observed daily inflow, outflow (discharge), and pool elevation data for the period of record starting in May 1975, just as the pool was filling through the present (Oct 2009) are available. The data are presented in the following Figure C-23.

1.4.6 Unimpaired Flow

The existing unimpaired flow data set was updated through 2008 for use in the yield analysis. The daily data was smoothed using 3-, 5-, or 7-day averaging to eliminate small negative values. Although this averaging affects the peak values, the volume is the same and the yield computations were done on the smoothed data. A plot of this smoothed unimpaired daily flow averaged over each year for the period of record 1939 – 2008 is shown in Figure C-24. Daily flows for critical drought periods are plotted in more detail in Figures C-25 – C-29.

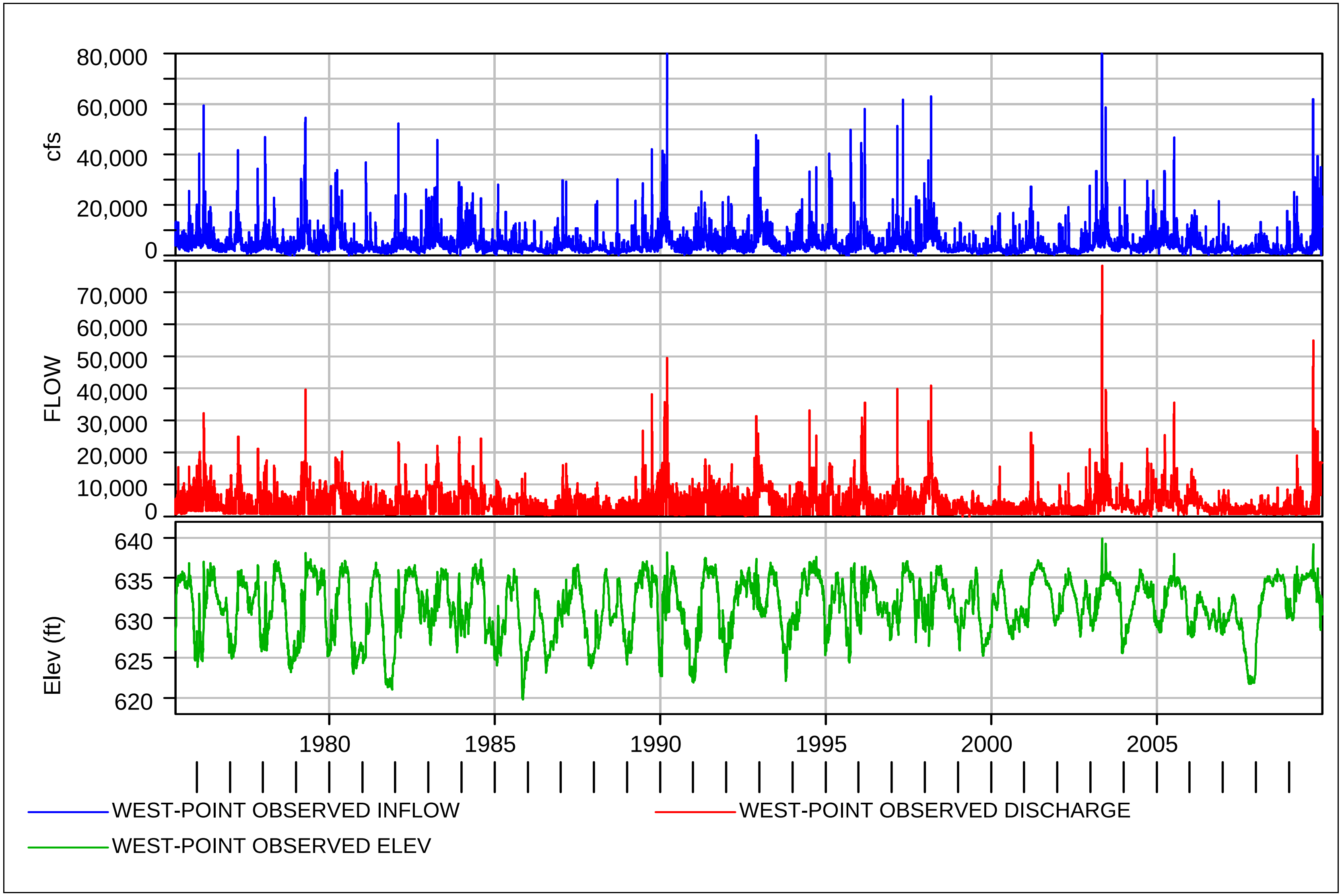

Figure C-23. West Point Inflow-Outflow-Pool Elevation (Jan 1975-Dec 2009)

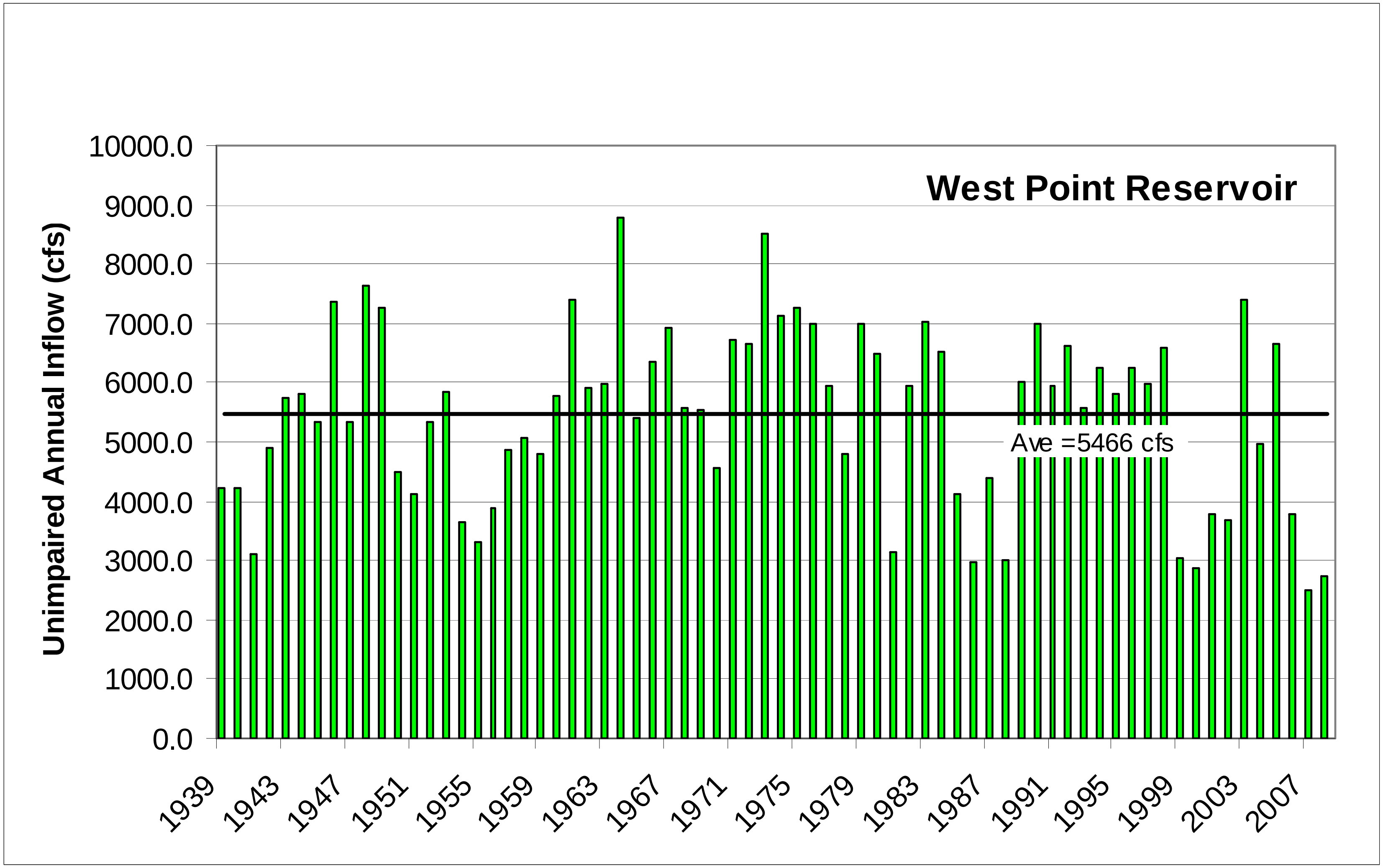

Figure C-24. West Point Unimpaired Annual Inflow Jan 1939 to Dec 2008

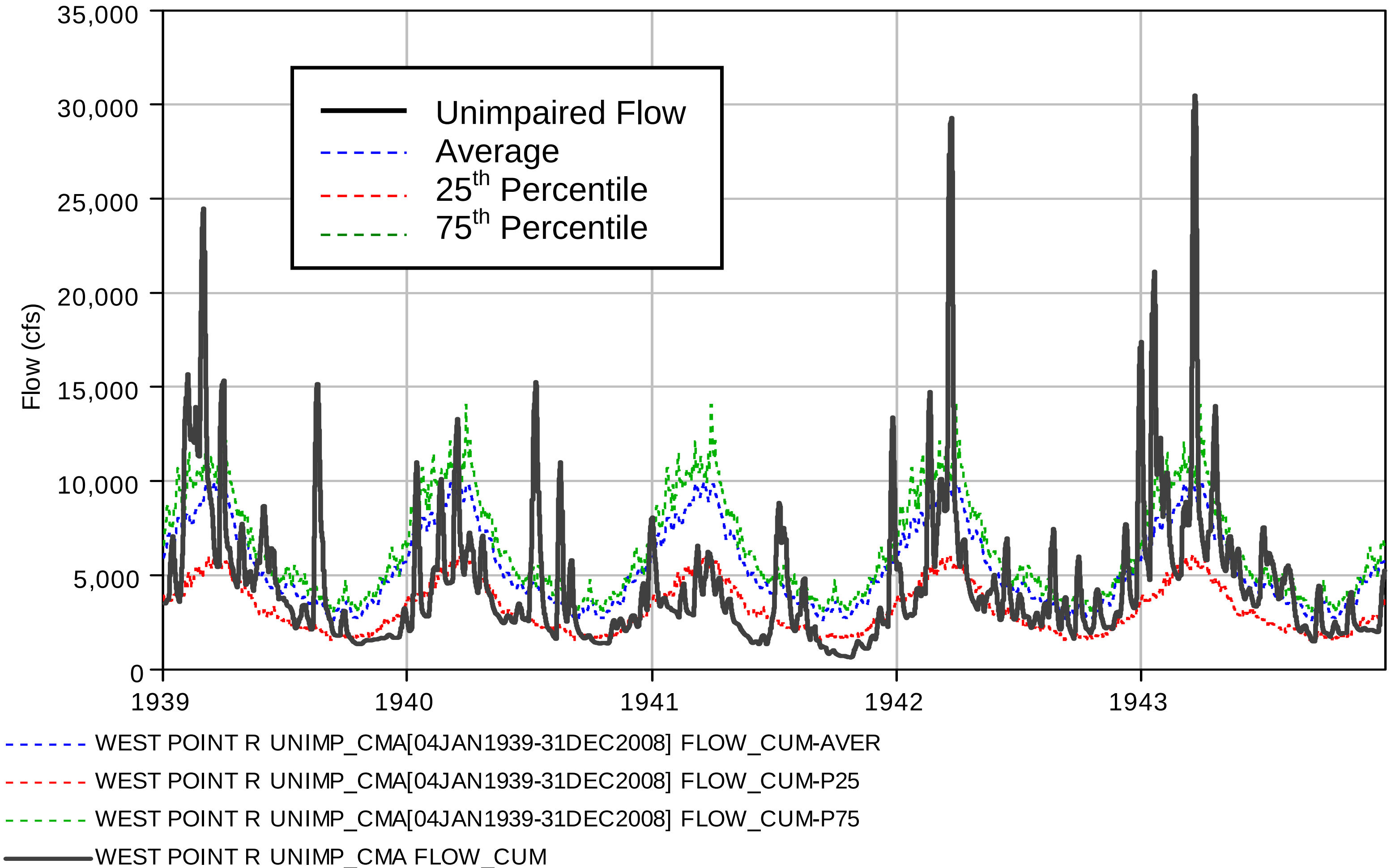

Figure C-25. West Point Unimpaired Inflow – 1940's Drought; 75th Percentile, Average and 25th Percentile Flow

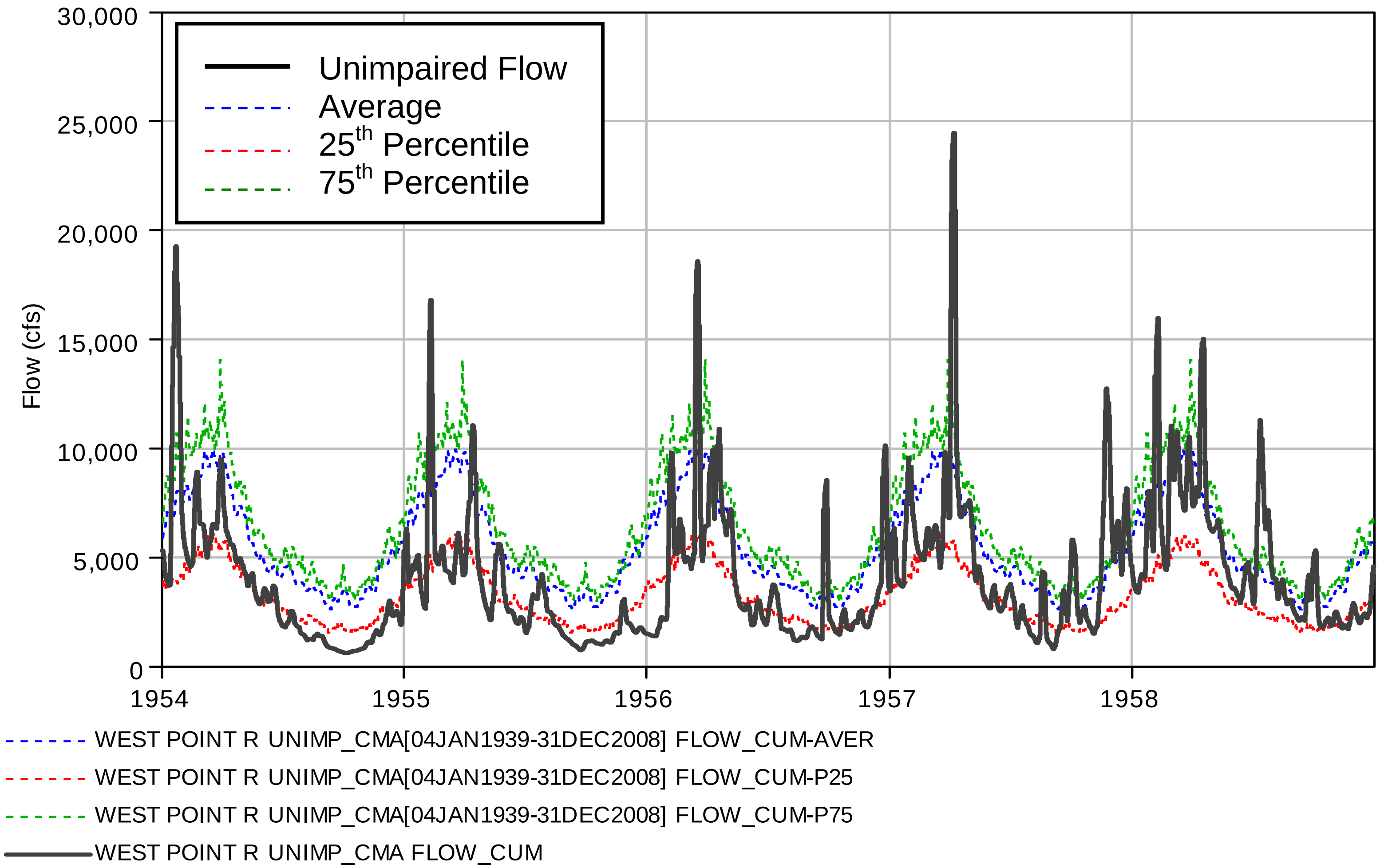

Figure C-26. West Point Unimpaired Inflow – 1950's Drought; 75th Percentile, Average and 25th Percentile Flow

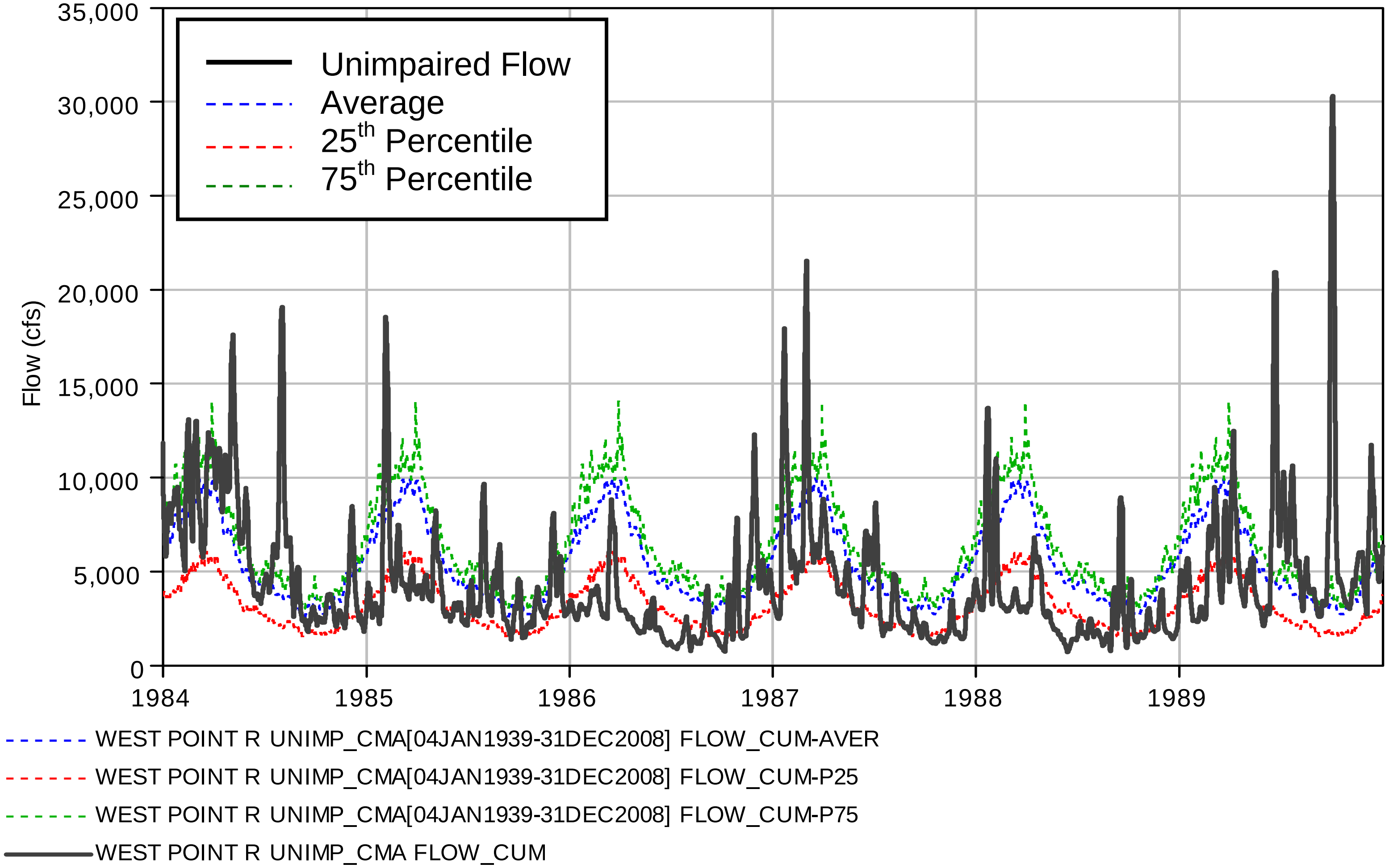

Figure C-27. West Point Unimpaired Inflow – 1980's Drought; 75th Percentile, Average and 25th Percentile Flow

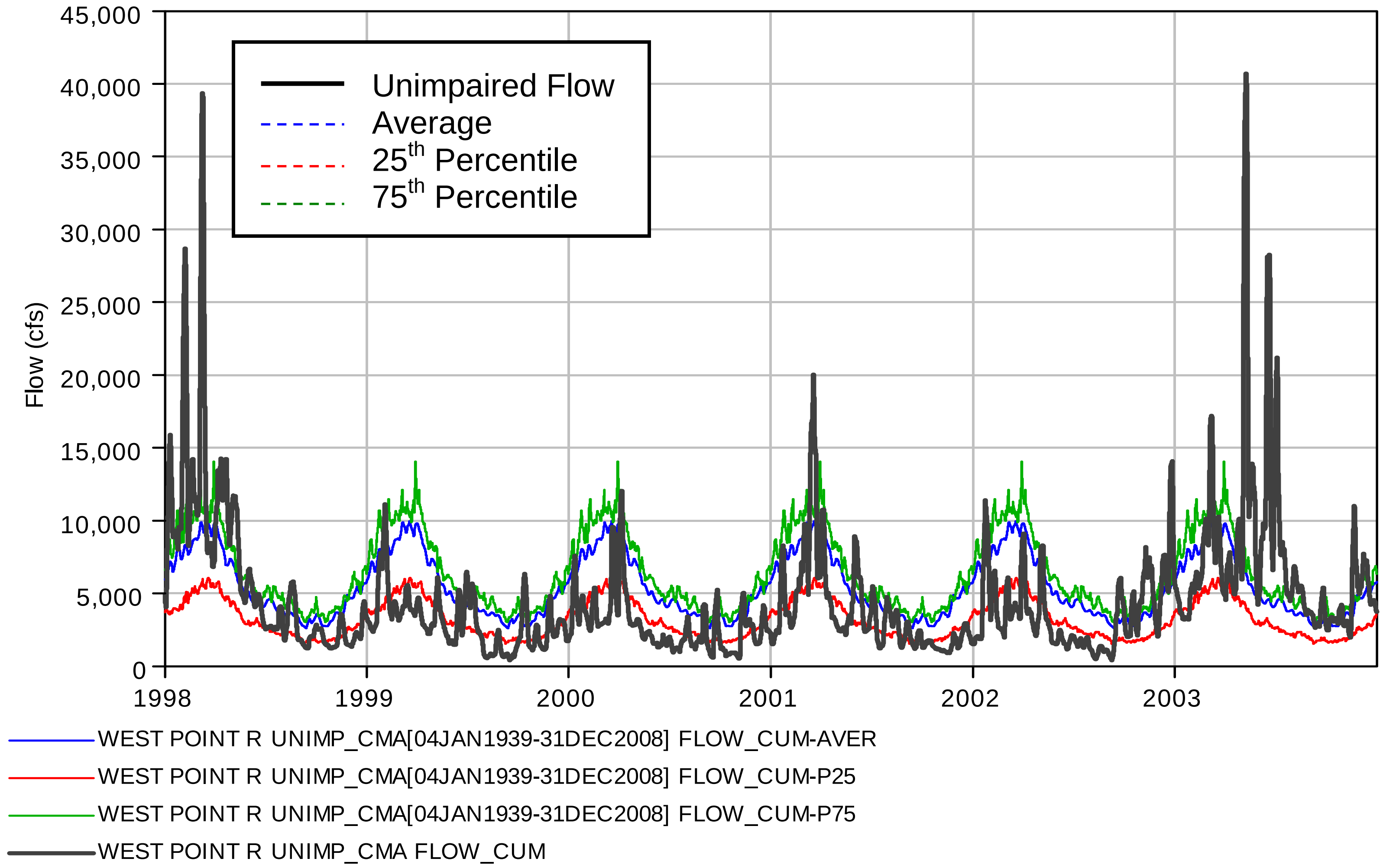

Figure C-28. West Point Unimpaired Inflow – 2000 Drought; 75th Percentile, Average and 25th Percentile Flow

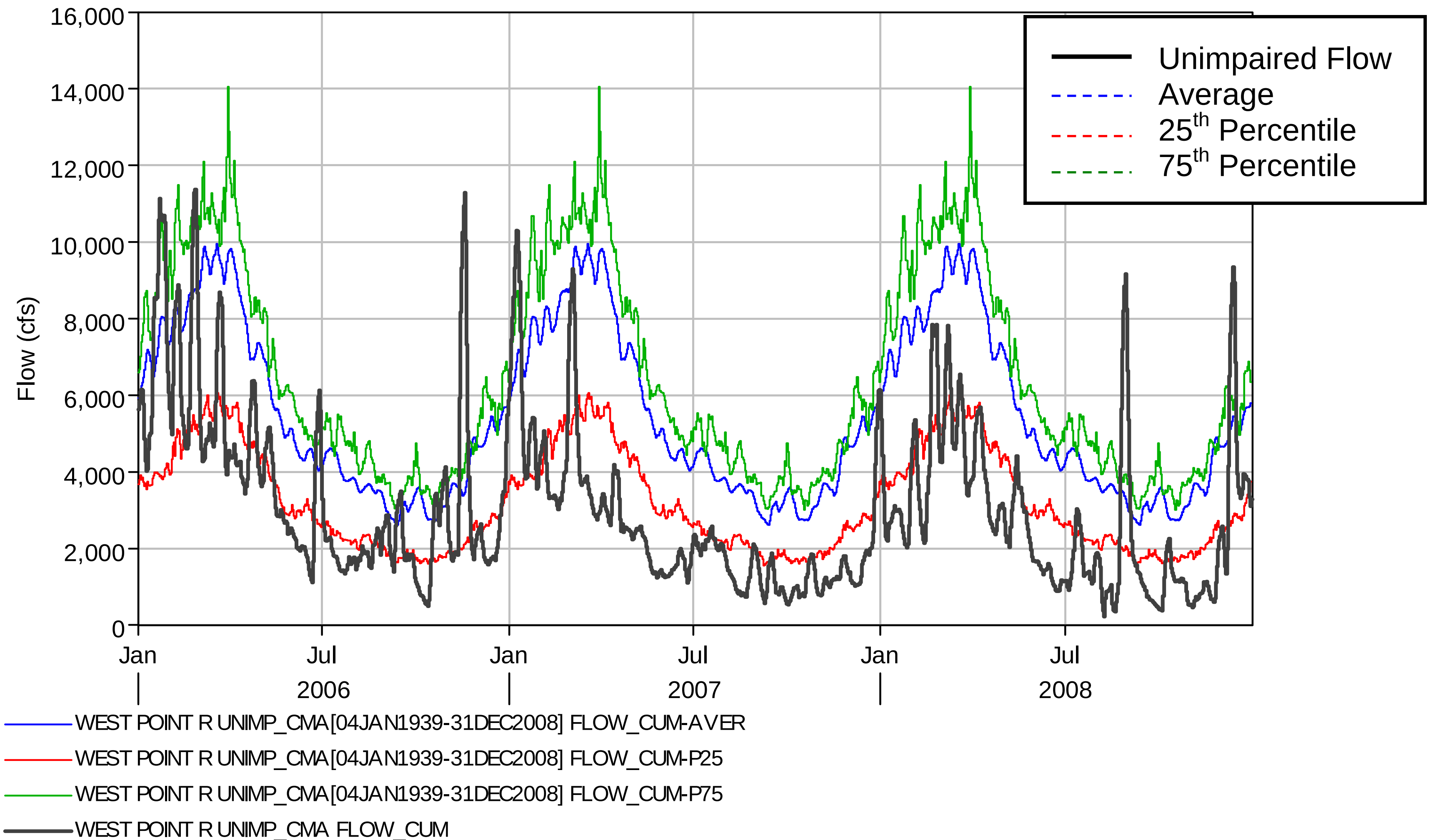

Figure C-29. West Point Unimpaired Inflow – 2007 Drought; 75th Percentile, Average and 25th Percentile Flow

1.5 WALTER F. GEORGE DAM (LAKE EUFAULA)

Walter F. George Lock and Dam is located on the Chattahoochee River at mile 75, approximately one mile north of Fort Gaines, Georgia and approximately 1.6 miles upstream from the Georgia State Highway 37 bridge. The dam crosses the Alabama-Georgia state line with the earth dike on the west bank entirely in Henry County, Alabama. The earth dike on the east is entirely in Clay County, Georgia. The project was completed in June 1963.

Walter F. George Dam is a multiple-purpose project with major project purposes including, hydroelectric power, navigation, recreation, fish and wildlife development and water quality. The project was not designed for flood control. An aerial photo of the dam is shown in Figure C-30.

Figure C-30. Walter F. George Dam

1.5.1 Drainage Area

The drainage area above Walter F. George Lock and Dam is 7,460 square miles. In the drainage area above Walter F. George Lock and Dam there are nine power developments and two multiple-purpose dams. Seven of the power projects are owned and operated by the Georgia Power Company. They are: Morgan Falls, Langdale, Riverview, Bartletts Ferry, Goat Rock, Oliver, and North Highlands. The City Mills Dam and Eagle and Phenix Mills Dam are independently owned and operated. These are very low head projects which have no effect on river hydraulics. Buford and West Point Dams are federal projects operated by the Corps of Engineers and are multiple-purpose dams that provide flood protection, production of hydroelectric power, water supply, recreation, instream flow, and increased flows for navigation during low-flow seasons. The drainage area and federal and Georgia Power Company dams are shown on the following Figure C-31.

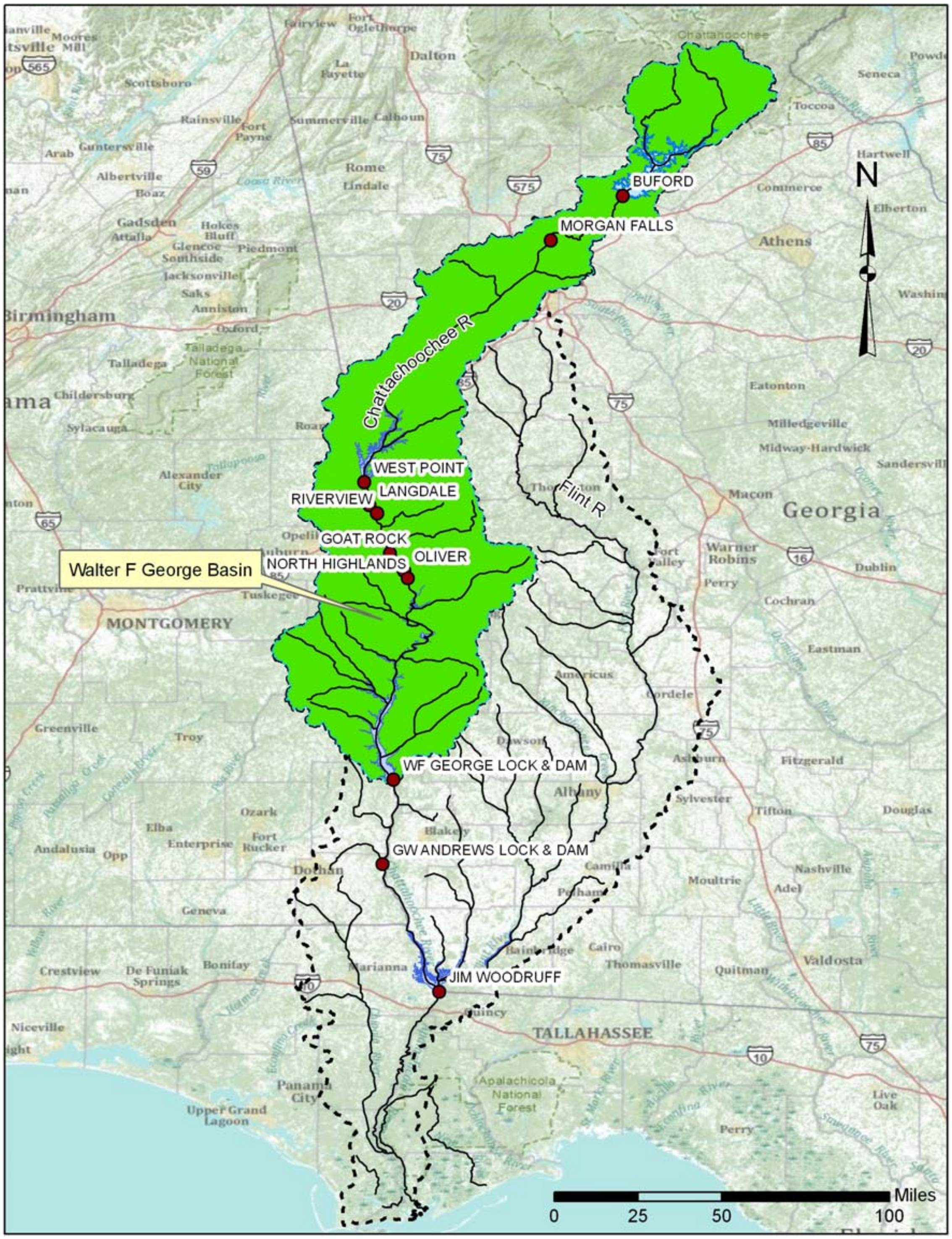

Figure C-31. Walter F. George Basin Map

For the single reservoir yield analysis in this report, only the area below West Point was used for local inflow to Walter F. George. This drainage area is the difference in the West Point and Walter F. George drainage areas and is equal to 4,020 square miles. This Walter F. George Basin below West Point area is shown in the following Figure C-32.

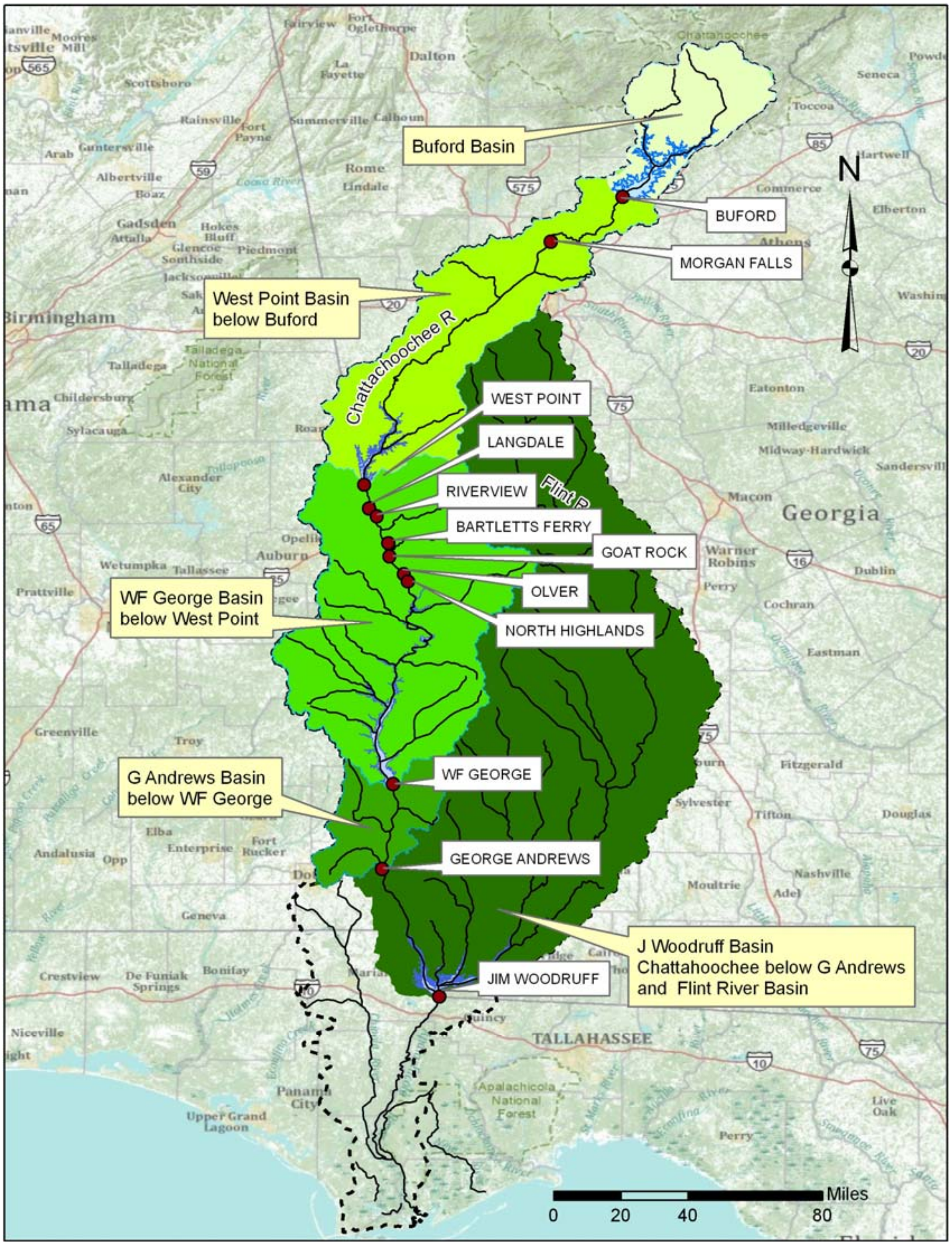

Figure C-32. Incremental Drainage Basin Map for Federal Projects on the ACF

1.5.2 General Features

The dam consists of a powerhouse, a gated spillway, a lock in and adjacent to the original river channel, and earth dikes extending to high ground on both banks. The lock is 82 by 450 feet with a maximum lift of 88 feet. The project has a 130,000 kW power plant with appurtenances, and a reservoir extending up the Chattahoochee River 85 miles to Columbus, Georgia and Phenix City, Alabama. The reservoir provides a nine-foot minimum depth for navigation from the dam to Columbus and Phenix City. The principal features of the structure are, from left to right bank, an earth dike, the navigation lock, the concrete gated spillway, the powerhouse with intake section constituting part of the dam, and an earth dike.

1.5.2.1 Dam

Overall length of the structure including the lock and powerhouse sections is 13,585 feet, or 2.6 miles.

1.5.2.2 Reservoir

The reservoir at maximum summer operating level (conservation pool) of elevation 190, covers an area of 45,180 acres and has a total storage of 934,400 acre-feet. The pool extends up the Chattahoochee River 85 miles to Columbus, Georgia. At the minimum operating level (conservation pool), elevation 184, the reservoir covers an area of 36,375 acres and has a total storage of 690,000 acre-feet. Area and capacity curves are shown on Figure C-33 and in Table C-7.

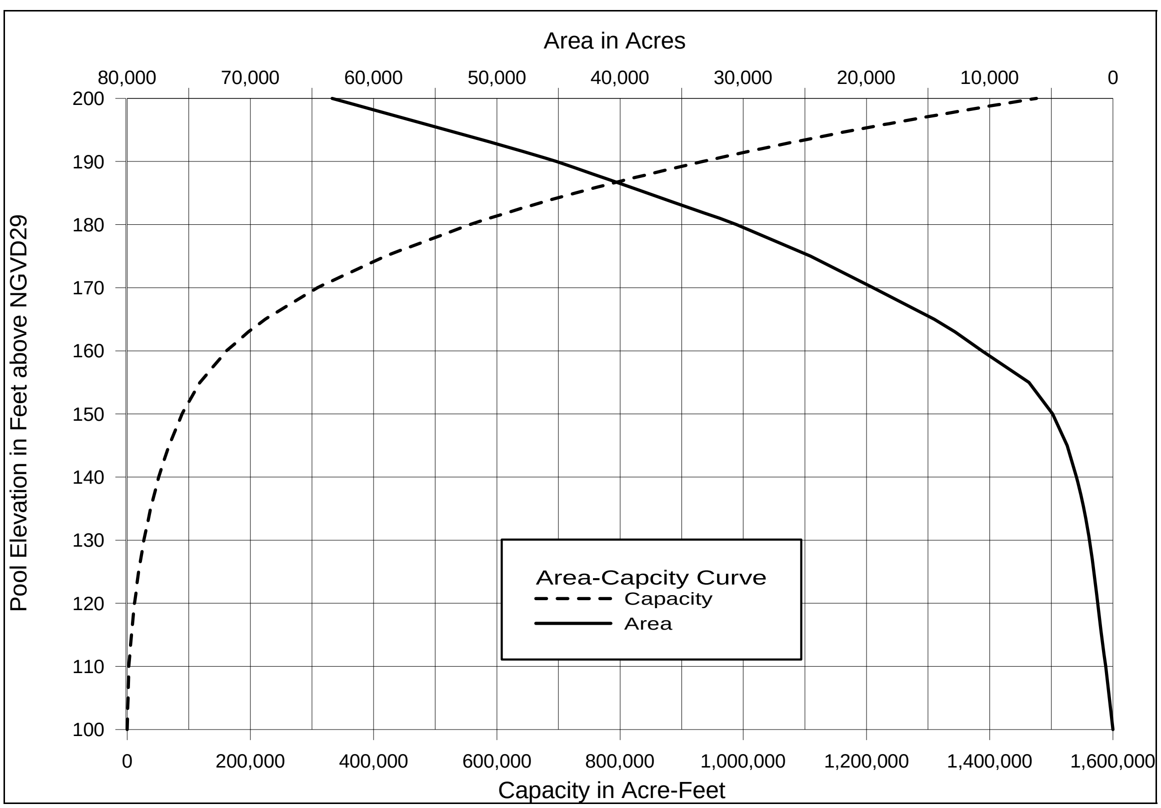

Figure C-33. Walter F. George Area – Capacity Curves

Table C-7. Walter F. George Reservoir Area and Capacity

Pool Elev (ft NGVD 29	Total Area (ac)	Total Storage (ac-ft)
100	8	10
105	248	550
110	587	2,610
115	902	6,340
120	1,248	11,680
125	1,550	18,670
130	1,894	27,240
135	2,375	37,920
140	2,966	51,210
145	3,720	67,830
150	4,895	89,100
155	6,815	118,140
160	10,624	161,500
*163	12,815	196,700
165	14,501	224,000
170	19,457	308,700
175	24,556	419,000
180	30,577	556,300
181	31,897	587,600
182	33,396	620,200
183	34,880	654,400
184	36,375	690,000
185	37,784	727,100
186	39,210	765,600
187	40,735	805,500
**188	42,210	847,100
189	43,665	890,000
***190	45,181	934,400
191	46,850	980,500
192	48,615	1,028,100
193	50,356	1,077,600
194	52,250	1,129,000
195	54,045	1,182,100
196	55,975	1,237,100
197	57,800	1,294,000
198	59,650	1,352,700
199	61,528	1,413,300
200	63,375	1,475,800

* Crest of gated spillway

** Top of power pool - December through April

*** Top of power pool - June through September

1.5.3 Top of Conservation Pool

The top of conservation pool varies during the year from elevation 188 to 190 feet. Whenever surplus water is available the criteria is to hold the pool at elevation 190 from 1 June through 31 October, then decrease to 188 feet by 1 December, then hold 188 feet unti1 1 May, and then increase to 190 feet by 1 June, as shown in Figure C-34.

1.5.4 Regulation Plan

The Walter F. George pool is regulated between the minimum pool elevation 184 and 190. The pool may rise above elevation 190 for short periods of time during high flow periods. A major operating constraint is the structural limitation that the difference between the headwater and tailwater must not exceed 88 feet at any time. In addition to reservoir constraints, downstream water needs will, at times, require outflow from Walter F. George to be fairly evenly distributed throughout each week.

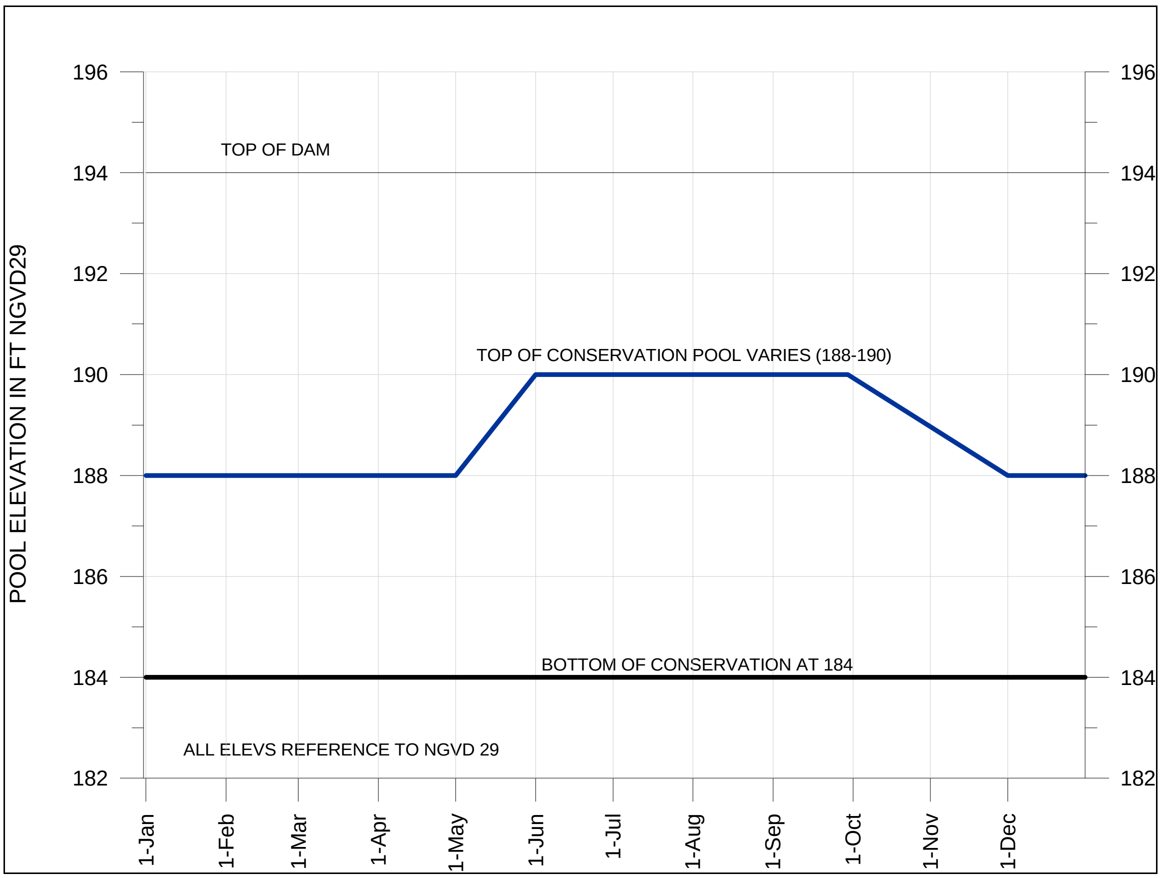

Figure C-34. Top and Bottom of Walter F. George Conservation Pool

The storage for the yield analysis will be based on the storage in the conservation pool from elevation 184 to 188 - 190 (depending on the time of year).

1.5.5 Surface Water Inflows

Observed daily inflow, outflow (discharge), and pool elevation data for the period of record starting in January 1964, just after the pool filled, through the present (Oct 2009) are available. The data are presented in the following Figure C-35.

1.5.6 Unimpaired Flow

The existing unimpaired flow data set was updated through 2008 for use in the yield analysis. The daily data was smoothed using 3-, 5-, or 7-day averaging to eliminate small negative values. Although this averaging affects the peak values, the volume is the same and the yield computations were done on the smoothed data. A plot of this smoothed unimpaired daily flow averaged over each year for the period of record 1939 – 2008 is shown in Figure C-36. Daily flows for critical drought periods are plotted in more detail in Figures C-37 – C-41.

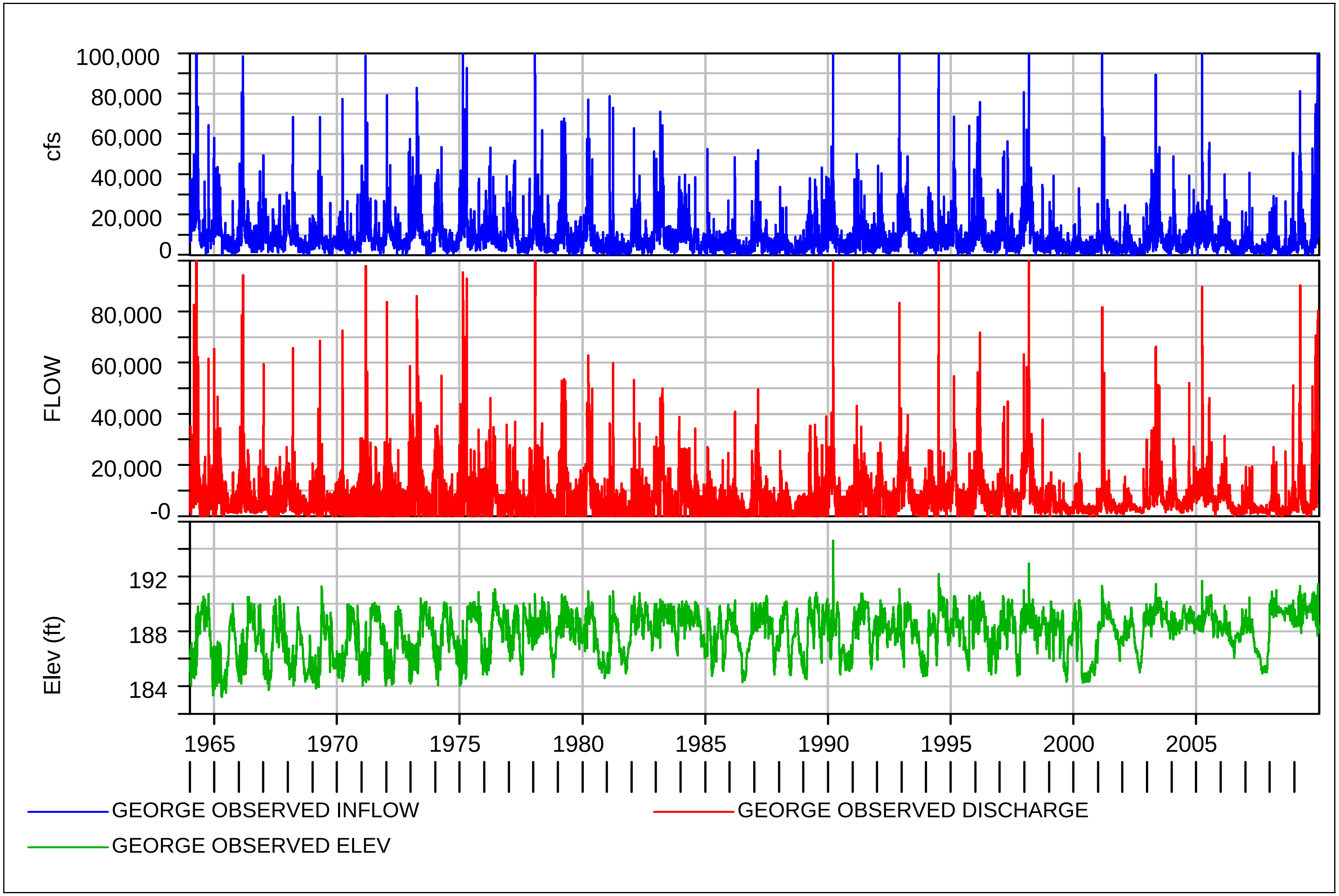

Figure C-35. Walter F. George Inflow-Outflow-Pool Elevation (Jan 1964-Dec 2009)

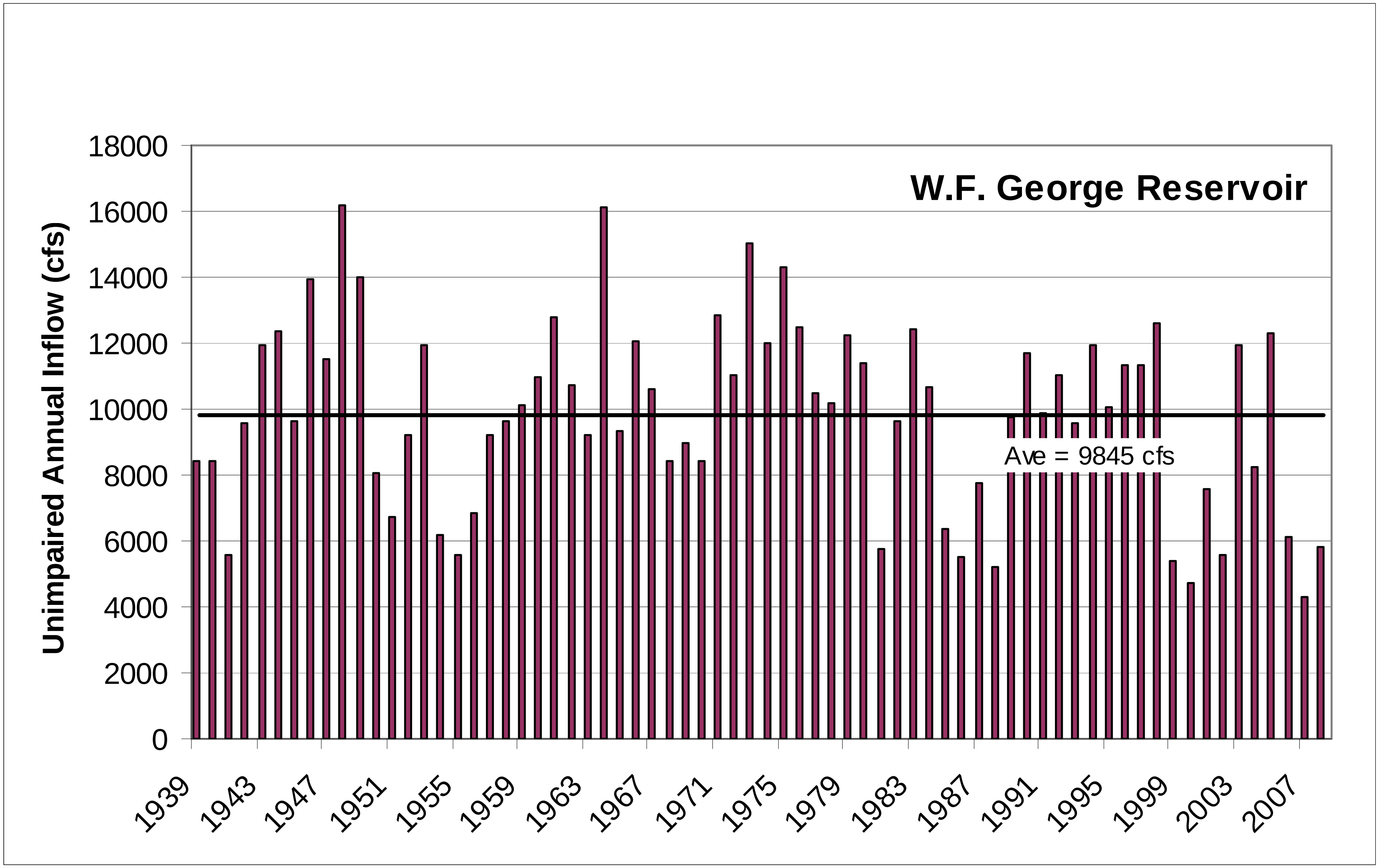

Figure C-36. Walter F. George Unimpaired Annual Inflow Jan 1939 to Dec 2008

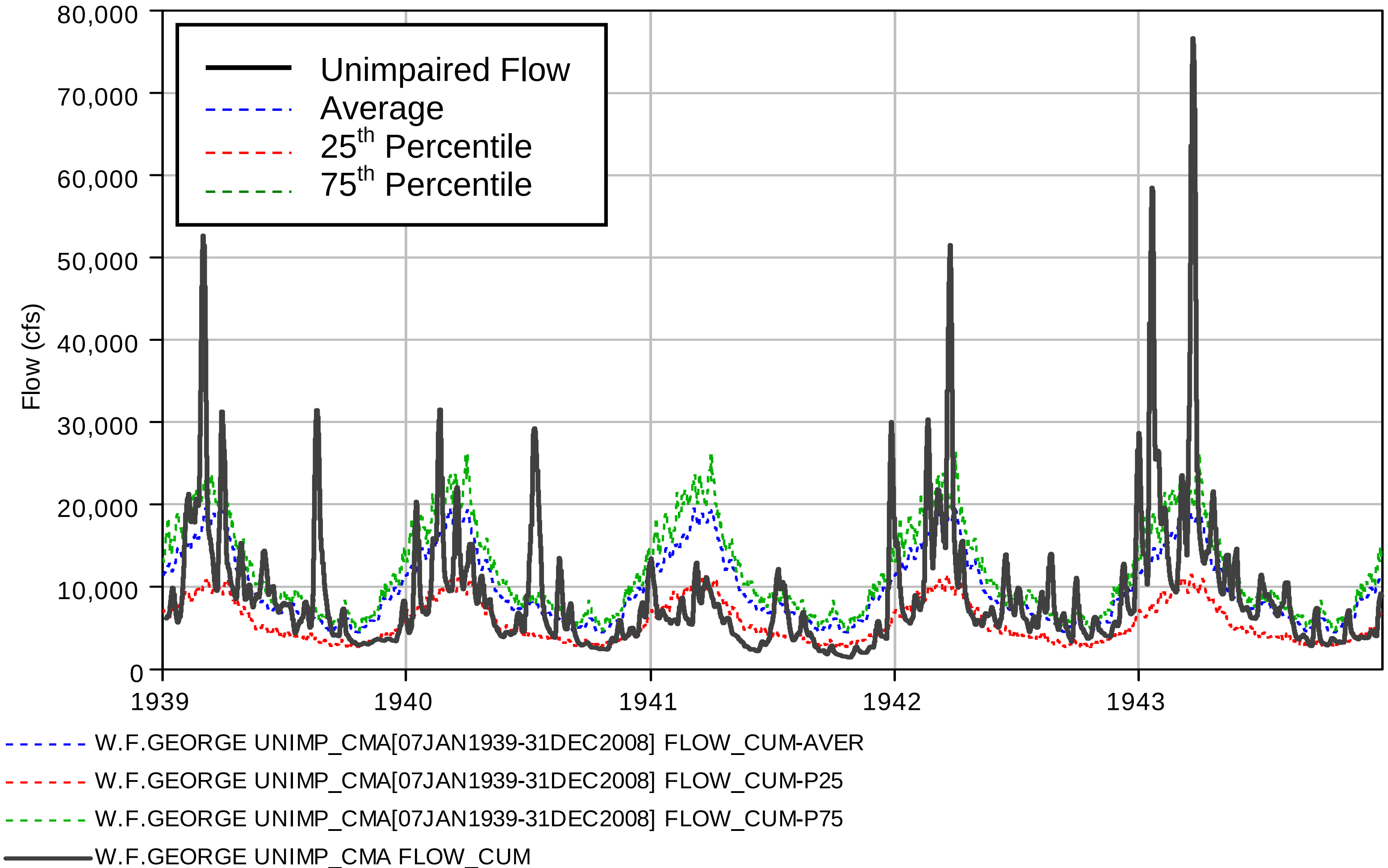

Figure C-37. Walter F. George Unimpaired Inflow – 1940's Drought; 75th Percentile, Average and 25th Percentile Flow

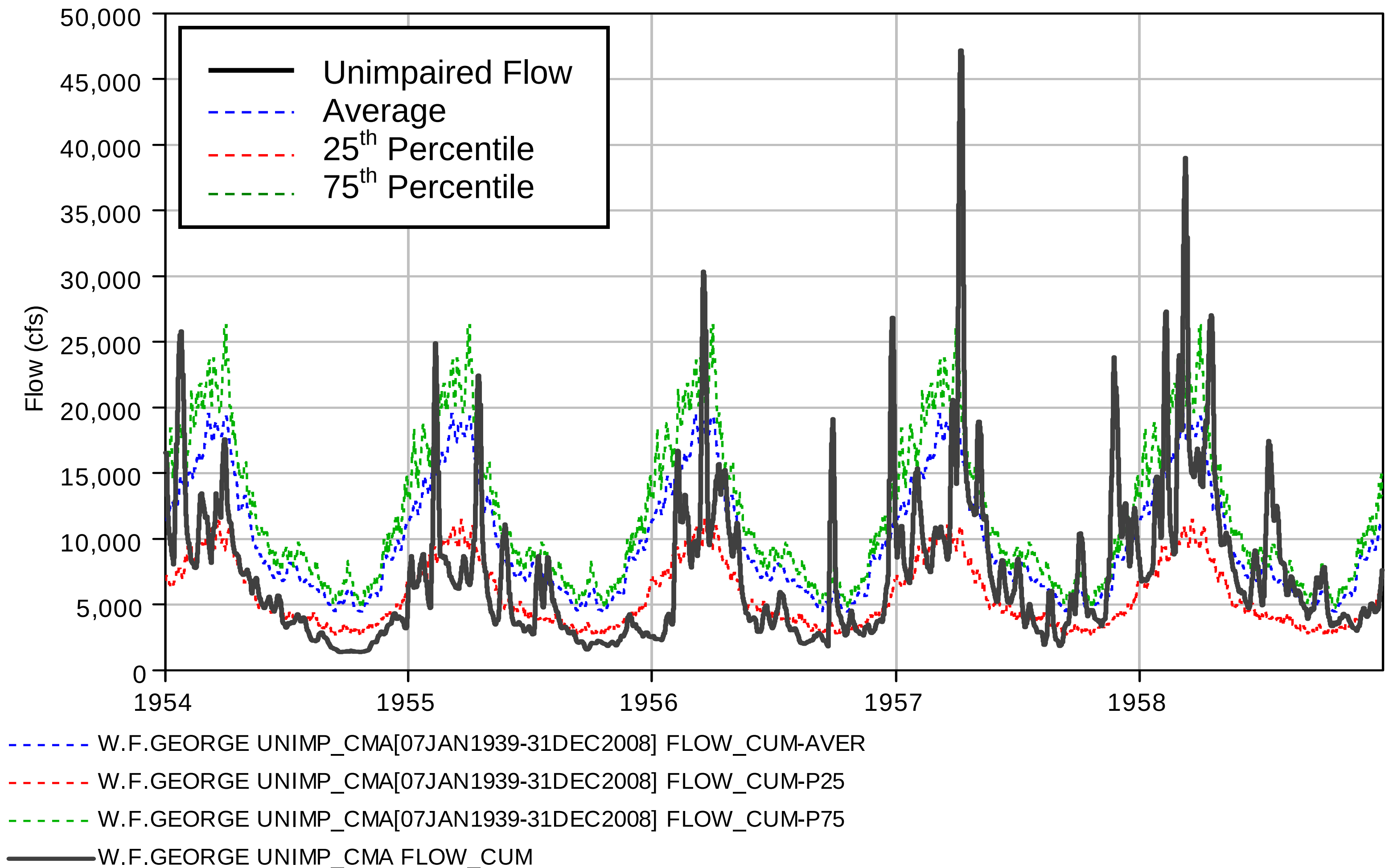

Figure C-38. Walter F. George Unimpaired Inflow – 1950's Drought; 75th Percentile, Average and 25th Percentile Flow

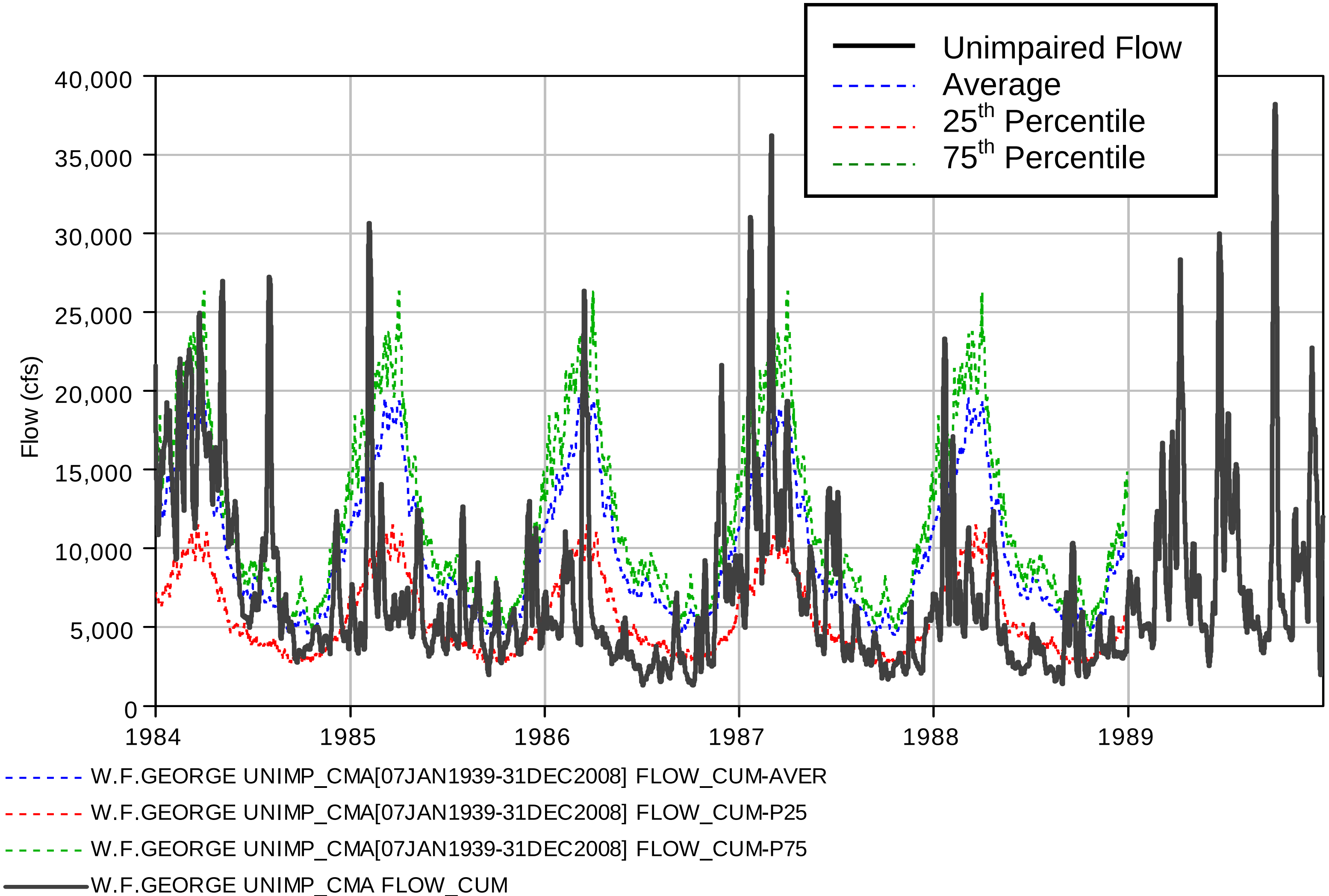

Figure C-39. Walter F. George Unimpaired Inflow – 1980's Drought; 75th Percentile, Average and 25th Percentile Flow

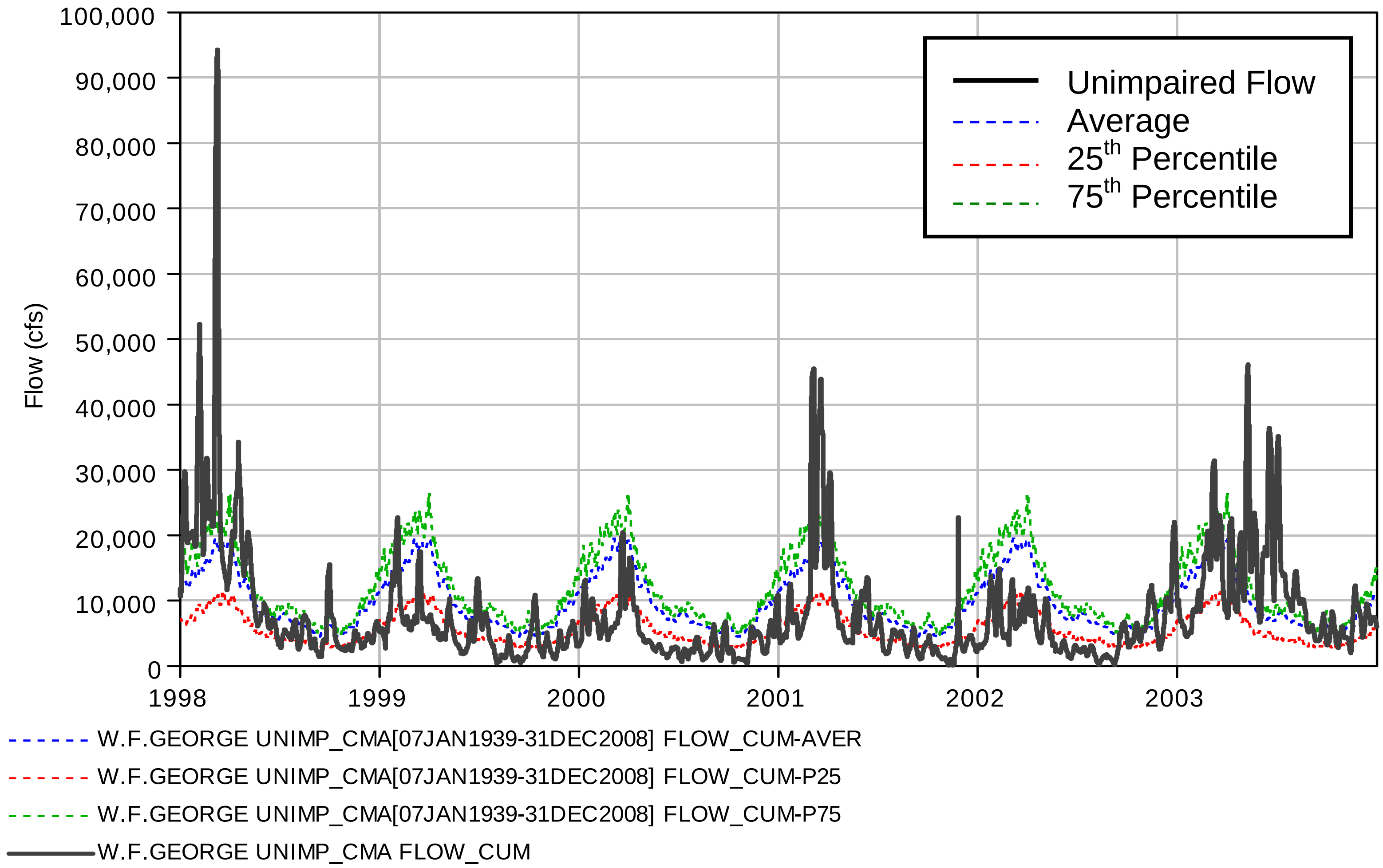

Figure C-40. Walter F. George Unimpaired Inflow – 2000 Drought; 75th Percentile, Average and 25th Percentile Flow

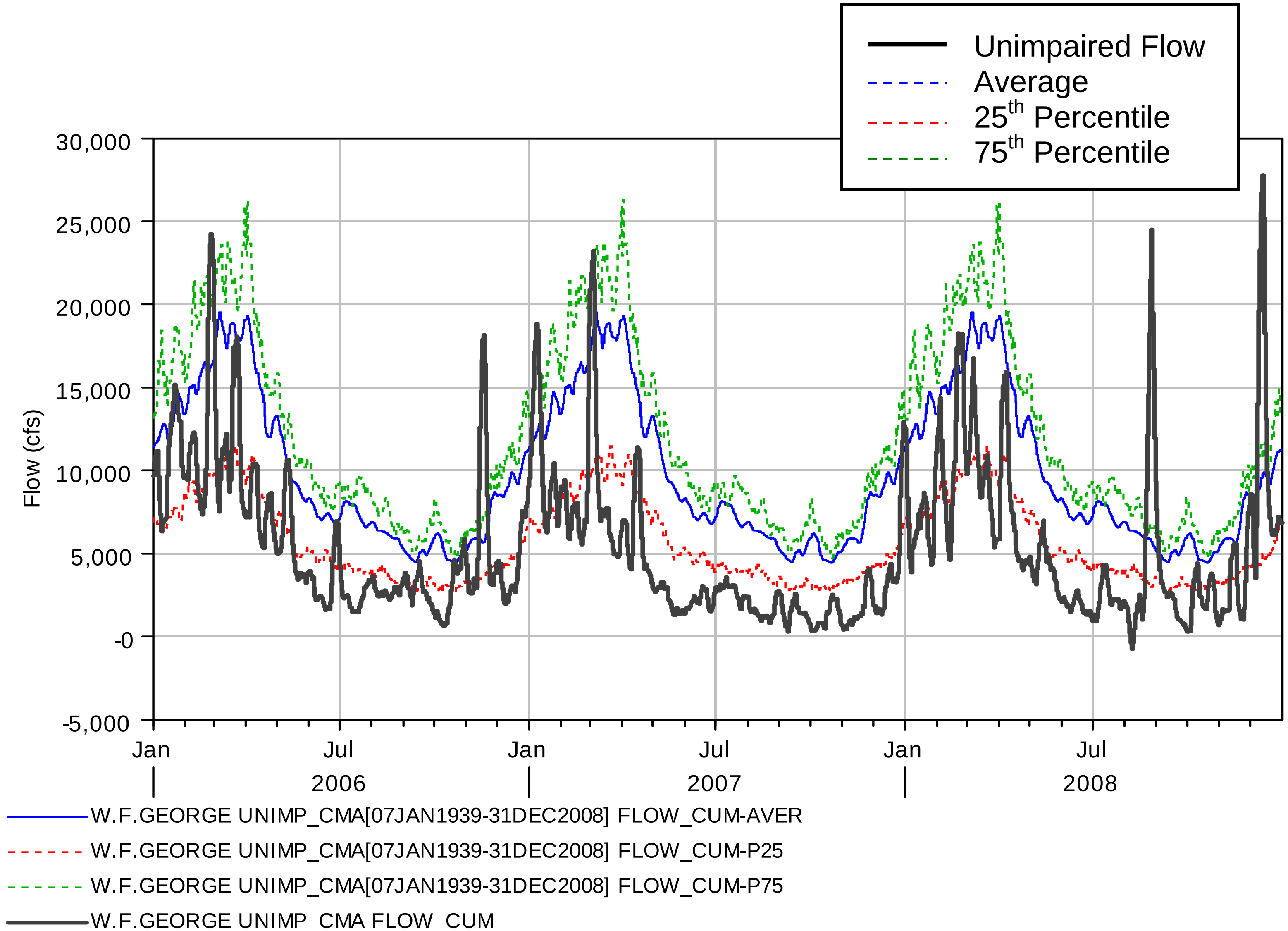

Figure C-41. Walter F. George Unimpaired Inflow – 2007 Drought; 75th Percentile, Average and 25th Percentile Flow

1.6 ResSim MODELING

The ResSim model for the ACF Basin is shown below in Figure C-42.

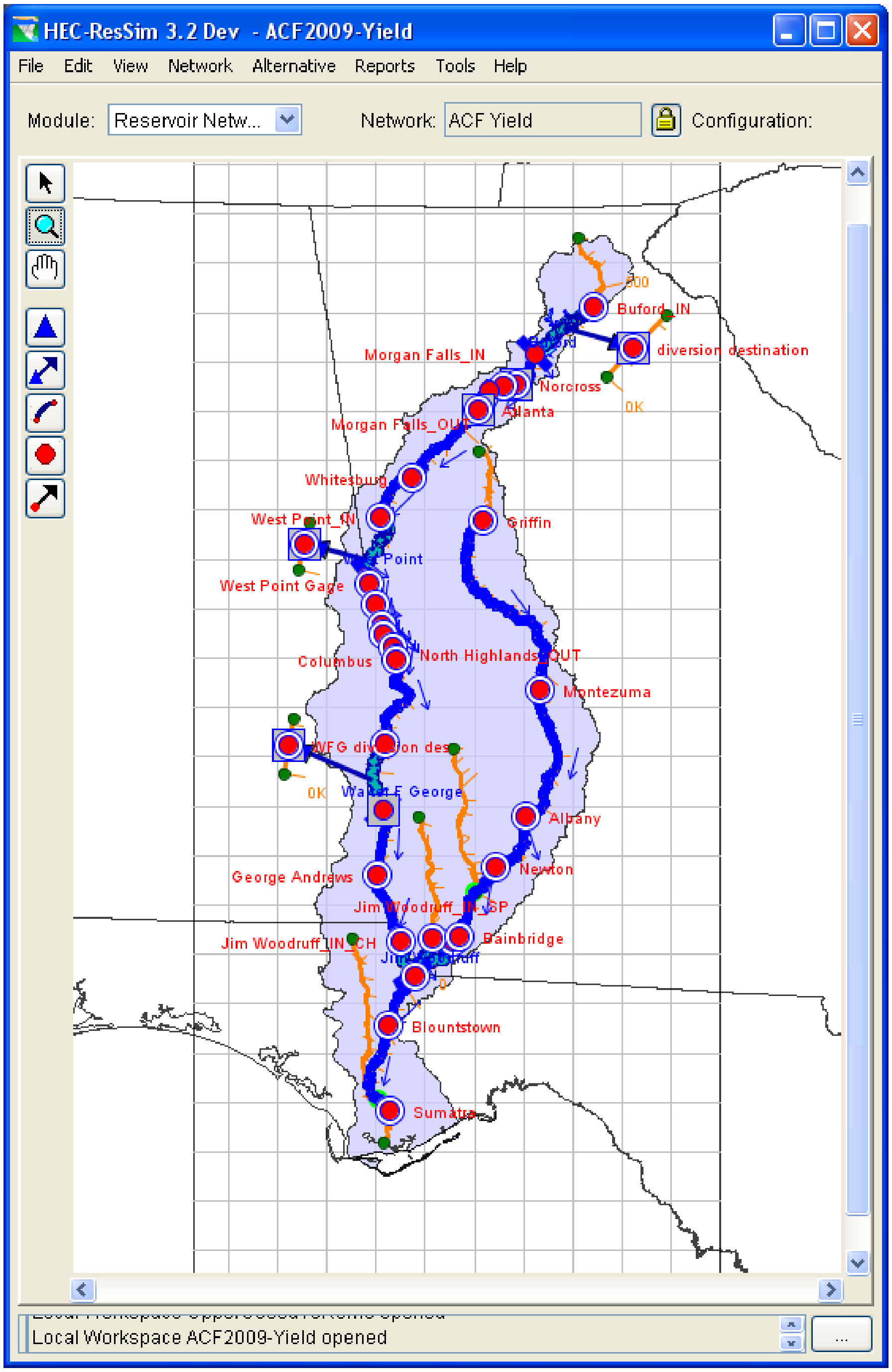

Figure C-42. ACF ResSim Model Schematic

ResSim version 3.2 Dev, November 2009 was utilized using the ResSim Watershed "ACF2009-Yield" and the network "ACF Yield". The ACF ResSim model includes four reservoirs, 19 non-reservoir locations and three diversion destinations. The fourth reservoir, Jim Woodruff, is run-of-river and not included in the yield analysis. Physical characteristics of each reservoir incorporated into the model using the latest published reservoir operation manual. Yield computations are dependent on the conservation storage and hydrology. The regulation plan section for each reservoir above describes the conservation storage. The ResSim operation set only includes the diversion yield rules and the downstream flood control rules. Reservoir guidelines for determining releases are defined using the operation set. Method C (System Yield) also includes tandem rules in the operation set for the system yield analysis from Walter F. George.

Simulations were created for each of the five indentified drought periods. The beginning and end period was selected to capture the drawdown and refill of all projects. Buford, having the greatest amount of storage and smallest drainage area, determined the duration of the simulation period. Each yield method (A, B and C) includes one simulation for each of five drought periods. A total of 40 simulations were run. This included 15 simulations under Method A, 15 simulations under Method B and 10 simulations under Method C (5 without diversion and 5 with diversions). Each simulation determined the yield for a particular reservoir and drought period. Simulation naming uses the drought label from Table C-8. For example Method A simulation name for the 1980 drought is “1980 wo Div”, Method B is “1980 w Div” and Method C is “1980 System Yield”.

Table C-8. Drought Periods

Drought Periods	Label
1940-1941	1940
1954-1958	1950
1984-1989	1980
1999-2003	2000
2006-2008	2007

Method A does not include the net river withdrawals and Method B does include the net river withdrawals in the yield determination. Each storage reservoir has a different operating set for the Method A and B alternatives, YieldNoDiv and YieldWDiv respectively.

For Methods A and B the upstream reservoir is the primary reservoir and the yield is met first before proceeding downstream. Projects are full at the beginning of the drought period simulation. None of the yield is returned to the system. This assumes that the yield is diverted from the system and is consumptively used. For instance, on the ACF, this means that the yield computed at Buford was not counted as inflow to West Point, downstream. This methodology determines the conservative individual project yield. As mentioned in the “Methods Employed in Critical Yield Analysis” section, for the Method C simulations the reservoirs are operated together to compute a system yield at Walter F. George.

A diversion outlet is added to each of the three reservoirs (Buford, West Point and Walter F. George). Water from the reservoir is diverted through the outlet to a dummy location not connected to the system. None of the diverted water is returned to the system. The yield represents the maximum continuous flow of water through this outlet during one of the five drought periods using all available conservation storage.

1.7 RESULTS

Table C-9 below presents the results from each of the simulations for Method A, and the pool elevations and yield flow values are presented graphically in Figures C-43 – C-45. The flow represents the total release from the reservoir. When the flow hydrograph rises above the constant yield value, flows are released through the reservoir.

Table C-9. ACF Project Yield Analysis without River Diversions, Method A

	Drought Period					
Project	**1940**	**1950**	**1980**	**2000**	**2007**	**Critical Yield**
Lanier	1,776	1,802	1,465	1,518	1,631	1,465
West Point	1,736	1,359	1,746	1,538	1,167	1,167
Walter F. George	1,903	1,589	1,424	785	572	572

Method A critical yield for Buford is 1,465 cfs and the critical period is the 1980's drought period
Method A critical yield for West Point is 1,167 cfs and the critical period is the 2007 drought period
Method A critical yield for Walter F. George is 572 cfs and the critical period is the 2007 drought period

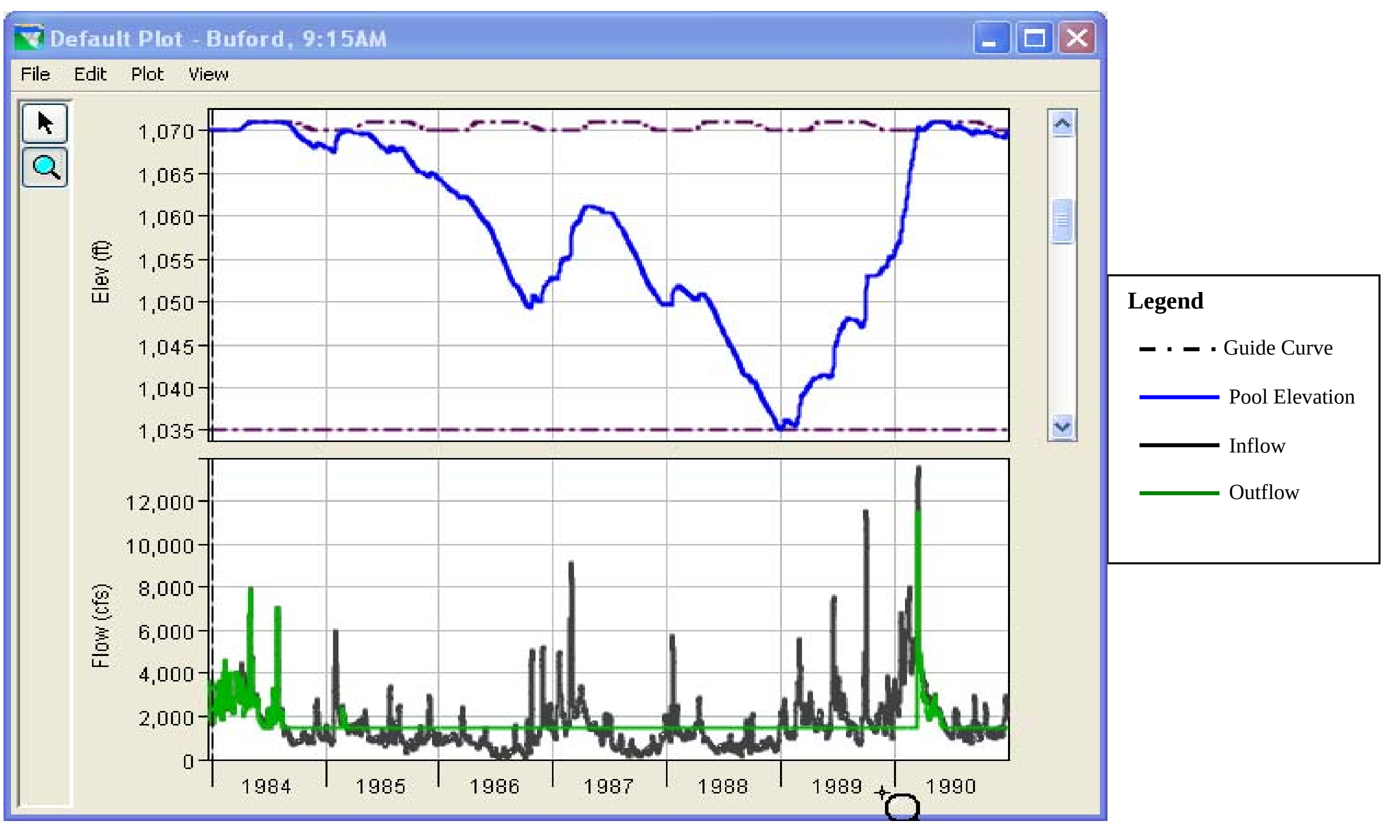

Figure C-43. Buford Critical Yield Result, Method A (No Diversions)

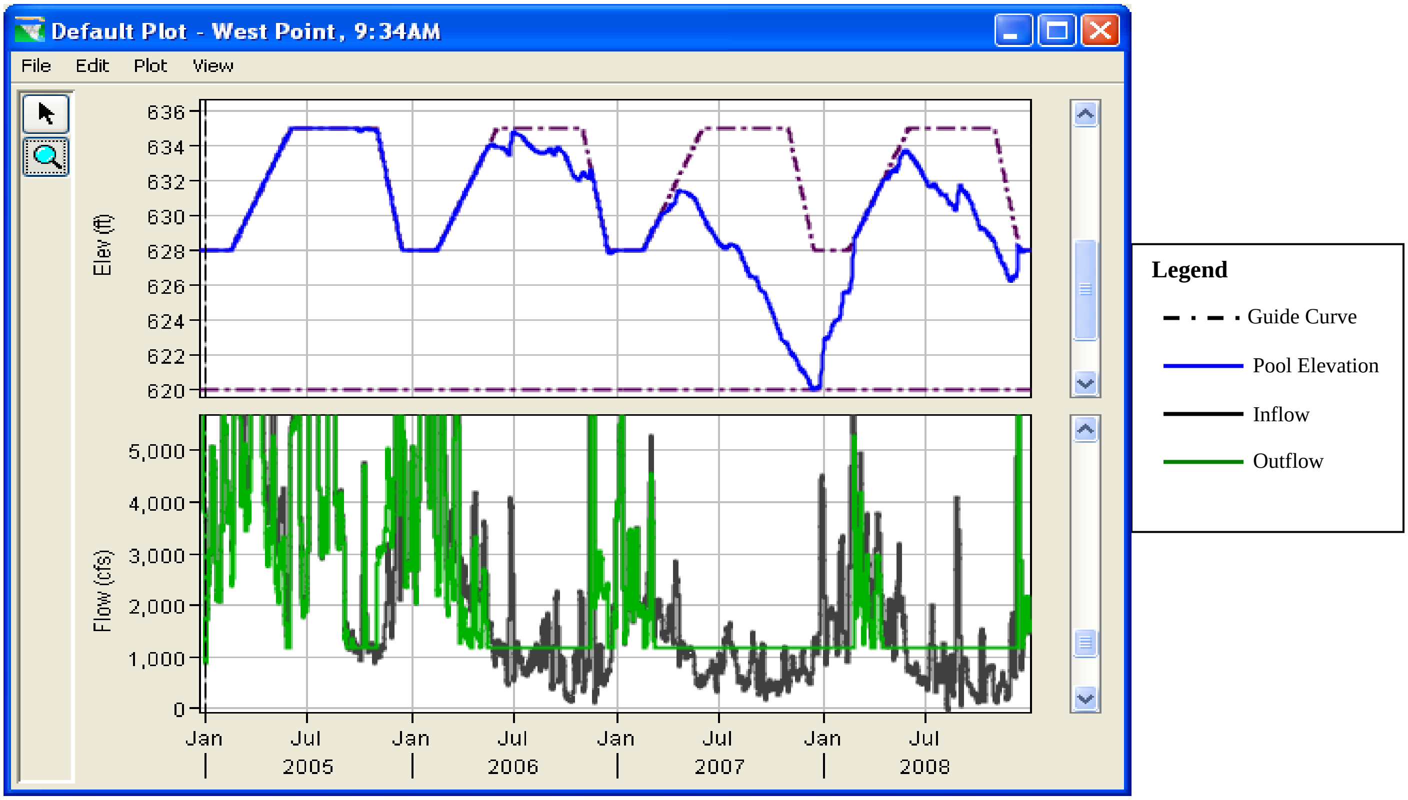

Figure C-44. West Point Critical Yield Result, Method A (No Diversions)

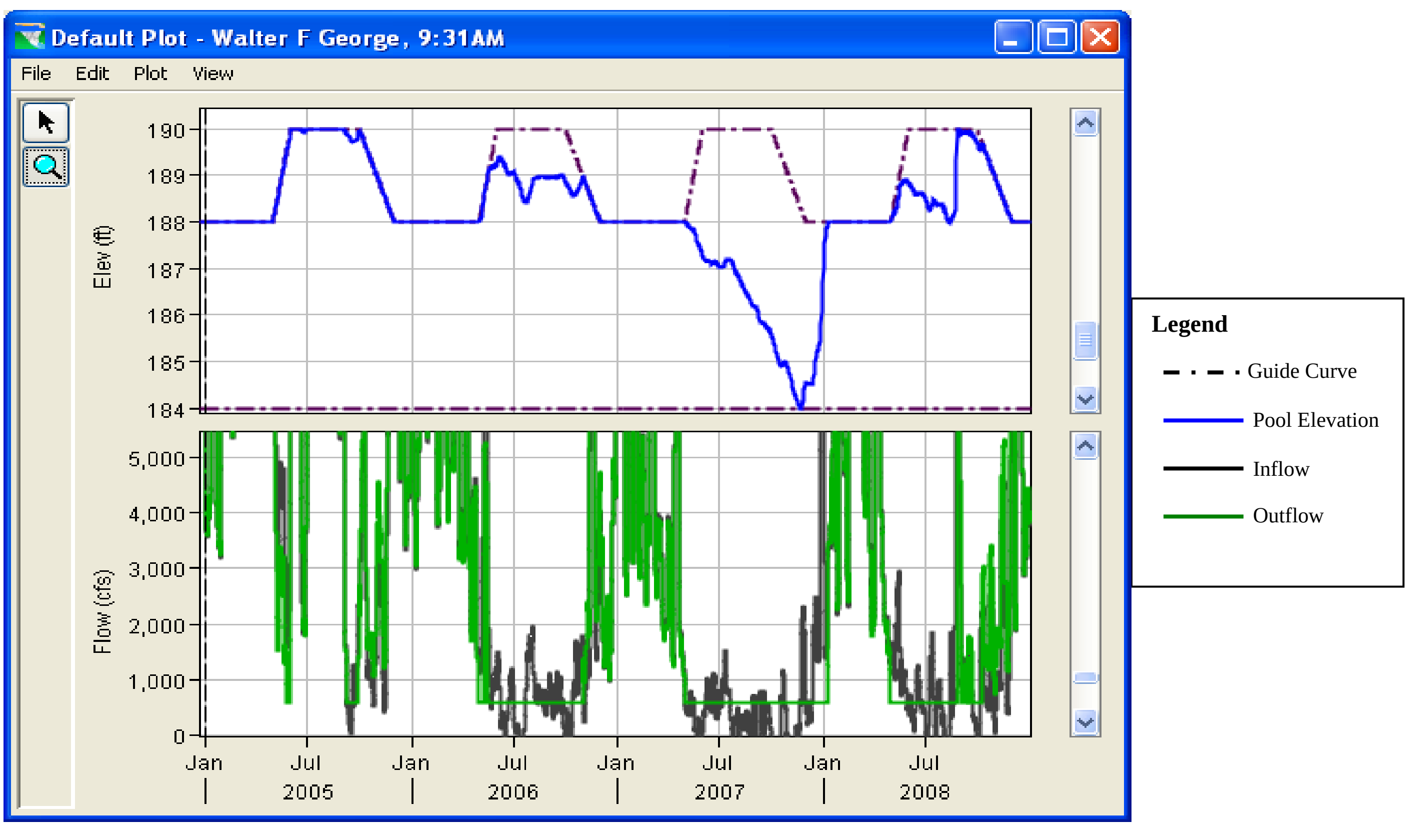

Figure C-45. Walter F. George Critical Yield Result, Method A (No Diversions)

The drawdown period for each drought period is listed in Table C-10.

Table C-10. ACF Yield Drawdown Period

Drought Label	Buford	West Point	Walter F. George
1940's	Jun 1939 - Feb 1946	Apr 1941 - Jan 1942	May 1941 - Dec 1941
1950's	Apr 1954 - Apr 1962	May 1954 - Feb 1955	May 1954 - Feb 1955
1980's	Mar 1985 - Mar 1990	Mar 1986 - Dec 1986	May 1986 - Nov 1986
2000	Jun 1998 - Sep 2004	Apr 2000 - Feb 2001	Apr 2000 - Dec 2000
2007	Mar 2006 – Oct 2009*	Mar 2007 - Feb 2008	Apr 2007 - Jan 2008

* Estimated based on actual refill

Table C-11 below captures the impact of net year 2007 river withdrawals above the lakes from the Chattahoochee River and tributaries. Graphical results of the pool elevation and yield are presented in Figures C-46, C-47, and C-48. As expected the yield values are reduced because the inflow into the reservoirs is reduced by the river withdrawal amounts. The critical yield reduction for Buford, West Point and Walter F. George is 0.4%, 23.7% and 17.9% respectfully.

Lake Lanier does not refill during the simulation period because unimpaired flow data through 2009 was not available at the time of analysis. The Corps will run the analysis through 2009 when flow data becomes available.

Table C-11. ACF Projects Yield Analysis with River Diversions, Method B

	Drought Period					
Project	1940	1950	1980	2000	2007	Critical Yield
Lanier	1,772	1,798	1,460	1,513	1,628	1,460
West Point	1,449	1,077	1,454	1,230	891	891
Walter F. George	1,763	1,496	1,317	682	470	470

Method B critical yield for Buford is 1,460 cfs and the critical period is the 1980's drought period
Method B l yield for West Point is 891 cfs and the critical period is the 2007 drought period
Method B yield for Walter F. George is 470 cfs and the critical period is the 2007 drought period

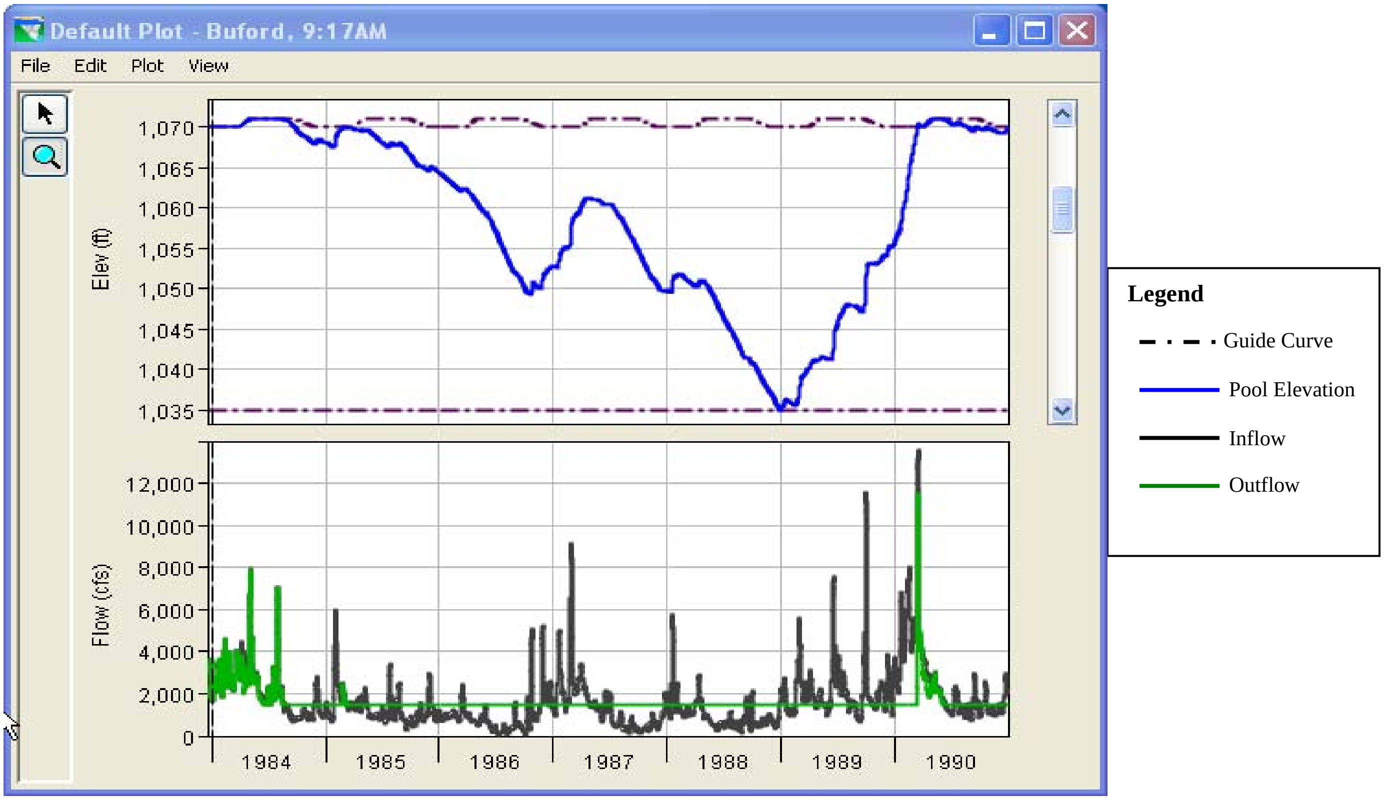

Figure C-46. Buford Critical Yield Result, Method B (With Diversions)

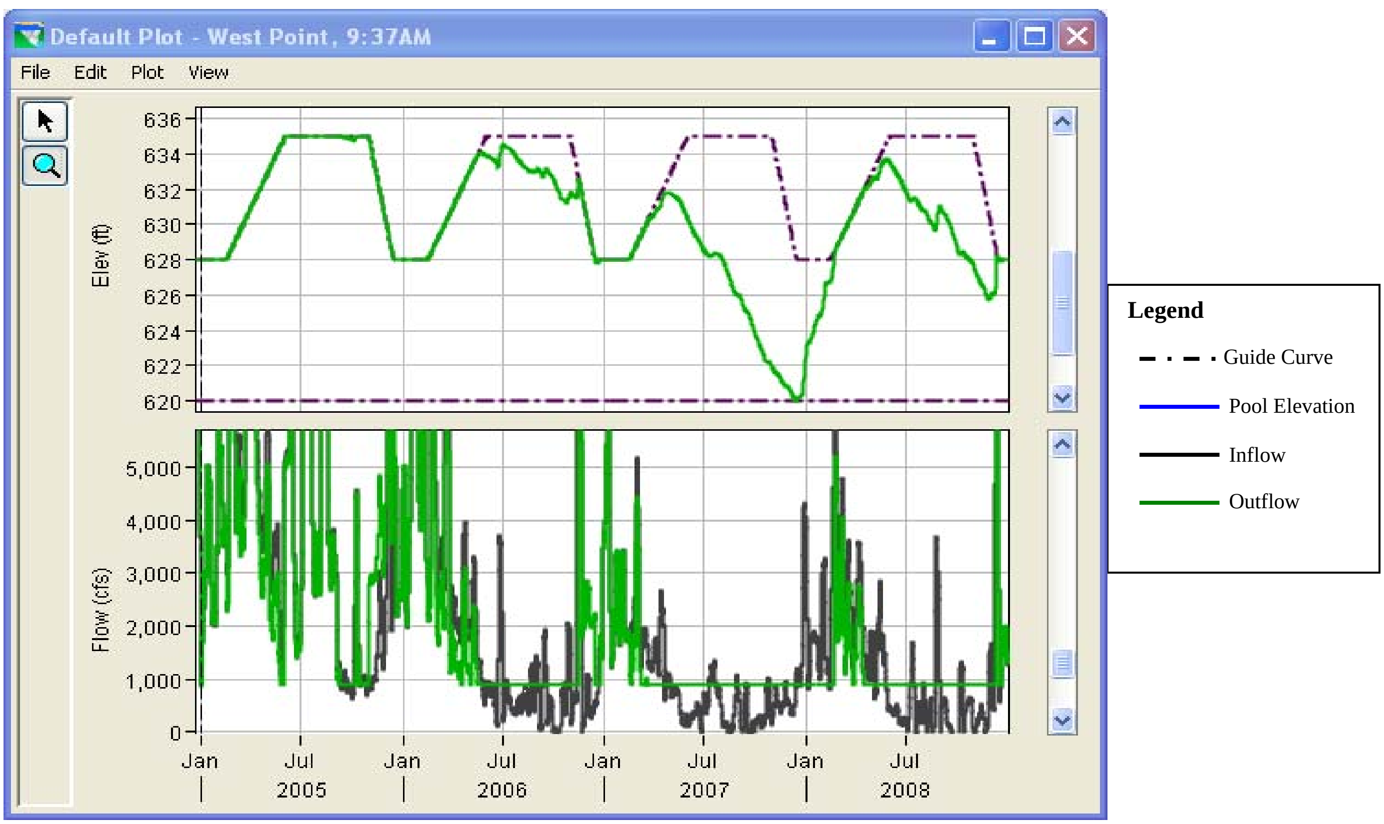

Figure C-47. West Point Critical Yield Result, Method B (With Diversions)

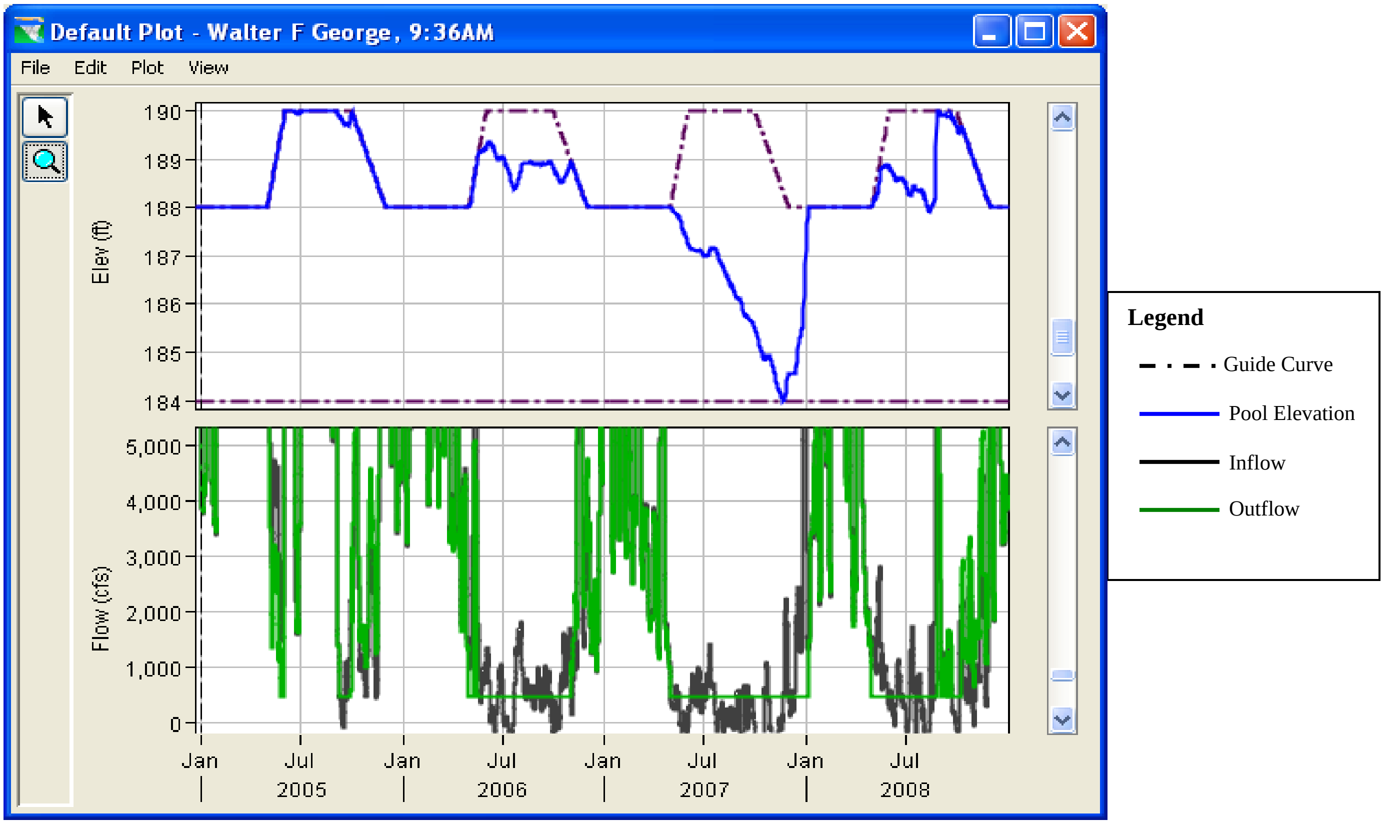

Figure C-48. Walter F. George Critical Yield Result, Method B (With Diversions)

Table C-12 presents the results from ACF system analysis, Method C. The table shows that, using the 2007 river diversions, the system yield is reduced 16%, from 4370 cfs to 3683 cfs. Graphical results are presented in Figure C-49 and Figure C-50.

Table C-12. ACF System Yield Analysis, Method C

	Drought Period					
Project	**1940**	**1950**	**1980**	**2000**	**2007**	**Critical Yield**
System with Diversions	5,471	4,616	4,671	4,019	3,683	**3,683**
System without Diversions	6,124	5,231	5,338	4,738	4,370	**4,370**

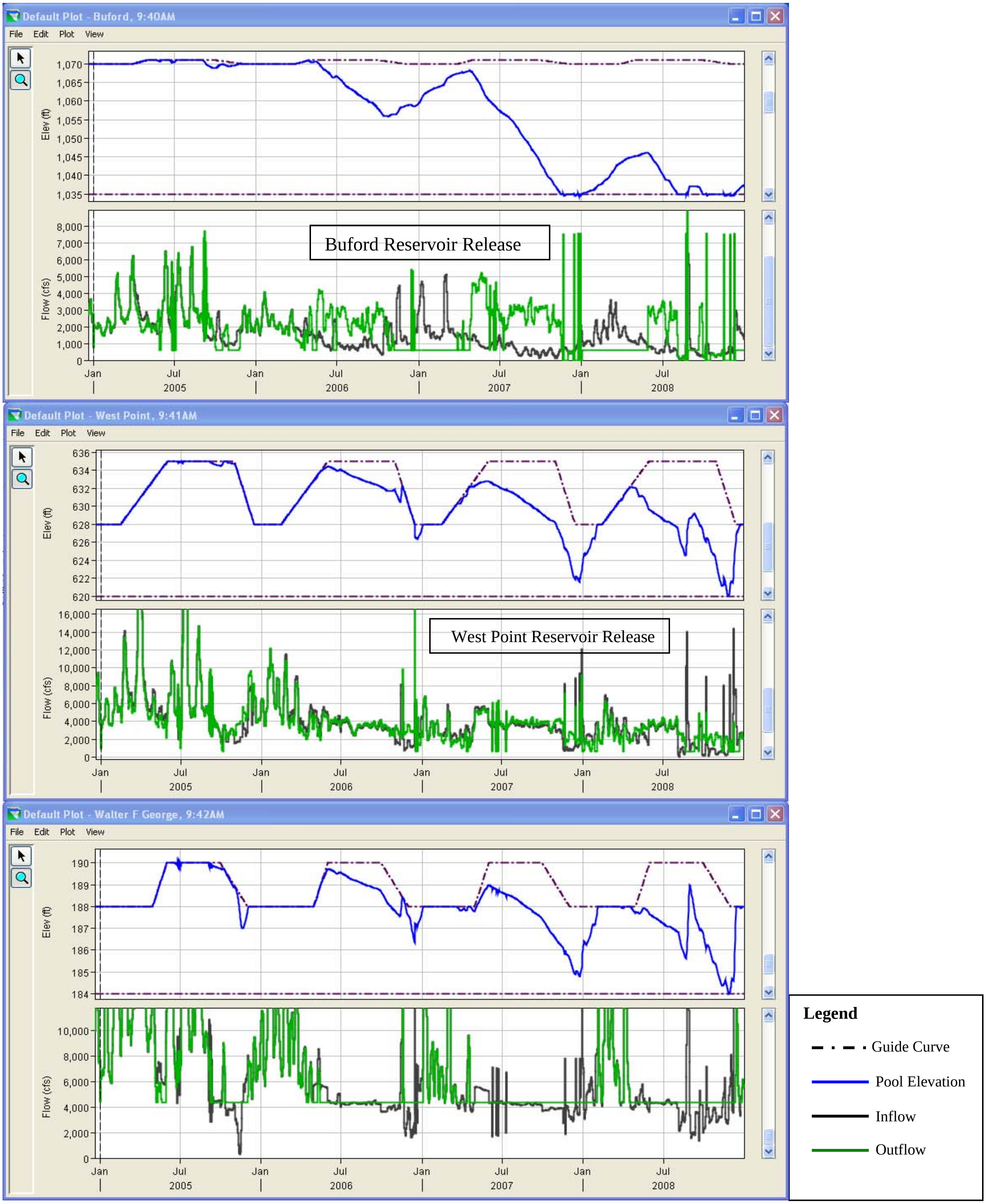

Figure C-49. System Critical Yield Result, Method C (No Diversions)

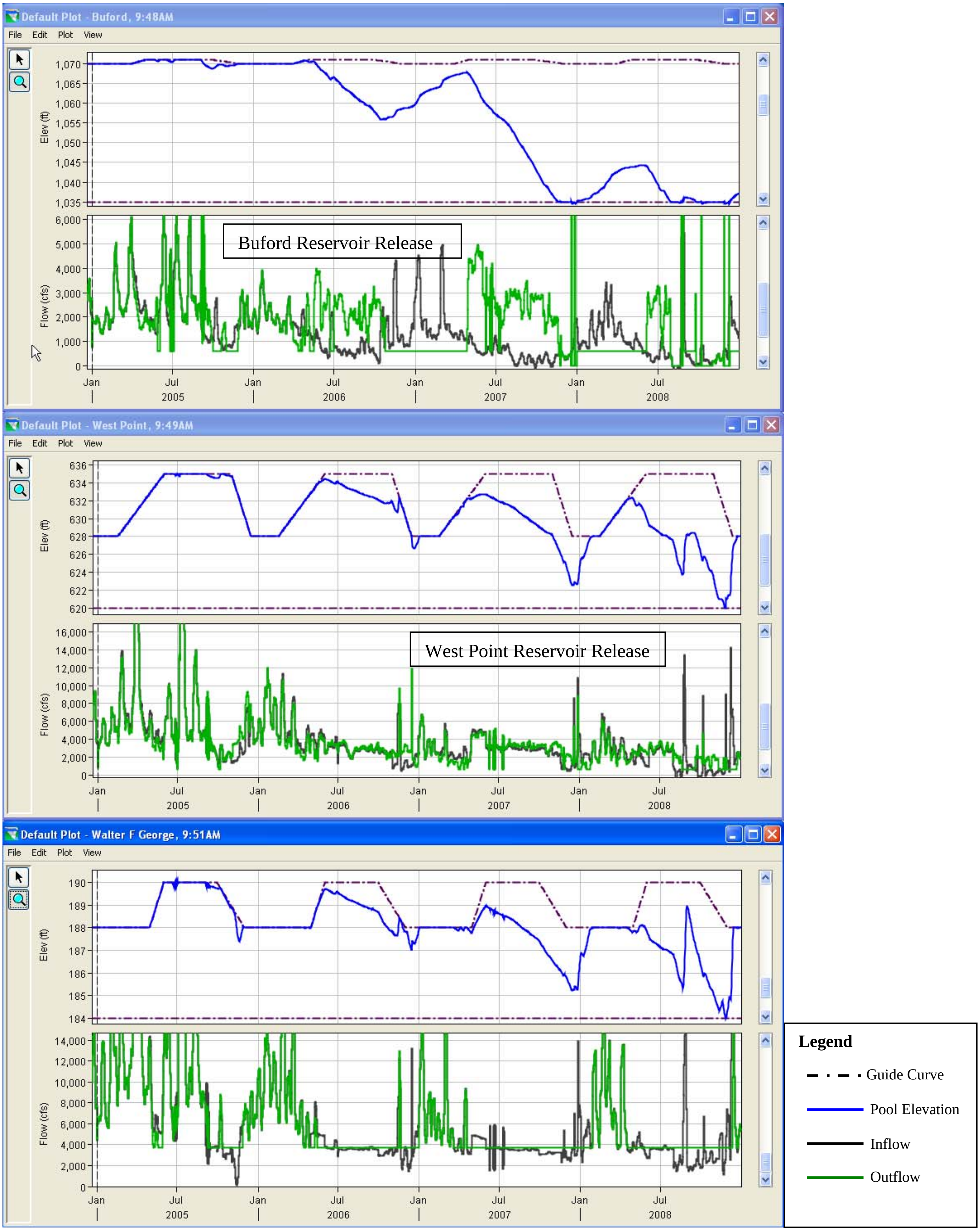

Figure C-50. System Critical Yield Result, Method C (With Diversions)