

Data Evaluation

During CY 2008, pre-discharge samples were collected at Ponds A-4, B-5, and C-2 to facilitate annual valve exercise. All pre-discharge data suggested acceptable water quality. By design, a valve exercise results in a small amount of water being discharged through the outlet, but not enough water to reach the downstream POC monitoring locations. As such, A-4 and B-5 were successfully exercised with no water reaching the downstream POCs. Pond C-2 was not exercised due to a broken valve handle; C-2 will be exercised during CY 2009.

3.1.3 Rocky Flats Hydrology

The following section provides information for all automated surface-water monitoring and precipitation gage locations at the Site that operated during CY 2008. For locations with continuous flow measurement, graphical discharge summaries are provided. Graphical summaries are also provided for all precipitation gage locations. Numerical discharge and precipitation values are included in the tables in Appendix A.

Groundwater hydrology is also addressed. This includes a discussion of groundwater levels in various areas of interest via the preparation of hydrographs and potentiometric surface maps. Flow velocities are also calculated. Hydrographs for monitoring wells are included in Appendix A.

3.1.3.1 General Hydrologic Setting

Streams and seeps at the Site are largely ephemeral, with stream reaches gaining or losing flow, depending on the season and precipitation amounts. Surface-water flow across the Site is primarily from west to east, with three major drainages traversing the Site. Fourteen ponds (plus several small stock ponds) collect surface-water runoff, although only 12 ponds are within the COU and maintained by LM. The Site drainages and ponds, including their respective pertinence to this report, are described below and shown on Figure 3–32.

In September 2008, the Site began the reconfiguration (breaching) of several of the dams in sections of North and South Walnut Creeks. The reconfiguration eliminates the dams from ongoing monitoring and maintenance requirements and returns the stream reaches to a more natural system, while preserving existing wetlands and habitat. The project was completed in March 2008 (see Section 2.3).

The major stream drainages leading out of the Refuge, from north to south, are Rock Creek, Walnut Creek, and Woman Creek. North Walnut Creek flows through the A-Series Ponds and South Walnut Creek flows through the B-Series Ponds; both are tributaries to Walnut Creek. The hydrologic routing diagram (as of December 31, 2008) for the locations included in this report is shown on Figure 3–33.

The groundwater hydrology is generally characterized by relatively thin, shallow saturated materials (in the COU, typically on the order of a few dozen feet thick and less than 50 feet deep). This shallow saturated interval occurs within the unconsolidated Rocky Flats Alluvium, hillslope colluvium, valley-fill alluvium, artificial fill, and the weathered portion of the underlying bedrock. Collectively, these materials are referred to as the upper hydrostratigraphic

unit (UHSU). Regionally, groundwater flows from west to east within the UHSU of the pediment surfaces, except where locally diverted toward generally east-west trending drainages that bisect these pediments. Groundwater typically discharges at seeps and springs along pediment edges, or as baseflow to surface water. Vertical flow is sharply limited by the low-permeability claystones underlying the unconsolidated surficial materials. This underlying low-permeability bedrock surface comprises the Arapahoe and Laramie Formations, which are typically undifferentiated; the gentle eastward dip of the unconformity marking the contact between this bedrock and the overlying unconsolidated surficial materials acts to direct the groundwater flow. Locally, this bedrock may include sandstone lenses that subcrop or are sufficiently shallow to be included in the UHSU. For a more thorough description of the hydrogeology at Rocky Flats, refer to EG&G (1995a).

Surface Water

Walnut Creek

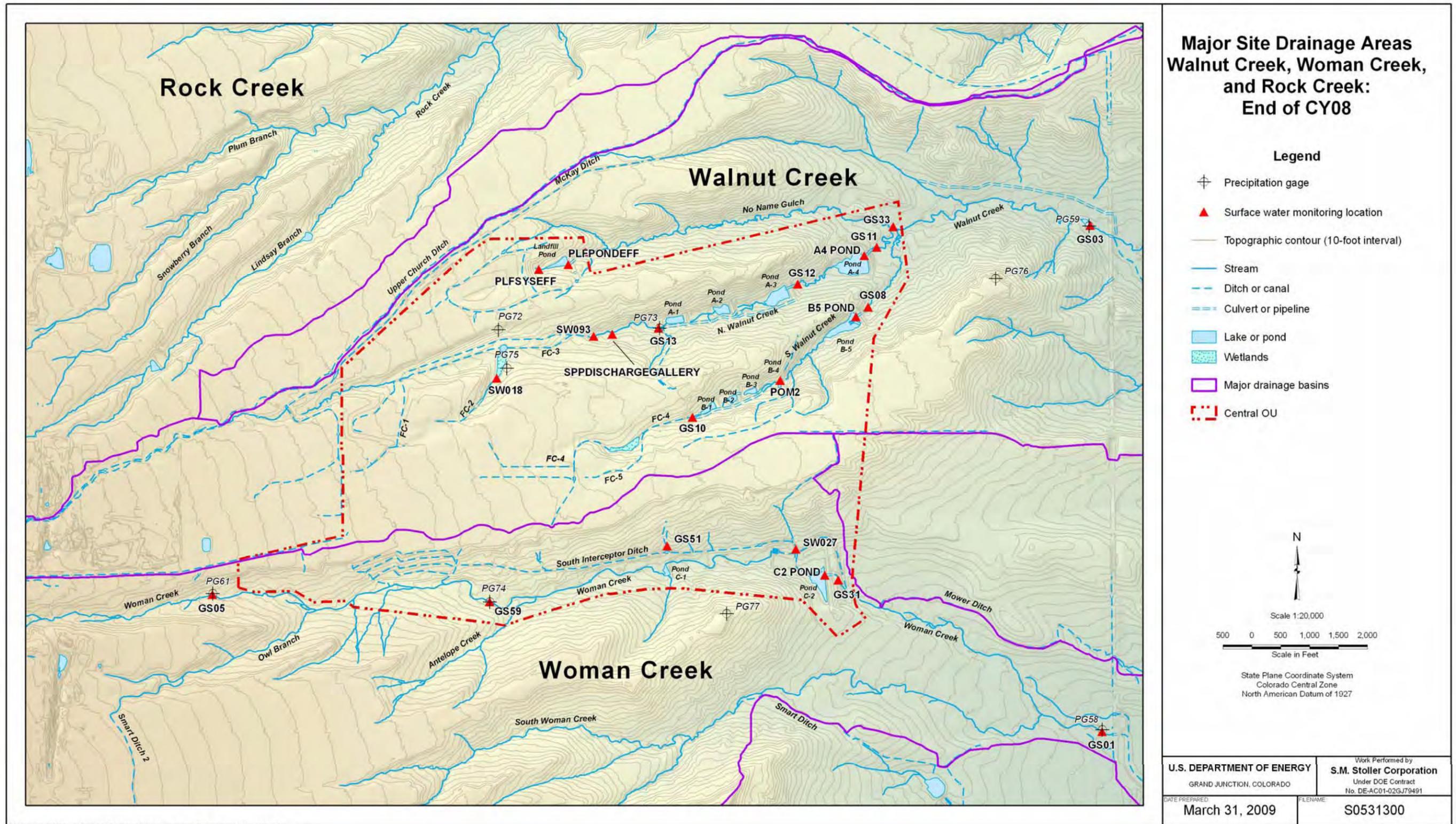
Walnut Creek receives surface-water flow from the central third of the Refuge, including the majority of the COU. It consists of several tributaries: McKay Ditch, No Name Gulch, North Walnut Creek, and South Walnut Creek. These tributaries join Walnut Creek upstream of the Refuge's eastern boundary (Indiana Street). East of Indiana Street, Walnut Creek flows through a diversion structure normally configured to divert flow to the Broomfield Diversion Ditch around Great Western Reservoir and into Big Dry Creek. The Walnut Creek tributaries, from north to south, are described below.

McKay Ditch

The McKay Ditch was formerly a tributary to Walnut Creek within the Refuge boundary, but was diverted in July 1999 into a new pipeline to keep McKay Ditch water from commingling with water in Walnut Creek upstream of Indiana Street. Although no longer a contributor to Walnut Creek, the McKay Ditch drainage is described here to clarify water routing. The new configuration allows the City of Broomfield to direct water from the South Boulder Diversion Canal, across the northern portion of the Refuge and directly into Great Western Reservoir, without entering Walnut Creek. This configuration prevents the commingling of McKay Ditch water with discharged water from the Site ponds. McKay Ditch (as well as both the McKay Bypass Canal and McKay Bypass Pipeline) are outside the COU; these features are not maintained by LM.

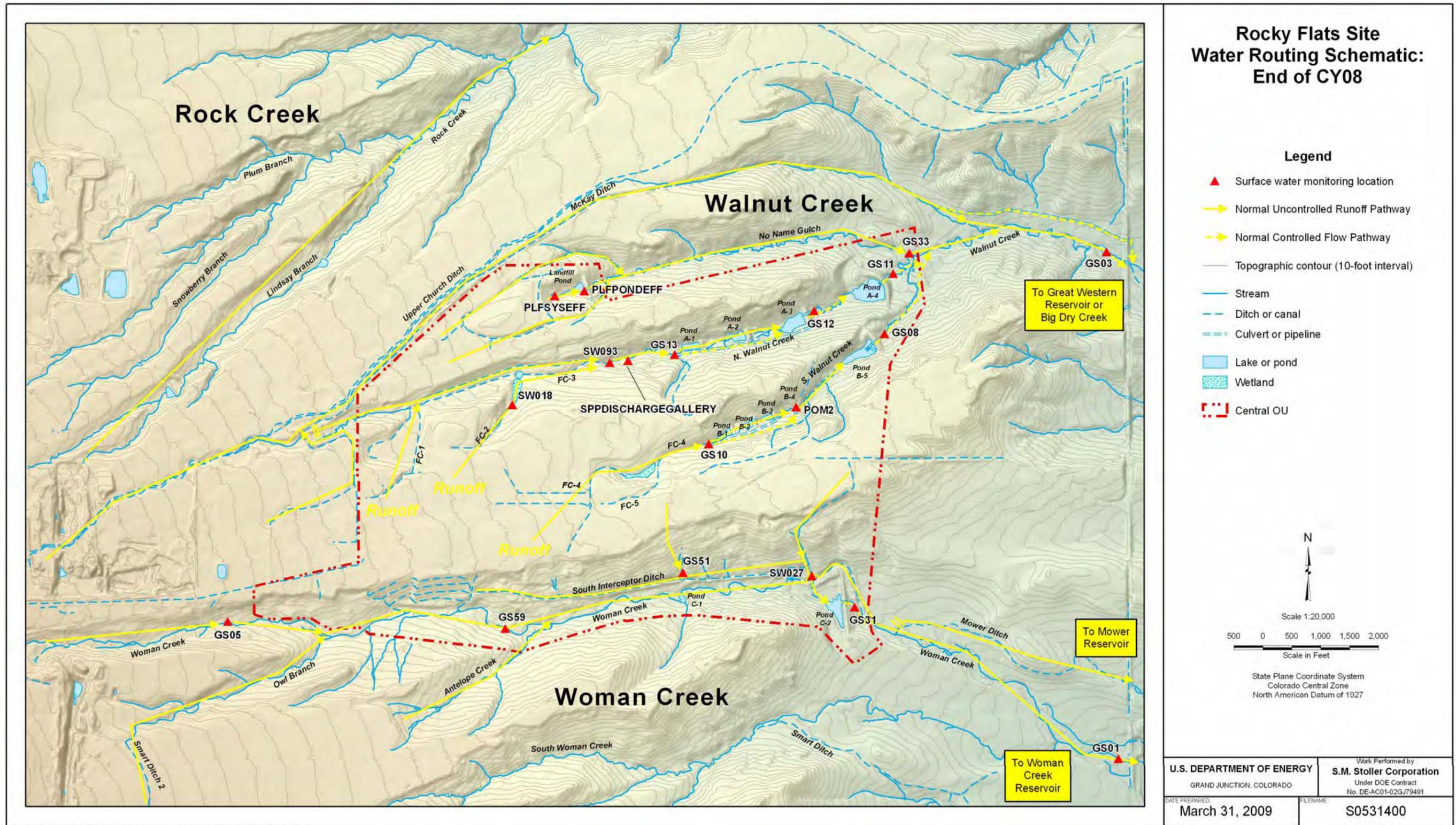
No Name Gulch

This drainage is located downstream of the Landfill Pond. A surface-water diversion ditch is constructed around the perimeter of the PLF to divert surface-water runoff around the landfill area to No Name Gulch. Effluent from the PLFTS and runoff from the area surrounding the Landfill Pond are the sole surface-water sources to the Landfill Pond. The Landfill Pond is normally operated in a flow-through configuration, although the pool level often drops below the outlet works.



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Figure 3-32. Major Site Drainage Areas - Walnut Creek, Woman Creek, and Rock Creek: End of CY 2008



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Figure 3-33. Rocky Flats Site Water Routing Schematic: End of CY 2008

North Walnut Creek

Runoff from the northern portion of the COU flows into this drainage, which has four ponds (Ponds A-1, A-2, A-3, and A-4). Dams A-1 and A-2 were breached in 2008-2009 (see Section 2.3). The combined capacity of the A-Series Ponds is approximately 174,000 cubic meters (m³) (46 million gallons or 141 acre-feet). In the normal operational configuration, Ponds A-1 and A-2 receive flow for stormwater attenuation and wetland habitat; the stoplog structures control water levels in these ponds, with water subsequently flowing to Pond A-3 for retention. Pond A-3 is discharged in batches to the A-Series “terminal pond” Pond A-4. If routine discharge of retained water is warranted, Pond A-4 is isolated, sampled, and water is released if surface water-quality criteria are met. Criteria for emergency discharge, regardless of pre-discharge pond sampling results, are detailed in the *Emergency Response Plan for Rocky Flats Site Dams* (ERP) (DOE 2008h).

South Walnut Creek

Runoff from the central portion of the COU flows into this drainage, which has five ponds (Ponds B-1, B-2, B-3, B-4, and B-5). Dams B-1, B-2, B-3, and B-4 were breached in 2008–2009 (see Section 2.3). The combined capacity of the South Walnut Creek B-Series Ponds is approximately 93,000 m³ (25 million gallons or 76 acre-feet). In the normal operational configuration, Ponds B-1, B-2, B-3, and B-4 receive flow for stormwater attenuation and wetland habitat; the stoplog structures control water levels in these ponds, with water subsequently flowing to “terminal pond” Pond B-5. If routine discharge of retained water is warranted, Pond B-5 is sampled and water is released if surface water-quality criteria are met. Criteria for emergency discharge, regardless of pre-discharge pond sampling results, are detailed in the ERP.

Woman Creek

South of the COU is Woman Creek, which flows through Pond C-1 and off-Site onto Refuge lands toward Indiana Street. The Woman Creek drainage basin extends eastward from the base of the foothills, near Coal Creek Canyon, to Standley Lake. In the current configuration, Woman Creek flows into the Woman Creek Reservoir located east of Indiana Street and upstream of Standley Lake, where the water is held until it is pump-transferred to Big Dry Creek by the Woman Creek Reservoir Authority.

South Interceptor Ditch

In the southern portion of the COU, and tributary to Woman Creek, is the SID drainage. Surface-water runoff from the southern portion of the COU is captured by the SID, which flows from west to east into Pond C-2. If routine discharge of retained water is warranted, Pond C-2 is sampled and water is released to Woman Creek if surface water-quality criteria are met. Criteria for emergency discharge, regardless of pre-discharge pond sampling results, are detailed in the ERP.

Other Drainages

The third major drainage, other than Walnut and Woman Creeks, is Rock Creek. The Rock Creek drainage covers the northwestern portion of the Refuge. East-sloping alluvial plains to the

west, several small stock ponds within the creek bed, and multiple steep gullies and stream channels to the east characterize the drainage channel. This entire basin is outside the COU.

Smart Ditch/South Woman Creek, located south of Woman Creek, is also completely outside the COU. The D-Series Ponds (D-1 and D-2) are located on Smart Ditch. This drainage and these ponds are not maintained by LM.

3.1.3.2 Surface-Water Hydrologic Data Presentation

Flow Data Collection and Computation

Data obtained at a continuous surface-water gaging station on a stream or conveyance, such as an irrigation ditch, consist of a continuous record of stage,¹³ individual measurements of flow throughout a range of stages, and notations regarding factors that might affect the relation of stage to flow rate. These data, together with supplemental information such as climatological records, are used to compute daily mean discharges.

Continuous records of stage are obtained with electronic recorders that store stage values at selected time intervals or secondarily with radio-telemetry data-collection platforms that transmit near real-time data at selected time intervals to a central database for subsequent processing. Direct field measurements of flow are made with current meters, using methods adapted by the U.S. Geological Survey, or with flumes or weirs that are calibrated to provide a relation of observed stage to flow rate. These methods are described by Carter and Davidian (1968) and by Rantz (1982a, 1982b).

In computing flow records for nonstandard flow-control devices, results of individual measurements are plotted against the corresponding stage, and stage-flow rate relation curves are constructed. From these curves, rating tables indicating the computed flow rate for any stage within the range of the measurements are prepared. For standard devices (e.g., flumes and weirs), rating tables indicating the flow rate for any stage within the range of the device are prepared based on the geometry of the device. If it is necessary to define extremes of flow outside the range of the device, the curves can be extended using (1) logarithmic plotting, (2) velocity-area studies, (3) results of indirect measurements of peak flow rate, such as slope-area or contracted-opening measurements, and computation of flow over dams or weirs, or (4) step-back-water techniques.

Daily mean discharges are computed by averaging the individual flow measurements using the stage-flow rate curves or tables. If the stage-flow rate relation is subject to change because of frequent or continual change in the physical features that form the control, the daily mean discharge is determined by the shifting-control method, in which correction factors based on the individual flow rate measurements and notes by the personnel making the measurements are applied to the gage heights before the flow rates are determined from the curves or tables. This shifting-control method also is used if the stage-flow rate relation is changed temporarily because of aquatic vegetation growth or debris on the control. For some gaging stations, formation of ice in the winter can obscure the stage-flow rate relations so that daily mean discharges need to be estimated from other information, such as temperature and precipitation

¹³ Stage is the water level (in units such as feet or meters) in a conveyance structure.

records, notes of observations, and records for other gaging stations in the same or nearby basins for comparable periods.

For most gaging stations, there may be periods when no gage-height record is obtained or the recorded gage height is faulty so that it cannot be used to compute daily mean discharge or contents. This record loss occurs when recording instruments malfunction or otherwise fail to operate properly, intakes are plugged, the stilling well is frozen, or for various other reasons. For such periods, the daily discharges are estimated from the recorded range in stage, previous or following record, field discharge measurements, climatological records, and comparison with other gaging-station records from the same or nearby basins. Information explaining how estimated daily discharge values are identified in gaging-station records is provided in the “Identifying Estimated Daily Discharge” section.

Data Presentation

The information published for each continuous-record surface-water gaging station consists of six parts: the station description, a map showing the drainage area for the station, a plot of the daily mean discharge for the CY(s), a table of daily mean discharge values for the CY with summary data, a tabular statistical summary of monthly mean discharge data for the CY, and a summary statistics table that includes statistical data of annual discharge and runoff. The tables are included in Appendix A, while the other information is presented below.

Station Description

The station description provides, under various headings, descriptive information included gaging-station location, drainage area, period of record, and gage information. The following information is provided:

- **Location**—This entry provides the gaging-station state plane coordinates and geographic location. Gaging station state plane coordinates were obtained by geographic positioning system or digitized from Site geographic information system (GIS) coverages.
- **Drainage Area**—This entry provides the drainage area (in acres) of the gaged basin. If, because of unusual natural conditions or artificial controls, some part of the basin does not contribute flow to the total flow measured at the gage, the noncontributing drainage area also is identified. Drainage area is usually measured using digital techniques and the most accurate maps available. Because the type of map available might vary from one drainage basin to another, the accuracy of digitized drainage areas also can vary. Drainage areas are updated as better maps become available. Some of the gaging stations included in this report measure stage and flow rate in channels that convey water to or from reservoirs or other features; these channels might have little or no contributing drainage area. Drainage areas in this report were provided by Site GIS coverages.¹⁴

¹⁴ Drainage area maps show Site configuration at the end of CY 2007.

- **Period of Record**—This entry provides the period for which the Site has been collecting records at the gage. This entry includes the month and year of the start of collection of hydrologic records by the Site and the words “to current year” if the records are to be continued into the following year.
- **Gage**—This entry provides the type of gage currently in use, and a condensed history of the types and locations of previous gages.

Daily Mean Discharge Values

The daily mean discharge values computed for each gaging station during a CY are listed in the body of the data tables in Appendix A. In the monthly “Flow Rate” summary part of the table, the line headed “Average” lists the average flow rate, in cfs, during the month; and the lines headed “Maximum” and “Minimum” list the maximum and minimum daily mean discharges for each month. Total discharge for the month also is expressed in cubic feet (“Cubic Feet”), gallons (“Gallons”), and acre-feet (“Acre-Feet”). The term “Partial Data” denotes a month with incomplete data.

Summary Statistics

A section of the table titled “Annual Summaries for CY08” follows the monthly mean data section. This section provides a statistical summary of annual flow rates and discharge for the labeled CY. The applicable units are to the left of the table value. The term “PARTIAL DATA” denotes a year with incomplete data.

Identifying Estimated Daily Discharge

Estimated daily discharges published in water-discharge tables and figures of this annual report are identified by *italicizing* individual daily values or through color coding in hydrographs. For periods of no data, a gap is shown on the hydrographs.

Other Records Available

Information used in the preparation of the records in this report, such as discharge-measurement notes, gage-height records, and rating tables, are on file. Information on the availability of the unpublished information or on the published statistical analyses is available from personnel involved with data collection at the Site.

3.1.3.3 Surface-Water Discharge Data Summaries

Site-Wide Discharge Summary

Discharge summaries for the two major Site drainages receiving flow from the COU (Walnut and Woman Creeks) are given on Figure 3–34 and Figure 3–35.¹⁵ Walnut Creek flows are measured at GS03 and Woman Creek flows are measured at GS01. Figure 3–36 shows the relative total CY 1997–2008 discharge volumes from the major Site drainages as measured at Site POEs and POCs. Through CY 2004, Walnut Creek discharged larger volumes than Woman Creek due to the contribution of imported water and runoff from impervious surfaces. After final

¹⁵ The pre-closure period is for the dates 1/1/97–10/1/05; the post-closure period is for the dates 10/1/05–12/31/08.

closure in CY 2005, the reduction of discharge in Walnut Creek and the corresponding change in relative volumes is clearly observed.

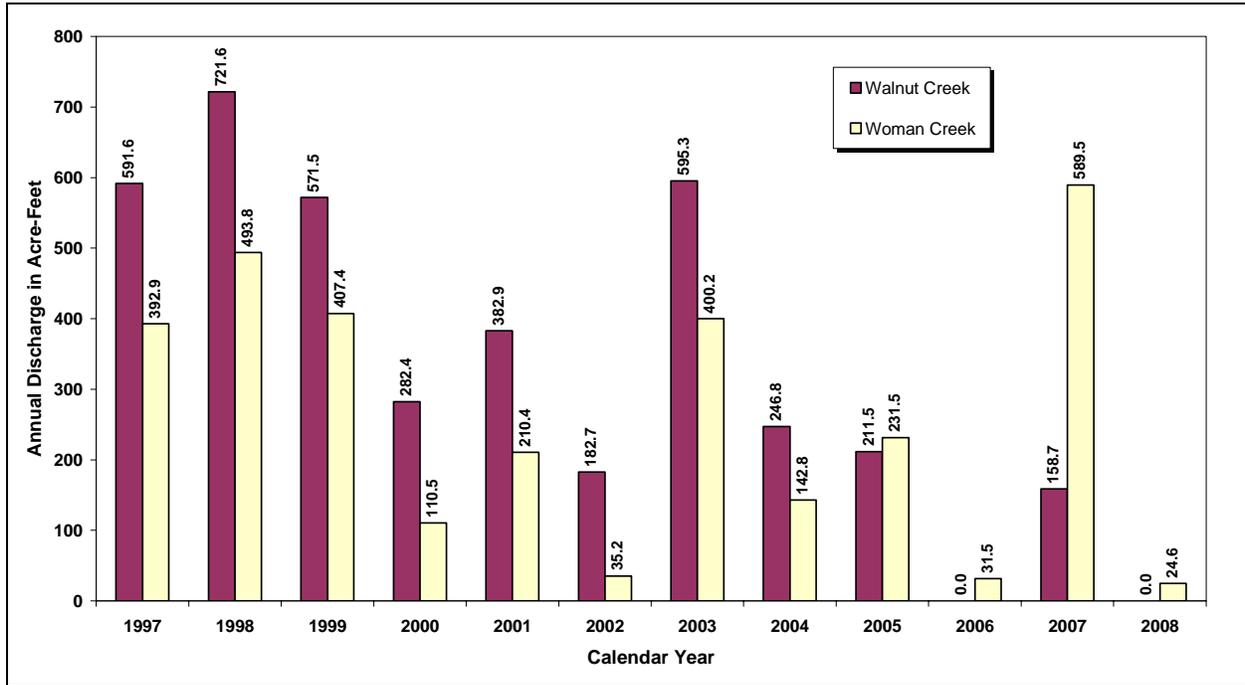


Figure 3–34. Annual Discharge Summary from Major Site Drainages: CY 1997–2008

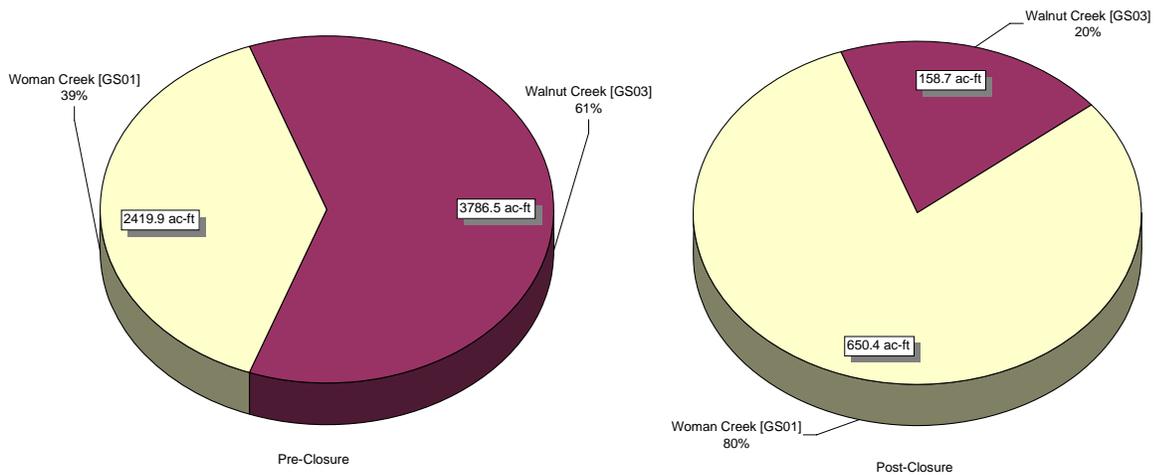


Figure 3–35. Relative Total Discharge Summary from Major Site Drainages: Pre- and Post-Closure Periods

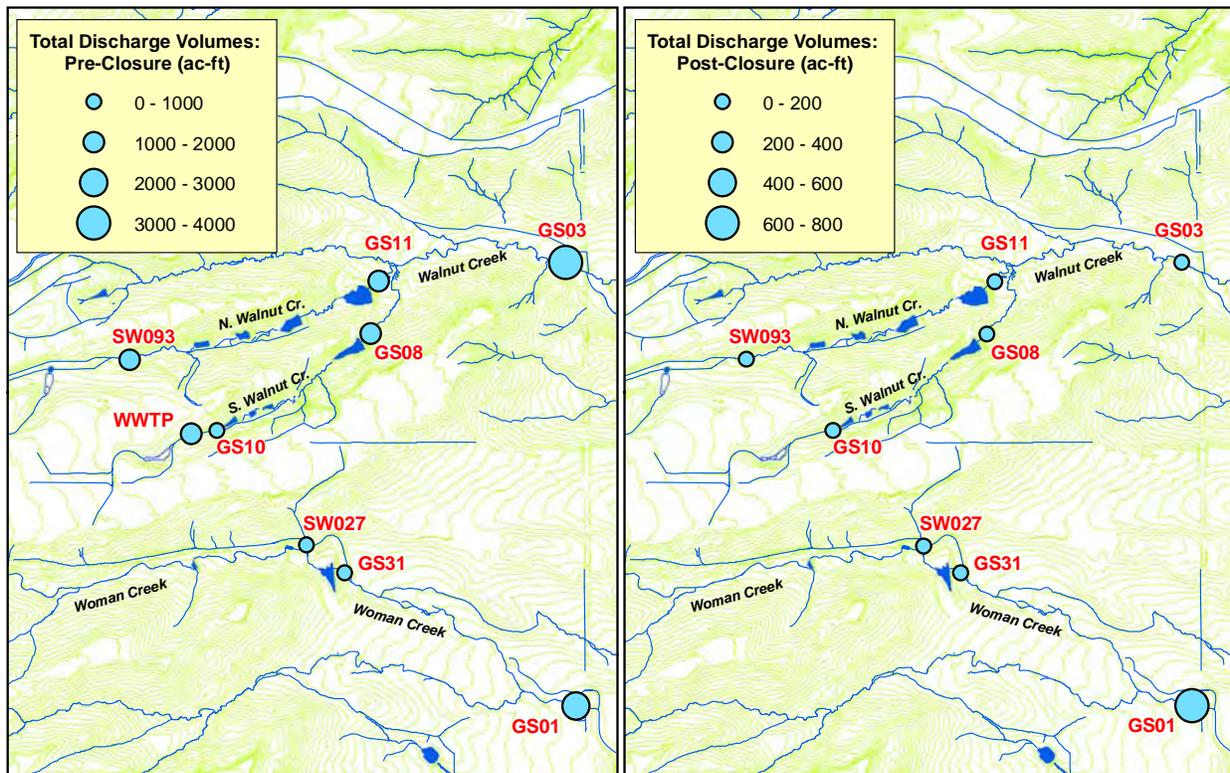


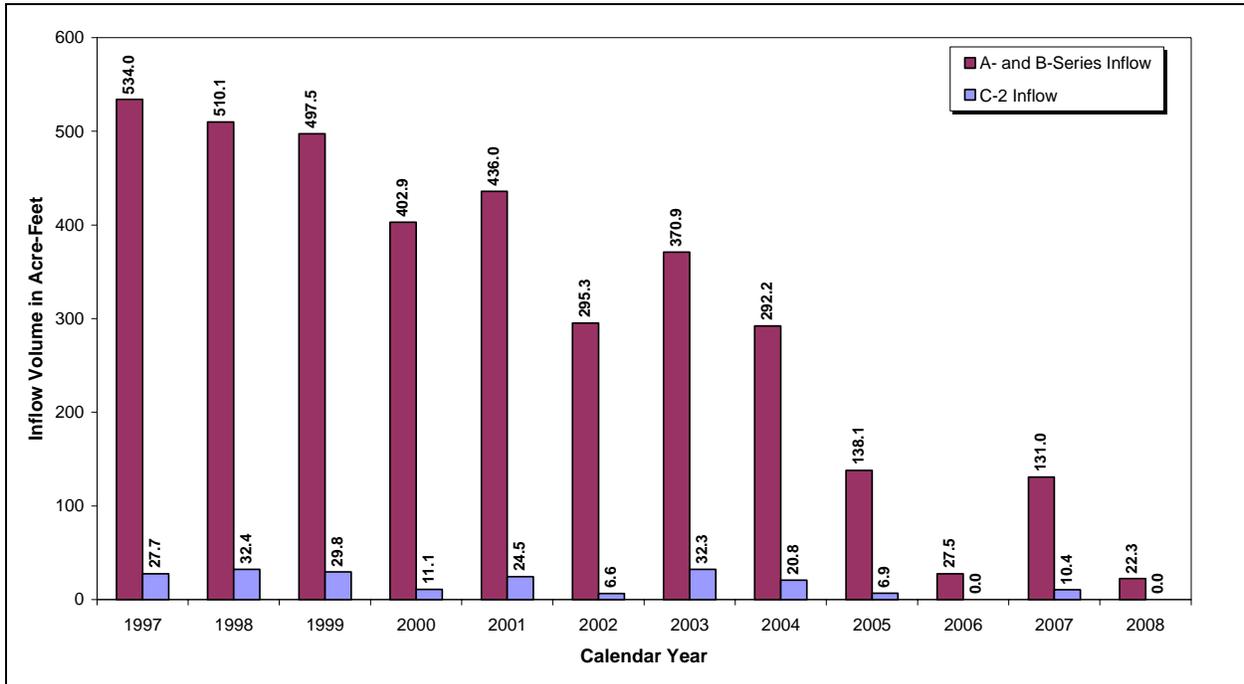
Figure 3–36. Map Showing Relative CY 1997–2008 Discharge Volumes for POEs and POCs: Pre- and Post-Closure Periods

Pond Discharge Summary

Figure 3–37 and Figure 3–38 show the annual ponds inflows and outflows, respectively. Due to the intermittent pump transfers of Pond B-5 water to Pond A-4, the volumes for the A- and B-Series Ponds are combined. The reduction in pond water volumes as the Site progressed toward closure is clearly observed. Figure 3–39 and Figure 3–40 show the relative total CY 1997–2008 discharge volumes from the ponds (as measured at GS08, GS11, and GS31) and from the major drainages tributary to the ponds (as measured at GS10, SW027, SW091, SW093, and the former Waste Water Treatment Plant [WWTP] [995POE]).^{16, 17} Pond inflows do not necessarily equal outflows for any given year due to the storage of water in the ponds across water years, evaporative/seepage losses/gains, and local runoff to the ponds.

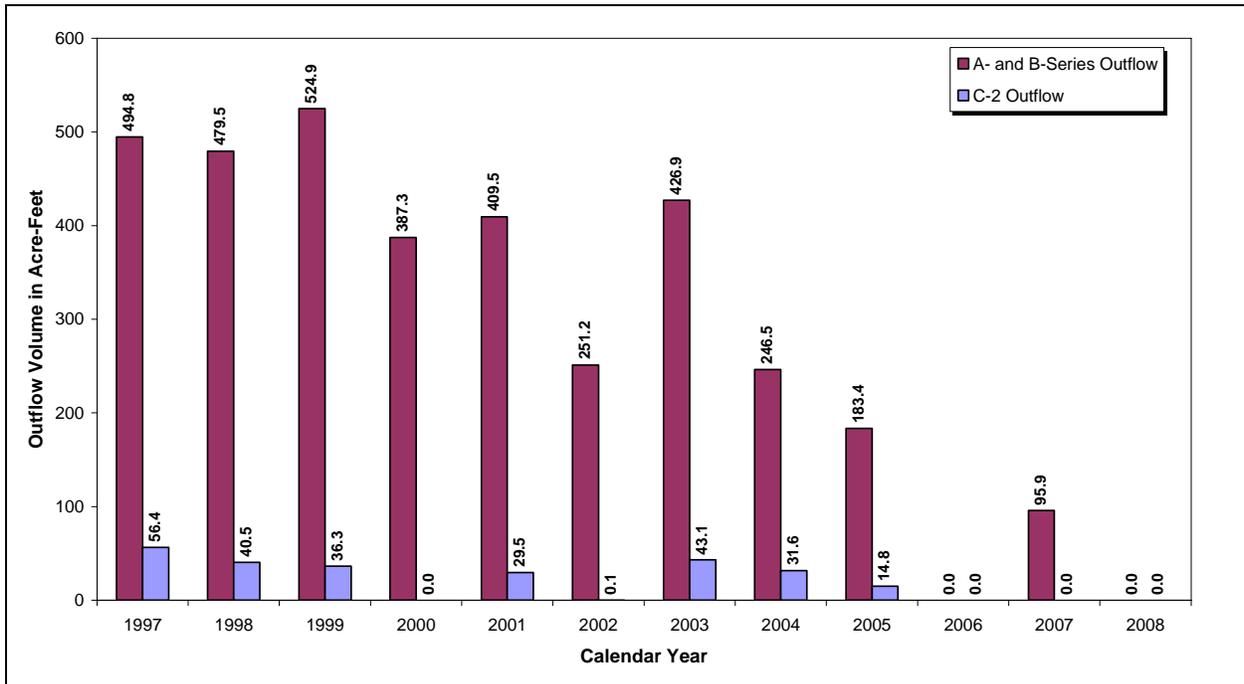
¹⁶ The WWTP was removed from service on November 4, 2004.

¹⁷ The pre-closure period is for the dates 1/1/97–10/1/05; the post-closure period is for the dates 10/1/05–12/31/08.



Notes: A- and B-Series Inflow is the sum of GS10, the former WWTP, and SW093. The C-2 Inflow is the volume measured at SW027.

Figure 3–37. Pond Inflows: CY 1997–2008



Notes: A- and B-Series Outflow is the sum of GS11 and GS08. The C-2 Outflow is the volume measured at GS31.

Figure 3–38. Pond Outflows: CY 1997–2008

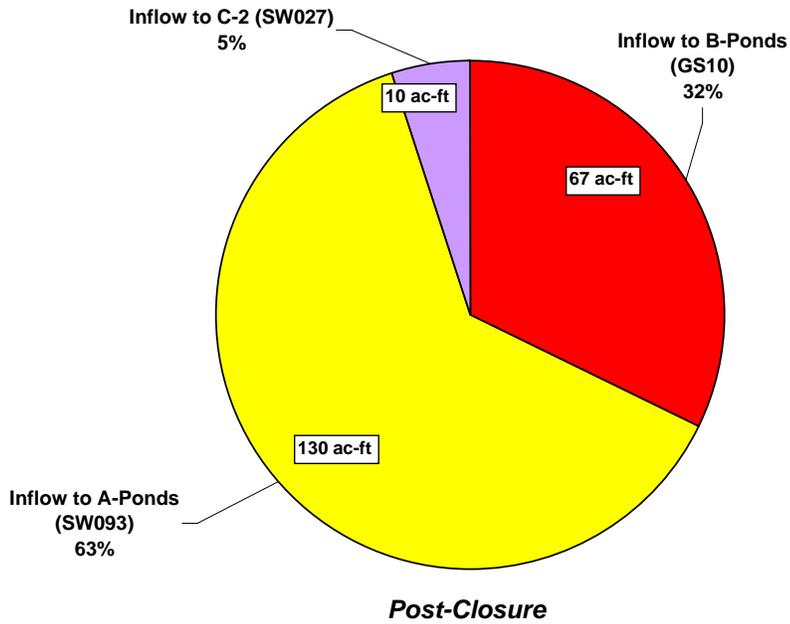
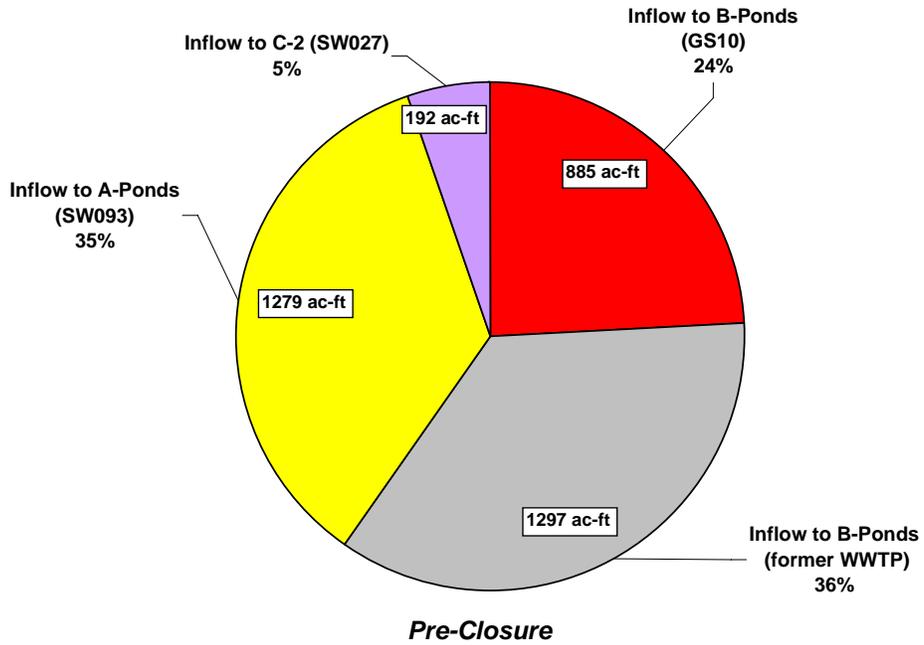


Figure 3–39. Relative Total Inflow Volumes for Site Ponds: Pre- and Post-Closure Periods

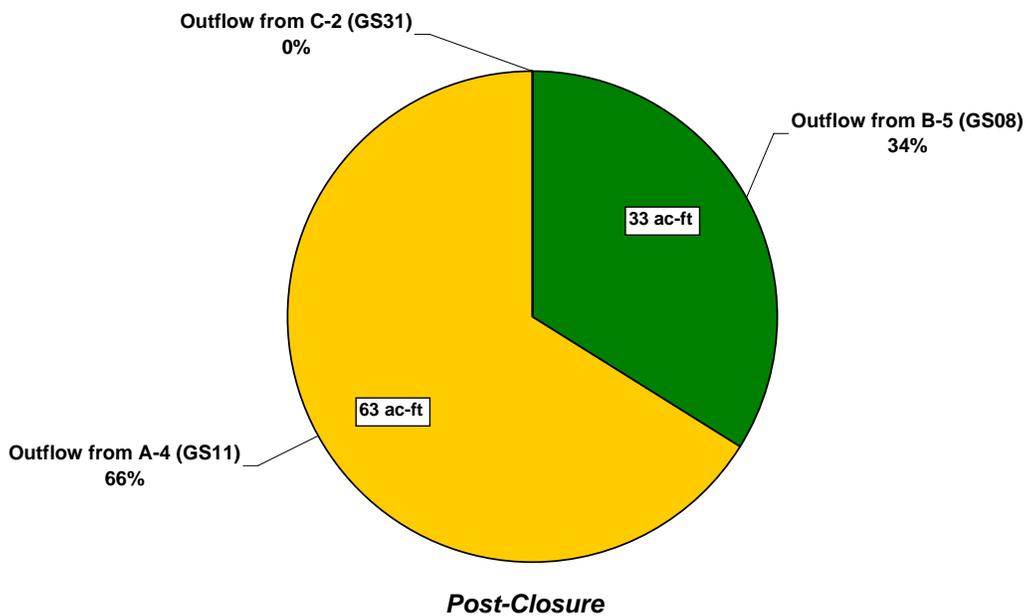
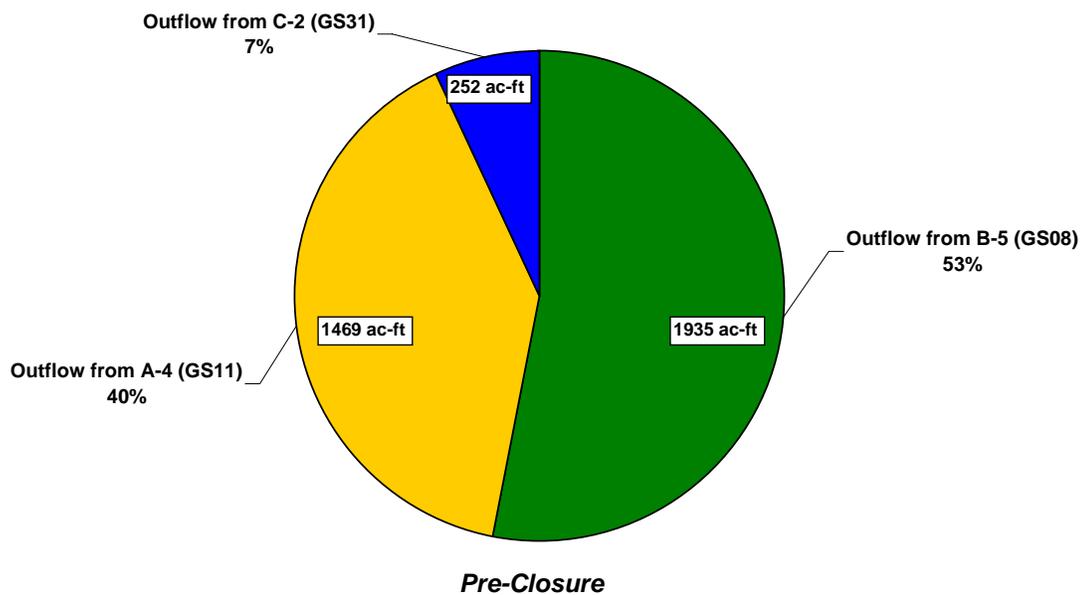


Figure 3–40. Relative Total Outflow Volumes for Site Ponds: Pre- and Post-Closure Periods

GS01: Woman Creek at Indiana Street

Location—Woman Creek 200 feet upstream of Indiana Street; State Plane: E2093824, N744889.

Drainage Area—The basin includes the Woman Creek drainage and southern portions of the COU; areas west of Highway 93 also contribute runoff (total drainage acreage undetermined).

Period of Record—September 16, 1991, to current year.

Gage—Water-stage recorder and 18-inch Parshall flume (flume is located just east of Indiana Street, sampling conducted on Site property); prior to March 24, 1998, flow measurement was at the on-Site sampling location using a 9-inch Parshall flume.

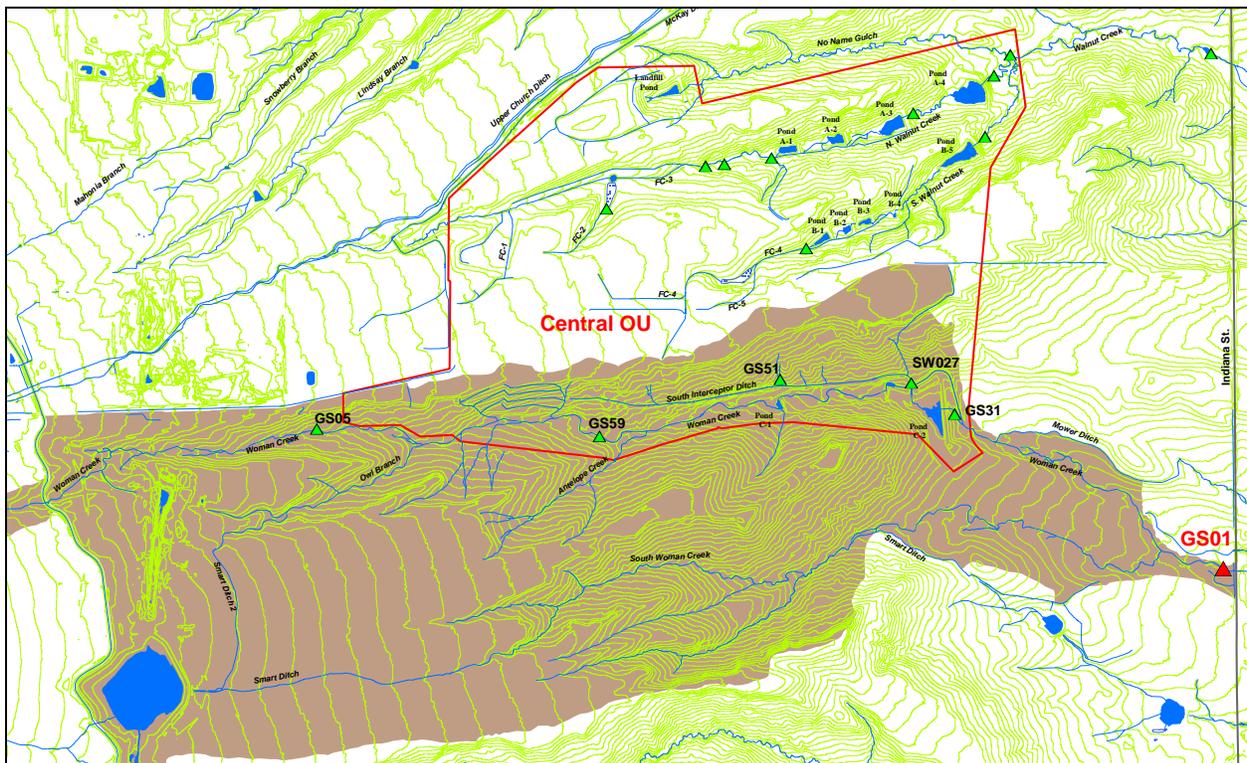


Figure 3–41. GS01 Drainage Area

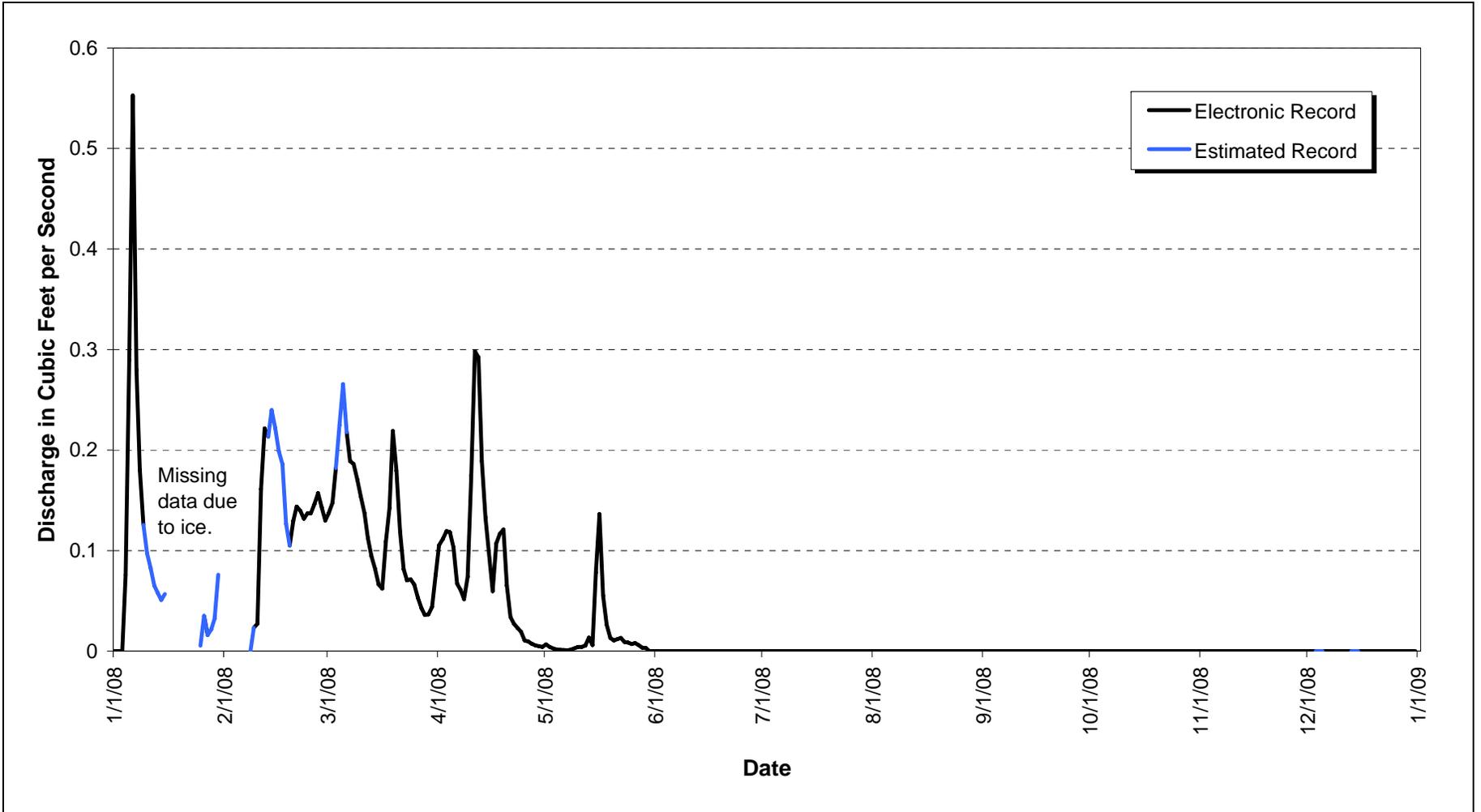


Figure 3-42. CY 2008 Mean Daily Hydrograph at GS01: Woman Creek at Indiana Street

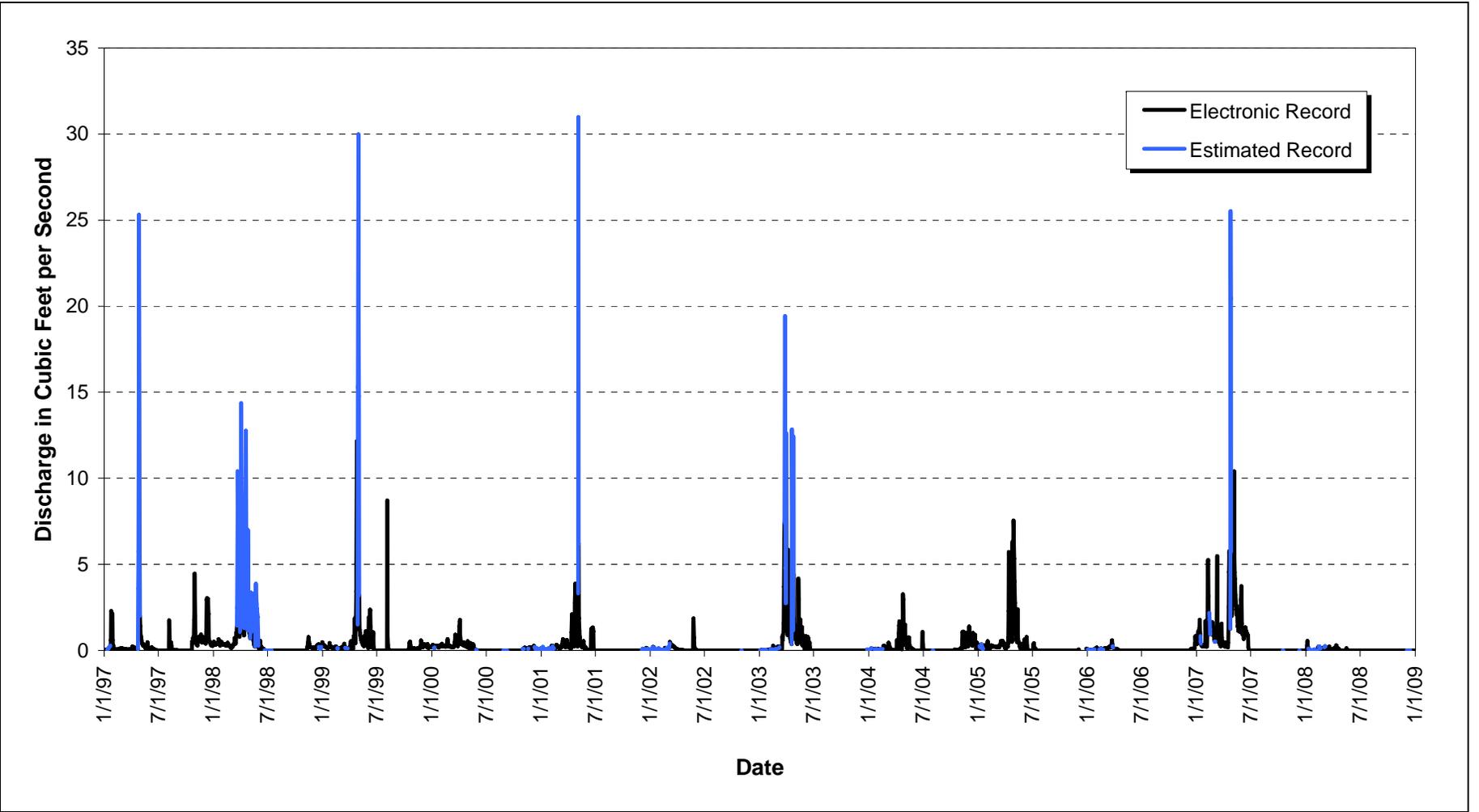


Figure 3-43. CY 1997-2008 Mean Daily Hydrograph at GS01: Woman Creek at Indiana Street

GS03: Walnut Creek at Indiana Street

Location—Walnut Creek at Flume Pond outlet upstream of Indiana Street; State Plane: E2093618, N753646.

Drainage Area—The basin includes the Walnut Creek drainage and the majority of the COU; areas west of Highway 93 also contribute runoff (total drainage acreage undetermined).

Period of Record—September 2, 1991, to current year.

Gage—Water-stage recorder and parallel 6-inch and 36-inch Parshall flumes prior to November 5, 2002. Rated stream section during flume construction (GS03T; November 5, 2002–February 12, 2003). Three-foot HL flume starting February 12, 2003.

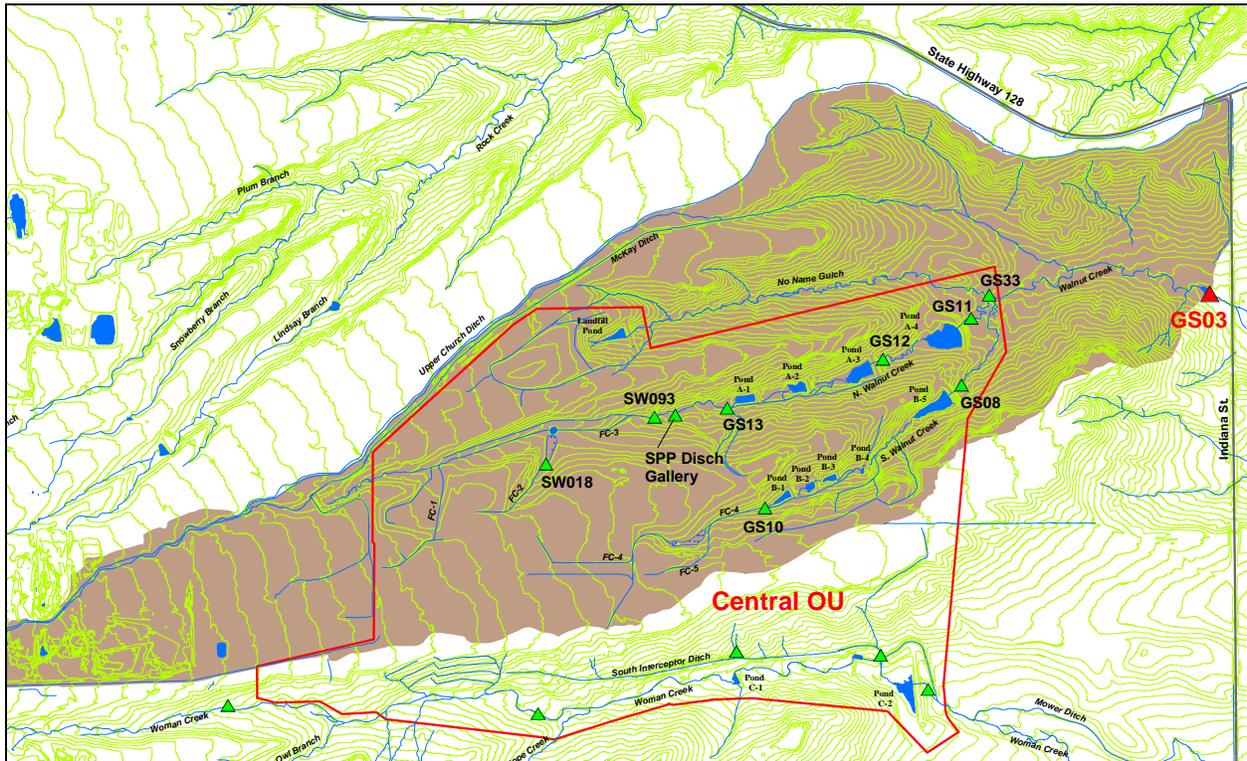


Figure 3–44. GS03 Drainage Area

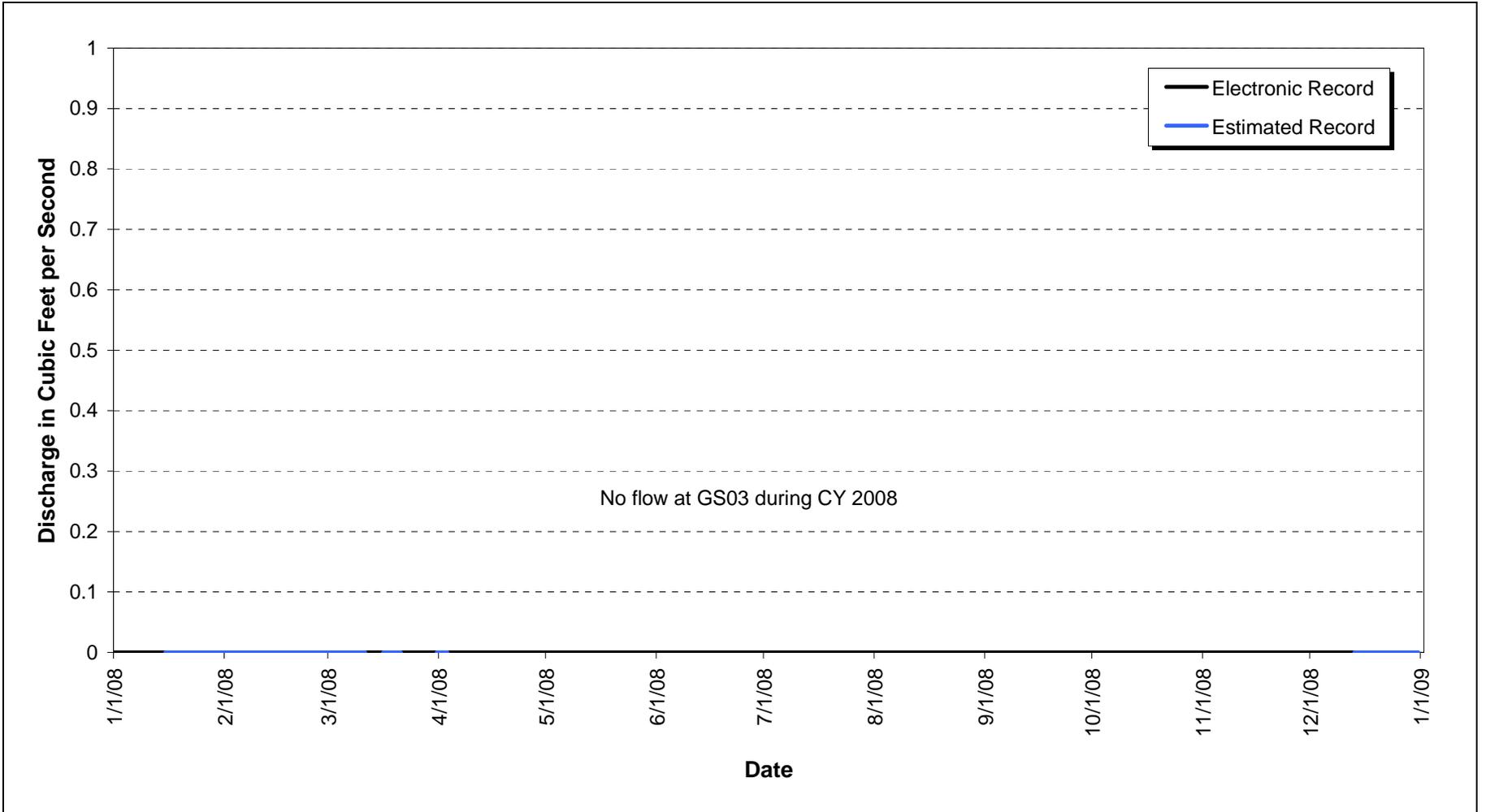


Figure 3-45. CY 2008 Mean Daily Hydrograph at GS03: Walnut Creek at Indiana Street

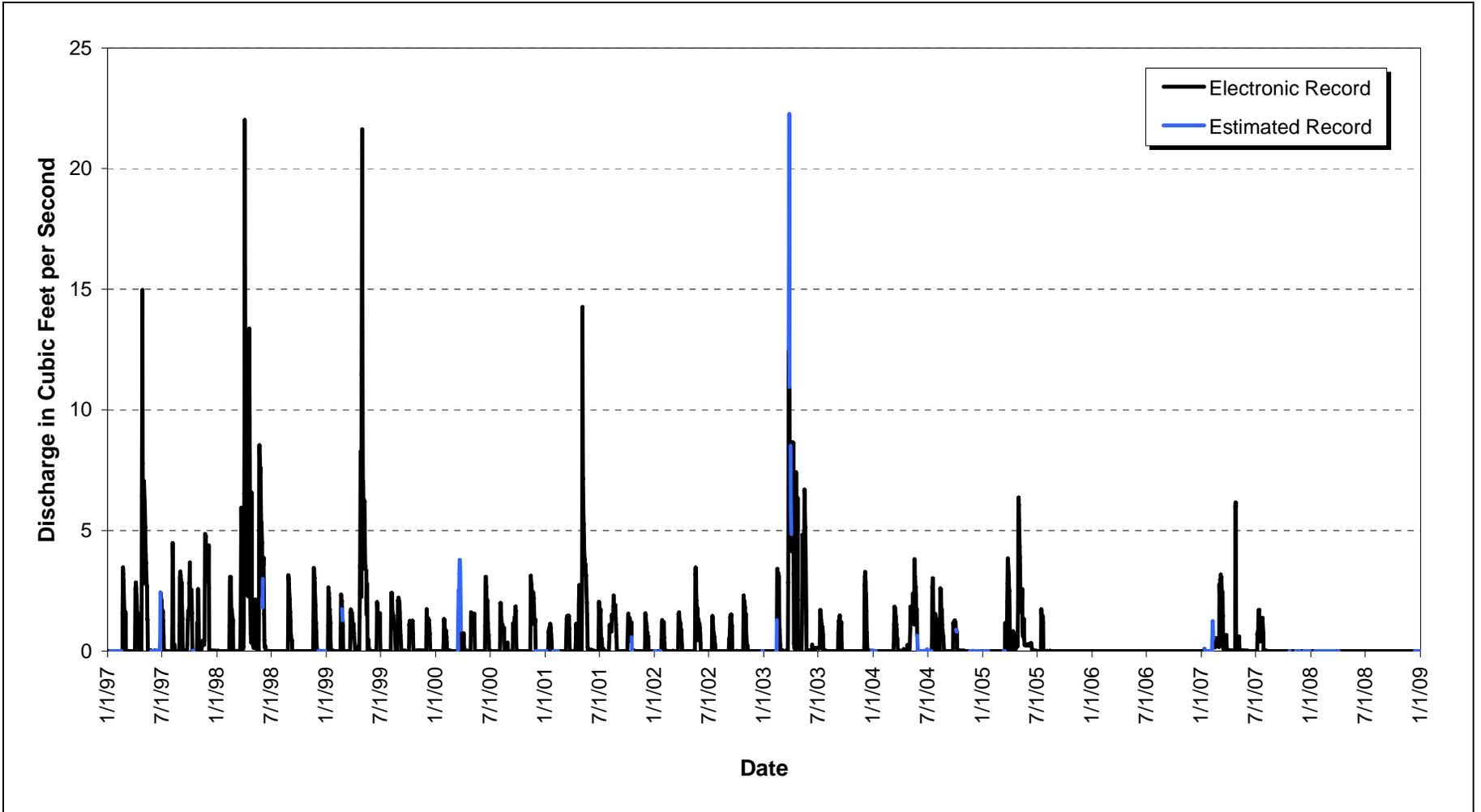


Figure 3-46. CY 1997-2008 Mean Daily Hydrograph at GS03: Walnut Creek at Indiana Street

GS05: North Woman Creek at West Fenceline

Location—Woman Creek east of western Site boundary; State Plane: E2078429, N747264.

Drainage Area—The basin includes a portion of the Woman Creek drainage; areas west of Highway 93 also contribute runoff (total drainage acreage undetermined).

Period of Record—September 23, 1991, to current year.

Gage—Water-stage recorder and 9-inch Parshall flume with weir insert.

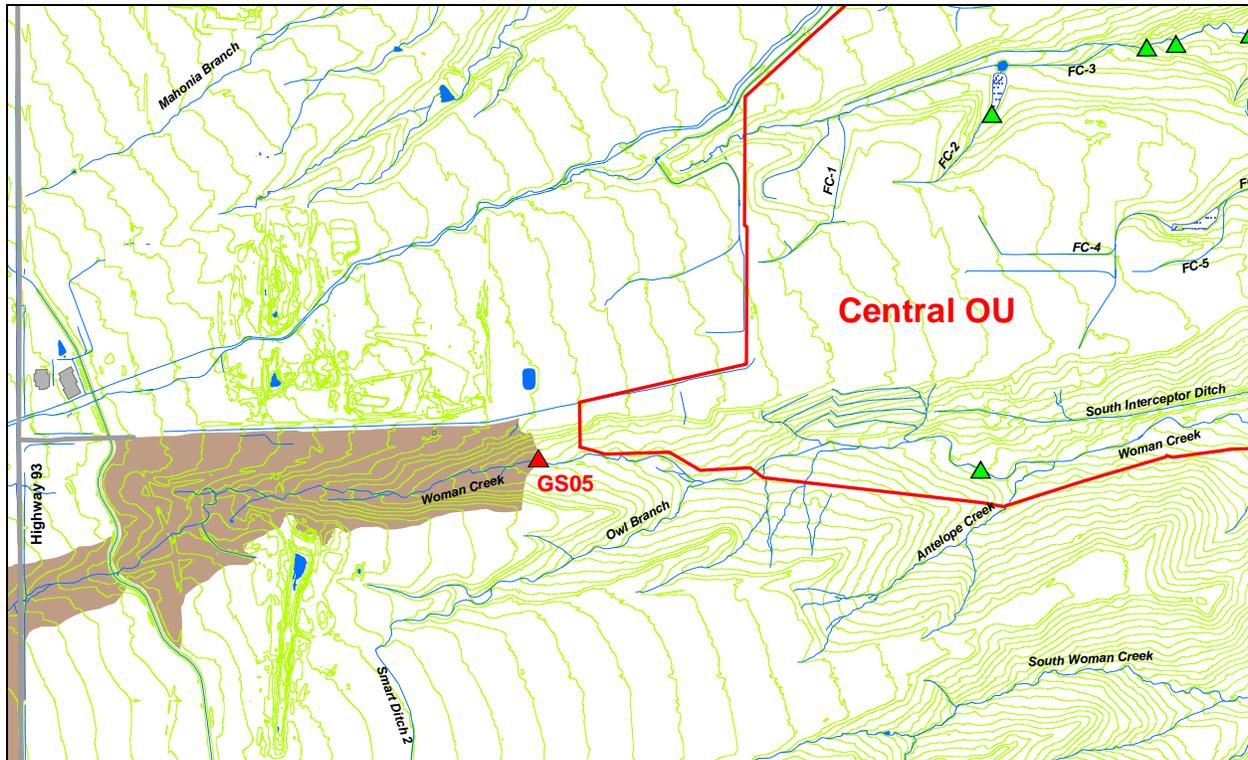


Figure 3–47. GS05 Drainage Area

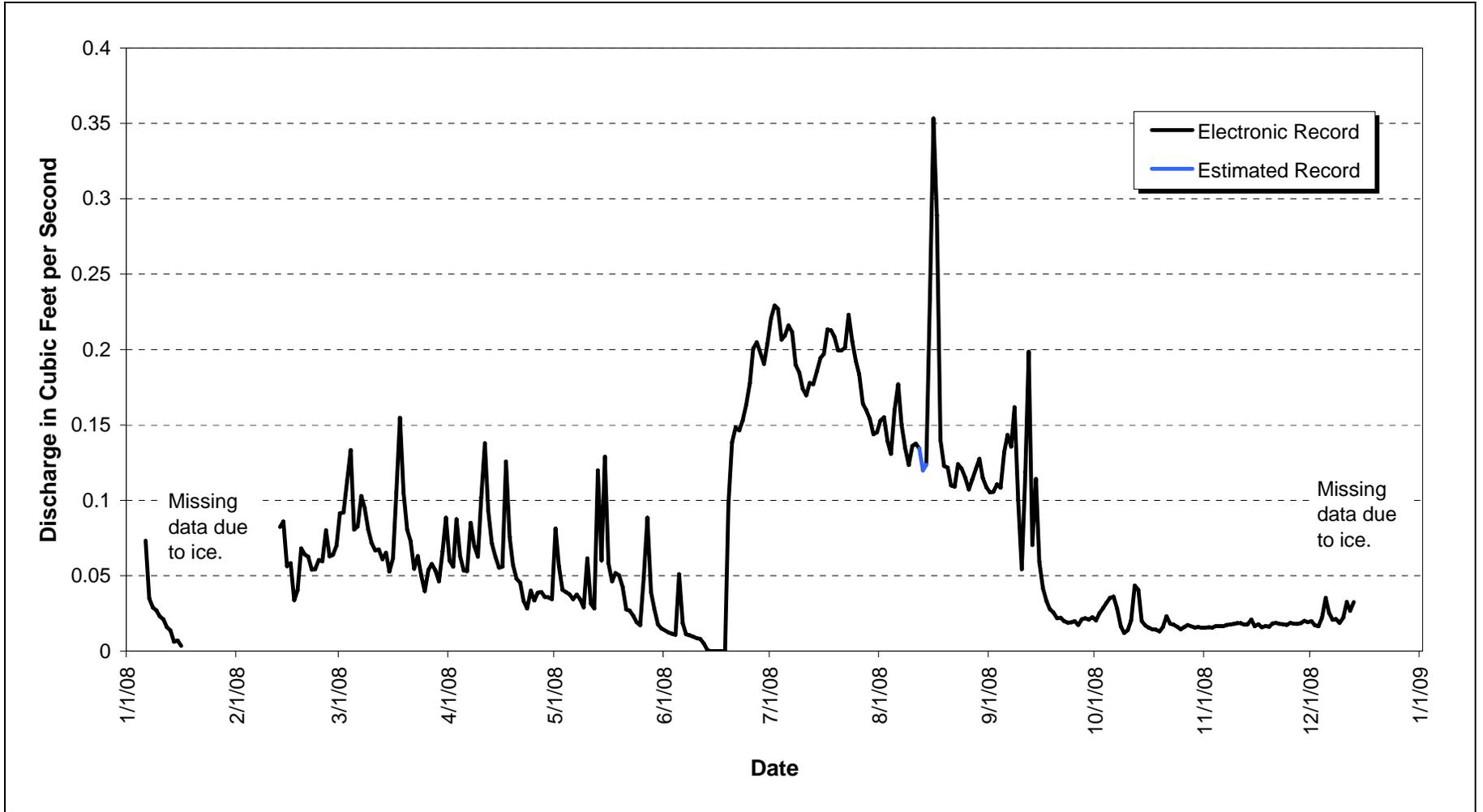


Figure 3-48. CY 2008 Mean Daily Hydrograph at GS05: North Woman Creek at West Fenceline

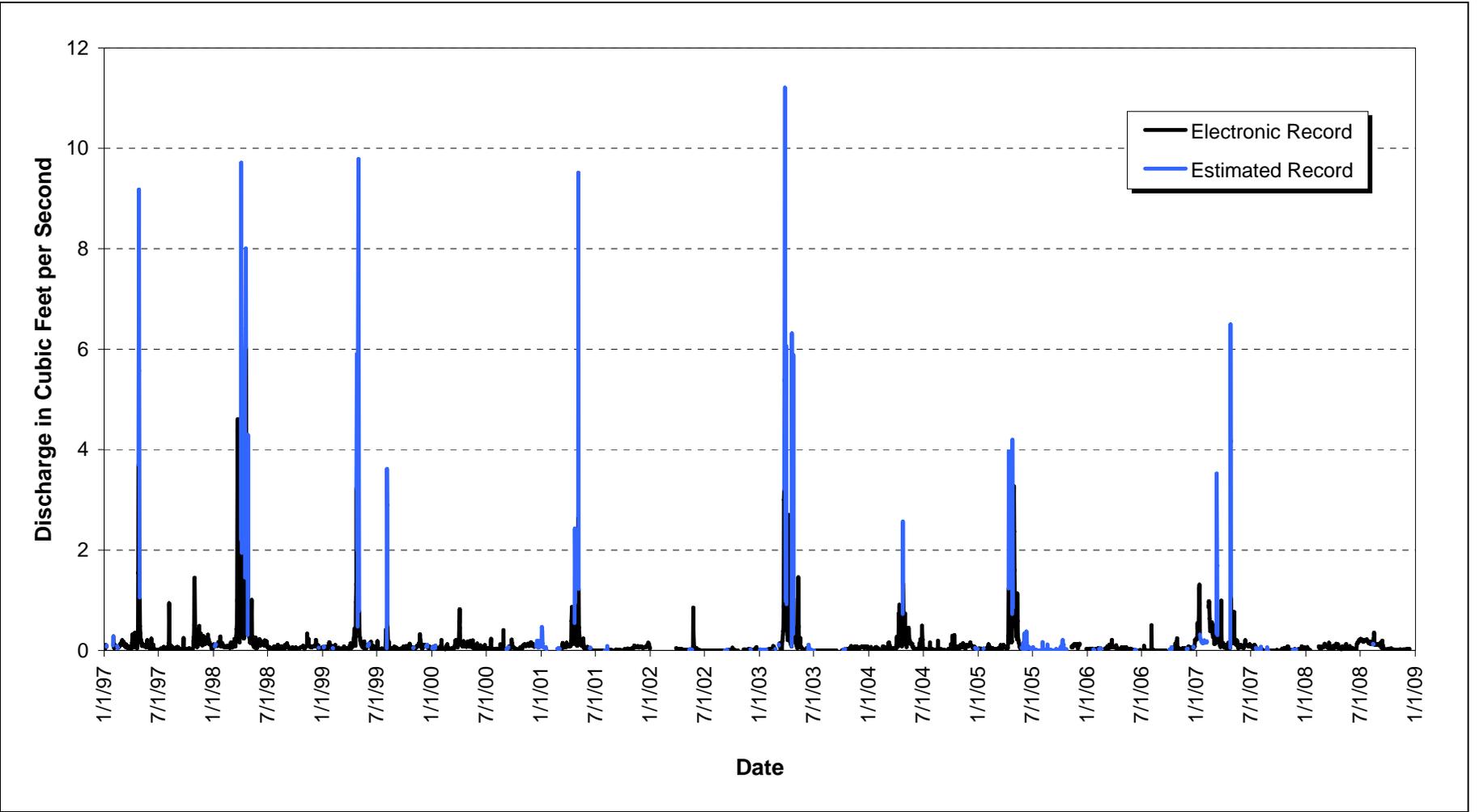


Figure 3-49. CY 1997-2008 Mean Daily Hydrograph at GS05: North Woman Creek at West Fenceline

GS08: South Walnut Creek at Pond B-5 Outlet

Location—South Walnut Creek at Pond B-5 outlet; State Plane: E2089778, N752231.

Drainage Area—The basin includes the South Walnut Creek drainage and central portions of the COU (total of 311.0 acres).

Period of Record—March 23, 1994, to current year.

Gage—Water-stage recorder and 24-inch Parshall flume.

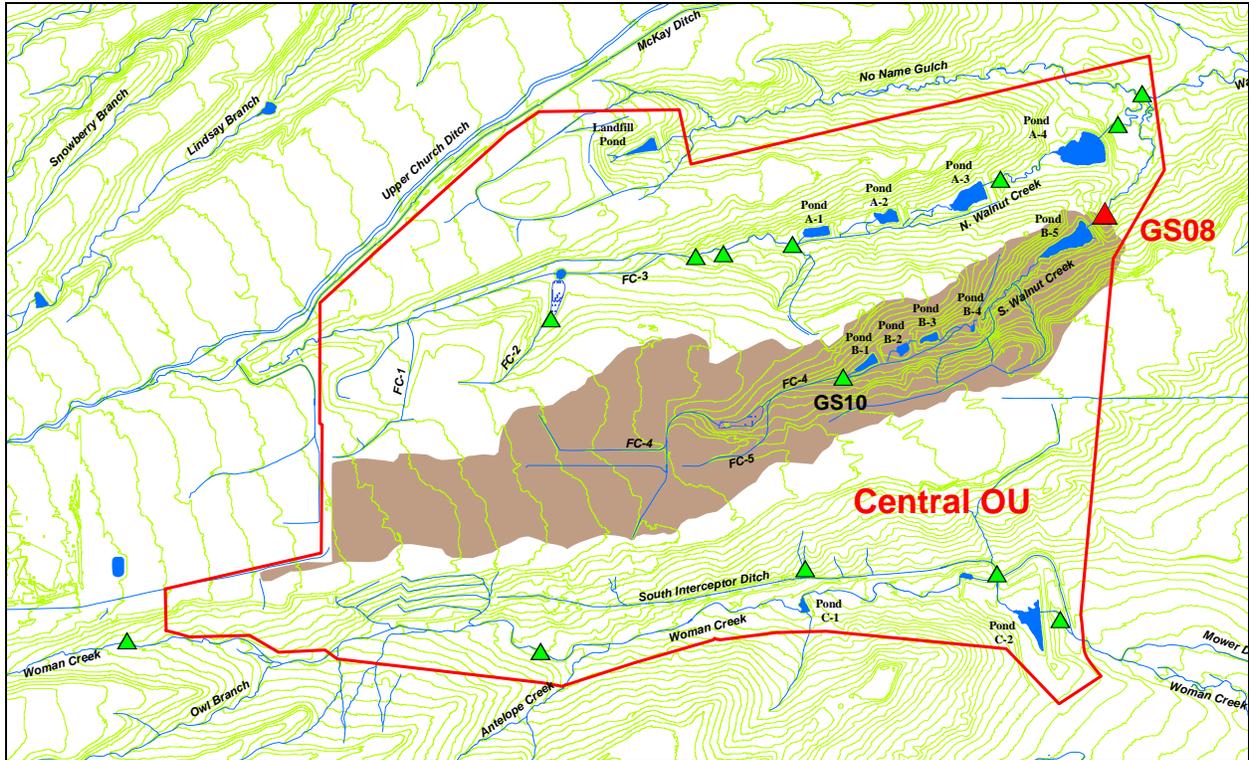


Figure 3–50. GS08 Drainage Area

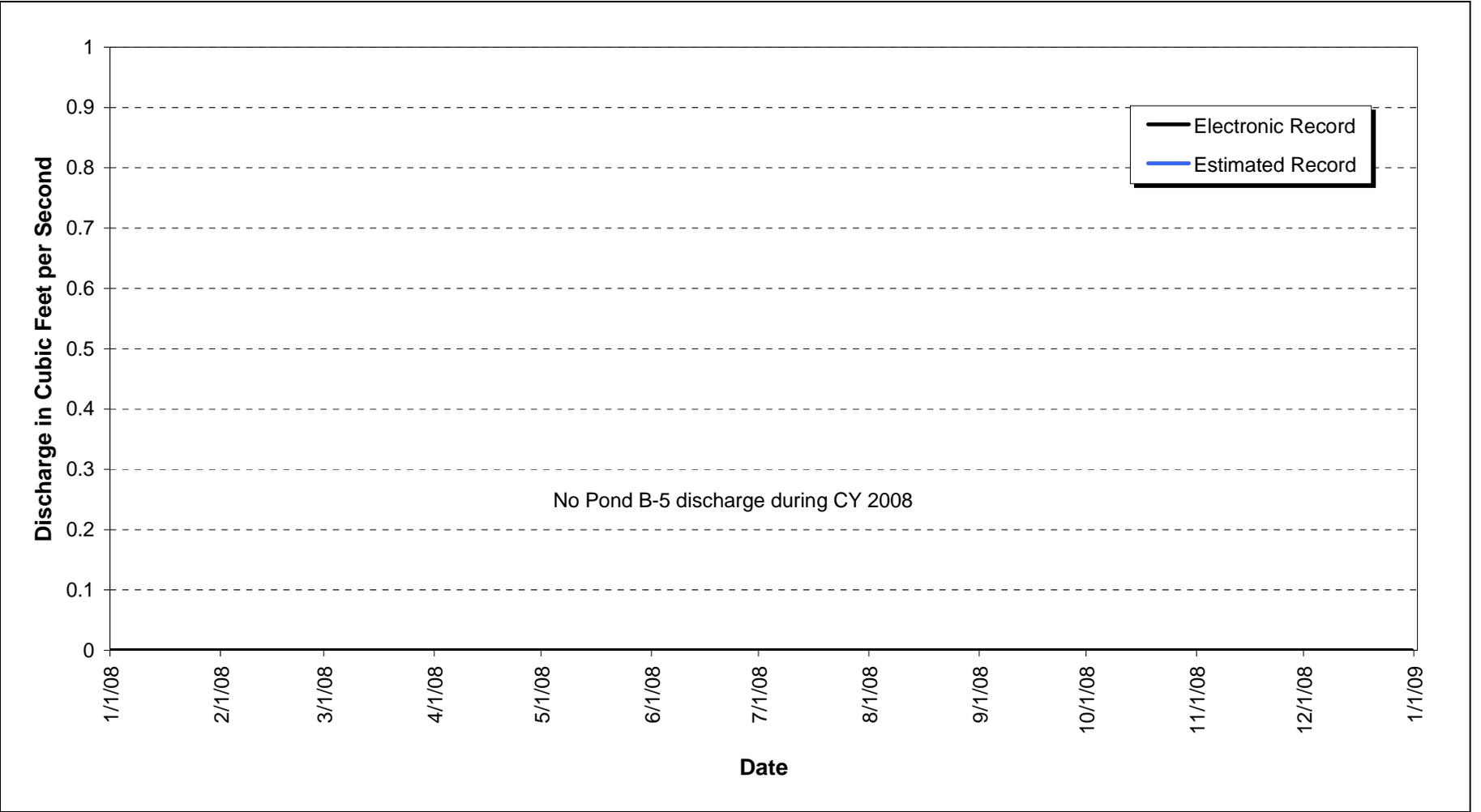


Figure 3-51. CY 2008 Mean Daily Hydrograph at GS08: South Walnut Creek at Pond B-5 Outlet

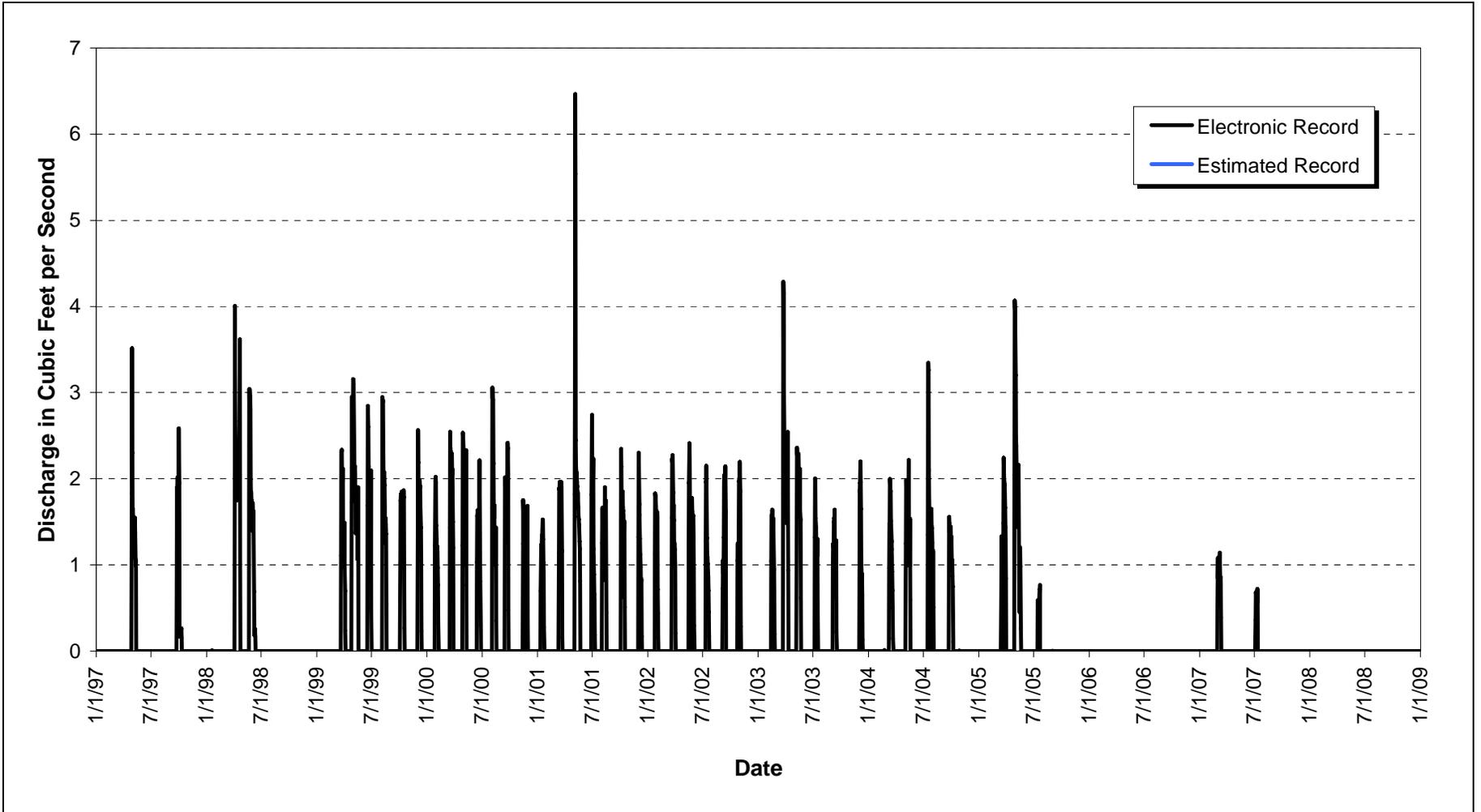


Figure 3-52. CY 1997-2008 Mean Daily Hydrograph at GS08: South Walnut Creek at Pond B-5 Outlet

GS10: South Walnut Creek at Pond B-1 Bypass

Location—South Walnut Creek above Pond B-1 Bypass; State Plane: E2086741, N750329.

Drainage Area—The basin includes the central portion of the COU (total of 206.0 acres).

Period of Record—April 1, 1993, to current year.

Gage—Water-stage recorder and 9-inch Parshall flume with weir insert.

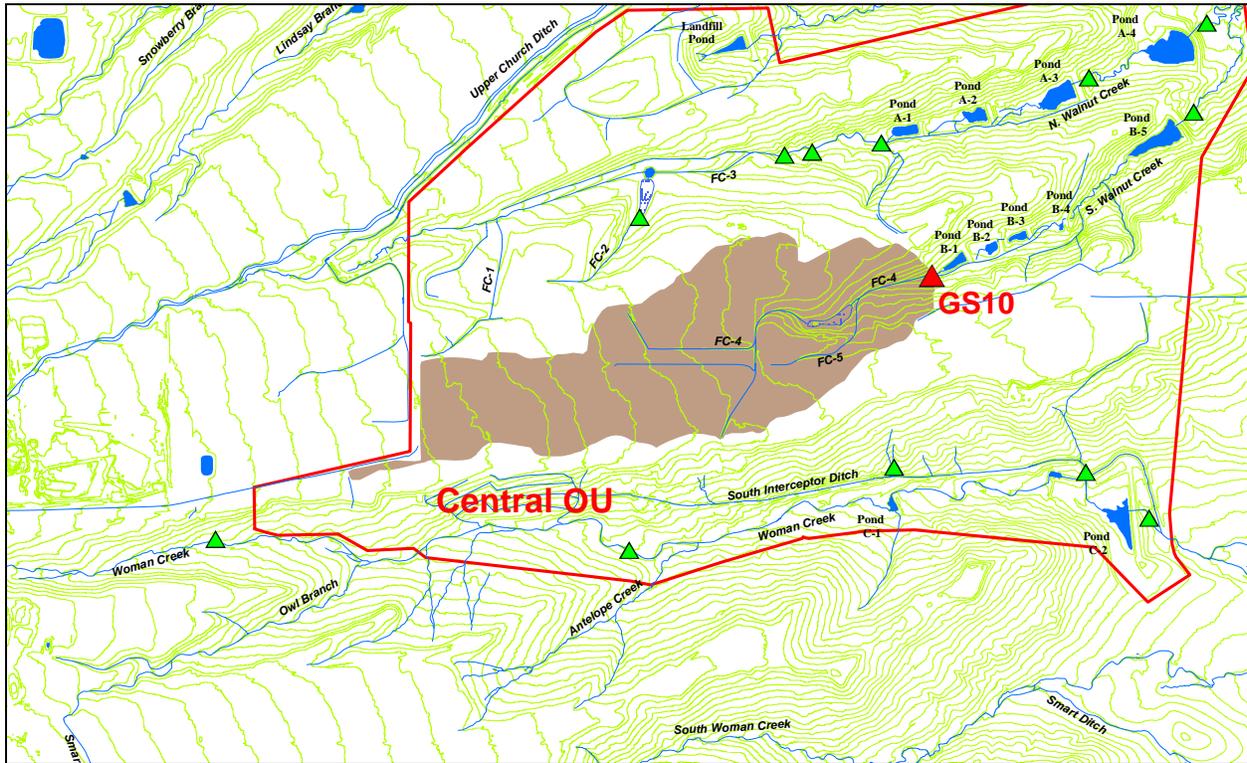


Figure 3–53. GS10 Drainage Area

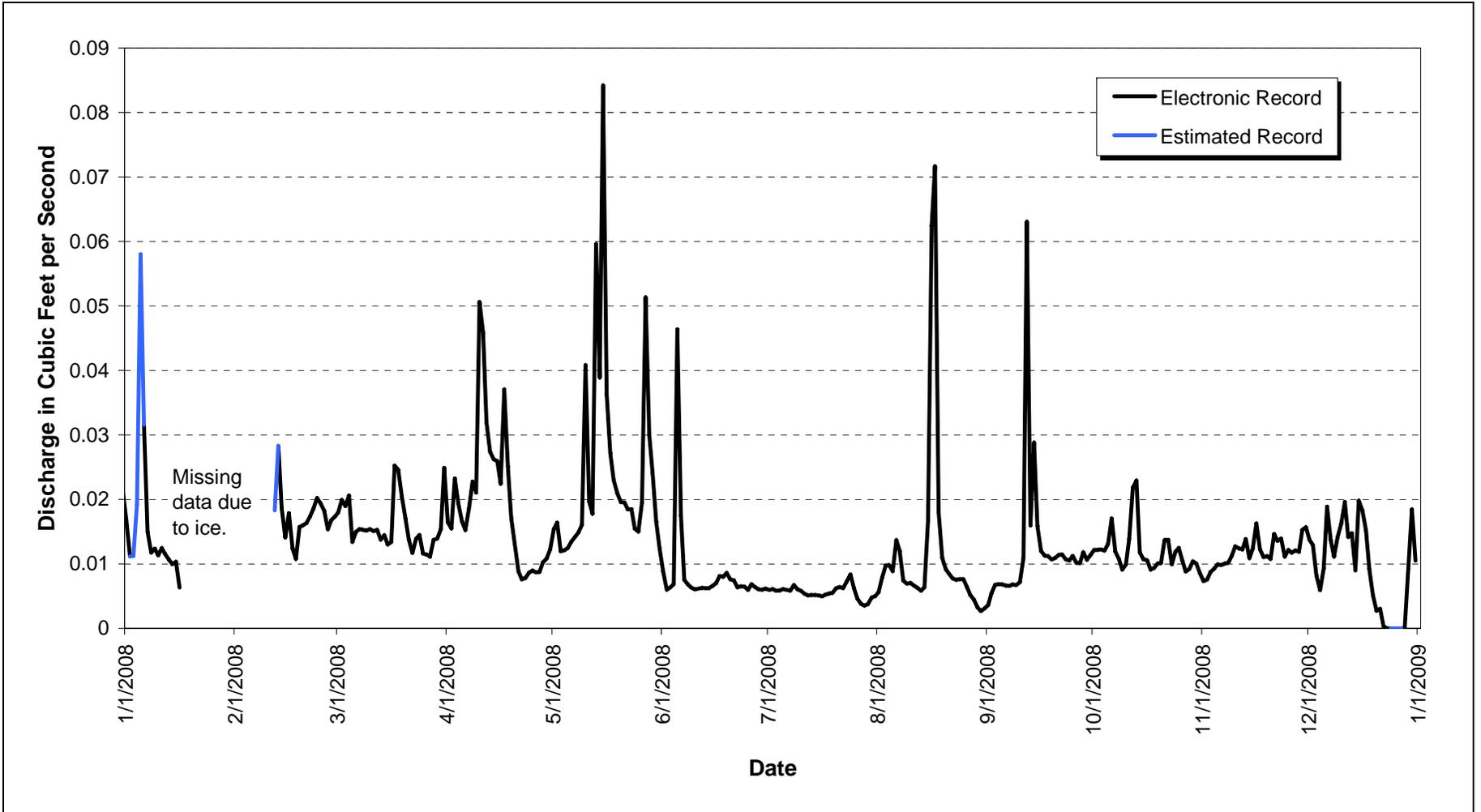


Figure 3-54. CY 2008 Mean Daily Hydrograph at GS10: South Walnut Creek at Pond B-1 Bypass

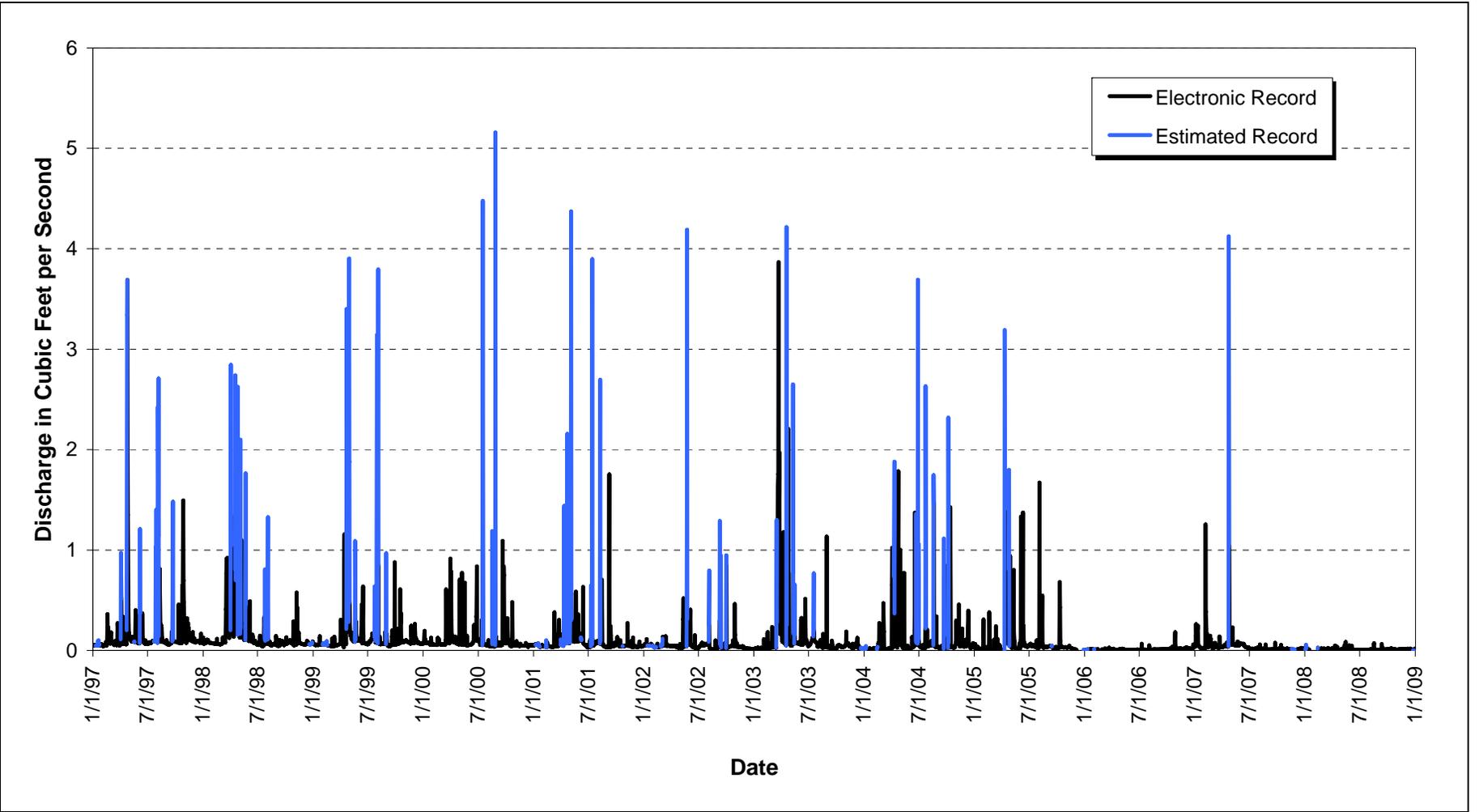


Figure 3-55. CY 1997-2008 Mean Daily Hydrograph at GS10: South Walnut Creek at Pond B-1 Bypass

GS11: North Walnut Creek at Pond A-4 Outlet

Location—North Walnut Creek at Pond A-4 outlet; State Plane: E2089930, N753265.

Drainage Area—The basin includes the North Walnut Creek drainage and northern portions of the COU (total of 395.0 acres).

Period of Record—May 12, 1992, to current year.

Gage—Water-stage recorder and 24-inch Parshall flume.

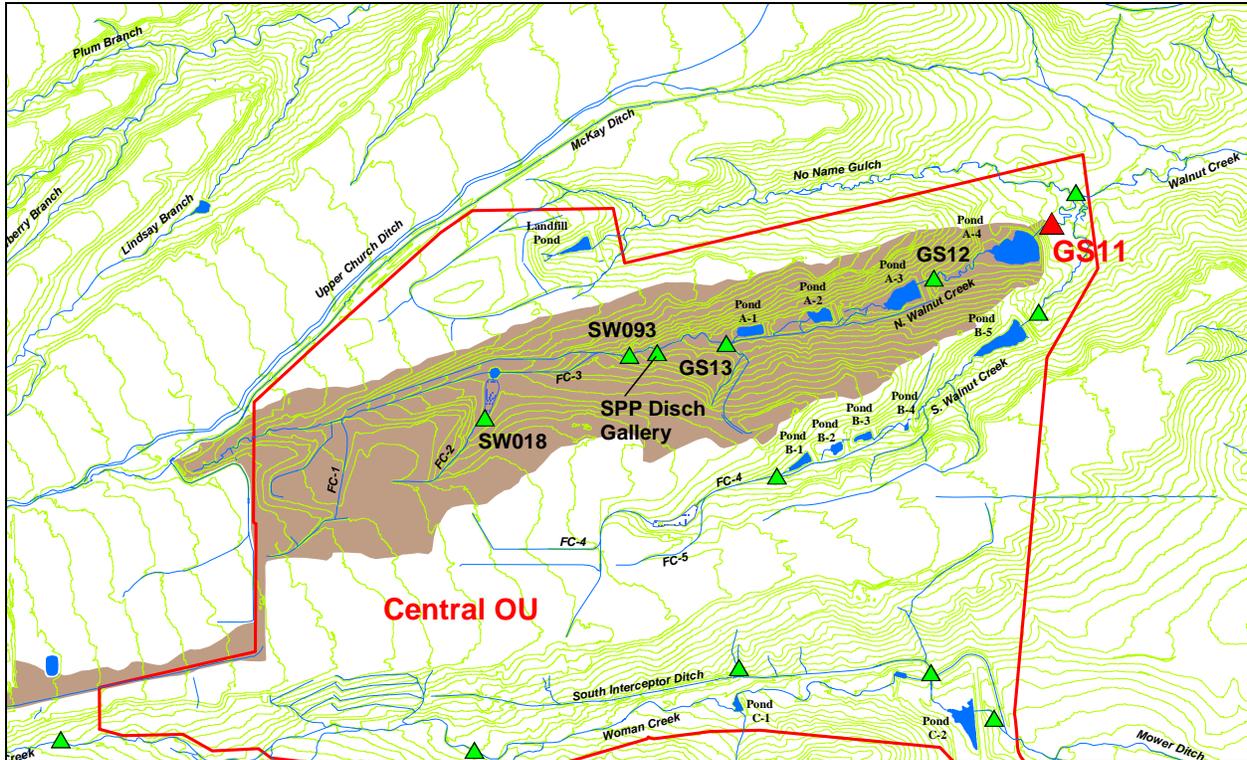


Figure 3–56. GS11 Drainage Area

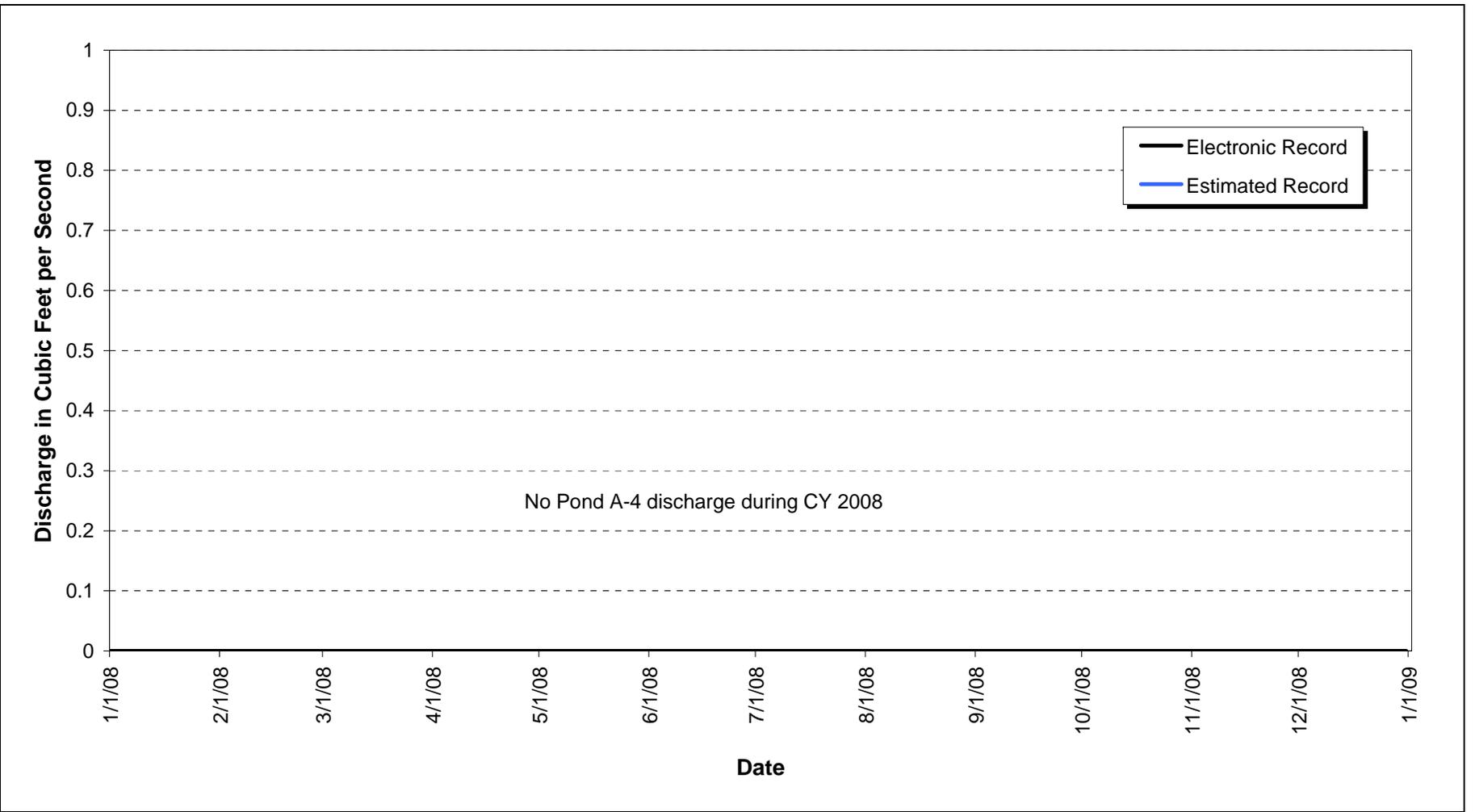


Figure 3-57. CY 2008 Mean Daily Hydrograph at GS11: North Walnut Creek at Pond A-4 Outlet

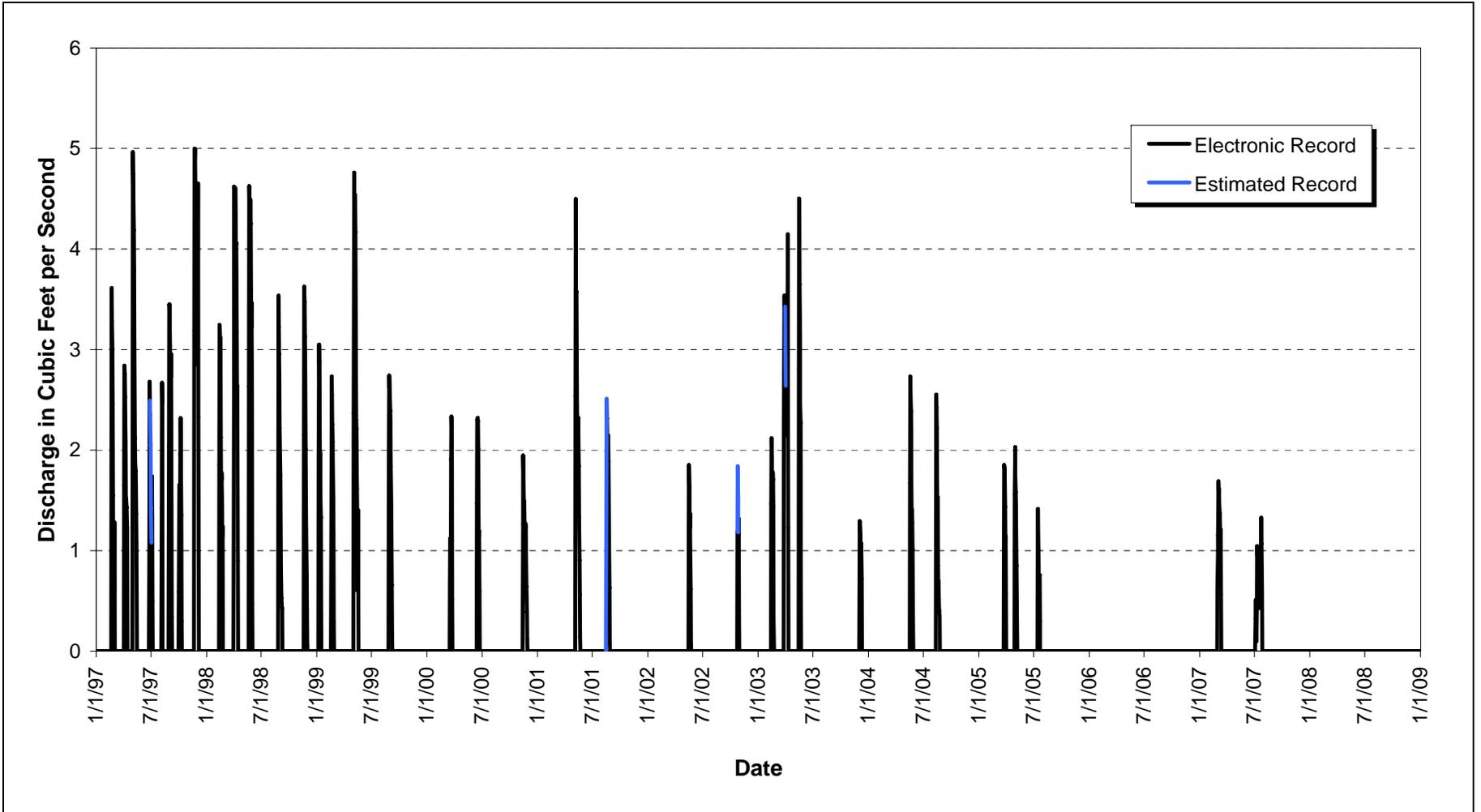


Figure 3-58. CY 1997-2008 Mean Daily Hydrograph at GS11: North Walnut Creek at Pond A-4 Outlet

GS12: North Walnut Creek at Pond A-3 Outlet

Location—North Walnut Creek at Pond A-3 outlet; State Plane: E2088564, N752629.

Drainage Area—The basin includes the North Walnut Creek drainage and northern portions of the COU (total of 361.7 acres).

Period of Record—May 13, 1992, to current year.

Gage—Water-stage recorder and 30-inch Parshall flume.

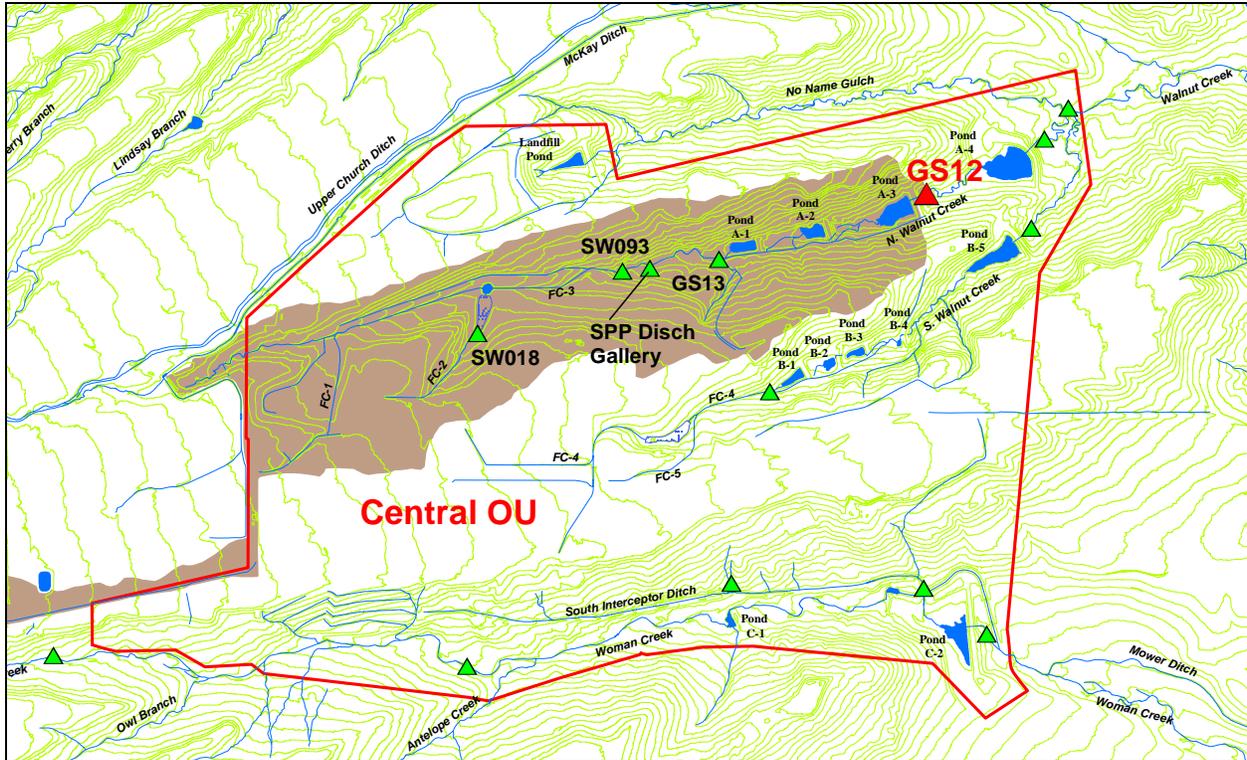


Figure 3–59. GS12 Drainage Area

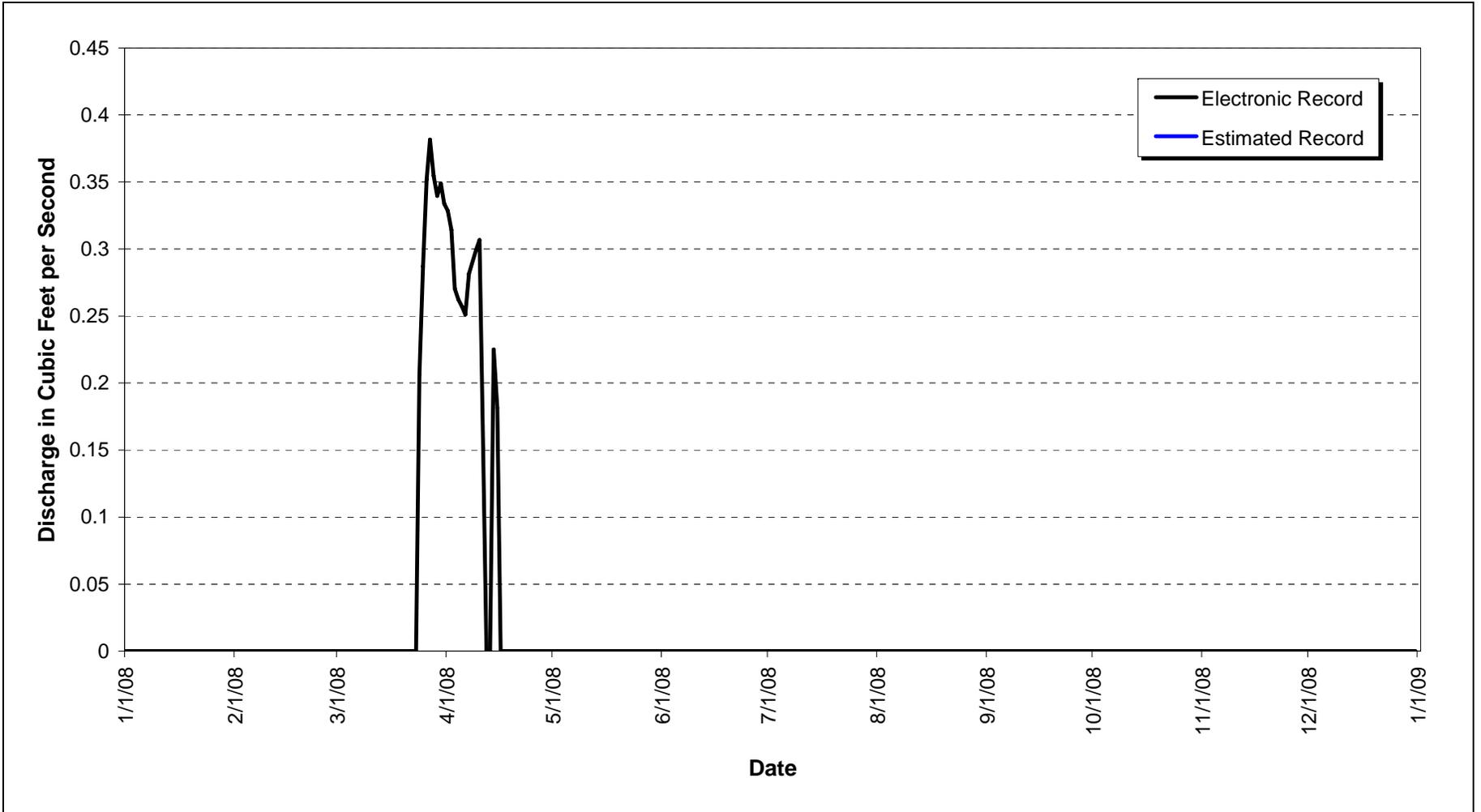


Figure 3-60. CY 2008 Mean Daily Hydrograph at GS12: North Walnut Creek at Pond A-3 Outlet

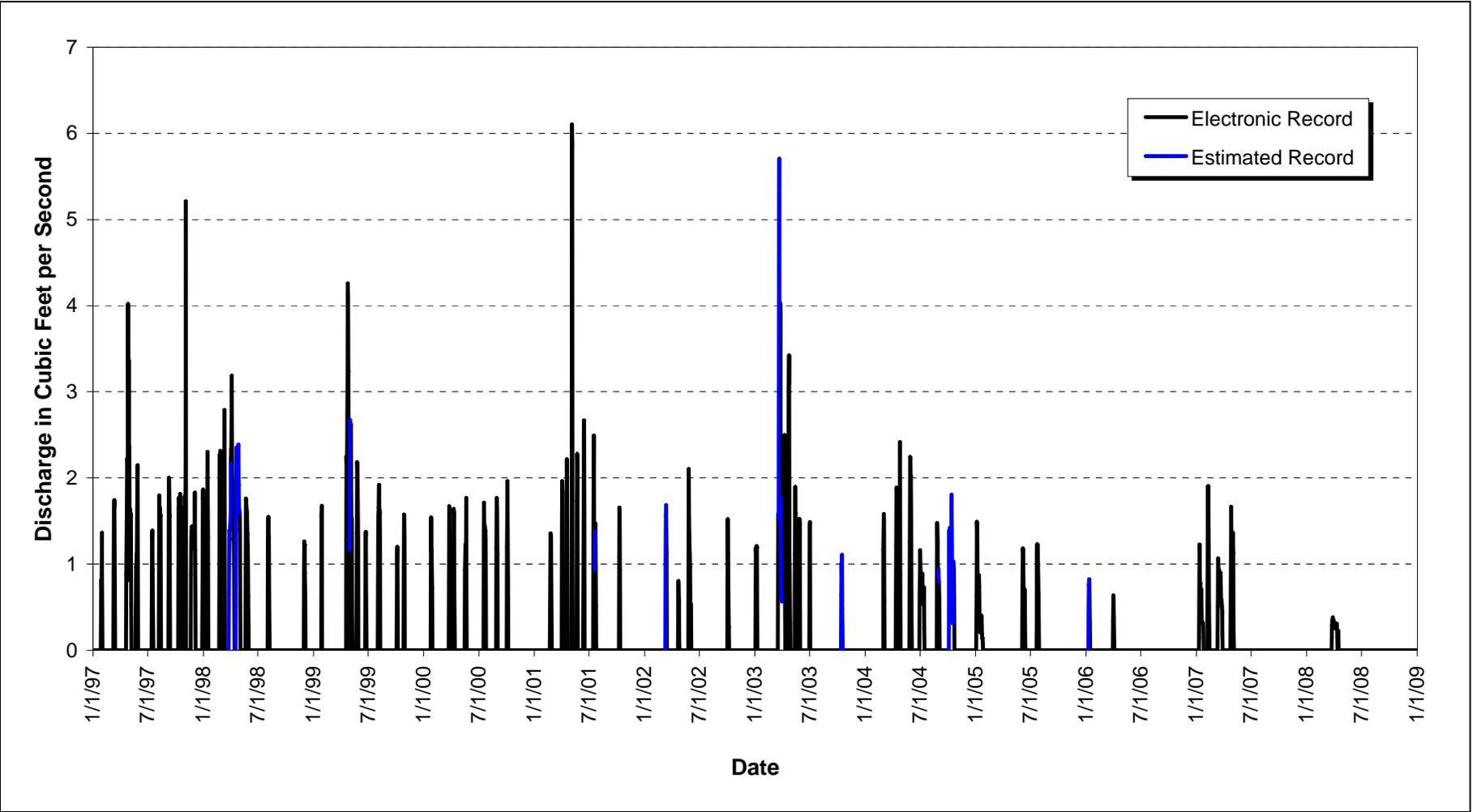


Figure 3-61. CY 1997-2008 Mean Daily Hydrograph at GS12: North Walnut Creek at Pond A-3 Outlet

GS13: North Walnut Creek at Pond A-1 Bypass

Location—North Walnut Creek at A-1 Bypass; State Plane: E2086153, N751870.

Drainage Area—The basin includes the North Walnut Creek drainage and northwestern portions of the COU (total of 260.8 acres).

Period of Record—October 1, 2005, to current year.

Gage—Water-stage recorder and 6-inch Parshall flume.

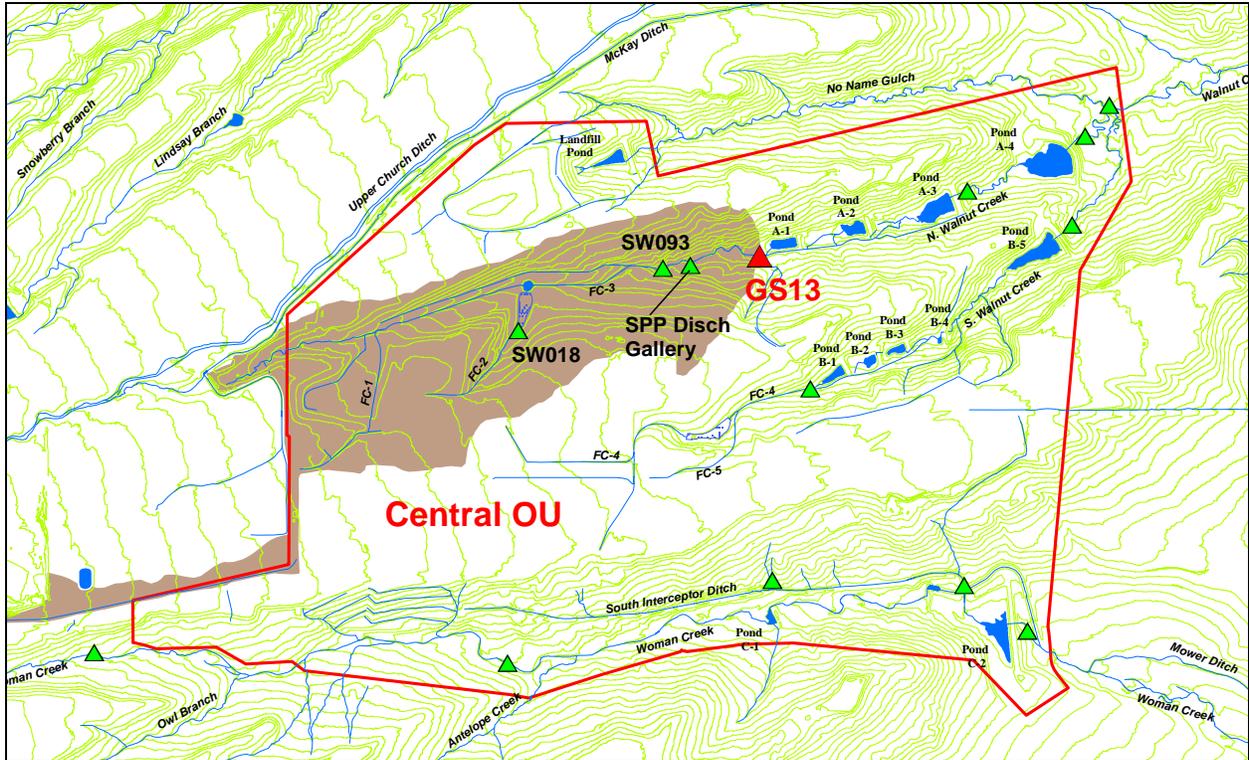


Figure 3–62. GS13 Drainage Area

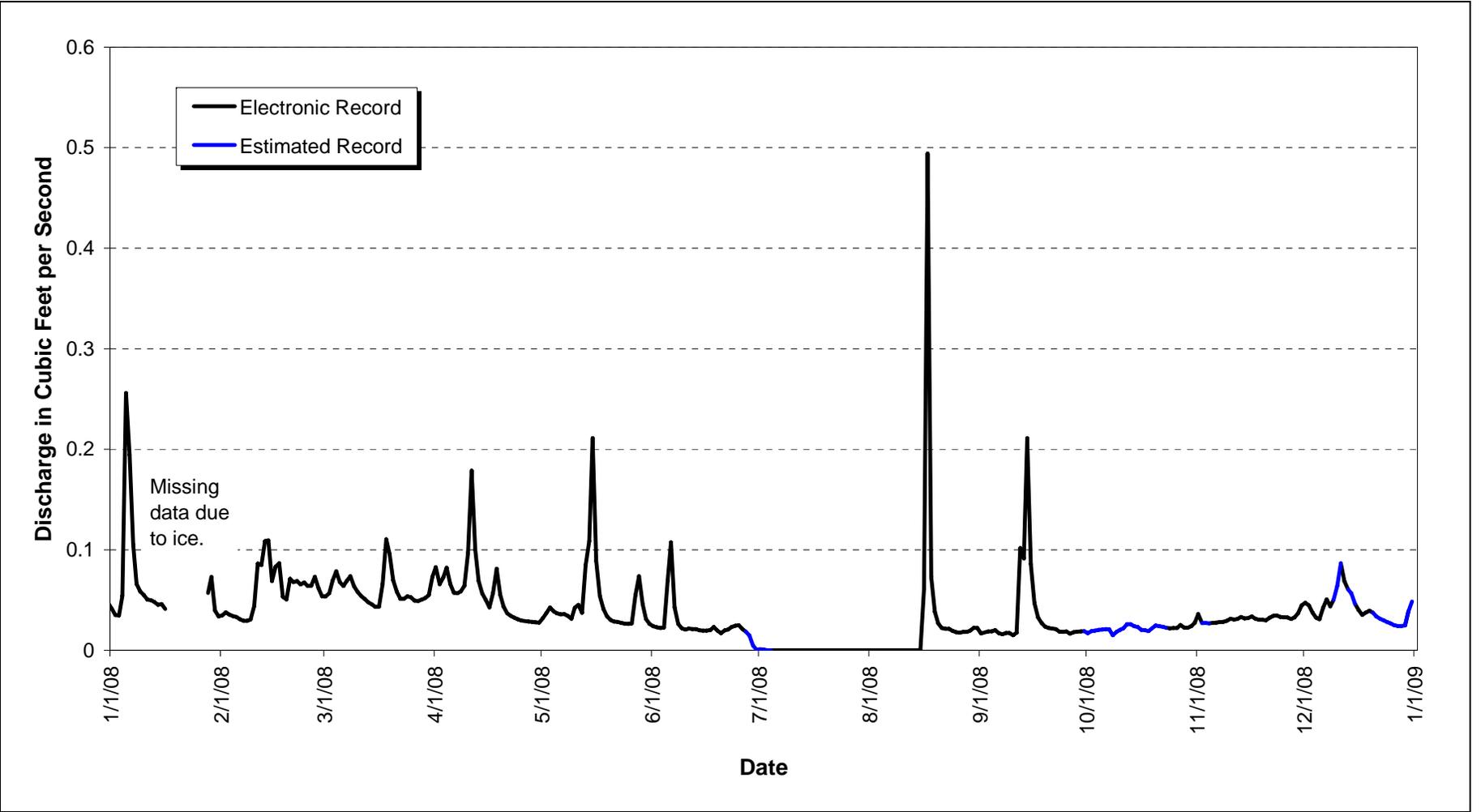


Figure 3-63. CY 2008 Mean Daily Hydrograph at GS13: North Walnut Creek at Pond A-1 Bypass

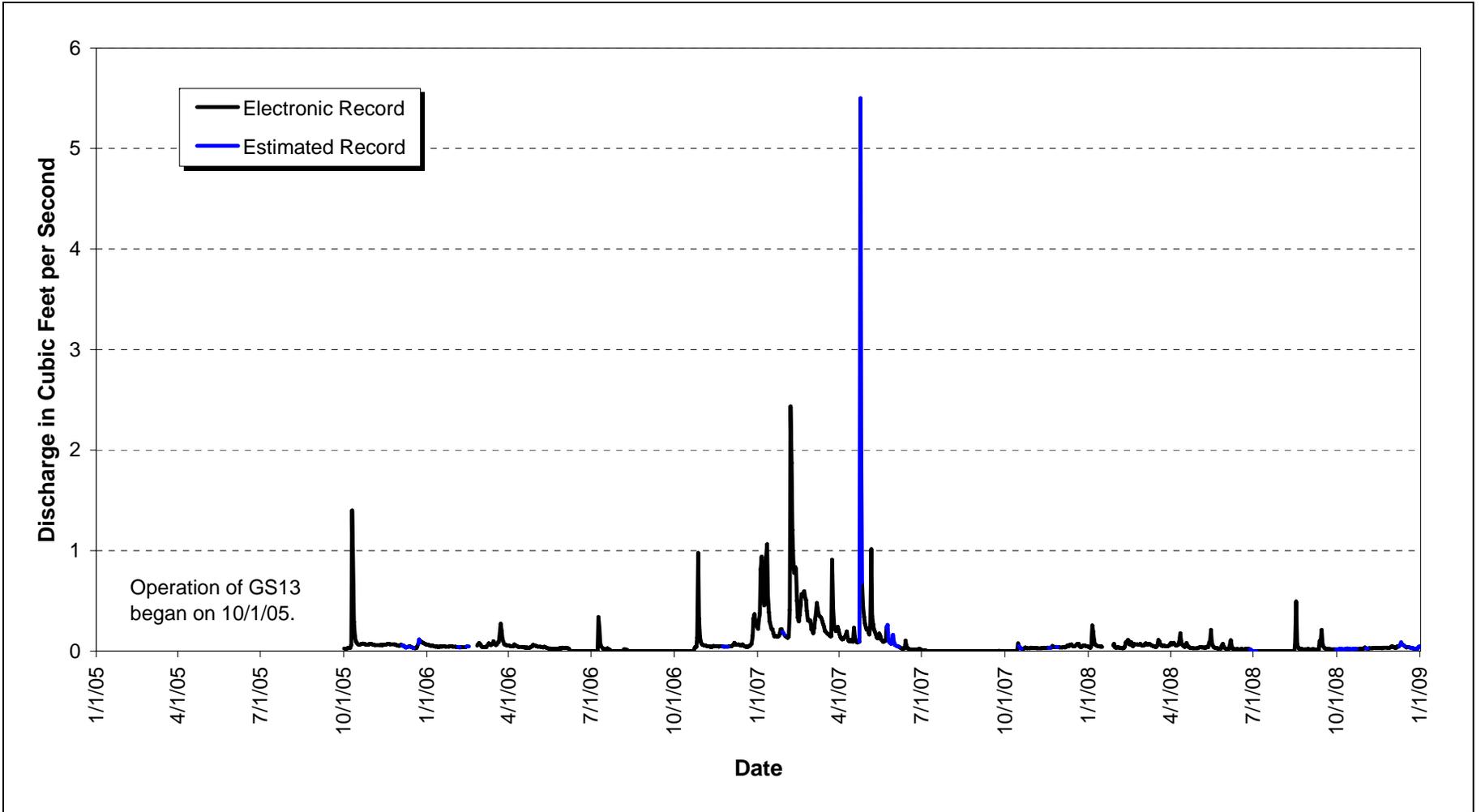


Figure 3-64. CY 2005-2008 Mean Daily Hydrograph at GS13: North Walnut Creek at Pond A-1 Bypass

GS31: Woman Creek at Pond C-2 Outlet

Location—Pond C-2 outlet; State Plane: E2089261, N747512.

Drainage Area—The basin includes a portion of the southern COU draining to the SID and the area surrounding Pond C-2 (total of 204.1 acres).

Period of Record—October 1, 1996, to current year.

Gage—Water-stage recorder and 24-inch Parshall flume.

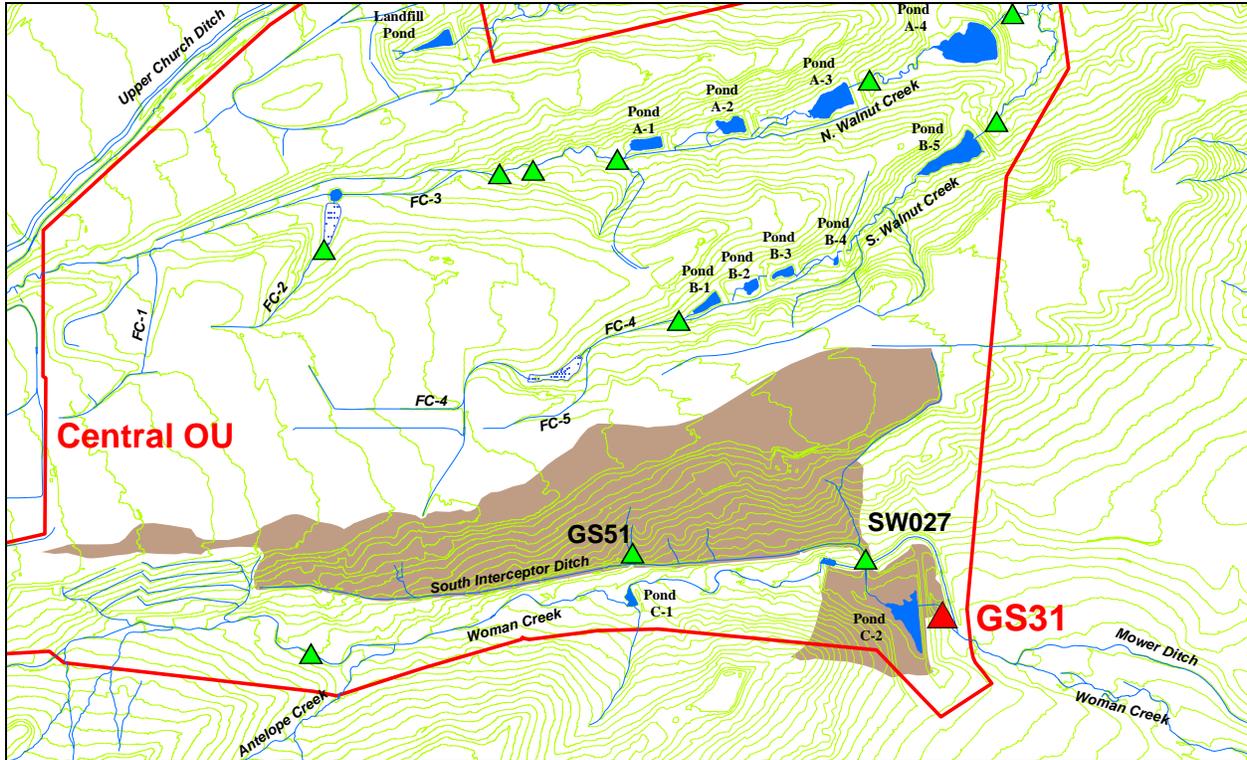


Figure 3–65. GS31 Drainage Area

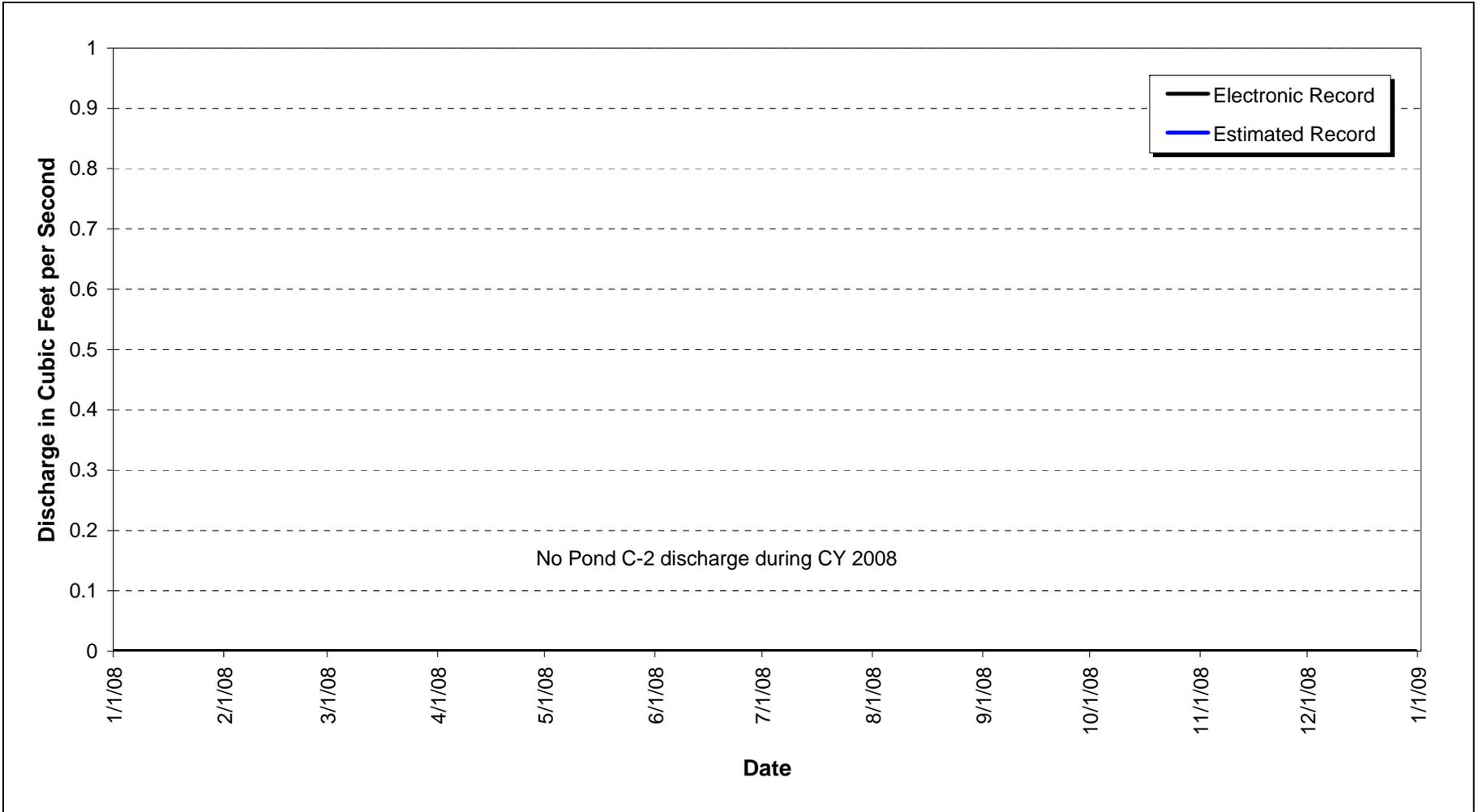


Figure 3-66. CY 2008 Mean Daily Hydrograph at GS31: Woman Creek at Pond C-2 Outlet

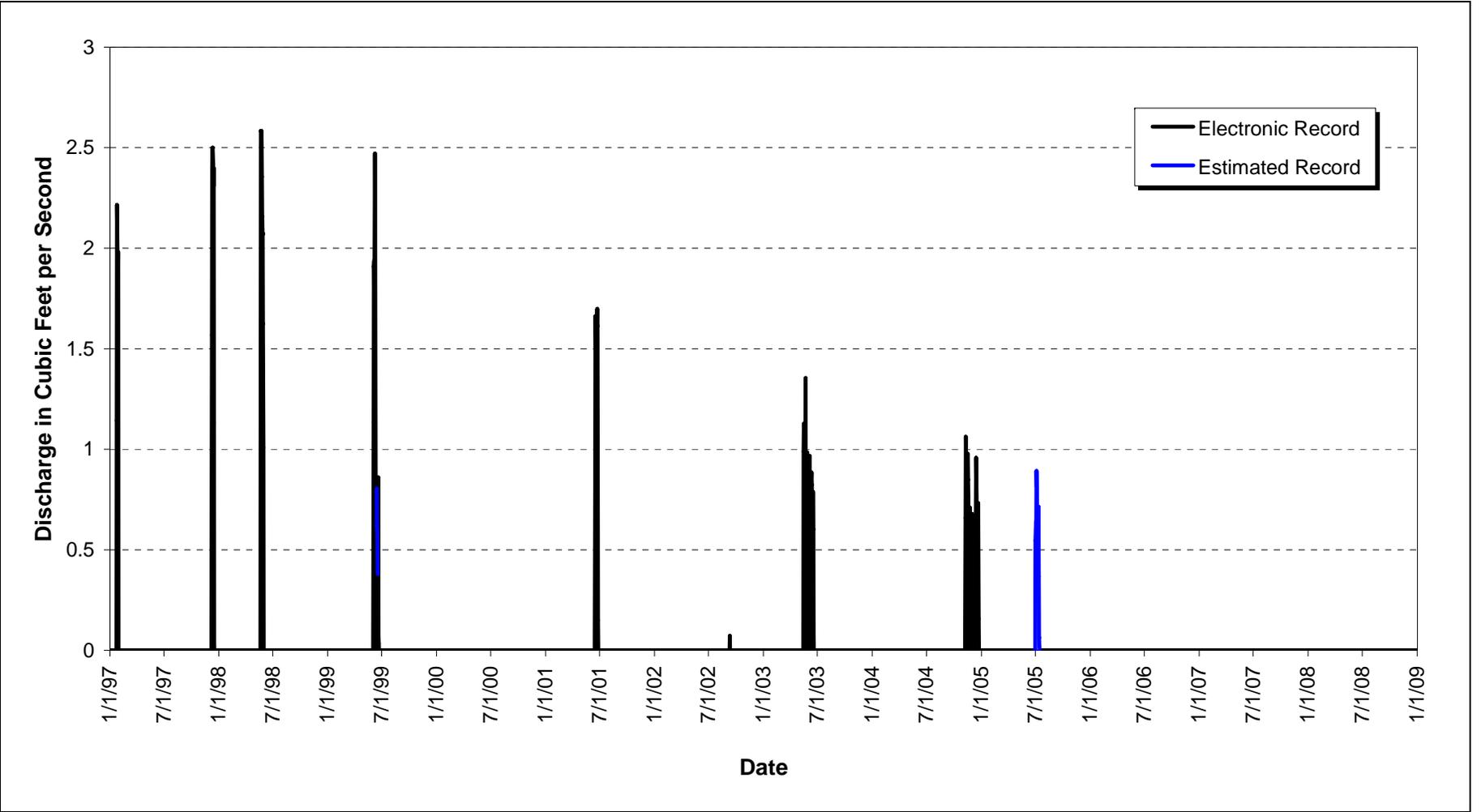


Figure 3-67. CY 1997-2008 Mean Daily Hydrograph at GS31: Woman Creek at Pond C-2 Outlet

GS33: No Name Gulch at Walnut Creek

Location—No Name Gulch at Walnut Creek; State Plane: E2090210, N753623.

Drainage Area—The basin is the No Name Gulch drainage (total of 295.3 acres).

Period of Record—September 16, 1997, to current year.

Gage—Water-stage recorder and 9.5-inch Parshall flume.

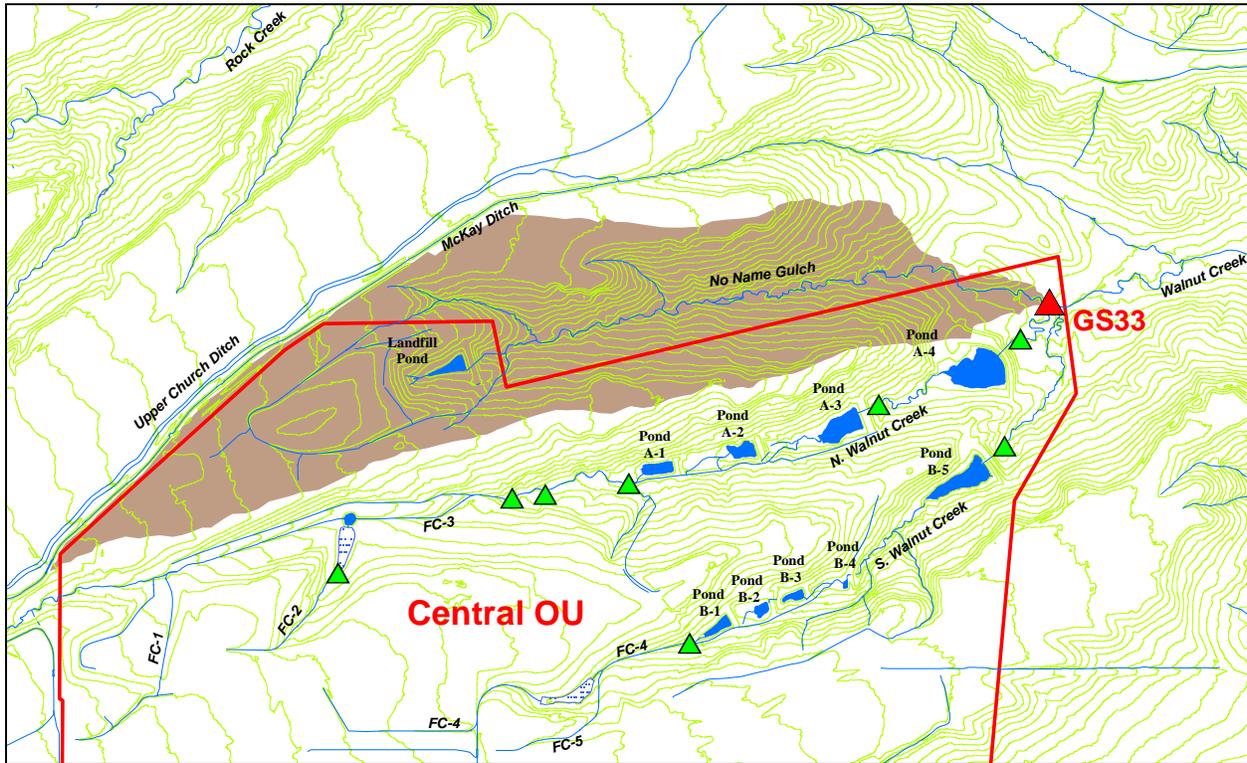


Figure 3–68. GS33 Drainage Area

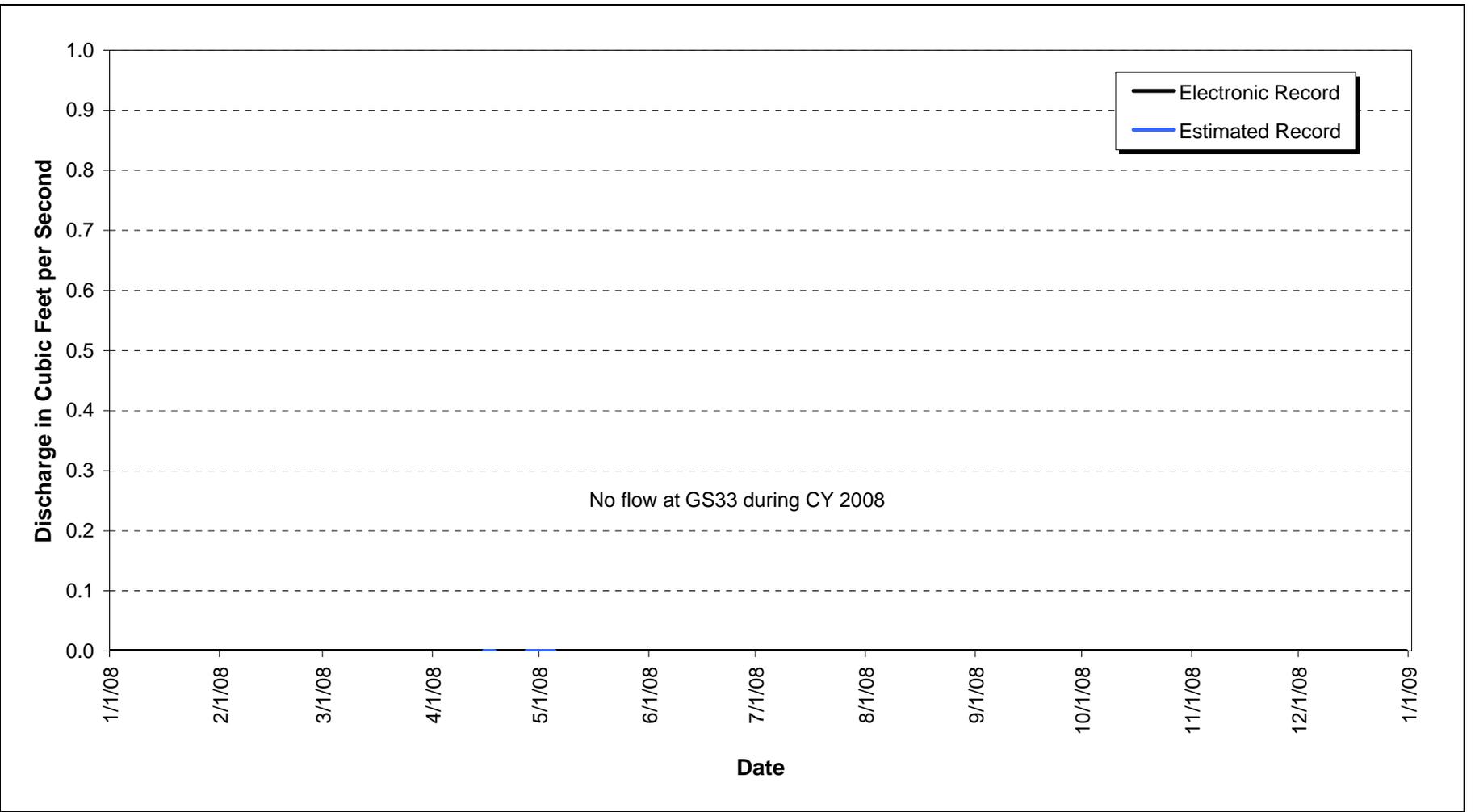


Figure 3-69. CY 2008 Mean Daily Hydrograph at GS33: No Name Gulch at Walnut Creek

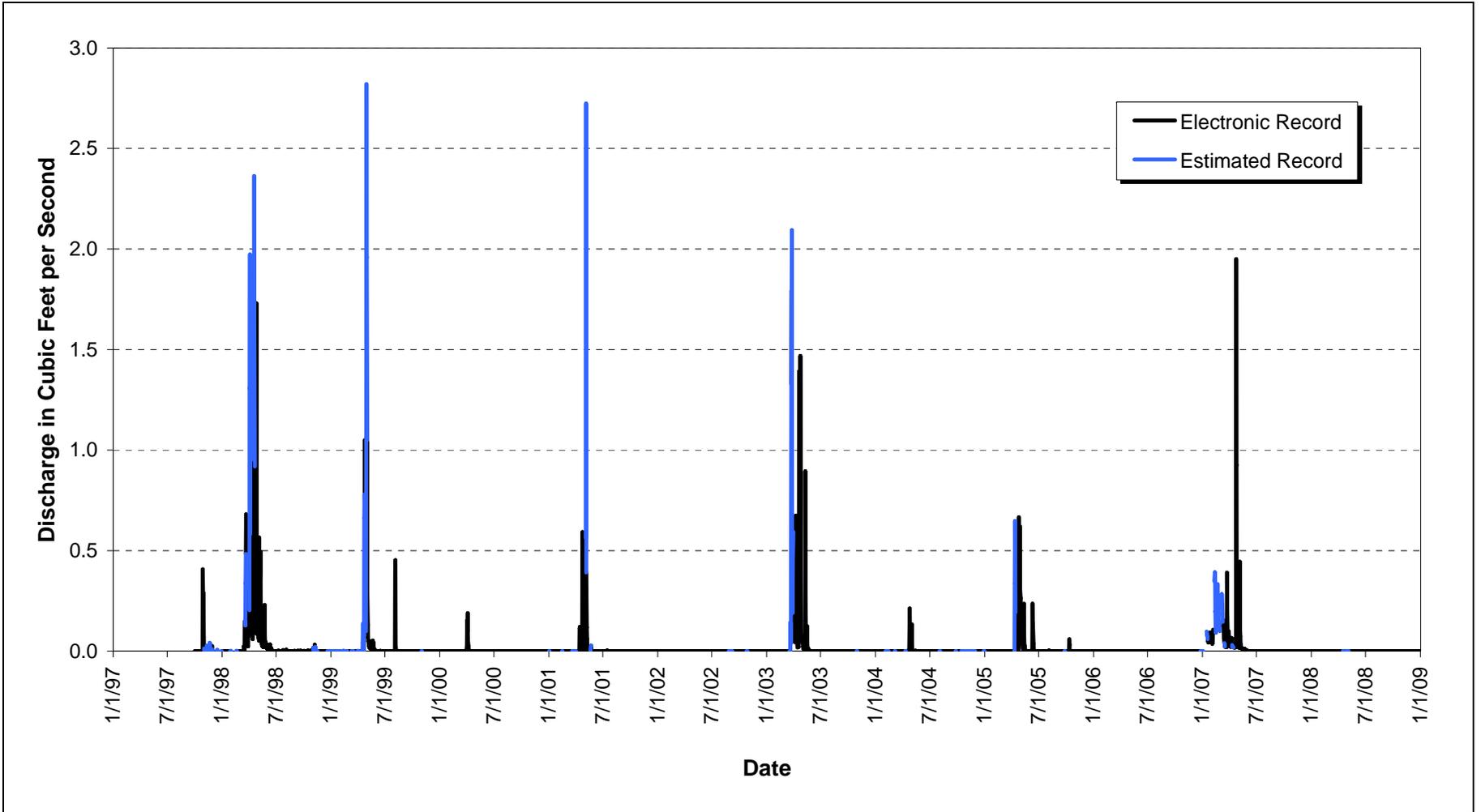


Figure 3-70. CY 1997-2008 Mean Daily Hydrograph at GS33: No Name Gulch at Walnut Creek

GS51: Ditch South of 903 Pad

Location—Ditch south of 903 Pad; State Plane: E2086300, N748102.

Drainage Area—The basin includes an area south and west of the former 903 Pad (total of 16.0 acres).

Period of Record—August 13, 2001, to current year.

Gage—Water-stage recorder and 0.75-foot H-flume.

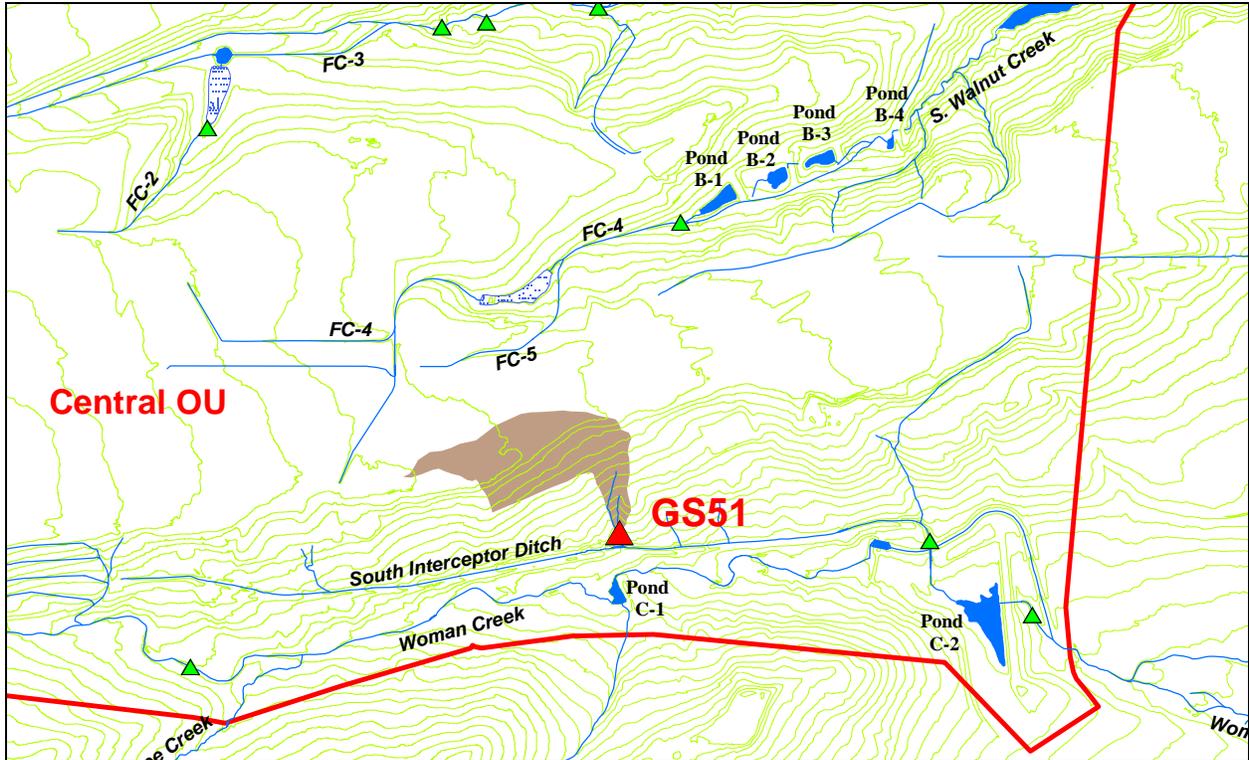


Figure 3–71. GS51 Drainage Area

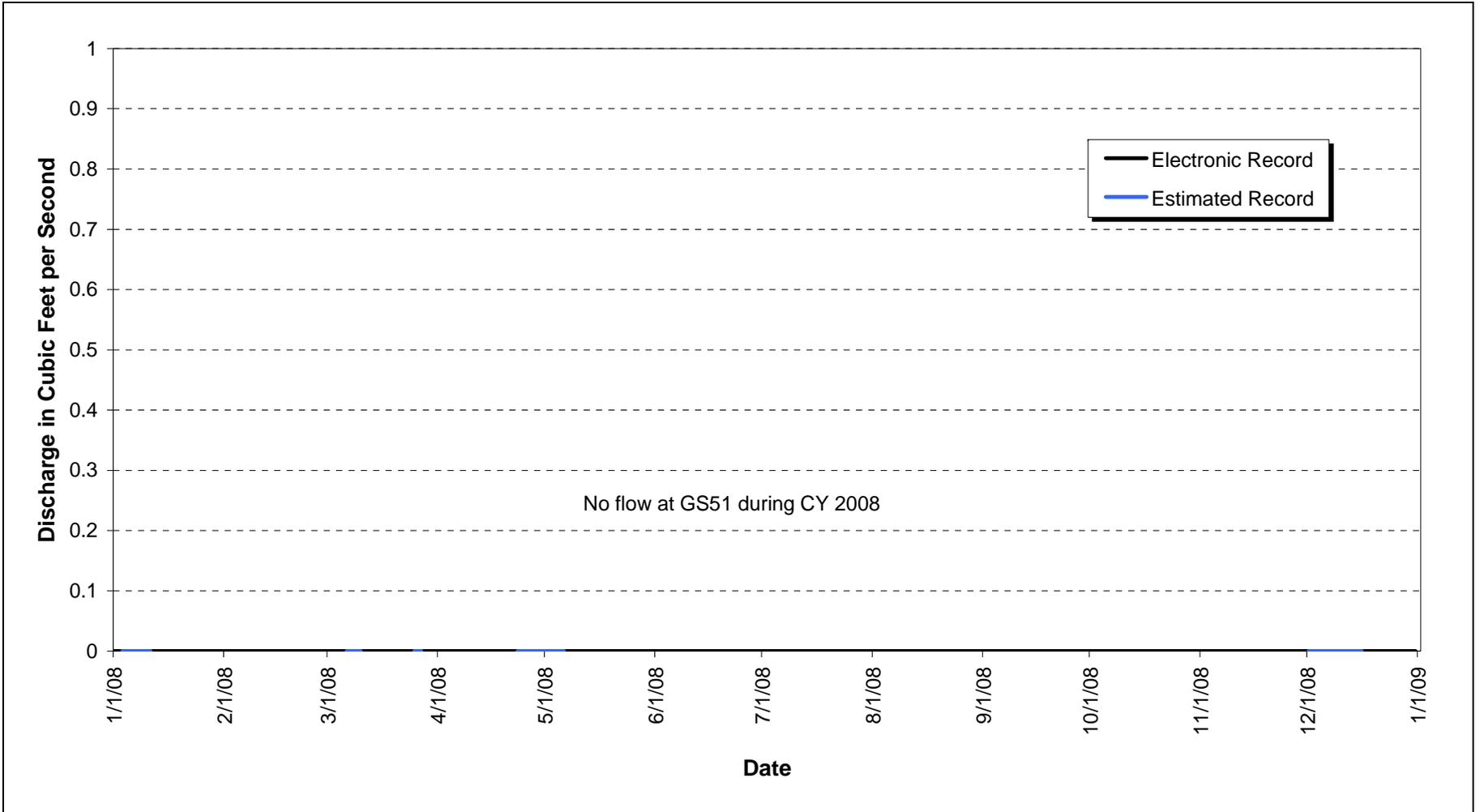


Figure 3-72. CY 2008 Mean Daily Hydrograph at GS51: Ditch South of 903 Pad

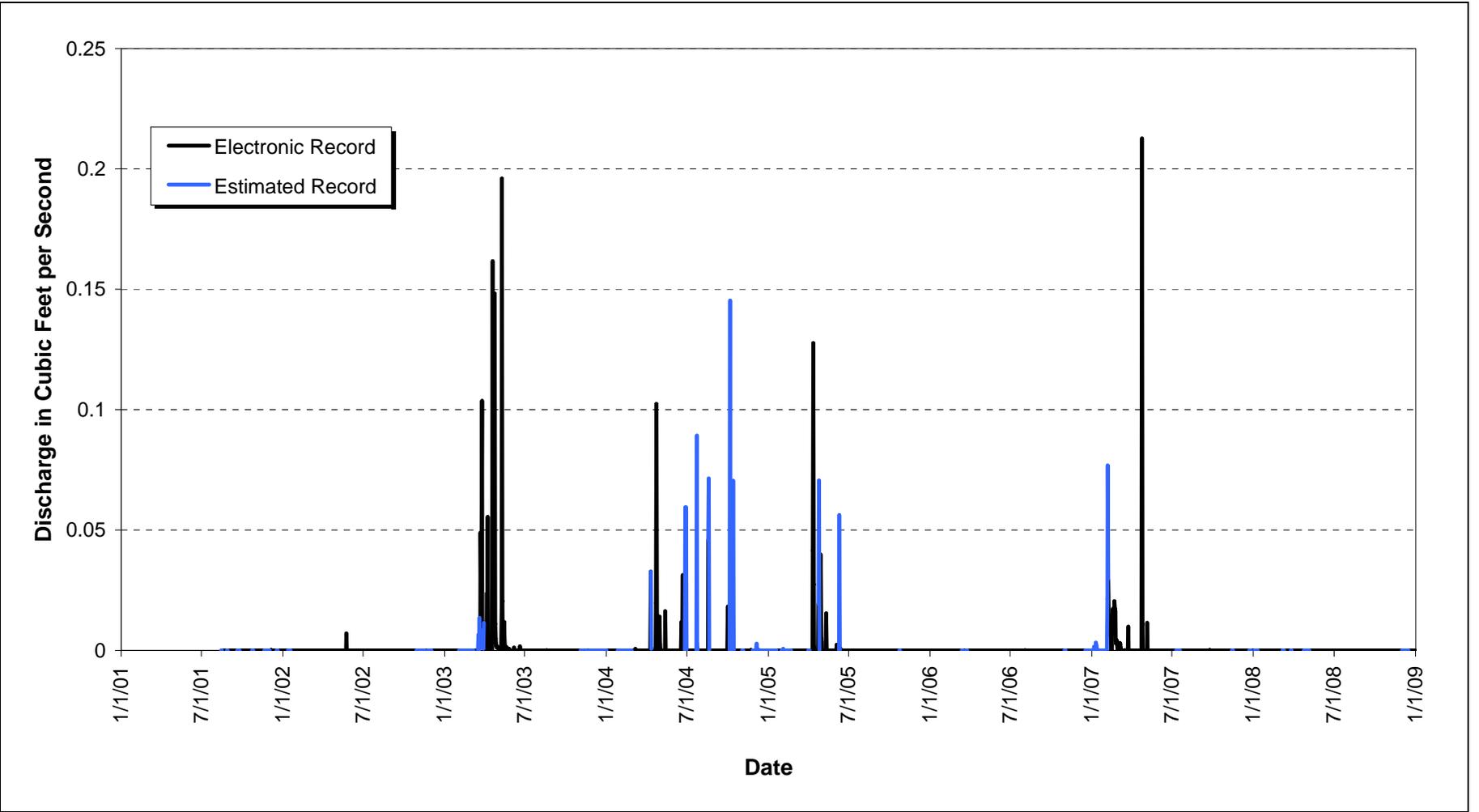


Figure 3-73. CY 2001-2008 Mean Daily Hydrograph at GS51: Ditch South of 903 Pad

GS59: Woman Creek Upstream of Antelope Springs Confluence

Location—Woman Creek 900 feet upstream of Antelope Springs confluence; State Plane: E2083228, N747139.

Drainage Area—The basin includes upstream reaches of Woman Creek; areas west of Highway 93 also contribute runoff (total drainage acreage undetermined).

Period of Record—November 20, 2002, to current year.

Gage—Water-stage recorder and 1.5-foot Parshall flume.

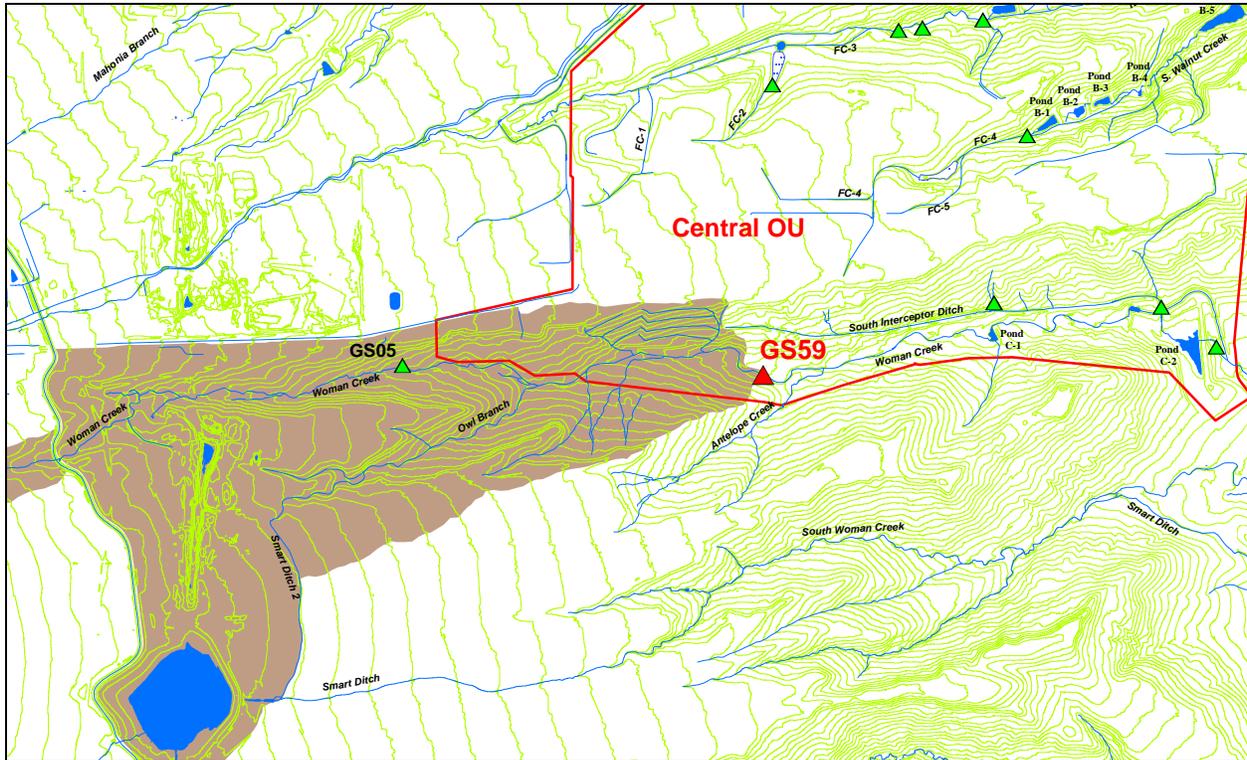


Figure 3–74. GS59 Drainage Area

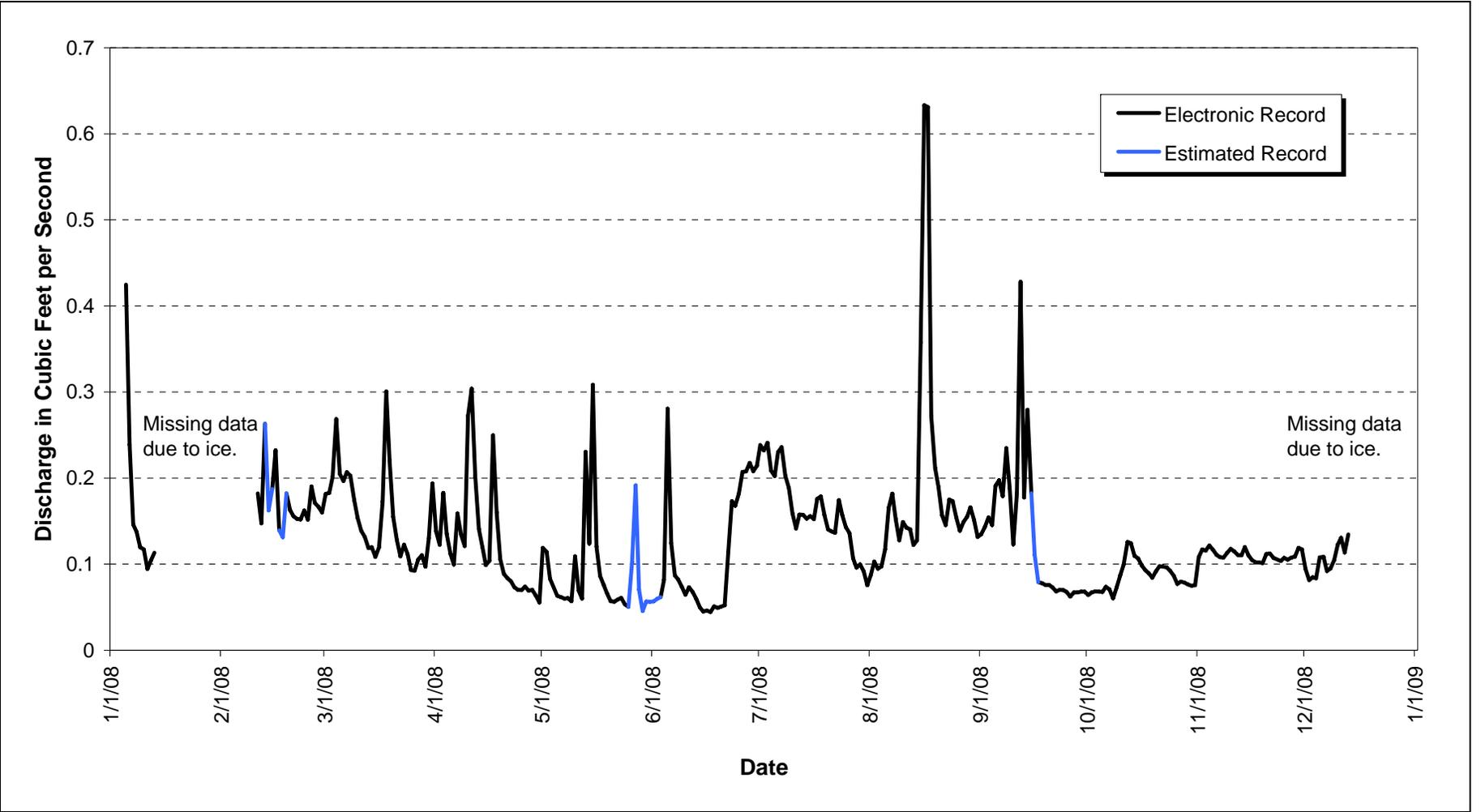


Figure 3-75. CY 2008 Mean Daily Hydrograph at GS59: Woman Creek Upstream of Antelope Springs Confluence

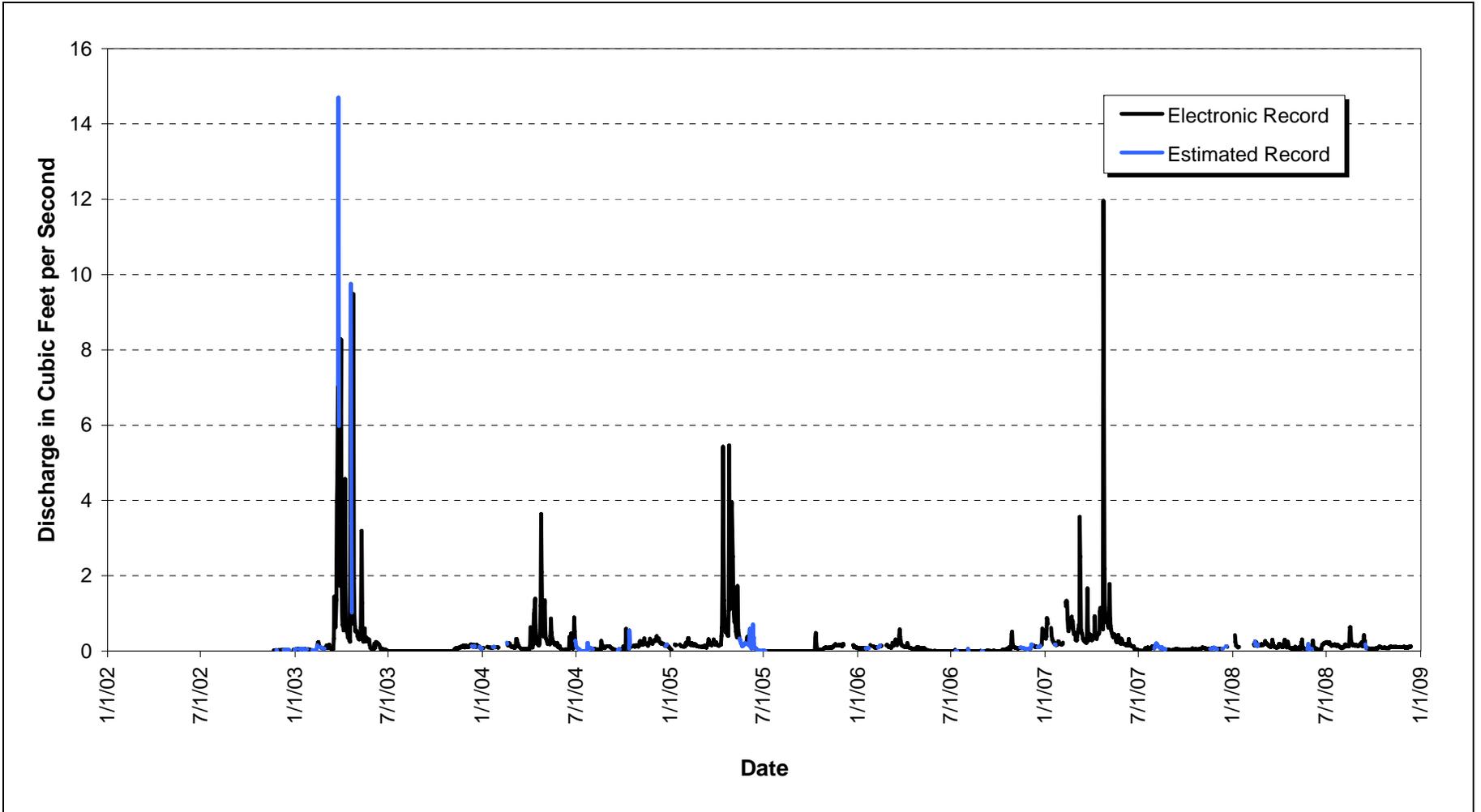


Figure 3-76. CY 2002-2008 Mean Daily Hydrograph at GS59: Woman Creek Upstream of Antelope Springs Confluence

SPPDISCHARGE GALLERY: SPPTS DG

Location—SPPTS DG tributary to North Walnut Creek; State Plane: E2085350, N751764.

Drainage Area—Not applicable; the SPPDISCHARGE GALLERY receives effluent flow from the SPPTS.

Period of Record—April 10, 2007, to current year.

Gage—Water-stage recorder and 0.6-foot HS flume.

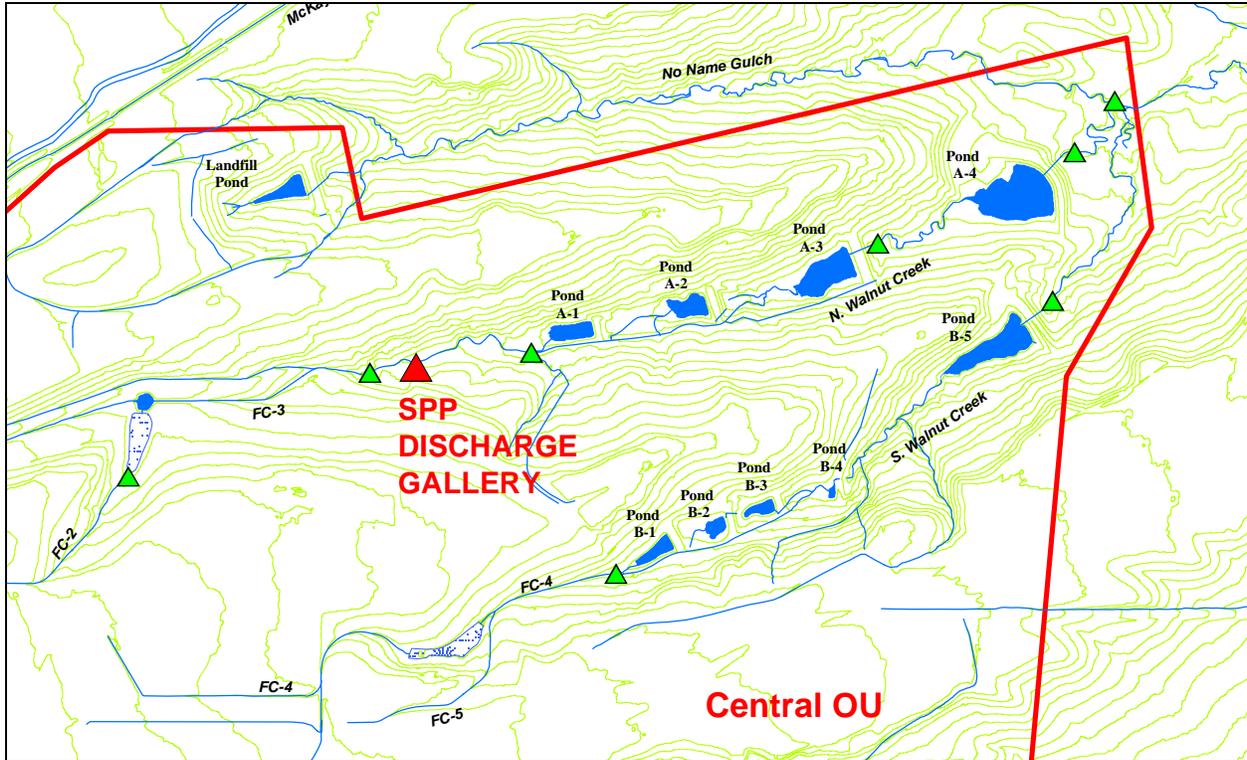


Figure 3–77. SPPDISCHARGE GALLERY Location

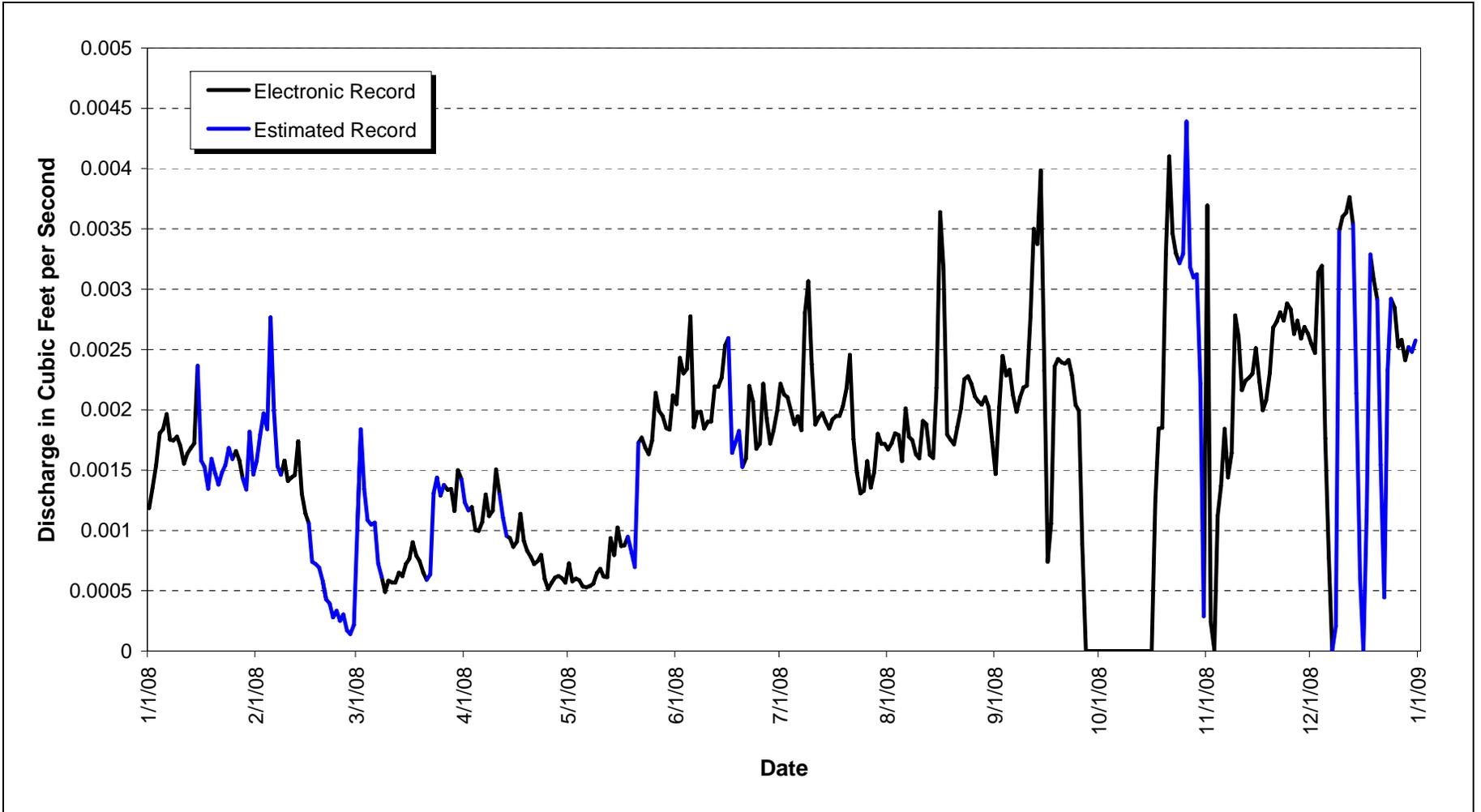


Figure 3-78. CY 2008 Mean Daily Hydrograph at SPPDISCHARGE GALLERY

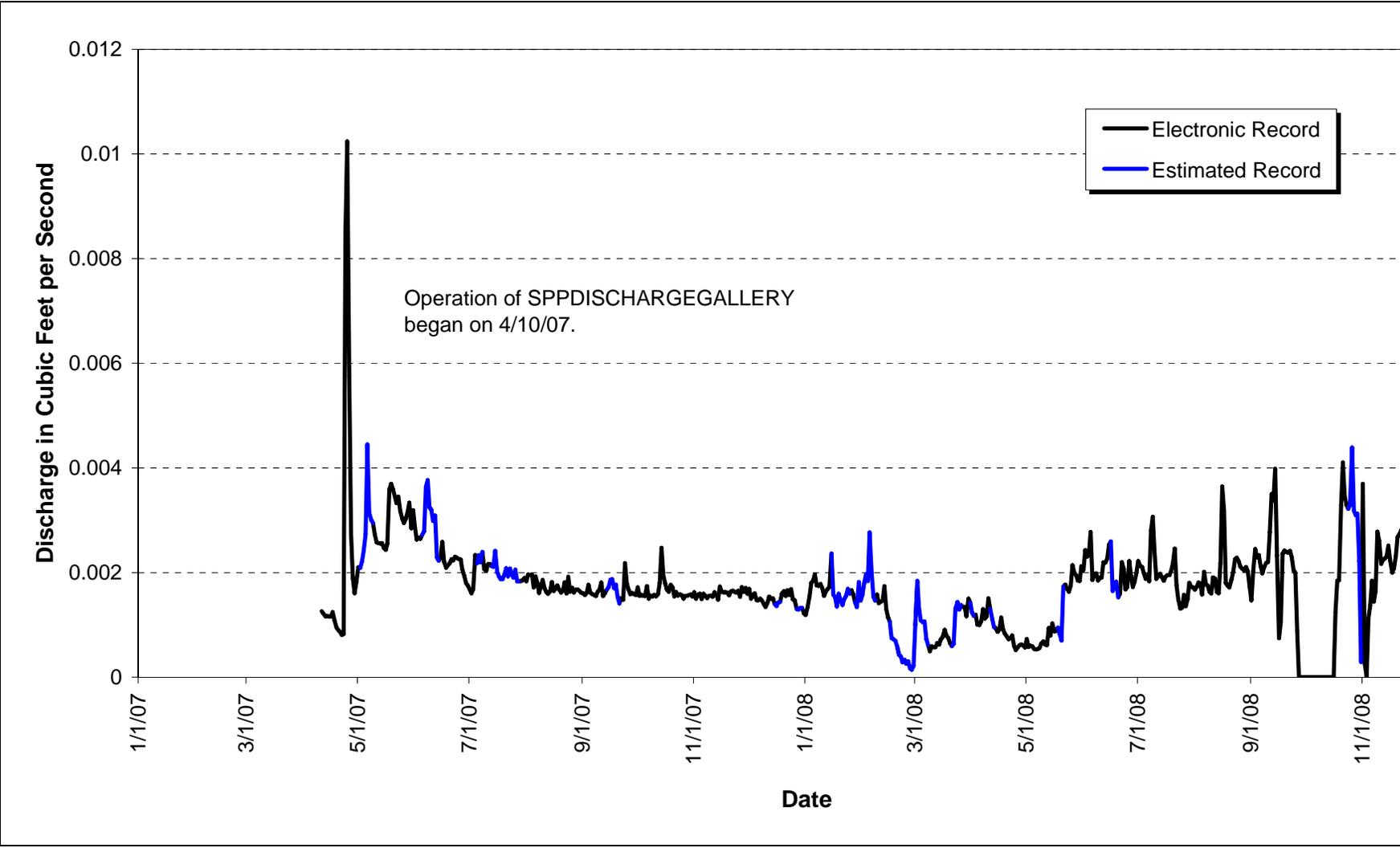


Figure 3-79. CY 2007-2008 Mean Daily Hydrograph at SPPDISCHARGE GALLERY

SW018: FC-2 at FC-2 Wetland

Location—FC-2 drainage just upstream of FC-2 wetland; State Plane: E2083351, N751006.

Drainage Area—The basin includes FC-2 areas tributary to North Walnut Creek (total of 42.4 acres).

Period of Record—October 10, 2003, to current year.

Gage—Water-stage recorder and 1-foot Parshall flume through September 12, 2006. One-foot H flume installed on September 13, 2006.

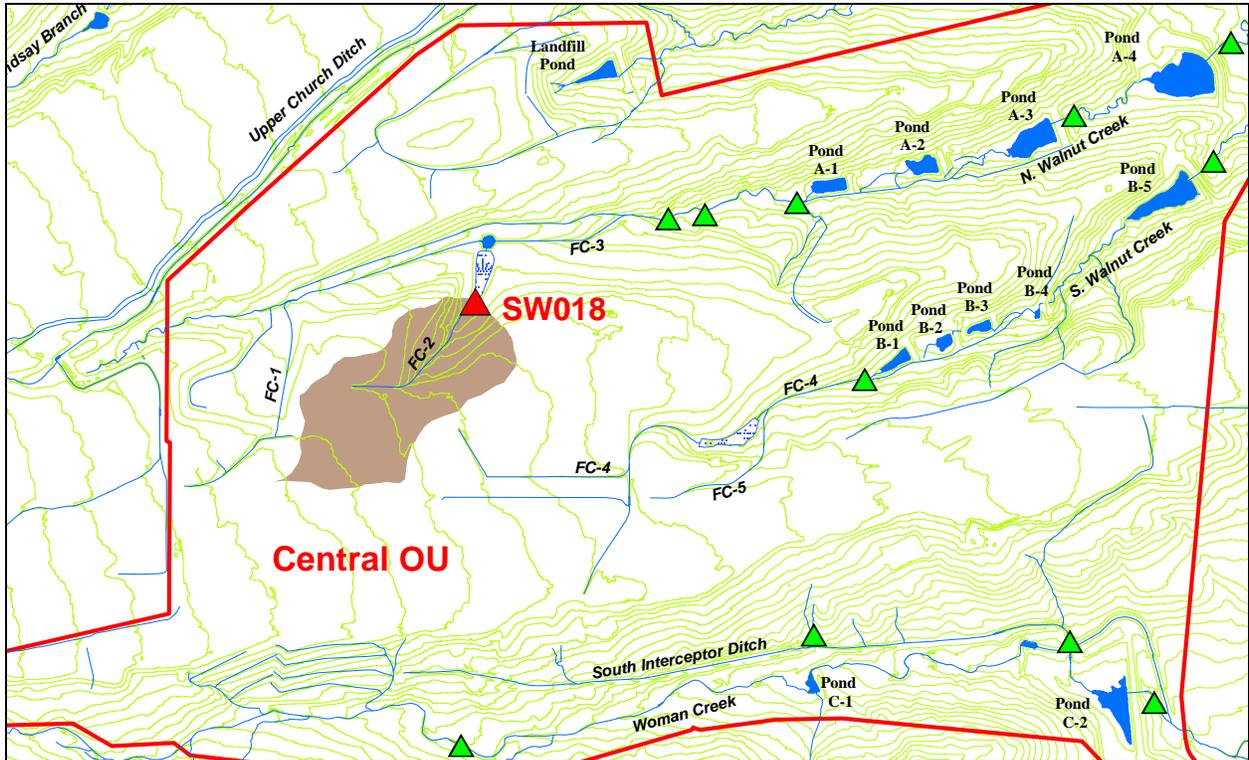


Figure 3–80. SW018 Drainage Area

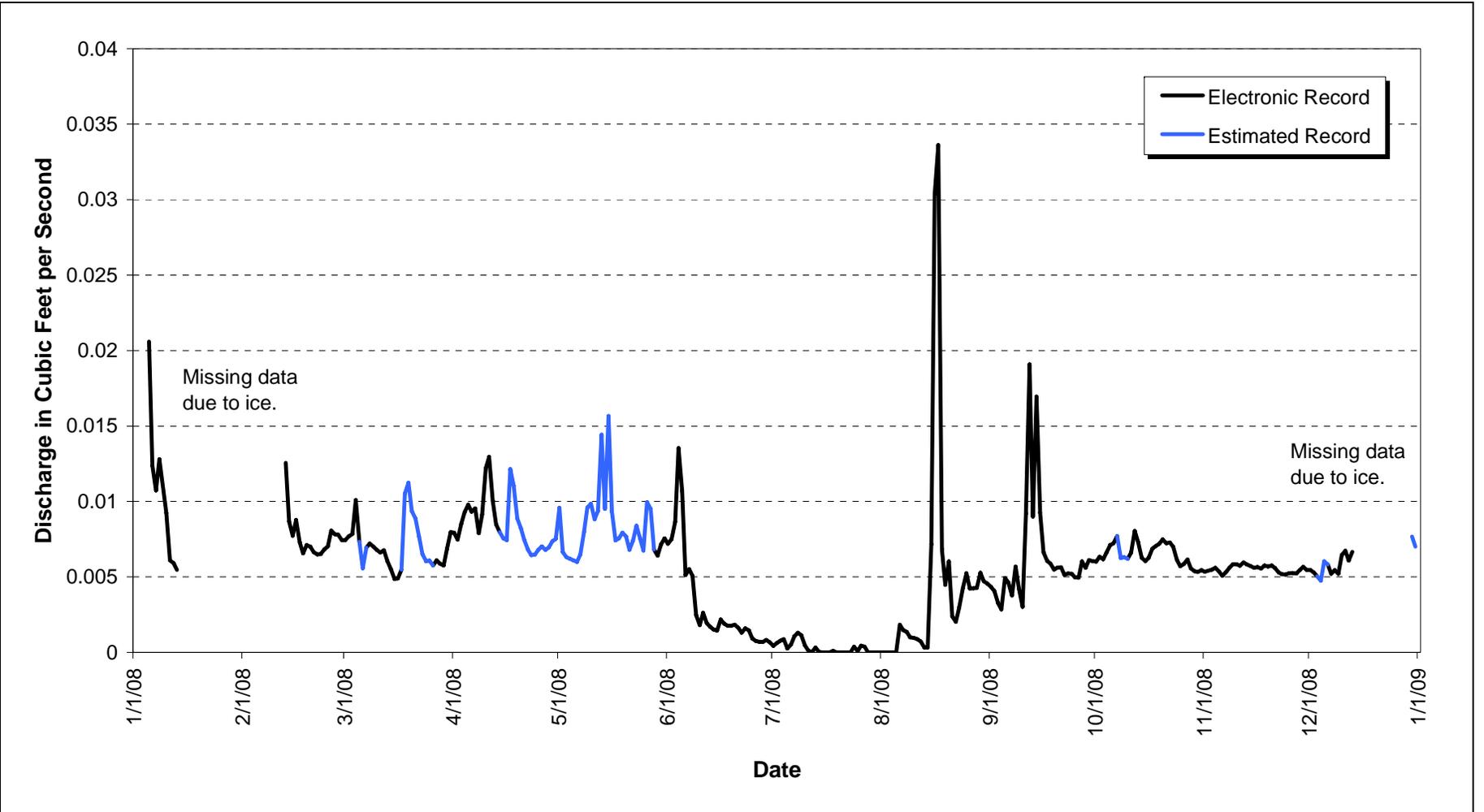


Figure 3-81. CY 2008 Mean Daily Hydrograph at SW018: FC-2 at FC-2 Wetland

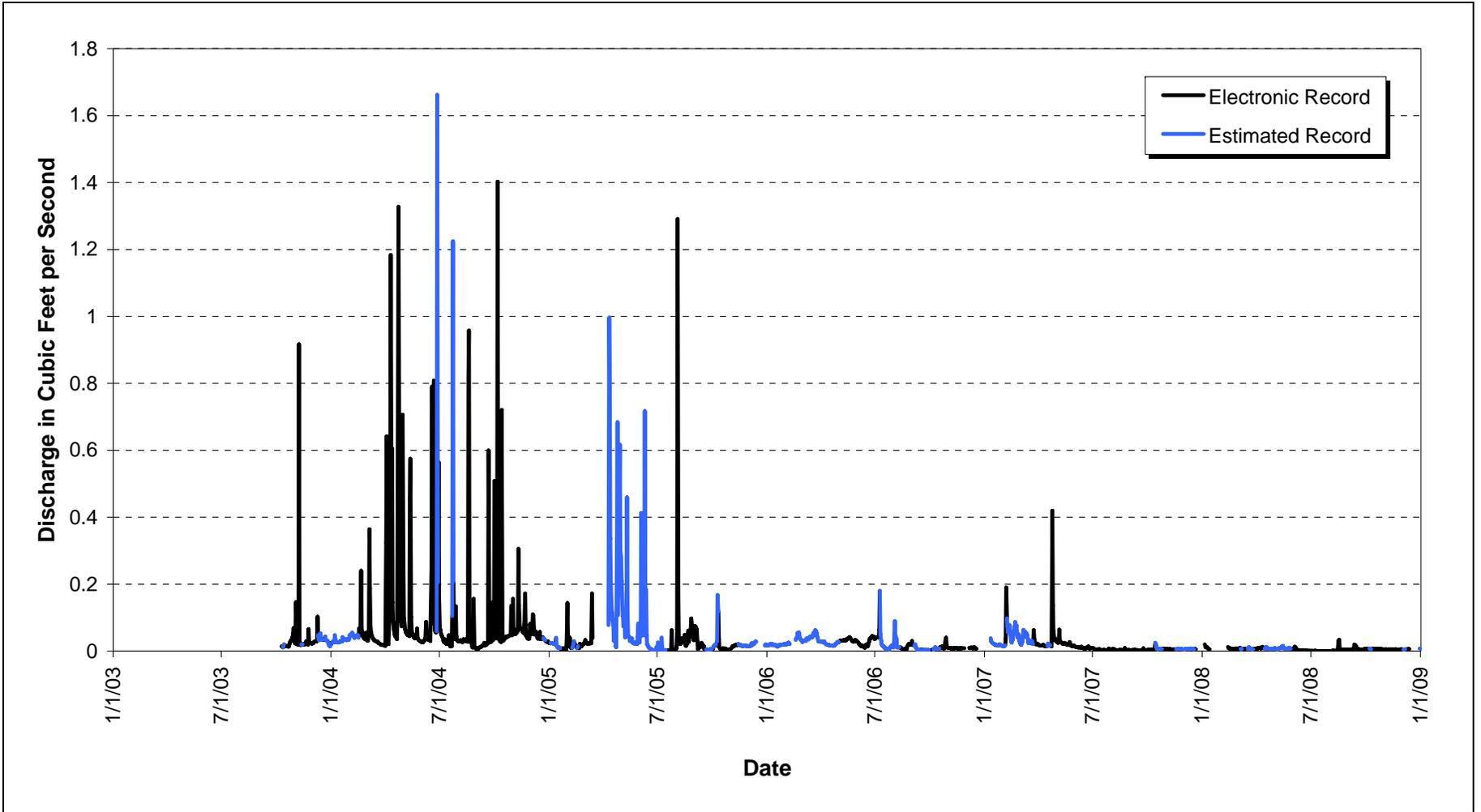


Figure 3-82. CY 2003-2008 Mean Daily Hydrograph at SW018: FC-2 at FC-2 Wetland

SW027: SID at Pond C-2

Location—East end of SID at Pond C-2; State Plane: E2088527, N748044.

Drainage Area—The basin includes a portion of the southern COU drained by the SID (total of 177.6 acres).

Period of Record—September 11, 1991, to current year.

Gage—Water-stage recorder and dual, parallel 120° V-notch weirs.

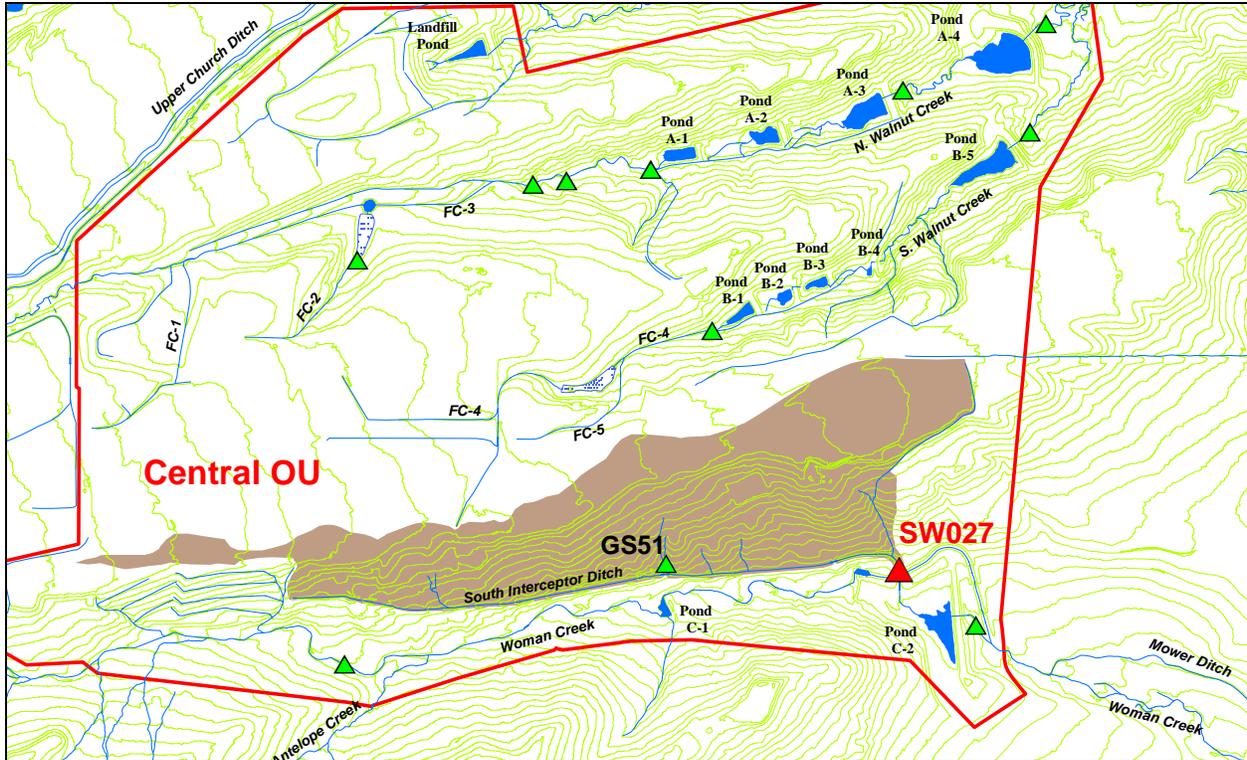


Figure 3–83. SW027 Drainage Area

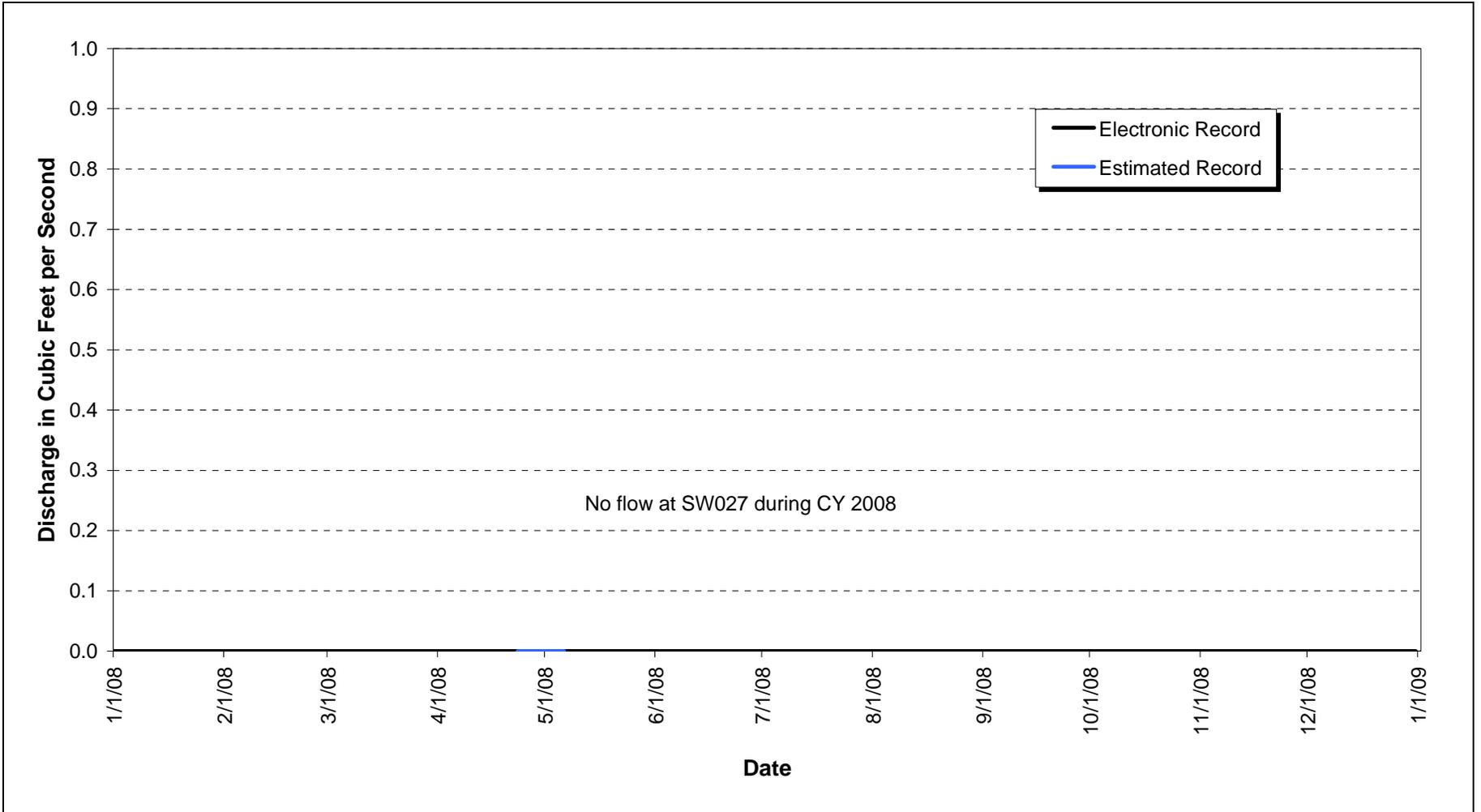


Figure 3-84. CY 2008 Mean Daily Hydrograph at SW027: SID at Pond C-2

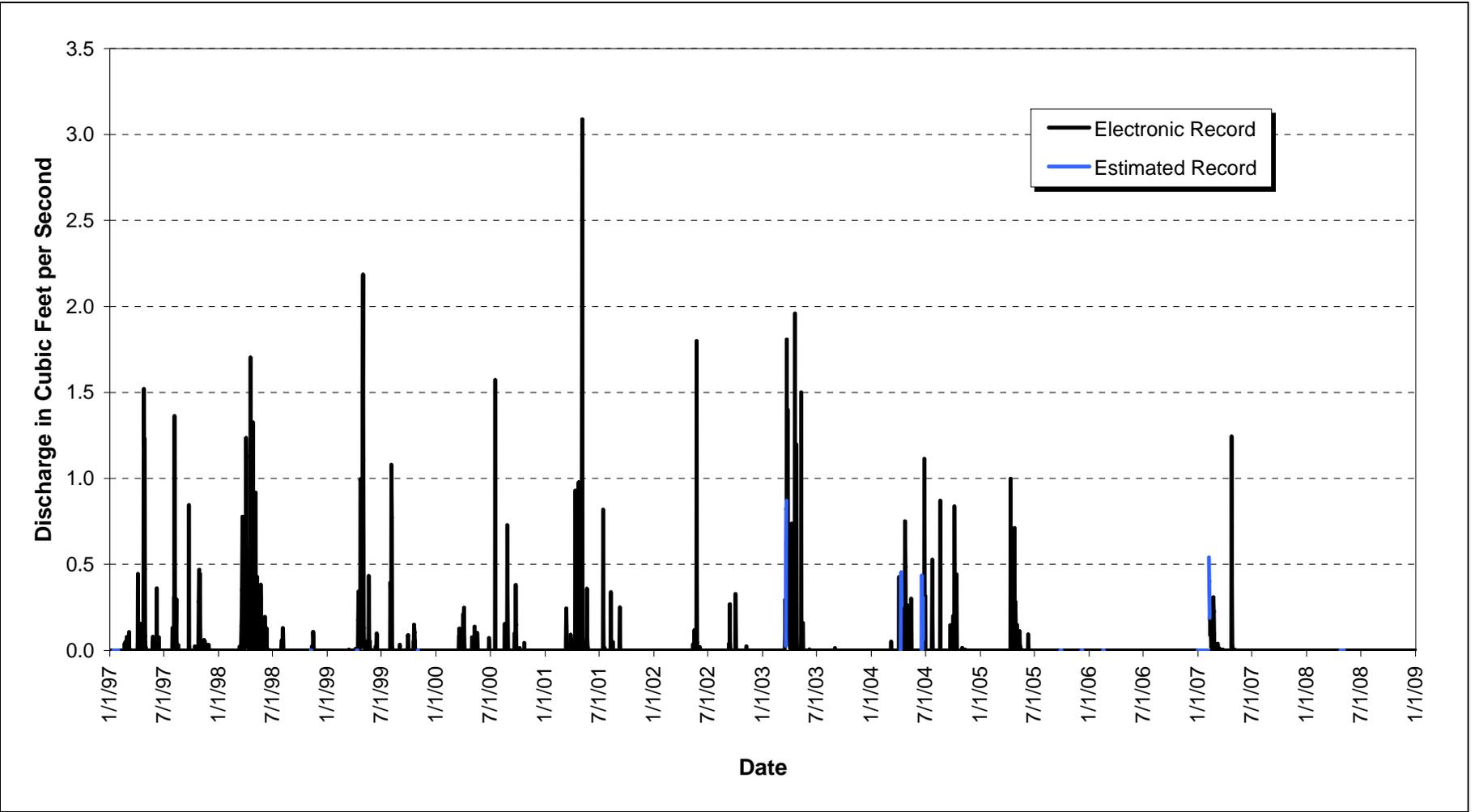


Figure 3-85. CY 1997-2008 Mean Daily Hydrograph at SW027: SID at Pond C-2

SW093: North Walnut Creek Upstream of Pond A-1 Bypass

Location—North Walnut Creek 1,300 feet above Pond A-1 Bypass; State Plane: E2085030, N751730.

Drainage Area—The basin includes the northwestern portion of the COU drained by FC-3 (total of 220.0 acres).

Period of Record—September 11, 1991, to current year.

Gage—Water-stage recorder and 36-inch suppressed, rectangular, sharp-crested weir to January 27, 2003; rated stream section during new flume construction (SW093T; January 27, 2003–May 29, 2003). Three-foot H flume starting May 29, 2003.

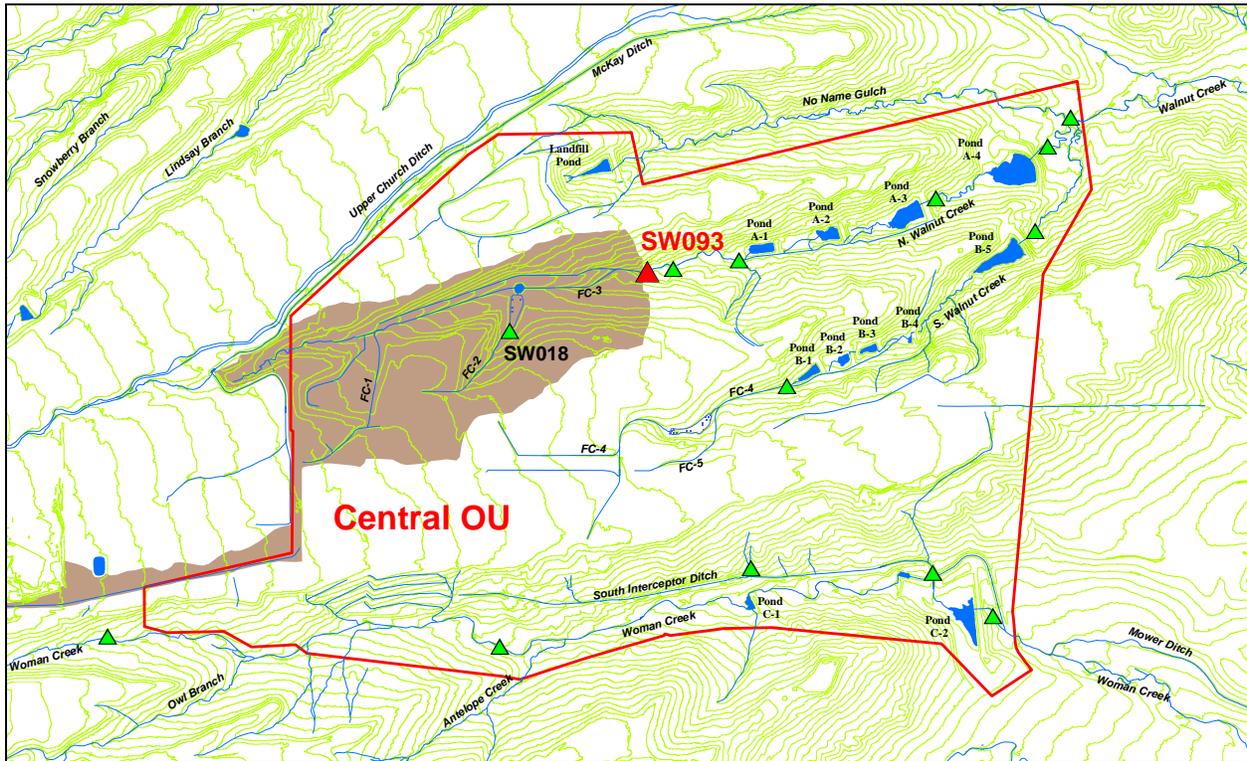


Figure 3–86. SW093 Drainage Area

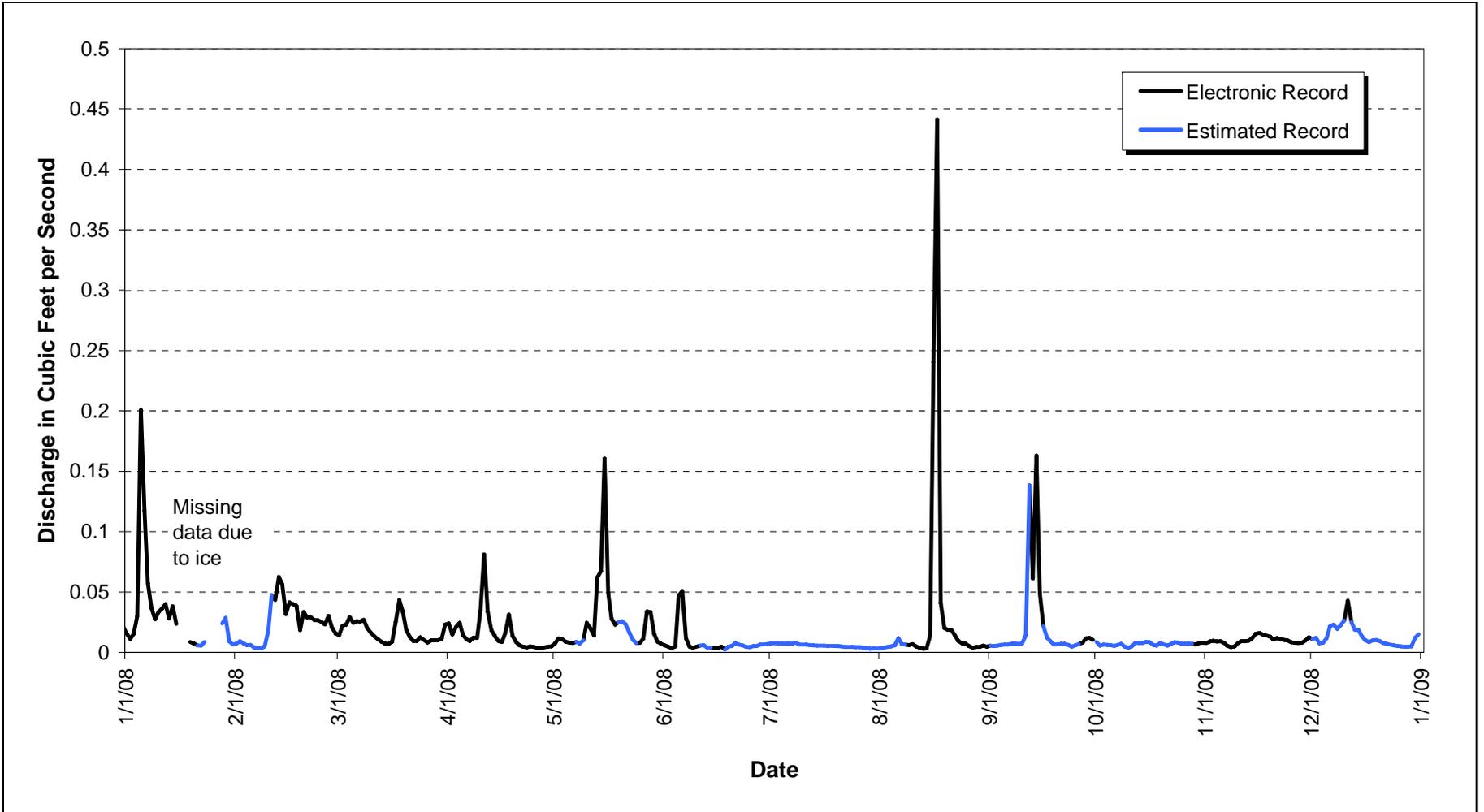


Figure 3-87. CY 2008 Mean Daily Hydrograph at SW093: North Walnut Creek Upstream of Pond A-1 Bypass

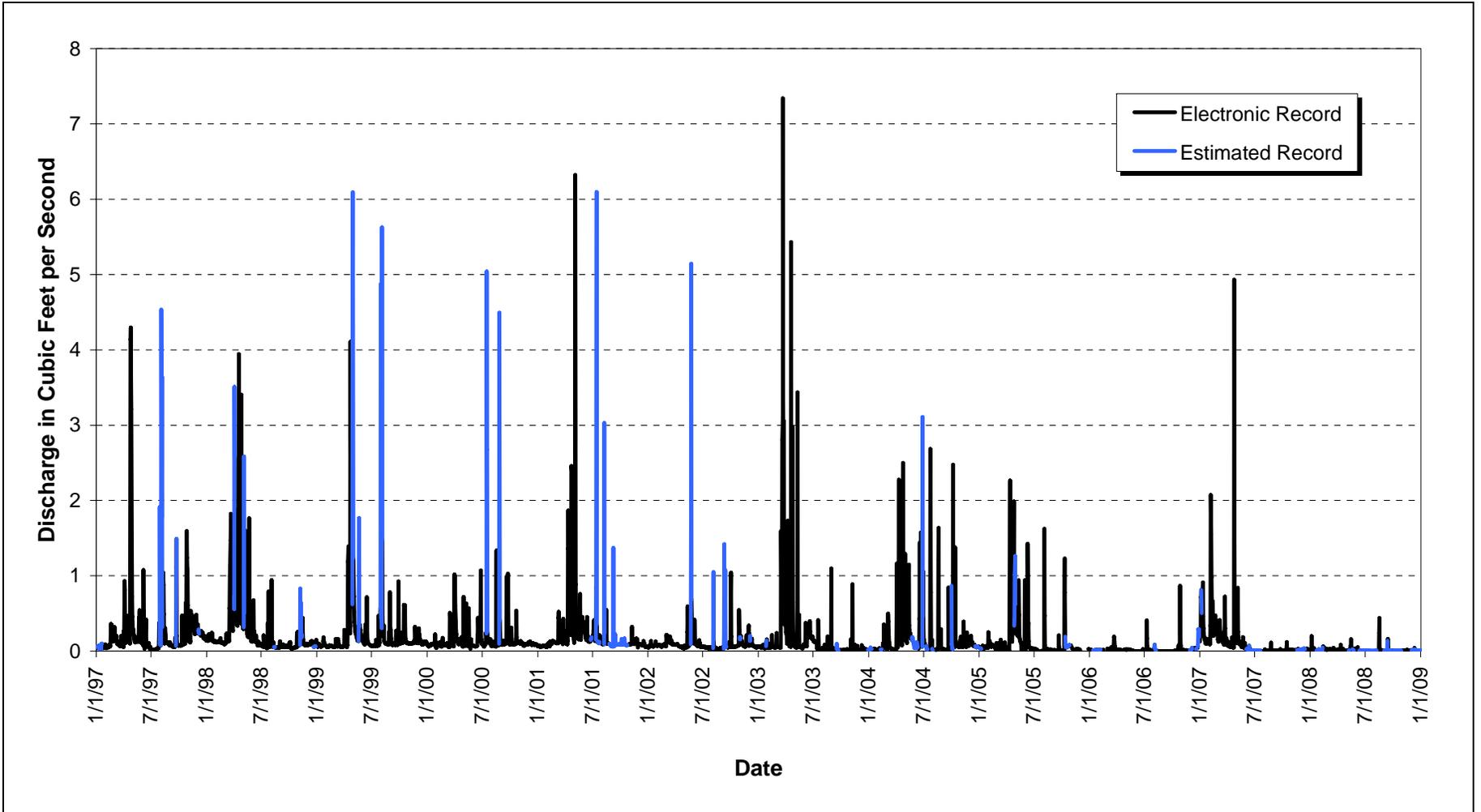


Figure 3-88. CY 1997-2008 Mean Daily Hydrograph at SW093: North Walnut Creek Upstream of Pond A-1 Bypass

3.1.3.4 Precipitation Data

During CY 2008, nine precipitation gages were operated as part of the automated surface-water monitoring network (Table 3–42 and Figure 3–89). The locations employ tipping-bucket rain gages generally mounted at ground level. Precipitation totals are logged on 5-minute intervals, 15-minute intervals, or both. The gages are not heated and will not accurately record equivalent precipitation for all snowfall events. The following sections present several figures (Figure 3–90, Figure 3–91, Figure 3–92, Figure 3–93, Figure 3–94, and Figure 3–95) summarizing the precipitation data collected for CY 1997–2008.

Table 3–42. Monitoring Network Precipitation Gage Information

Location Code (Surface-Water Gage)	Easting (State Plane)	Northing (State Plane)	Period of Operation
PG58 [GS01]	2093835.22	744921.16	10/11/96–current year
PG59 [GS03]	2093598.99	753629.51	4/1/96–current year
PG61 [GS05]	2078432.10	747285.45	4/1/96–current year
PG72 [NA]	2083387.82	751851.00	6/7/05–3/26/08
PG73 [GS13]	2086169.70	751862.47	9/27/05–current year
PG74 [GS59]	2083245.00	747172.00	9/5/06–current year
PG75 [SW018]	2083522.00	751181.00	3/27/08–current year
PG76 [NA]	2091963.00	752705.00	3/28/07–current year
PG77 [NA]	2087329.00	746937.00	8/23/07–current year

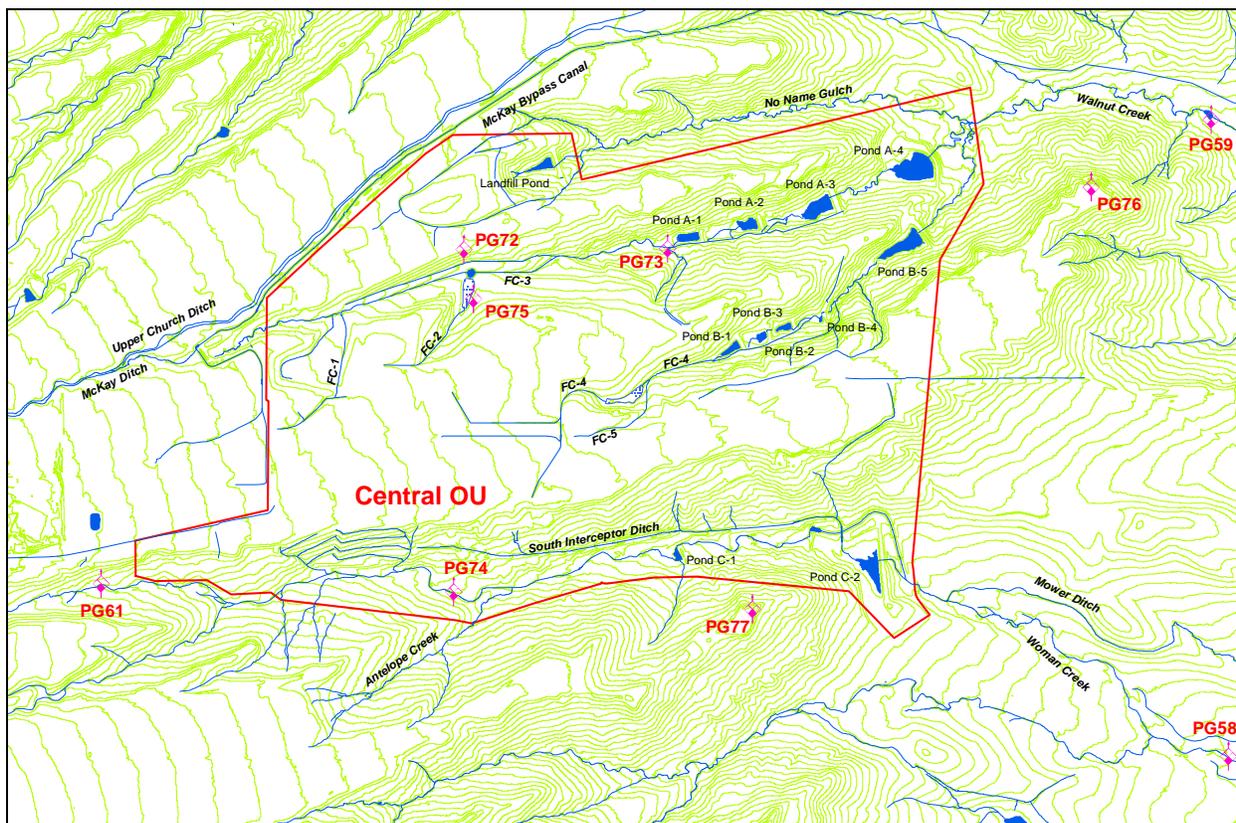
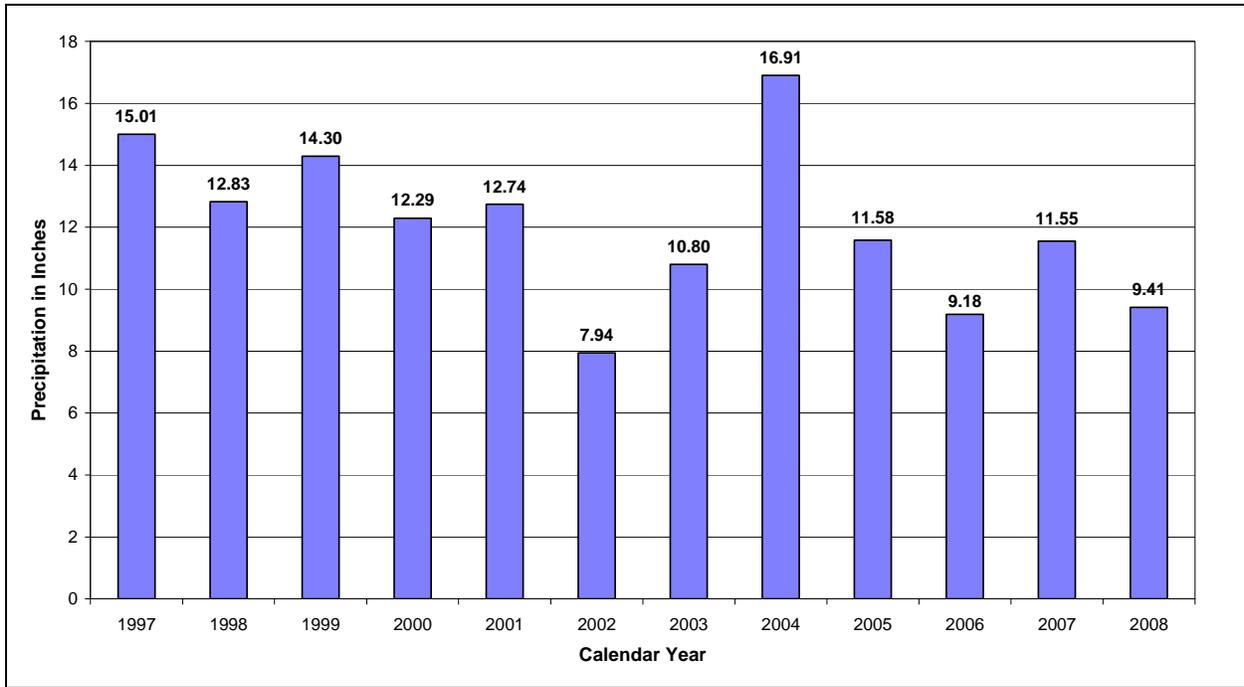


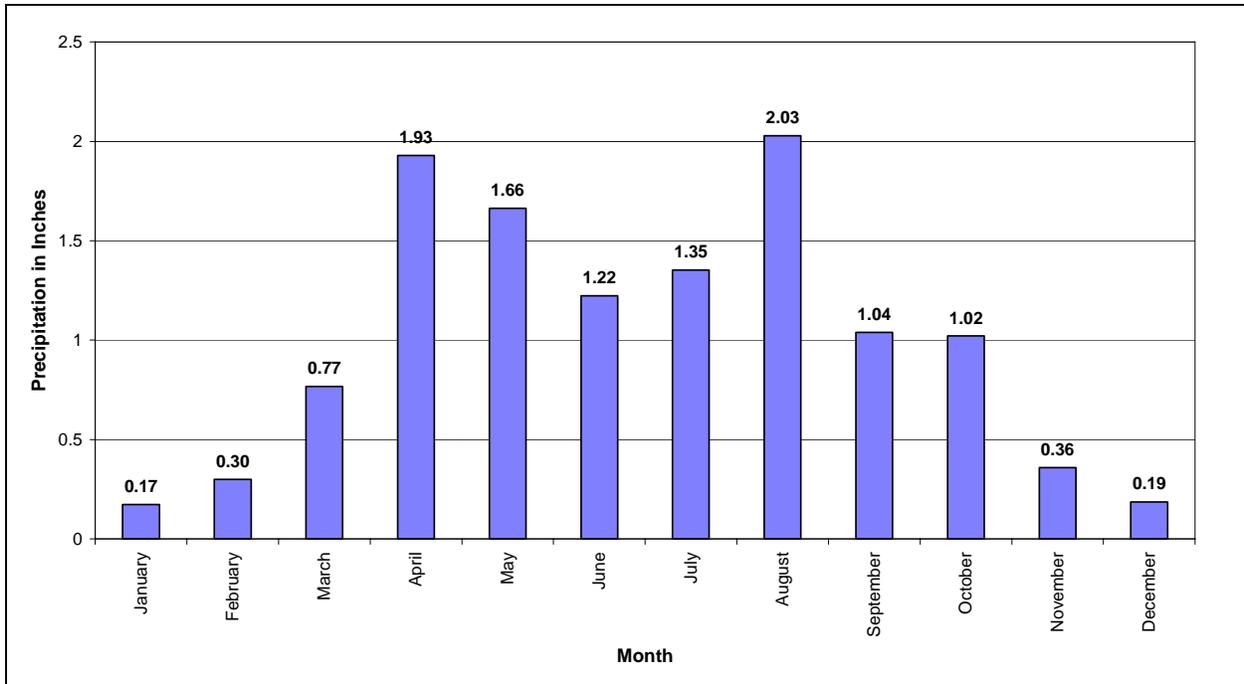
Figure 3–89. Site Precipitation Gages: CY 2008

CY 1997–2008 Summary



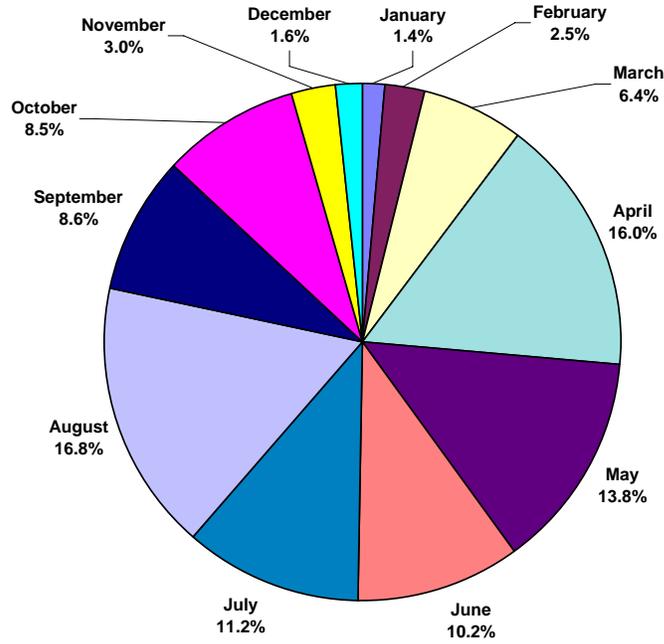
Note: Arithmetic average of gages in operation.

Figure 3–90. Annual Total Precipitation for CY 1997–2008



Note: Arithmetic average of gages in operation.

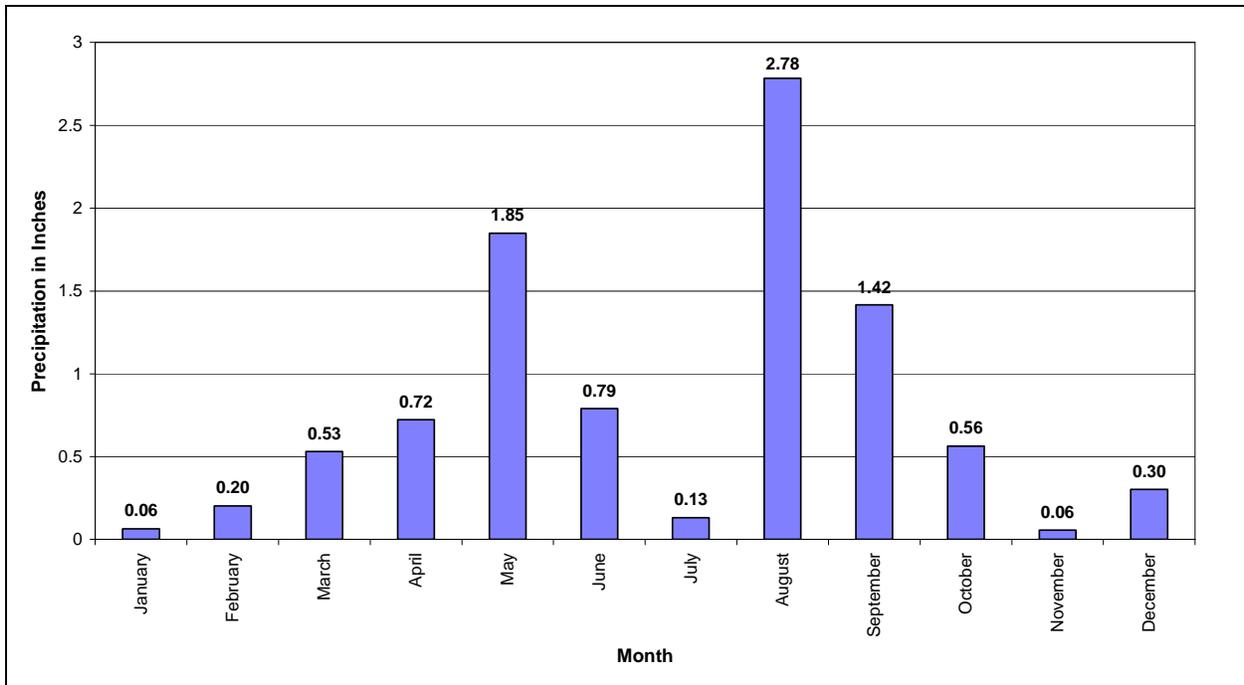
Figure 3–91. Average Monthly Precipitation for CY 1997–2008



Note: Arithmetic average of gages in operation.

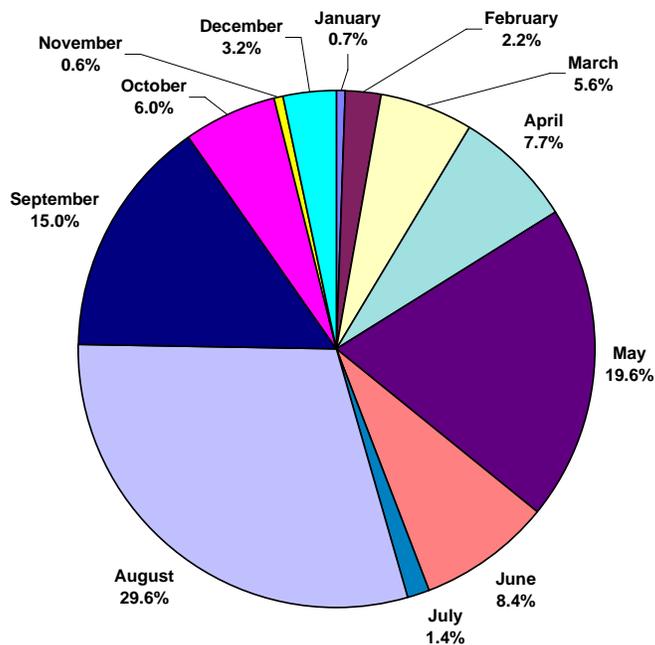
Figure 3-92. Relative Monthly Precipitation Totals for CY 1997-2008

CY 2008 Summary



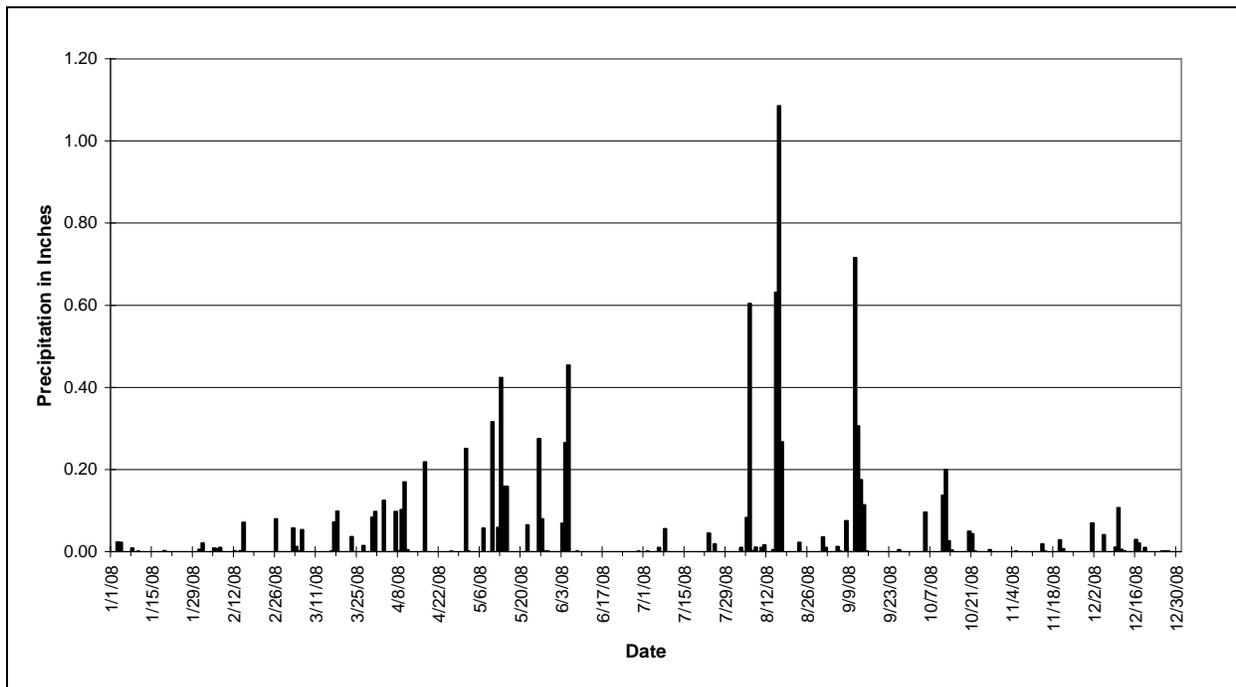
Note: Arithmetic average of gages in operation.

Figure 3-93. Monthly Precipitation for CY 2008



Note: Arithmetic average of gages in operation.

Figure 3–94. Relative Monthly Precipitation Volumes for CY 2008



Note: Arithmetic average of gages in operation.

Figure 3–95. Daily Precipitation Totals for CY 2008

3.1.3.5 Groundwater Flow

This section summarizes groundwater elevations and flow characteristics. Groundwater elevation data are discussed through the construction and interpretation of potentiometric surface maps and hydrographs. Groundwater flow characteristics are then assessed, including flow velocities.

Groundwater Elevations

Groundwater elevation data were collected at the start of the second and fourth quarters in 2008; these data are included in Appendix A. While the vast majority of water levels across the Site are measured manually by field personnel, groundwater elevations are monitored at select wells using dedicated instrumentation. Appendix A contains a discussion of the automated water-level collection.

The second and fourth quarter groundwater elevation data were plotted and hand-contoured to create potentiometric surface maps. The potentiometric surface map for second quarter CY 2008 is included as Figure 3–96, and the map for the fourth quarter of CY 2008 is included as Figure 3–97. These maps are derived from manual water-level measurements.

Monitoring wells at Rocky Flats are screened within the UHSU. The UHSU encompasses unconsolidated surface materials such as Rocky Flats Alluvium, hillslope colluvium, valley-fill alluvium, and artificial fill (all of which are often referred to as “alluvium”), and underlying weathered bedrock (most often the Cretaceous-aged Laramie Formation or the Cretaceous-aged Arapahoe Formation). A well screened entirely within the weathered bedrock may yield different water levels than an adjacent well screened in the alluvium.

Seeps posted on both potentiometric surface maps are from the 1995 Hydrogeologic Characterization Report (EG&G 1995a). This depiction of seeps is the best available map of the seeps for the Site. However, it is no longer accurate, having been most strongly affected by the removal of all artificial water sources, as well as land surface reconfiguration (e.g., excavations and placement of fill) in some areas. Potentiometric surface maps for 2008 are based on many fewer locations than pre-closure years and are, therefore, less detailed in comparison. The areas of interest in post-closure years are the former IA and adjacent areas.

There are several locations on the potentiometric maps labeled as dry. Wells are labeled as dry if they are measured to be dry, or if the water level measured is below the bottom of the screened interval (water below the screen is stagnant and may not reflect the actual groundwater level). The locations labeled as dry may indicate areas that are unsaturated. These areas are a result of limited groundwater, caused by a reduction in recharge from precipitation (e.g., droughts, such as that in 2002) or the reduction in contributions from artificial sources (e.g., removal of water lines, foundation drains, and dust suppression water). However, many wells in the monitoring network do not fully penetrate the UHSU; therefore, a location’s being depicted as dry may not indicate that it is an area of unsaturated UHSU, as the UHSU may be saturated at depths greater than that of the associated well.

Unsaturated areas in 2008 are similar to those depicted in 2007. In general, unsaturated areas in the second and fourth quarters are associated with each of the three groundwater treatment systems. At the SPPTS, wells 70799, 70899, and 70999 were dry. Wells 95299, 95699, and

95899, located in the vicinity of the ETPTS, were also dry, as was well 16199 in the vicinity of the MSPTS. These areas are typically dry due to the dewatering effects of the associated groundwater intercept trenches associated with the treatment systems. Other wells that were observed to be dry in 2008 include 90299, 04091, 37591, and 37691. These wells are historically dry (see the “Hydrographs” section for more details on these wells). Groundwater flow paths in 2008 are consistent with conditions in 2007, as estimated from the potentiometric surface maps (Figure 3–96 and Figure 3–97).

Water levels in 2008 appear to have stabilized following Site closure activities; they no longer appear to be influenced by changes to the foundation drain systems or artificial water sources. Prior to closure, other influences—most particularly, the addition of imported water to the hydrologic system (application of dust suppression waters)—were also major factors in some areas, but this no longer seems to be the case. Water levels in 2008 are influenced by seasonal variations and are more dependent on precipitation than what has been generally observed in former years. Water levels are slightly higher in the second quarter than the fourth quarter because of seasonal influences (recharge from spring precipitation, followed by drier conditions and continuing discharge via baseflow and evapotranspiration). Note that well 45608 is artesian (and has been since installation), as indicated on the potentiometric surface maps. Refer to the “Hydrographs” section for more information on this well.

Precipitation in 2008 was recorded at nine locations across the Site. The “total” precipitation (i.e., as measured by unheated rain gages, which do not accurately reflect precipitation totals related to snowfall) recorded at the Site in CY 2008 was 9.41 inches. This value is about 25 percent less than the historic (1993-2007) average estimated total annual precipitation, which is 12.56 inches. Figure 3–90 summarizes precipitation totals for recent CYs, and displays the total precipitation for 2008. Note that the amount shown for 2003 incorporates March data from the Site’s former 61-meter meteorology tower, which included a heated precipitation gage that recorded precipitation from the multi-foot March 2003 snowstorm more accurately than did the unheated gages operated by the Water Programs Group. See Section 3.1.3.4 for additional discussion of precipitation.

Hydrographs

Water-level measurements provide additional information on the hydrogeologic conditions surrounding the wells, including well recharge patterns. Hydrographs were prepared and are included in Appendix A. Selected hydrographs are discussed here, but it may be helpful to refer to the referenced hydrographs throughout the following discussion.

As discussed above, groundwater levels at select wells across the Site are monitored using dedicated downhole instrumentation. The automated as well as manually collected water-level data were used to generate hydrographs. Therefore, wells equipped with the automated instrumentation are represented by two hydrographs. Appendix A includes the automated water-level hydrographs superimposed over the manual water-level curves.

As in the previous annual reports (DOE 2007e, 2008g) and similar to the treatment of analytical data as discussed above, water-level data for original and replacement wells are combined into a single hydrograph under the assumption that the corresponding data are continuous. (As additional data are collected this assumption may prove to be false at some locations, in which

case the corresponding data will no longer be pooled.) Water-level data used for these hydrographs includes routine, pre-sampling, and special-request measurements.

Water-level elevations were calculated by subtracting the measured depth to water from the surveyed elevation of the top of the well casing. When wells were found to be dry, the water level posted on the hydrograph is equivalent to the elevation of the bottom of the well casing, as calculated from the total depth of well casing recorded during its installation. The same water level is posted when the measured water level is found to be below the bottom of the screened interval, because this water is not in hydraulic connection with saturated materials and is therefore likely not representative.

In the past wells have been grouped and discussed by geographic proximity, hydrologic setting, and contamination plume. In 2008 many of these wells are represented by hydrographs that display a strong seasonal signature; the impacts of Site closure activities are no longer readily apparent. The wells displaying strong seasonal patterns will not be discussed in depth; however there are some variances that will be discussed.

After closure activities in 2005 and with the removal of artificial water sources and sinks, hydrographs display seasonal patterns (DOE 2007e, 2008g). Strong seasonal correlations are best represented by the wells monitoring the buried drainage that hosts the VC Plume upgradient of FC-2 (in particular wells 33604 and 33703) and the North Walnut Creek drainage (wells 51605, 1786, and 10594; note that well 1786 is not in the RFLMA network but has been retained in case SPPTS-related objectives warrant its use as a monitoring point). Hydrographs for these wells display seasonal variations; rising limbs are evident during spring months and falling limbs during winter months. Seasonal variations are most apparent in the post-closure years (2006–2008) for most of the hydrographs. Wells in the North Walnut Creek drainage area also display effects of sampling, which is most apparent in well 00203, located south of the former Solar Evaporation Ponds (SEPs). Water levels drop in May after a sampling event in which this well had to be dewatered. Other wells in the North Walnut Creek drainage area also display similar effects from sampling events, such as 70099, P210089, and 79605.

Although water-level hydrographs generally display seasonal patterns in 2008, some variations are observed, such as the dry conditions seen routinely at the Site, and artesian flow (which is more rare). Hydrographs of wells observed to be dry throughout 2008 include those for wells 90299, 04091, 95299, 37691, and 37591. These wells are all historically dry, with the exception of well 37591. The hydrograph for well 37591, located in the former Contractors' Yard portion of the southeastern IA near former B891, shows a drop in water elevations in post-closure years. The water monitored by this well appears to have been fed by artificial water sources, and after the removal of these sources the area has dewatered.

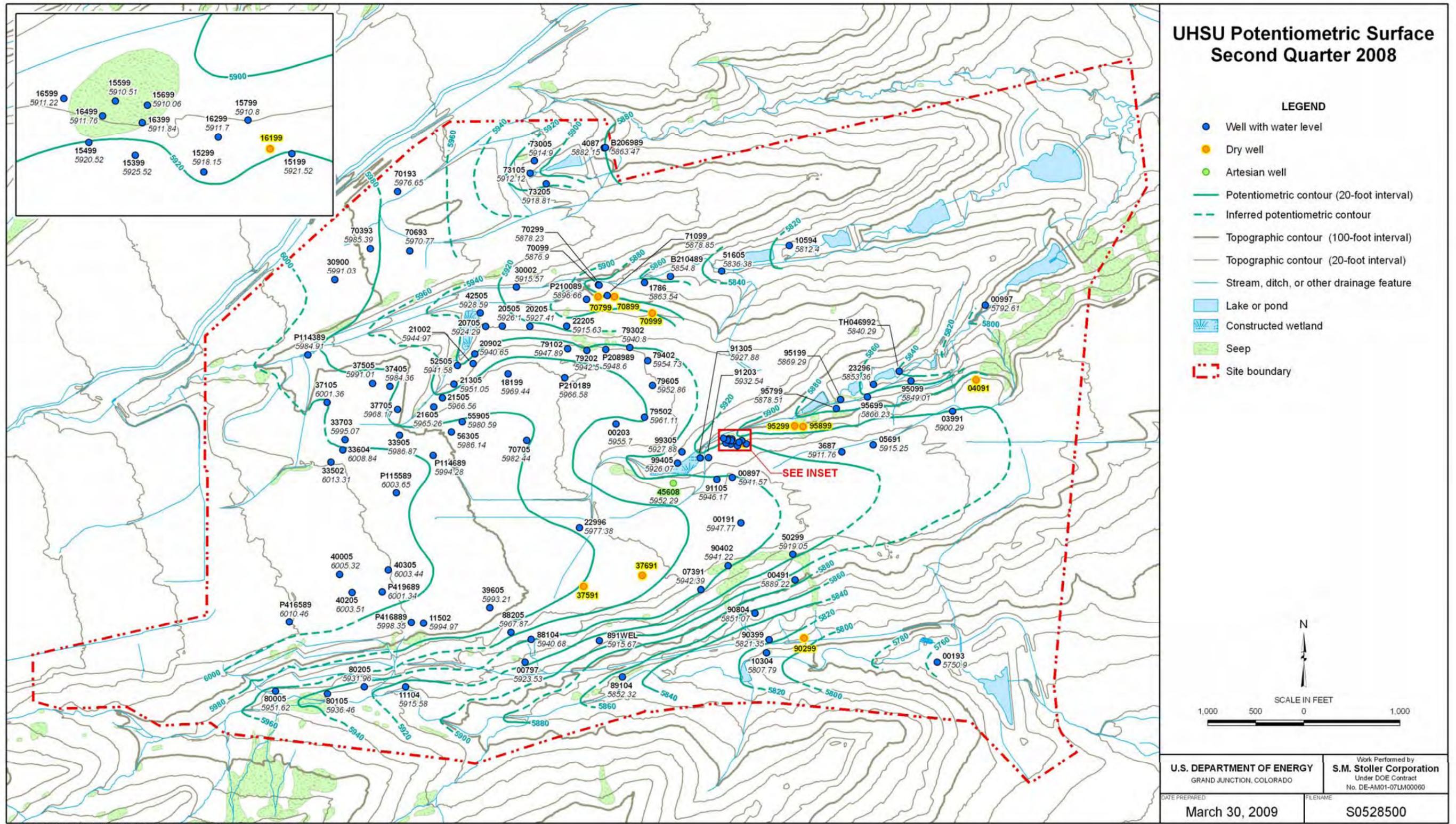


Figure 3-96. UHSU Potentiometric Contours: Second Quarter CY 2008

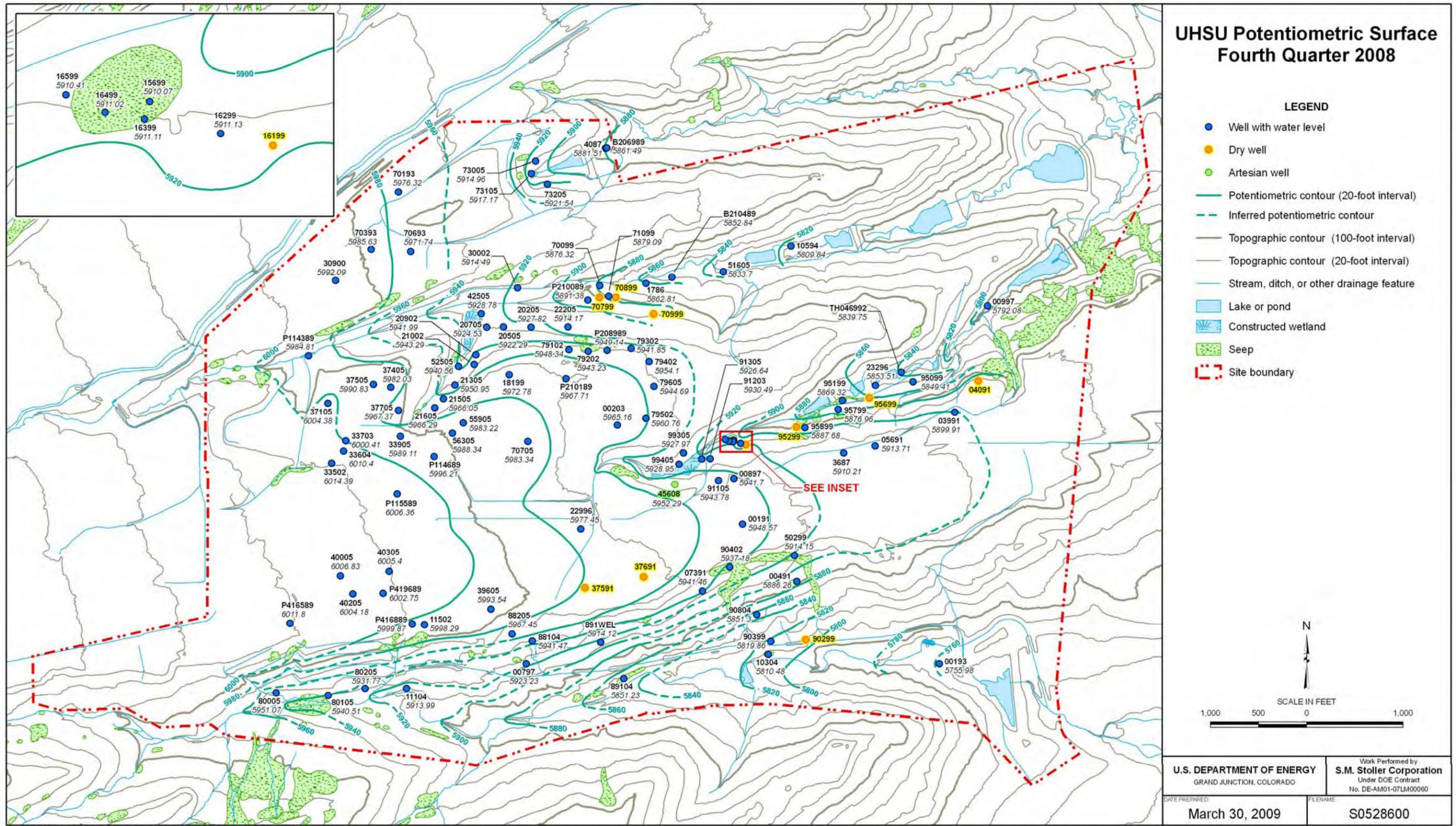


Figure 3-97. UHSU Potentiometric Contours: Fourth Quarter CY 2008

Well 45605, installed to monitor water collected by the disrupted French drain south of former B991, was located within the slump that developed beginning in January 2006. The slump south of former B991 was regraded in 2007 (DOE 2008g). This well was abandoned following fourth-quarter sampling in October 2007, and replacement well 45608 was installed in March 2008 (see Section 3.1.5.4 for more information on this well). While original well 45605 was never observed to have artesian flow, replacement well 45608, located just 9 feet west, has exhibited continuous artesian flow since its installation. Well 45608 therefore appears to intercept the water from the remnants of the French drain and act as an outlet for that collected groundwater. This is possible because the ground surface at well 45608 is now 14 feet lower than it was at original well 45605, due to the hillside regrading. The lower elevation of the top of casing appears to allow waters in the French drain to exit the well as artesian flow. This flow was estimated to be 0.79 gallon per minute (gpm) on May 30, 2008.

As discussed in Section 3.1.1.2, several obsolete or unnecessary wells were abandoned during 2008 (refer to Table 3–1). Of those wells that had been a part of the groundwater monitoring network at closure, water-level data were not collected in 2008 from those that previously supported monitoring of the OU 1 Plume, a well that was downgradient of the MSPTS, and another near the East Shed (southeast of the MSPTS). The other wells are represented by 2008 water-level data, and are represented by hydrographs, as indicated in Table 3–43.

Table 3–43. List of Abandoned Wells with Hydrographs

Location	Date Abandoned	2008 Hydrographs Generated?
TH046992	11/12/08	Yes
70299	8/27/08	Yes
15199	8/25/08	Yes
15299	8/26/08	Yes
15399	8/26/08	Yes
15499	8/26/08	Yes
15599	8/26/08	Yes
15799	8/26/08	Yes

Groundwater Flow Velocities

Groundwater flow directions and velocities in 2008 are generally consistent with those reported in 2007. Flow directions, water-level data, geological information, and completed well designs and locations support the selection of several well pairs for the calculation of linear groundwater flow velocities, also referred to as seepage velocities. Using the potentiometric surface maps, a pair of wells is potentially useful if a line drawn between them is perpendicular (or nearly so) to the potentiometric contour lines between the two wells, and there are no intervening drainages or artificial groundwater control structures (such as the groundwater intercept trenches that are a component of three of the four treatment systems, and the GWIS at the PLF).

Well pairs selected for use in this report are generally the same as those selected in 2007, although several changes were made. Well 21505 was used instead of 21605 as the downgradient pairing to well 56305 in order to better reflect the flow direction indicated by the potentiometric

surface map, and well pair 90299-00491 was not used because well 90299 was dry. In addition, well abandonments eliminated the downgradient wells in each of the following well pairs: 91105-15499, 91105-15399, 00897-15499, and 00897-15399.

The seepage velocity (v) may be calculated using the Darcy equation:

$$v = \left(\frac{K}{n} \right) \left(\frac{dh}{dl} \right)$$

where

K = hydraulic conductivity

n = effective porosity

dh/dl = hydraulic gradient.

This calculation is most sensitive to the hydraulic gradient and value of K used, because for all calculations of v in this report a porosity of 0.1 (consistent with previous Annual RFCA Groundwater Monitoring Reports as well as post-closure RFLMA reports) is used.

The hydraulic gradient was calculated from groundwater elevation data collected in the second and fourth quarters of 2008. Results of this calculation typically differ slightly when using data from one quarter versus that from another, but the differences are typically not large.

Calculated seepage velocities are only useful as estimates. These velocities are most often used to estimate the travel time of conservative (nonreactive) constituents. Reactive constituents will tend to migrate more slowly than the calculated velocity. These calculated velocities do not take into account properties such as sorption and chemical reactions (e.g., precipitation, biodegradation, and volatilization) that can strongly influence the migration rate of groundwater contaminants.

For each well pair, the value of K selected for this calculation was based on the predominant lithologic unit comprising the flow path between the two wells. This is based on the core logs for the respective wells and the published geology (EG&G 1995b), as well as information from the hydrographs (i.e., whether the saturated interval is typically restricted to the bedrock or includes surficial materials). If more than one lithology is represented between the wells and, from the hydrographs, appears to comprise a meaningful fraction of the saturated interval, an average K was calculated from the lithologies. K values used for these calculations are from EG&G (1995a), Table G-2, with subsequently modified values for Rocky Flats Alluvium and valley-fill alluvium (RMRS 2000a; Safe Sites 2001, 2002).

One factor that may cause significant error in estimated seepage velocities is the presence of artificial fill in many portions of the former IA. The K for Rocky Flats Alluvium is used because the source of the fill was typically deposits of Rocky Flats Alluvium. However, it is unlikely that the backfilled alluvium has the internal structure or is as compacted as the original deposits, resulting in a higher effective porosity and K than the published values for Rocky Flats Alluvium. Where well pairs cross former buildings that were backfilled with concrete rubble and alluvium, the effective porosity and K values will be higher still. For this report, well pairs crossing areas of sufficiently thick backfill deposits may use the K for Rocky Flats Alluvium rather than that for the original lithology, under the assumption that the entire area of

backfill/regrading has a hydraulic conductivity closer to that of Rocky Flats Alluvium than to a lower-permeability unit.

An example well pair may serve to illustrate some of the related difficulties. Well 18199 is located between former B776 and B771. It screens Rocky Flats Alluvium and sandstone of the Arapahoe Formation (the “No. 1 Sandstone;” EG&G 1995a). Groundwater in this area previously flowed toward the west as a result of the B771 foundation drain system. Following disruption of this drain, groundwater flow is anticipated to be more northerly, potentially through the rubble- and alluvium-backfilled subsurface remnants of B771. Well 20505 was selected as the downgradient well in this well pair. This well screens artificial fill, clays, claystone, and silty claystone. The transect from 18199 to 20505 is mostly occupied by the artificial fill of the B771 closure, and that fill is essentially reworked alluvium. During the second quarter of 2008, the water level in well 18199 was within the bedrock, while that in well 20505 was within the artificial fill. Therefore, an average hydraulic conductivity of the Arapahoe Formation No. 1 Sandstone (well 18199) and Rocky Flats Alluvium (well 20505) was used to calculate the second quarter seepage velocity between this well pair. Note that during the fourth quarter of 2008, the water level in both wells was within bedrock. The average hydraulic conductivity of the sandstone (well 18199) and claystone (well 20505) was used to calculate the fourth quarter seepage velocity.

As noted above, these calculated velocities are based in part on data displayed on the hydrographs: where water is shown above the bedrock contact, hydraulic conductivities for the unconsolidated surficial material (e.g., Rocky Flats Alluvium or colluvium) are included for this calculation. If the hydrographs show water is typically restricted to the bedrock, the K value for the generalized bedrock type at that well is selected. Note that, similar to the alluvial deposits, the extreme variability of bedrock lithologies (e.g., from claystone to silty claystone to clayey siltstone to siltstone) is often reflected in cores from the screened interval of a given well, but a single K value is selected to represent the well. Table 3–44 presents the results of the calculation of seepage velocities. Refer to Figure 3–1 for the respective locations of the wells. Estimated velocities range from 9 feet per year (ft/yr) (within the siltstone bedrock from well P210189 to well 79102 in the vicinity of the SEPs) to 447 ft/yr (within the artificial fill and sandstone beneath the hillslope from well 18199 to well 20505 in the B771 area). The resulting travel time between each well in a well pair ranges from approximately 10 months (from well 88205 to well 00797 in the vicinity of the 881 Hillside) to over 107 years (from well 40305 at former B444 to well 39605 at former B881). In general, the velocities are comparable to those calculated prior to Site closure (e.g., K-H 2004b), and are also similar to those discussed in 2007. Note that the average velocity between the well pairing 40305-39605 (11.37 ft/yr, or approximately 100 years total travel time) is about half that calculated for the 2007 report. This is because the K values were revised to better represent the bedrock lithology in each of these two wells. For a more detailed discussion of flow between well pairs by area, refer to the 2006 and 2007 annual reports (DOE 2007e and 2008g, respectively).

Table 3-44. Calculated Flow Velocities for 2008

Well Pair	Area	2007 Quarter	Geological Unit	WL Elevation, Well 1	WL Elevation, Well 2	dh (ft)	dl (ft)	dh/dl (hydraulic gradient)	Calculated K (cm/s)	v (ft/yr)	Time to Traverse Transect (yr)
P115589-P114689	North IA	2	Qrf	6003.65	5994.28	9.37	550.14	0.017	4.18E-04	73.66	7.47
P115589-P114689	North IA	4	Qrf	6006.36	5996.21	10.15	550.14	0.018	4.18E-04	79.79	6.89
P114689-56305	North IA/B559	2	Qrf / Qrf/KaKlclst	5994.28	5986.14	8.14	304.74	0.027	3.14E-04	86.70	3.51
P114689-56305	North IA/B559	4	Qrf / Qrf/KaKlclst	5996.21	5988.34	7.87	304.74	0.026	3.14E-04	83.90	3.63
56305-21505	B559	2	Qrf/KaKlclst	5986.14	5966.56	19.58	319.61	0.061	2.09E-04	132.75	2.41
56305-21505	B559	4	Qrf/KaKlclst	5988.34	5966.05	22.29	319.61	0.070	2.09E-04	150.81	2.12
18199-20505	B771	2	KaNo.1ss / Qrf/KaKlclst	5969.44	5926.1	43.34	500.43	0.087	4.99E-04	446.88	1.12
18199-20505	B771	4	KaNo.1ss / KaKlclst	5972.78	5922.29	50.49	500.43	0.101	3.94E-04	411.75	1.22
P416589-80105	OLF	2	Qrf / Qrf/KaKlclst	6010.46	5936.46	74	846.63	0.087	3.14E-04	283.71	2.98
P416589-80105	OLF	4	Qrf / Qrf/KaKlclst	6011.8	5940.51	71.29	846.63	0.084	3.14E-04	273.56	3.09
40305-39605	South IA	2	Qrf/KaKlclst / KaKlclst	6003.44	5993.21	10.23	1126.39	0.009	1.12E-04	10.54	106.89
40305-39605	South IA	4	Qrf/KaKlclst / KaKlclst	6005.4	5993.54	11.86	1126.39	0.011	1.12E-04	12.20	92.32
40005-P419689	South IA	2	Qrf/KaKlclst / Qrf/KaNo.1ss	6005.32	6001.34	3.98	478.87	0.008	4.06E-04	34.93	13.71
40005-P419689	South IA	4	Qrf/KaKlclst / Qrf/KaNo.1ss	6006.83	6002.75	4.08	478.87	0.009	4.06E-04	35.79	13.38
P419689-11502	South IA	2	Qrf/KaNo.1ss / KaKlclst	6001.34	5994.97	6.37	535.27	0.012	3.02E-04	37.18	14.40
P419689-11502	South IA	4	Qrf/KaNo.1ss / KaKlclst	6002.75	5998.29	4.46	535.27	0.008	3.02E-04	26.04	20.56
40305-22996	South IA/ 800 Area	2	Qrf/KaKlclst / Qrf ^a	6003.44	5977.38	26.06	2037.05	0.013	3.14E-04	41.52	49.06
40305-22996	South IA/ 800 Area	4	Qrf/KaKlclst / Qrf ^a	6005.4	5977.45	27.95	2037.05	0.014	3.14E-04	44.58	45.70
88205-00797	881 Hillside	2	Qrf/KaKlclst / Qrf	5967.87	5923.53	44.34	343.12	0.129	3.14E-04	419.83	0.82
88205-00797	881 Hillside	4	Qrf/KaKlclst / Qrf	5967.45	5923.23	44.22	343.12	0.129	3.14E-04	418.69	0.82
00191-00491	903 Pad-Lip	2	Qrf/KaKlclst	5947.77	5889.22	58.55	816.98	0.072	2.09E-04	155.30	5.26
00191-00491	903 Pad-Lip	4	Qrf/KaKlclst	5948.57	5886.26	62.31	816.98	0.076	2.09E-04	164.92	4.95

Table 3-44 (continued). Calculated Flow Velocities for 2008

Well Pair	Area	2007 Quarter	Geological Unit	WL Elevation, Well 1	WL Elevation, Well 2	dh (ft)	dl (ft)	dh/dl (hydraulic gradient)	Calculated K (cm/s)	v (ft/yr)	Time to Traverse Transect (yr)
07391-10304	Ryan's Pit/ Woman Ck.	2	Qc/KaKlclst	5942.39	5807.79	134.6	948.74	0.142	4.71E-05	69.12	13.73
07391-10304	Ryan's Pit/ Woman Ck.	4	Qc/KaKlclst	5941.46	5810.48	130.98	948.74	0.138	4.71E-05	67.28	14.10
91105-91203	Oil Burn Pit #2	2	Qrf/KaKlslt / KaKlclst	5946.17	5932.54	13.63	242.17	0.056	1.12E-04	65.30	3.71
91105-91203	Oil Burn Pit #2	4	Qrf/KaKlslt / KaKlclst	5943.78	5930.49	13.29	242.17	0.055	1.12E-04	63.59	3.81
P210189- 79102	SEPs	2	KaKlslt / KaKlclst	5965.84	5947.89	17.95	301.98	0.059	1.48E-05	9.13	33.09
P210189- 79102	SEPs	4	KaKlslt / KaKlclst	5967.71	5948.34	19.37	301.98	0.064	1.48E-05	9.82	30.74
79102-22205	North of SEPs	2	KaKlclst / KaKlslt	5947.89	5915.63	32.26	235.62	0.137	1.48E-05	20.97	11.24
79102-22205	North of SEPs	4	KaKlclst / KaKlslt	5948.34	5914.17	34.17	235.62	0.145	1.48E-05	22.21	10.61
79502-99305	SEPs/B991	2	KaKlclst / Qrf/KaKlclst	5961.11	5927.88	33.23	532.37	0.062	1.05E-04	67.91	7.84
79502-99305	SEPs/B991	4	KaKlclst / Qrf/KaKlclst	5960.76	5927.97	32.79	532.37	0.062	1.05E-04	66.91	7.96
70393-70693	PU&D/PLF	2	Qrf	5985.39	5970.77	14.62	410.48	0.036	4.18E-04	154.04	2.66
70393-70693	PU&D/PLF	4	Qrf	5985.63	5971.74	13.89	410.48	0.034	4.18E-04	146.35	2.80
30900-30002	PU&D/ N. Walnut Ck.	2	Qrf/KaNo.1ss / KaKlclst	5991.03	5915.57	75.46	1890.74	0.040	3.02E-04	124.68	15.16
30900-30002	PU&D/ N. Walnut Ck.	4	Qrf/KaNo.1ss / KaKlclst	5992.09	5914.49	77.6	1890.74	0.041	3.02E-04	128.24	14.74

Notes: WL = water level; dh (ft) = difference in height, in feet; dl (ft) = distance between wells, in feet; cm/s = centimeters per second; v (ft/yr) = velocity in feet per year; yr = years.
Qrf = Rocky Flats Alluvium; Qc = colluvium; KaNo.1ss = Arapahoe Formation No. 1 Sandstone; KaKlclst = undifferentiated Arapahoe/Laramie Formation claystone; KaKlslt = undifferentiated Arapahoe/Laramie Formation siltstone.

^aBedrock lithology estimated due to incomplete core log for well 22996.

In the one case where a well pairing changed from 2007 (current well pair 56305-21505 that replaced pair 56305-21605, mentioned above), calculated flow velocities decreased from an average of approximately 181 ft/yr using the previous pairing to approximately 142 ft/yr. This change was made because well pair 56305-21505 reflects a more viable flow path (more nearly perpendicular to potentiometric contours) than the previous pairing.

All Evaluation wells were sampled in 2008, and therefore new information regarding contaminant transport is available for most source areas. As discussed in more detail in Section 3.1.5, contaminant concentrations are largely consistent with those reported in previous years.

Velocities and travel times were calculated for a well pair in the Ryan's Pit Plume (source-area Evaluation well 07391 to AOC well 10304). Both were sampled in 2008. Analytical data from samples collected in 2008 from well 10304 did not confirm a detection of TCE reported in the latter well in 2007, suggesting that the 2007 result was not an indication that the leading edge of the Ryan's Pit/903 Pad Plume had reached this well. However, more data will be required to confirm this.

In the Individual Hazardous Substance Site (IHSS) 118.1 area, data from well 20505 (downgradient from source-area well 18199) continued to show no detections of carbon tetrachloride or chloroform, the most notable contaminants from IHSS 118. Seepage velocities summarized in Table 3-44 indicate that these contaminants could have been detected in well 20505 beginning in 2006, but this has still not occurred. This may be evidence of contaminant retardation, or it could indicate that groundwater is being diverted in another direction or that these constituents are being degraded before they reach well 20505. While the flow path from 18199 to 20505 appears reasonable, groundwater may be diverted by the presence of disrupted foundation drains and associated corridors, the backfilled B771, and backfilled/disrupted subsurface utility corridors around the sides of the building.

In the former SEP area, travel times for a potential southeastern route for nitrate contamination were calculated to be slightly less than 8 years, using the 79502-99305 well pairing. Although the results from 2008 sampling included the highest nitrate concentration detected in samples from well 99305 (1.1 mg/L in June, 0.77 mg/L in November), these concentrations do not suggest that the potential flow path from 79502 to 99305 represents a significant transport mechanism for the SPP.

Overall, groundwater flow paths and flow velocities in 2008 show little change from previous years.

3.1.4 Surface-Water Data Interpretation and Evaluation

3.1.4.1 Surface Water-Quality Summaries

This section presents water-quality summaries for select analytes for the period January 1, 1997, through December 31, 2008 (CY 1997-2008), for the locations operational in CY 2008.