Event Mean Concentrations of Stormwater Runoff From Rural Roadways in Florida

Alachua, Jackson, Leon, Orange and Seminole Counties

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TABLE OF CONTENTS

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

The Florida Department of Environmental Protection (FDEP) and the five water management districts utilize event mean concentration (EMC) values determined from a variety of studies to calculate pollutant loads from Florida Department of Transportation (FDOT) roadways. These loads are used in a number of different ways, including environmental resource permitting (ERP), total maximum daily load (TMDL) development and calculation of basin management action plan (BMAP) load allocations. Inaccurate load estimates have significant cost implications when they are used to identify FDOT's responsibility for load reductions associated with TMDL implementation or mitigation for pollutant loads in the permitting process. Most of the data used for development of the statewide EMCs are based on studies of urban (curb and gutter) sections of road with high percentages of impervious area, substantially different from rural conditions. FDOT had concerns that the statewide EMCs were not representative of its many rural roadways.

Storm event sampling was conducted at five rural highway sites with the primary objective of determining whether or not there was a difference in total nitrogen (TN) and total phosphorus (TP) EMCs from rural roads versus urban roads. A total of 131 samples were collected, including 7 first-flush samples, at five rural roadway sites in Alachua, Jackson, Leon, Orange and Seminole Counties. Samples were evaluated for TN, nitrates, ammonia nitrogen, total Kjeldahl nitrogen (TKN), TP, cadmium, chromium, copper, lead, zinc, and total suspended solids (TSS), and hardness. Nutrient and metal EMC values for each site were developed using the 124 samples that were not considered first flush. Nutrient EMCs for each of the five study sites are presented in Table ES-1, and metal EMCs are provided in Table ES-2.

EMC values from the five sites in this study were used to update the statewide highway EMC values. The revised highway EMCs are presented in Table ES-3. These revised EMC values incorporate changes Applied Technology and Management, Inc. (ATM) recommended in its report entitled "Determination of Appropriate Highway EMC Values for Use within FDOT District 1" (ATM, 2010). ATM's investigation included of a detailed review of the studies and data used to develop the statewide EMCs. The report is included as Appendix F.

Sampling results from this study indicate the following:

1. There was not a discernible difference in the TN EMCs at the five rural sites [0.631 to 2.5 milligrams per liter (mg/L)] compared with the TN EMCs for other sites in the statewide database (0.635 to 2.15 mg/L). The percent of nitrates and ammonia nitrogen at three of the five rural sites was 20 percent or less compared with up to 70 percent for urban roads. Lower levels of inorganic nitrogen suggested a lower relative level of anthropogenic input but also likely reflected the increased contact with vegetated areas of the right-of-way for the study sites with lower impervious areas.
2. There appeared to be a slight positive correlation between average annual daily traffic (AADT) and nitrates in roadway runoff, suggesting that increased nitrogen oxides in the atmosphere due to combustion converted to nitrates upon contact with water and led to elevated nitrates in stormwater. Byproducts from vehicles on FDOT roadways, however, represented only a portion of combustion activities that may contribute to nitrogen oxides in the atmosphere. Surrounding population density and vehicle use on non-FDOT facilities as well as contributions from other combustion sources, e.g., power plants, were also potential contributors to atmospheric nitrogen.
3. The State Road (SR) 61 location within the Wakulla Springs BMAP area had a median nitrate concentration of 0.143 mg/L. This was well below the TMDL nitrate target of 0.35 mg/L, so it was unlikely that untreated direct discharges from FDOT facilities in the springshed were contributing to the impairment.
4. The County Road (CR) 236 location within the Santa Fe River BMAP area had a median nitrate concentration of 0.287 mg/L. This was below the TMDL nitrate target of 0.35 mg/L, so it was unlikely that untreated direct discharges from FDOT facilities in the springshed were contributing to the impairment.
5. High levels of bed sediment phosphorus (BSP) in four of the rural sampling site drainage areas might have been partially responsible for substantially elevated TP EMCs at these four locations. BSP is a measure of the amount of naturally occurring phosphorus contained within the soils underlying the watershed that drains to the sampling point. This suggested that for areas with high phosphorus soils, a considerable portion of the TP load might have been due to natural conditions and included a high percent of phosphorus that is not biologically available. It is likely that

the impact that soils had on the TP EMC was greater in areas with lower impervious surfaces because there was greater contact between the water and the soil.

6. In the absence of anthropogenic inputs of phosphorus, e.g., fertilizers, sites with low impervious areas and low BSP were expected to yield low TP EMCs.
7. The heavy metal concentrations in untreated runoff from these five rural roadway study sites were considerably lower than the EMCs presented in Harper and Baker (2007) for urban roads.

Researchers have investigated the water quality of highway runoff in Florida for more than 35 years in conjunction with a variety of research objectives, including studies specifically designed to determine highway EMC values. Runoff data, including results from this study, consistently showed a high degree of variability between different events. Regional variability was also an important consideration for both TN and TP. Rural roads in less populated areas such as the three sites at CR 236, I-10, and SR 61 will likely have TN EMCs comparable to other more populated areas, but the speciation of nitrogen is expected to favor more naturally occurring sources with less biologically available nitrogen. With TP EMCs, runoff from rural highways appeared to be substantially impacted by the amount of phosphorus in the underlying sediments, so that much of the input from highway runoff was from naturally occurring sources. In the application of EMCs for the purpose of assessing loads from FDOT facilities, the following actions are recommended.

1. Incorporate the recommendations of ATM's 2010 report entitled "Determination of Appropriate Highway EMC Values for Use within FDOT District 1" (see Appendix F) and the results of this study to update the statewide EMC table.
2. Where data are available for older studies used to determine the statewide EMCs, replace average values with median values for TN and TP because median values are more representative of central tendency.
3. Where data are available, use regional or local values in lieu of generalized statewide values to calculate nutrient loads from highways.
4. Continue to update the statewide EMC values as additional data become available.
5. Promote recognition that not all nitrogen and phosphorus are created equal. In areas demonstrated or expected to have runoff influenced by naturally occurring conditions, e.g., low percent of inorganic nitrogen relative to TN or high TP due to underlying soil conditions, work with regulators to identify management actions that

target anthropogenic sources and reductions that are likely to lead to water quality improvements.

Table ES-1. Summary of Nutrient Water Quality Data

Location	NOx Sample Median (mg/L)	NOx % of TN load	NH4 Sample Median (mg/L)	NH4 % of TN load	TKN Sample Median (mg/L)	Org N Sample Median (mg/L)	Org N % of TN load	TN Sample Median (mg/L)	TP Sample Median (mg/L)
CR 236	0.287	20	0.080	4	1.58	1.487	76	1.83	1.02
SR 61	0.143	16	NC	5	1.08	1.01	79	1.27	0.425
SR 8	0.052	13	NC	3	0.591	0.591	84	0.631	0.116
SR 417	0.580	29	0.025	1	0.940	0.940	70	1.60	0.410
SR 429	0.545	15	0.155	7	1.90	1.780	78	2.50	0.769
First Flush	0.953		0.255		2.70	2.39		4.10	0.786

NC - median value not calculated.

Table ES-2. Summary of Metals EMCs based on Sample Median

Location	Cadmium (µg/L)	Chromium (µg/L)	Copper (µg/L)	Lead (µg/L)	Zinc (µg/L)
CR 236	NC	2.6	2.6	4.8	29.8
SR 61	NC	1.80	2.00	1.07	7.50
SR 8	NC	NC	1.53	NC	6.90
SR 417	NC	1.4	3.5	0.43	19
SR 429	NC	NC	4.5	0.68	47
First Flush	NC	3.2	4.5	3.8	33.2

NC - median value not calculated.

Table ES-3. Updated Statewide EMCs

Location	Reference	Dates of Sample Collection	Number of Events Sampled	Drainage Area (acres)	% Impervious	Average Daily Traffic	2012 Average Daily Traffic	Range of Rainfall for Events Sampled (inches)	TN (mg/L)	TP (mg/L)	Bed Sediment Phosphorus (ppm) Average (Range)	EMC Statistic Used
Broward County (6-lane)	Hardee et al. (1978)	April 1975-July 1977	45	58.3	36%	20,000	53,000	0.06-2.50	0.635	0.057	187 (100 - 200)	Median
Maitland Blvd	German (1983)	April 1975-April 1979 (Samples collected in April, August, and December)	13-18	16.8[1]	Not specified	Not specified	53,500	Not specified	1.30	0.240	534 (0 - 3840)	Median
I-4 Maitland Interchange	Harper (1985); Yousef et al. (1986)	April 1983-May 1984	16	3.95[2]	100%	15,000	17,500	0.33-3.23	1.40	0.170	499 (221 - 768)	Mean
Winter Park I-4	Harper (1990)	January 1987-January 1988	10	1.17	100%	60-70,000	140,000	0.08-2.19	1.60	0.230	534 (0 - 3840)	Mean
Orlando I-4	Harper (1990)	January 1987-December 1987	13	1.30	70%	60-70,000	195,773	0.04-2.77	2.15	0.550	534 (0 - 3840)	Mean
Bayside Bridge - Tampa	Stoker (1996)	August 1993 - September 1995	24	12.9	100%	36-56,000	58,500	0.12-3.15	1.10	0.100	537 (70 - 3122)	Median
Tallahassee	ERD (2000)	July 1999-November 1999	11	1.0	90%	Not specified	48,500	Not specified	1.10	0.166	626 (100 - 3084)	Mean
Orlando - US 441[3]	ERD (2005) - unpublished data	April 2004-August 2004	23	12	74%	NA	28,000	NA	0.683	0.085	NA	NA
Richard Road (Lee County)	Johnson Engineering (2006)	Dec 2004-Nov 2005	9	7.56	49%	33,000	26,500	0.32-3.21	1.68	0.247	633 (184 - 2040)	Median
US 41 (Lee County)	Johnson Engineering (2008)	Sept 2005-August 2006	6	6.89	62%	61,000	61,000	0.25-1.03	0.666	0.109	633 (184 - 2040)	Median
Labelle (Hendry County)	Johnson Engineering (2009a)	August 2006-Oct 2007	7	6.80	84%	9,000	14,900	0.16-4.40	1.10	0.129	633 (184 - 2040)	Median
Flamingo Drive (Collier County)	Johnson Engineering (2009b)	April 2007-Sept 2007	8	16.95	65%	28,500	23,500	0.19-2.47	0.881	0.049	302 (221 - 352)	Median
I-75, Exit 404 - Alachua County	ATM	April 2010-Oct 2011	27	7.4	29%	37,500	37,500	0.28-3.06	1.83	1.02	534 (0 - 3840)	Median
State Road 61 - Leon County	ATM	Sept 2010-Jan 2013	27	4.5	33%	10,846	10,846	0.38-2.54	1.27	0.425	626 (100 - 3084)	Median
I-10, Exit 152 - Jackson County	ATM	February 2012-August 2013	25	3.3	30%	19,100	19,100	0.42-3.47	0.631	0.116	363 (0 - 968)	Median
State Road 417 - Seminole County	ATM	June 2010-May 2013	23	22.9	30%	40,300	40,300	0.59-6.38	1.60	0.410	540 (233 - 950)	Median
State Road 429 - Orange County	ATM	August 2010-May 2013	22	9.7	32%	29,000	29,000	0.48-3.18	2.50	0.769	534 (0 - 3840)	Median
Geometric Mean									1.20	0.198		

[1] Drainage area is estimated.

[2] Represents just the area draining to the sampling point at the retention pond.

[3] Report and data not available for review. Information based on Harper and Baker (2007), Table 4-10.

Rural highway study sites.

NA = not available.

Sources: Harper and Baker (2007); Johnson Engineering (2006; 2008; 2009a; 2009b); Terziotti et al. (2010).

1.0 INTRODUCTION

1.1 STUDY BACKGROUND

The Florida Department of Environmental Protection (FDEP) and the five water management districts utilize event mean concentration (EMC) values determined from a variety of studies to calculate pollutant loads from Florida Department of Transportation (FDOT) roadways. These loads are used in a number of different ways, including environmental resource permitting (ERP), total maximum daily load (TMDL) development and calculation of basin management action plan (BMAP) load allocations. Inaccurate load estimates have significant cost implications when they are used to identify FDOT's responsibility for load reductions associated with TMDL implementation or mitigation for pollutant loads in the permitting process.

Roadway EMCs currently used by the agencies are based primarily upon results from Harper and Baker (2007). In 2010, the roadway nutrient EMCs were updated to include the results of four roadway studies conducted in southwest Florida for FDOT District 1. The studies used to develop the nutrient EMCs currently in use are summarized in Table 1-1. FDOT is concerned that these urban EMCs are not representative of its many rural roadways. Most of the data used for development of the statewide EMCs are based on studies of urban (curb and gutter) sections of road with high percentages of impervious area, substantially different from rural conditions. Therefore, FDOT sought to gather additional data from rural roadways throughout the state to expand upon the existing EMC database. The results of this investigation are presented in this report.

1.2 STUDY OBJECTIVES

The primary objective of this study was to determine whether there are substantive differences between nutrient EMCs, primarily total nitrogen (TN) and total phosphorus (TP), measured from rural roadways versus those measured from urban roadways. Study results can be used to enhance and improve the existing statewide database of nutrient EMCs. In addition, runoff concentrations of five heavy metals, chromium, cadmium, copper, lead, and zinc were measured and EMCs were developed. Total suspended solids (TSS) and hardness were also measured.

Table 1-1. Characteristics of Stormwater Sampling Sites Currently Used to Determine Highway EMCs

Location	Reference	Dates of Sample Collection	Number of Events Sampled	Drainage Area (acres)	% Impervious	Average Daily Traffic	2012 Average Daily Traffic	Range of Rainfall for Events Sampled (inches)	TN (mg/L)	TP (mg/L)	Bed Sediment Phosphorus (ppm)	EMC Statistic Used
Broward County (6-lane)	Hardee et al. (1978)	April 1975-July 1977	45	58.3	36%	20,000	53,000	0.06-2.50	0.96	0.077	187	Mean
I-95 Miami bridge	McKenzie and Irwin (1983)	Nov 1979 (1 event); Mar 1981 (1 event); May 1981 (2 events)	4	1.43	100%	70,000	54,500	0.08-0.65	3.20	0.160	187	Median
Maitland Blvd	German (1983)	April 1975-April 1979 (Samples collected in April, August, and December)	13-18	16.8[1]	Not specified	Not specified	53,500	Not specified	1.30	0.240	534	Median
I-4 Maitland Interchange[2]	Harper (1985)	April 1983-May 1984	16	3.95[2]	100%	31,400[4]	17,500	0.33-3.23	1.40	0.170	499	NA
I-4 Maitland Interchange	Yousef et al. (1986)	April 1983-May 1984	16	48.9[3]	Not specified	15,000	17,500	0.33-3.23	1.40	0.170	499	NA
I-4 Epcot Interchange	Yousef et al. (1986)	June 1983 - November 1984	14	20.5	Not specified	Not specified	58,500	Not specified	3.16	0.420	353	NA
Winter Park I-4	Harper (1990)	January 1987-January 1988	10	1.17	100%	60-70,000	140,000	0.08-2.19	1.60	0.230	534	Mean
Orlando I-4	Harper (1990)	January 1987-December 1987	13	1.30	70%	60-70,000	195,773	0.04-2.77	2.15	0.550	534	Mean
Bayside Bridge - Tampa	Stoker (1996)	August 1993 - September 1995	24	12.9	100%	36-56,000	58,500	0.12-3.15	1.10	0.100	537	Median
Tallahassee[5]	ERD (2000)	July 1999-November 1999	11	1.0	90%	NA	48,500	NA	1.10	0.166	626	Mean
Orlando - US 441[5]	ERD (2005) - unpublished data	April 2004-August 2004	23	NA	NA	NA	28,000	NA	0.683	0.085	NA	NA
Richard Road (Lee County)	Johnson Engineering (2006)	Dec 2004-Nov 2005	9	7.56	49%	33,000	26,500	0.32-3.21	1.56	0.279	633	Mean
US 41 (Lee County)	Johnson Engineering (2008)	Sept 2005-August 2006	6	6.89	62%	61,000	61,000	0.25-1.03	0.832	0.121	633	Mean
Labelle (Hendry County)	Johnson Engineering (2009a)	August 2006-Oct 2007	7	6.80	84%	9,000	14,900	0.16-4.40	1.306	0.17	633	Mean
Flamingo Drive (Collier County)	Johnson Engineering (2009b)	April 2007-Sept 2007	8	16.95	65%	28,500	23,500	0.19-2.47	0.937	0.060	302	Mean
								Geometric Mean	1.37	0.167		

[1] Drainage area is estimated.
[2] Represents just the area draining to the sampling point at the retention pond.
[3] Includes total area draining to the retention pond.
[4] Includes both east and westbound traffic.
[5] Report and data not available for review. Information based on Harper and Baker (2007), Table 4-10.

NA = not available.

Sources: Harper and Baker (2007); Johnson Engineering (2006; 2008; 2009a; 2009b); Terziotti et al. (2010).

2.0 METHODOLOGY

2.1 SITE SELECTION AND DESCRIPTIONS

Sites were evaluated and selected based on several criteria. The most important requirement was to identify rural sites with low percentages of impervious surface that did not receive any offsite runoff. In addition, to the extent possible, sites with varying soil types were sought. Two sites that were selected initially, one on State Road (SR) 44 in Volusia County and one on SR 77 north of Panama City in Bay County, had to be relocated after several months of unsuccessful attempts to collect valid samples. The 30-inch submerged pipe at SR 44 did not generate sufficient velocities during storm events to get acceptable flow measurements, and the dry pipe at SR 77 had severe sedimentation problems that could not be fixed despite numerous attempts. Sampling sites are presented in Figure 2-1.

2.1.1 I-75 AT COUNTY ROAD 236, ALACHUA COUNTY

The sampling site in Alachua County was located at Exit 404 off Interstate (I) 75 (Figure 2-2), about 4 miles northwest of the town of High Springs. This site was within the boundary of the Santa Fe River BMAP planning area in waterbody segment (WBID) 3638, an unnamed slough to the Santa Fe River. The BMAP addresses nutrient, specifically nitrate, and dissolved oxygen impairments in the Santa Fe River and associated springs.

The basin upstream of the flow collection point was approximately 7.4 acres and included 740 linear feet of the three southbound lanes of I-75, a portion of the southwest “cloverleaf,” a portion of the southbound on-ramp, a portion of the southbound off-ramp, and approximately 530 linear feet of County Road (CR) 236. Impervious area was estimated to be 29 percent. The sample collection point was inside an 18-inch concrete culvert that discharged to a concrete-lined ditch that ultimately drained to a wooded/swampy area west of the interchange and north of CR 236. The estimated average annual daily traffic (AADT) for this location was 37,500 in 2012.

2.1.2 STATE ROAD 61, LEON COUNTY

The sampling site in Leon County was located on SR 61 approximately 7.5 miles north of I-10 (Figure 2-3). This site was within the upper portion of the Wakulla Springs BMAP planning area in WBID 611. The Wakulla BMAP addresses a nutrient, specifically nitrate, impairment in the Upper Wakulla River and Wakulla Springs. No impairments were identified for WBID 611.

Two sampling configurations were used at this site. The first setup placed the flow sensor in a submerged 36-inch corrugated pipe that discharged into a wet pond. The original drainage area included approximately 1,950 linear feet of both northbound and southbound lanes of SR 61. Collection of a valid sample under the initial setup required very heavy rainfall to generate sufficient flow in the pipe. It became apparent that this setup would not yield the required number of samples with the desired range of rainfall and runoff. Three usable samples were collected between September 2010 and July 2011 before the sample collection point was relocated to the concrete ditch adjacent to the wet pond prior to discharge into the pond. The change in sampling location reduced the total drainage area to about 4.5 acres by eliminating the southbound lanes and right-of-way and slightly less than one-half of the central median area. Impervious area was estimated to be 33 percent. The estimated AADT for this location was 10,846 in 2012.

2.1.3 I-10 AT STATE ROAD 69, JACKSON COUNTY

The sampling site in Jackson County was located adjacent to the westbound off-ramp of Exit 152 (Grand Ridge / Blountstown) on I-10 (Figure 2-4) in WBID 439, Jenkins Creek. The site was not within any BMAP planning area, and no impairments were identified for the WBID.

The basin upstream of the flow collection point was approximately 3.3 acres and included approximately 800 linear feet of the two westbound traffic lanes and north right-of-way. Impervious area was estimated to be 30 percent. The sample collection point was positioned to avoid an agricultural area adjacent to the north boundary of the right-of-way. Flow at the collection point was directed through a box flume to develop sufficient water depth for sample collection. The estimated AADT for this location was 19,100 in 2012.

2.1.4 STATE ROAD 417, SEMINOLE COUNTY

The sampling site in Seminole County was located on Toll Road 417 (SR 417) maintained by the Florida Turnpike Enterprise (Figure 2-5). The site was within the Lake Jesup BMAP planning area in WBID 2999, Bear Creek. Bear Creek is a tributary to Howell Creek, which drains into Lake Jesup. No impairments were identified for Bear Creek.

The basin upstream of the flow collection point was 22.9 acres and included approximately 3,500 linear feet of both northbound and southbound lanes and rights-of-way. Impervious area was estimated to be 30 percent. The sampling collection point was inside a 36-inch corrugated metal outfall pipe into a predominantly dry pond. The estimated AADT for this location was 40,300 in 2012.

2.1.5 STATE ROAD 429, ORANGE COUNTY

The sampling site in Orange County was located on Toll Road 429 (SR 429), operated by the Orange County Expressway Authority (Figure 2-6). The site was within the overlapping area of the Upper Ocklawaha and Wekiva River BMAP planning areas in WBID 2835B, the drainage area to Lake Apopka.

The basin upstream of the flow collection point was about 9.7 acres and included approximately 1,800 linear feet of northbound lanes and right-of-way and 2,100 linear feet of southbound lanes and right-of-way. Impervious area was estimated to be 32 percent. The sample collection point was inside a 30-inch corrugated metal culvert outfall pipe into a dry pond. The estimated AADT for this location was 29,000 in 2012.

2.2 SAMPLING EQUIPMENT

All five sampling sites used the same basic equipment for water quality sample collection. Automated, refrigerated, programmable ISCO Avalanche 6712 samplers were used at each of the five sites to collect flow-weighted and composited water quality samples from storm runoff events. Peripheral equipment connected to the sampler included an ISCO 674 rain gage and an ISCO 750 series low-profile area velocity flow module and sensor. A deep-cycle 12-volt battery connected to a solar panel powered the sampler. When a sample was collected, field personnel were notified via text message from a global system for mobile communications (GSM) modem attached to the sampler. For site locations where the Avalanche sampler could not be enclosed inside a security fence, samplers were secured in locked, fiberglass boxes. A typical sampler and site setup is shown in Figure 2-7.

2.2.1 AUTOMATED SAMPLERS

ISCO refrigerated Avalanche samplers were programmed to collect flow-weighted composite samples at each of the sites. Sampling events can be triggered based on velocity, discharge, level, rainfall, or a combination of these factors. Sampling programs and event triggers were optimized for each site based on that site's individual characteristics. Periodic adjustments were made at the beginning of the study as the flow behaviors for each site became better understood. Peripheral equipment was connected to each sampler to collect rainfall, velocity, level, and flow information.

2.2.2 FLOW MONITORING EQUIPMENT

ISCO 750 low-profile flow modules were connected to the Avalanche samplers and secured inside the outfall pipe or to the bottom of the drainage ditch. The 750 modules record level and velocity and calculate flow using information provided on the discharge pipe or channel shape.

2.2.3 RAIN GAUGE

An ISCO Model 674 rain gauge was connected directly to the Avalanche sampler. This tipping-bucket style rain gauge was capable of measuring rainfall in increments of 0.01 inch for rainfall intensities of up to 22 inches per hour (inch/hr). The 8-inch top opening was covered with a screen to prevent leaves and other debris from clogging the gauge. A three-point leveling system was used to ensure maximum accuracy. Gauges were mounted at each site on a 4-inch-by-4-inch wood post and connected to the ISCO sampler, where rainfall data were logged to the sampler's internal memory.

2.2.4 SOLAR PANEL

Deep-cycle marine batteries were used to power the sampling equipment. Once the samplers were activated, however, the power requirements of the refrigerated units rapidly depleted the batteries. Each site was equipped with a 110-watt solar panel connected to the batteries to help keep the batteries charged until the samples could be retrieved and to recharge the batteries between sampling events.

2.3 SAMPLING PROCEDURE

Sampling was conducted in compliance with FDEP Standard Operating Procedures for sample collection and preservation (FDEP, 2008).

Stormwater samples collected as part of this study were flow-weighted, composite samples collected over the duration of the storm event or until the 5-gallon sample bottle was full. When a triggering event occurred, the sampling program was activated. For all but the SR

417 site, sample events were triggered when the water level in the discharge pipe or channel reached a specified level, generally, 0.25 to 0.3 foot. Because there was standing water occasionally present in the pipe at SR 417, water level was not a reliable trigger, and rainfall and rainfall intensity were used instead.

Once the sampling program was triggered, the sampler collected a 500-milliliter (mL) stormwater sample every time a specified volume of flow had passed over the sensor. Sampling continued until flow stopped or until the 5-gallon sample bottle was full. For purposes of inclusion in the calculations to determine EMC values, a valid composite sample consisted of a minimum of three individual 500-mL samples. Water quality results from storm events resulting in just one or two samples are considered representative of the first flush.

A text message alerted field personnel when a sampling program was enabled. Once the storm event was over, samples were retrieved from the ISCO sampler as soon as practicable, generally within less than 24 hours. Samples for nutrient, metals, and TSS analysis were transferred into three pre-preserved sample jars provided by the analytical laboratory. Prior to sample transfer, the 5-gallon collection bottle was shaken vigorously to ensure adequate mixing of the composite sample. Samples were placed on ice in a cooler and transported to the laboratory. If the sample was collected during the laboratory’s regular business hours, samples were delivered immediately. If samples were collected outside of regular business hours, i.e., weekends and evenings, samples were kept on ice and delivered on the next business day.

2.4 LABORATORY ANALYSES

Nutrient parameters reported by the laboratories include nitrate+nitrite, ammonia, total Kjeldahl nitrogen (TKN), TN, and TP. [For simplicity, nitrate+nitrite nitrogen is referred to as “nitrate(s)” or “NOx” throughout this report.] In addition, samples were evaluated for TSS, hardness, chromium, cadmium, copper, lead, and zinc. All laboratories utilized for analyses were certified by the National Environmental Laboratory Accreditation Conference (NELAC).

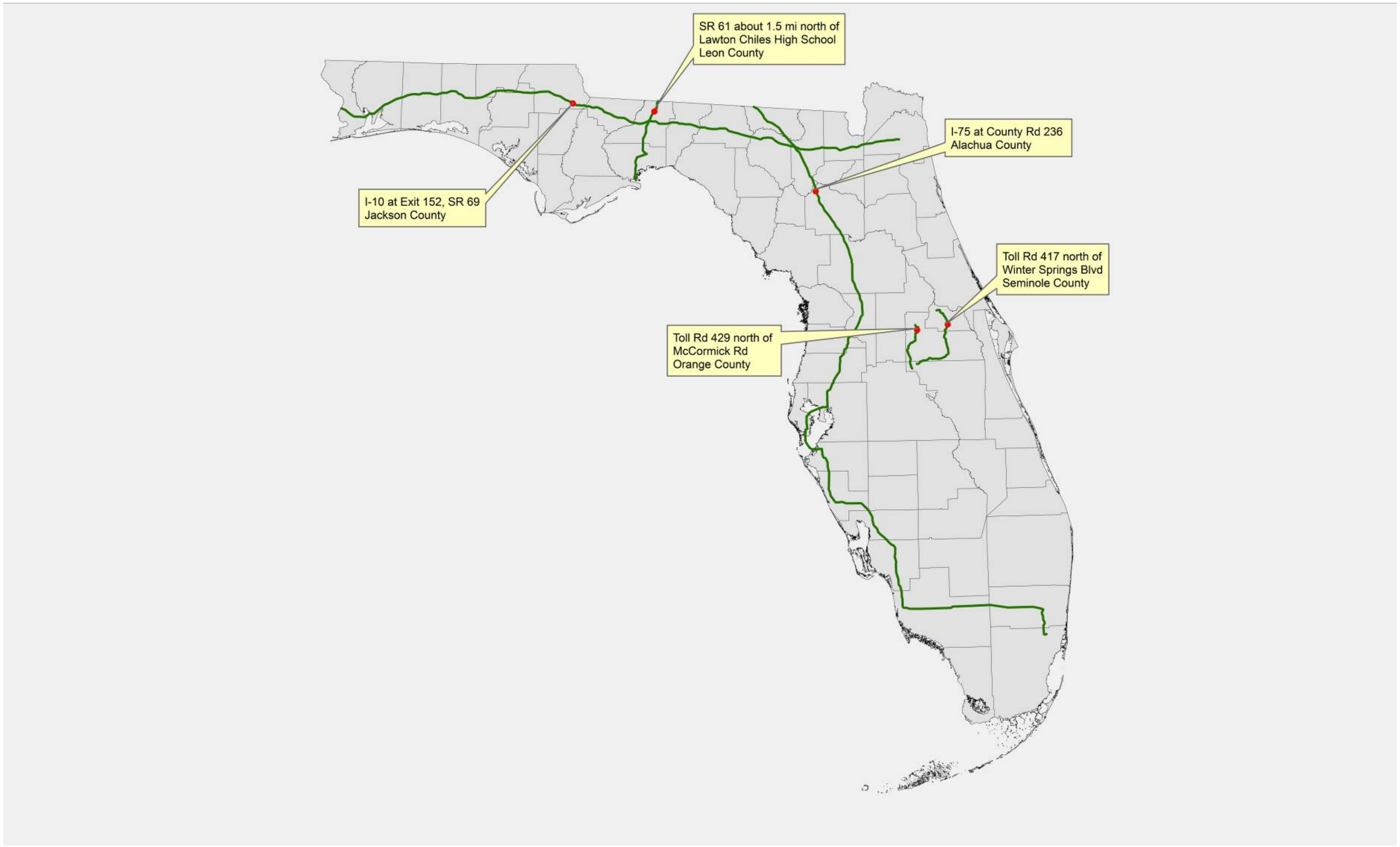


Figure 2-1
Locations of Rural Roadway Sampling Sites

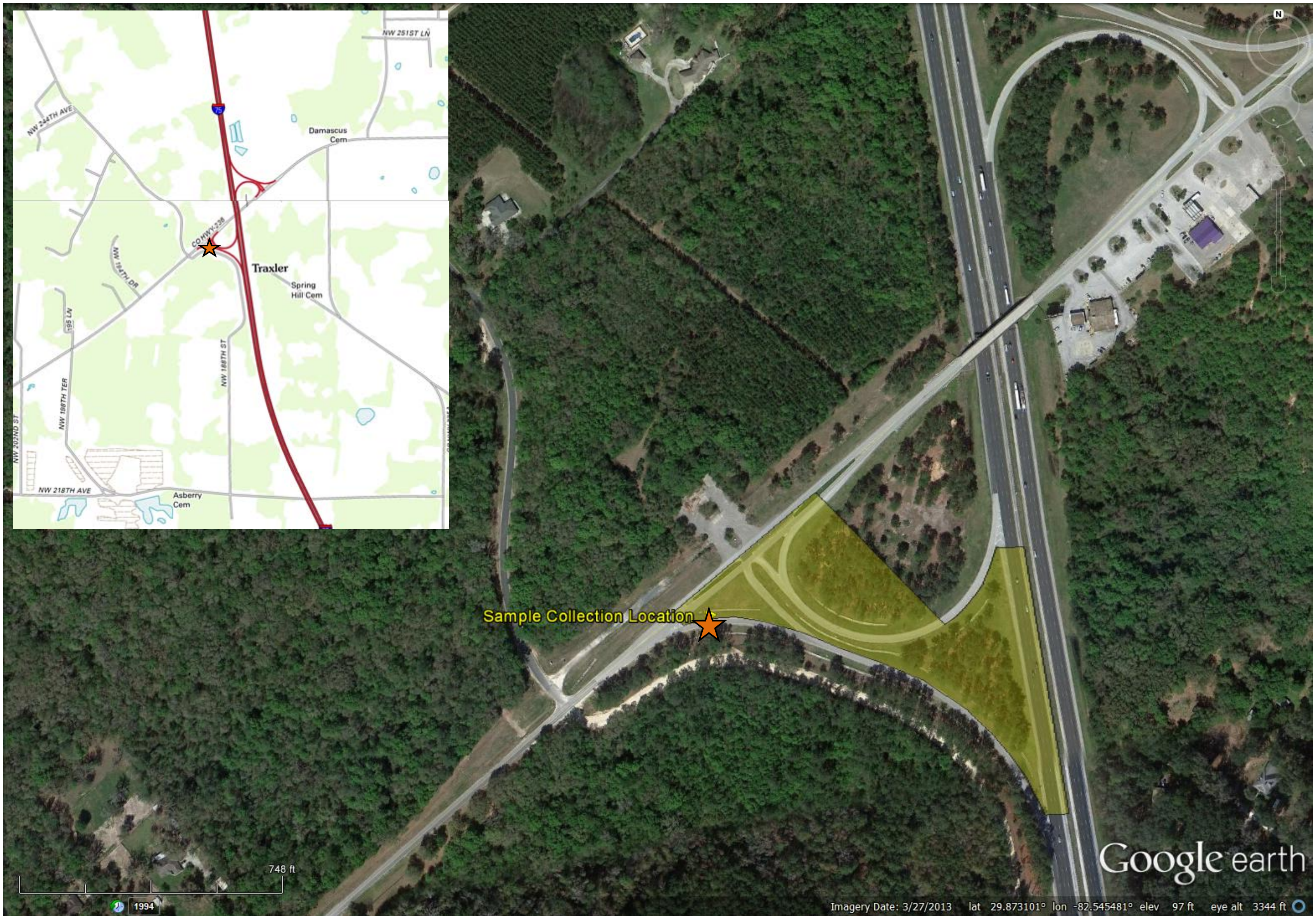


Figure 2-2

Interstate 75 at County Road 236 Sample Site and Drainage Basin Location

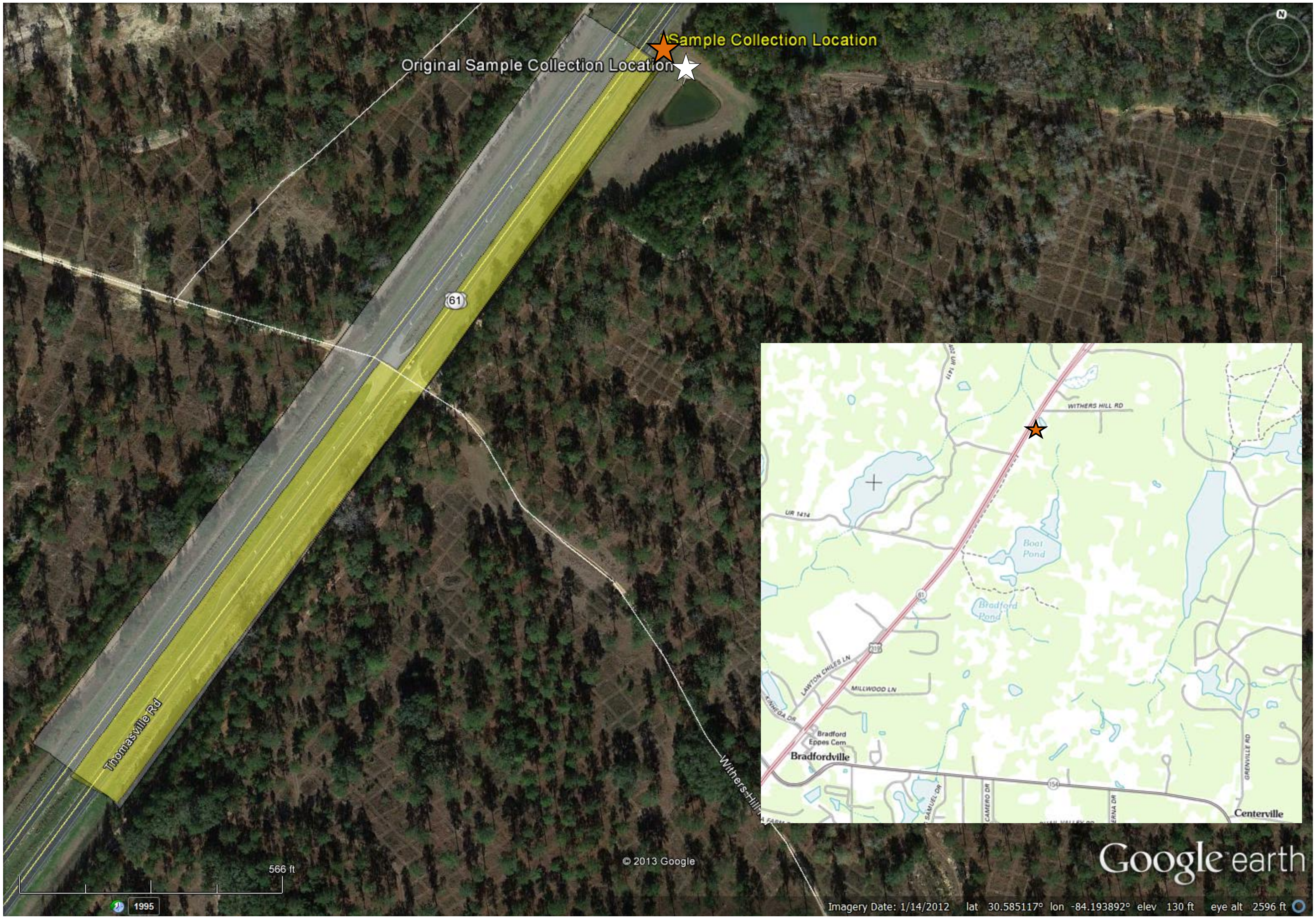


Figure 2-3

State Road 61 Sample Site and Drainage Basin Location

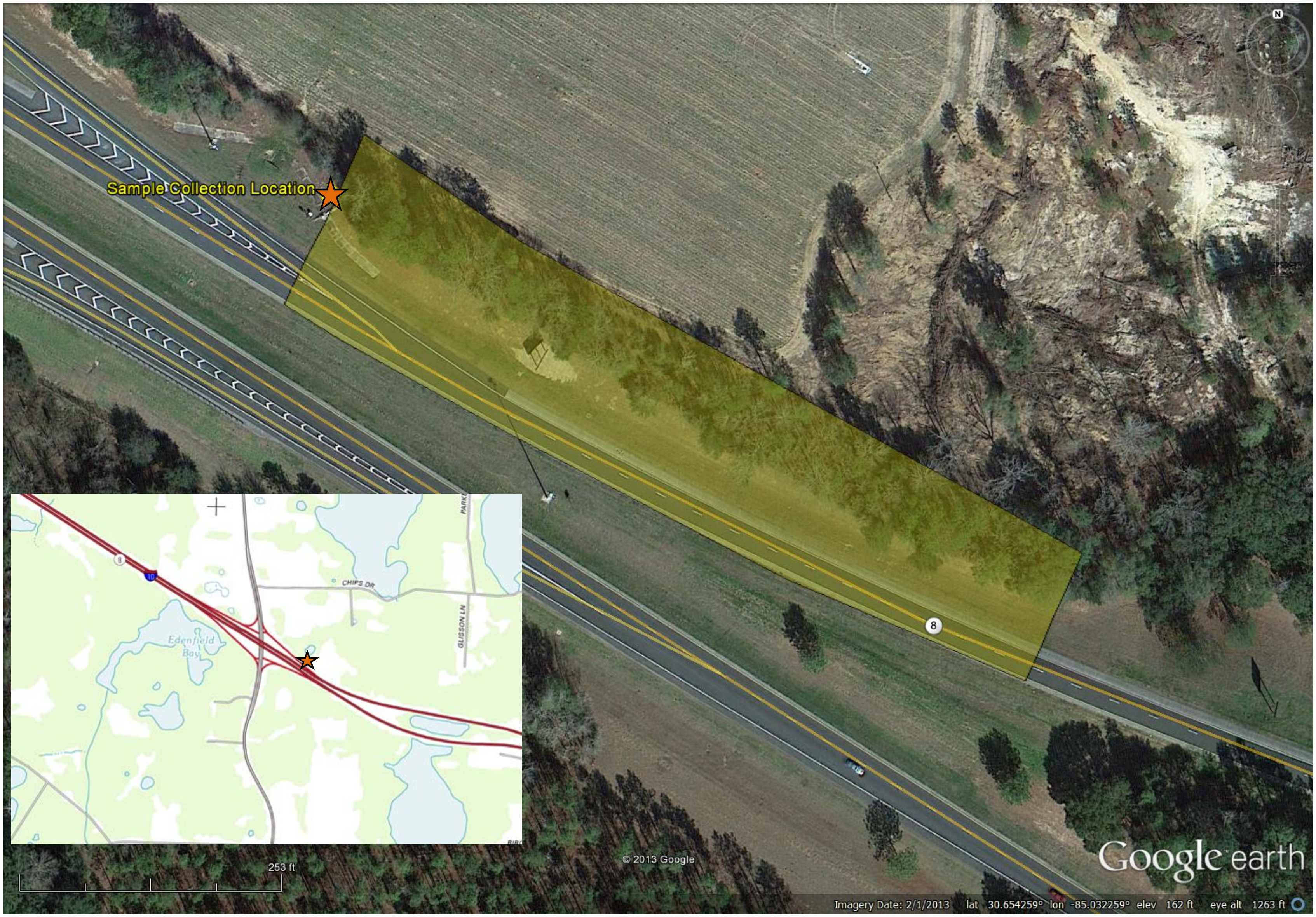


Figure 2-4
Interstate 10 at State Road 69 Sample Site and Drainage Basin Location

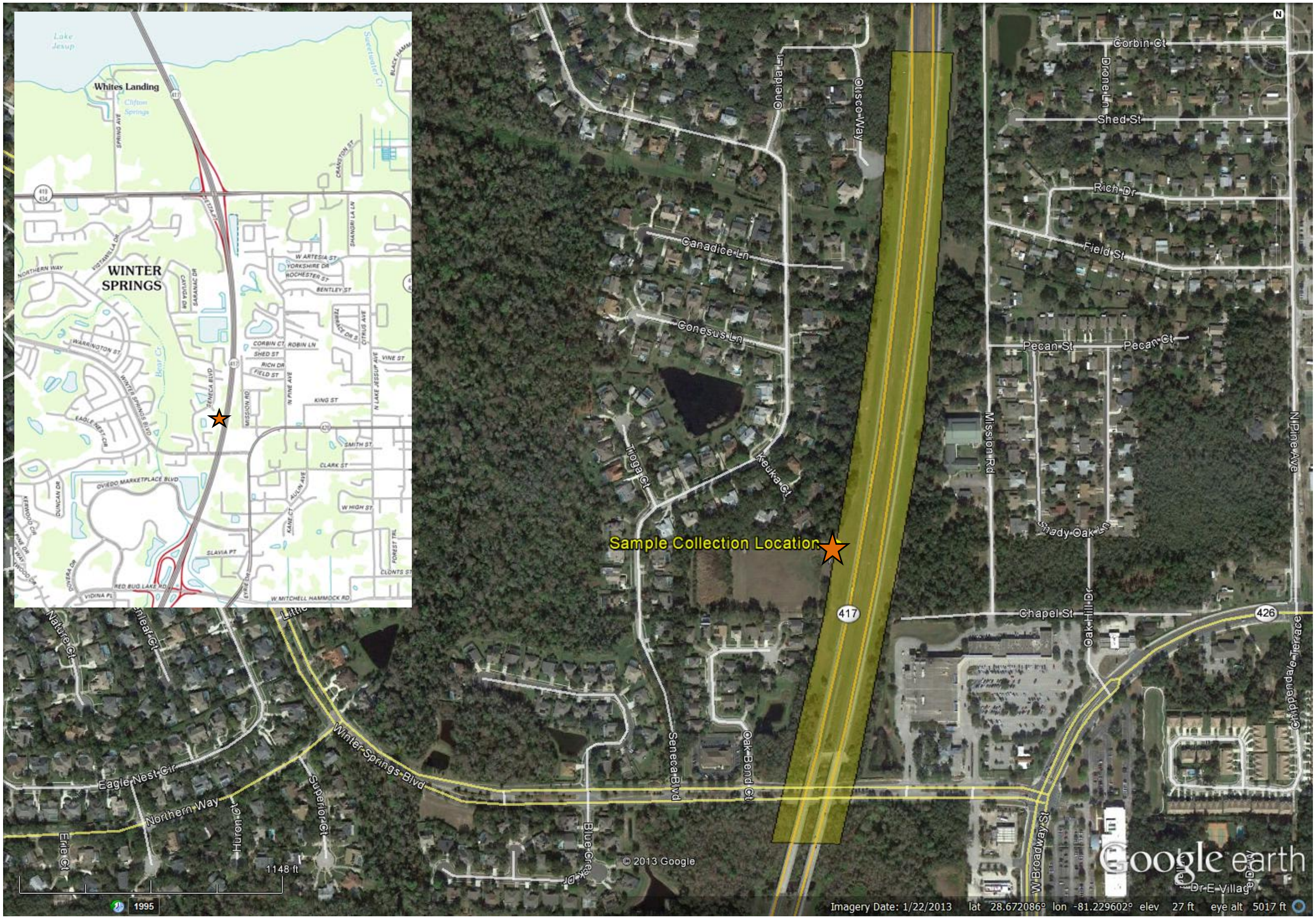
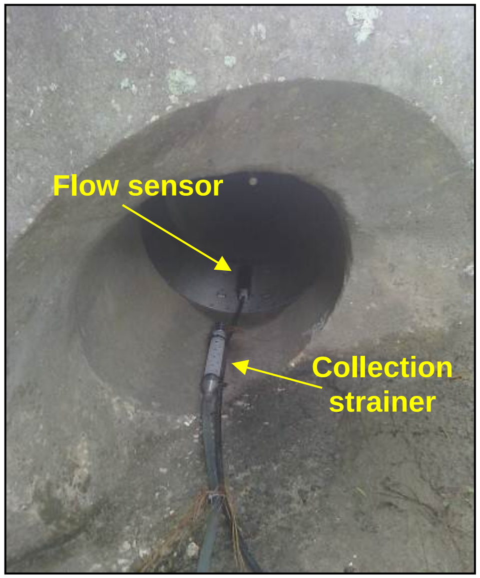


Figure 2-5
State Road 417 Sample Site and Drainage Basin Location

Figure 2-6

State Road 429 Sample Site and Drainage Basin Location

Solar panel and rain gage



Flow sensor and sample collection tube

Automated sampler in security box

Figure 2-7
Typical Site Setup

3.0 RESULTS

Two different computation methods were used to develop nutrient EMC values for each of the five sampling sites. The first, more conventional, method calculates EMCs based on the results of composite samples collected from each of the storm events. For this method, the median, geometric mean, and arithmetic mean EMC values were calculated for each site because the calculations used to determine the statewide EMCs are a combination of these three statistics. Median values from individual storm events were used for some of the studies, and arithmetic averages were used for others. The final statewide EMC values were calculated using the geometric mean of all of the studies. For non-normally distributed data, such as stormwater EMC values, the median and geometric means should be similar. The arithmetic mean will always be higher than the geometric mean but it is not a good metric for EMC data because it is overly influenced by data outliers. The arithmetic mean is not a good indicator of central tendency for non-normally distributed data and is presented here for comparison purposes only.

The second calculation approach used total storm event discharge in conjunction with composite sample water quality results to determine single-flow-weighted EMCs for all of the combined storm events. This method gives a more accurate picture of the total measured load over the study period, and EMCs calculated in this way are comparable to the EMCs calculated in the conventional way. It does not represent the total actual load because not every storm event was captured. By normalizing to a flow-based EMC, however, the resulting number is expected to be reasonably representative of the average long-term EMC for the site. EMCs for metals were calculated using three metrics – median, geometric mean, and arithmetic average. Summaries of sampled storm events as well as the results of the EMC analyses are presented in the following sections.

3.1 <u>I-75 AT COUNTY ROAD 236, ALACHUA COUNTY</u>

3.1.1 RAINFALL EVENTS

Storm event samples were collected for 29 rainfall events between April 30, 2010 and October 10, 2011. Hydrographs for storm sampling events are included in Appendix A. Twenty-seven samples were included in the development of EMC values for this site. Samples collected on June 3 and Jun 18, 2010, consisted of just one and two samples, respectively, and were representative of first-flush water quality. Rainfall for these events was 0.27 inch on June 3 and 0.34 inch on June 19. Rainfall for the samples used for EMC determination ranged from 0.28 to 3.06 inches.

Due to equipment malfunctions, rainfall data were lost for three of the sample events. Rainfall for these events was determined from the St. Johns River Water Management District (SJRWMD) NEXRAD data for a single pixel area of 1.42 square miles around the sample collection point (pixel 148671). The Suwannee River Water Management District (SRWMD) maintains a rainfall gage where U.S. Highway (US) 441 crosses the Santa Fe River near High Springs, but the gage is located 4 miles from the sample site, so the NEXRAD data were judged to be the most representative alternative data source.

Figure 3-1 shows the relationship between total storm event discharge and rainfall. The three NEXRAD-estimated rainfall data points were included in this regression analysis since total event flow data were available for these three events. Even when these points were excluded from the analyses, the data correlation was nearly identical, i.e., $R^2 = 0.7918$.

3.1.2 LABORATORY RESULTS AND EMC VALUES, I-75 AT COUNTY ROAD 236

Laboratory results for nutrient water quality parameters at I-75 and CR 236 are shown in Table 3-1. Complete results as reported by the laboratory are included in Appendix A. The nutrient EMCs calculated using the geometric mean, arithmetic mean, and median parameter values are also summarized in Table 3-1. Flow-weighted EMC values for nutrient water quality parameters are presented in Table 3-2. Laboratory results and EMC values for the metals and TSS sampling are provided in Table 3-3.

As is typical of stormwater runoff, nutrient EMC values for individual storm events were highly variable over the 18-month study period. The consistently high values for TP are of particular interest, with a median EMC of 1.02 milligrams per liter (mg/L) and a flow-weighted EMC of 1.05 mg/L. This was more than six times the current statewide EMC value of 0.167 mg/L. Individual TP values ranged from 0.532 mg/L to 2.78 mg/L. One possible explanation for such high TP values is the phosphatic nature of the underlying soils in the area that is reflected in the runoff water quality.

The median TN EMC for this site was 1.83 mg/L, compared with the current statewide EMC value of 1.37 mg/L. The flow-weighted TN EMC was 2.00 mg/L. Individual TN measurements ranged from a low of 0.386 mg/L to a high of 8.08 mg/L. It is not particularly surprising that the TN at this site was higher than the statewide EMC since much of the drainage area was vegetated and more than half of the TN was organic nitrogen, ranging from 51 percent to 90 percent. Sixteen of the 27 samples were 75 percent or more organic nitrogen. Percent of nitrate in TN ranged from 5 percent to 44 percent, and measured concentrations of nitrates varied from 0.046 mg/L to 1.63 mg/L. Nitrates were about 20 percent of the TN load (see Table 3-2), suggesting some level of anthropogenic input. Ammonia nitrogen was just 4 percent of total load. By comparison, in the study done by Stoker (1996) of the 100 percent impervious Bayside Bridge in Tampa, nitrates were more than 56 percent of the input TN load, and ammonia nitrogen was almost 12 percent of total load. The resulting median TN EMC from Stoker's study was only 1.10 mg/L, but 0.64 mg/L was nitrates and 0.13 mg/L was ammonia nitrogen.

The TMDL target for the Santa Fe River and associated springs is 0.35 mg/L nitrate. The TMDL is currently being implemented through the Santa Fe River BMAP. Results of this study suggest that FDOT rural roadway facilities are not a major source of nitrate loading to the Santa Fe River. The median nitrate EMC for the untreated stormwater discharge was 0.287 mg/L, below the target of 0.35 mg/L. The geometric mean and flow-weighted EMC were slightly higher than the target, at 0.362 mg/L and 0.396 mg/L, respectively. Fifteen of the 27 samples were below 0.35 mg/L nitrates.

Twenty-four of the 27 samples had cadmium concentrations below the method detection limit (MDL) of 0.14 micrograms per liter (µg/L), two samples were below an MDL of 1.4 µg/L, and just one storm event resulted in a measurable cadmium concentration of 0.43 µg/L. No median value was calculated because so many samples were below the MDL. Chromium concentrations ranged from 0.77 µg/L to 9.8 µg/L, with a median value of 2.6 µg/L. Copper values varied from 0.54 µg/L to 8.0 µg/L, with a median of 2.6 µg/L, and lead ranged from 0.82 µg/L to 19 µg/L, with a median value of 4.8 µg/L. Zinc concentrations ranged from 13.0 µg/L to 72.2 µg/L and had a median of 29.8 µg/L.

3.2 STATE ROAD 61, LEON COUNTY

3.2.1 RAINFALL EVENTS

Storm event samples were collected for 28 rainfall events, 27 of which are included in the development of the EMC values for this site. Hydrographs for storm sampling events are included in Appendix B. The last sample collected on January 30, 2013 consisted of just one sample, so it was not considered a valid composite for EMC development. However, it did provide information regarding first-flush values. For this event, 0.62 inch of rain fell over a period of 18 minutes. Rainfall for the samples used for EMC determination ranged from 0.38 to 2.54 inches.

Rainfall and flow data for the period from June 25, 2012 to August 6, 2012 were lost due to an equipment malfunction. In addition, the rain gage did not record data for the events on October 1, 2012 and December 20, 2012. Event rainfall for these samples was estimated using Northwest Florida Water Management District (NWFWMD) Station 654 – Bannerman Road near Thomasville Road, located 2.3 miles southwest of the sample point. These rainfall data were compared with data, if available, from three additional nearby stations as shown in Table 3-4 and Figure 3-2 to determine if the values measured at the Bannerman Road site should be adjusted based upon rainfall at other surrounding stations. Figure 3-3 shows the relationship between total storm event discharge and rainfall.

3.2.2 LABORATORY RESULTS AND EMC VALUES, STATE ROAD 61

Laboratory results for nutrient water quality parameters at SR 61 are shown in Table 3-5. Complete results as reported by the laboratory are included in Appendix B. The nutrient EMCs calculated using the geometric mean, arithmetic mean, and median parameter values are also summarized in Table 3-5. Flow-weighted EMC values for nutrient water quality parameters are presented in Table 3-6. Laboratory results and EMC values for the metals and TSS sampling are provided in Table 3-7.

The area that drains to the sampling site at SR 61 is located in the upper portion of the Wakulla Springs BMAP area, and the nutrient parameter of concern is nitrates. The TMDL target value for the springs and run is 0.35 mg/L nitrates. The EMC for nitrates ranged from below the MDL of 0.012 mg/L to 0.717 mg/L. The median, geometric mean, and arithmetic mean for nitrates were 0.143 mg/L, 0.105 mg/L, and 0.199 mg/L, respectively, all well below the TMDL and BMAP target value. The flow-weighted nitrates EMC of 0.189 mg/L was also well below the target. Of the 27 samples used to develop the nitrates EMC, six were above the TMDL target and represented 43 percent of the total measured nitrates load.

Like the site in Alachua County, the SR 61 study area was characterized by phosphatic soils, which was reflected in the relatively high EMC values for TP. Individual TP values ranged from 0.196 mg/L to 1.08 mg/L, with a median value of 0.425 mg/L. The flow-weighted EMC value was 0.484 mg/L.

The median TN EMC at SR 61 was 1.27 mg/L, slightly below the current statewide EMC value of 1.37 mg/L. The flow-weighted TN EMC was 1.16 mg/L. Individual TN measurements ranged from a low of 0.434 mg/L to a high of 3.43 mg/L. All but one sample was 60 percent or more organic nitrogen, and organic nitrogen constituted nearly 79 percent of the TN load. Only eight samples contained measurable amounts of ammonia nitrogen, which was 5 percent of TN load, with the remaining 16 percent of load from nitrates.

Fifteen of the 27 samples had cadmium concentrations below the MDL of 0.104 μg/L, nine samples were below an MDL of 0.9 μg/L, and the remaining three samples ranged from 0.800 μg/L to 1.00 μg/L. No median value was calculated because so many samples were below the MDL. Chromium concentrations ranged from below the MDL of 0.34 μg/L to 151 μg/L, with a median value of 2.0 μg/L. Copper values varied from 0.873 μg/L to 8.39 μg/L, with a median of 2.00 μg/L, and lead ranged from below the MDL of 0.670 μg/L to 74.7 μg/L, with a median value of 1.07 μg/L. Zinc concentrations ranged from 3.50 μg/L to 68.2 μg/L and had a median of 7.50 μg/L.

3.3 STATE ROAD 8 (I-10), JACKSON COUNTY

3.3.1 RAINFALL EVENTS

Storm event samples were collected for 28 rainfall events between February 19, 2012 and August 20, 2013. Twenty-five of these events were included in the development of EMC values for this site. Hydrographs for storm sampling events are included in Appendix C. Rainfall from events used for EMC determination ranged from 0.42 to 3.47 inches. The relationship between rainfall and event discharge is shown in Figure 3-4.

3.3.2 LABORATORY RESULTS AND EMC VALUES

Laboratory results for nutrient water quality parameters at I-10, Exit 152, are shown in Table 3-8. Complete results as reported by the laboratory are included in Appendix C. The nutrient EMCs calculated using the geometric mean, arithmetic mean, and median parameter values are also summarized in Table 3-8. Flow-weighted EMC values for nutrient water quality parameters are shown in Table 3-9. Laboratory results and EMC values for the metals and TSS sampling are provided in Table 3-10.

TP EMCs measured at this site were very different from the other four study areas, possibly due to a lower level of phosphates in the soils. Individual TP values ranged from below detection of 0.014 mg/L to 0.523 mg/L, with a median value of 0.116 mg/L. The flow-weighted EMC value was 0.139 mg/L.

TN values ranged from 0.268 to 4.84 over the 18-month sampling period, with median, geometric mean, and arithmetic averages of 0.631 mg/L, 0.722 mg/L, and 0.946 mg/L, respectively. The flow-weighted TN EMC was 0.706 mg/L. All but one sample was 72 percent or more organic nitrogen, and organic nitrogen was 84 percent of the total measured TN load. Just five of 25 samples contained measurable amounts of ammonia nitrogen, which was 3 percent of TN load, with the remaining 13 percent of load from nitrates.

Twenty of the 25 samples had cadmium concentrations below the MDL of 0.104 µg/L, three samples were below an MDL of 0.9 µg/L, and the remaining two samples had concentrations of 0.110 µg/L and 0.177 µg/L. No median value was calculated because so many samples were below the MDL. Fifteen chromium concentrations were below the MDL of 0.34 µg/L, two samples were below an MDL of 2.0 µg/L, with the remaining eight samples ranging from 1.05 µg/L to 11.4 µg/L. No median was calculated for chromium. Copper values varied from 0.441 µg/L to 7.82 µg/L, with a median of 1.53 µg/L, and lead ranged from below the MDL of 0.670 µg/L (16 samples) to 43.3 µg/L. The median for lead was not calculated. Zinc concentrations ranged from 3.00 µg/L to 105 µg/L and had a median of 6.90 µg/L. The sample collected January 30, 2013 was notable in that TSS was very high (610 mg/L), as were all metals values, as well as TN and TP. Except for cadmium, the highest measured values for metals, TN, and TP occurred with this sample. The event was a relatively small storm, with 0.69 inch of rainfall, that resulted in a very small amount of runoff characterized by a composite sample of just three 500 mL discrete samples.

3.4 STATE ROAD 417, SEMINOLE COUNTY

3.4.1 RAINFALL EVENTS

Storm event samples were collected for 28 rainfall events between June 17, 2010 and May 2, 2013, 23 of which were used to calculate the site-specific EMC values. Hydrographs for storm sampling events are included in Appendix D. Total rain for these 23 events ranged from 0.59 to 6.38 inches. Review of data from the other five sampling events showed that although the rainfall was sufficient to enable the sampling program, the flow velocities generated in the pipe were extremely low. The flow was so low that it generated invalid readings from the instrument, indicating more flow had passed than actually had. Since the sampling was flow based, the sampler was collecting "flow-weighted" samples that were more likely standing water in the pipe. It was unlikely that sufficient water had actually passed through the pipe to flush out any standing water.

Due to an equipment malfunction, rainfall and flow data were not available for the sample collected on April 14, 2013. Rainfall for this event was estimated by averaging rainfall from two nearby gages, one located east of the site (KFLCASSE8) and one located to the west (MD7073) (Figure 3-5).

The maximum rainfall event of 6.38 inches began at 11:55 p.m. on October 7, 2011 and ended at 1:40 a.m. on October 9, 2011 (Figure 3-6). Thirty-five 500-mL samples were collected between 1:27 a.m. and 5:21 a.m. on October 8, 2011, at which point the sample bottle was filled to capacity. For purposes of calculating the flow-based EMC for this event, only the flow and rainfall that occurred prior to 6:00 a.m. on October 8 were included. The composite sample collected was not considered representative of the latter portion of the rainfall event. The break at 6:00 a.m. occurred between more intense periods of rainfall when flow had dropped to a minimum prior to increasing with the next rain squall. However, total flow and rainfall over the entire 26-hour period were used to determine the relationship between flow and rainfall (Figure 3-7).

3.4.2 LABORATORY RESULTS AND EMC VALUES

Laboratory results for nutrient water quality parameters at SR 417 are shown in Table 3-11. Complete results as reported by the laboratory are included in Appendix D. The nutrient EMCs calculated using the geometric mean, arithmetic mean, and median parameter values are also summarized in Table 3-11. Flow-weighted EMC values for nutrient water quality parameters are presented in Table 3-12. Laboratory results and EMC values for the metals and TSS sampling are provided in Table 3-13.

The SR 417 site was located in the Lake Jesup BMAP area. The TMDL for Lake Jesup requires reductions in both TN and TP, but the BMAP only targets TP at this time. TMDL targets are expressed as both loads and concentrations, with a TP target of 0.096 mg/L. In the BMAP, FDOT District 5 was assigned a total TP reduction of 397 pounds TP.

TP EMC values at the SR 417 site ranged from 0.039 mg/L to 5.5 mg/L, with a median value of 0.41 mg/L. The flow-weighted EMC was 0.58 mg/L. These values are substantially higher than the "transportation facilities" EMC of 0.28 mg/L TP that was used in the development of the Lake Jesup TMDL and more than twice the statewide EMC of 0.167 mg/L.

The median TN EMC at SR 417 was 1.60 mg/L, which was higher than the statewide EMC of 1.37 mg/L. The flow-weighted TN EMC was 1.73 mg/L. Individual TN measurements ranged from 0.38 mg/L to 3.9 mg/L, with organic nitrogen accounting for 23 percent to 100 percent of TN. Percent nitrates ranged from 0 percent to 76 percent TN. About half of the samples, 11 out of 23, contained measurable amounts of ammonia nitrogen and accounted for up to 8 percent of TN. Organic nitrogen was 70 percent of total load, nitrates were 29 percent, and ammonia nitrogen, just 1 percent.

Twenty-one of the 23 samples had cadmium concentrations below the MDL of 0.14 μg/L, and the remaining two samples were 0.19 μg/L and 0.99 μg/L. No median value was calculated because so many samples were below the MDL. Chromium concentrations ranged from below the MDL of 1.0 μg/L to 3.4 μg/L, with a median value of 1.4 μg/L. Copper values varied from 1.2 μg/L to 10 μg/L, with a median of 3.5 μg/L, and lead ranged from 0.13 μg/L to 1.9 μg/L, with a median value of 0.43 μg/L. Zinc concentrations ranged from 11 μg/L to 120 μg/L and had a median of 19 μg/L.

3.5 STATE ROAD 429, ORANGE COUNTY

3.5.1 RAINFALL EVENTS

Storm event samples were collected for 23 rainfall events between August 13, 2010 and May 3, 2013, 22 of which were used to calculate the site-specific EMC values. Hydrographs for storm sampling events are included in Appendix E. Total rain for these 22 events ranged from 0.48 to 3.18 inches. A sample collected on September 19, 2012 after 0.53 inch of rain included just two sample draws, so it was evaluated as representative of the first flush. The relationship between event discharge and rainfall is shown in Figure 3-8.

Due to a rain gage malfunction, rain data were not available for the sample collected on June 28, 2011. Rainfall data were taken from Station MPOPF1, the Florida Automated Weather Network station for Apopka, located 1.2 miles northwest of the sample collection point (Figure 3-9).

3.5.2 LABORATORY RESULTS AND EMC VALUES

Laboratory results for nutrient water quality parameters at SR 429 are shown in Table 3-14. Complete results as reported by the laboratory are included in Appendix E. The nutrient EMCs calculated using the geometric mean, arithmetic mean, and median parameter values are also summarized in Table 3-14. Flow-weighted EMC values for nutrient water quality parameters are presented in Table 3-15. Laboratory results and EMC values for the metals and TSS sampling are provided in Table 3-16.

The SR 429 sampling site was located within the Upper Ocklawaha BMAP area about three-quarters of a mile east of the shore of Lake Apopka. The Lake Apopka TMDL for TP is one of several TMDLs being implemented as part of the Upper Ocklawaha BMAP. The individual TP samples at this site ranged from below the MDL of 0.046 mg/L to 60 mg/L, with a median value of 0.769 mg/L. The high TP value of 60 mg/L occurred after a relatively small rainfall event of 0.60 inch and an extended period of no rain. The runoff associated with this event was about 0.34 percent of the total measured discharge, yet the TP load from the event accounted for almost 26 percent of the total measured TP load.

The TN EMC values ranged from 0.49 mg/L to 28 mg/L, with a median value of 2.5 mg/L. The flow-weighted TN EMC was 2.31 mg/L. The sample that measured 28 mg/L was collected on February 22, 2012 and, at the time of sample retrieval, fertilizer granules were visible in the discharge pipe and on the roadway. The nitrates in this sample were 9.4 mg/L, the highest value recorded over the course of the study. Maximum values of copper (51.0 µg/L) and zinc (1400 µg/L), trace elements typically found in fertilizer, were also recorded with this sample, as was a high value of TP, 6.5 mg/L. Despite the high concentrations of nutrients, the total loads resulting from this event were comparatively small because the total volume of runoff was small. TN and TP loads for this event accounted for 2.7 percent and 1.8 percent of total load, respectively, and nitrates load for this event was 5.9 percent of the total measured nitrates load. Overall, nitrates represented 20 percent of TN load, ammonia nitrogen, 4 percent, and organic nitrogen, 76 percent.

Just three of the 22 chromium samples were above the MDL, which ranged from 0.14 μg/L to 1.4 μg/L. The three measurable samples ranged from 0.14 μg/L to 0.22 μg/L. No median value was calculated because so many samples were below the MDL. Twelve chromium concentrations were below the MDL, which ranged from 1.0 μg/L to 10 μg/L. The 10 samples with measurable concentrations of chromium ranged from 1.1 μg/L to 2.5 μg/L. No median was calculated for chromium. Copper values varied from 2.2 μg/L to 51 μg/L, with a median of 4.5 μg/L, and lead ranged from below the MDL of 0.076 μg/L to 12 μg/L, with a median value of 0.68 μg/L. Zinc concentrations ranged from 19 μg/L to 1,400 μg/L and had a median of 47 μg/L.

3.6 FIRST-FLUSH RESULTS

Detailed water quality results for five first-flush samples are shown in Tables 3-17 and 3-18. These samples were collected when the sampling program was enabled, but the storm event did not generate sufficient flow to obtain a minimum of three individual 500-mL samples for a composite sample. Not surprisingly, concentrations in the first-flush samples were generally higher than a site's median EMC.

3.7 SUMMARY OF WATER QUALITY DATA

A summary of nutrient and metal water quality data for each of the five sites and the five first-flush samples is provided in Tables 3-19 and 3-20. There was extensive variation in median EMC values between the five sample locations, with the lowest TN and TP values occurring at the I-10 site. The median TN EMC ranged from 0.631 mg/L at the I-10 site to 2.50 mg/L at the SR 429 site, and the median TP EMC ranged from 0.116 mg/L at I-10 to 1.02 mg/L at the I-75 location. Organic nitrogen was the predominant component of total TN load, ranging from a low of 70 percent at SR 417 to a high of 84 percent at I-10. Nitrates ranged from 13 percent (I-10) to 29 percent (SR 417) of total TN load, and ammonia nitrogen ranged from 1 percent (SR 417) to 7 percent (SR 429) of TN load. The total inorganic nitrogen load (nitrates plus ammonia nitrogen) ranged from a low of 16 percent at I-10 to 30 percent at SR 417.

An EMC for cadmium was not calculated for any of the five sites because all but 11 of the 124 samples were below the MDL. A chromium EMC was calculated for CR 236, SR 61, and SR 417, but there were insufficient samples above the MDL to calculate EMCs for SR 8 and SR 429. The EMCs for chromium ranged from 1.4 µg/L at SR 417 to 2.6 µg/L at CR 236. Copper EMCs were calculated for all sites and ranged from 1.53 µg/L at SR 8 to 4.5 µg/L at SR 429. No lead EMC was calculated at SR 8 because 16 of the 25 samples were below the MDL. Lead EMCs ranged from 0.43 µg/L at SR 417 to 4.8 µg/L at CR 236. The EMCs for zinc ranged from 6.90 µg/L at SR 8 to 47 µg/L at SR 429. Overall, the runoff from SR 8 had the lowest levels of metals, with measurable concentrations occurring for copper and zinc only. The highest metals EMCs were measured at CR 236 (chromium and lead) and at SR 429 (copper and zinc).

Table 3-1. Nutrient EMC Results based on Individual Samples for CR 236

	EMC (mg/L)							% of TN		
Date	NOx	NH4		TKN	Org N	TN	TP	NOx	NH4	Org N
30-Apr-10	0.261	0.048		0.56	0.51	0.821	0.633	32%	6%	62%
4-May-10	0.188	0.009	U	0.81	0.80	0.998	0.532	19%	1%	80%
21-May-10	1.11	0.143		1.64	1.50	2.75	0.804	40%	5%	54%
6-Jun-10	0.193	0.032	I	1.06	1.03	1.25	0.606	15%	3%	82%
25-Jun-10	0.930	0.349		3.38	3.03	4.31	2.25	22%	8%	70%
30-Jun-10	0.136	0.060		0.93	0.87	1.07	0.649	13%	6%	81%
31-Jul-10	0.810	0.146		1.98	1.83	2.79	1.24	29%	5%	66%
5-Aug-10	1.61	0.176		2.01	1.83	3.62	1.38	44%	5%	51%
7-Aug-10	0.543	0.041		1.25	1.21	1.79	0.872	30%	2%	68%
18-Aug-10	0.402	0.163		1.65	1.49	2.05	1.82	20%	8%	73%
23-Aug-10	0.249	0.076		1.58	1.50	1.83	1.02	14%	4%	82%
29-Sep-10	0.286	0.026	I	1.01	0.98	1.30	0.874	22%	2%	76%
16-Nov-10	1.63	0.693		6.45	5.76	8.08	2.78	20%	9%	71%
5-Jan-11	0.654	0.152		2.58	2.43	3.23	1.74	20%	5%	75%
25-Jan-11	0.129	0.026	I	1.40	1.37	1.53	0.910	8%	2%	90%
3-Feb-11	0.097	0.019	I	0.82	0.80	0.917	0.794	11%	2%	87%
7-Feb-11	0.046	0.012	I	0.34	0.33	0.386	0.652	12%	3%	85%
10-Mar-11	0.242	0.094		2.00	1.91	2.24	1.15	11%	4%	85%
31-Mar-11	0.286	0.560		4.96	4.40	5.25	1.73	5%	11%	84%
14-May-11	0.576	0.343		3.29	2.95	3.87	1.72	15%	9%	76%
13-Jun-11	0.425	0.009	U	3.60	3.60	4.02	1.55	11%	0%	90%
27-Jun-11	0.797	0.080		3.29	3.21	4.09	1.68	19%	2%	78%
28-Jun-11	0.295	0.030		0.88	0.85	1.18	0.706	25%	3%	72%
20-Sep-11	1.25	0.248		5.28	5.03	6.53	2.56	19%	4%	77%
21-Sep-11	0.287	0.122		0.84	0.72	1.13	1.02	25%	11%	64%
25-Sep-11	0.236	0.102		1.02	0.92	1.26	0.904	19%	8%	73%
10-Oct-11	0.227	0.032		1.38	1.35	1.61	1.12	14%	2%	84%
Median	0.287	0.080		1.58	1.49	1.83	1.02			
Geomean	0.362	0.074		1.62	1.52	2.03	1.12			
Arithmetic Average	0.515	0.140		2.07	1.93	2.59	1.25			
Maximum	1.63	0.693		6.45	5.76	8.08	2.78			
Minimum	0.046	0.009	U	0.340	0.328	0.386	0.532			

Notes:

I = between method detection limit and practical quantification limit.

U = below method detection limit.

V = method blank contamination.

Table 3-2. Flow-Weighted EMCs Over Period of Study for CR 236

	Rainfall	Event Q	Event Load (lb)					
Date	(in)	(cf)	NOx	NH4	TKN	Org N	TN	TP
30-Apr-10	2.52	23861	0.389	0.072	0.83	0.76	1.22	0.94
4-May-10	1.31	9246	0.109	0.000	0.47	0.46	0.58	0.31
21-May-10	*1.55*	7506	0.520	0.067	0.77	0.70	1.29	0.38
6-Jun-10	0.63	4131	0.050	0.008	0.27	0.27	0.32	0.16
25-Jun-10	0.60	1492	0.087	0.033	0.31	0.28	0.40	0.21
30-Jun-10	*0.87*	2137	0.018	0.008	0.12	0.12	0.14	0.09
31-Jul-10	3.06	21764	1.101	0.198	2.69	2.49	3.79	1.68
5-Aug-10	0.88	2149	0.216	0.024	0.27	0.25	0.49	0.19
7-Aug-10	0.47	1470	0.050	0.004	0.11	0.11	0.16	0.08
18-Aug-10	1.05	2298	0.058	0.023	0.24	0.21	0.29	0.26
23-Aug-10	1.44	7147	0.111	0.034	0.70	0.67	0.82	0.46
29-Sep-10	0.28	4079	0.073	0.007	0.26	0.25	0.33	0.22
16-Nov-10	0.31	1188	0.121	0.051	0.48	0.43	0.60	0.21
5-Jan-11	0.48	1447	0.059	0.014	0.23	0.22	0.29	0.16
25-Jan-11	1.98	15870	0.127	0.026	1.38	1.36	1.51	0.90
3-Feb-11	1.17	6807	0.041	0.008	0.35	0.34	0.39	0.34
7-Feb-11	1.36	21247	0.061	0.016	0.45	0.44	0.51	0.86
10-Mar-11	1.17	6726	0.102	0.039	0.84	0.80	0.94	0.48
31-Mar-11	0.52	2039	0.036	0.071	0.63	0.56	0.67	0.22
14-May-11	1.16	5085	0.183	0.109	1.04	0.94	1.23	0.55
13-Jun-11	1.53	13613	0.361	0.000	3.06	3.06	3.42	1.32
27-Jun-11	0.61	4998	0.249	0.025	1.03	1.00	1.28	0.52
28-Jun-11	1.59	11577	0.213	0.022	0.64	0.61	0.85	0.51
20-Sep-11	1.11	7113	0.555	0.110	2.34	2.23	2.90	1.14
21-Sep-11	1.36	9630	0.173	0.073	0.50	0.43	0.68	0.61
25-Sep-11	1.18	8627	0.127	0.055	0.55	0.49	0.68	0.49
10-Oct-11	*2.06*	15454	0.219	0.031	1.33	1.30	1.55	1.08
Total Measured Discharge (cf)		218702						
Total Measured Load (lb)			5.41	1.13	21.92	20.78	27.33	14.35
Flow-Weighted EMC (mg/L)			0.396	0.083	1.61	1.52	2.00	1.05

Note:

Red italics = rainfall established from St. Johns River Water Management District NexRad data.

Table 3-3. Metals EMC Results based on Individual Samples for CR236

	Sample Results						
Date	Cadmium (µg/L)	Chromium (µg/L)	Copper (µg/L)	Lead (µg/L)	Zinc (µg/L)	Hardness (mg/L)	TSS (mg/L)
30-Apr-10	0.14 U	1.9 I	4.5	2.0	13.0	24.8	19
4-May-10	0.14 U	1.4 I	1.2	0.82	13.4	25.6	9
21-May-10	0.14 U	2.5	2.0	3.9	35.6	30.3	23
6-Jun-10	0.14 U	2.0 I	1.2	1.3	39.9	24.4	22
25-Jun-10	0.14 U	2.6	3.0	2.7	41.0	35.9	17
1-Jul-10	0.14 U	1.7 I	1.4	0.84	14.2	22.8	12
31-Jul-10	0.14 U	2.3	2.6	4.8	29.8	21.9	27
5-Aug-10	0.14 U	1.5 I,V	3.1	3.1	20.6	28.1	24
7-Aug-10	0.14 U	1.1 I,V	2.2	1.2	14.1	29.4	9
18-Aug-10	0.14 U	1.0 U	2.7	1.1	33.4	42.9	25
23-Aug-10	0.14 U	3.6	2.1	5.1	19.6	24.5	31
29-Sep-10	0.20 U	0.77 I	1.9	1.2	15.8	28.4	16
16-Nov-10	0.14 U	8.1	6.2	18	65.8	52.2	180
5-Jan-11	0.14 U	9.8	3.7	19	50.1	39.1	96
25-Jan-11	0.14 U	3.40	2.2	7.2	37.8	33.1	32
3-Feb-11	0.14 U	3.4	2.6	5.4	35.4	35.1	14
7-Feb-11	0.14 U	3.7	1.2	3.8	26.7	27.6	18
10-Mar-11	0.14 U	3.0	3.2	10	22.5	36.8	105
31-Mar-11	0.14 U	6.5	4.3	12	72.2	42.3	110
14-May-11	0.14 U	3.9	3.4	7.4	57.4	38.7	575
13-Jun-11	0.14 U	6.0	4.5	13	54.4	31.6	127
27-Jun-11	1.4 U	10 U	8.0	13	53.4	45.3	157
28-Jun-11	1.4 U	10 U	3.8 I	6.1 I	27.6	31.2	50
20-Sep-11	0.14 U	2.6	1.7	7.0	36	30	68
21-Sep-11	0.14 U	1.0 U	0.62 I	0.85	18	28	16
25-Sep-11	0.14 U	1.3 I	0.54 I	1.4	21	27	16
10-Oct-11	0.43 I	2.8	1.6	5.2	25	37	47
Median	NC	2.6	2.6	4.8	29.8		
Geomean	NC	2.8	2.3	3.8	29.3		
Arithmetic Average	NC	3.6	2.8	5.8	33.1		
Maximum	0.43 I	9.8	8.0	19	72.2		
Minimum	0.14 U	0.77 I	0.54 I	0.82	13.0		

Notes:

I = between method detection limit and practical quantification limit.

NC = not calculated.

U = below method detection limit.

V = method blank contamination.

Table 3-4. Backup Rainfall Stations for SR 61 EMC Sampling Site

Station	Location Relative to Sample Site	Location	
		Latitude	Longitude
Station 654	2.3 mi SW	30.56218	-84.21885
KFLTALLA21	3.0 mi SW	30.55	-84.22
MD7294	5.1 mi NNW	30.66	-84.21
KFLTALLA44	3.3 mi ESE	30.54	-84.17

Table 3-5. Nutrient EMC Results based on Individual Samples for SR 61

	EMC (mg/L)									% of TN		
Date	NOx		NH4		TKN	Org N	TN	TP		NOx	NH4	Org N
27-Sep-10	0.366		0.408		1.15	0.742	1.52	0.671		24%	27%	49%
16-Nov-10	0.305		0.076	I	0.863	0.787	1.17	0.823		26%	6%	67%
15-Jul-11	0.126		0.207	I	3.30	3.09	3.43	0.582		4%	6%	90%
19-Feb-12	0.133		0.067	U	1.13	1.13	1.26	0.340		11%	0%	90%
27-Feb-12	0.064		0.067	U	0.568	0.568	0.632	0.237		10%	0%	90%
27-Feb-12	0.012	U	0.067	U	0.434	0.434	0.434	0.303		0%	0%	100%
3-Mar-12	0.211		0.067	U	0.785	0.785	0.996	0.256		21%	0%	79%
14-Mar-12	0.465		0.067	U	1.22	1.22	1.69	0.361		28%	0%	72%
3-Apr-12	0.688		0.116		1.34	1.22	2.03	0.584		34%	6%	60%
13-May-12	0.133		0.235		1.85	1.62	1.98	0.475		7%	12%	82%
14-May-12	0.038	I	0.212	I	1.36	1.15	1.40	0.376		3%	15%	82%
31-May-12	0.409		0.067	U	0.921	0.921	1.33	0.633		31%	0%	69%
1-Jun-12	0.156		0.067	U	1.23	1.23	1.39	0.629		11%	0%	88%
14-Jun-12	0.202		0.081	I	2.87	2.79	3.07	0.773		7%	3%	91%
25-Jun-12	0.013	I	0.067	U	0.625	0.625	0.638	0.258		2%	0%	98%
25-Jun-12	0.012	U	0.067	U	0.498	0.498	0.498	0.196		0%	0%	100%
3-Jul-12	0.363		0.067	U	1.51	1.51	1.87	0.258		19%	0%	81%
4-Jul-12	0.143		0.067	U	1.08	1.08	1.22	0.198		12%	0%	89%
5-Aug-12	0.012	U	0.067	U	0.824	0.824	0.824	0.425		0%	0%	100%
6-Aug-12	0.012	U	0.067	U	0.905	0.905	0.905	0.317		0%	0%	100%
29-Aug-12	0.217		0.067	U	1.21	1.21	1.43	0.290		15%	0%	85%
8-Sep-12	0.022	I	0.067	U	0.520	0.520	0.542	0.438		4%	0%	96%
18-Sep-12	0.255		0.067	U	1.01	1.01	1.27	0.805		20%	0%	80%
1-Oct-12	0.067		0.067	U	0.681	0.681	0.748	0.532		9%	0%	91%
3-Oct-12	0.061		0.067	U	0.551	0.551	0.612	0.411		10%	0%	90%
20-Dec-12	0.717		0.197	I	2.02	1.82	2.74	1.08		26%	7%	67%
26-Dec-12	0.161		0.067	U	1.16	1.16	1.32	0.586		12%	0%	88%
Median	0.143		NC		1.08	1.01	1.27	0.425				
Geomean	0.105		NC		1.03	0.985	1.19	0.428				
Arithmetic Average	0.199		NC		1.17	1.11	1.37	0.475				
Maximum	0.717		0.408		3.30	3.09	3.43	1.08				
Minimum	0.012	U	0.067	U	0.434	0.434	0.434	0.196				

Notes:

I = between method detection limit and practical quatification limit.

NC = not calculated.

U = below method detection limit.

Table 3-6. Flow-Weighted EMCs Over Period of Study for SR 61

Date	Rainfall (in)	Event Q (cf)	Event Load (lb) NOx	NH4	TKN	Org N	TN	TP
27-Sep-10	1.56	15634	0.357	0.398	1.122	0.724	1.484	0.655
16-Nov-10	1.60	25333	0.482	0.120	1.365	1.245	1.850	1.302
15-Jul-11	0.98	2529	0.020	0.033	0.521	0.488	0.542	0.092
19-Feb-12	2.04	12294	0.102	0.000	0.867	0.867	0.967	0.261
27-Feb-12	1.05	6520	0.026	0.000	0.231	0.231	0.257	0.096
27-Feb-12	0.54	6861	0.000	0.000	0.186	0.186	0.186	0.130
3-Mar-12	2.54	13578	0.179	0.000	0.665	0.665	0.844	0.217
14-Mar-12	1.07	5282	0.153	0.000	0.402	0.402	0.557	0.119
3-Apr-12	0.82	1798	0.077	0.013	0.150	0.137	0.228	0.066
13-May-12	0.79	1404	0.012	0.021	0.162	0.142	0.174	0.042
14-May-12	0.72	5357	0.013	0.071	0.455	0.384	0.468	0.126
31-May-12	1.92	6089	0.155	0.000	0.350	0.350	0.506	0.241
1-Jun-12	0.41	2239	0.022	0.000	0.172	0.172	0.194	0.088
14-Jun-12	0.38	2041	0.026	0.010	0.366	0.355	0.391	0.098
25-Jun-12	*1.9*	*9193*	0.007	0.000	0.359	0.359	0.366	0.148
25-Jun-12	*0.8*	*4854*	0.000	0.000	0.151	0.151	0.151	0.059
3-Jul-12	*1.4*	*7221*	0.164	0.000	0.681	0.681	0.843	0.116
4-Jul-12	*0.6*	*4065*	0.036	0.000	0.274	0.274	0.310	0.050
5-Aug-12	*2.4*	*11166*	0.000	0.000	0.574	0.574	0.574	0.296
6-Aug-12	*0.4*	*3276*	0.000	0.000	0.185	0.185	0.185	0.065
29-Aug-12	*1.3*	4165	0.056	0.000	0.315	0.315	0.372	0.075
8-Sep-12	0.67	8994	0.012	0.000	0.292	0.292	0.304	0.246
18-Sep-12	0.70	10125	0.161	0.000	0.638	0.638	0.803	0.509
1-Oct-12	*1.2*	3187	0.013	0.000	0.135	0.135	0.149	0.106
3-Oct-12	1.00	6859	0.026	0.000	0.236	0.236	0.262	0.176
20-Dec-12	*0.5*	813	0.036	0.010	0.103	0.093	0.139	0.055
26-Dec-12	0.63	5068	0.051	0.000	0.367	0.367	0.418	0.185
Total Measured Discharge (cf)		185944						
Total Measured Load (lb)			2.19	0.676	11.33	10.65	13.52	5.619
Flow-Weighted EMC (mg/L)			0.189	0.058	0.976	0.917	1.16	0.484

Notes:

Red italics = rainfall established from nearby rain gauge.

Green italics = event discharge estimated from discharge-rainfall relationship for other samples (see Figure 3-3).

Table 3-7. Metals EMC Results based on Individual Samples for SR 61

	Sample Results						
	Cadmium	Chromium	Copper	Lead	Zinc	Hardness	TSS
Date	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(mg/L)	(mg/L)
27-Sep-10	0.900 U	2.00 U	1.06 I	0.670 U	35.8	25	11
16-Nov-10	0.800	1.80	2.17	0.670 U	68.2	25	11
15-Jul-11	1.00 I	151	4.34	1.70 I	64.9	25.7	77
19-Feb-12	0.9 U	30.7	2.18	1.28 I	10.2	27.7	14
27-Feb-12	0.9 U	5.30 I	1.68	2.06 I	8.90	33.0	27
27-Feb-12	0.9 U	2.20 I	1.24 I	1.22 I	5.60	53.6	11
3-Mar-12	0.9 U	2.70 I	1.71 I	1.82 I	7.50	25.8	19
14-Mar-12	0.9 U	2 U	2.50	2.32 I	9.80	21.1	8
3-Apr-12	0.9 U	2.0 U	3.68	0.670 U	8.30	20	4
13-May-12	0.9 U	3.30	4.01	0.740	6.60	26.0	3
14-May-12	0.9 U	2 U	2.53	0.724 I	3.80 I	30.3	4
31-May-12	0.104 U	1.58	1.97	0.670 U	6.00	19.5	4
1-Jun-12	0.104 U	1.01 I	3.29	0.670 U	3.9 I	32.3	9
14-Jun-12	0.900 I	16.7	8.39	74.7	63.2	180	420
25-Jun-12	0.104 U	0.340 U	1.47	0.670 U	3.50 I	49.2	2.0
25-Jun-12	0.104 U	0.340 U	0.873 I	0.670 U	3.60 I	48.7	2.0
3-Jul-12	0.104 U	1.21 I	2.33	1.31 I	10.6	24.8	13
4-Jul-12	0.104 U	1.44	2.93	1.59 I	8.50	31.1	10
5-Aug-12	0.104 U	0.691 I	1.44	0.670 U	4.30 I	28.2	5
6-Aug-12	0.104 U	0.833 I	1.36 I	0.670 U	4.20 I	51.2	2.0
29-Aug-12	0.104 U	8.12	1.07 I	0.670 U	5.00 I	40.6	4
8-Sep-12	0.104 U	1.43	1.12 I	0.670 U	6.30	31.7	9
18-Sep-12	0.104 U	1.44	2.33	1.78 I	7.50	42.2	11
1-Oct-12	0.104 U	0.560 I	1.88	2.77	7.40	30.0	48
3-Oct-12	0.104 U	0.931 I	1.73	1.07 I	4.90 I	38.9	12
20-Dec-12	0.104 U	2.26	6.82	16.8	16.5	42.9	26
26-Dec-12	0.104 U	0.699 I	2.00	2.54 I	7.90	32.6	38
Median	NC	1.80	2.00	1.07	7.50		
Geomean	NC	2.11	2.14	1.37	8.89		
Arithmetic Average	NC	9.06	2.52	4.51	14.6		
Maximum	1.00	151	8.39	74.7	68.2		
Minimum	0.104 U	0.340 U	0.873 I	0.670 U	3.50		

Notes:

I = between method detection limit and practical quatification limit.

NC = not calculated.

U = below method detection limit.

Table 3-8. Nutrient EMC Results based on Individual Samples for SR 8 (I-10)

	EMC (mg/L)										% of TN		
Date	NOx		NH4		TKN	Org N	TN	TP		NOx	NH4	Org N
19-Feb-12	0.052		0.067	U	0.705	0.705	0.757	0.087		7%	0%	93%
27-Feb-12	0.067		0.067	U	0.476	0.476	0.543	0.116		12%	0%	88%
3-Mar-12	0.081		0.067	I	0.690	0.623	0.771	0.065		11%	9%	81%
31-May-12	0.335		0.176	I	1.60	1.42	1.94	0.346		17%	9%	74%
26-Jul-12	0.065		0.067	U	0.385	0.385	0.450	0.099		14%	0%	86%
3-Aug-12	0.052		0.119	I	1.29	1.17	1.34	0.181		4%	9%	87%
21-Aug-12	0.012	I	0.067	U	0.771	0.771	0.783	0.192		2%	0%	98%
30-Jan-13	1.20		0.067	U	3.64	3.64	4.84	0.523		25%	0%	75%
23-Feb-13	0.012	U	0.067	U	0.609	0.609	0.609	0.069		0%	0%	100%
24-Feb-13	0.017	I	0.067	U	0.614	0.614	0.631	0.117		3%	0%	97%
25-Feb-13	0.012	U	0.067	U	0.591	0.591	0.591	0.099		0%	0%	100%
25-Feb-13	0.095		0.067	U	0.486	0.486	0.581	0.406		16%	0%	84%
19-Mar-13	1.95		0.067	U	0.606	0.606	2.56	0.158		76%	0%	24%
23-Mar-13	0.048		0.067	U	0.591	0.591	0.639	0.108		8%	0%	92%
30-Jun-13	0.078		0.067	U	0.415	0.415	0.493	0.114		16%	0%	84%
3-Jul-13	0.012	U	0.067	U	0.351	0.351	0.351	0.090		0%	0%	100%
4-Jul-13	0.012	U	0.067	U	0.268	0.268	0.268	0.050	I	0%	0%	100%
5-Jul-13	0.012	U	0.067	U	0.314	0.314	0.314	0.035	I	0%	0%	100%
7-Jul-13	0.015	I	0.067	U	0.470	0.470	0.485	0.156		3%	0%	97%
30-Jul-13	0.066		0.067	U	0.517	0.517	0.583	0.139		11%	0%	89%
13-Aug-13	0.173		0.087	I	1.30	1.21	1.47	0.306		12%	6%	83%
14-Aug-13	0.083		0.067	U	0.580	0.580	0.663	0.014	U	13%	0%	87%
14-Aug-13	0.013	I	0.103	I	0.908	0.805	0.921	0.177		1%	11%	87%
17-Aug-13	0.012	U	0.067	U	0.359	0.359	0.359	0.129		0%	0%	100%
20-Aug-13	0.205		0.067	U	0.520	0.520	0.725	0.092		28%	0%	72%
Median	0.052		NC		0.591	0.591	0.631	0.116				
Geomean	0.051		NC		0.624	0.611	0.722	0.119				
Arithmetic Average	0.187		NC		0.762	0.740	0.946	0.155				
Maximum	1.95		0.176		3.64	3.64	4.84	0.523				
Minimum	0.012	U	0.067	U	0.268	0.268	0.268	0.014	U			

Notes:

I = between method detection limit and practical quantification limit.

NC = not calculated.

U = below method detection limit.

Table 3-9. Flow-Weighted EMCs Over Period of Study at SR 8 (I-10)

	Rainfall	Event Q	Event Load (lb)					
Date	(in)	(cf)	NOx	NH4	TKN	Org N	TN	TP
19-Feb-12	1.20	2665	0.009	0.000	0.117	0.117	0.126	0.014
27-Feb-12	0.51	901	0.004	0.000	0.027	0.027	0.031	0.007
3-Mar-12	3.47	12155	0.061	0.051	0.524	0.473	0.585	0.049
31-May-12	1.65	1184	0.025	0.013	0.118	0.105	0.143	0.026
26-Jul-12	2.72	6218	0.025	0.000	0.149	0.149	0.175	0.038
3-Aug-12	1.28	2053	0.007	0.015	0.165	0.150	0.172	0.023
21-Aug-12	1.64	1500	0.001	0.000	0.072	0.072	0.073	0.018
30-Jan-13	0.69	697	0.052	0.000	0.158	0.158	0.211	0.023
23-Feb-13	0.64	2044	0.000	0.000	0.078	0.078	0.078	0.009
25-Feb-13	2.21	3955	0.004	0.000	0.152	0.152	0.156	0.029
25-Feb-13	1.98	3486	0.000	0.000	0.129	0.129	0.129	0.022
25-Feb-13	1.82	7668	0.045	0.000	0.233	0.233	0.278	0.194
19-Mar-13	1.03	1004	0.122	0.000	0.038	0.038	0.160	0.010
23-Mar-13	1.53	3900	0.012	0.000	0.144	0.144	0.156	0.026
30-Jun-13	1.66	4527	0.022	0.000	0.117	0.117	0.139	0.032
3-Jul-13	2.59	3800	0.000	0.000	0.083	0.083	0.083	0.021
4-Jul-13	1.43	5073	0.000	0.000	0.085	0.085	0.085	0.016
5-Jul-13	1.77	2043	0.000	0.000	0.040	0.040	0.040	0.004
7-Jul-13	0.62	879	0.001	0.000	0.026	0.026	0.027	0.009
30-Jul-13	1.21	2697	0.011	0.000	0.087	0.087	0.098	0.023
13-Aug-13	1.34	3188	0.034	0.017	0.259	0.241	0.293	0.061
14-Aug-13	1.11	2839	0.015	0.000	0.103	0.103	0.118	0.000
14-Aug-13	0.42	993	0.001	0.006	0.056	0.050	0.057	0.011
17-Aug-13	1.19	4078	0.000	0.000	0.091	0.091	0.091	0.033
20-Aug-13	1.13	3085	0.039	0.000	0.100	0.100	0.140	0.018
Total Measured Discharge (cf)		82633						
Total Measured Load (lb)			0.491	0.103	3.151	3.049	3.642	0.716
Flow-Weighted EMC (mg/L)			0.095	0.020	0.611	0.591	0.706	0.139

Table 3-10. Metals EMC Results based on Individual Samples for SR 8

	Sample Results						
	Cadmium	Chromium	Copper	Lead	Zinc	Hardness	TSS
Date	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(mg/L)	(mg/L)
19-Feb-12	0.9 U	2.10 I	2.24	0.670 U	11.0	12.8	12
27-Feb-12	0.9 U	2 U	1.37 I	1.03 I	12.1	11.2	28
3-Mar-12	0.9 U	2.0 U	1.29 I	0.670 U	7.90	11.6	19
31-May-12	0.104 U	0.340 U	1.85	0.670 U	13.7	15.7	29
26-Jul-12	0.104 U	0.340 U	0.831 I	0.670 U	7.90	7.1	15
3-Aug-12	0.104 U	0.340 U	1.56	0.670 U	6.40	12.6	3
21-Aug-12	0.104 U	0.340 U	0.441 I	0.670 U	6.90	2.7	14
30-Jan-13	0.110 I	11.4	7.82	43.3	105	19.1	610
23-Feb-13	0.104 U	1.05 I	1.04 I	3.00	12.8	23.0	24
24-Feb-13	0.104 U	1.52	0.822 I	3.15	11.5	19.5	31
25-Feb-13	0.177 I	1.63	1.74	6.13	16.5	20.0	56
25-Feb-13	0.104 U	1.64	1.09 I	5.69	14.8	18.1	45
19-Mar-13	0.104 U	0.340 U	1.53	0.670 U	5.70	5.40	3
23-Mar-13	0.104 U	0.404 I	1.59	0.750 I	7.10	17.2	15
30-Jun-13	0.104 U	0.340 U	0.928 I	0.670 U	4.50 I	18.9	22
3-Jul-13	0.104 U	0.340 U	1.51	0.670 U	4.10 I	22.9	5 I
4-Jul-13	0.104 U	0.340 U	0.753 I	0.670 U	3.00 I	23.5	2.0 U
5-Jul-13	0.104 U	0.340 U	1.41	0.670 U	3.40 I	14.8	6 I
7-Jul-13	0.104 U	0.340 U	2.42	0.670 U	5.00 I	23.7	3 I
30-Jul-13	0.104 U	0.340 U	1.81	0.670 U	4.90 I	10.6	7 I
13-Aug-13	0.104 U	0.340 U	1.77	0.670 U	5.80	14.8	13
14-Aug-13	0.104 U	0.340 U	1.68	0.670 U	5.20 I	9.0	7
14-Aug-13	0.104 U	0.340 U	2.39	1.01 I	32.9	8.6	16
17-Aug-13	0.104 U	0.647 I	1.16 I	0.670 U	3.80 I	29.1	7 I
20-Aug-13	0.104 U	0.340 U	2.52	0.688 I	5.30 I	13.2	6 I
Median	NC	NC	1.53	NC	6.90		
Geomean	NC	NC	1.48	NC	8.20		
Arithmetic Average	NC	NC	1.74	NC	12.7		
Maximum	0.274	11.4	7.82	43.3	105		
Minimum	0.104 U	0.340 U	0.441	0.670 U	3.00		

Notes:

I = between method detection limit and practical quantification limit.

NC = not calculated.

U = below method detection limit.

Table 3-11. Nutrient EMC Results based on Individual Samples for SR 417

Date	EMC (mg/L)						% of TN		
	NOx	NH4	TKN	Org N	TN	TP	NOx	NH4	Org N
17-Jun-10	1.0	0.15	1.6	1.4	2.6	0.58	38%	6%	56%
1-Jul-10	0.048 U	0.010 U	0.38	0.38	0.38	0.089	0%	0%	100%
4-Jul-10	1.2	0.013 I	0.38	0.36	1.6	0.039 I	76%	1%	23%
7-Aug-10	0.42	0.051	0.88	0.83	1.3	0.45	32%	4%	64%
8-Aug-10	0.59	0.024 I	1.0	0.98	1.6	0.21	37%	2%	61%
21-Aug-10	1.0	0.017 I	0.63	0.61	1.7	0.081	59%	1%	36%
24-Sep-10	1.1	0.052 U	0.94 V	0.94	2.0	0.29	55%	0%	47%
17-Jan-11	1.8	0.080 I	1.8	1.7	3.6	0.76	50%	2%	48%
21-Jan-11	0.58	0.025 U	2.5	2.5	3.1	2.5	19%	0%	81%
25-Jan-11	1.2	0.19	1.2	1.0	2.4	0.41	50%	8%	42%
25-Jun-11	0.54	0.15	1.5	1.4	2.0	0.44	27%	8%	68%
27-Jun-11	0.20	0.053 I	0.93	0.88	1.1	0.23	18%	5%	80%
15-Jul-11	0.32	0.025 U	1.2	1.2	1.5	0.24	21%	0%	79%
22-Jul-11	0.69	0.025 U	1.2	1.2	1.9	5.5	37%	0%	63%
2-Aug-11	0.43	0.025 U	0.35	0.35	0.78	0.26	55%	0%	45%
23-Sep-11	0.048 U	0.025 U	0.81	0.81	0.81	0.89	0%	0%	100%
9-Oct-11	0.048 U	0.025 U	0.82	0.82	0.82	3.3	0%	0%	100%
10-Oct-11	1.4	0.025 U	0.78	0.78	2.1	1.6	64%	0%	36%
10-Jun-12	0.44	0.025 U	1.1	1.1	1.5	0.12	29%	0%	73%
14-Jun-12	0.21	0.025 U	0.80	0.80	1.0	0.51	21%	0%	80%
14-Apr-13	0.94	0.025 U	2.9 I	2.9	3.9	0.20 U	24%	0%	74%
29-Apr-13	0.50	0.183	2.2	2.0	2.7	0.718	19%	7%	75%
2-May-13	0.59	0.042	0.69	0.65	1.3	0.226	45%	3%	50%
Median	0.580	NC	0.940	0.940	1.60	0.410			
Geomean	0.459	NC	0.996	0.963	1.59	0.408			
Arithmetic Average	0.665	NC	1.16	1.11	1.82	0.854			
Maximum	1.8	0.19	2.9	2.9	3.9	5.5			
Minimum	0.048	0.010 U	0.35	0.35	0.38	0.039			

Notes:

I = between method detection limit and practical quantification limit.

NC = not calculated.

U = below method detection limit.

V = method blank contamination.

Table 3-12. Adjusted Flow-Weighted EMCs Over Period of Study for SR 417

	Rainfall	Event Q	Event Load (lb)					
Date	(in)	(cf)	NOx	NH4	TKN	Org N	TN	TP
17-Jun-10	1.30	5118	0.320	0.048	0.511	0.463	0.831	0.185
1-Jul-10	2.69	40326	0.000	0.000	0.957	0.957	0.957	0.224
4-Jul-10	1.02	9167	0.687	0.007	0.217	0.210	0.904	0.022
7-Aug-10	0.93	4136	0.108	0.013	0.227	0.214	0.336	0.116
8-Aug-10	1.66	18516	0.682	0.028	1.156	1.128	1.849	0.243
21-Aug-10	1.30	3948	0.246	0.004	0.155	0.151	0.419	0.020
24-Sep-10	1.28	7292	0.501	0.000	0.428	0.428	0.910	0.132
17-Jan-11	1.35	1914	0.215	0.010	0.215	0.206	0.430	0.091
21-Jan-11	1.19	3783	0.137	0.000	0.590	0.590	0.732	0.590
25-Jan-11	1.13	9022	0.676	0.107	0.676	0.569	1.352	0.231
25-Jun-11	1.35	16471	0.555	0.154	1.542	1.388	2.057	0.452
27-Jun-11	1.00	4343	0.054	0.014	0.252	0.238	0.298	0.062
15-Jul-11	2.10	55028	1.099	0.000	4.122	4.122	5.222	0.824
22-Jul-11	1.24	6134	0.264	0.000	0.460	0.460	0.724	2.106
2-Aug-11	1.23	15252	0.409	0.000	0.333	0.333	0.743	0.248
23-Sep-11	0.75	4868	0.000	0.000	0.246	0.246	0.246	0.270
9-Oct-11	2.35	20624	0.000	0.000	1.056	1.056	1.056	4.249
10-Oct-11	0.59	8142	0.712	0.000	0.396	0.396	1.108	0.813
10-Jun-12	1.76	30388	0.835	0.000	2.087	2.087	2.846	0.228
14-Jun-12	1.88	33781	0.443	0.000	1.687	1.687	2.109	1.076
14-Apr-13	*2.70*	*51645*	3.031	0.000	9.350	9.350	12.574	0.645
29-Apr-13	1.10	2718	0.085	0.031	0.373	0.342	0.458	0.122
2-May-13	1.52	4722	0.174	0.012	0.203	0.191	0.383	0.067
Total Measured Discharge (cf)		357338						
Total Measured Load (lb)			11.23	0.429	27.24	26.81	38.54	13.02
Flow-Weighted EMC (mg/L)			0.504	0.019	1.22	1.20	1.73	0.58

Notes:

Red italics = rainfall established from nearby rain gauge.

Table 3-13. Metals EMC Results based on Individual Samples for SR 417

	Sample Results						
Date	Cadmium (µg/L)	Chromium (µg/L)	Copper (µg/L)	Lead (µg/L)	Zinc (µg/L)	Hardness mg/L	TSS mg/L
17-Jun-10	0.99	1.9 I	5.4	0.58 I	29 V	33	15
1-Jul-10	0.14 U	2.0 I	2.8	0.29 I	12 V	17	4.0
4-Jul-10	0.14 U	1.9 I	1.6	0.13 I	13 V	47	3.8
7-Aug-10	0.14 U	1.3 I,V	3.3	0.20 I	11	24	8.4
8-Aug-10	0.14 U	1.1 I,V	2.8	0.24 I	13	44	5.8
21-Aug-10	0.14 U	1.4 I	3.7	0.46 I	24	28	7.6
24-Sep-10	0.14 U	2.0	6.0	1.4	15	28	28
17-Jan-11	0.19 I	1.4	5.3	0.78	31	32	2.0 U
21-Jan-11	0.14 U	2.6	10	1.6	31	42	68
25-Jan-11	0.14 U	2.2	5.9	0.81	19	36	28
25-Jun-11	0.14 U	1.5 I	7.2	1.5	26	22	32
27-Jun-11	0.14 U	1.0 U	3.3	0.28 I	22	42	6.4
15-Jul-11	0.14 U	1.0 U	3.0	0.49 I	19	13	24
22-Jul-11	0.14 U	1.5 I	5.2	0.34 I	20	25	11
2-Aug-11	0.14 U	1.1 I	3.0	0.23 I	16	26	7.6
23-Sep-11	0.14 U	1.0 U	3.5	0.25 I	18	29	8.4
9-Oct-11	0.14 U	1.0 U	3.2	0.29 I	19	23	13
10-Oct-11	0.14 U	1.0 U	1.2	0.15 I	18	110	7.4
10-Jun-12	0.14 U	2.1	4.7	1.5	23	15	82
14-Jun-12	0.14 U	3.4	4.8	1.9	18	17	64
14-Apr-13	0.14 U	1.0 U	3.4	0.43	120	35	6.2
29-Apr-13	0.14 U	1.1 I	8.5	1.4	59	32	13
2-May-13	0.14 U	1.0 U	3.1	0.37 I	15	38	5.8
Median	NC	1.4	3.5	0.43	19		
Geomean	NC	1.4	3.9	0.49	21		
Arithmetic Average	NC	1.5	4.4	0.68	26		
Maximum	0.99	3.4	10	1.9	120		
Minimum	0.14 U	1.0 U	1.2	0.13	11		

Notes:

I = between method detection limit and practical quantification limit.

NC = not calculated.

U = below method detection limit.

V = method blank contamination.

Table 3-14. Nutrient EMC Results based on Individual Samples for SR 429

	EMC (mg/L)						% of TN		
Date	NOx	NH4	TKN	Org N	TN	TP	NOx	NH4	Org N
13-Aug-10	0.35	0.056	4.3	4.2	4.7	0.73	7%	1%	90%
27-Aug-10	0.33	0.061	0.88	0.82	1.2	0.51	28%	5%	68%
6-Sep-10	0.23	0.086	1.3	1.2	1.5	0.66	15%	6%	81%
17-Jan-11	1.7	0.85	2.8	2.0	4.5	1.2	38%	19%	43%
21-Jan-11	1.9	0.24	2.2	2.0	4.1	2.2	46%	6%	48%
25-Jan-11	0.82	0.19	2.1	1.9	3.0	0.61	28%	7%	66%
28-Jun-11	0.048 U	0.36	4.9	4.5	4.9	1.0	0%	7%	93%
7-Jul-11	0.59	0.14	2.0	1.9	2.6	1.5	23%	5%	72%
18-Jul-11	0.64	0.10	1.8	1.7	2.5	0.36	27%	4%	71%
23-Feb-12	9.4	0.41 I	19	19	28	6.5	34%	1%	66%
6-Jun-12	1.9	0.20	2.5	2.3	4.4	0.90	43%	5%	52%
10-Jun-12	0.46	0.17	1.7	1.5	2.1	0.44	21%	8%	70%
8-Jul-12	0.78	0.22	1.6	1.4	2.4	2.4	33%	9%	58%
9-Jul-12	0.048 U	0.031 I	0.49	0.46	0.49	0.046 U	0%	6%	94%
8-Aug-12	1.4	0.048 I	2.7	2.7	4.1	2.0	34%	1%	65%
29-Aug-12	0.43	0.10	0.48	0.38	0.91	0.56	47%	11%	42%
6-Sep-12	0.90	0.19	1.1	0.91	2.0	1.2	45%	10%	46%
4-Oct-12	0.12	0.066	0.66	0.59	0.78	0.807	15%	8%	76%
14-Apr-13	3.8	0.50 U	8.8	8.8	13	60	29%	0%	68%
21-Apr-13	0.50	0.238	2.1	1.9	2.6	0.434	19%	9%	72%
2-May-13	0.15	0.116	0.39	0.27	0.54	0.242	28%	21%	51%
3-May-13	0.16	0.086	0.45	0.36	0.61	0.265	26%	14%	60%
Median	0.545	0.155	1.90	1.78	2.50	0.769			
Geomean	0.537	0.146	1.75	1.55	2.42	0.905			
Arithmetic Average	1.21	0.203	2.92	2.74	4.13	3.84			
Maximum	9.4	0.85	19	18.59	28	60			
Minimum	0.048 U	0.031 I	0.39	0.274	0.49	0.046 U			

Notes:

I = between method detection limit and practical quantification limit.

U = below method detection limit.

Table 3-15. Flow-Weighted EMCs Over Period of Study for SR 429

Date	Rainfall (in)	Event Q (cf)	Event Load (lb) NOx	NH4	TKN	Org N	TN	TP
13-Aug-10	1.08	3532	0.077	0.012	0.948	0.936	1.036	0.161
27-Aug-10	1.43	730	0.015	0.003	0.040	0.037	0.055	0.023
6-Sep-10	1.96	6729	0.097	0.036	0.546	0.510	0.630	0.277
17-Jan-11	1.36	1726	0.183	0.092	0.302	0.210	0.485	0.129
21-Jan-11	0.51	1039	0.123	0.016	0.143	0.127	0.266	0.143
25-Jan-11	1.35	10131	0.519	0.120	1.328	1.208	1.834	0.386
28-Jun-11	*2.3*	21754	0.000	0.489	6.654	6.166	6.654	1.358
7-Jul-11	0.82	7818	0.288	0.068	0.976	0.908	1.269	0.732
18-Jul-11	0.48	2715	0.108	0.017	0.305	0.288	0.407	0.061
23-Feb-12	0.54	312	0.183	0.008	0.370	0.362	0.545	0.127
6-Jun-12	0.65	548	0.065	0.007	0.086	0.079	0.151	0.031
10-Jun-12	1.45	7069	0.203	0.075	0.750	0.675	0.971	0.194
8-Jul-12	0.78	310	0.015	0.004	0.031	0.027	0.046	0.046
9-Jul-12	2.24	20866	0.000	0.040	0.638	0.598	0.638	0.000
8-Aug-12	1.04	841	0.074	0.003	0.142	0.139	0.215	0.105
29-Aug-12	0.77	453	0.012	0.003	0.014	0.011	0.026	0.016
6-Sep-12	1.02	843	0.047	0.010	0.058	0.048	0.105	0.063
4-Oct-12	2.18	8589	0.064	0.035	0.354	0.318	0.418	0.433
14-Apr-13	0.60	490	0.116	0.000	0.269	0.269	0.398	1.835
21-Apr-13	3.18	20990	0.655	0.312	2.752	2.440	3.407	0.569
2-May-13	0.90	3512	0.033	0.025	0.086	0.060	0.118	0.053
3-May-13	2.11	21167	0.211	0.114	0.595	0.481	0.806	0.350
Total Measured Discharge (cf)		142163						
Total Measured Load (lb)			3.090	1.489	17.39	15.90	20.48	7.092
Flow-Weighted EMC (mg/L)			0.348	0.168	1.96	1.79	2.31	0.80

Notes:

Red italics = rainfall established from nearby rain gauge.

Table 3-16. Metals EMC Results based on Individual Samples for SR 429

	Sample Results						
	Cadmium	Chromium	Copper	Lead	Zinc	Hardness	TSS
Date	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(mg/L)	(mg/L)
13-Aug-10	0.22 I	1.0 U	4.2	0.59 I	21	13	14
27-Aug-10	0.16 I	1.2 I	2.2	0.076 U	30	12	5.0
7-Sep-10	0.14 U	1.1 I	4.4	0.70 I	21	10	14
17-Jan-11	0.14 I	1.0 U	4.3	0.65 I	84	18	12
21-Jan-11	0.14 U	1.5 I	2.9	0.26 I	46	18	9.3
25-Jan-11	0.14 U	2.2	5.1	1.2	36	11	18
28-Jun-11	0.68 U	5.1 U	11	5.5	65 V	24	110
7-Jul-11	1.4 U	10 U	7.2	2.6 I	46	17	38
18-Jul-11	0.14 U	1.2 I	5.1	1.4	45	17	20
23-Feb-12	1.4 U	10 U	51.0	12	1400	150	300
6-Jun-12	0.14 U	2.5	11	2.4	130	28	51
10-Jun-12	0.14 U	2.4	10	2.5	69	16	61
8-Jul-12	1.4 U	10 U	17	1.4 I	260	46	69
9-Jul-12	0.14 U	1.0 U	5.0	0.79	35	13	48
8-Aug-12	0.14 U	1.7 I	4.5 V	0.30 I	60	15	14
29-Aug-12	0.14 U	1.3 I	2.4	0.31 I	68	10	6.4
6-Sep-12	0.14 U	1.0 U	3.0	0.20 I	47	14	4.0
5-Oct-12	0.14 U	1.0 U	2.4	0.18 I	46	7.3	3.6
14-Apr-13	0.14 U	1.0 U	7.5	0.58 I	19	23	24
21-Apr-13	0.14 U	1.4 I	4.9	0.87 V	47	13	6.7
2-May-13	0.14 U	1.0 U	3.3	0.30 I	49	12	4.4
3-May-13	0.14 U	1.0 U	3.0	0.46 I	20	8.1	5.8
Median	NC	NC	4.5	0.68	47		
Geomean	NC	NC	5.4	0.76	55		
Arithmetic Average	NC	NC	7.8	1.60	120		
Maximum	1.4 U	10 U	51.0	12	1400		
Minimum	0.14 U	1.0 U	2.2	0.076 U	19		

Notes:

I = between method detection limit and practical quantification limit.

NC = not calculated.

U = below method detection limit.

V = method blank contamination.

Table 3-17. Nutrient First-Flush Water Quality Results

Location	Date	EMC (mg/L)								% of TN		
		NOx		NH4		TKN	Org N	TN	TP	NOx	NH4	Org N
I-75 at County Road 236	3-Jun-10	0.731		0.107		2.20	2.09	2.93	0.786	25%	4%	71%
I-75 at County Road 236	18-Jun-10	1.42		0.294		4.47	4.18	5.89	5.14	24%	5%	71%
State Road 61	30-Jan-13	0.953		0.067	U	3.56	3.56	4.51	0.372	21%	0%	79%
I-10 at Exit 152	29-Apr-13	0.012	U	0.255	I	2.27	2.02	2.27	0.628	0%	11%	89%
I-10 at Exit 152	29-Jun-13	1.50		0.146	I	1.09	0.944	2.59	0.090	58%	6%	36%
I-10 at Exit 152	11-Jul-13	0.028	I	0.067	U	0.672	0.672	0.700	0.088	4%	0%	96%
State Road 429	19-Sep-12	1.40		0.314		2.70	2.39	4.10	1.19	34%	8%	58%
Median		0.953		0.146		2.27	2.09	2.93	0.628			

Notes:

I = between method detection limit and practical quantification limit.

U = below method detection limit.

Table 3-18. Metals and TSS First-Flush Water Quality Results

		Sample Results						
		Cadmium	Chromium	Copper	Lead	Zinc	Hardness	TSS
Location	Date	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(mg/L)	(mg/L)
I-75 at County Road 236	3-Jun-10	0.14 U	3.2	1.5	3.8	33.2	23.6	ND
I-75 at County Road 236	18-Jun-10	0.38 I	3.9	6.1	4.6	82.4	67.7	67
State Road 61	30-Jan-13	0.104 U	7.6	8.0	18.7	30.8	37.2	384
I-10 at Exit 152	29-Apr-13	0.104 U	4.0	7.21	10.7	62.6	20.1	166
I-10 at Exit 152	29-Jun-13	0.274 I	1.23 I	4.48	2.40 I	20.7	27.5	132
I-10 at Exit 152	11-Jul-13	0.104 U	0.340 U	2.23	0.670 U	7.50	31.2	4
State Road 429	19-Sep-12	0.18 I	1.7 I	1.8	3.0	86	14	6.0
Median		NC	3.2	4.5	3.8	33.2	27.5	100

Notes:

I = between method detection limit and practical quantification limit.

NC = not calculated.

ND = no data.

U = below method detection limit.

Table 3-19. Summary of Nutrient Water Quality Data

Location	NOx		NH4		TKN	Org N		TN	TP
	Sample Median (mg/L)	% of TN load	Sample Median (mg/L)	% of TN load	Sample Median (mg/L)	Sample Median (mg/L)	% of TN load	Sample Median (mg/L)	Sample Median (mg/L)
CR 236	0.287	20	0.080	4	1.58	1.487	76	1.83	1.02
SR 61	0.143	16	NC	5	1.08	1.01	79	1.27	0.425
SR 8	0.052	13	NC	3	0.591	0.591	84	0.631	0.116
SR 417	0.580	29	0.025	1	0.940	0.940	70	1.60	0.410
SR 429	0.545	15	0.155	7	1.90	1.780	78	2.50	0.769
First Flush	0.953		0.255		2.70	2.39		4.10	0.786

NC - median value not calculated.

Table 3-20. Summary of Metals EMCs based on Sample Median

Location	Cadmium (µg/L)	Chromium (µg/L)	Copper (µg/L)	Lead (µg/L)	Zinc (µg/L)
CR 236	NC	2.6	2.6	4.8	29.8
SR 61	NC	1.80	2.00	1.07	7.50
SR 8	NC	NC	1.53	NC	6.90
SR 417	NC	1.4	3.5	0.43	19
SR 429	NC	NC	4.5	0.68	47
First Flush	NC	3.2	4.5	3.8	33.2

NC - median value not calculated.

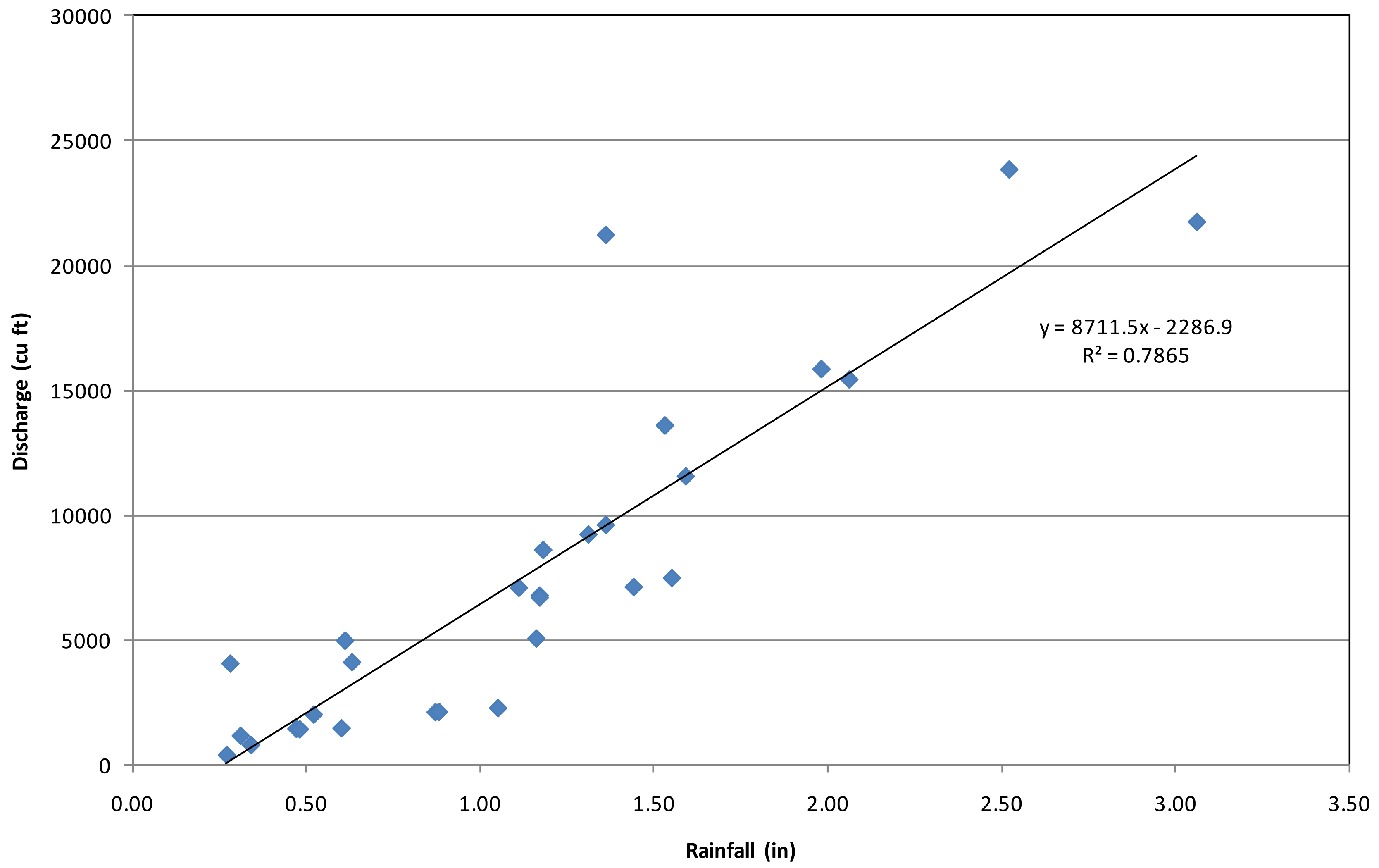


Figure 3-1
Relationship between Event Discharge and Event Rainfall at the I-75 at CR 236 Sampling Site

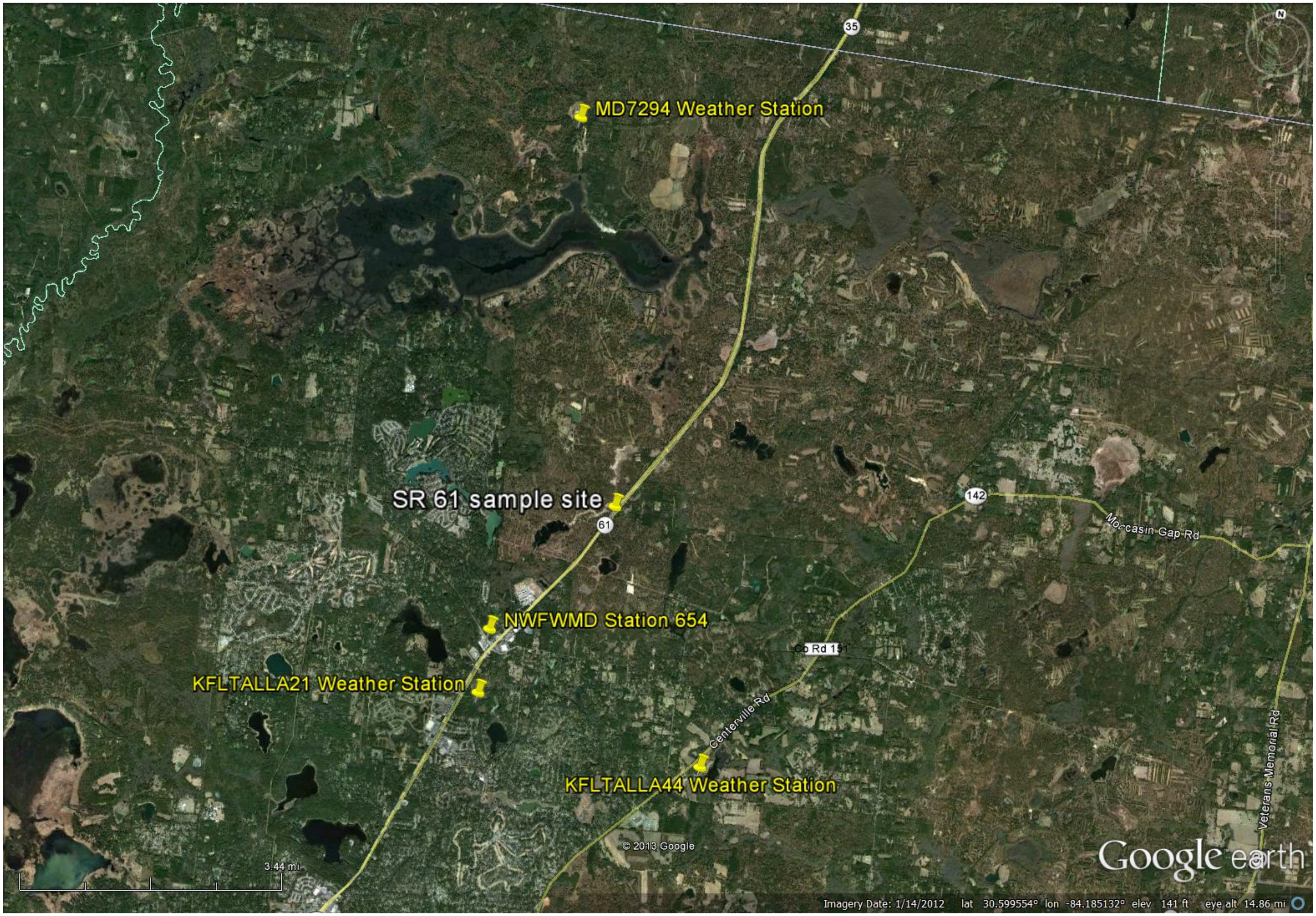


Figure 3-2
Rainfall Stations Used to Obtain Missing Rainfall Data at State Road 61 Sample Site

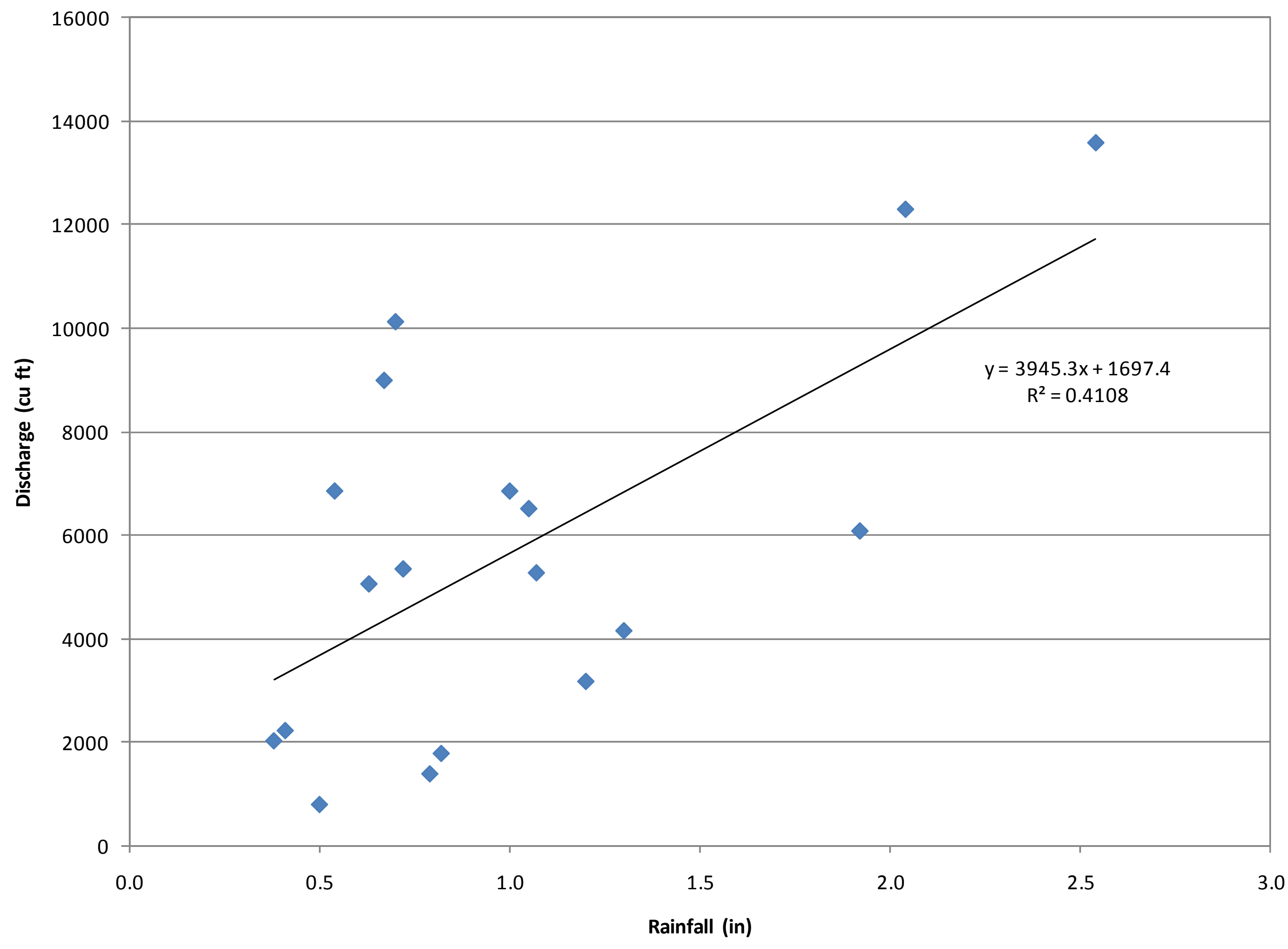


Figure 3-3
Relationship between Event Discharge and Event Rainfall at the State Road 61 Sampling Site

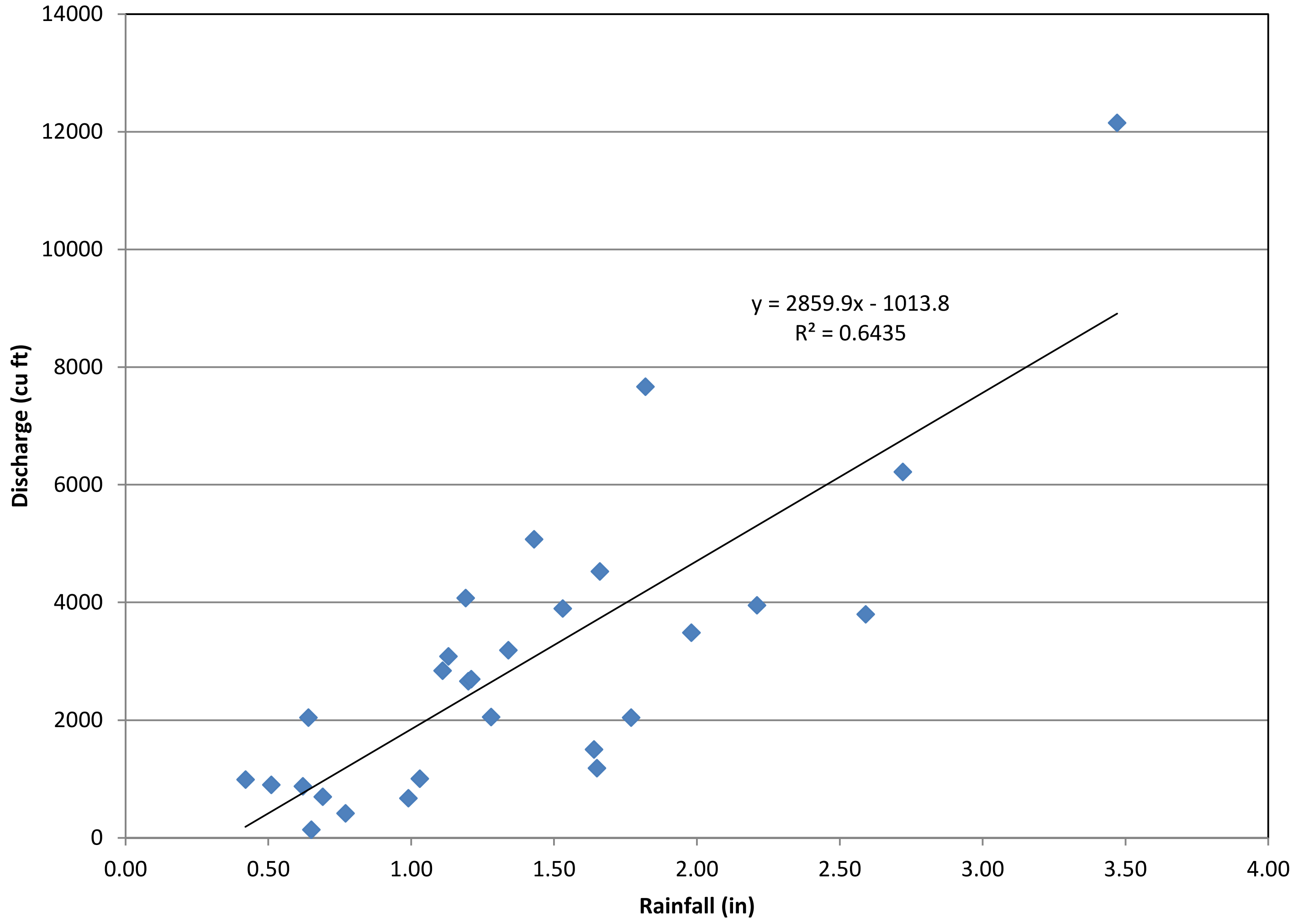


Figure 3-4

Relationship between Event Discharge and Event Rainfall at the State Road 8 (I-10) Sampling Site

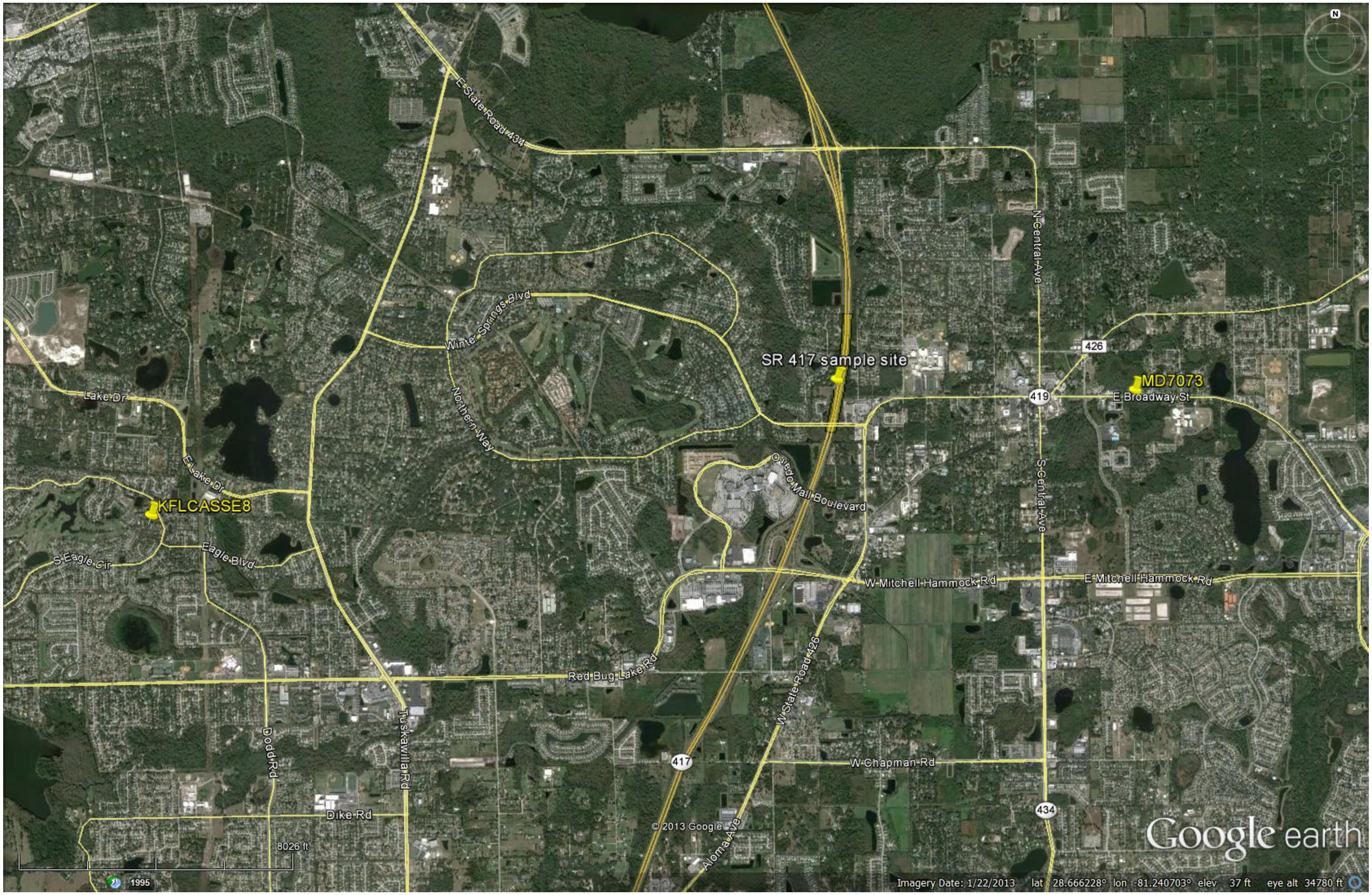


Figure 3-5

Rainfall Stations Used to Obtain Missing Rainfall Data at State Road 417 Sample Site

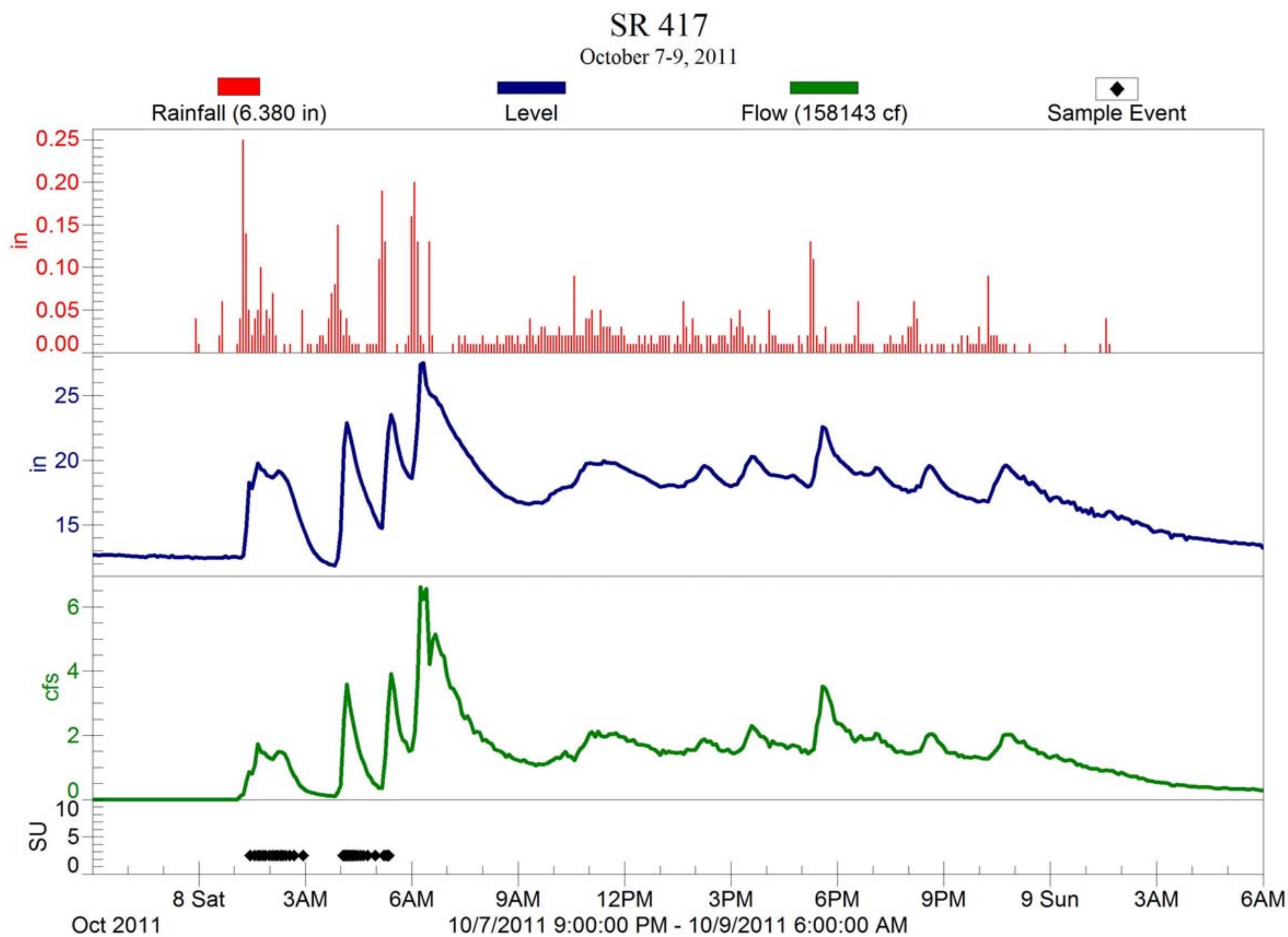


Figure 3-6
Storm Event at State Road 417, October 7-9, 2011

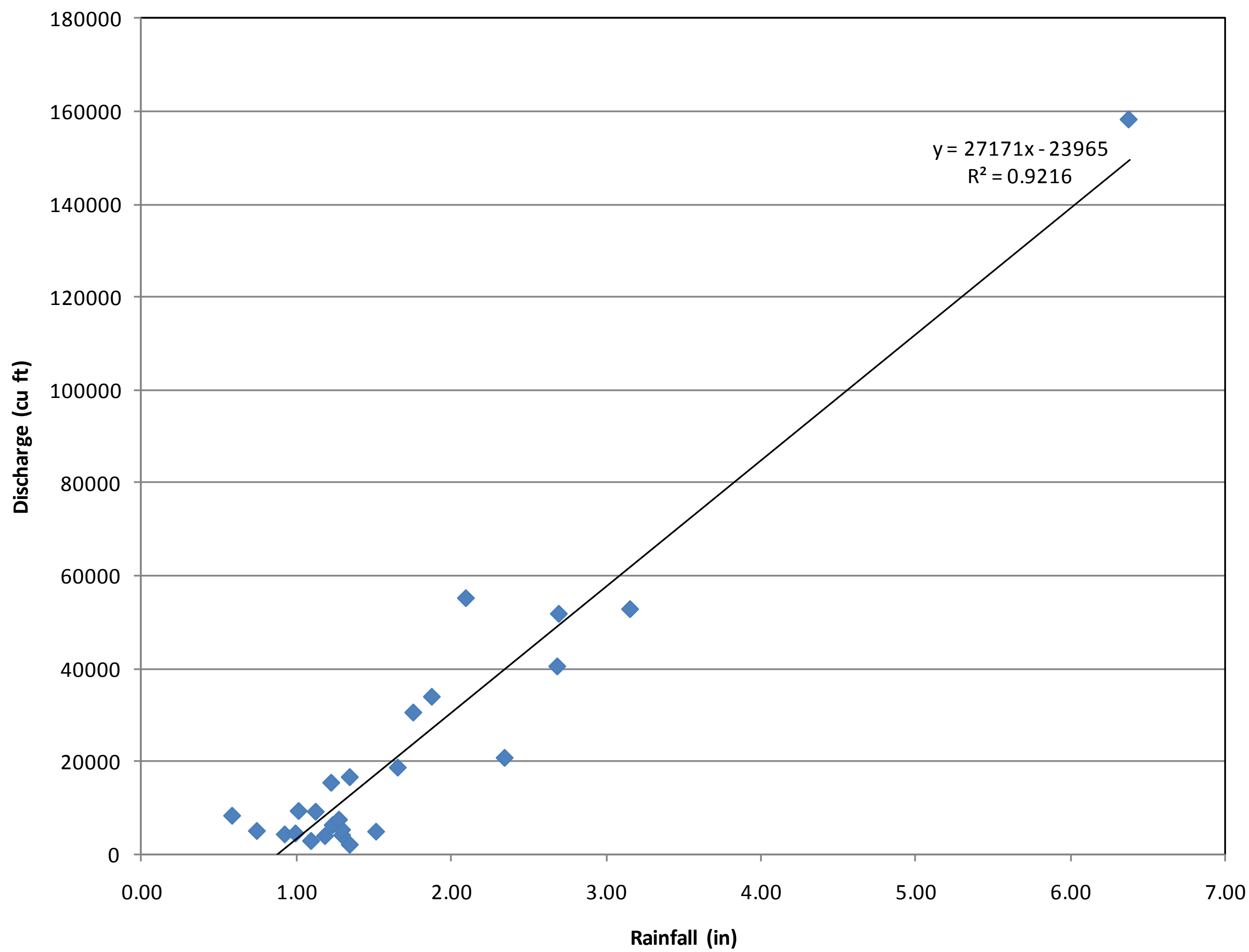


Figure 3-7

Relationship between Event Discharge and Event Rainfall at the State Road 417 Sampling Site

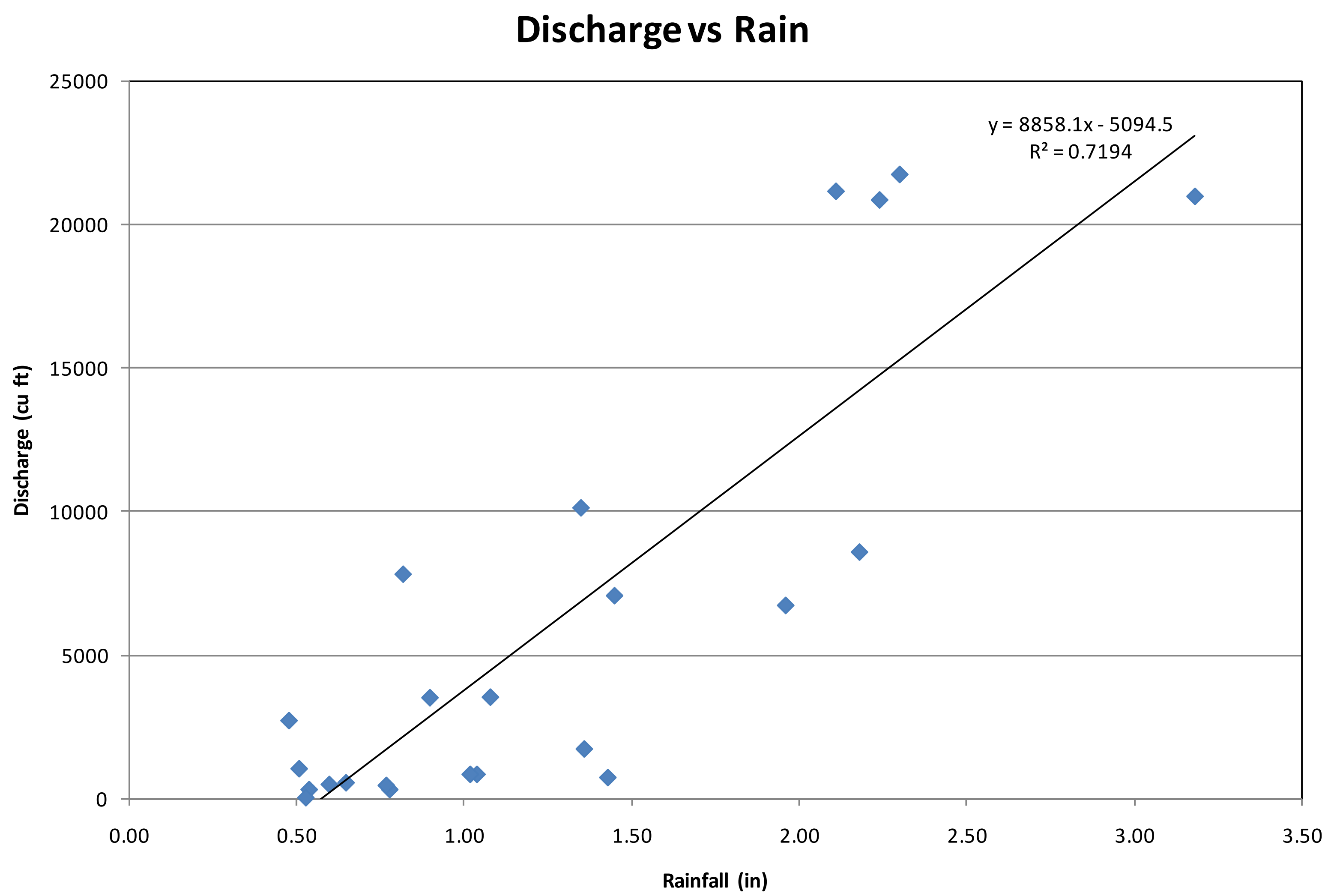


Figure 3-8
Relationship between Event Discharge and Event Rainfall at the State Road 429 Sampling Site

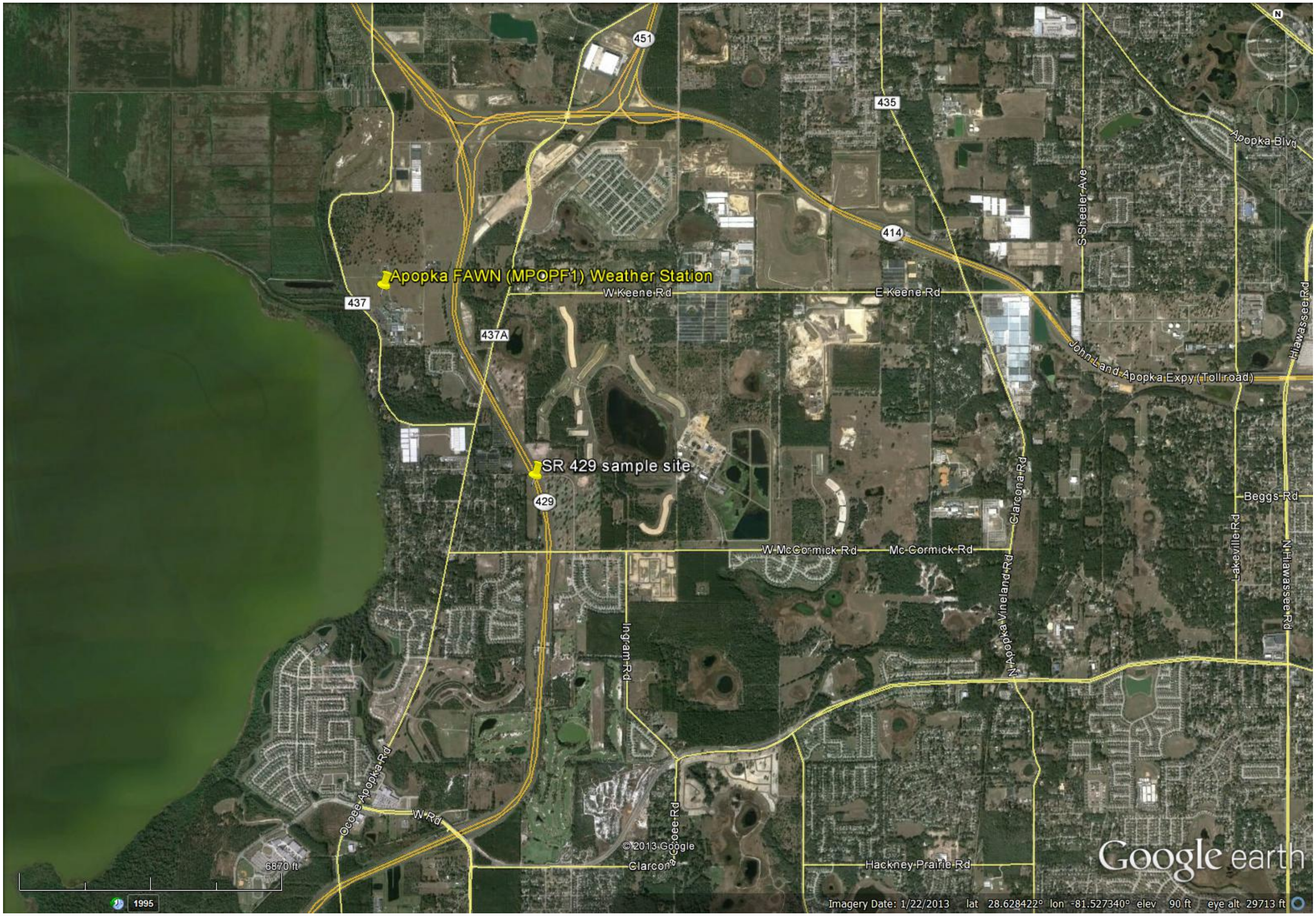


Figure 3-9

Rainfall Station Used to Obtain Missing Rainfall Data at State Road 429 Sample Site

4.0 DISCUSSION OF RESULTS

4.1 UPDATED STATEWIDE NUTRIENT EMCS

Table 1-1 presents the individual studies that form the basis for the TN and TP statewide highway EMC values that FDEP currently uses for environmental resource permitting of stormwater treatment systems [see Table 3.4 of the Stormwater Quality Applicant's Handbook (FDEP, 2010)]. Applied Technology and Management, Inc. (ATM) conducted a review of the studies used to develop these statewide highway EMCs on behalf of FDOT District 1 (ATM, 2010). The complete study, "Determination of Appropriate Highway EMC Values within FDOT District 1," is included as Appendix F. Recommendations based on this review are summarized as follows.

1. Data from the I-4 Maitland interchange in Harper (1985) and Yousef et al. (1986) are the same data. Duplicate data should be removed from the calculations.
2. The I-95 Miami bridge study (McKenzie et al., 1983) was a reconnaissance study with a small sample size (four samples), and the highest rainfall event was just 0.65 inch. In addition, much of the runoff from the bridge was diverted through downdrains and never flowed through the sample point. The small number of events combined with the lack of higher rainfall events make this study unsuitable for inclusion in the calculation of statewide EMCs. There are sufficient studies with more robust data sets on which to base the EMCs.
3. Data collected as part of the I-4 Epcot interchange study (Yousef et al., 1986) are representative of first flush, not composite samples, and are not appropriate for inclusion in calculation of statewide EMCs. These data should be removed from the calculation.

Table 4-1 provides updated TN and TP EMC values that incorporate the results from this study as well as the recommendations in the ATM (2010) report. In addition, arithmetic averages from studies were replaced with median values if the information was available. Median values are a better representation of central tendency for non-normally distributed data sets. For consistency with FDEP's most recently completed calculations, the statewide EMC values are calculated as the geometric mean of the EMCs from individual studies. The TN and TP EMCs are 1.20 mg/L and 0.198 mg/L, respectively. For comparison, the EMC values calculated as a median of the results from individual studies for TN and TP are 1.27 mg/L and 0.170 mg/L, respectively.

4.2 REGIONAL VARIATIONS IN NUTRIENT EMCS

4.2.1 TOTAL PHOSPHORUS EMCS

An unexpected result of this study was the high measured TP values in the roadway runoff at four of the five sites. There appeared to be some correlation between bed sediment phosphorus (BSP) concentrations and the concentration of TP in the stormwater runoff. BSP is a measure of the amount of naturally occurring phosphorus contained within the soils underlying the watershed that drains to the sampling point. The U.S. Geological Survey (USGS) used data it compiles on the chemical composition of stream-channel sediments to assist with characterization of the contribution of phosphorus to streams from weathering and erosion of surficial geologic materials. This dataset was used to develop a map of BSP in the southeastern United States to identify the potential for geologic materials to contribute non-anthropogenic phosphorus to receiving waters (Terziotti et al., 2010). Figure 4-1 shows the locations of EMC sampling sites relative to the BSP regions delineated by Terziotti et al. (2010). The average BSP for the regions in which each EMC site was located, as well as the range of BSP for the region, are provided in Table 4-1. The BSP values shown are representative of natural or background conditions.

One factor that likely affects the influence of the BSP on TP in basin runoff is percent impervious area. Runoff from basins with a low percent of impervious area has greater interaction with the phosphatic soils and is more likely to have increased TP due to background conditions. For basins with very high impervious areas, most of the influence of BSP on the TP in runoff is expected to be due to transfer from vehicles entering and leaving the highway. It is also noted that the range of BSP within a single geologic mapping unit can be quite large, 0 to 3,840 parts per million (ppm) in some cases, so even though the average value is relatively high, the BSP in the drainage area could actually be much lower than the average. For these reasons, the TP EMCs in areas with relatively high BSP (499 ppm or greater) include both low and high values. It does appear clear from the data, however, that highway runoff from areas with a low average BSP and low percent of impervious area, e.g., the Broward County study and the I-10 site in this study, have generally lower EMC values for TP.

4.2.2 TOTAL NITROGEN EMCS

The TN EMCs for the five study sites generally fell within the range of TN EMCs for the studies used to develop the statewide EMCs, ranging from 0.698 mg/L at the I-10 site to 2.50 mg/L at the SR 429 site. There were differences, however, in the relative amounts of inorganic [ammonium (NH_4), NOx] and organic nitrogen between some of the rural study sites and the urban sites. The rural sites in Alachua, Leon, and Jackson Counties had 20 percent or less inorganic nitrogen components compared with up to 70 percent at other highway sites (Table 4-2). The inorganic nitrogen components of the SR 417 and SR 429 sites were comparable to the results for other study sites in central Florida (I-4 Maitland Interchange, Winter Park I-4, and Orlando I-4).

There also appeared to be some correlation between the amount of nitrates in highway runoff and AADT, with nitrates increasing as AADT increased (Figure 4-2). The high heat of combustion creates nitrogen oxides as a byproduct contained in the exhaust from gasoline- and diesel-powered cars and trucks. Nitrogen oxides dissolve easily in water and, through deposition and other chemical processes, convert to nitrate in stormwater runoff, so a positive correlation between traffic volume and nitrates was not unexpected. It is important to note, however, that other factors can influence the amount of nitrogen oxides in the atmosphere. In densely populated areas, vehicle traffic not related to FDOT facilities increases the input of nitrogen oxides to the atmosphere. Combustion of coal and oil at electric power plants is another anthropogenic source of nitrogen oxides. Combustion in any form, either anthropogenic or natural, e.g., forest fires, generates nitrogen oxides. The extreme heat of lightning strikes creates nitrogen oxides, although the relative amount of nitrogen oxides created in this way is likely small.

4.3 METALS EMCS

A comparison of highway metals EMCs developed by Harper and Baker (2007) and the metals EMCs measured as part of this study is provided in Table 4-3. To maintain consistency for the comparison, median values of the data in Table 4-10 from Harper and Baker (2007) were calculated instead of using the arithmetic averages shown. The maximum cadmium value from this study was 1.00 µg/L, which is considerably lower than the median value of 2.4 µg/L (mean 4 µg/L) reported by Harper and Baker (2007) (range 0.1 to 8 µg/L).

Overall values from individual events for chromium ranged from below detection of 0.34 µg/L at SR 61 and I-10 to 151 µg/L at SR 61. Calculated EMCs ranged from 1.05 µg/L at I-10 to 2.6 µg/L at CR 236. An EMC value for SR 429 was not calculated because more than half of the samples were below the MDL. The median chromium EMC value reported by Harper and Baker (2007) is 4 µg/L (mean of 7 µg/L), which is significantly higher than the values determined from this study.

Individual event copper values ranged from 0.441 to 51.0 µg/L, with site EMCs ranging from 1.37 µg/L at I-10 to 4.5 µg/L at SR 429. These EMCs are much lower than the median value of 38 µg/L (mean of 32 µg/L) reported by Harper and Baker (2007) (range of 7 to 67 µg/L).

The event maximum for lead was 74.7 µg/L measured at SR 61, and the minimum was below the MDL of 0.076 µg/L at SR 429. Individual site EMCs ranged from 0.43 µg/L at SR 417 to 4.8 µg/L at CR 236. Harper and Baker (2007), presented lead EMCs from nine studies, with results ranging from 11 µg/L to 590 µg/L. The median lead value was 181 µg/L, but Harper and Baker suggest an EMC of 11 µg/L based on the lowest measured EMC. EMCs from this study are considerably lower than these values.

The minimum event value for zinc of 3.5 µg/L was measured at SR 61, and the maximum of 1,400 µg/L was measured at SR 429. Site EMCs ranged from 7.5 µg/L at SR 61 to 47 µg/L at SR 429. These EMC values are considerably lower than the median zinc EMC of 74 µg/L (mean of 126 µg/L) provided in Harper and Baker (2007) (range 24 µg/L to 330 µg/L).

Table 4-1. Updated Statewide EMCs

Location	Reference	Dates of Sample Collection	Number of Events Sampled	Drainage Area (acres)	% Impervious	Average Daily Traffic	2012 Average Daily Traffic	Range of Rainfall for Events Sampled (inches)	TN (mg/L)	TP (mg/L)	Bed Sediment Phosphorus (ppm) Average (Range)	EMC Statistic Used
Broward County (6-lane)	Hardee et al. (1978)	April 1975-July 1977	45	58.3	36%	20,000	53,000	0.06-2.50	0.635	0.057	187 (100 - 200)	Median
Maitland Blvd	German (1983)	April 1975-April 1979 (Samples collected in April, August, and December)	13-18	16.8[1]	Not specified	Not specified	53,500	Not specified	1.30	0.240	534 (0 - 3840)	Median
I-4 Maitland Interchange	Harper (1985); Yousef et al. (1986)	April 1983-May 1984	16	3.95[2]	100%	15,000	17,500	0.33-3.23	1.40	0.170	499 (221 - 768)	Mean
Winter Park I-4	Harper (1990)	January 1987-January 1988	10	1.17	100%	60-70,000	140,000	0.08-2.19	1.60	0.230	534 (0 - 3840)	Mean
Orlando I-4	Harper (1990)	January 1987-December 1987	13	1.30	70%	60-70,000	195,773	0.04-2.77	2.15	0.550	534 (0 - 3840)	Mean
Bayside Bridge - Tampa	Stoker (1996)	August 1993 - September 1995	24	12.9	100%	36-56,000	58,500	0.12-3.15	1.10	0.100	537 (70 - 3122)	Median
Tallahassee	ERD (2000)	July 1999-November 1999	11	1.0	90%	Not specified	48,500	Not specified	1.10	0.166	626 (100 - 3084)	Mean
Orlando - US 441[3]	ERD (2005) - unpublished data	April 2004-August 2004	23	12	74%	NA	28,000	NA	0.683	0.085	NA	NA
Richard Road (Lee County)	Johnson Engineering (2006)	Dec 2004-Nov 2005	9	7.56	49%	33,000	26,500	0.32-3.21	1.68	0.247	633 (184 - 2040)	Median
US 41 (Lee County)	Johnson Engineering (2008)	Sept 2005-August 2006	6	6.89	62%	61,000	61,000	0.25-1.03	0.666	0.109	633 (184 - 2040)	Median
Labelle (Hendry County)	Johnson Engineering (2009a)	August 2006-Oct 2007	7	6.80	84%	9,000	14,900	0.16-4.40	1.10	0.129	633 (184 - 2040)	Median
Flamingo Drive (Collier County)	Johnson Engineering (2009b)	April 2007-Sept 2007	8	16.95	65%	28,500	23,500	0.19-2.47	0.881	0.049	302 (221 - 352)	Median
I-75, Exit 404 - Alachua County	ATM	April 2010-Oct 2011	27	7.4	29%	37,500	37,500	0.28-3.06	1.83	1.02	534 (0 - 3840)	Median
State Road 61 - Leon County	ATM	Sept 2010-Jan 2013	27	4.5	33%	10,846	10,846	0.38-2.54	1.27	0.425	626 (100 - 3084)	Median
I-10, Exit 152 - Jackson County	ATM	February 2012-August 2013	25	3.3	30%	19,100	19,100	0.42-3.47	0.631	0.116	363 (0 - 968)	Median
State Road 417 - Seminole County	ATM	June 2010-May 2013	23	22.9	30%	40,300	40,300	0.59-6.38	1.60	0.410	540 (233 - 950)	Median
State Road 429 - Orange County	ATM	August 2010-May 2013	22	9.7	32%	29,000	29,000	0.48-3.18	2.50	0.769	534 (0 - 3840)	Median
Geometric Mean									1.20	0.198		

[1] Drainage area is estimated.

[2] Represents just the area draining to the sampling point at the retention pond.

[3] Report and data not available for review. Information based on Harper and Baker (2007), Table 4-10.

Rural highway study sites.

NA = not available.

Sources: Harper and Baker (2007); Johnson Engineering (2006; 2008; 2009a; 2009b); Terziotti et al. (2010).

Table 4-2. Inorganic Nitrogen Species as Percent of TN at Highway Sample Sites

Location	Reference	% Impervious	Average Annual Daily Traffic	TN (mg/L)	NOx (mg/L)	% NOx	NH4 (mg/L)	% NH4	NOx + NH4 (mg/L)	% NOx + NH4	EMC Statistic Used
Broward County (6-lane)	Mattraw and Miller (1981)	36%	20,000	0.635	0.232	37%	0.028	4%	0.260	41%	Median
I-4 Maitland Interchange	Harper (1985); Yousef et al. (1986)	100%	15,000	1.40	0.29	21%	0.180	13%	0.470	34%	Mean
Winter Park I-4	Harper (1990)	100%	65,000	1.60	0.4	25%	0.088	6%	0.488	31%	Mean
Orlando I-4	Harper (1990)	70%	65,000	2.15	0.542	25%	0.131	6%	0.673	31%	Mean
Bayside Bridge - Tampa	Stoker (1996)	100%	46,000	1.10	0.64	58%	0.13	12%	0.77	70%	Median
Tallahassee	ERD (2000)	90%	48,500	1.10	0.508	46%	0.101	9%	0.609	55%	Mean
Richard Road (Lee County)	Johnson Engineering (2006)	49%	33,000	1.68	0.179	11%	0.211	13%	0.390	23%	Mean
US 41 (Lee County)	Johnson Engineering (2008)	62%	61,000	0.666	0.226	34%	0.046	7%	0.272	41%	Mean
Labelle (Hendry County)	Johnson Engineering (2009a)	84%	9,000	1.10	0.273	25%	0.160	15%	0.433	39%	Mean
Flamingo Drive (Collier County)	Johnson Engineering (2009b)	65%	28,500	0.881	0.064	7%	0.205	23%	0.269	31%	Mean
I-75, Exit 404 - Alachua County	ATM	29%	37,500	1.83	0.287	16%	0.080	4%	0.367	20%	Median
State Road 61 - Leon County	ATM	33%	10,846	1.27	0.143	11%	0.000	0%	0.143	11%	Median
I-10, Exit 152 - Jackson County	ATM	30%	19,100	0.631	0.052	8%	0.000	0%	0.052	8%	Median
State Road 417 - Seminole County	ATM	30%	40,300	1.60	0.580	36%	0.000	0%	0.580	36%	Median
State Road 429 - Orange County	ATM	32%	29,000	2.50	0.545	22%	0.155	6%	0.700	28%	Median

Rural highway study sites.

Table 4-3. Comparison of Harper and Baker (2007) EMC Results for Metals with Rural Highway Sites

	Cadmium (µg/L)		Chromium (µg/L)		Copper (µg/L)		Lead (µg/L)		Zinc (µg/L)	
Location	Range	Median	Range	Median	Range	Median	Range	Median	Range	Median
Harper and Baker (2007)	0.1 - 8	2.4	3 - 14	4	7 - 67	38	11 - 590	181 (11)[1]	24 - 330	74
CR 236	0.14U - 0.43	NC	0.77 - 9.8	2.6	0.54 - 8.0	2.6	0.82 - 19	4.8	13.0 - 72.2	29.8
SR 61	0.104U - 1.00	NC	0.34U - 151	2.0	0.873 - 8.39	2.00	0.670U - 74.7	1.07	3.50 - 68.2	7.50
SR 8	0.104U - 0.274	NC	0.340U - 11.4	NC	0.441 - 7.82	1.53	0.670U - 43.3	NC	3.00 - 105	6.90
SR 417	0.14U - 0.99	NC	1.0U - 3.4	1.4	1.2 - 10	3.5	0.13 -1.9	0.43	11 - 120	19
SR 429	0.14U - 1.4U	NC	1.0U - 10U	NC	2.2 - 51.0	4.5	0.076U - 12	0.68	19 - 1400	47

[1] Harper and Baker (2007) excluded all but one value to determine a recommended EMC for lead of 11 µg/L [see Table 4-10, Harper and Baker (2007)].
For purposes of comparison with results of this study, the median of lead values from all highway studies included in Table 4-10 were used.

Notes:
NC = not calculated.
U = below method detection limit.

Source: Harper and Baker (2007).

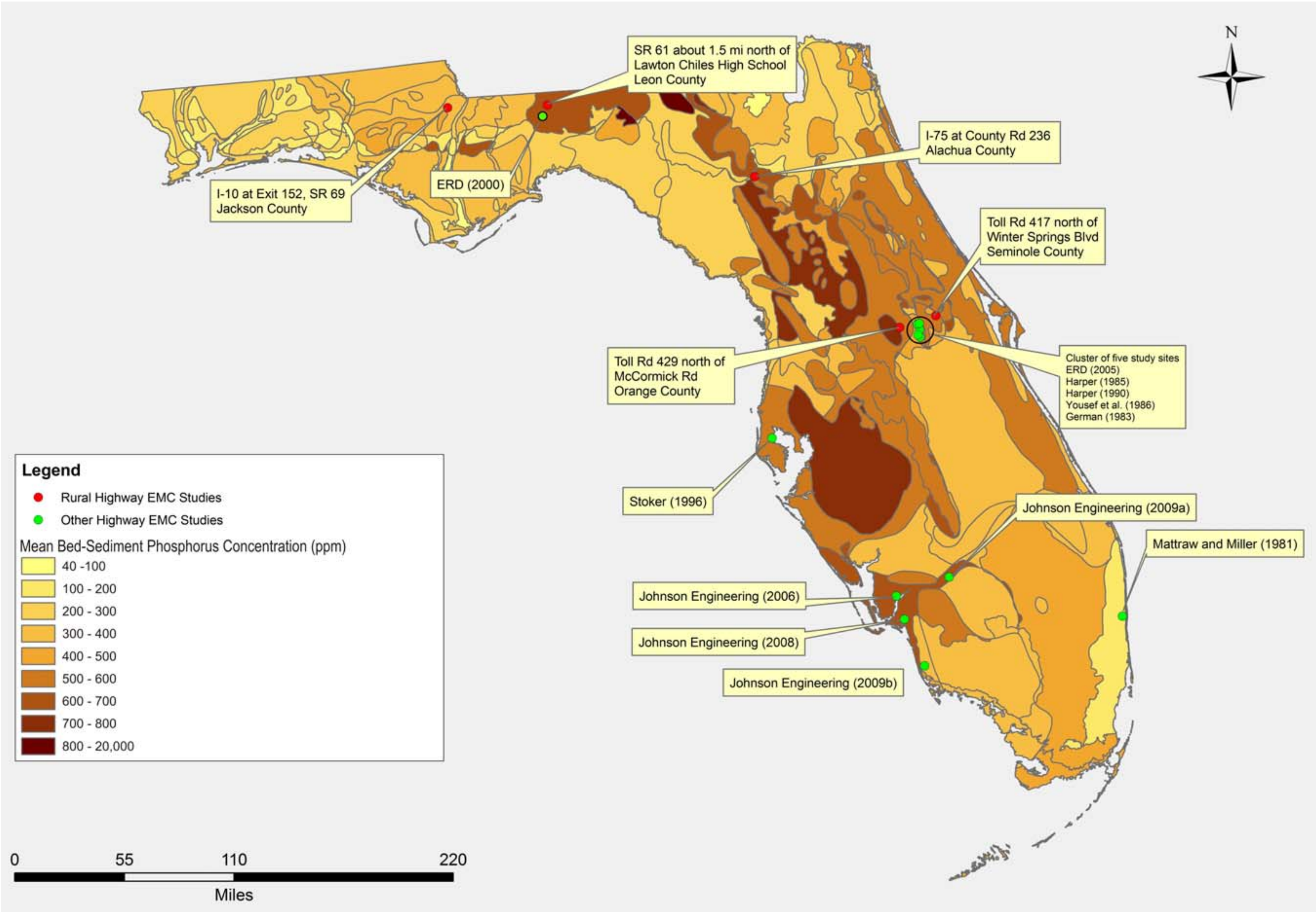


Figure 4-1

Bed-Sediment Phosphorus Concentration at Highway EMC Sampling Sites

(Terziotti et al., 2010)

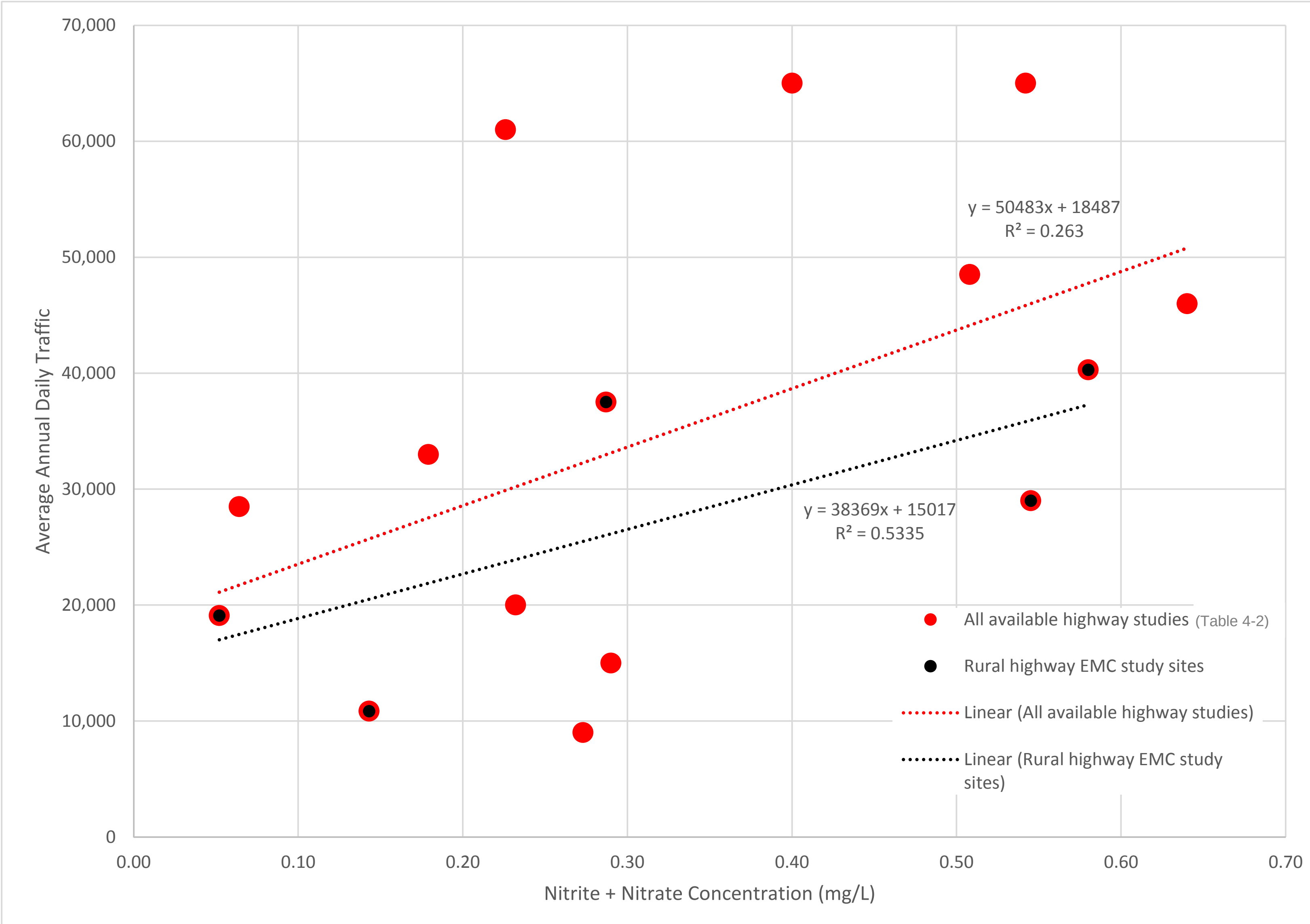


Figure 4-2
Relationship between Average Annual Daily Traffic and Highway EMC for Nitrite-Nitrate

5.0 CONCLUSIONS AND RECOMMENDATIONS

This study sought to identify whether or not there are substantive differences between EMCs from rural roadways versus urban roadways. The primary concern was with nutrient EMCs, but five heavy metal parameters were also assessed. Highway nutrient EMCs specified by FDEP (see Table 1-1) are used to calculate pollutant loads from FDOT roadways. These loads are used in a number of different ways, including permitting, TMDL development, and calculation of BMAP load allocations. Cost implications of inaccurate load estimates can be significant when they are used to identify FDOT's responsibility for load reductions associated with TMDL implementation or mitigation for pollutant loads in the permitting process. FDEP and the water management districts use studies based primarily on urban roads with high percentages of impervious area, typically between 60 and 100 percent. FDOT wanted to verify whether these studies were representative of its rural facilities. It completed this study to evaluate EMCs specific to rural roads and to update the existing statewide highway EMC database to be more inclusive of rural facilities. Impervious areas for the five rural study sites ranged from 29 to 33 percent. Additional modifications to the statewide EMC database based on ATM (2010) recommendations were also incorporated (see Table 4-1) and used as the basis for the following discussion.

A total of 131 samples, including seven first-flush samples, were collected at five rural roadway sites in Alachua, Jackson, Leon, Orange and Seminole Counties. Samples were evaluated for TN, nitrates, ammonia nitrogen, TKN, TP, cadmium, chromium, copper, lead, zinc, TSS and hardness. Results of these analyses indicate the following.

1. There was not a discernible difference in the TN EMCs at the five rural sites (0.631 to 2.5 mg/L) compared with the TN EMCs for other sites in the statewide database (0.635 to 2.15 mg/L). The percent of nitrates and ammonia nitrogen at three of the five rural sites was 20 percent or less compared to up to 70 percent for urban roads. Lower levels of inorganic nitrogen suggest a lower relative level of anthropogenic input but also likely reflect the increased contact with vegetated areas of the right-of-way for the study sites with lower impervious area.
2. There appears to be a slight positive correlation between AADT and nitrates in roadway runoff, suggesting that increased nitrogen oxides in the atmosphere due to combustion converts to nitrates upon contact with water and lead to elevated nitrates

in stormwater. Byproducts from vehicles on FDOT roadways, however, represent only a portion of combustion activities that may contribute to nitrogen oxides in the atmosphere. Surrounding population density and vehicle use on non-FDOT facilities as well as contributions from other combustion sources, e.g., power plants, are also potential contributors to atmospheric nitrogen.

3. The SR 61 location within the Wakulla Springs BMAP area had a median nitrate concentration of 0.143 mg/L. This was well below the TMDL nitrate target of 0.35 mg/L, so it is unlikely that untreated direct discharges from FDOT facilities in the springshed are contributing to the impairment.
4. The CR 236 location within the Santa Fe River BMAP area had a median nitrate concentration of 0.287 mg/L. This was below the TMDL nitrate target of 0.35 mg/L, so it was unlikely that untreated direct discharges from FDOT facilities in the springshed are contributing to the impairment.
5. High levels of BSP in four of the rural sampling site drainage areas may be partially responsible for substantially elevated TP EMCs at these four locations. BSP is a measure of the amount of naturally occurring phosphorus contained within the soils underlying the watershed that drains to the sampling point. This suggests that for areas with high phosphorus soils, a considerable portion of the TP load may be due to natural conditions and includes a high percent of phosphorus that is not biologically available. It is likely that the impact that soils have on the TP EMC is greater in areas with a low proportion of impervious areas because there is greater contact between the water and the soil.
6. In the absence of anthropogenic inputs of phosphorus, e.g., fertilizers, sites with low percent impervious area and low BSP are expected to yield low TP EMCs.
7. The heavy metal concentrations in untreated runoff from these five rural roadway study sites were considerably lower than the EMCs presented in Harper and Baker (2007) for urban roads. This suggests that metals in untreated runoff from rural roads are less likely to contribute to impairments than runoff from urban roads.

Researchers have investigated the water quality of highway runoff in Florida for more than 35 years in conjunction with a variety of research objectives, including studies specifically designed to determine highway EMC values. Runoff data, including results from this study, consistently show a high degree of variability between different events. Regional variability is also an important consideration for both TN and TP. Rural roads in less populated areas such as the three sites at CR 236, I-10, and SR 61 will likely have TN EMCs comparable to other more populated areas, but the speciation of nitrogen is expected to favor more naturally occurring sources with less biologically available nitrogen. With TP EMCs, runoff from rural highways appears to be substantially impacted by the amount of phosphorus in the underlying sediments, so that much of the input from highway runoff is from naturally occurring sources. In the application of EMCs for the purpose of assessing loads from FDOT facilities, the following actions are recommended.

1. Incorporate the recommendations of “Determination of Appropriate Highway EMC Values for Use within FDOT District 1” (ATM, 2010) and the results of this study to update the statewide EMC table.
2. Where data are available for older studies used to determine the statewide EMCs, replace average values with median values for TN and TP because median values are more representative of central tendency.
3. Where data are available, use regional or local values in lieu of generalized statewide values to calculate nutrient loads from highways.
4. Continue to update the statewide EMC values as additional data become available.
5. Promote recognition that not all nitrogen and phosphorus are created equal. In areas demonstrating or expected to have runoff influenced by naturally occurring conditions, e.g., low percent of inorganic nitrogen relative to TN or high TP due to underlying soil conditions, work with regulators to identify management actions that target anthropogenic sources and reductions that are likely to lead to water quality improvements.

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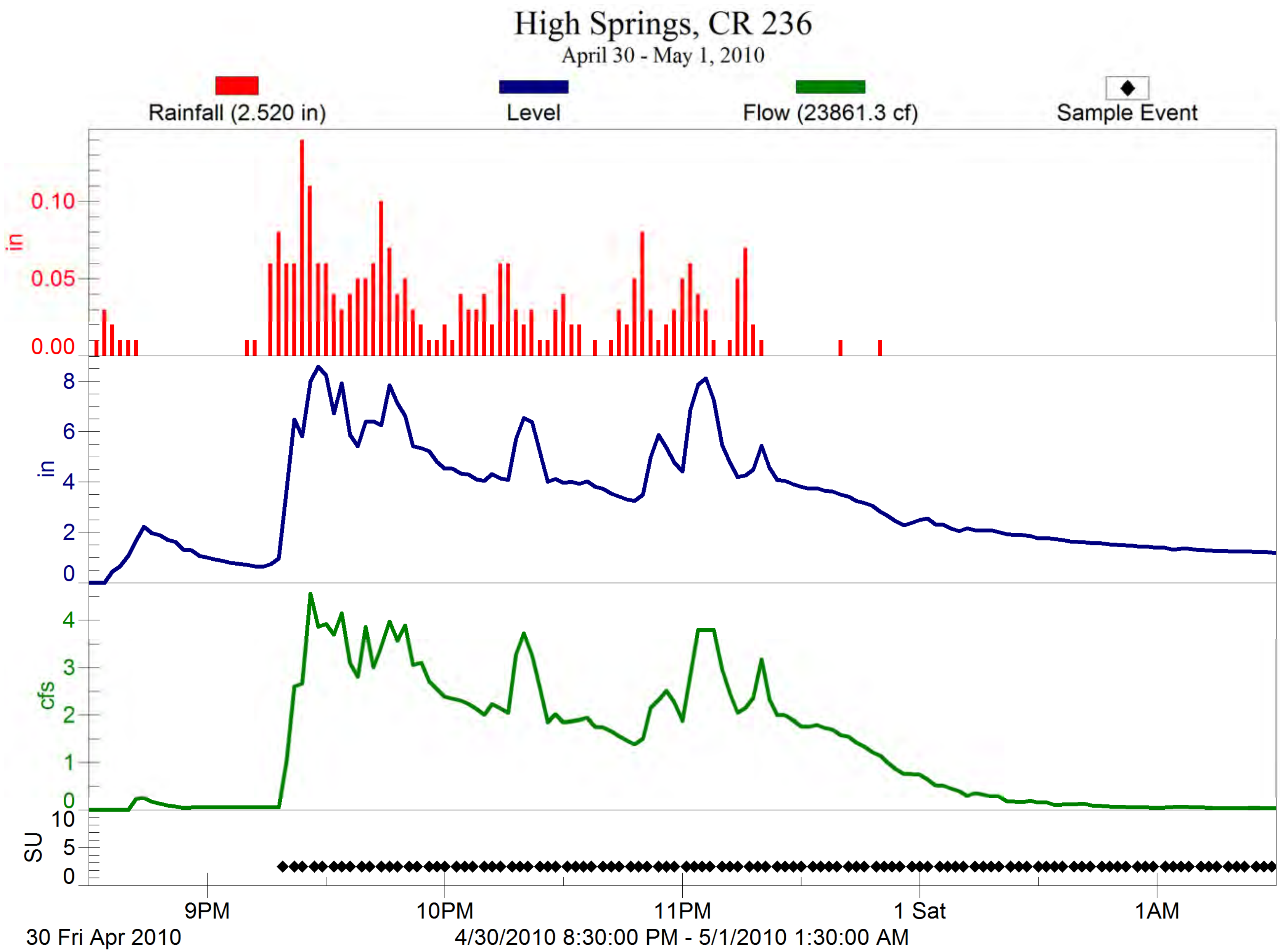
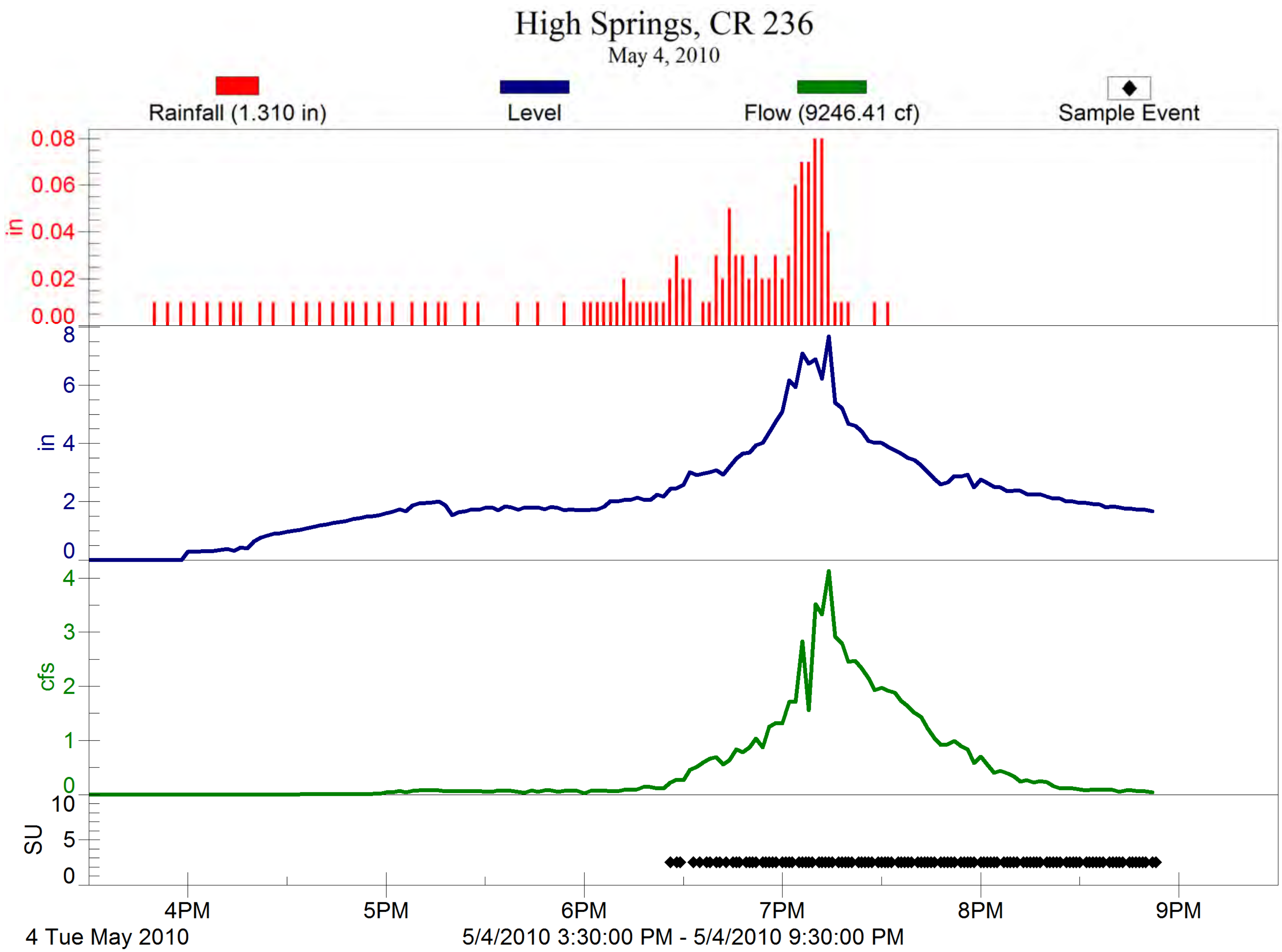
Appendix A

Storm Event Data for CR 236 Sampling Location

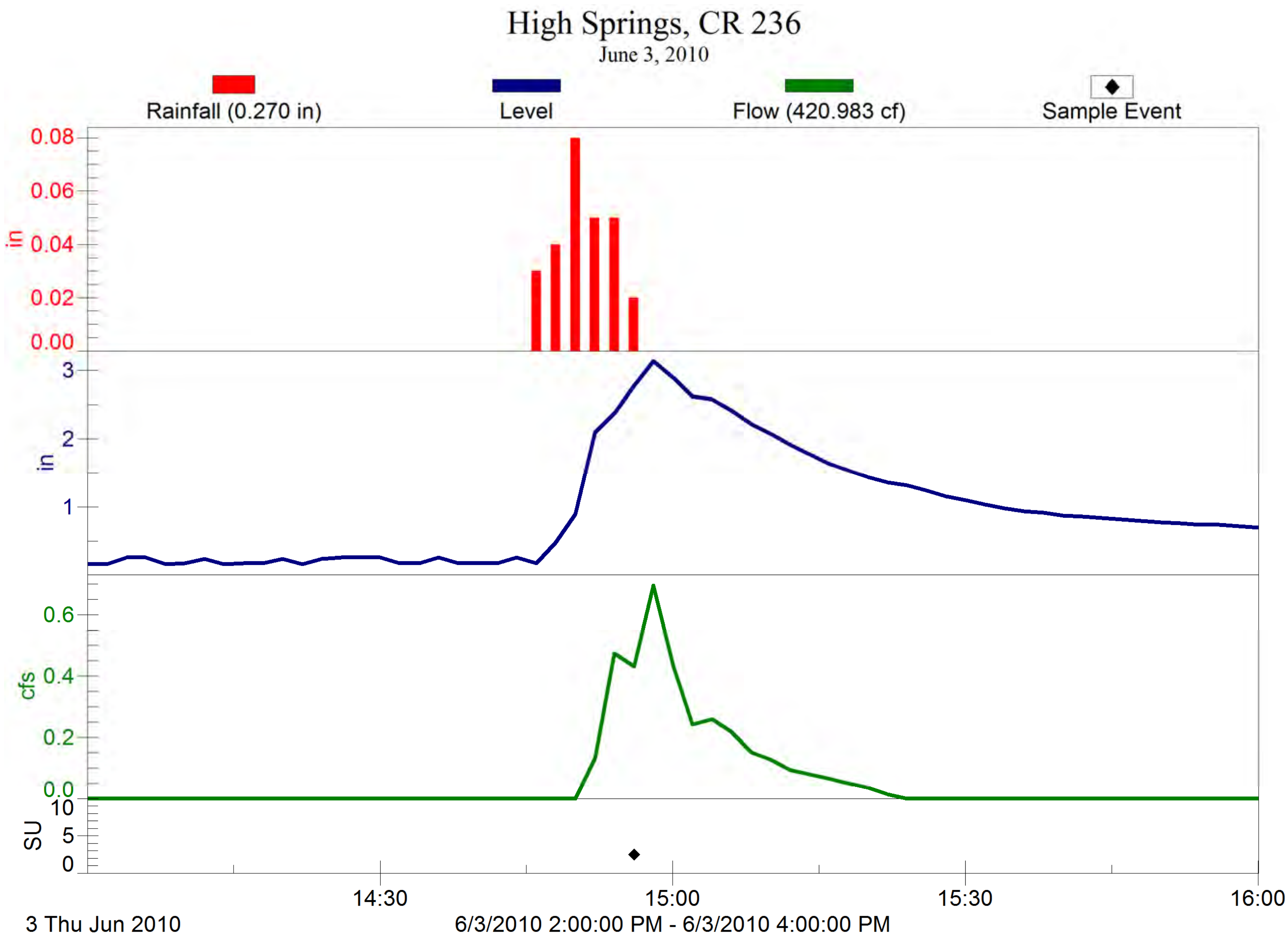
(Laboratory results included on the accompanying CD)



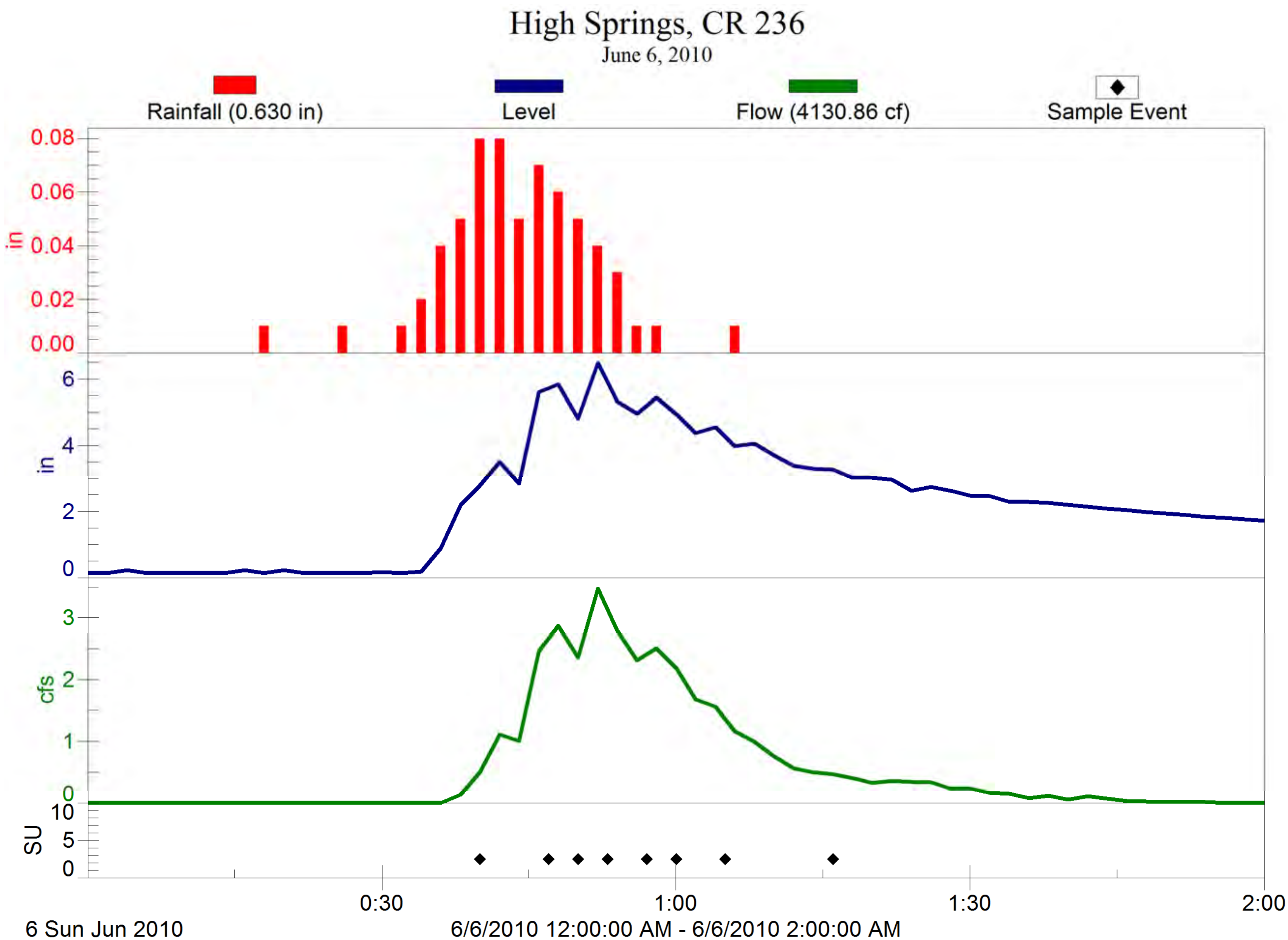
High Springs, CR 236
April 30 - May 1, 2010
Rainfall (2.520 in)
Level
Flow (23861.3 cf)
Sample Event
0.10
0.05
0.00
in
8
6
4
2
0
in
4
3
2
1
0
cfs
10
5
0
SU
9PM
10PM
11PM
1 Sat
1AM
30 Fri Apr 2010
4/30/2010 8:30:00 PM - 5/1/2010 1:30:00 AM

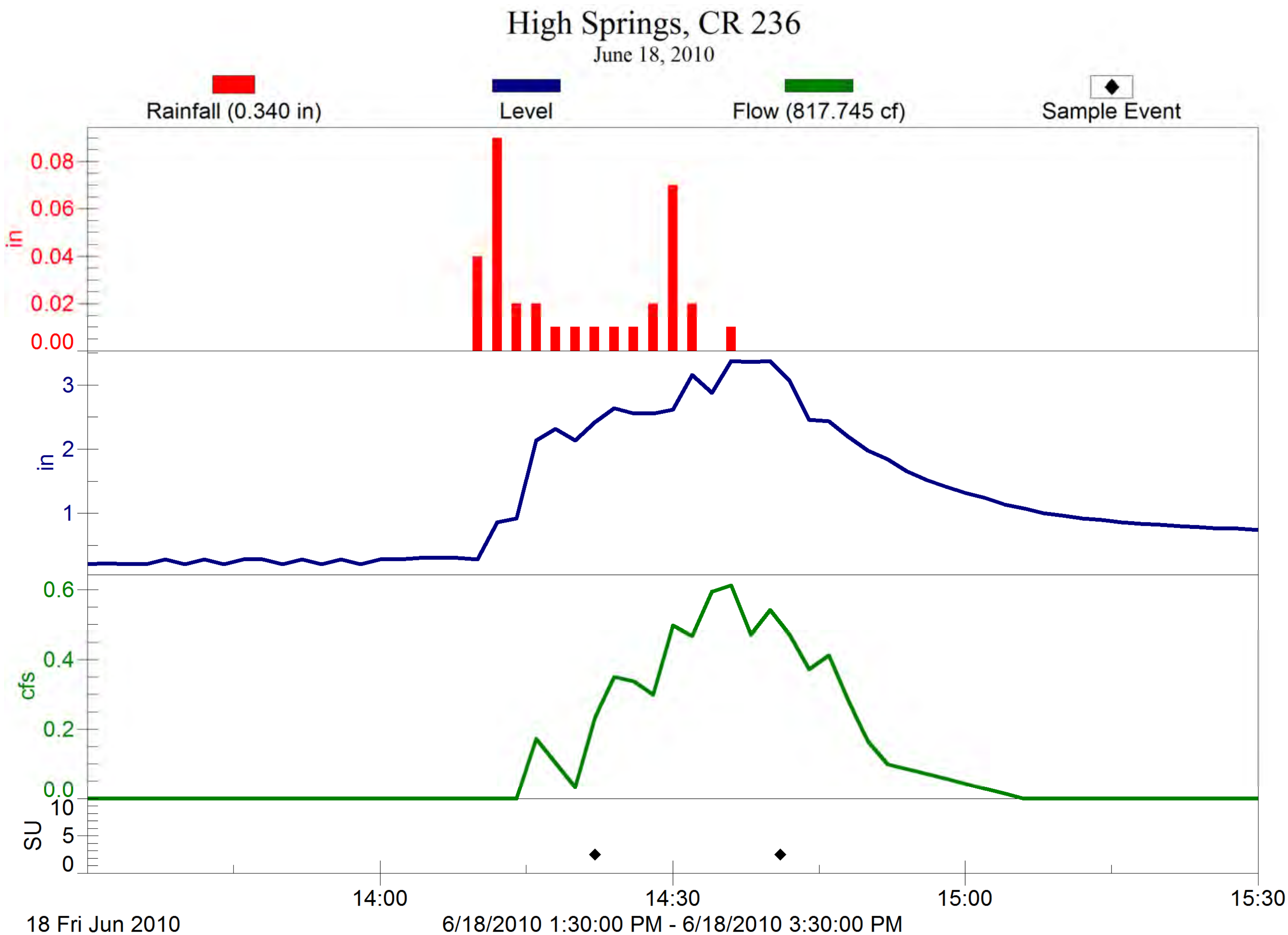


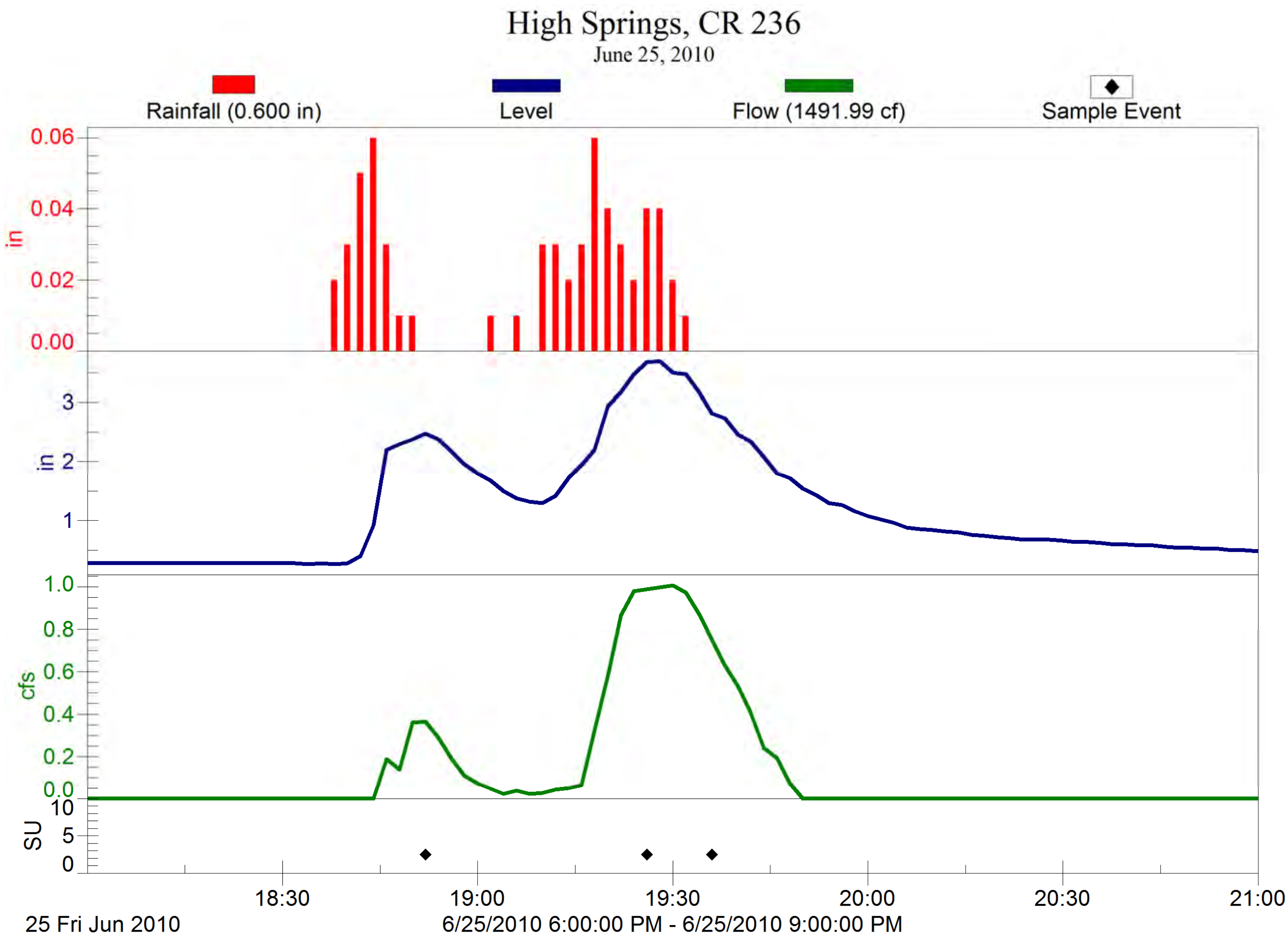
High Springs, CR 236
May 4, 2010
Rainfall (1.310 in)
Level
Flow (9246.41 cf)
Sample Event
in
0.08
0.06
0.04
0.02
0.00
in
8
6
4
2
0
cfs
4
3
2
1
0
SU
10
5
0
4PM
5PM
6PM
7PM
8PM
9PM
4 Tue May 2010
5/4/2010 3:30:00 PM - 5/4/2010 9:30:00 PM



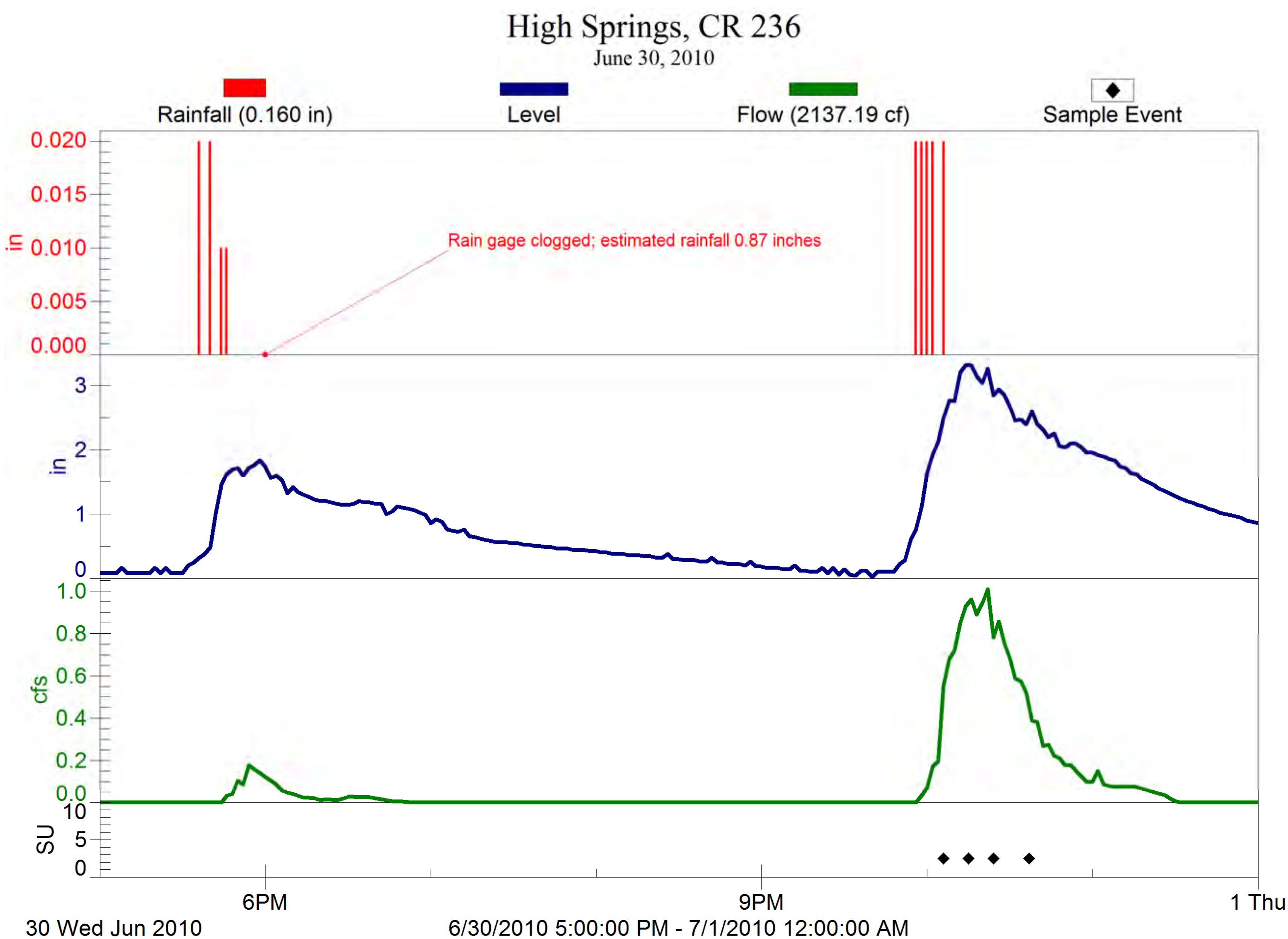
High Springs, CR 236
June 3, 2010
Rainfall (0.270 in)
Level
Flow (420.983 cf)
Sample Event
0.08
0.06
0.04
0.02
0.00
in
3
2
1
in
0.6
0.4
0.2
0.0
cfs
10
5
0
SU
14:30
15:00
15:30
16:00
3 Thu Jun 2010
6/3/2010 2:00:00 PM - 6/3/2010 4:00:00 PM

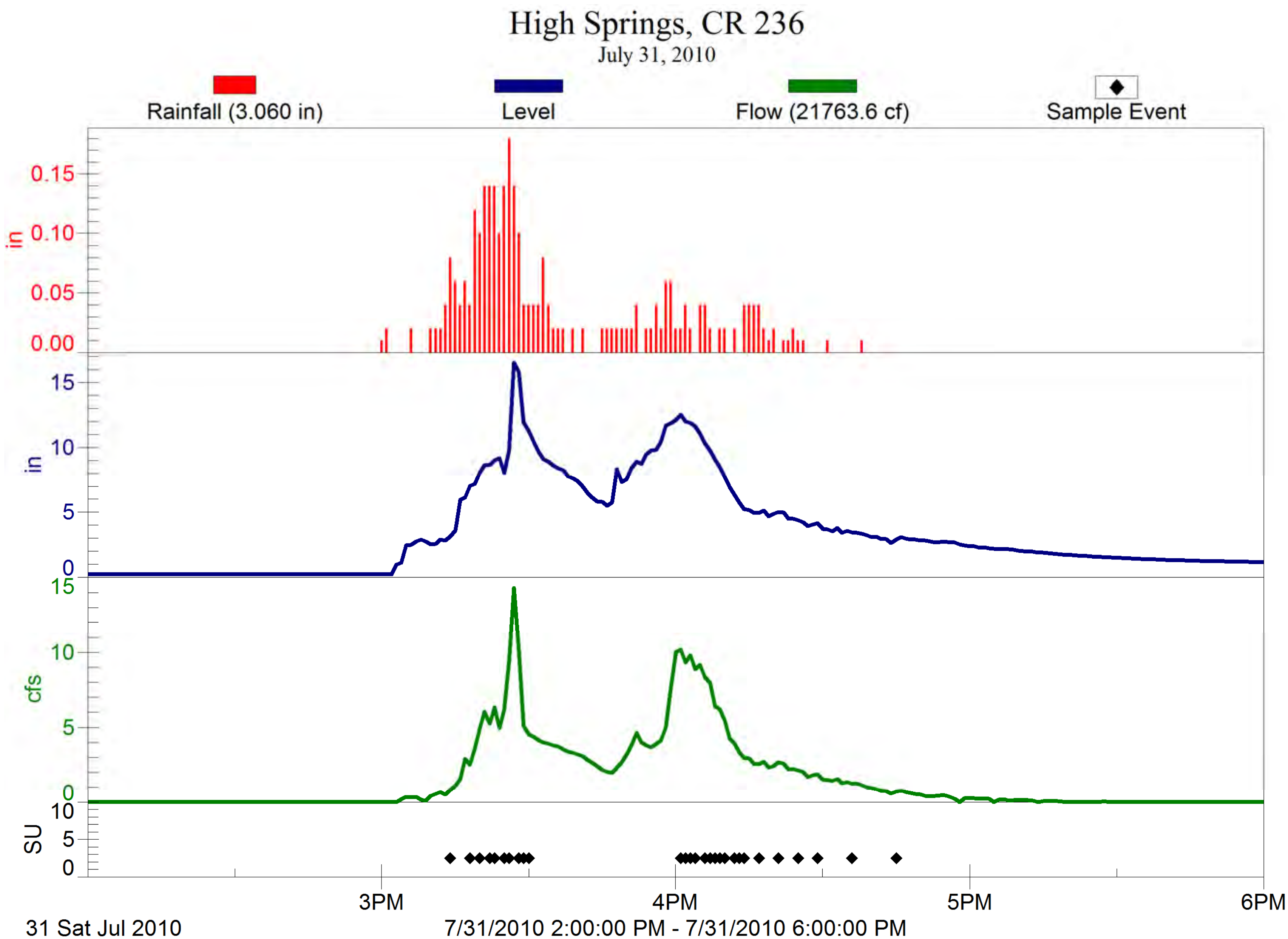

High Springs, CR 236
June 6, 2010
Rainfall (0.630 in)
Level
Flow (4130.86 cf)
Sample Event
0.08
0.06
0.04
0.02
0.00
in
6
4
2
0
in
3
2
1
0
cfs
10
5
0
SU
0:30
1:00
1:30
2:00
6 Sun Jun 2010
6/6/2010 12:00:00 AM - 6/6/2010 2:00:00 AM

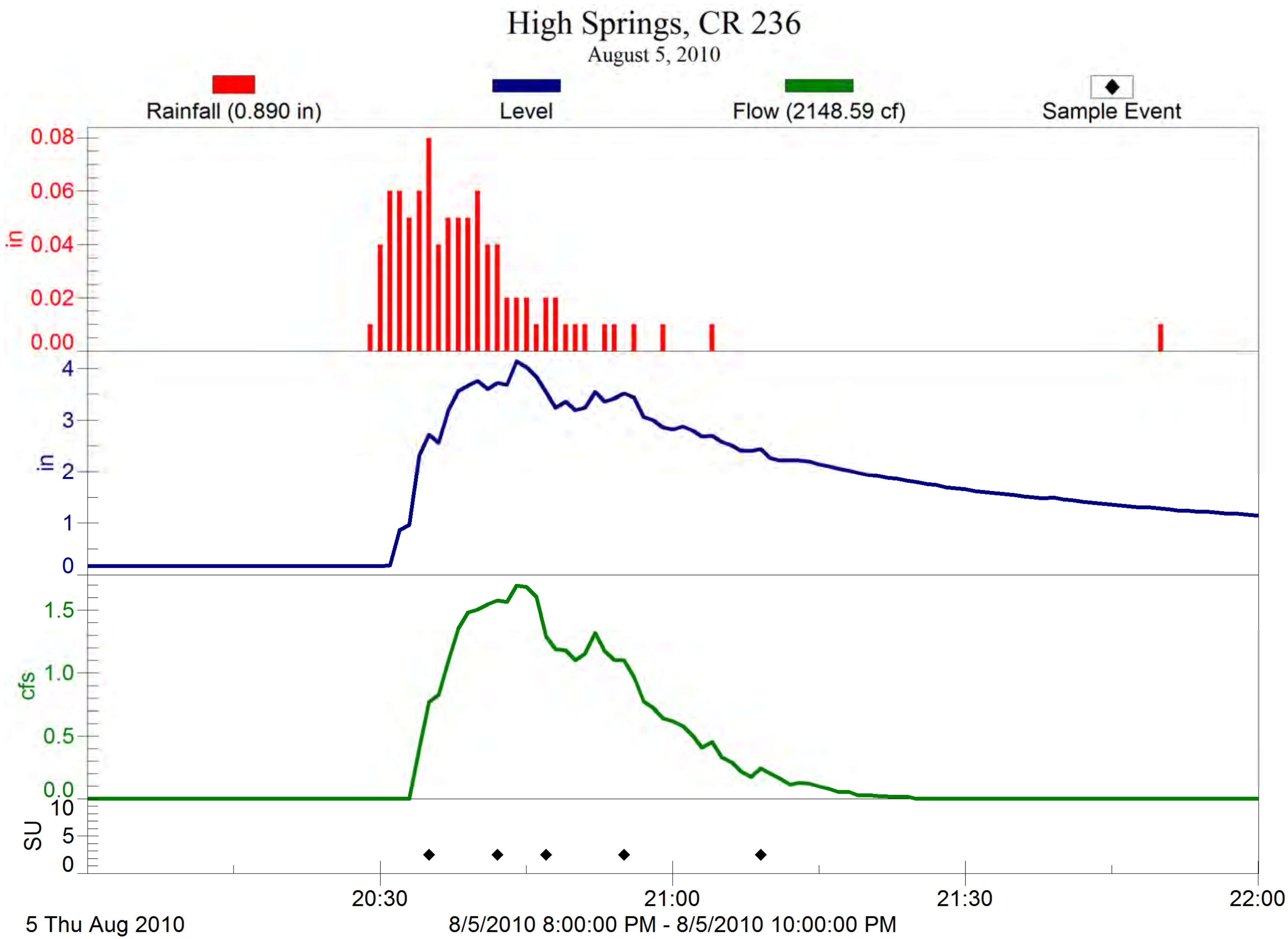

High Springs, CR 236
June 18, 2010
Rainfall (0.340 in)
Level
Flow (817.745 cf)
Sample Event
in
0.08
0.06
0.04
0.02
0.00
in
3
2
1
cfs
0.6
0.4
0.2
0.0
SU
10
5
0
14:00
14:30
15:00
15:30
18 Fri Jun 2010
6/18/2010 1:30:00 PM - 6/18/2010 3:30:00 PM

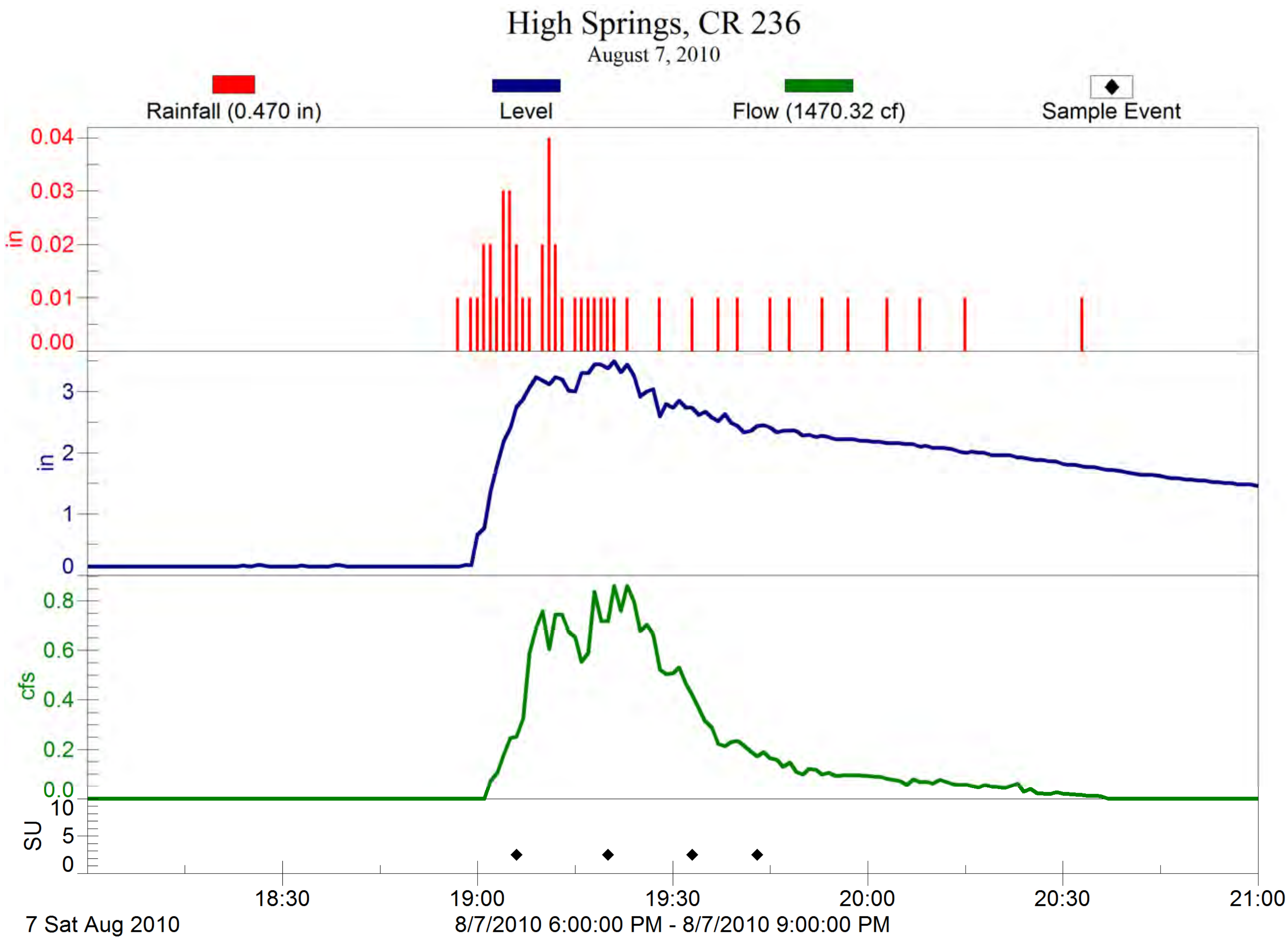


High Springs, CR 236
June 25, 2010
Rainfall (0.600 in)
Level
Flow (1491.99 cf)
Sample Event
0.06
0.04
0.02
0.00
in
3
2
1
in
1.0
0.8
0.6
0.4
0.2
0.0
cfs
10
5
0
SU
18:30
19:00
19:30
20:00
20:30
21:00
25 Fri Jun 2010
6/25/2010 6:00:00 PM - 6/25/2010 9:00:00 PM

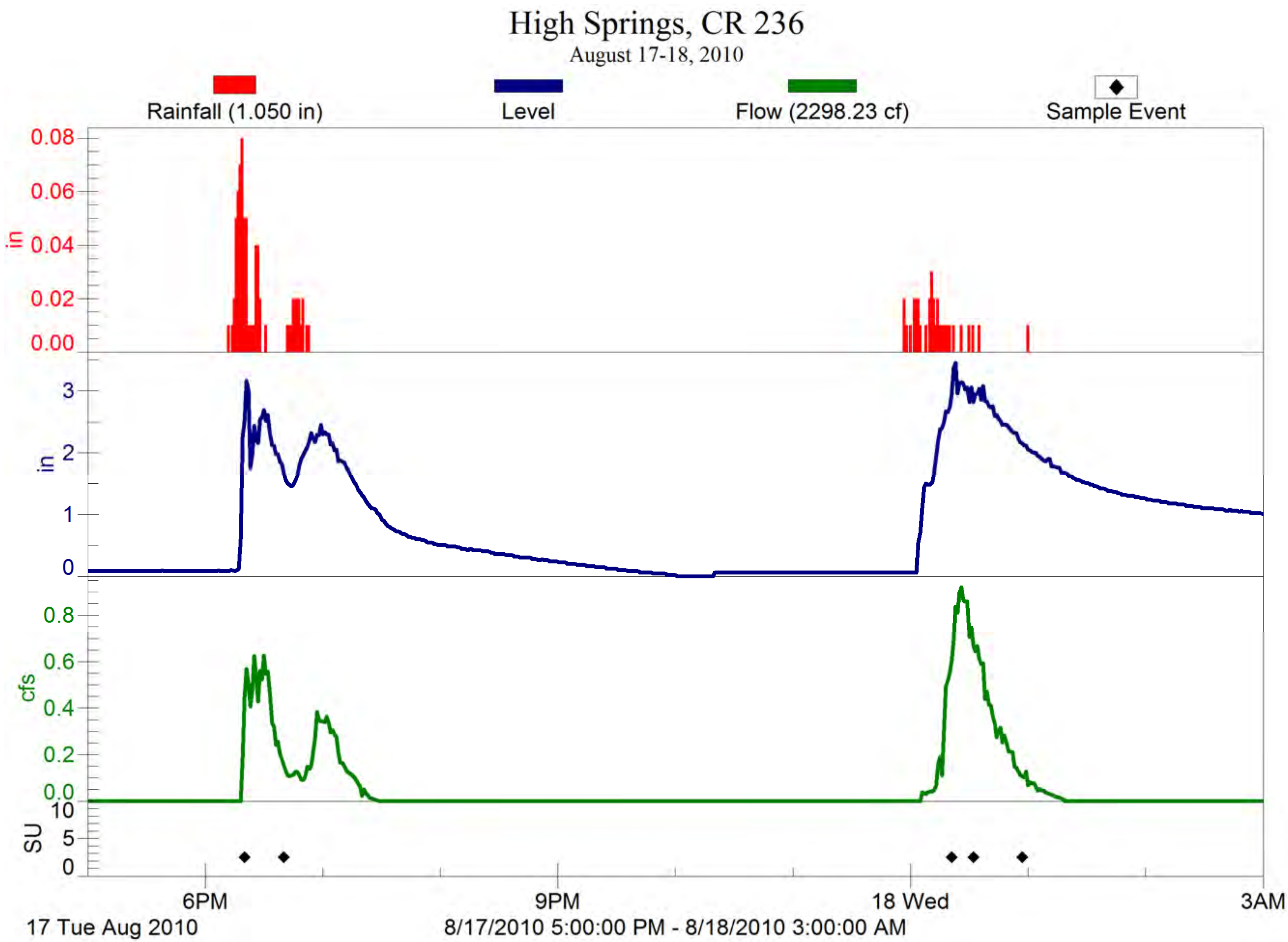

High Springs, CR 236
June 30, 2010
Rainfall (0.160 in)
Level
Flow (2137.19 cf)
Sample Event
Rain gage clogged; estimated rainfall 0.87 inches
0.020
0.015
0.010
0.005
0.000
in
3
2
1
0
in
1.0
0.8
0.6
0.4
0.2
0.0
cfs
10
5
0
SU
6PM
9PM
1 Thu
30 Wed Jun 2010
6/30/2010 5:00:00 PM - 7/1/2010 12:00:00 AM


High Springs, CR 236
July 31, 2010
Rainfall (3.060 in)
Level
Flow (21763.6 cf)
Sample Event
in
0.15
0.10
0.05
0.00
in
15
10
5
0
cfs
15
10
5
0
SU
10
5
0
3PM
4PM
5PM
6PM
31 Sat Jul 2010
7/31/2010 2:00:00 PM - 7/31/2010 6:00:00 PM

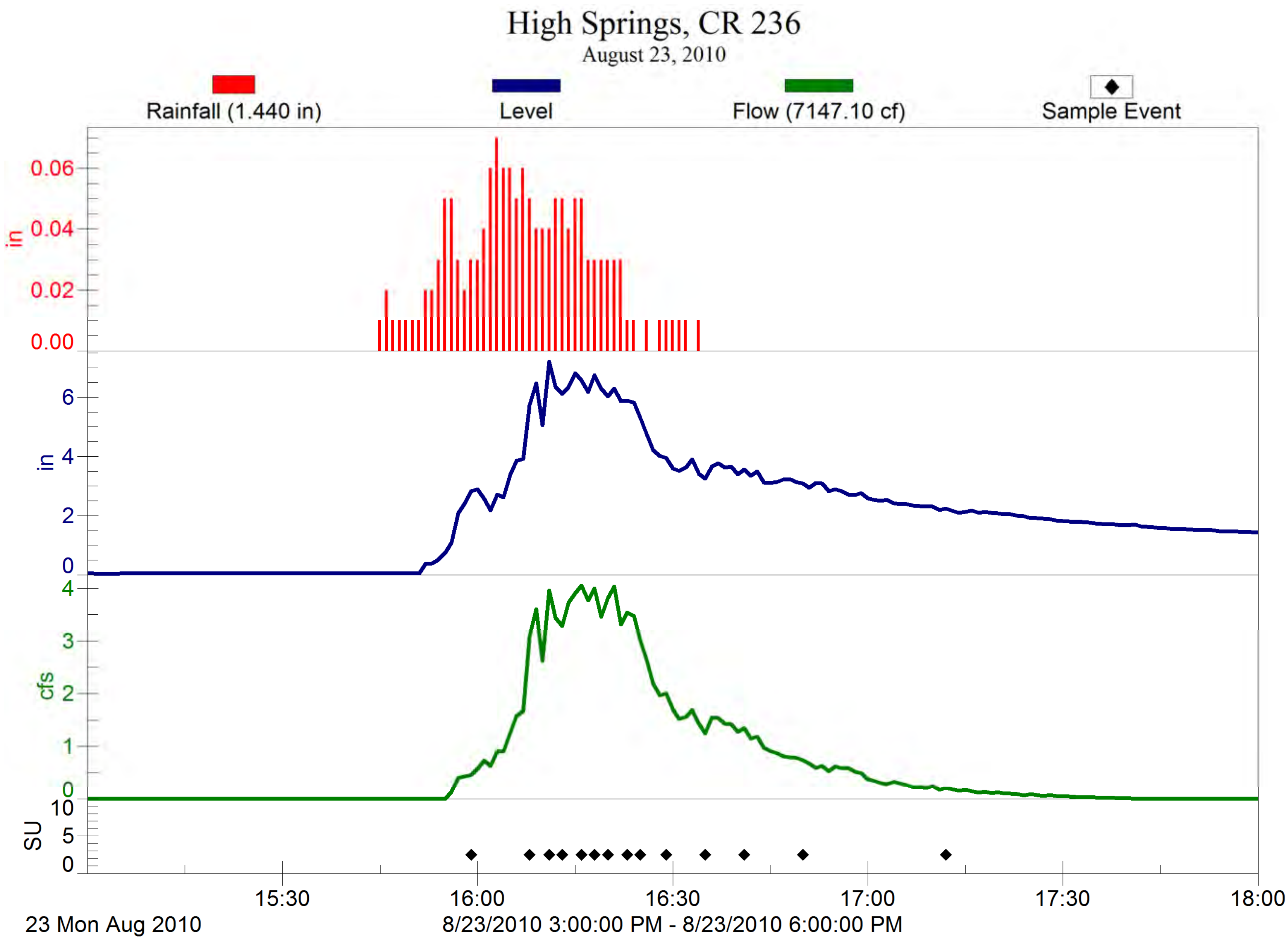

High Springs, CR 236
August 5, 2010
Rainfall (0.890 in)
Level
Flow (2148.59 cf)
Sample Event
in
0.08
0.06
0.04
0.02
0.00
in
4
3
2
1
0
cfs
1.5
1.0
0.5
0.0
SU
10
5
0
20:30
21:00
21:30
22:00
5 Thu Aug 2010
8/5/2010 8:00:00 PM - 8/5/2010 10:00:00 PM



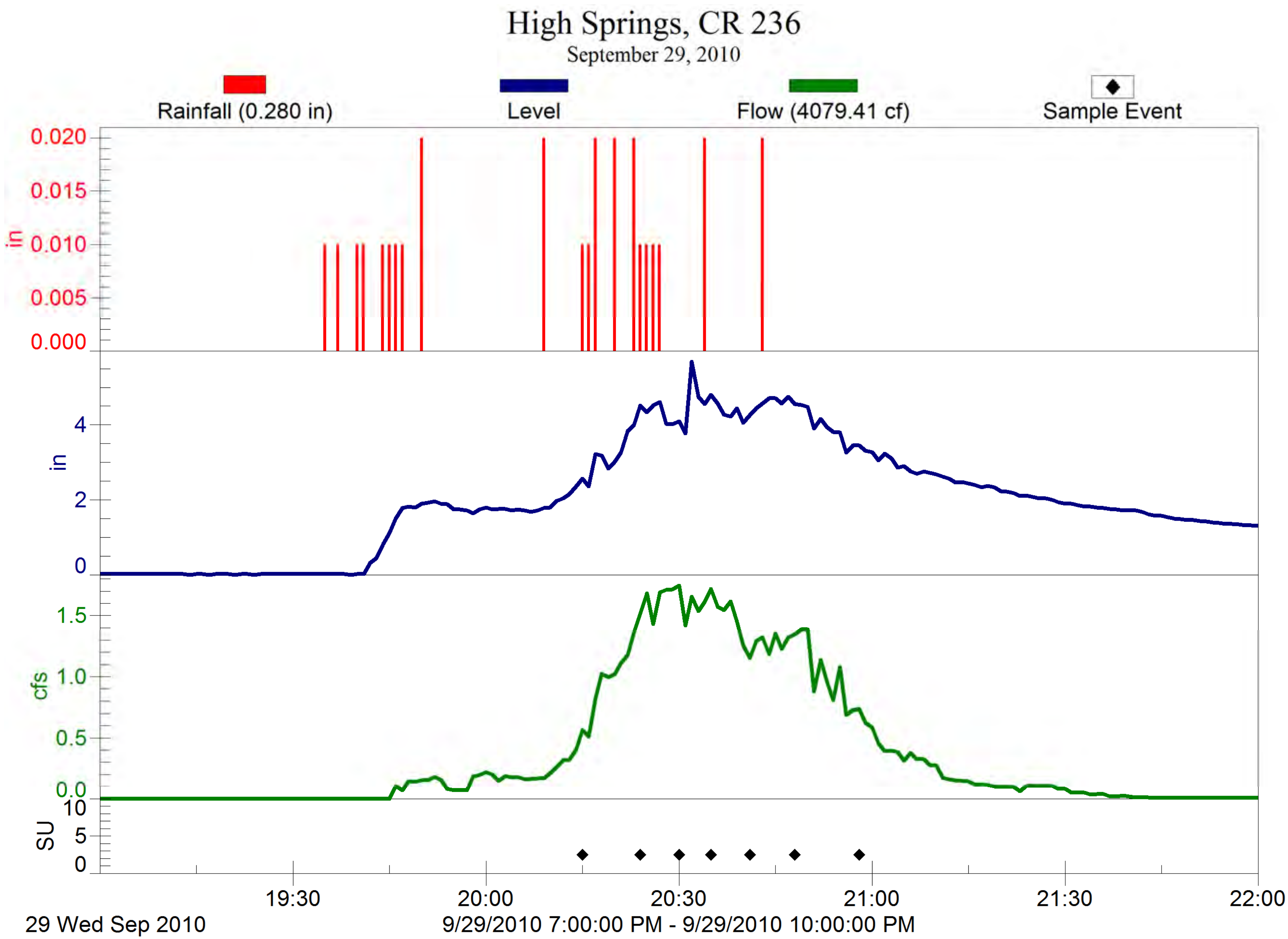
High Springs, CR 236
August 7, 2010
Rainfall (0.470 in)
Level
Flow (1470.32 cf)
Sample Event
0.04
0.03
0.02
0.01
0.00
in
3
2
1
0
in
0.8
0.6
0.4
0.2
0.0
cfs
10
5
0
SU
18:30
19:00
19:30
20:00
20:30
21:00
7 Sat Aug 2010
8/7/2010 6:00:00 PM - 8/7/2010 9:00:00 PM

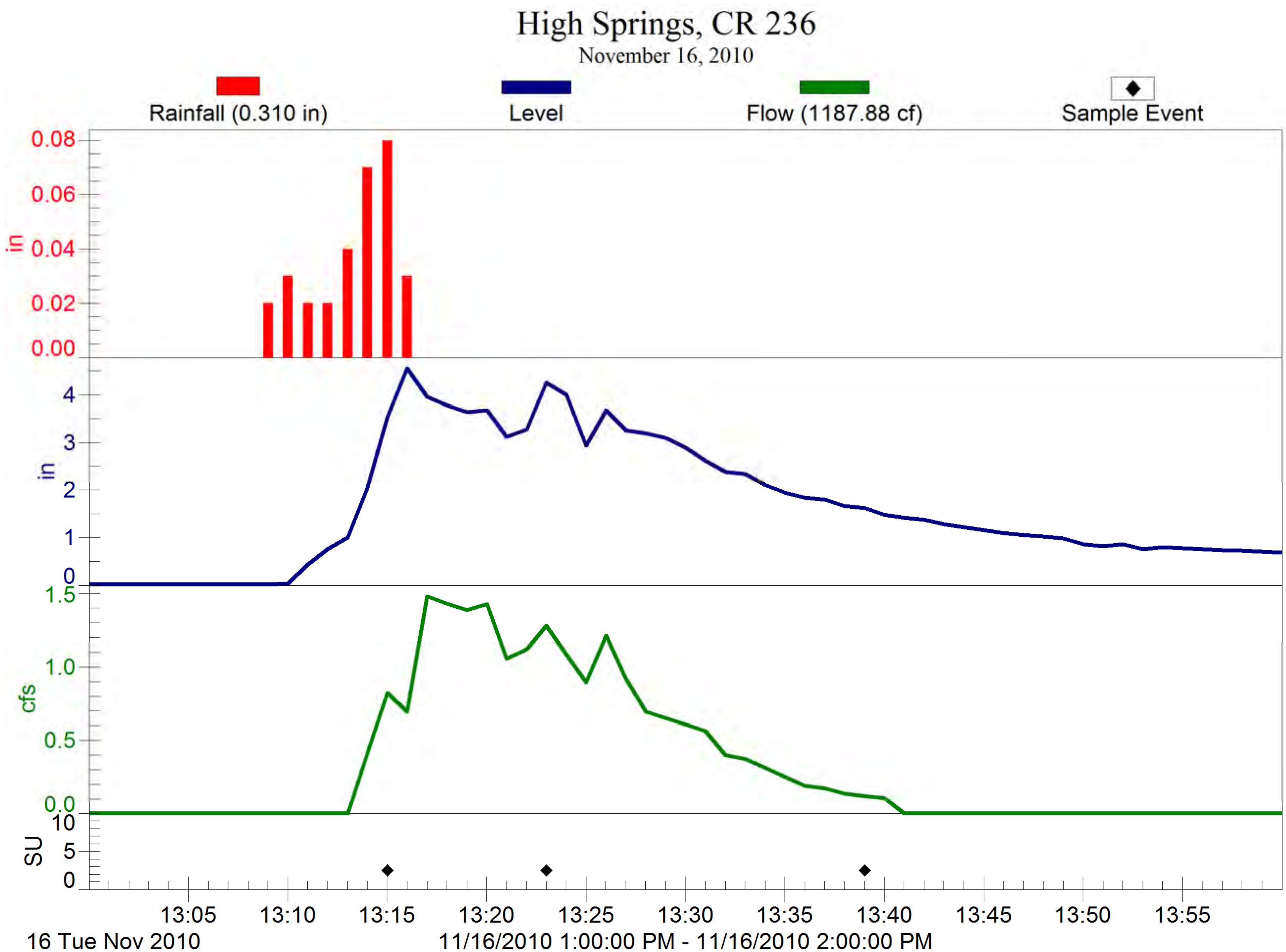


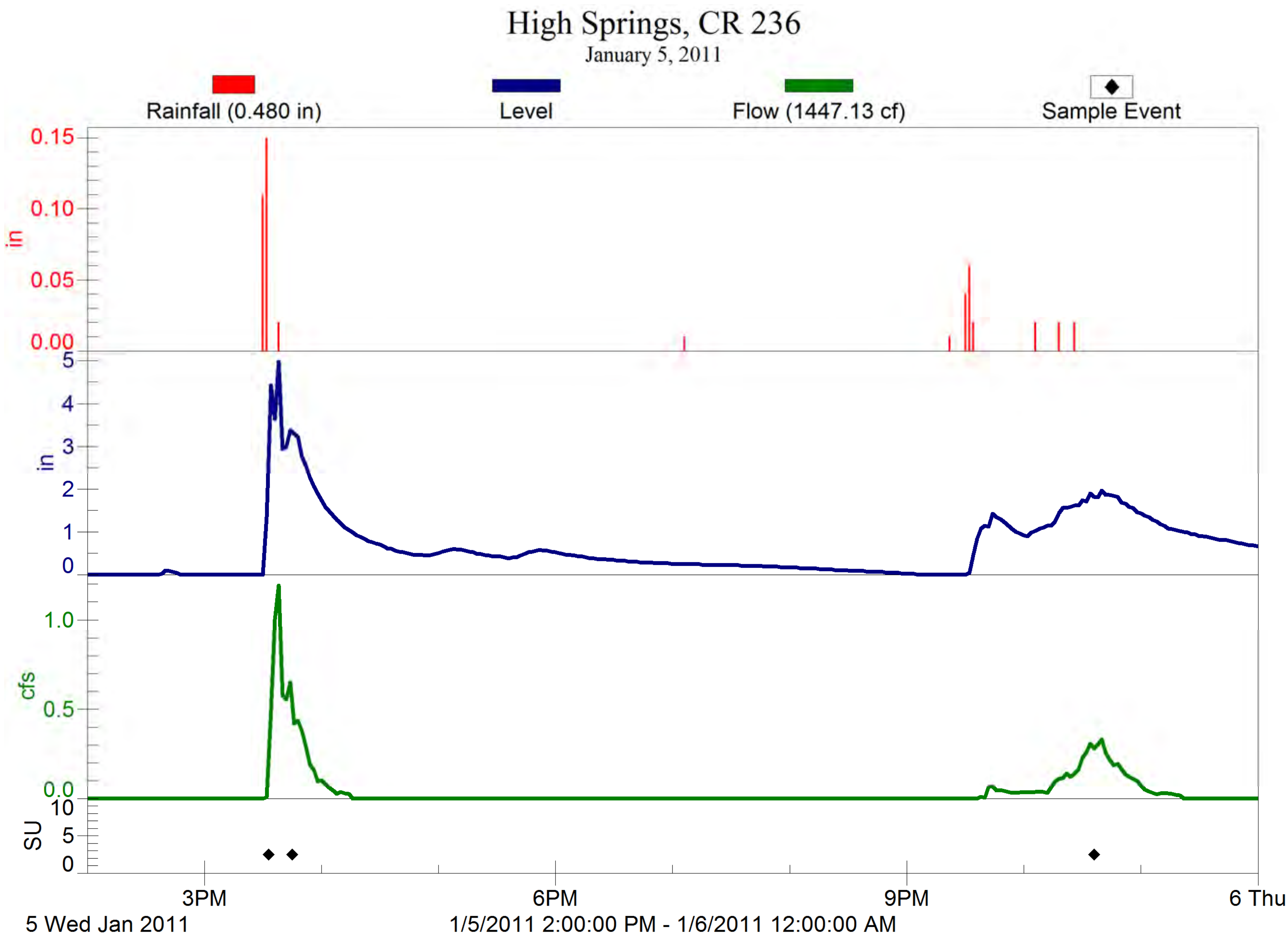
High Springs, CR 236
August 17-18, 2010
Rainfall (1.050 in)
Level
Flow (2298.23 cf)
Sample Event
in
0.08
0.06
0.04
0.02
0.00
in
3
2
1
0
cfs
0.8
0.6
0.4
0.2
0.0
SU
10
5
0
6PM
9PM
18 Wed
3AM
17 Tue Aug 2010
8/17/2010 5:00:00 PM - 8/18/2010 3:00:00 AM



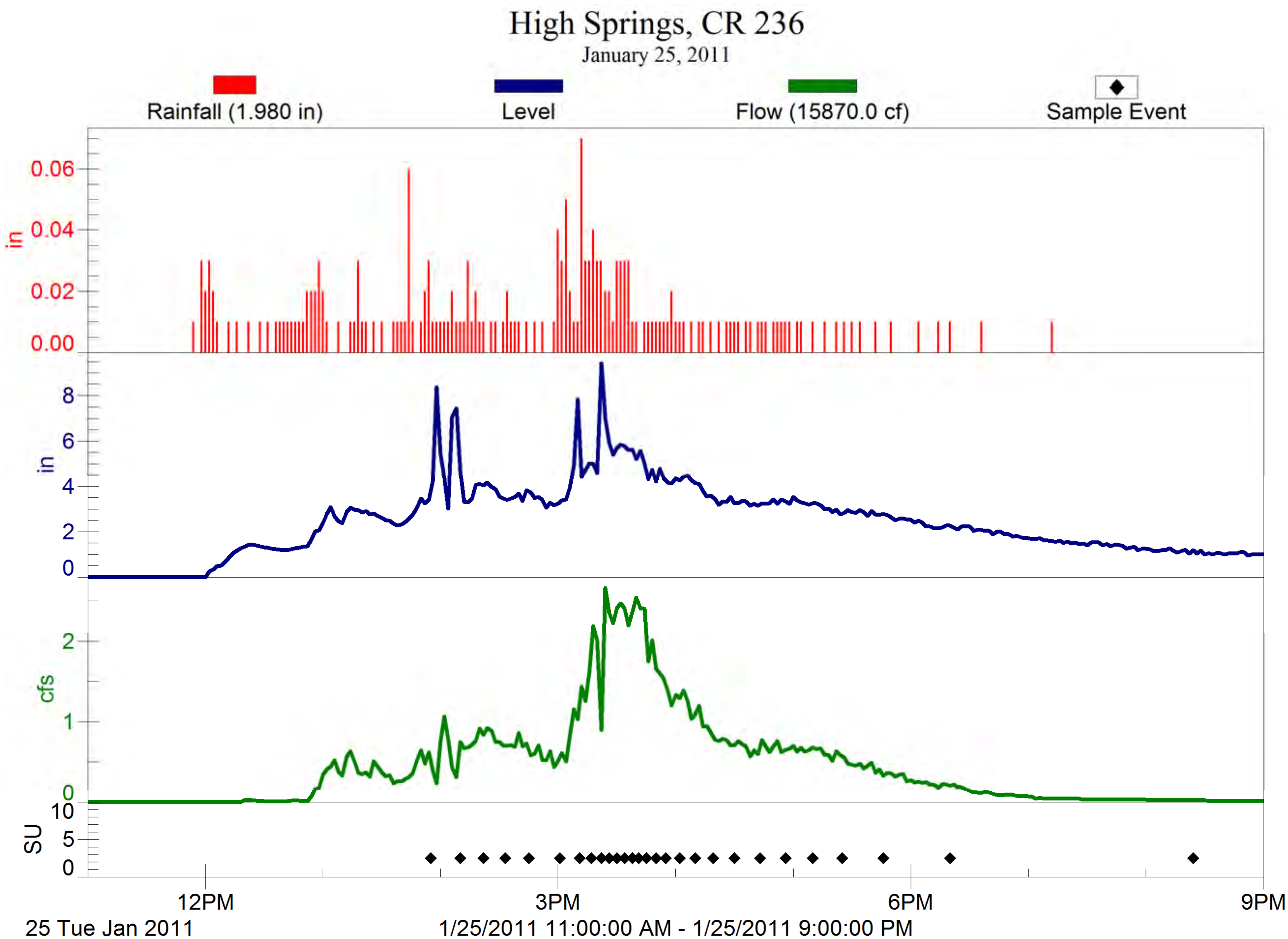
High Springs, CR 236
August 23, 2010
Rainfall (1.440 in)
Level
Flow (7147.10 cf)
Sample Event
in
0.06
0.04
0.02
0.00
in
6
4
2
0
cfs
4
3
2
1
0
SU
10
5
0
15:30
16:00
16:30
17:00
17:30
18:00
23 Mon Aug 2010
8/23/2010 3:00:00 PM - 8/23/2010 6:00:00 PM


High Springs, CR 236
September 29, 2010
Rainfall (0.280 in)
Level
Flow (4079.41 cf)
Sample Event
0.020
0.015
0.010
0.005
0.000
in
4
2
0
in
1.5
1.0
0.5
0.0
cfs
10
5
0
SU
19:30
20:00
20:30
21:00
21:30
22:00
29 Wed Sep 2010
9/29/2010 7:00:00 PM - 9/29/2010 10:00:00 PM

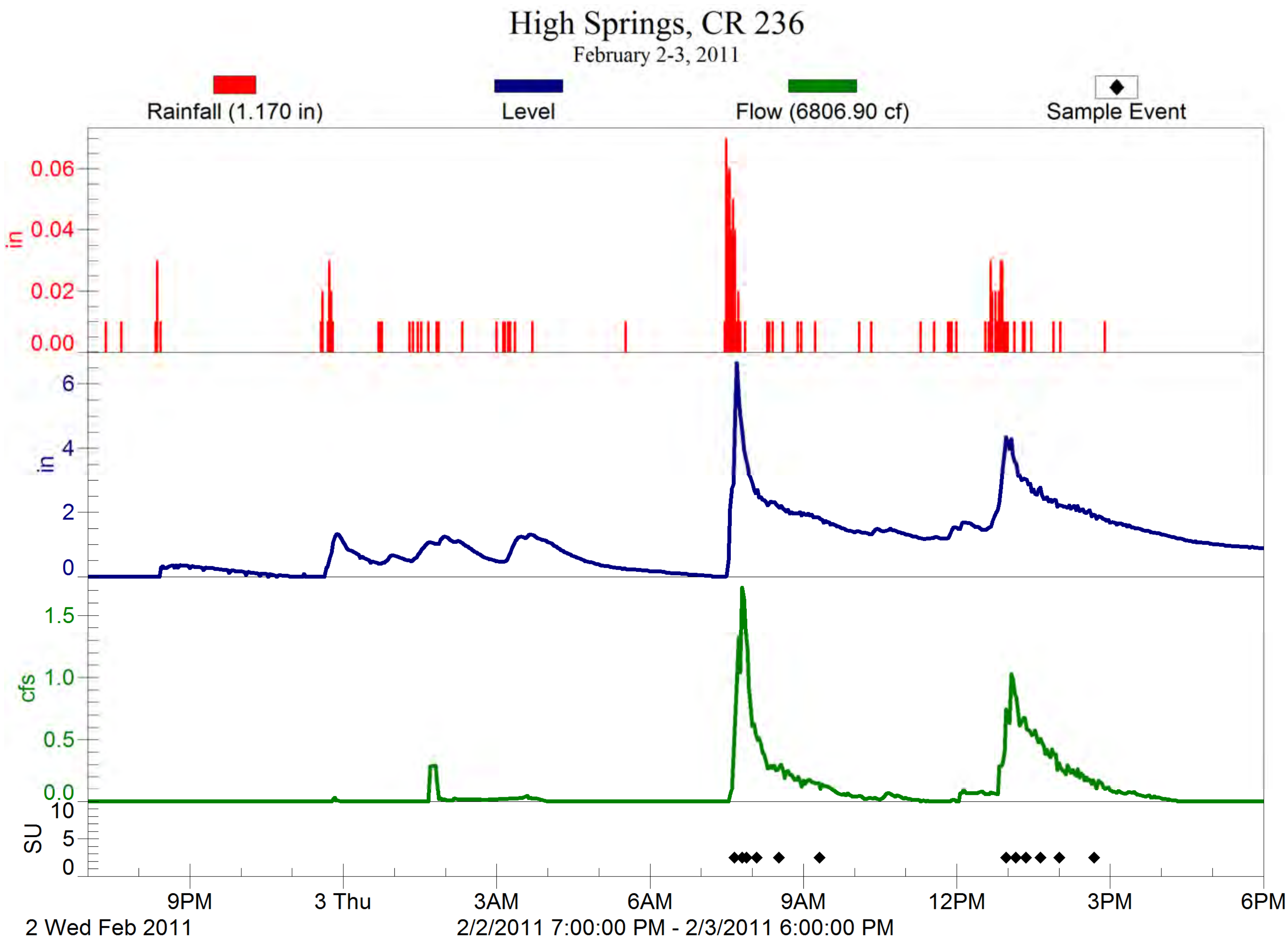

High Springs, CR 236
November 16, 2010
Rainfall (0.310 in)
Level
Flow (1187.88 cf)
Sample Event
0.08
0.06
0.04
0.02
0.00
in
4
3
2
1
0
in
1.5
1.0
0.5
0.0
cfs
10
5
0
SU
13:05
13:10
13:15
13:20
13:25
13:30
13:35
13:40
13:45
13:50
13:55
16 Tue Nov 2010
11/16/2010 1:00:00 PM - 11/16/2010 2:00:00 PM



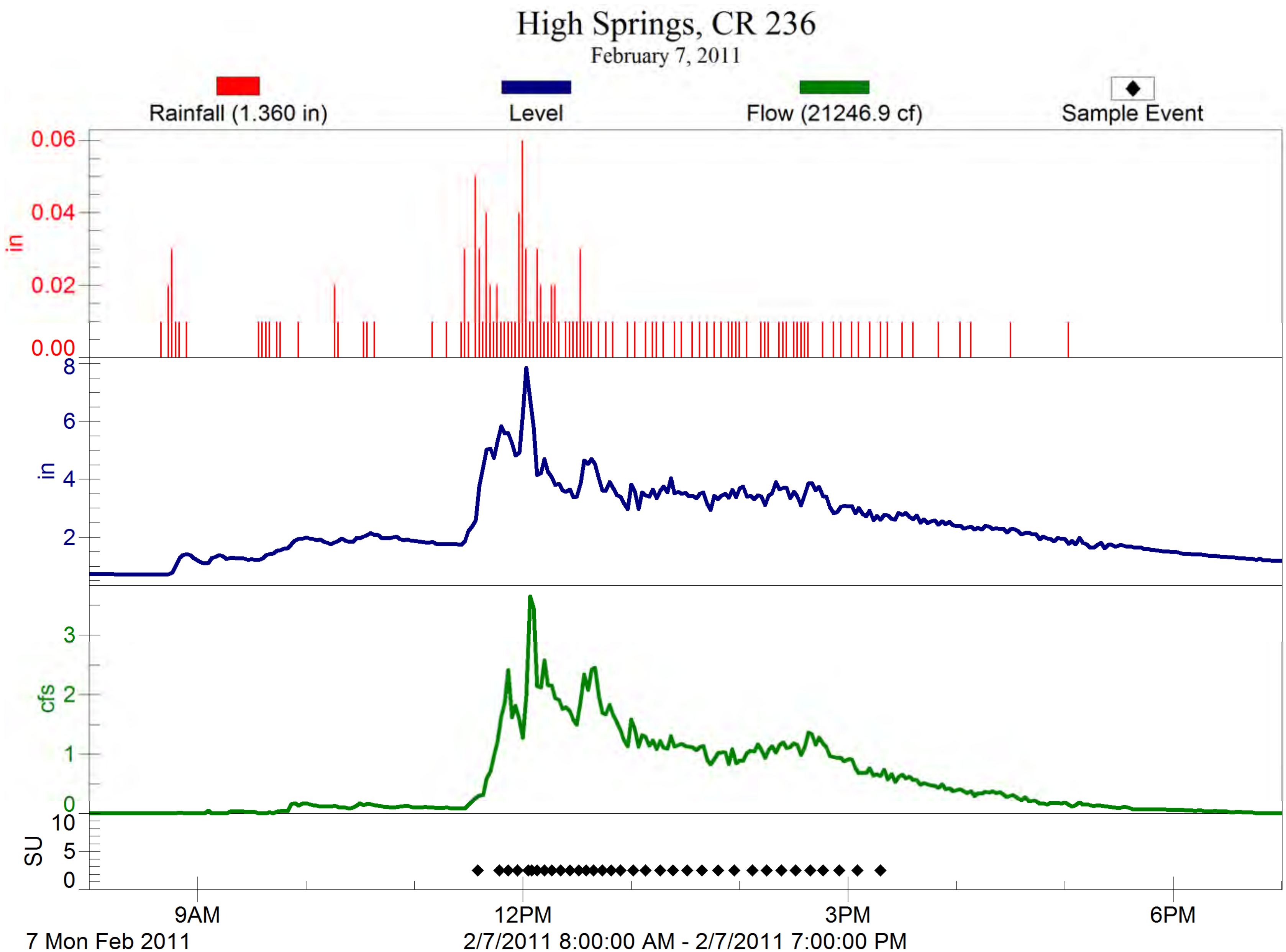
High Springs, CR 236
January 5, 2011
Rainfall (0.480 in)
Level
Flow (1447.13 cf)
Sample Event
0.15
0.10
0.05
0.00
in
5
4
3
2
1
0
in
1.0
0.5
0.0
cfs
10
5
0
SU
3PM
6PM
9PM
6 Thu
5 Wed Jan 2011
1/5/2011 2:00:00 PM - 1/6/2011 12:00:00 AM

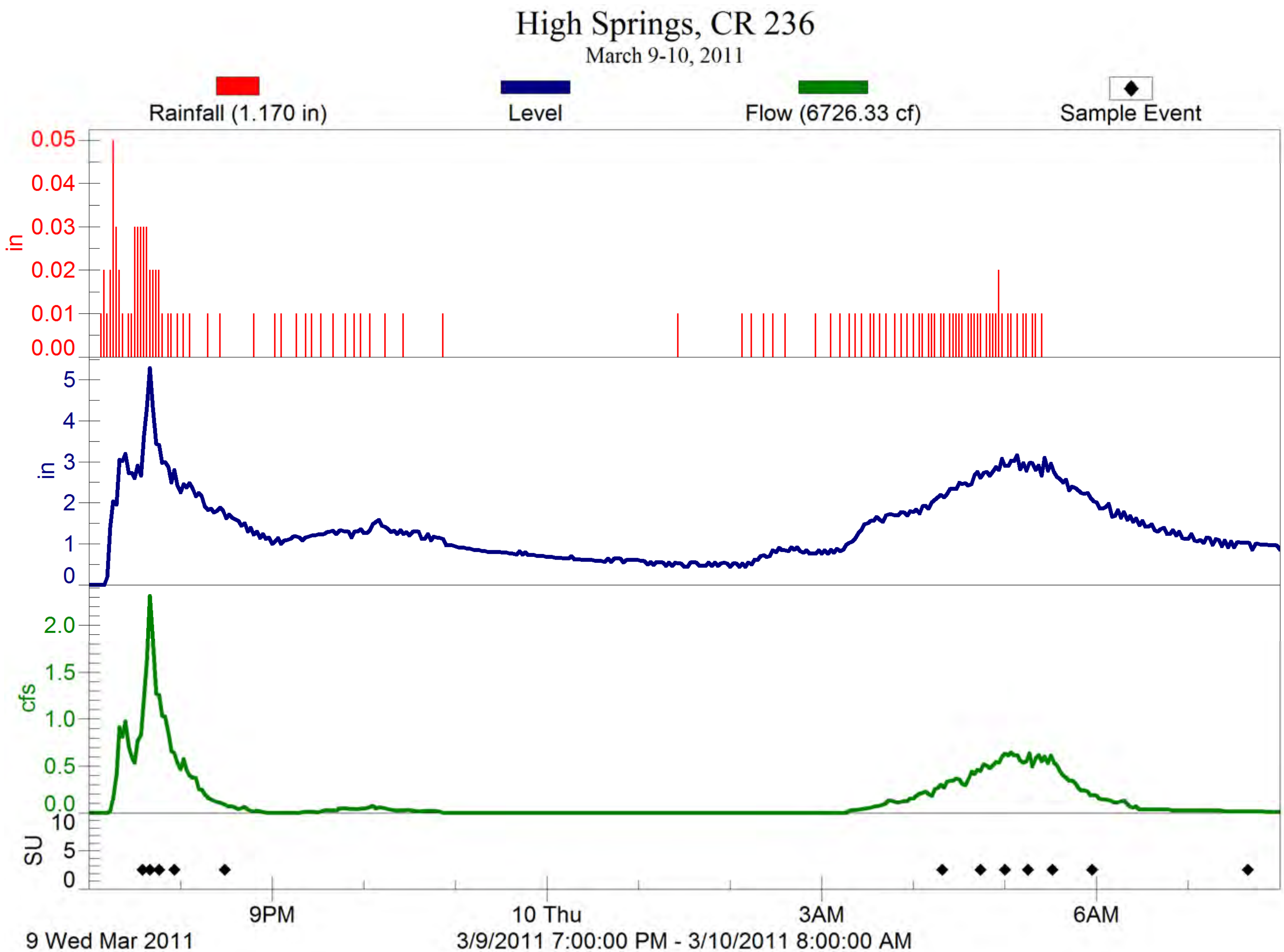


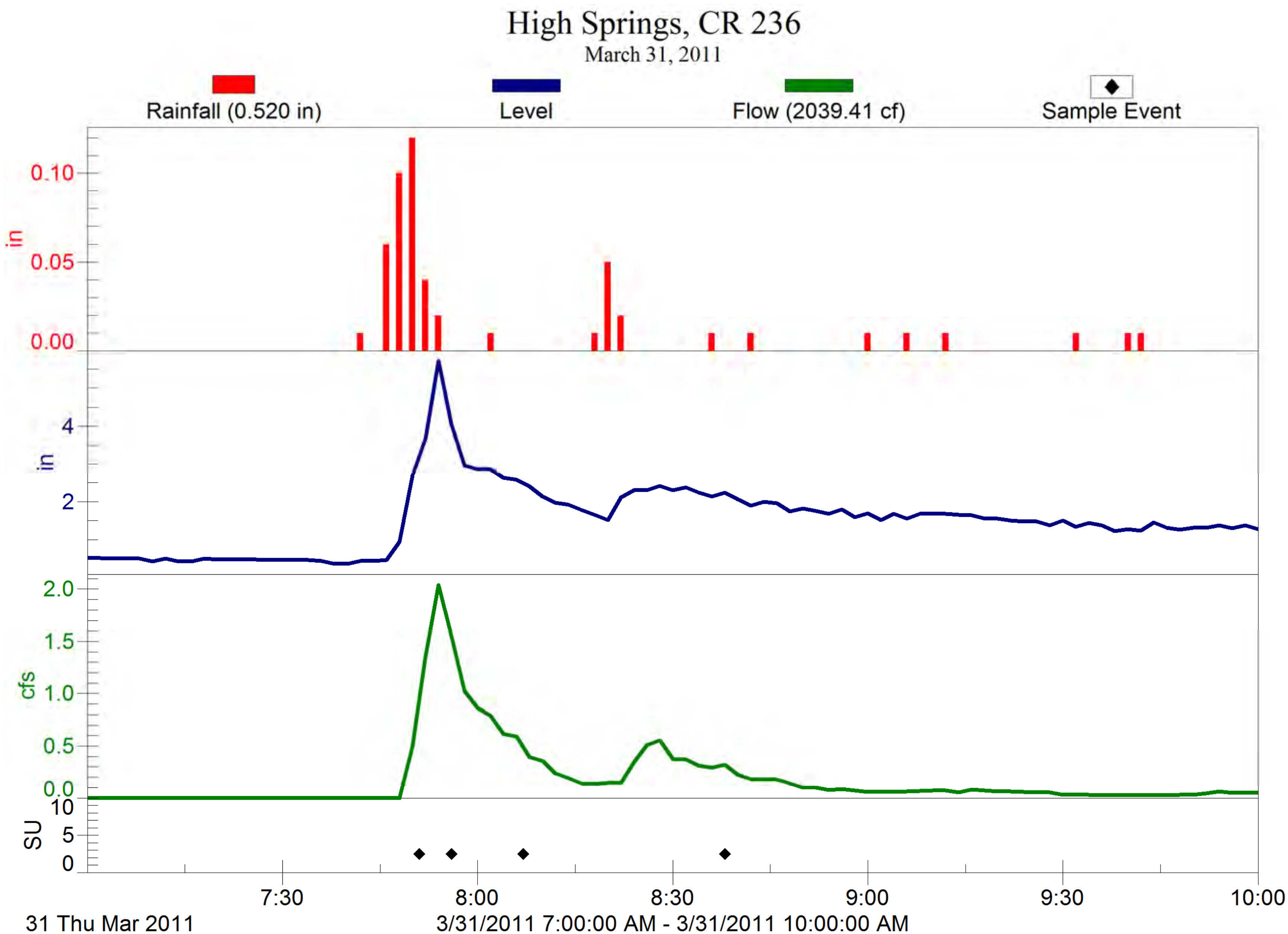
High Springs, CR 236
January 25, 2011
Rainfall (1.980 in)
Level
Flow (15870.0 cf)
Sample Event
in
0.06
0.04
0.02
0.00
in
8
6
4
2
0
cfs
2
1
0
SU
10
5
0
12PM
3PM
6PM
9PM
25 Tue Jan 2011
1/25/2011 11:00:00 AM - 1/25/2011 9:00:00 PM

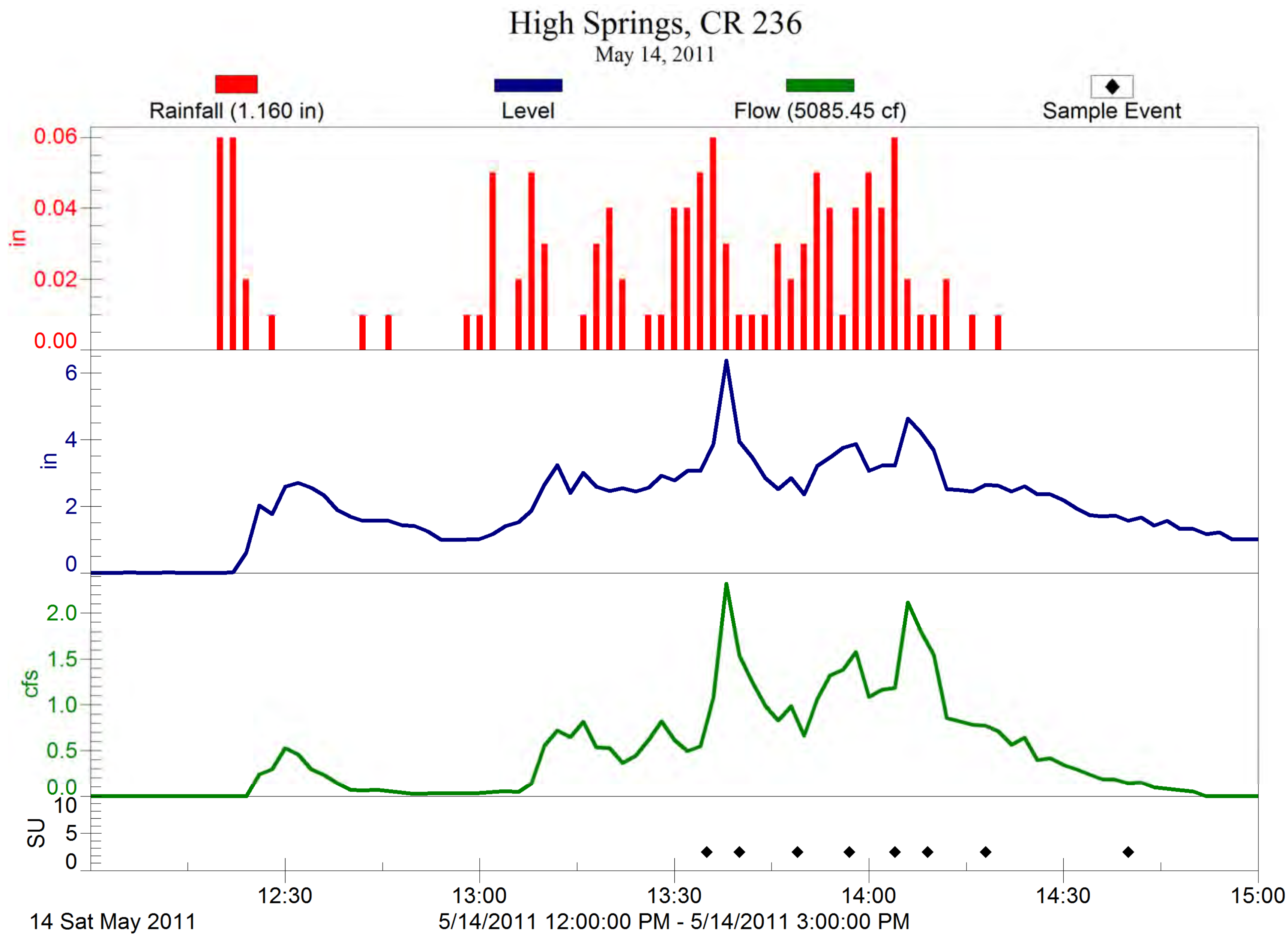


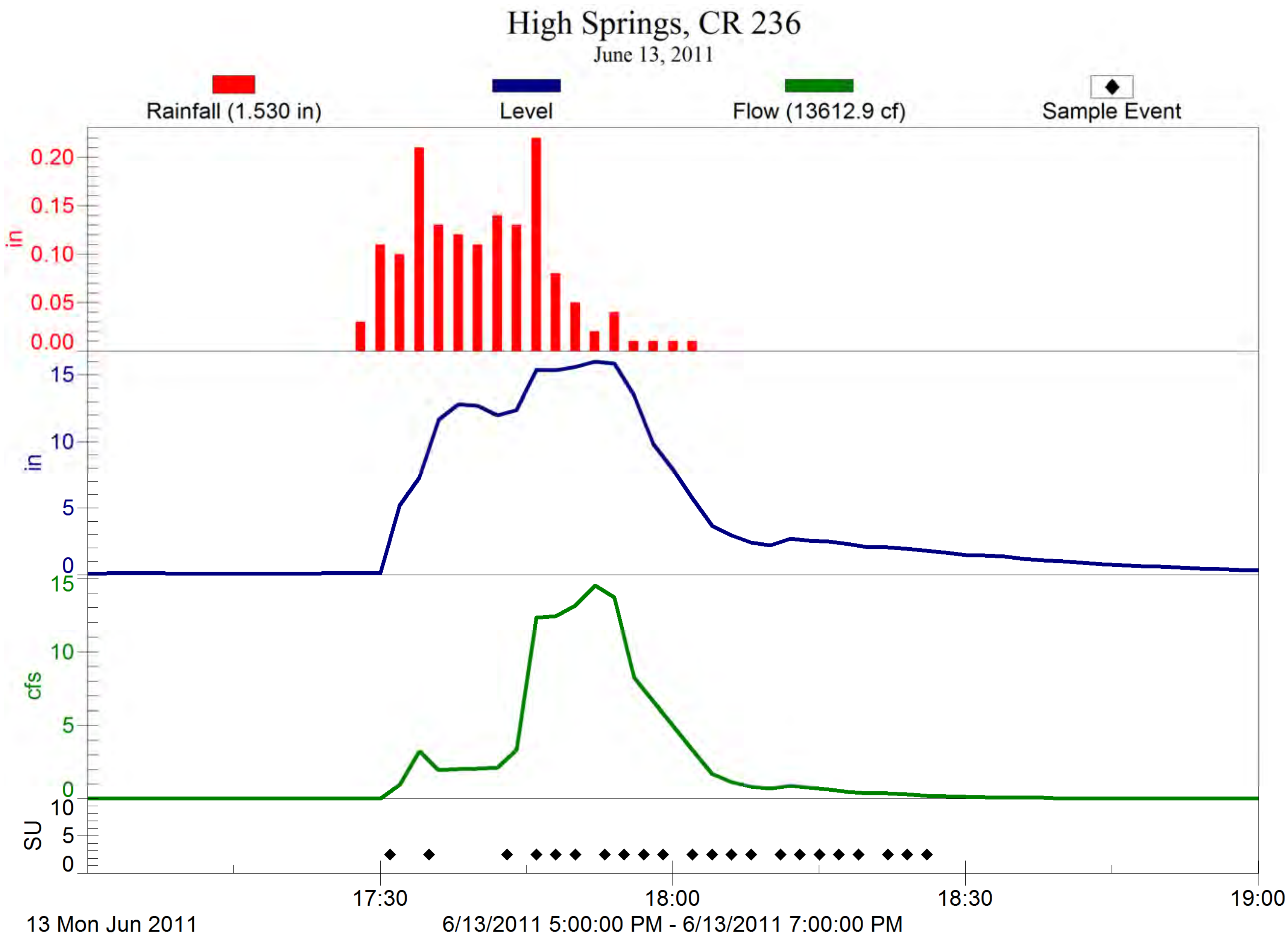
High Springs, CR 236
February 2-3, 2011
Rainfall (1.170 in)
Level
Flow (6806.90 cf)
Sample Event
in
0.06
0.04
0.02
0.00
in
6
4
2
0
cfs
1.5
1.0
0.5
0.0
SU
10
5
0
9PM
3 Thu
3AM
6AM
9AM
12PM
3PM
6PM
2 Wed Feb 2011
2/2/2011 7:00:00 PM - 2/3/2011 6:00:00 PM


High Springs, CR 236
February 7, 2011
Rainfall (1.360 in)
Level
Flow (21246.9 cf)
Sample Event
0.06
0.04
0.02
0.00
in
8
6
4
2
in
3
2
1
0
cfs
10
5
0
SU
9AM
12PM
3PM
6PM
7 Mon Feb 2011
2/7/2011 8:00:00 AM - 2/7/2011 7:00:00 PM

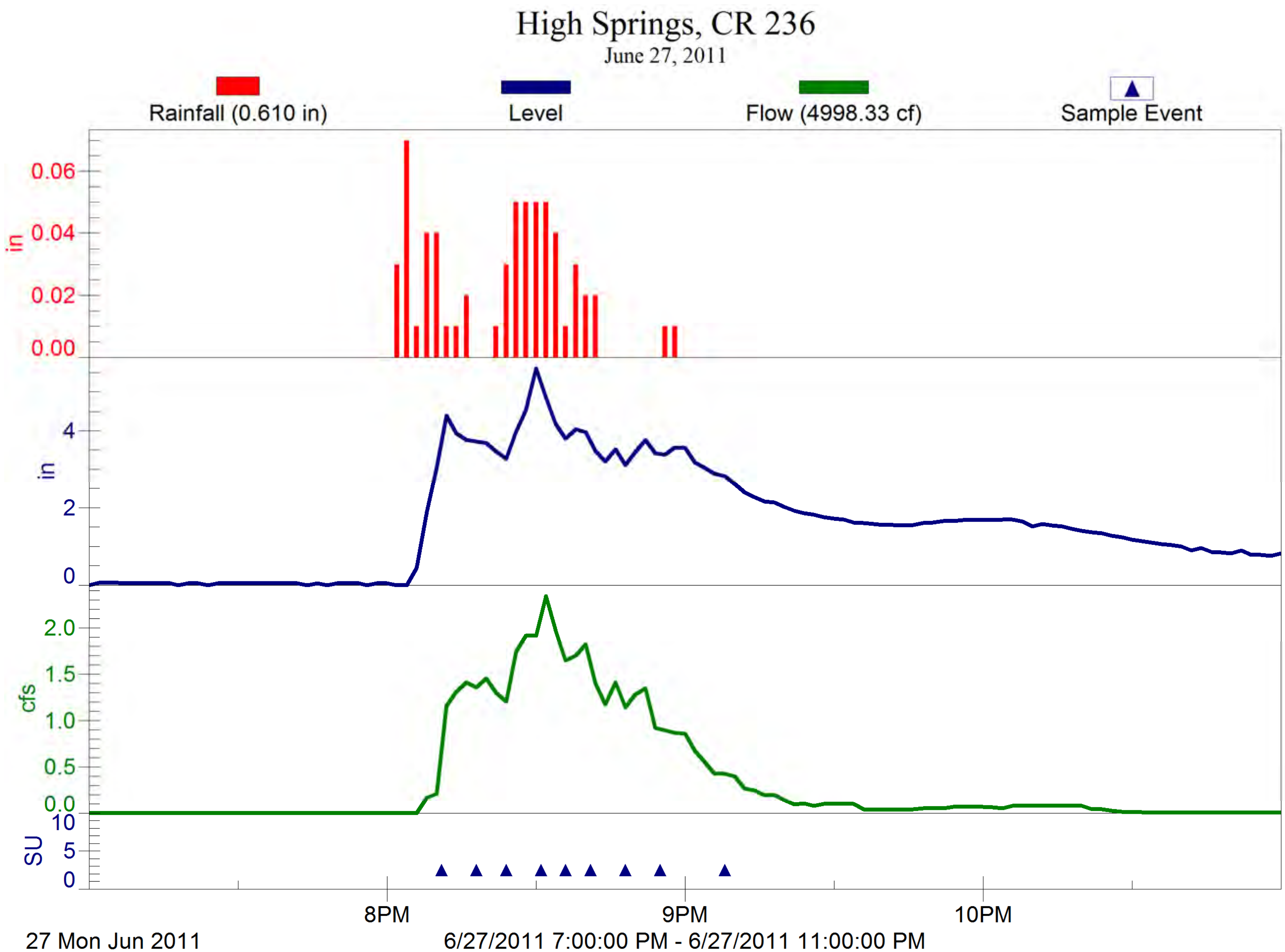

High Springs, CR 236
March 9-10, 2011
Rainfall (1.170 in)
Level
Flow (6726.33 cf)
Sample Event
in
0.05
0.04
0.03
0.02
0.01
0.00
in
5
4
3
2
1
0
cfs
2.0
1.5
1.0
0.5
0.0
SU
10
5
0
9PM
10 Thu
3AM
6AM
9 Wed Mar 2011
3/9/2011 7:00:00 PM - 3/10/2011 8:00:00 AM


High Springs, CR 236
March 31, 2011
Rainfall (0.520 in)
Level
Flow (2039.41 cf)
Sample Event
0.10
0.05
0.00
in
4
2
in
2.0
1.5
1.0
0.5
0.0
cfs
10
5
0
SU
7:30
8:00
8:30
9:00
9:30
10:00
31 Thu Mar 2011
3/31/2011 7:00:00 AM - 3/31/2011 10:00:00 AM

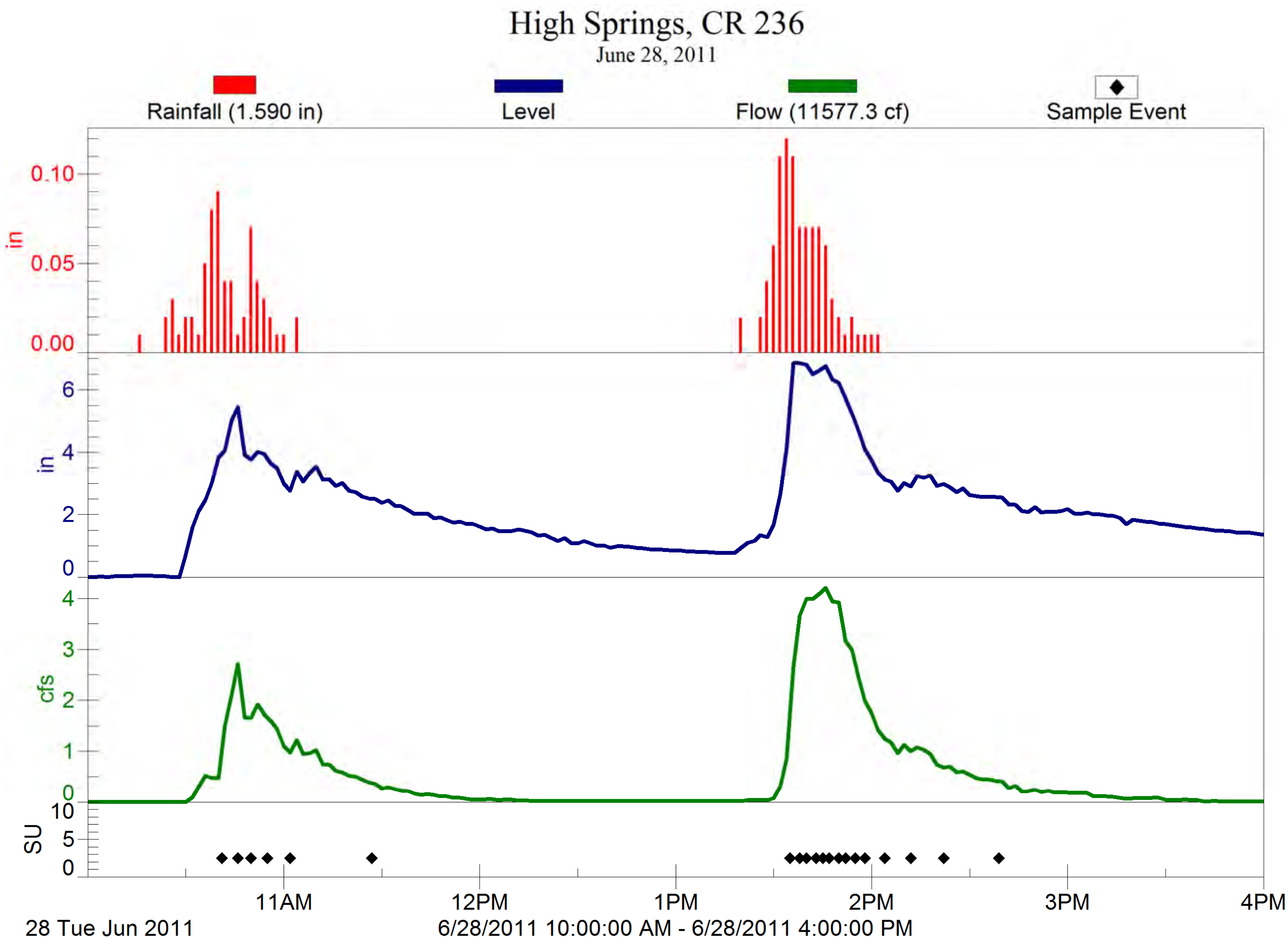

High Springs, CR 236
May 14, 2011
Rainfall (1.160 in)
Level
Flow (5085.45 cf)
Sample Event
0.06
0.04
0.02
0.00
in
6
4
2
0
in
2.0
1.5
1.0
0.5
0.0
cfs
10
5
0
SU
12:30
13:00
13:30
14:00
14:30
15:00
14 Sat May 2011
5/14/2011 12:00:00 PM - 5/14/2011 3:00:00 PM



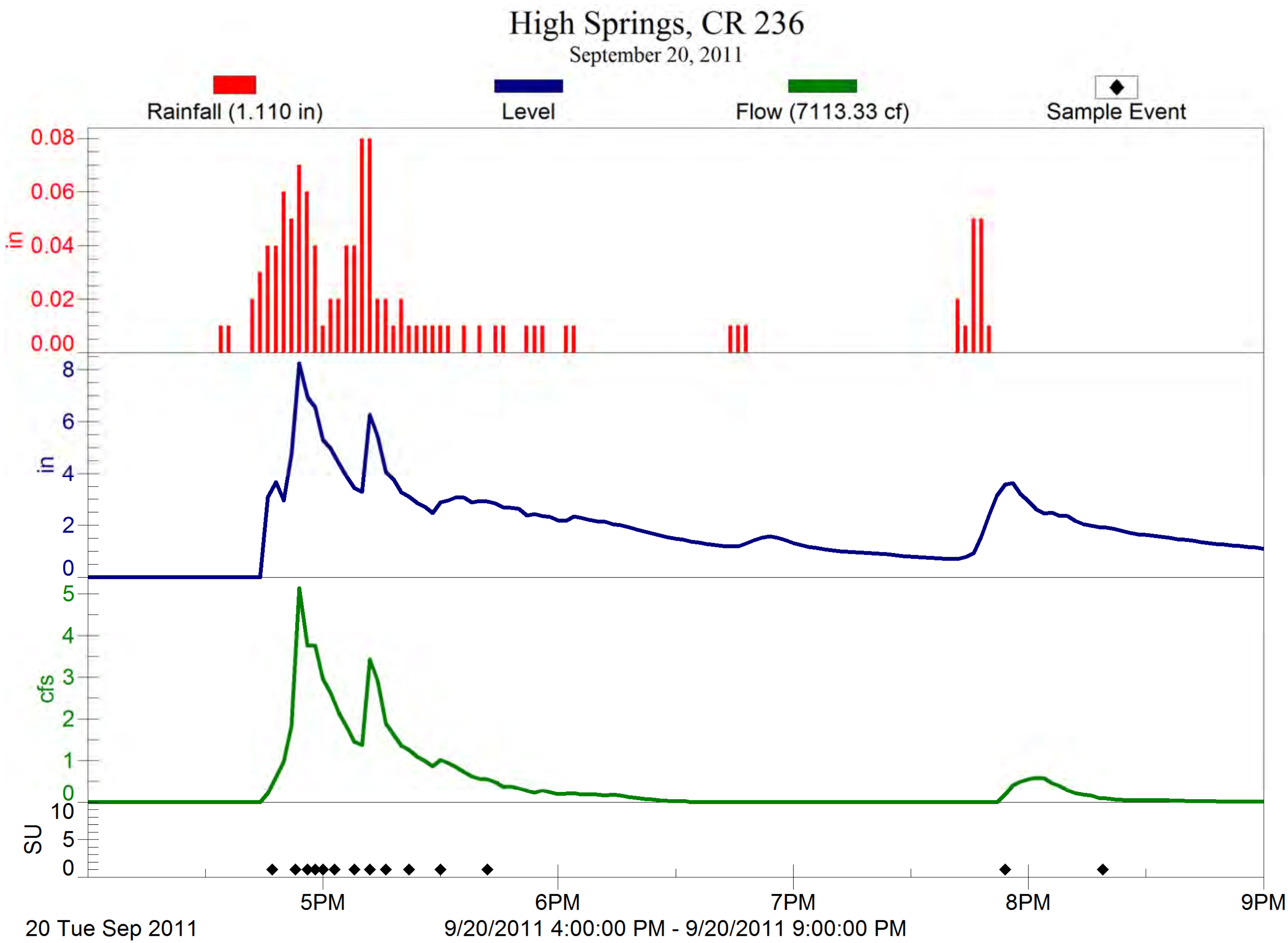
High Springs, CR 236
June 13, 2011
Rainfall (1.530 in)
Level
Flow (13612.9 cf)
Sample Event
0.20
0.15
0.10
0.05
0.00
in
15
10
5
0
in
15
10
5
0
cfs
10
5
0
SU
17:30
18:00
18:30
19:00
13 Mon Jun 2011
6/13/2011 5:00:00 PM - 6/13/2011 7:00:00 PM



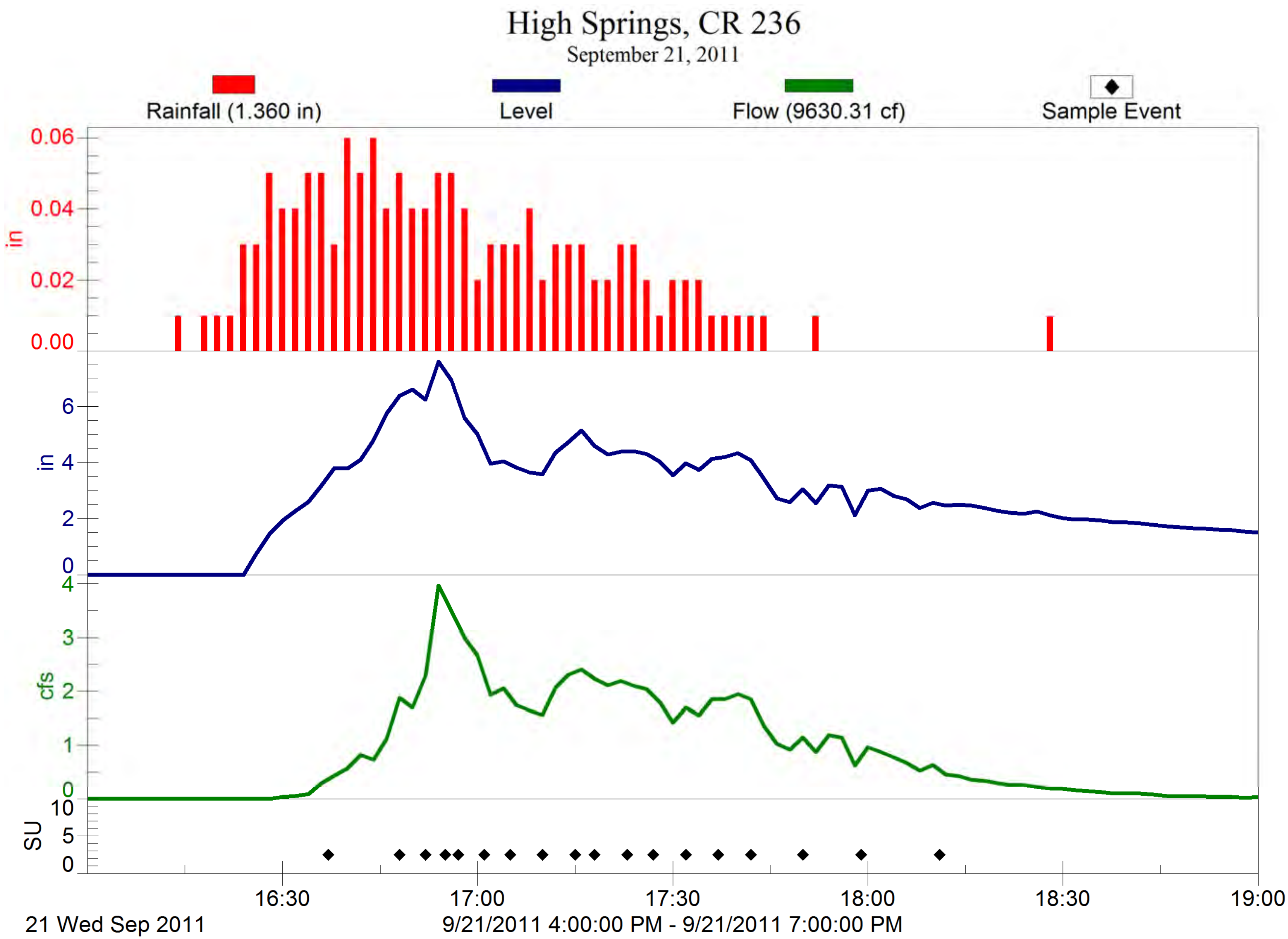
High Springs, CR 236
June 27, 2011
Rainfall (0.610 in)
Level
Flow (4998.33 cf)
Sample Event
0.06
0.04
0.02
0.00
in
4
2
0
in
2.0
1.5
1.0
0.5
0.0
cfs
10
5
0
SU
8PM
9PM
10PM
27 Mon Jun 2011
6/27/2011 7:00:00 PM - 6/27/2011 11:00:00 PM

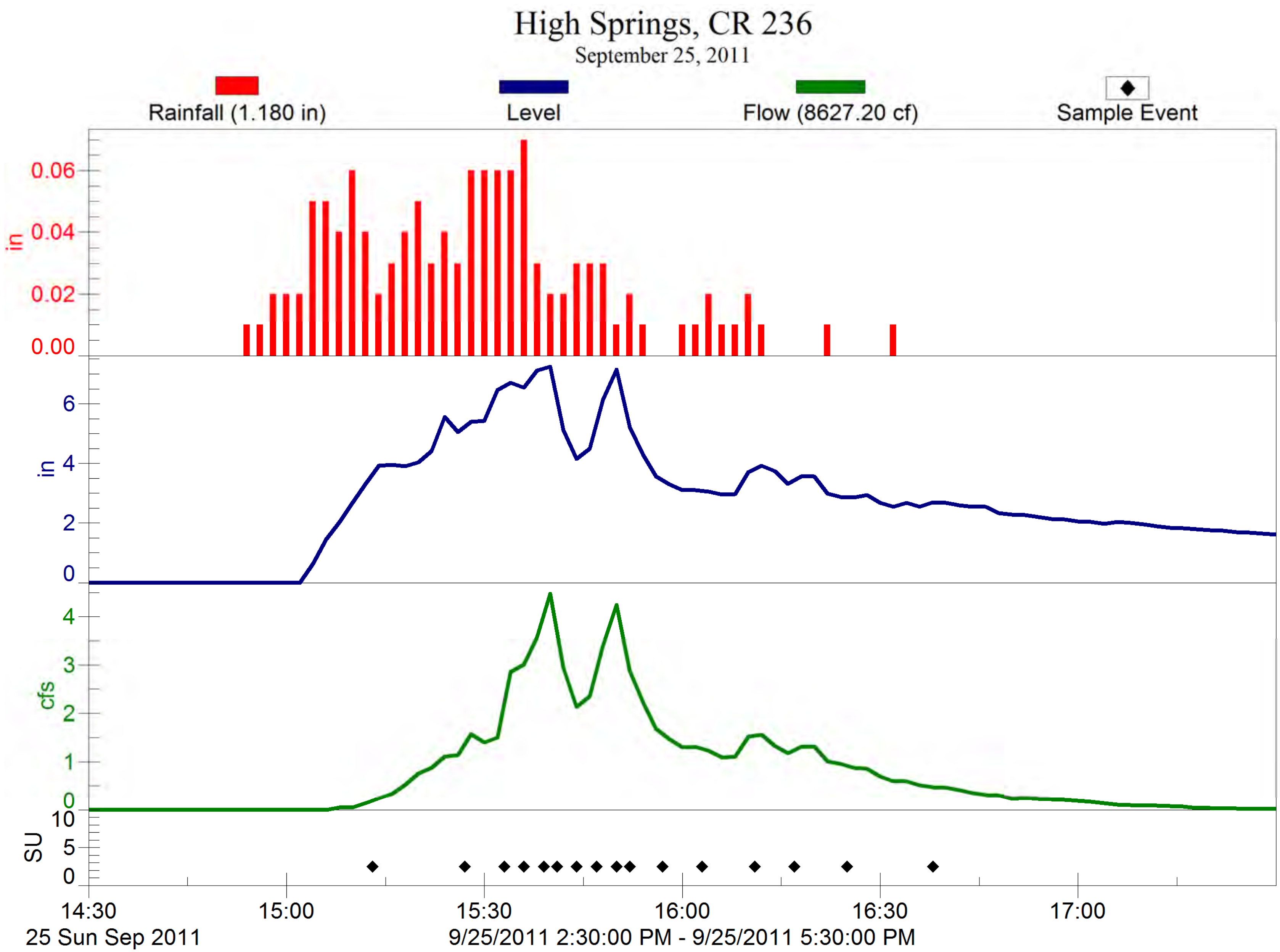


High Springs, CR 236
June 28, 2011
Rainfall (1.590 in)
Level
Flow (11577.3 cf)
Sample Event
in
0.10
0.05
0.00
in
6
4
2
0
cfs
4
3
2
1
0
SU
10
5
0
11AM
12PM
1PM
2PM
3PM
4PM
28 Tue Jun 2011
6/28/2011 10:00:00 AM - 6/28/2011 4:00:00 PM



High Springs, CR 236
September 20, 2011
Rainfall (1.110 in)
Level
Flow (7113.33 cf)
Sample Event
in
0.08
0.06
0.04
0.02
0.00
in
8
6
4
2
0
cfs
5
4
3
2
1
0
SU
10
5
0
5PM
6PM
7PM
8PM
9PM
20 Tue Sep 2011
9/20/2011 4:00:00 PM - 9/20/2011 9:00:00 PM

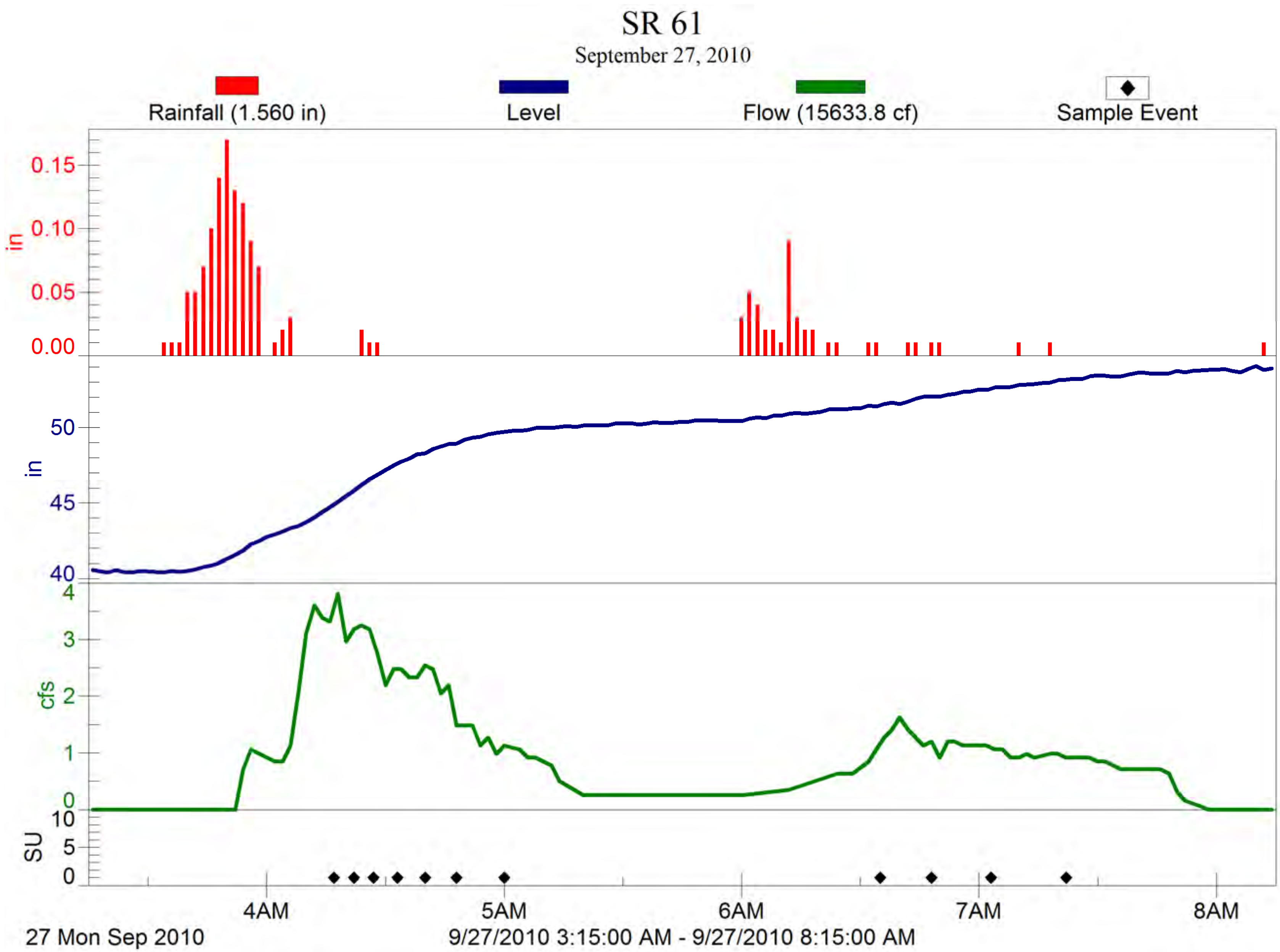

High Springs, CR 236
September 21, 2011
Rainfall (1.360 in)
Level
Flow (9630.31 cf)
Sample Event
0.06
0.04
0.02
0.00
in
6
4
2
0
in
4
3
2
1
0
cfs
10
5
0
SU
16:30
17:00
17:30
18:00
18:30
19:00
21 Wed Sep 2011
9/21/2011 4:00:00 PM - 9/21/2011 7:00:00 PM


High Springs, CR 236
September 25, 2011
Rainfall (1.180 in)
Level
Flow (8627.20 cf)
Sample Event
0.06
0.04
0.02
0.00
in
6
4
2
0
in
4
3
2
1
0
cfs
10
5
0
SU
14:30
25 Sun Sep 2011
15:00
15:30
16:00
16:30
17:00
9/25/2011 2:30:00 PM - 9/25/2011 5:30:00 PM

Appendix B

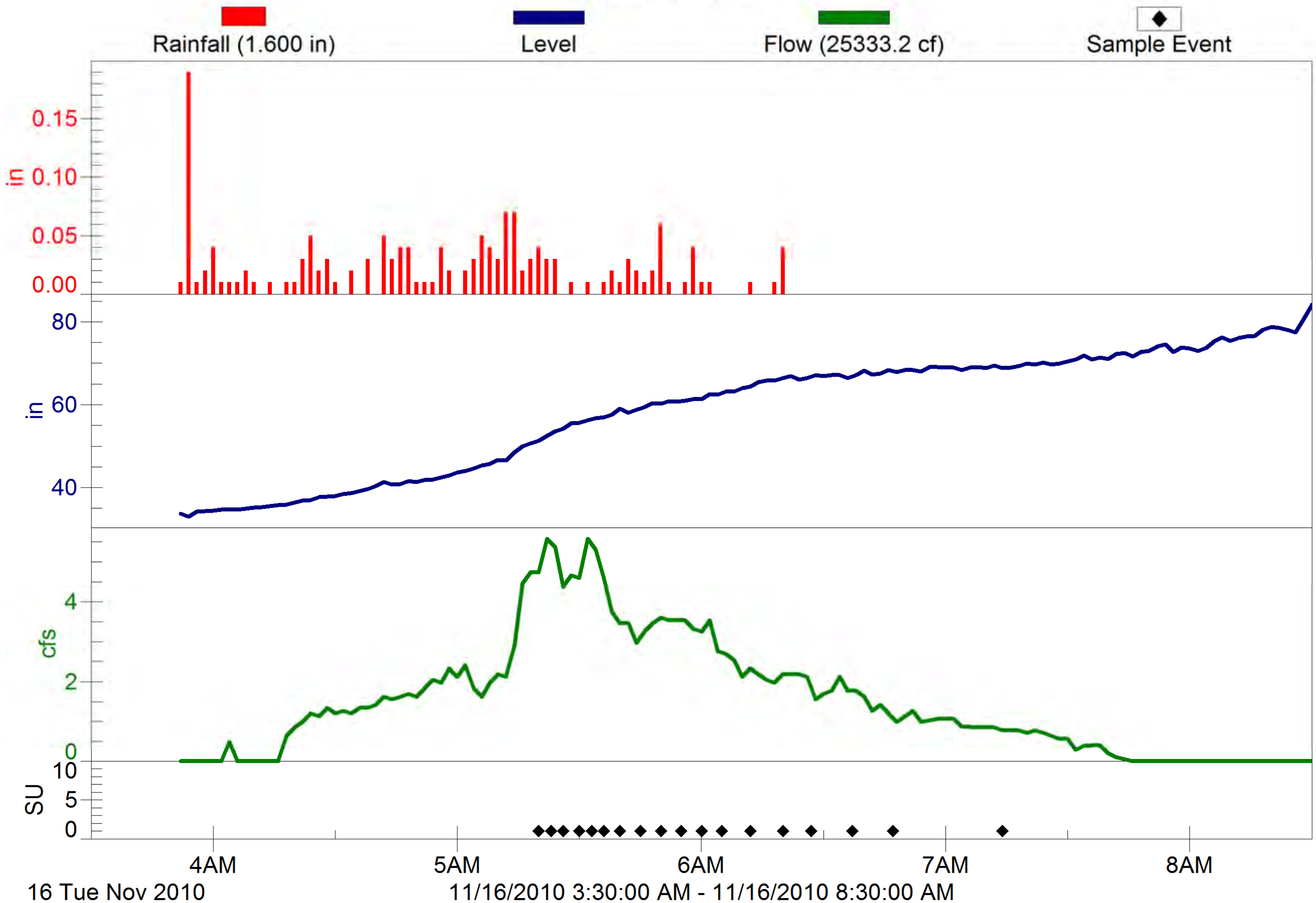
Storm Event Data for SR 61 Sampling Location

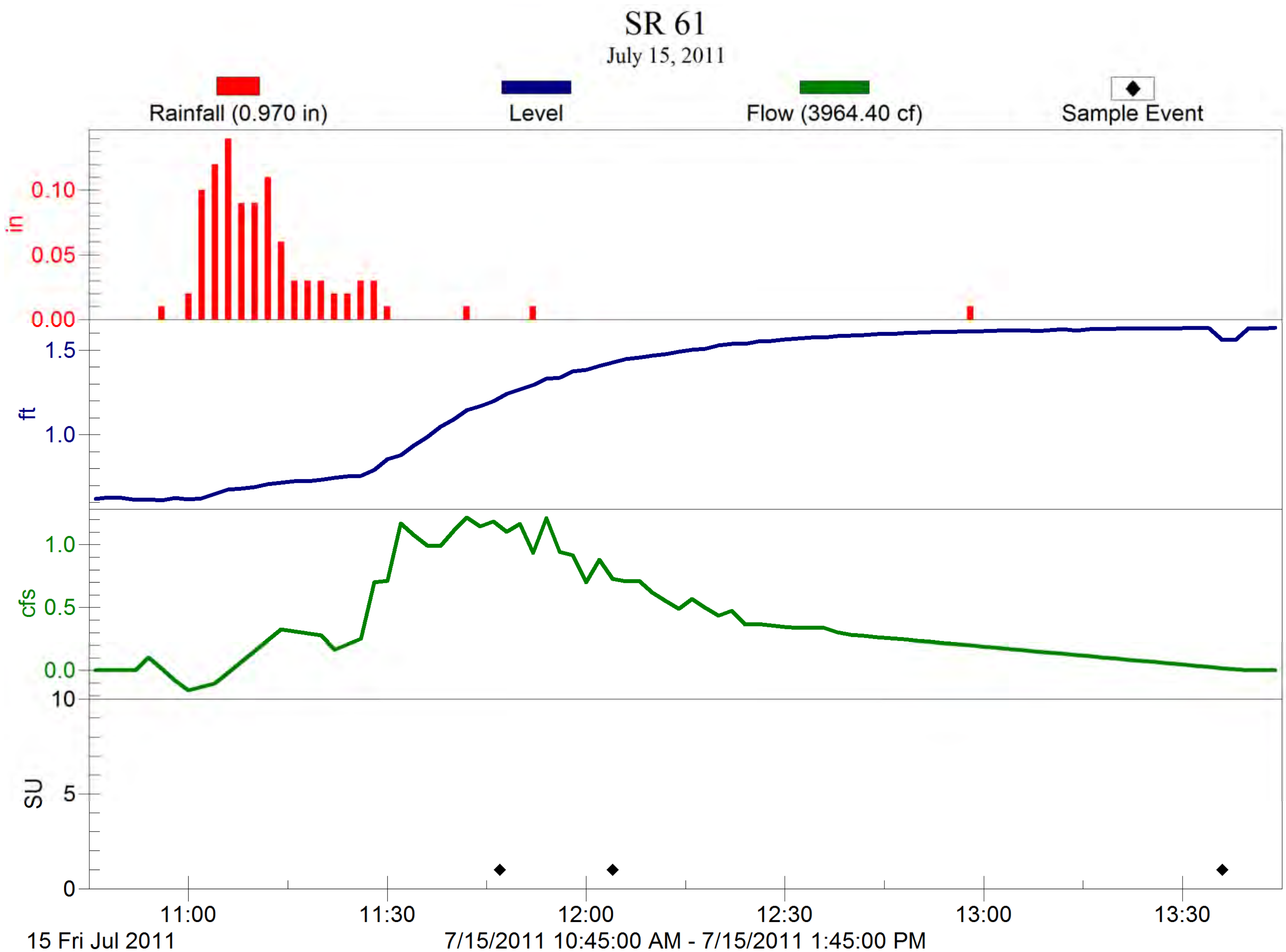
(Laboratory results included on the accompanying CD)



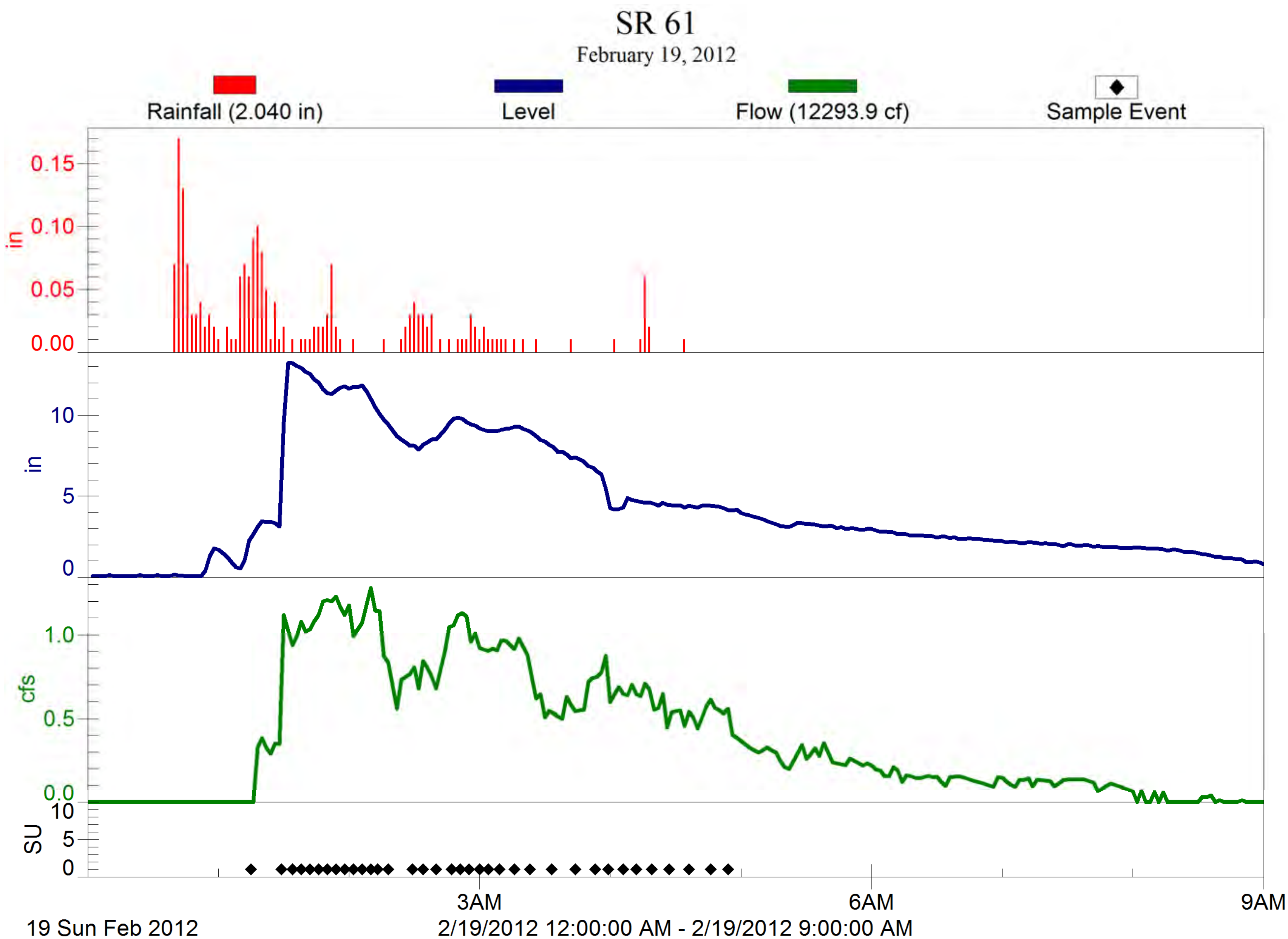
SR 61
September 27, 2010
Rainfall (1.560 in)
Level
Flow (15633.8 cf)
Sample Event
in
0.15
0.10
0.05
0.00
in
50
45
40
cfs
4
3
2
1
0
SU
10
5
0
4AM
5AM
6AM
7AM
8AM
27 Mon Sep 2010
9/27/2010 3:15:00 AM - 9/27/2010 8:15:00 AM

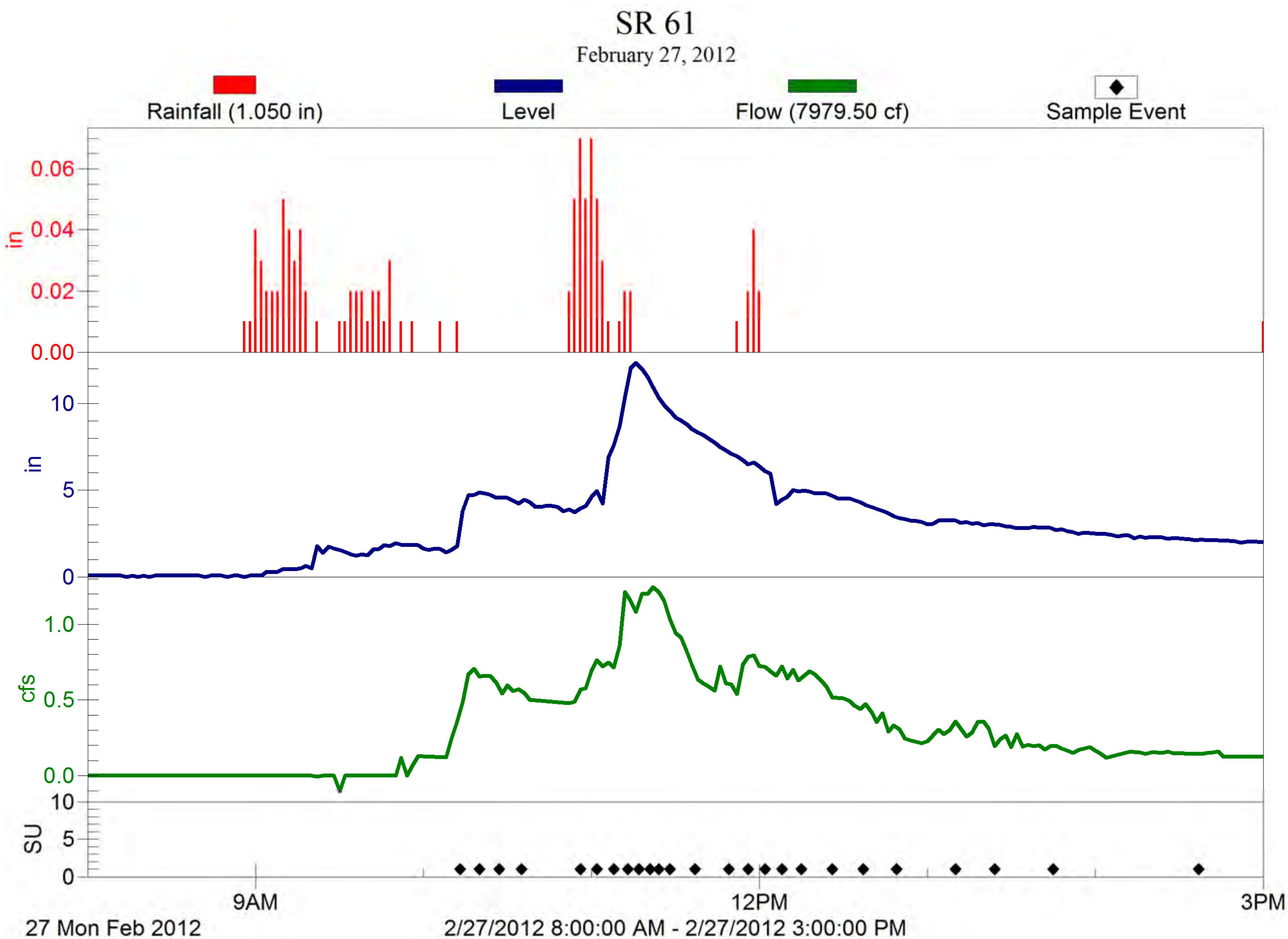
SR 61
November 16, 2010

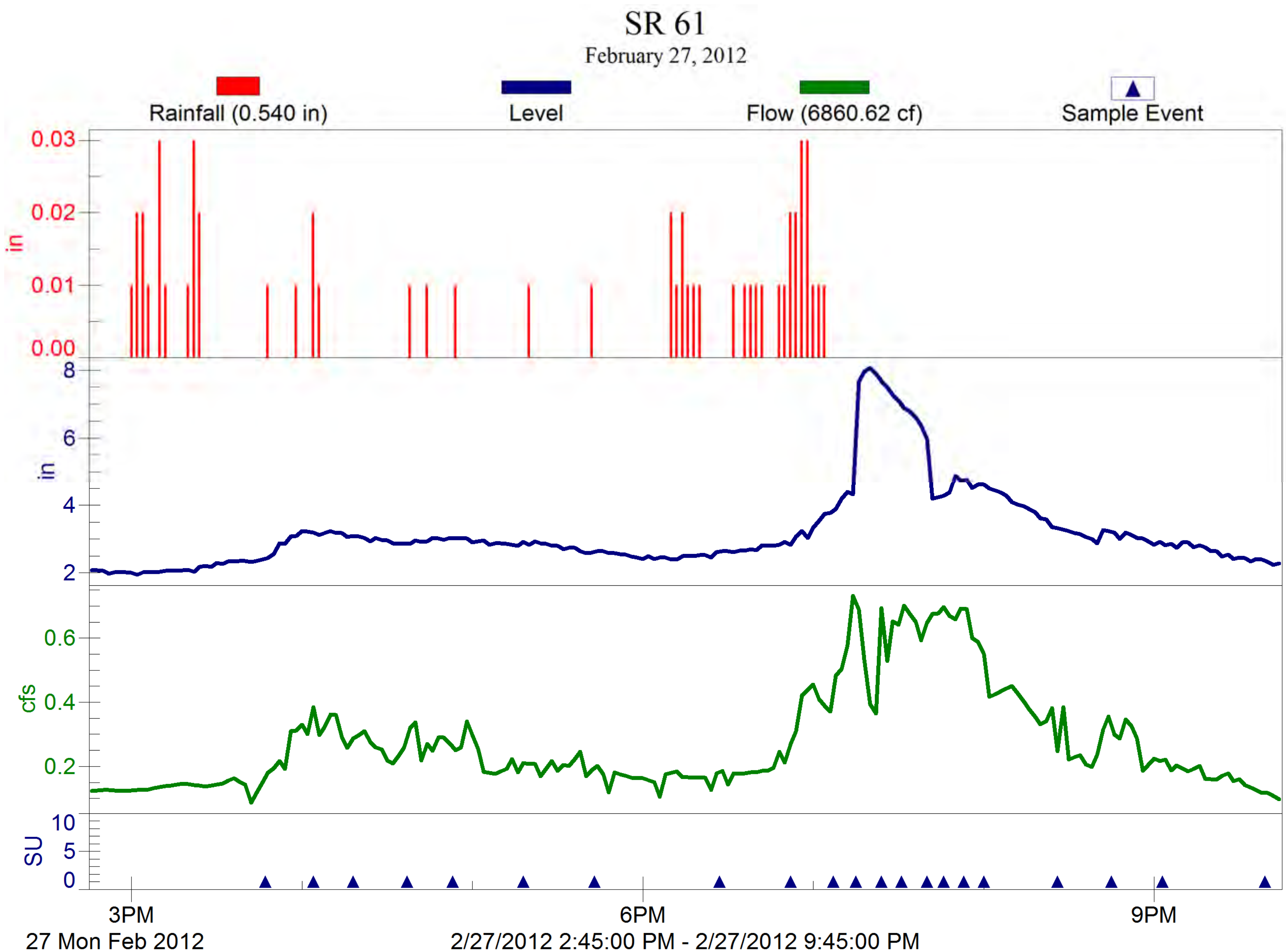




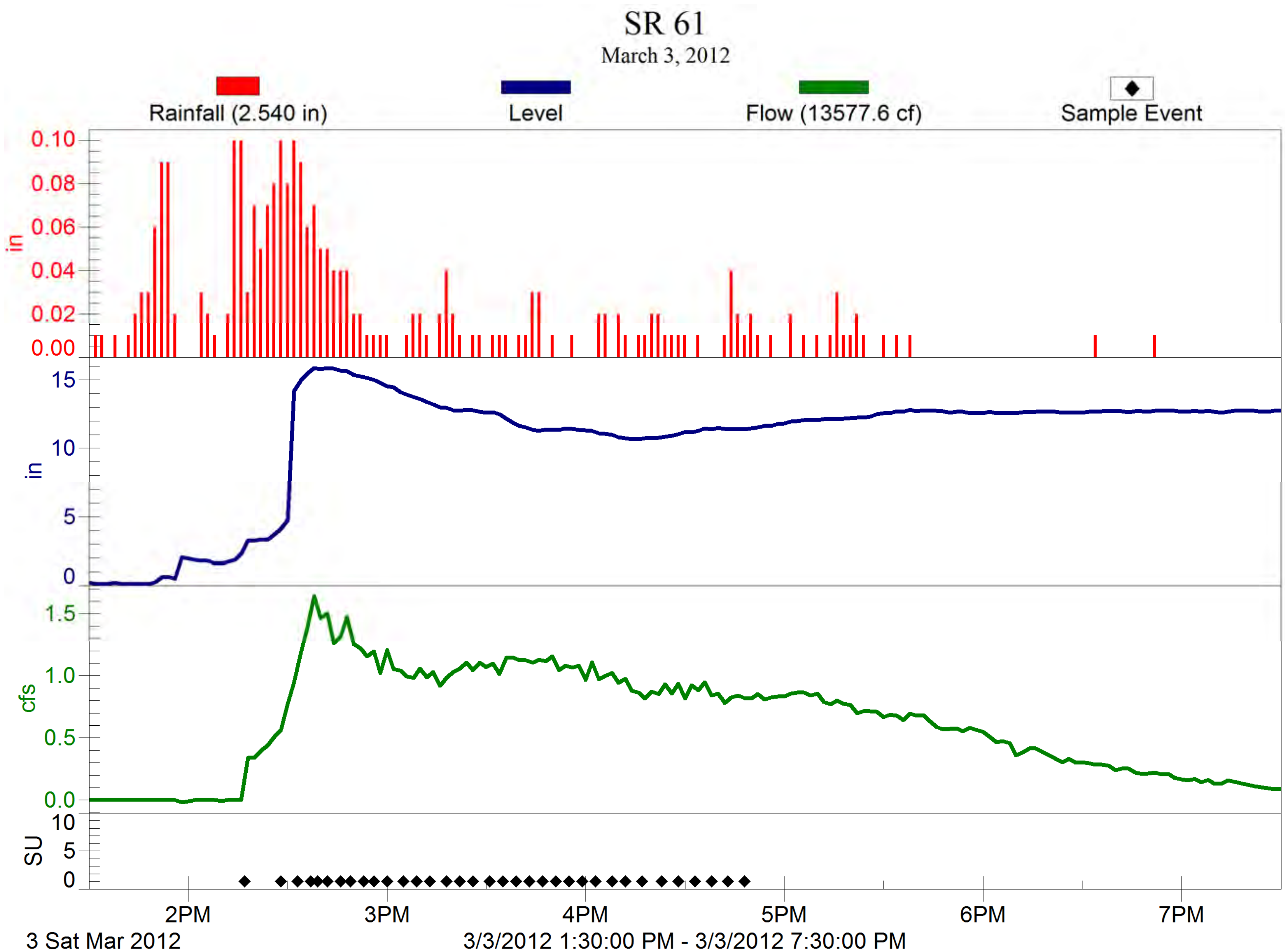
SR 61
July 15, 2011
Rainfall (0.970 in)
Level
Flow (3964.40 cf)
Sample Event
in
0.10
0.05
0.00
ft
1.5
1.0
cfs
1.0
0.5
0.0
SU
10
5
0
11:00
11:30
12:00
12:30
13:00
13:30
15 Fri Jul 2011
7/15/2011 10:45:00 AM - 7/15/2011 1:45:00 PM

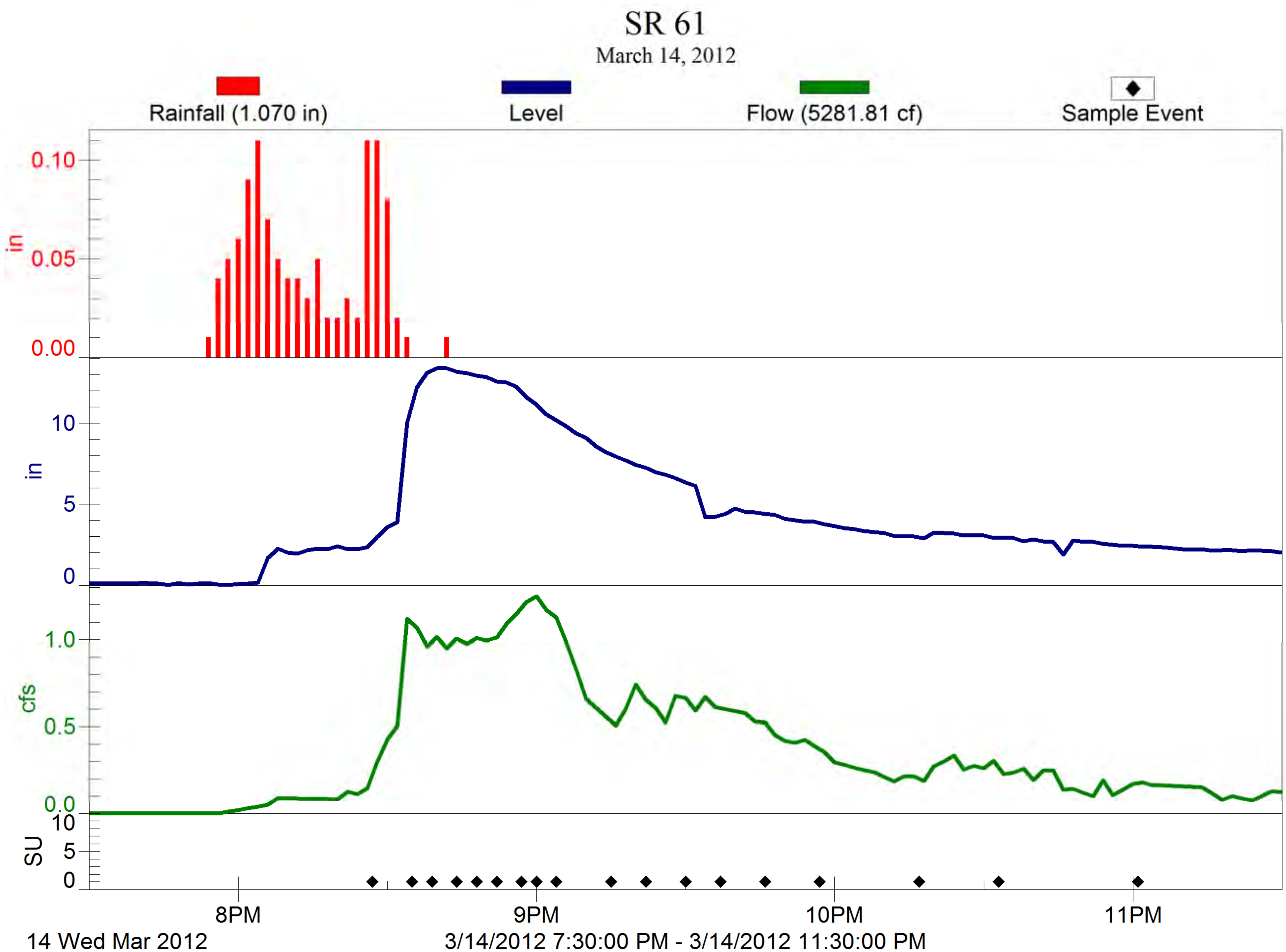

SR 61
February 19, 2012
Rainfall (2.040 in)
Level
Flow (12293.9 cf)
Sample Event
0.15
0.10
0.05
0.00
in
10
5
0
in
1.0
0.5
0.0
cfs
10
5
0
SU
3AM
6AM
9AM
19 Sun Feb 2012
2/19/2012 12:00:00 AM - 2/19/2012 9:00:00 AM


SR 61
February 27, 2012
Rainfall (1.050 in)
Level
Flow (7979.50 cf)
Sample Event
in
0.06
0.04
0.02
0.00
in
10
5
0
cfs
1.0
0.5
0.0
SU
10
5
0
9AM
12PM
3PM
27 Mon Feb 2012
2/27/2012 8:00:00 AM - 2/27/2012 3:00:00 PM

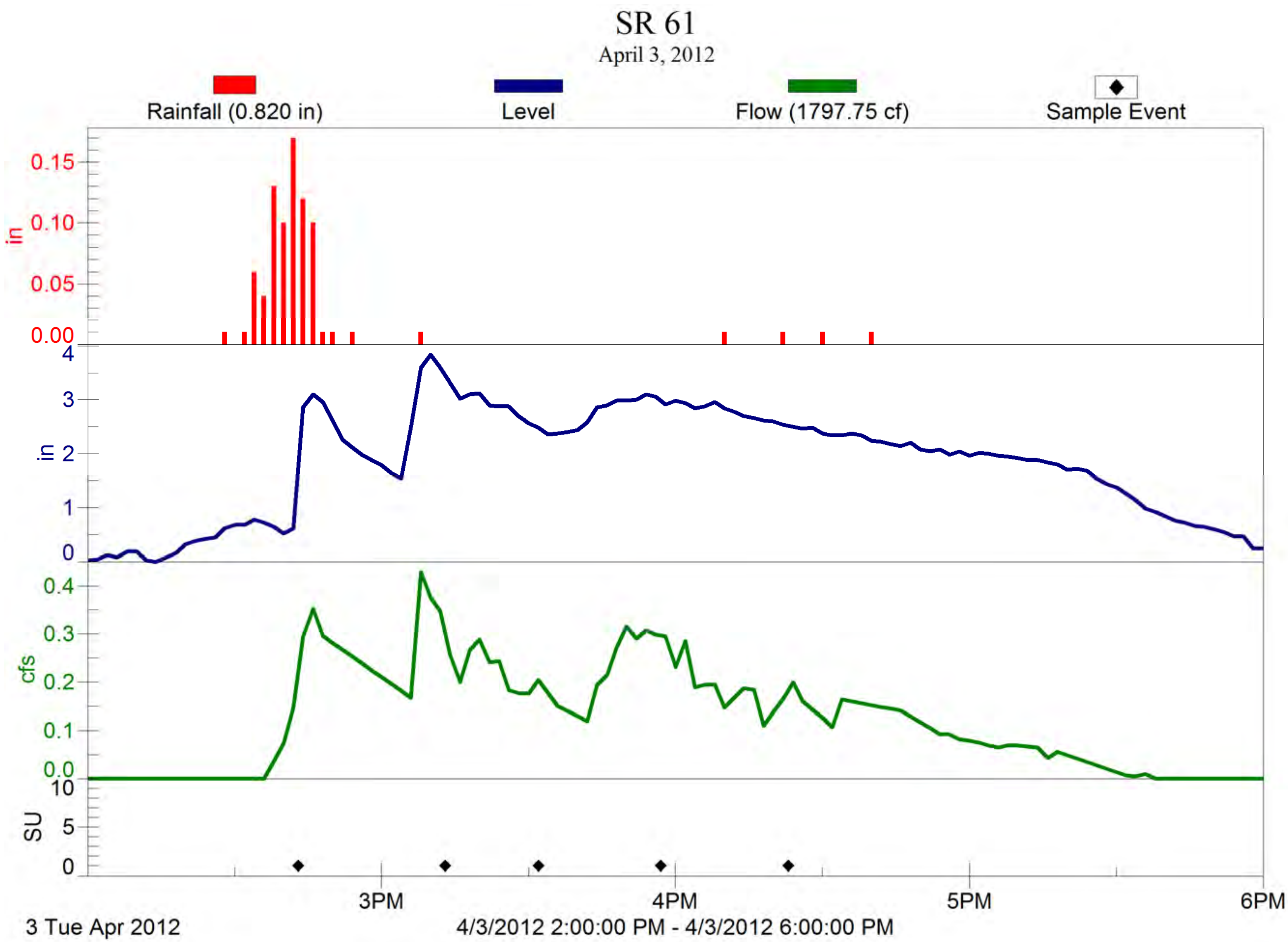


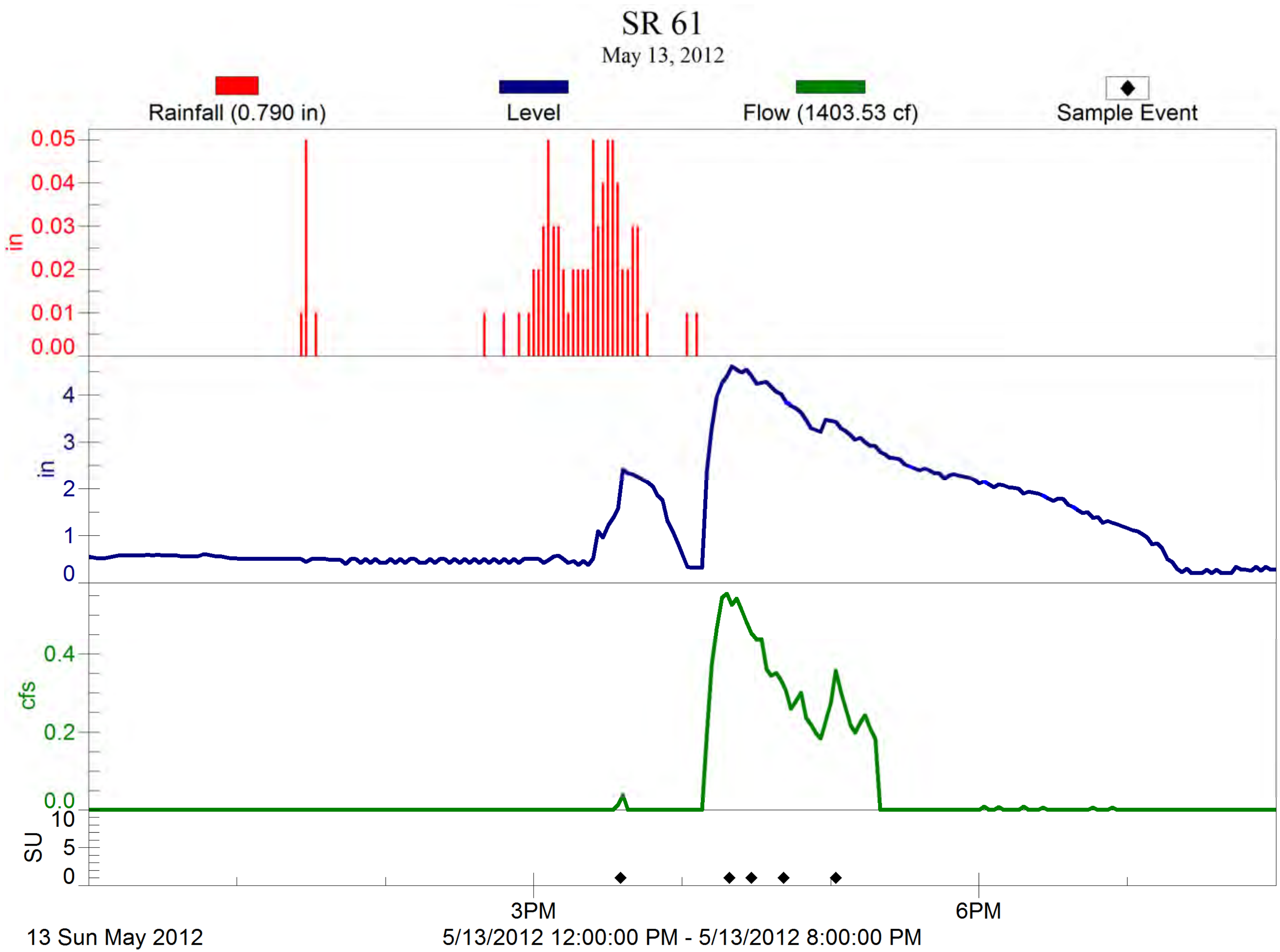
SR 61
February 27, 2012
Rainfall (0.540 in)
Level
Flow (6860.62 cf)
Sample Event
0.03
0.02
0.01
0.00
in
8
6
4
2
in
0.6
0.4
0.2
cfs
10
5
0
SU
3PM
6PM
9PM
27 Mon Feb 2012
2/27/2012 2:45:00 PM - 2/27/2012 9:45:00 PM


SR 61
March 3, 2012
Rainfall (2.540 in)
Level
Flow (13577.6 cf)
Sample Event
in
0.10
0.08
0.06
0.04
0.02
0.00
in
15
10
5
0
cfs
1.5
1.0
0.5
0.0
SU
10
5
0
2PM
3PM
4PM
5PM
6PM
7PM
3 Sat Mar 2012
3/3/2012 1:30:00 PM - 3/3/2012 7:30:00 PM

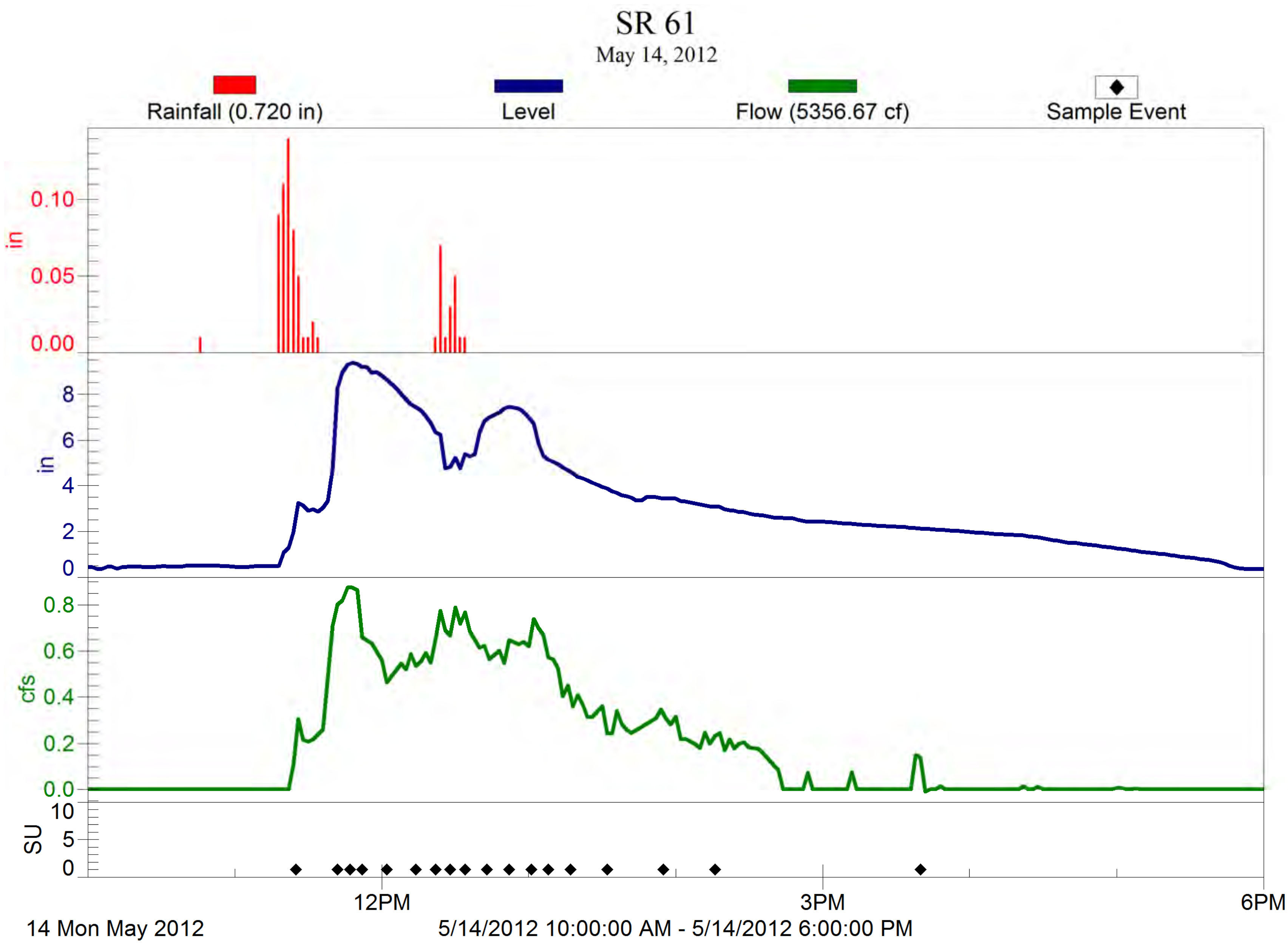


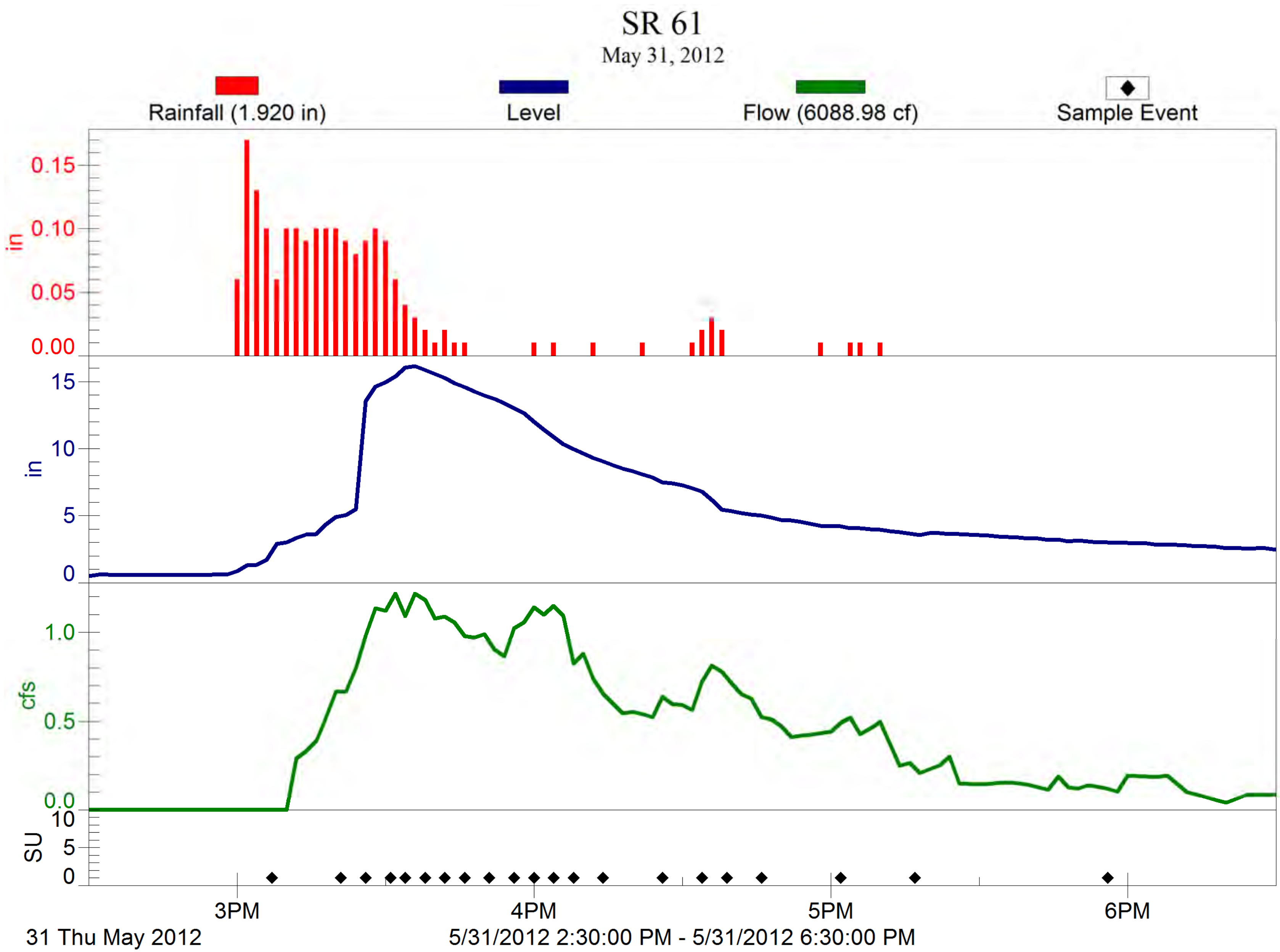
SR 61
March 14, 2012
Rainfall (1.070 in)
Level
Flow (5281.81 cf)
Sample Event
0.10
0.05
0.00
in
10
5
0
in
1.0
0.5
0.0
cfs
10
5
0
SU
8PM
9PM
10PM
11PM
14 Wed Mar 2012
3/14/2012 7:30:00 PM - 3/14/2012 11:30:00 PM


SR 61
April 3, 2012
Rainfall (0.820 in)
Level
Flow (1797.75 cf)
Sample Event
in
0.15
0.10
0.05
0.00
in
4
3
2
1
0
cfs
0.4
0.3
0.2
0.1
0.0
SU
10
5
0
3PM
4PM
5PM
6PM
3 Tue Apr 2012
4/3/2012 2:00:00 PM - 4/3/2012 6:00:00 PM

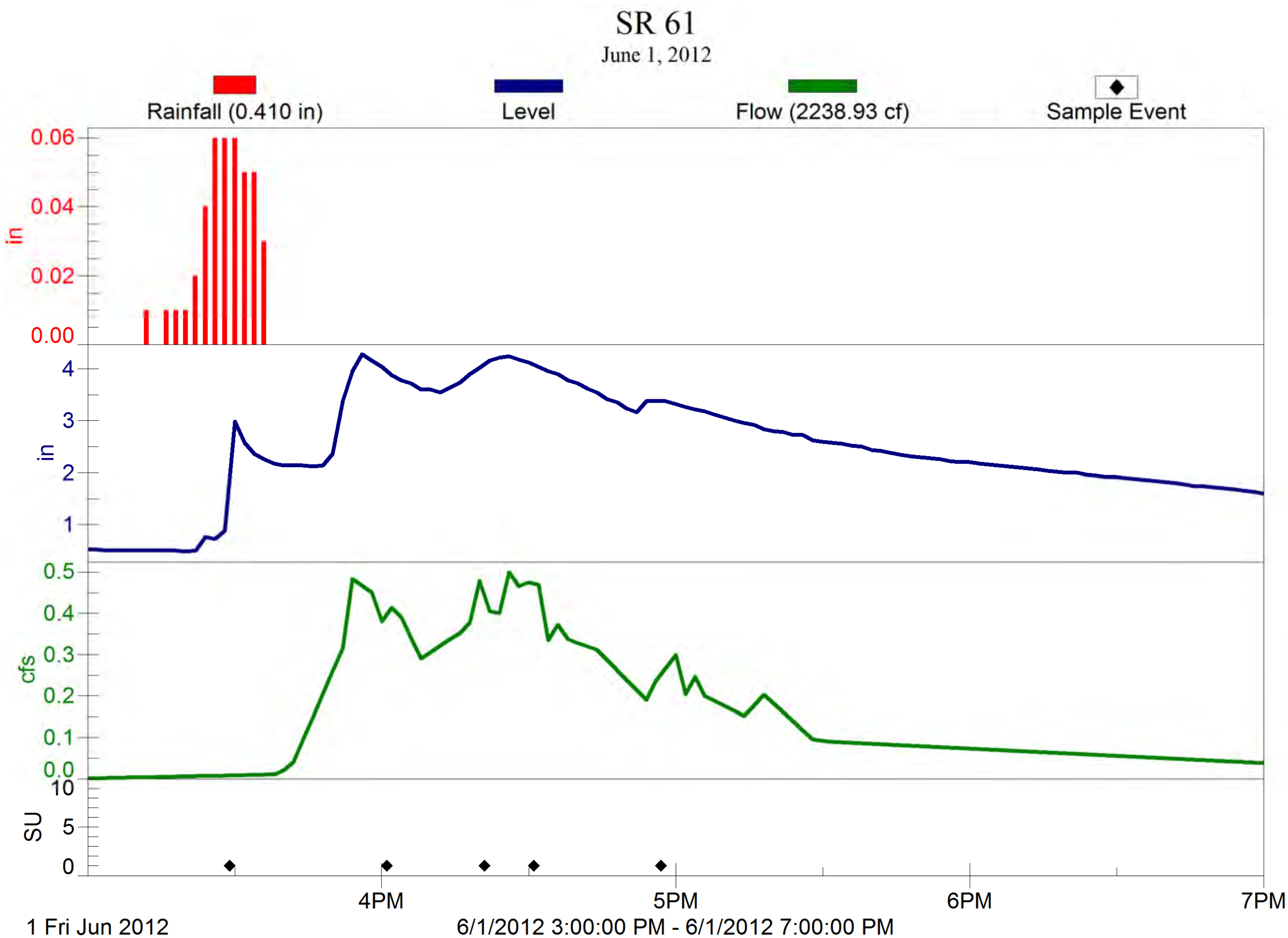


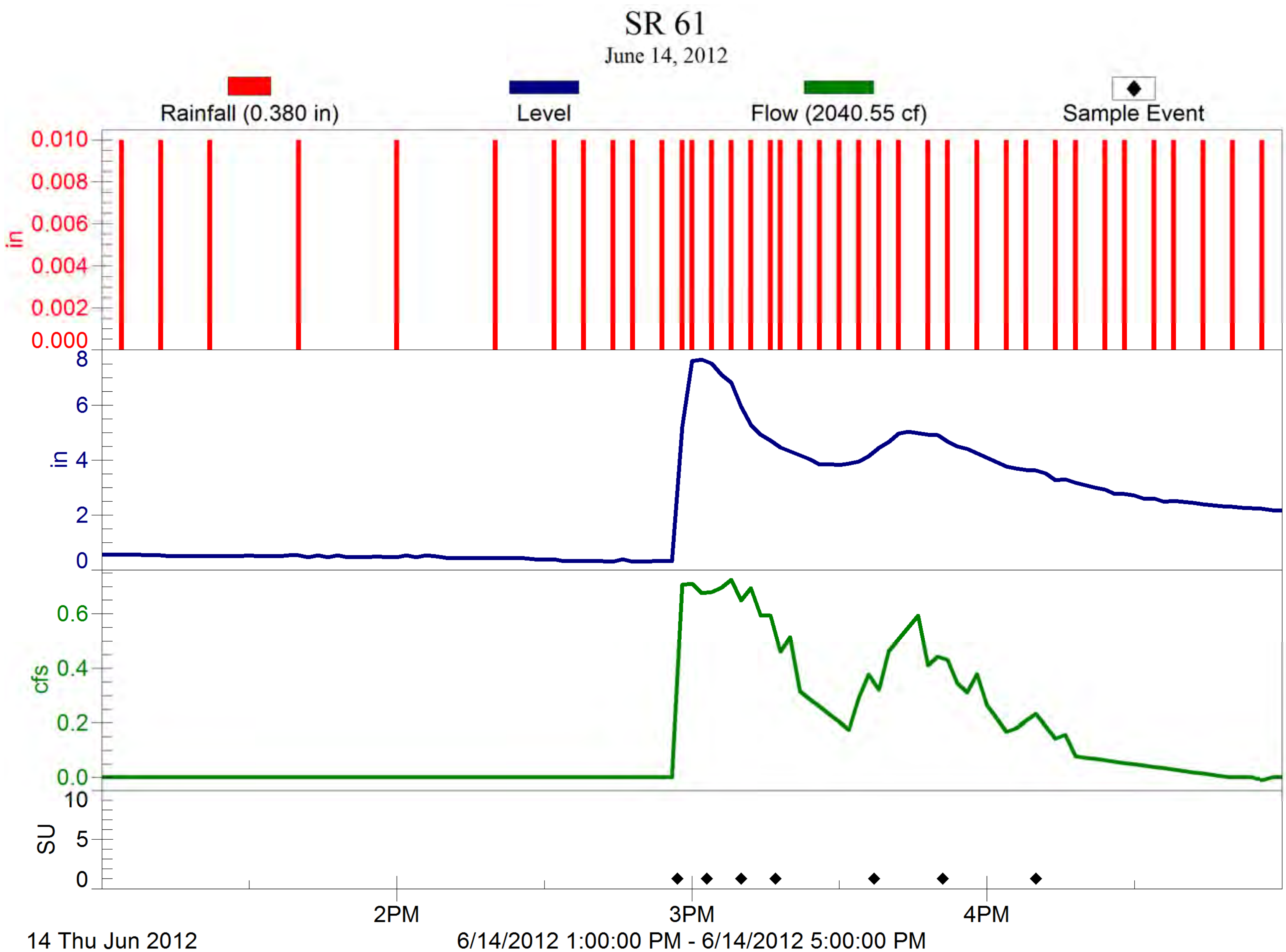
SR 61
May 13, 2012
Rainfall (0.790 in)
Level
Flow (1403.53 cf)
Sample Event
0.05
0.04
0.03
0.02
0.01
0.00
in
4
3
2
1
0
in
0.4
0.2
0.0
cfs
10
5
0
SU
3PM
6PM
13 Sun May 2012
5/13/2012 12:00:00 PM - 5/13/2012 8:00:00 PM


SR 61
May 14, 2012
Rainfall (0.720 in)
Level
Flow (5356.67 cf)
Sample Event
0.10
0.05
0.00
in
8
6
4
2
0
in
0.8
0.6
0.4
0.2
0.0
cfs
10
5
0
SU
12PM
3PM
6PM
14 Mon May 2012
5/14/2012 10:00:00 AM - 5/14/2012 6:00:00 PM



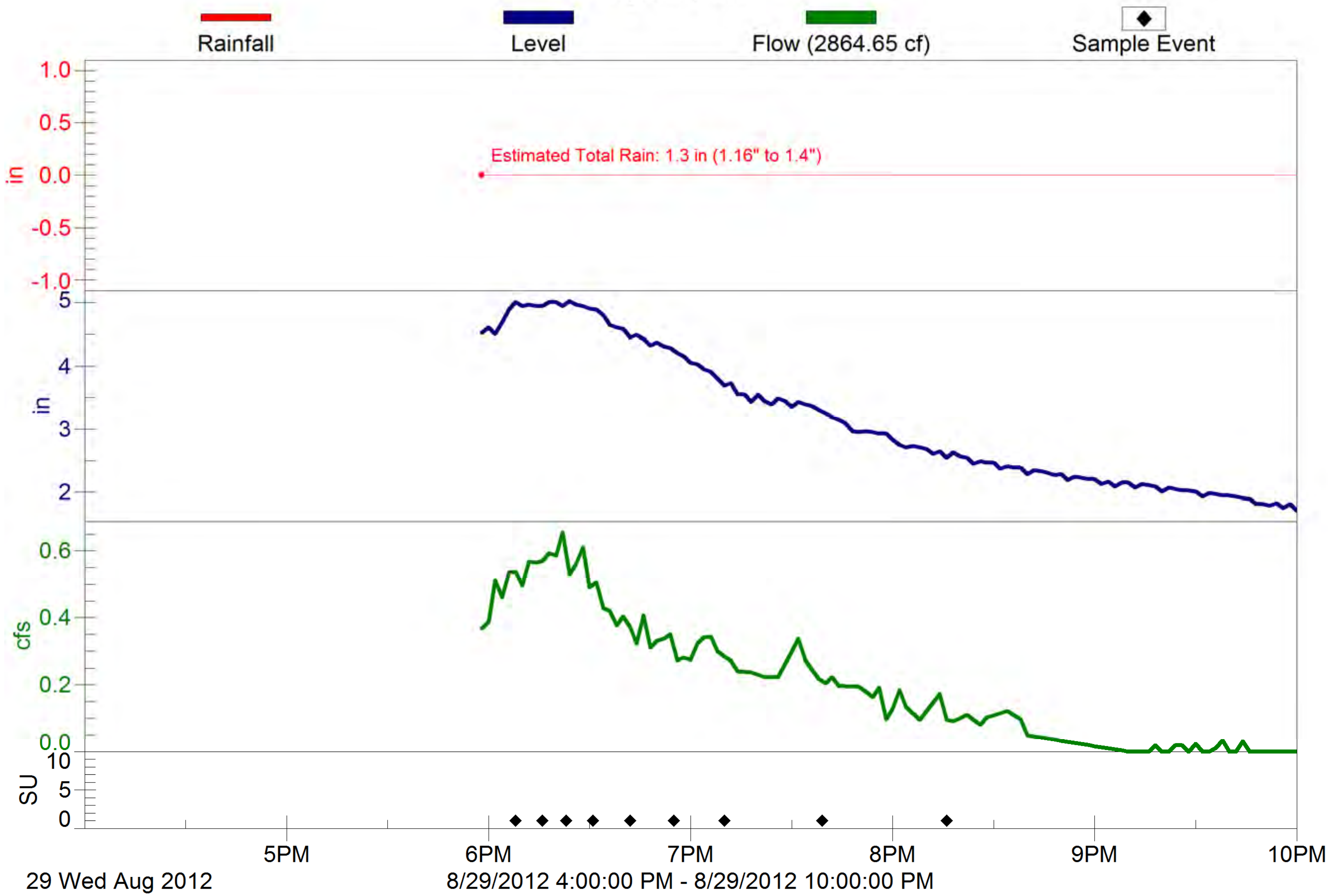
SR 61
May 31, 2012
Rainfall (1.920 in)
Level
Flow (6088.98 cf)
Sample Event
0.15
0.10
0.05
0.00
in
15
10
5
0
in
1.0
0.5
0.0
cfs
10
5
0
SU
3PM
4PM
5PM
6PM
31 Thu May 2012
5/31/2012 2:30:00 PM - 5/31/2012 6:30:00 PM

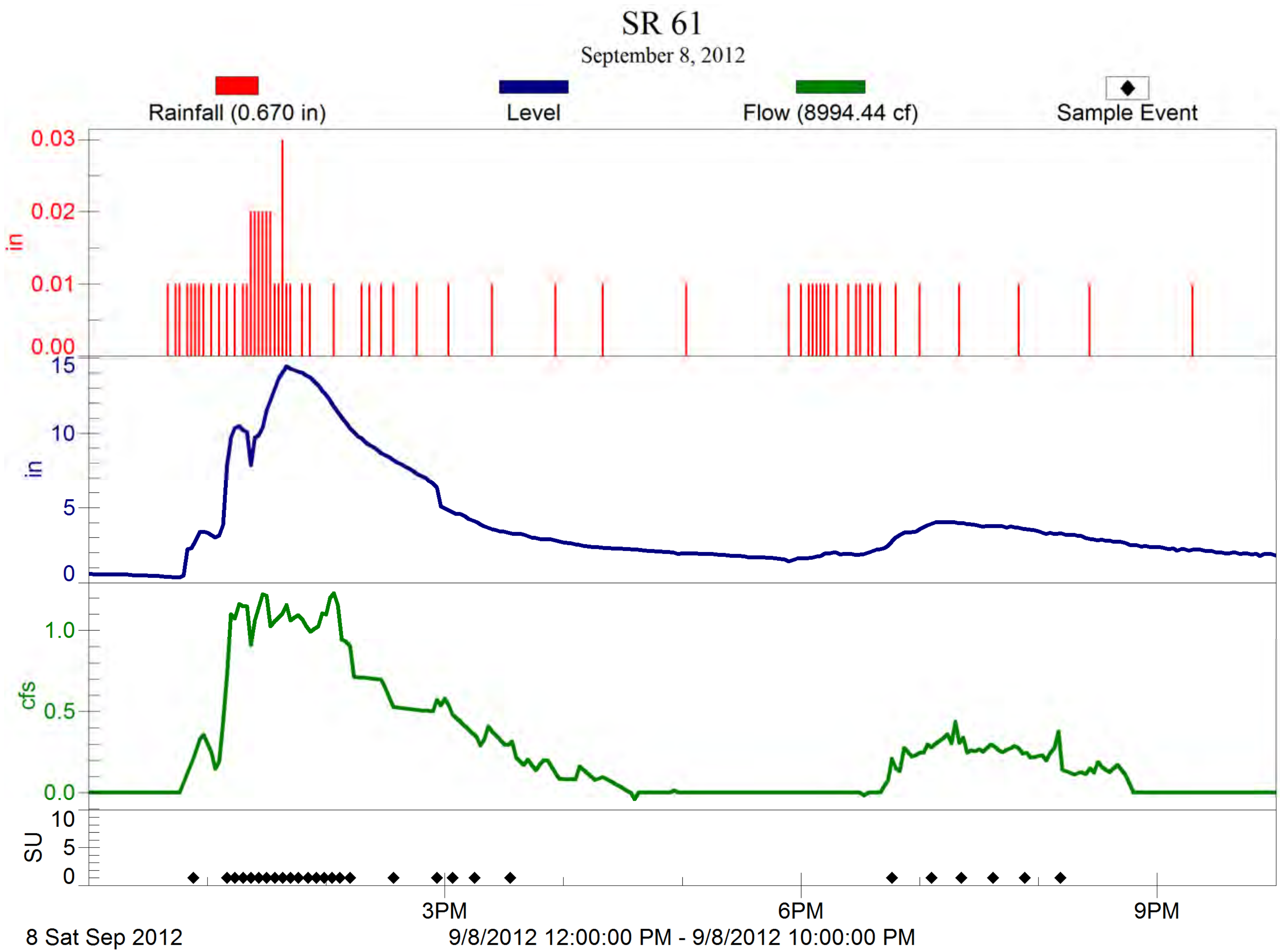

SR 61
June 1, 2012
Rainfall (0.410 in)
Level
Flow (2238.93 cf)
Sample Event
0.06
0.04
0.02
0.00
in
4
3
2
1
in
0.5
0.4
0.3
0.2
0.1
0.0
cfs
10
5
0
SU
4PM
5PM
6PM
7PM
1 Fri Jun 2012
6/1/2012 3:00:00 PM - 6/1/2012 7:00:00 PM


SR 61
June 14, 2012
Rainfall (0.380 in)
Level
Flow (2040.55 cf)
Sample Event
0.010
0.008
0.006
0.004
0.002
0.000
in
8
6
4
2
0
in
0.6
0.4
0.2
0.0
cfs
10
5
0
SU
2PM
3PM
4PM
14 Thu Jun 2012
6/14/2012 1:00:00 PM - 6/14/2012 5:00:00 PM

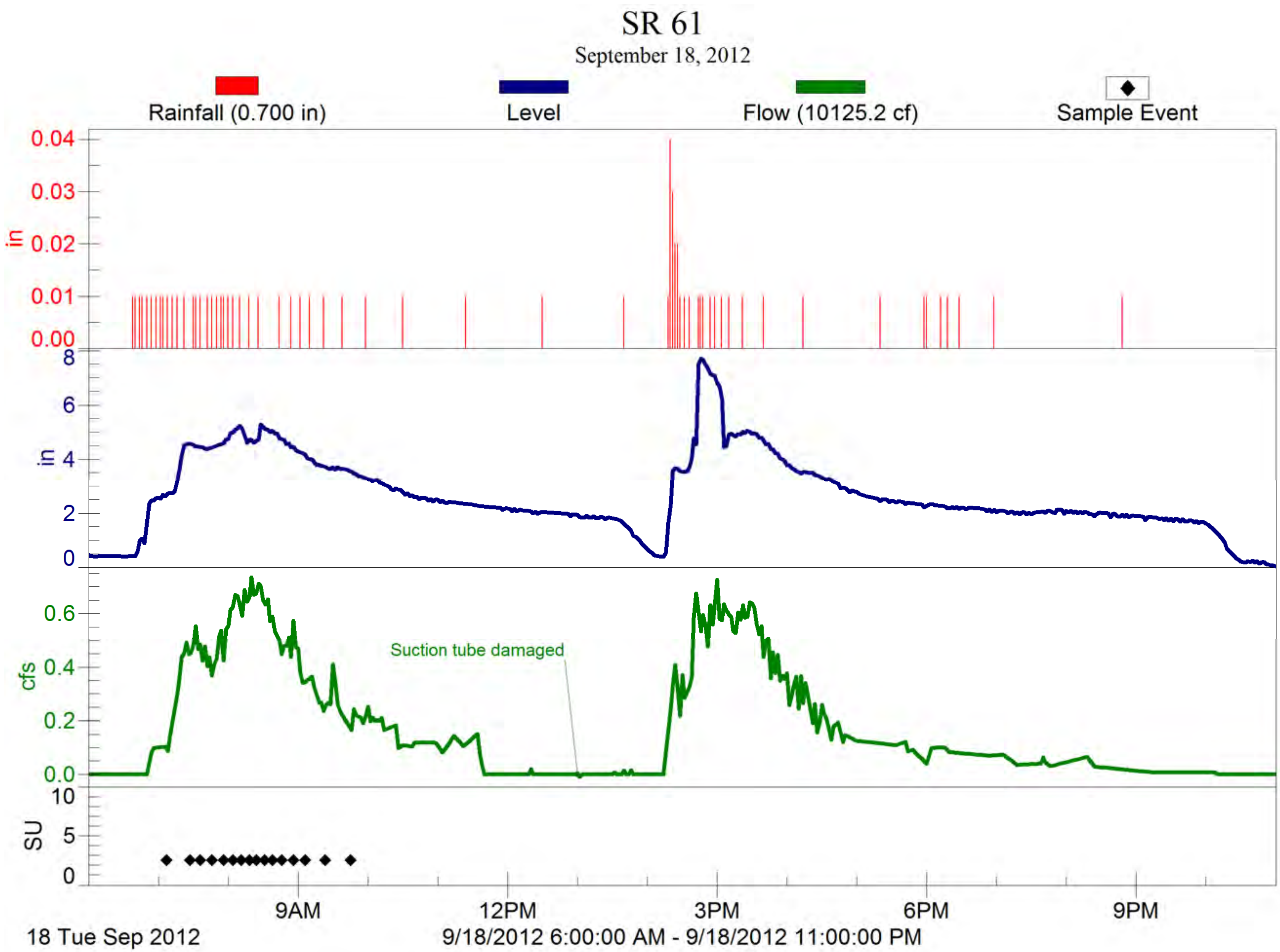
SR 61

August 29, 2012



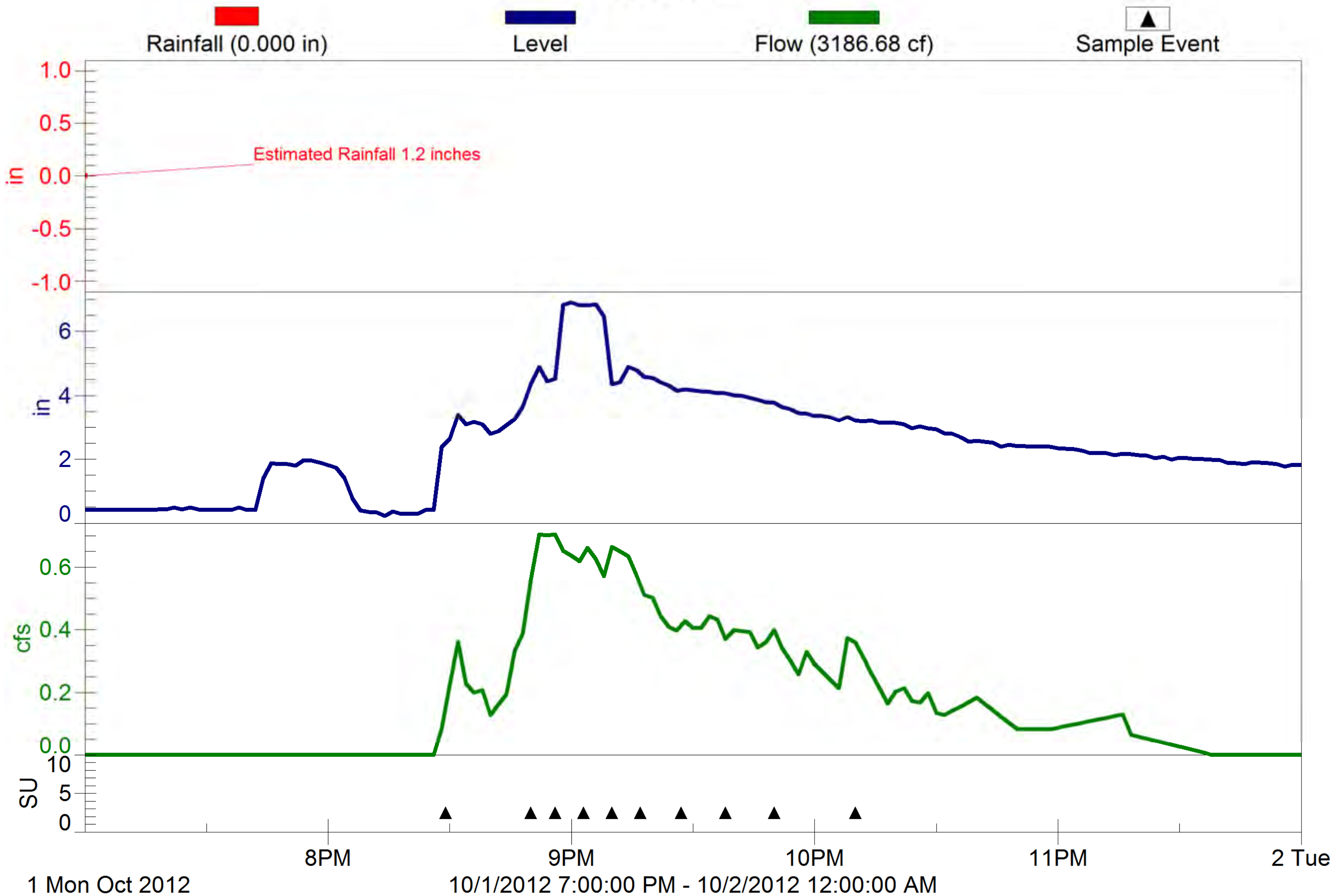


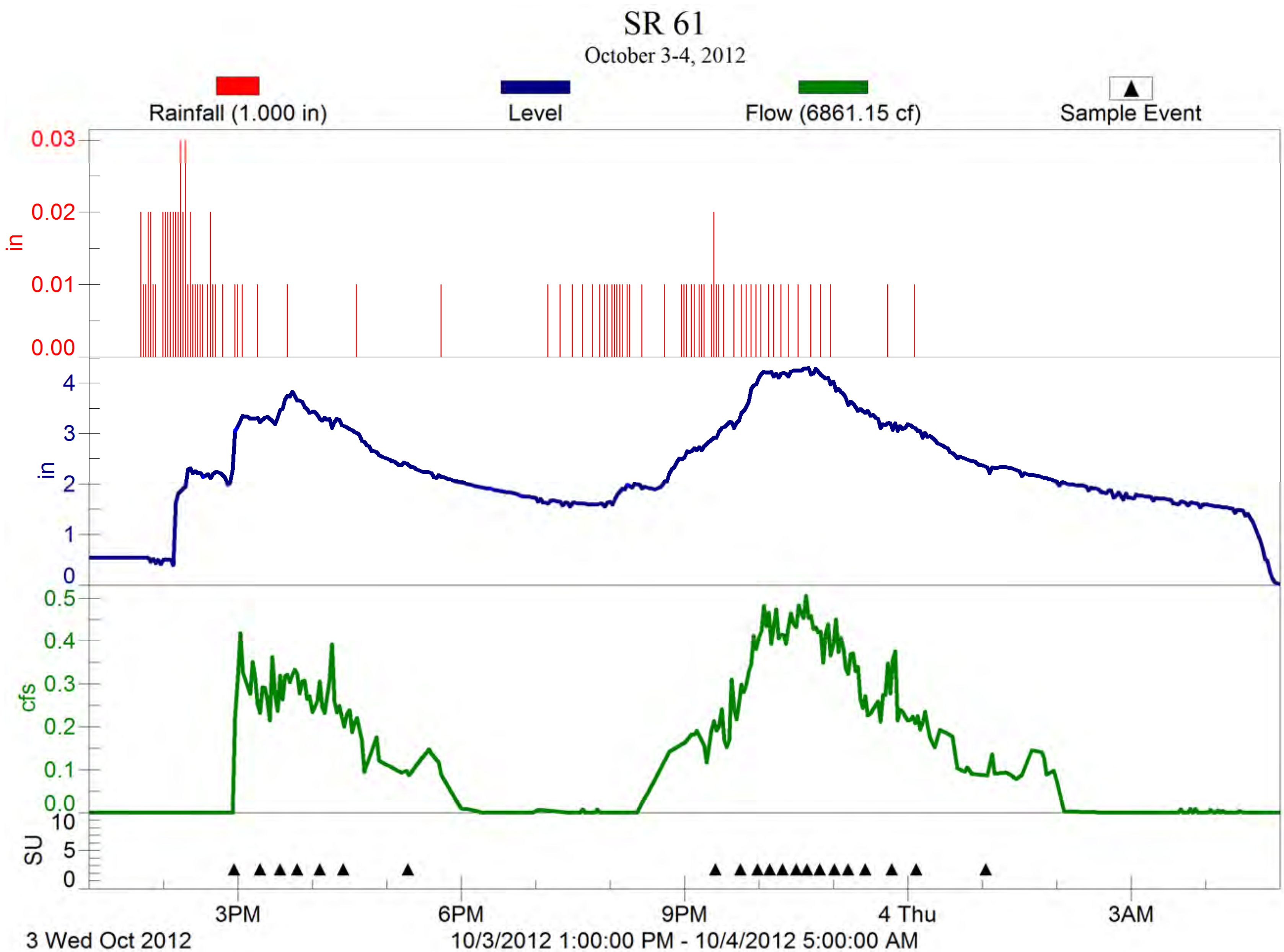
SR 61
September 8, 2012
Rainfall (0.670 in)
Level
Flow (8994.44 cf)
Sample Event
0.03
0.02
0.01
0.00
in
15
10
5
0
in
1.0
0.5
0.0
cfs
10
5
0
SU
3PM
6PM
9PM
8 Sat Sep 2012
9/8/2012 12:00:00 PM - 9/8/2012 10:00:00 PM

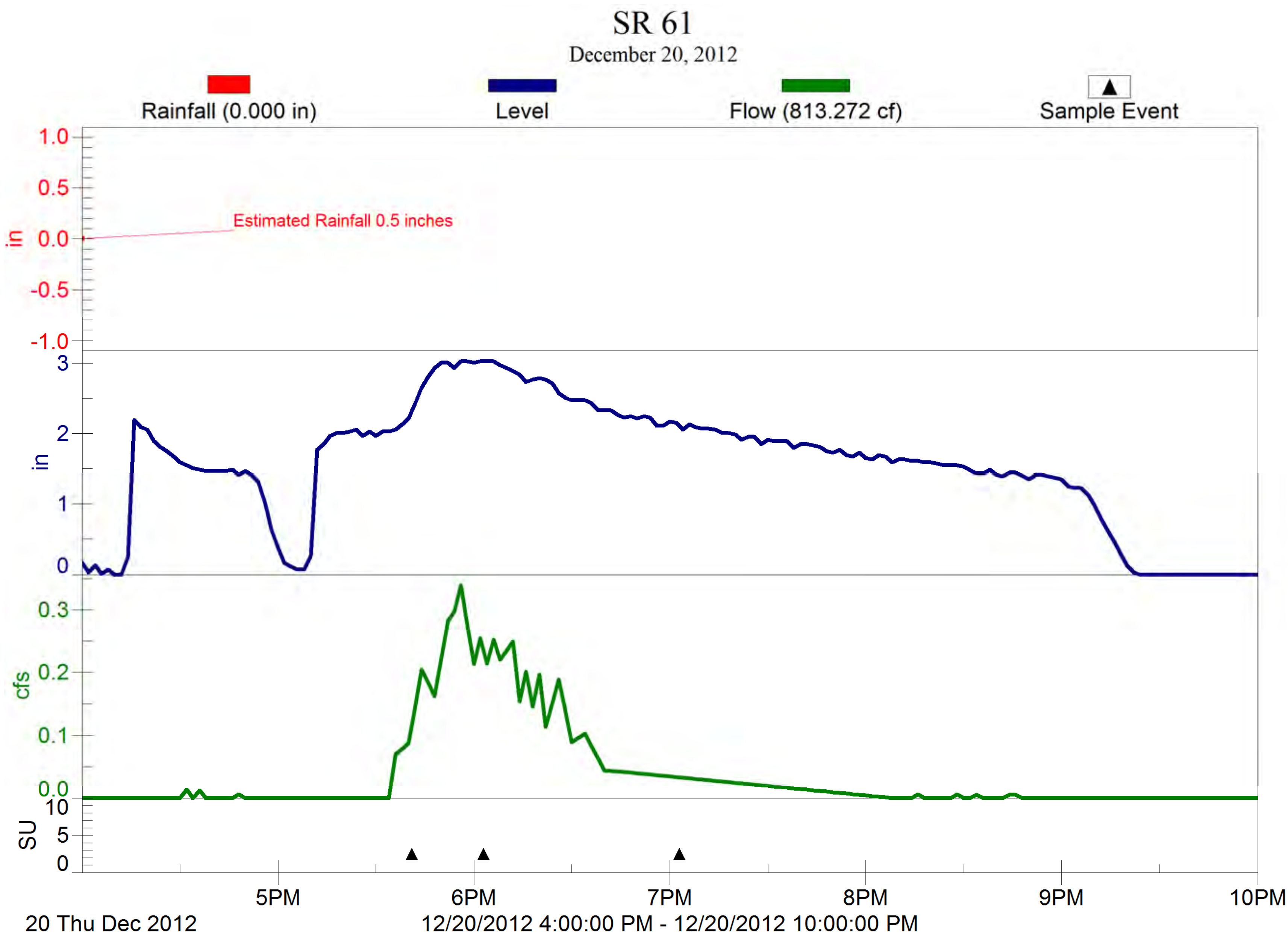

SR 61
September 18, 2012
Rainfall (0.700 in)
Level
Flow (10125.2 cf)
Sample Event
in
0.04
0.03
0.02
0.01
0.00
in
8
6
4
2
0
cfs
0.6
0.4
0.2
0.0
Suction tube damaged
SU
10
5
0
9AM
12PM
3PM
6PM
9PM
18 Tue Sep 2012
9/18/2012 6:00:00 AM - 9/18/2012 11:00:00 PM

SR 61

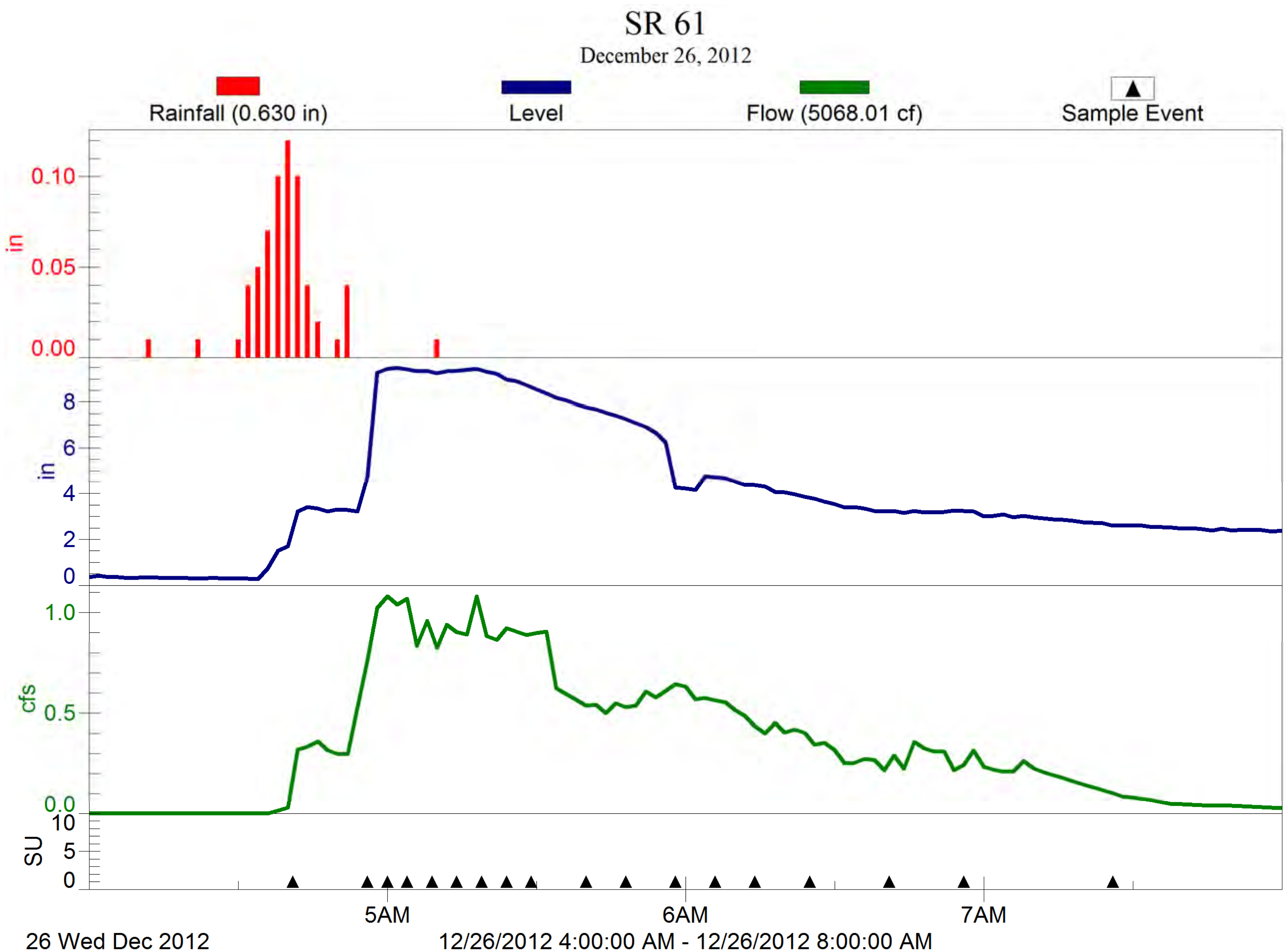
October 1, 2012

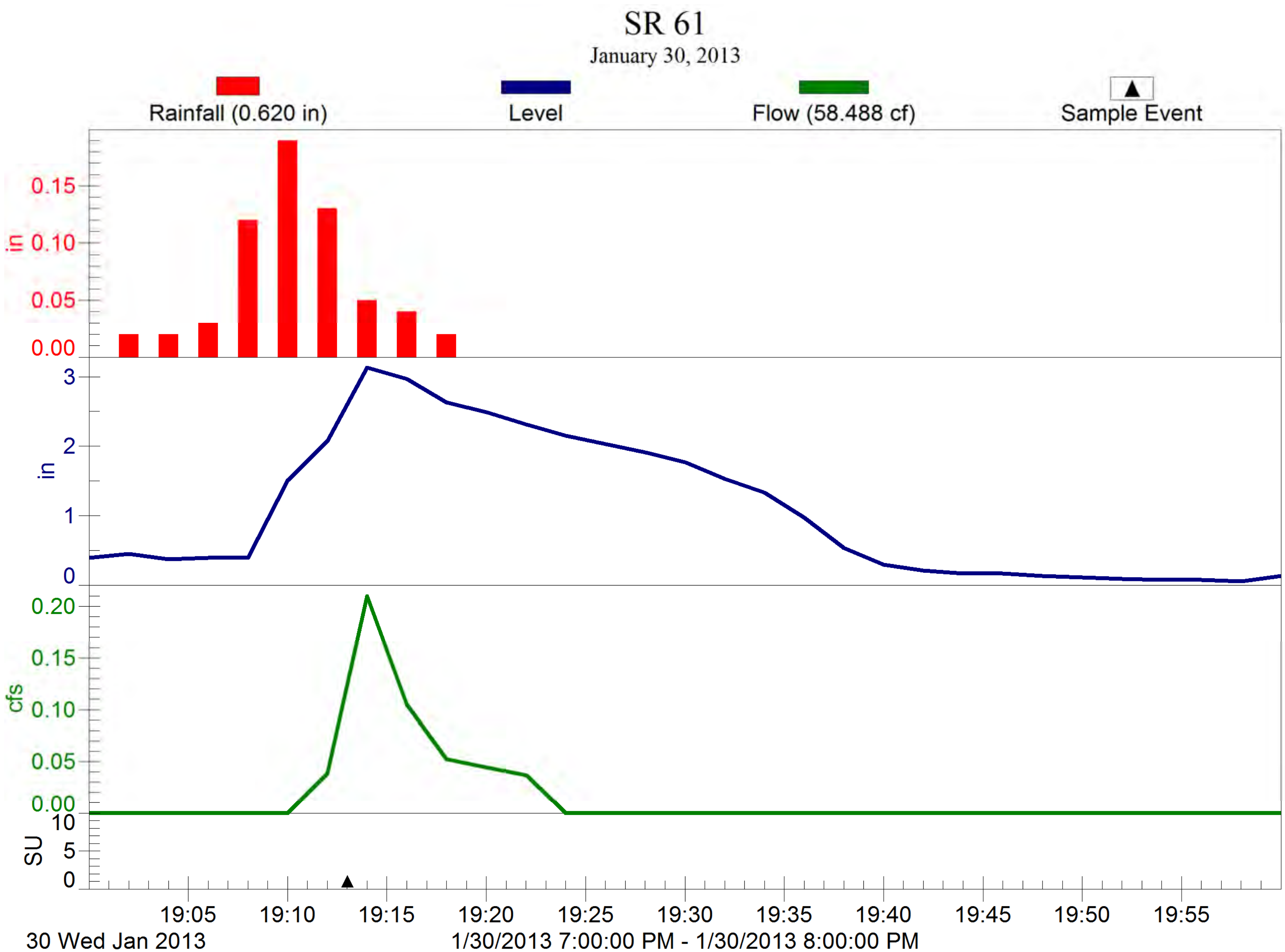



SR 61
October 3-4, 2012
Rainfall (1.000 in)
Level
Flow (6861.15 cf)
Sample Event
0.03
0.02
0.01
0.00
in
4
3
2
1
0
in
0.5
0.4
0.3
0.2
0.1
0.0
cfs
10
5
0
SU
3PM
6PM
9PM
4 Thu
3AM
3 Wed Oct 2012
10/3/2012 1:00:00 PM - 10/4/2012 5:00:00 AM



SR 61
December 20, 2012
Rainfall (0.000 in)
Level
Flow (813.272 cf)
Sample Event
Estimated Rainfall 0.5 inches
in
1.0
0.5
0.0
-0.5
-1.0
in
3
2
1
0
cfs
0.3
0.2
0.1
0.0
SU
10
5
0
5PM
6PM
7PM
8PM
9PM
10PM
20 Thu Dec 2012
12/20/2012 4:00:00 PM - 12/20/2012 10:00:00 PM

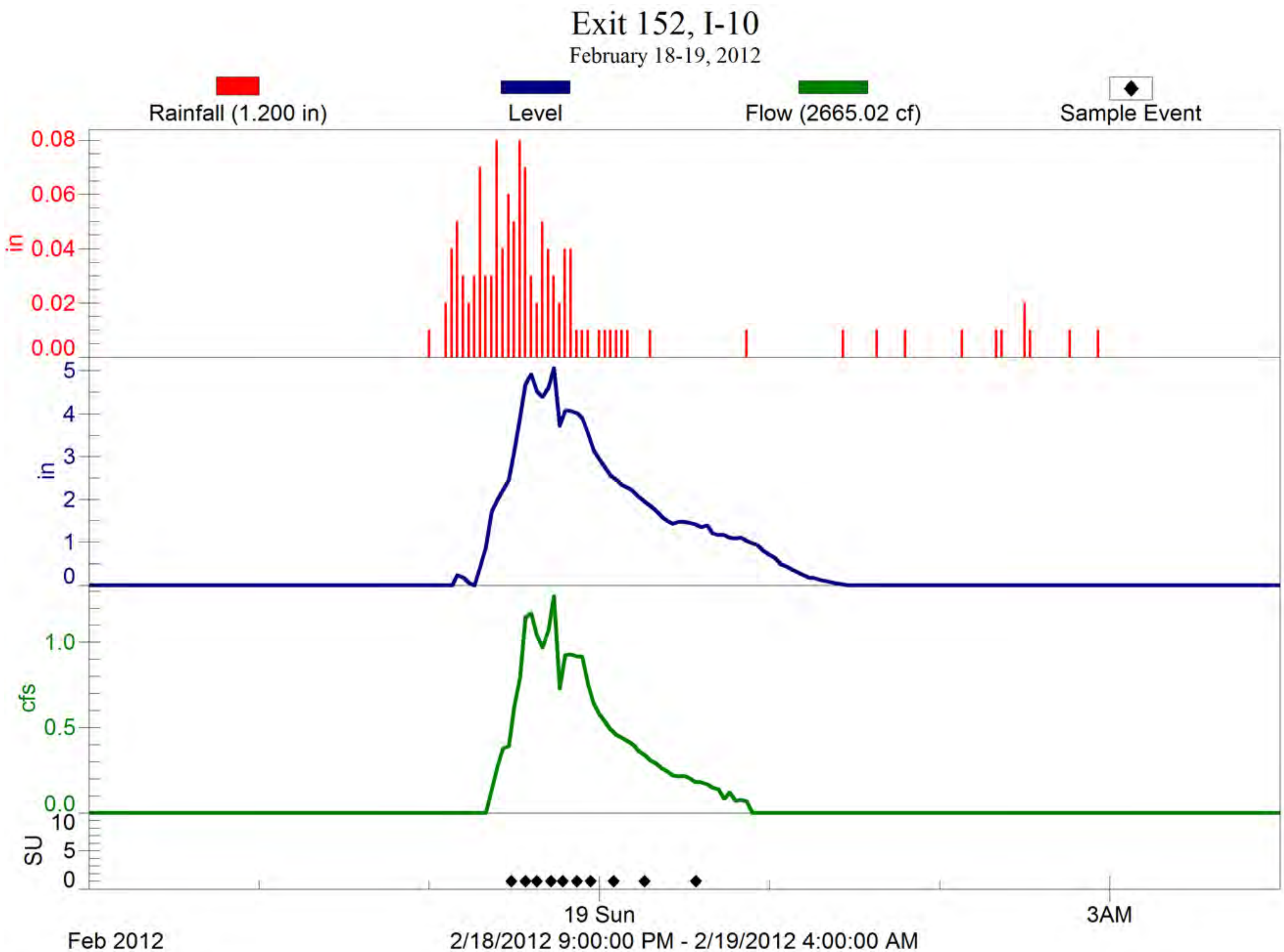

SR 61
December 26, 2012
Rainfall (0.630 in)
Level
Flow (5068.01 cf)
Sample Event
in
0.10
0.05
0.00
in
8
6
4
2
0
cfs
1.0
0.5
0.0
SU
10
5
0
5AM
6AM
7AM
26 Wed Dec 2012
12/26/2012 4:00:00 AM - 12/26/2012 8:00:00 AM


SR 61
January 30, 2013
Rainfall (0.620 in)
Level
Flow (58.488 cf)
Sample Event
in
0.15
0.10
0.05
0.00
in
3
2
1
0
cfs
0.20
0.15
0.10
0.05
0.00
SU
10
5
0
19:05
19:10
19:15
19:20
19:25
19:30
19:35
19:40
19:45
19:50
19:55
30 Wed Jan 2013
1/30/2013 7:00:00 PM - 1/30/2013 8:00:00 PM

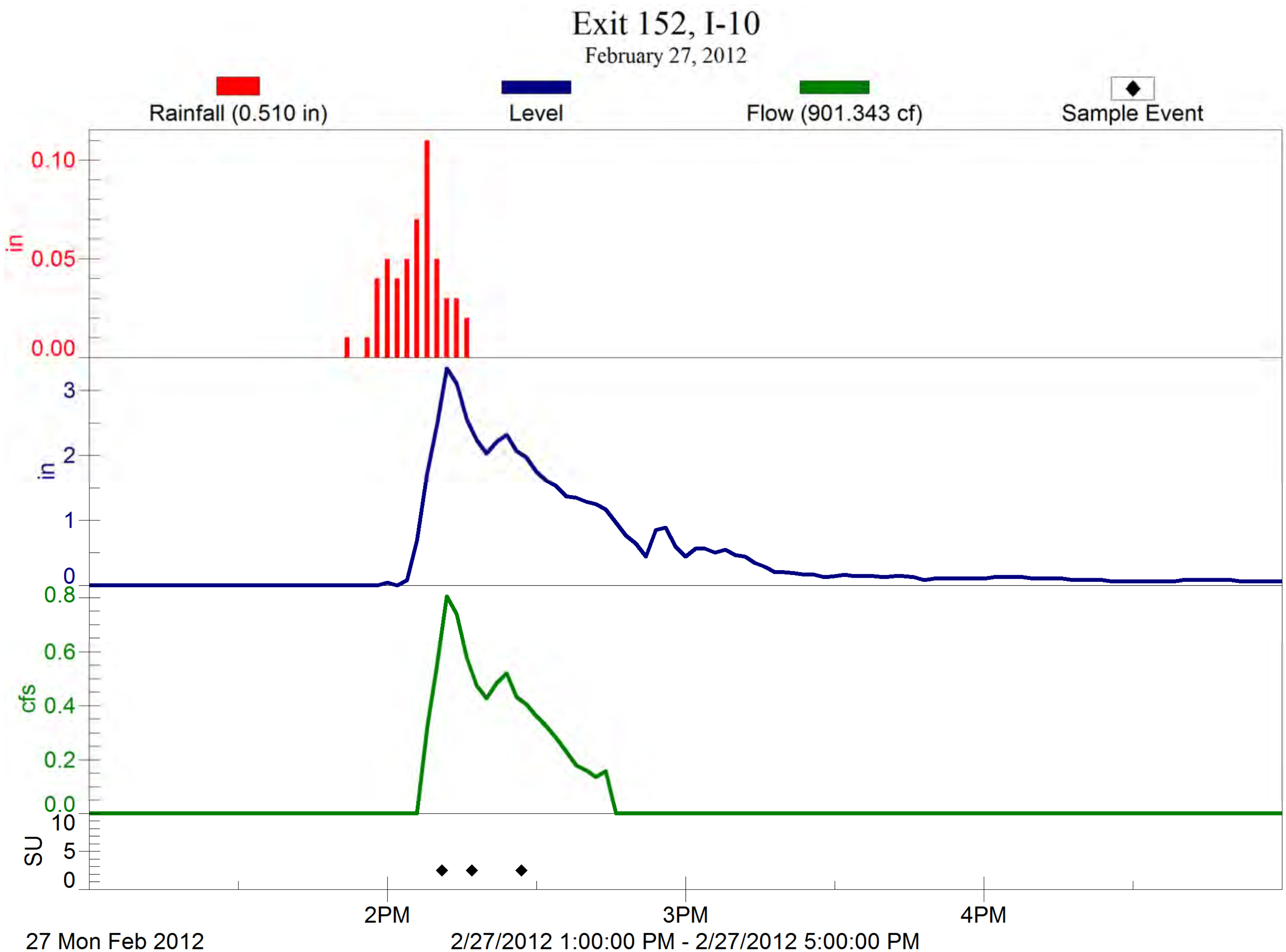
Appendix C

Storm Event Data for
SR 8 (Exit 152, 1-10) Sampling Location

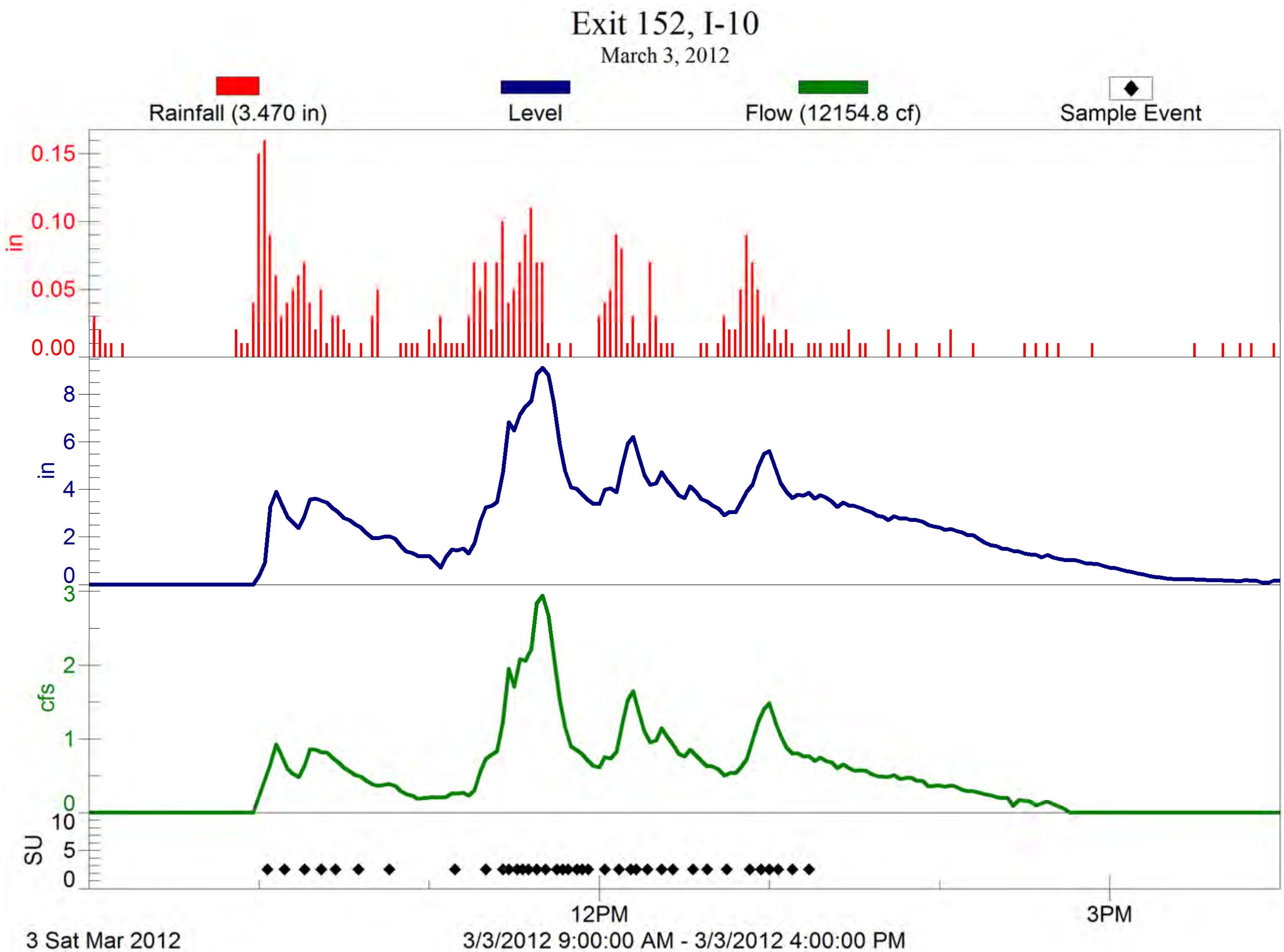
(Laboratory results included on the
accompanying CD)



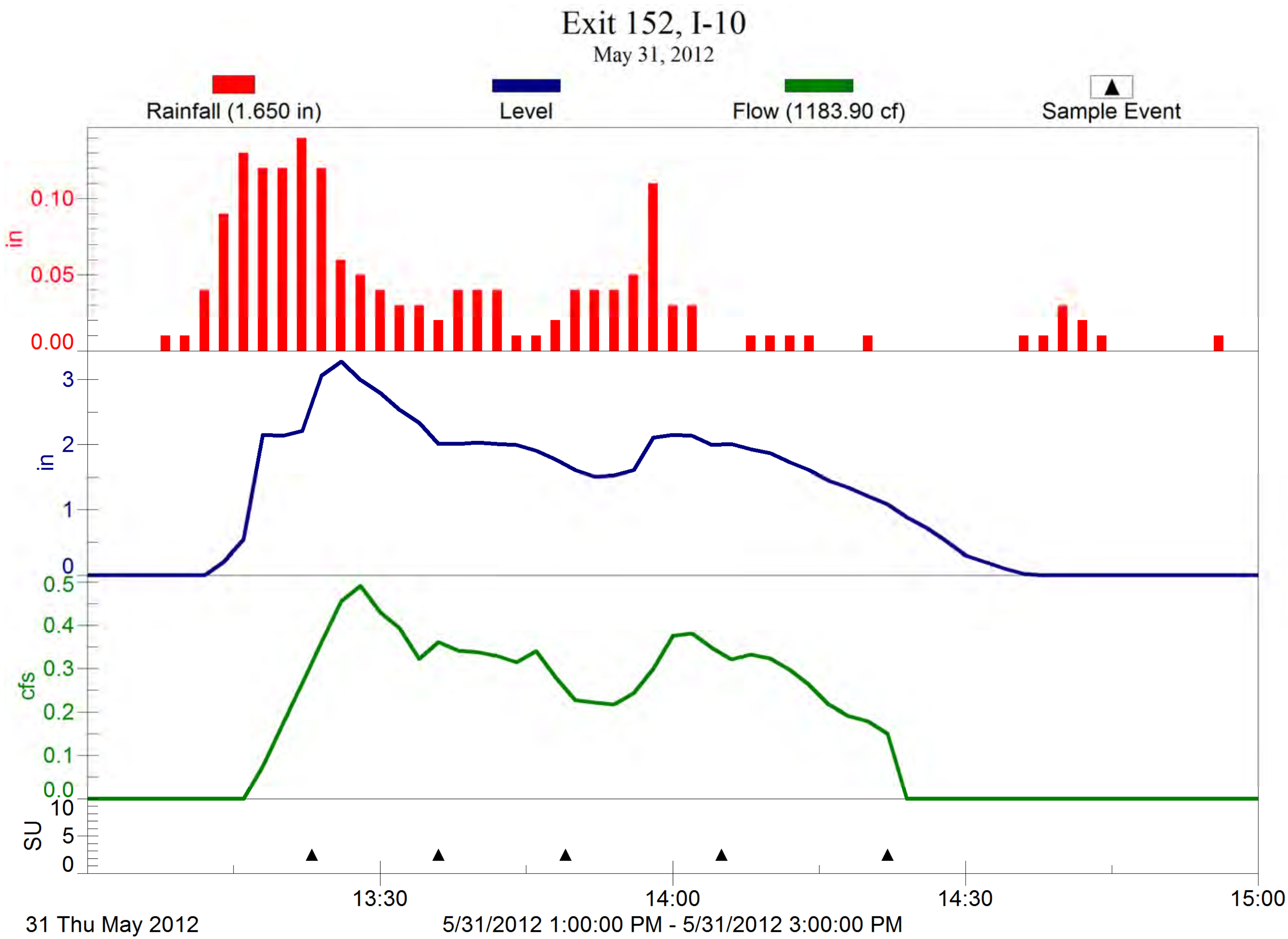
Exit 152, I-10
February 18-19, 2012
Rainfall (1.200 in)
Level
Flow (2665.02 cf)
Sample Event
0.08
0.06
0.04
0.02
0.00
in
5
4
3
2
1
0
in
1.0
0.5
0.0
cfs
10
5
0
SU
19 Sun
3AM
Feb 2012
2/18/2012 9:00:00 PM - 2/19/2012 4:00:00 AM



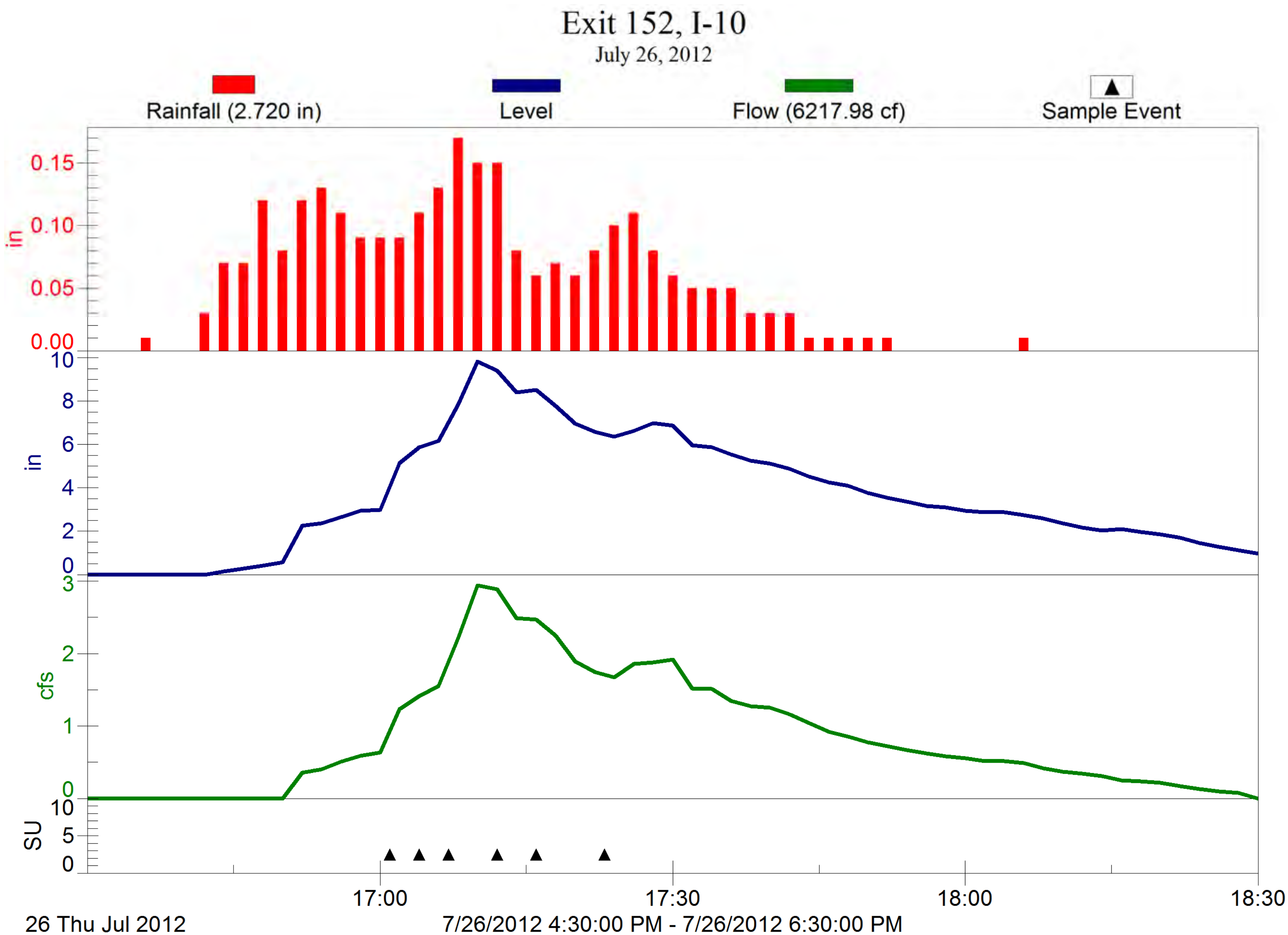
Exit 152, I-10
February 27, 2012
Rainfall (0.510 in)
Level
Flow (901.343 cf)
Sample Event
in
0.10
0.05
0.00
in
3
2
1
0
cfs
0.8
0.6
0.4
0.2
0.0
SU
10
5
0
2PM
3PM
4PM
27 Mon Feb 2012
2/27/2012 1:00:00 PM - 2/27/2012 5:00:00 PM



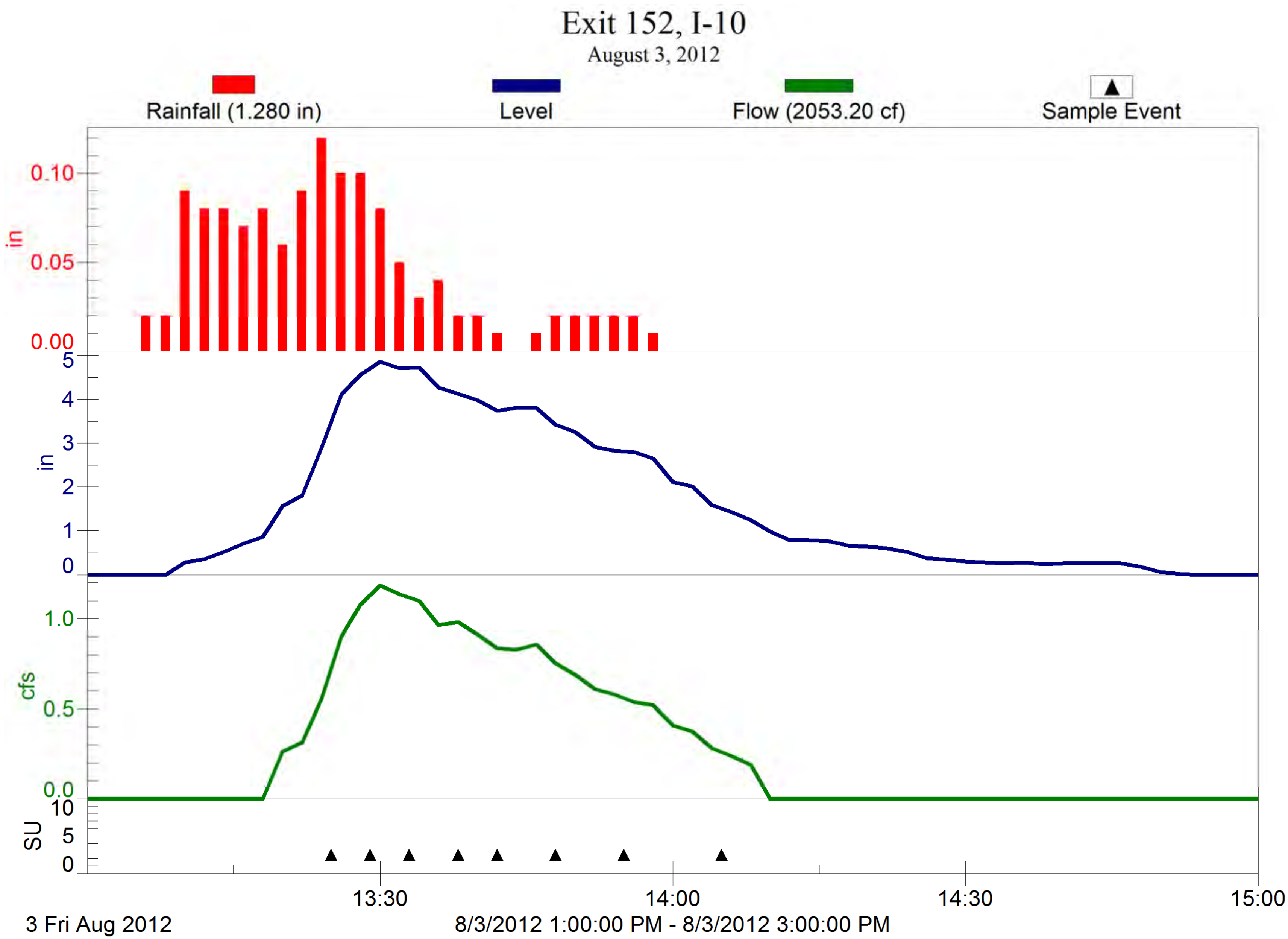
Exit 152, I-10
March 3, 2012
Rainfall (3.470 in)
Level
Flow (12154.8 cf)
Sample Event
in
0.15
0.10
0.05
0.00
in
8
6
4
2
0
cfs
3
2
1
0
SU
10
5
0
12PM
3PM
3 Sat Mar 2012
3/3/2012 9:00:00 AM - 3/3/2012 4:00:00 PM

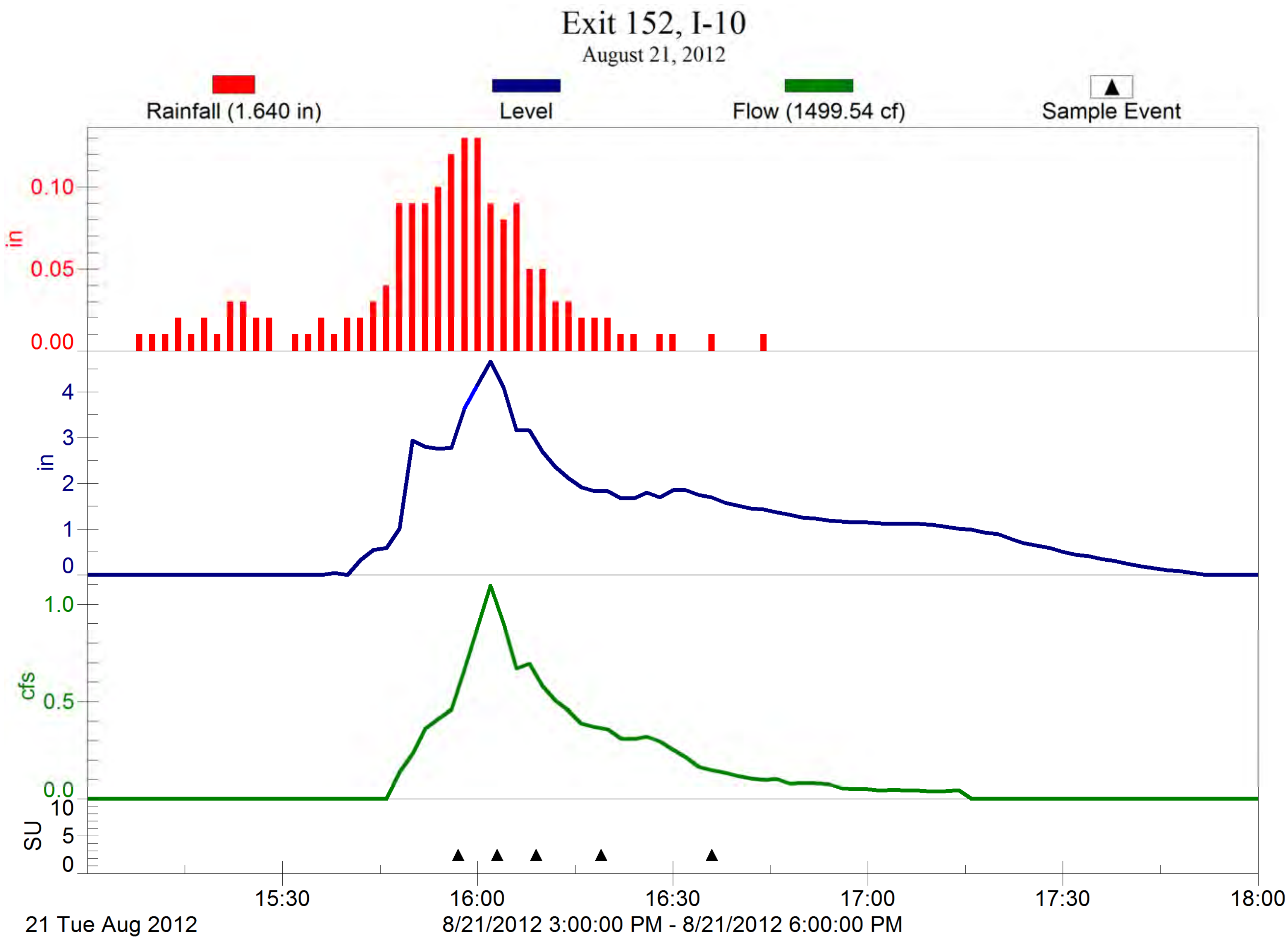


Exit 152, I-10
May 31, 2012
Rainfall (1.650 in)
Level
Flow (1183.90 cf)
Sample Event
in
0.10
0.05
0.00
in
3
2
1
0
cfs
0.5
0.4
0.3
0.2
0.1
0.0
SU
10
5
0
13:30
14:00
14:30
15:00
31 Thu May 2012
5/31/2012 1:00:00 PM - 5/31/2012 3:00:00 PM

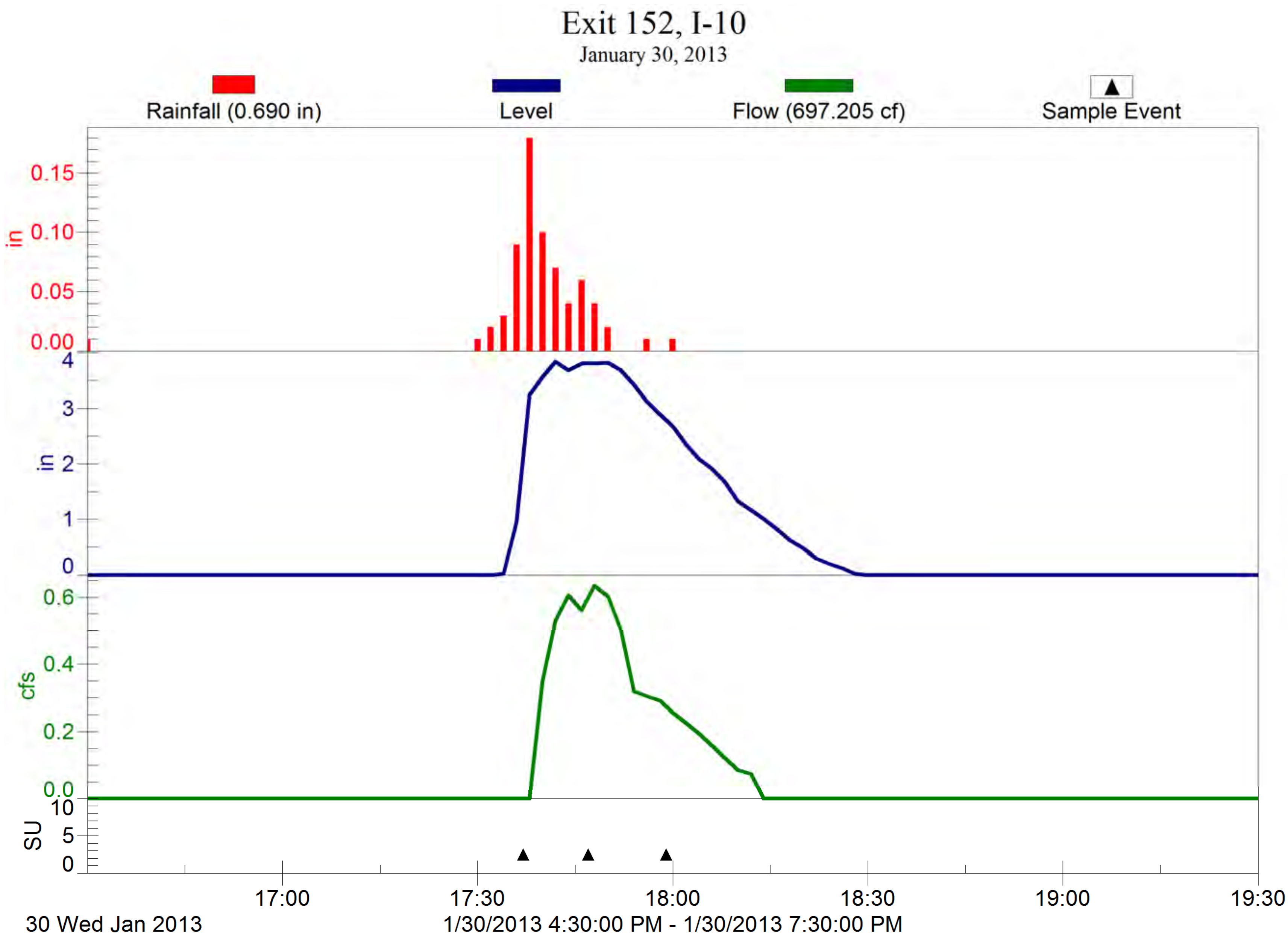


Exit 152, I-10
July 26, 2012
Rainfall (2.720 in)
Level
Flow (6217.98 cf)
Sample Event
in
0.15
0.10
0.05
0.00
10
8
6
4
2
0
in
3
2
1
0
cfs
10
5
0
SU
17:00
17:30
18:00
18:30
26 Thu Jul 2012
7/26/2012 4:30:00 PM - 7/26/2012 6:30:00 PM


Exit 152, I-10
August 3, 2012
Rainfall (1.280 in)
Level
Flow (2053.20 cf)
Sample Event
in
0.10
0.05
0.00
in
5
4
3
2
1
0
cfs
1.0
0.5
0.0
SU
10
5
0
13:30
14:00
14:30
15:00
3 Fri Aug 2012
8/3/2012 1:00:00 PM - 8/3/2012 3:00:00 PM



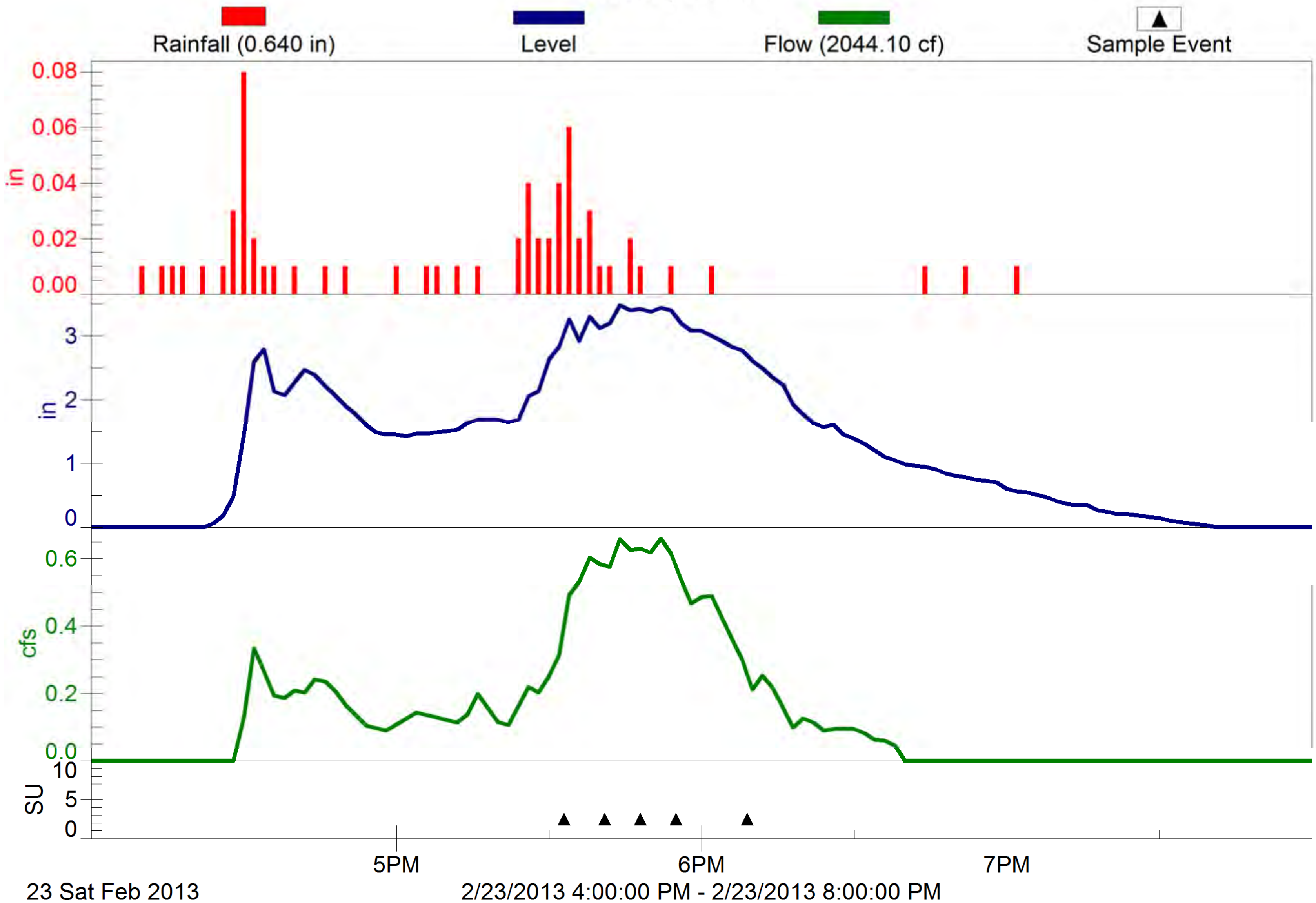
Exit 152, I-10
August 21, 2012
Rainfall (1.640 in)
Level
Flow (1499.54 cf)
Sample Event
in
0.10
0.05
0.00
in
4
3
2
1
0
cfs
1.0
0.5
0.0
SU
10
5
0
15:30
16:00
16:30
17:00
17:30
18:00
21 Tue Aug 2012
8/21/2012 3:00:00 PM - 8/21/2012 6:00:00 PM

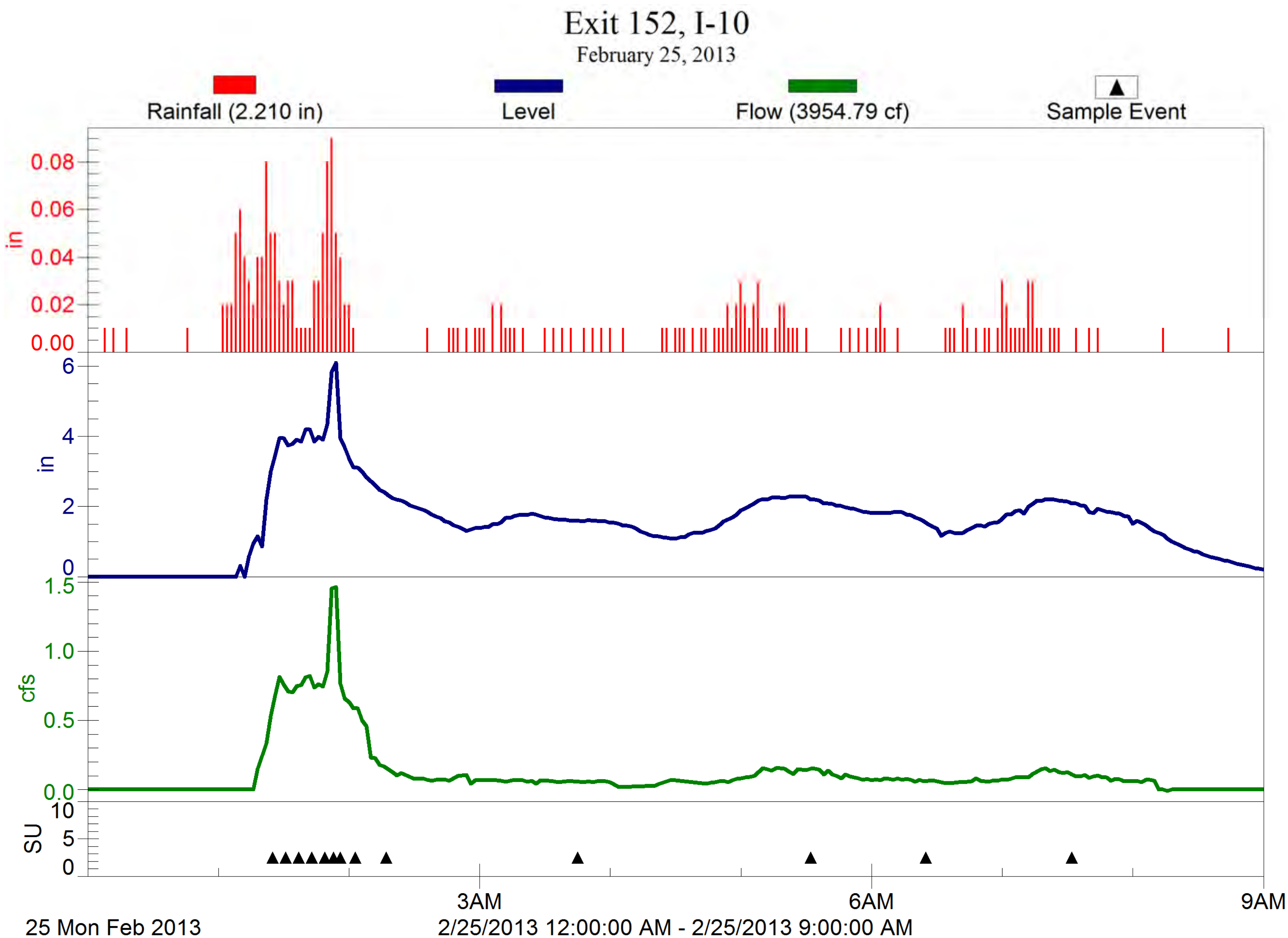


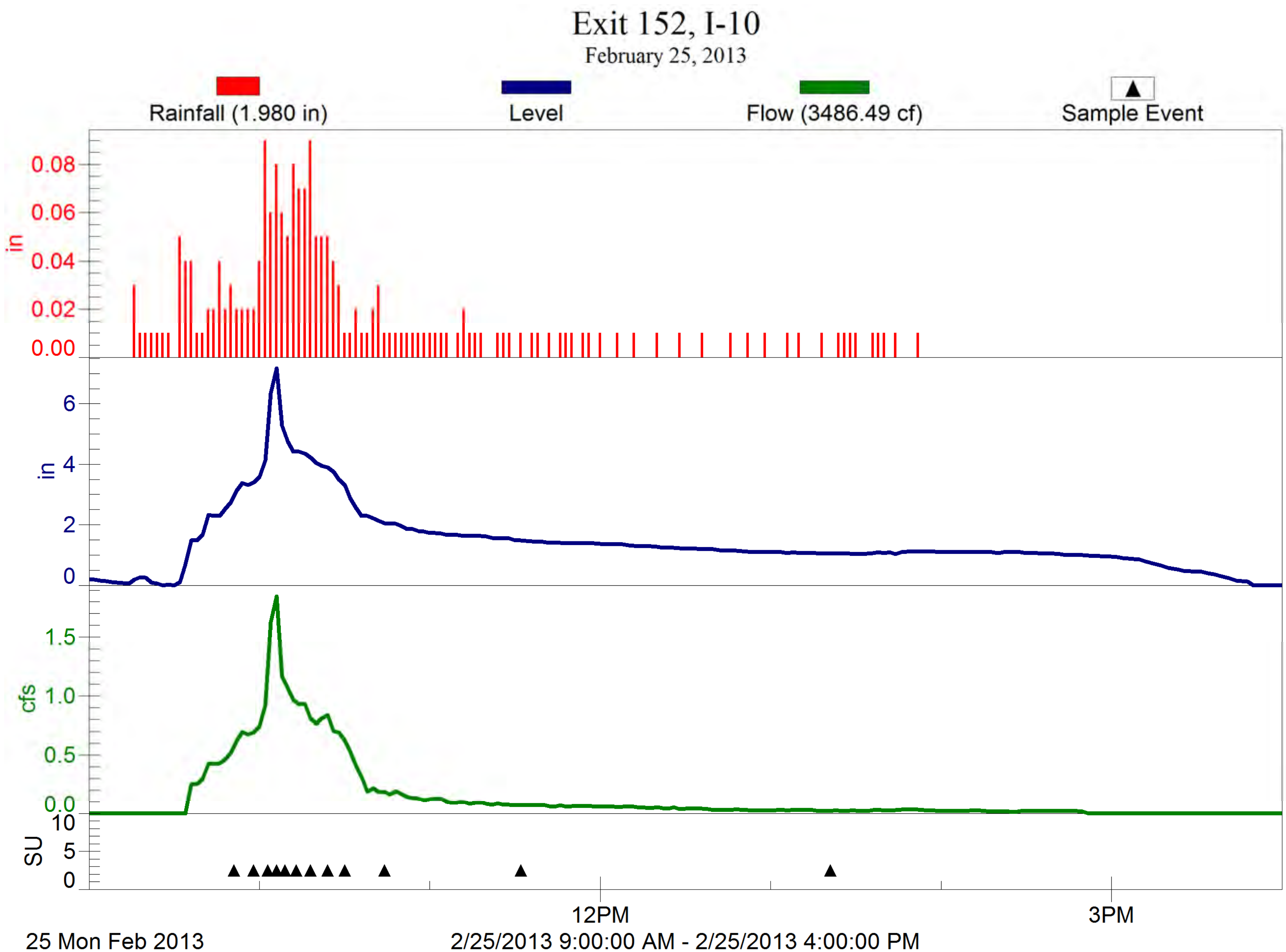
Exit 152, I-10
January 30, 2013
Rainfall (0.690 in)
Level
Flow (697.205 cf)
Sample Event
in
0.15
0.10
0.05
0.00
in
4
3
2
1
0
cfs
0.6
0.4
0.2
0.0
SU
10
5
0
17:00
17:30
18:00
18:30
19:00
19:30
30 Wed Jan 2013
1/30/2013 4:30:00 PM - 1/30/2013 7:30:00 PM

Exit 152, I-10

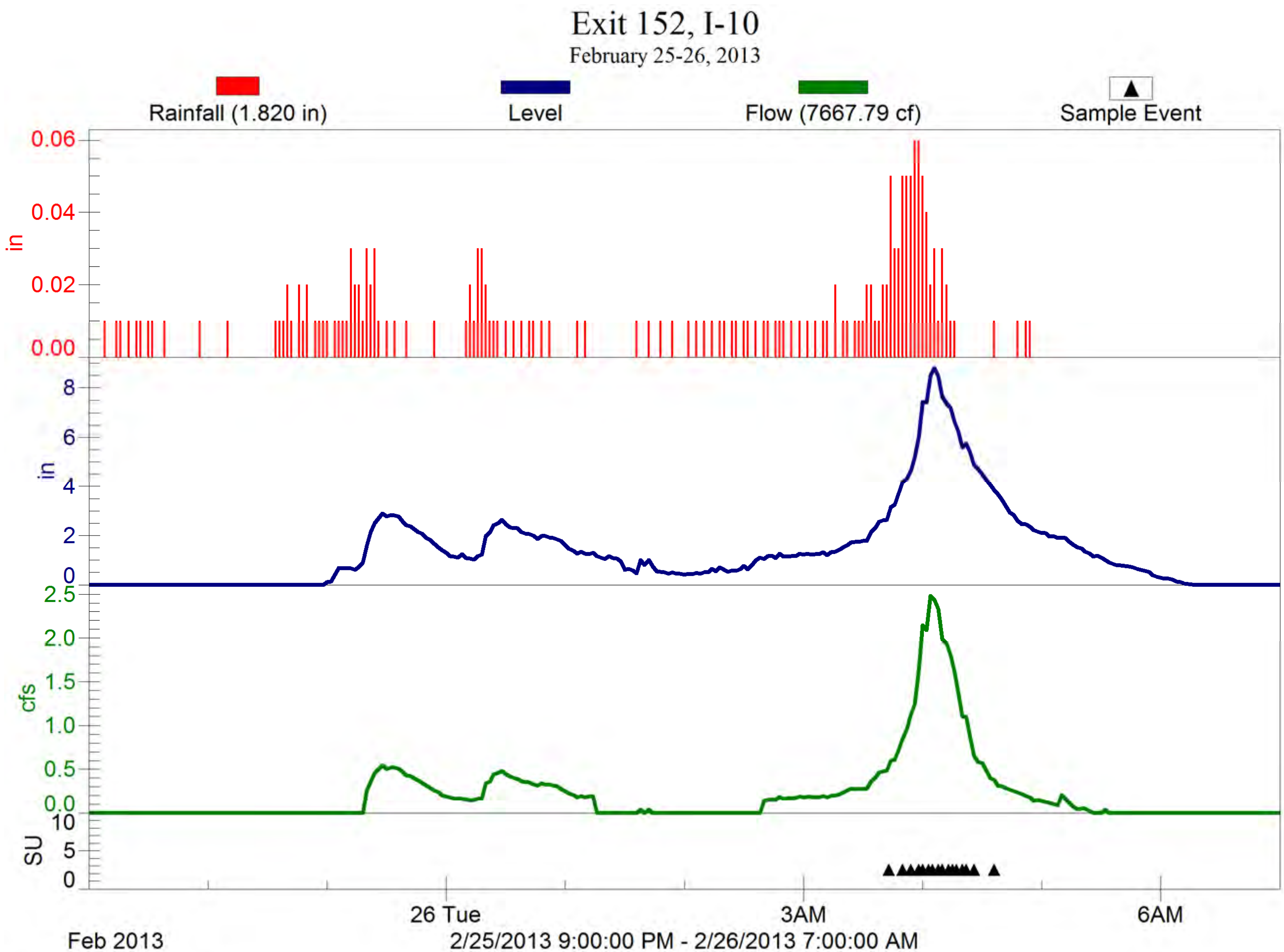
February 23, 2013

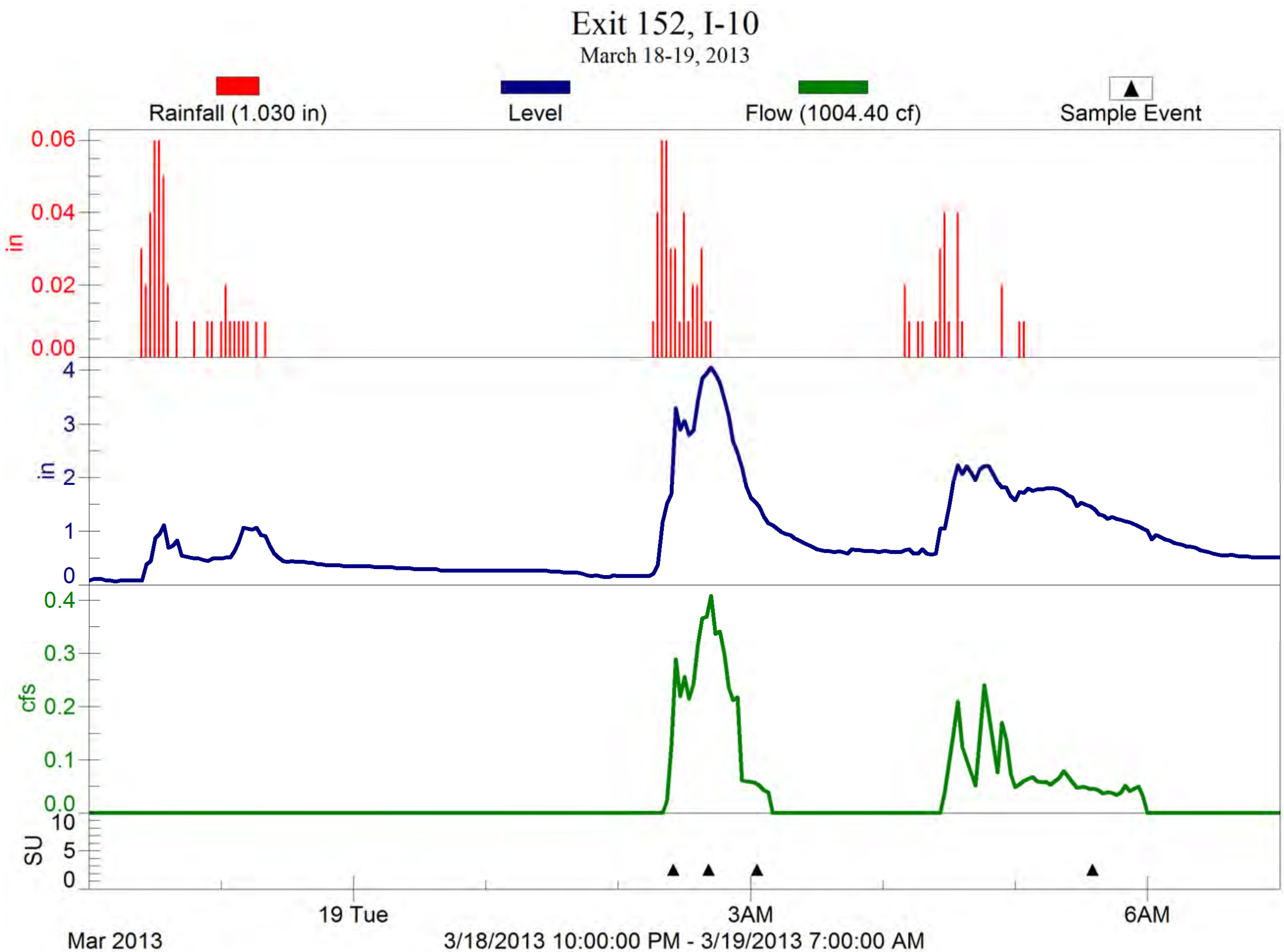



Exit 152, I-10
February 25, 2013
Rainfall (2.210 in)
Level
Flow (3954.79 cf)
Sample Event
0.08
0.06
0.04
0.02
0.00
in
6
4
2
0
in
1.5
1.0
0.5
0.0
cfs
10
5
0
SU
3AM
6AM
9AM
25 Mon Feb 2013
2/25/2013 12:00:00 AM - 2/25/2013 9:00:00 AM

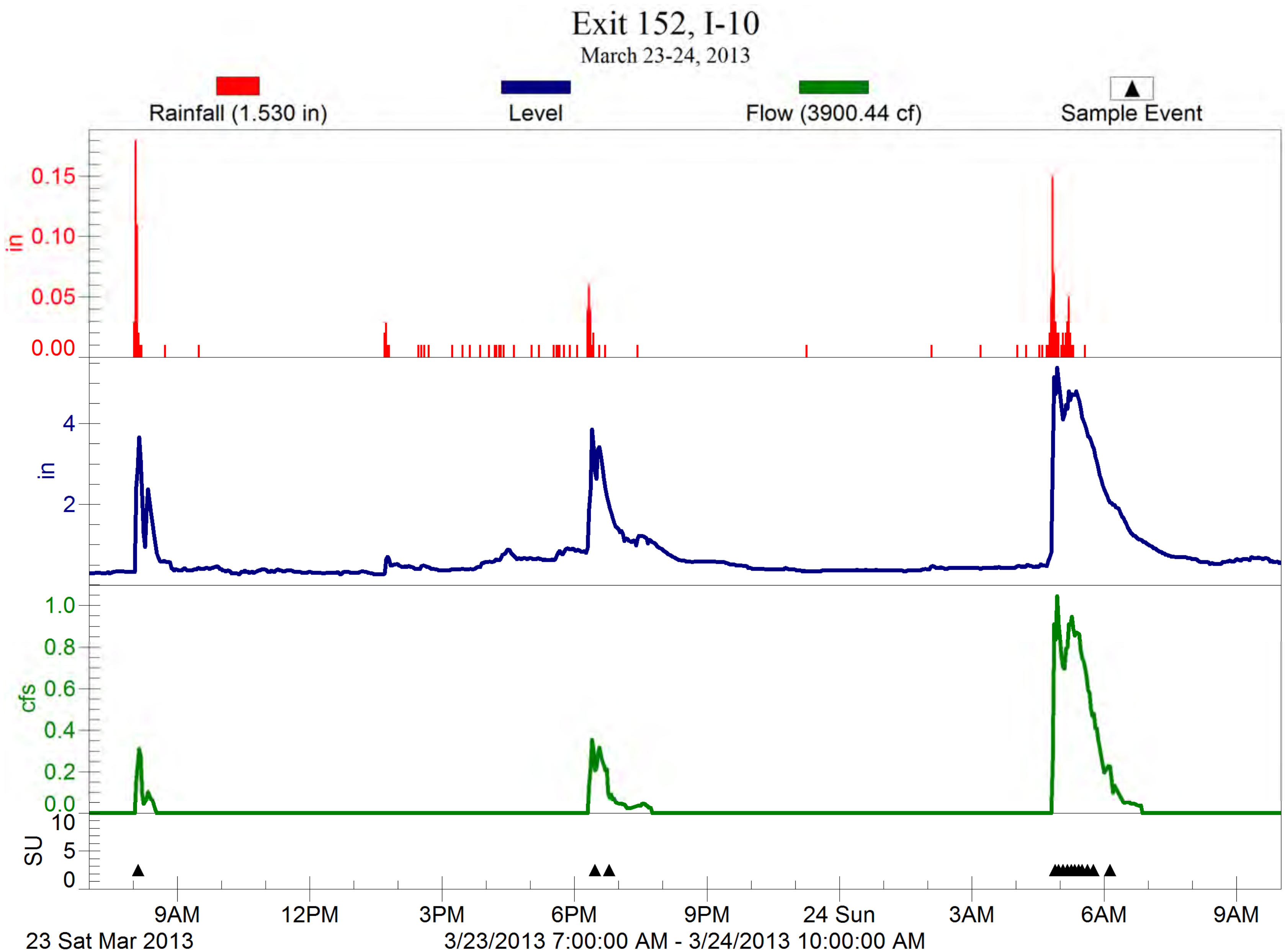


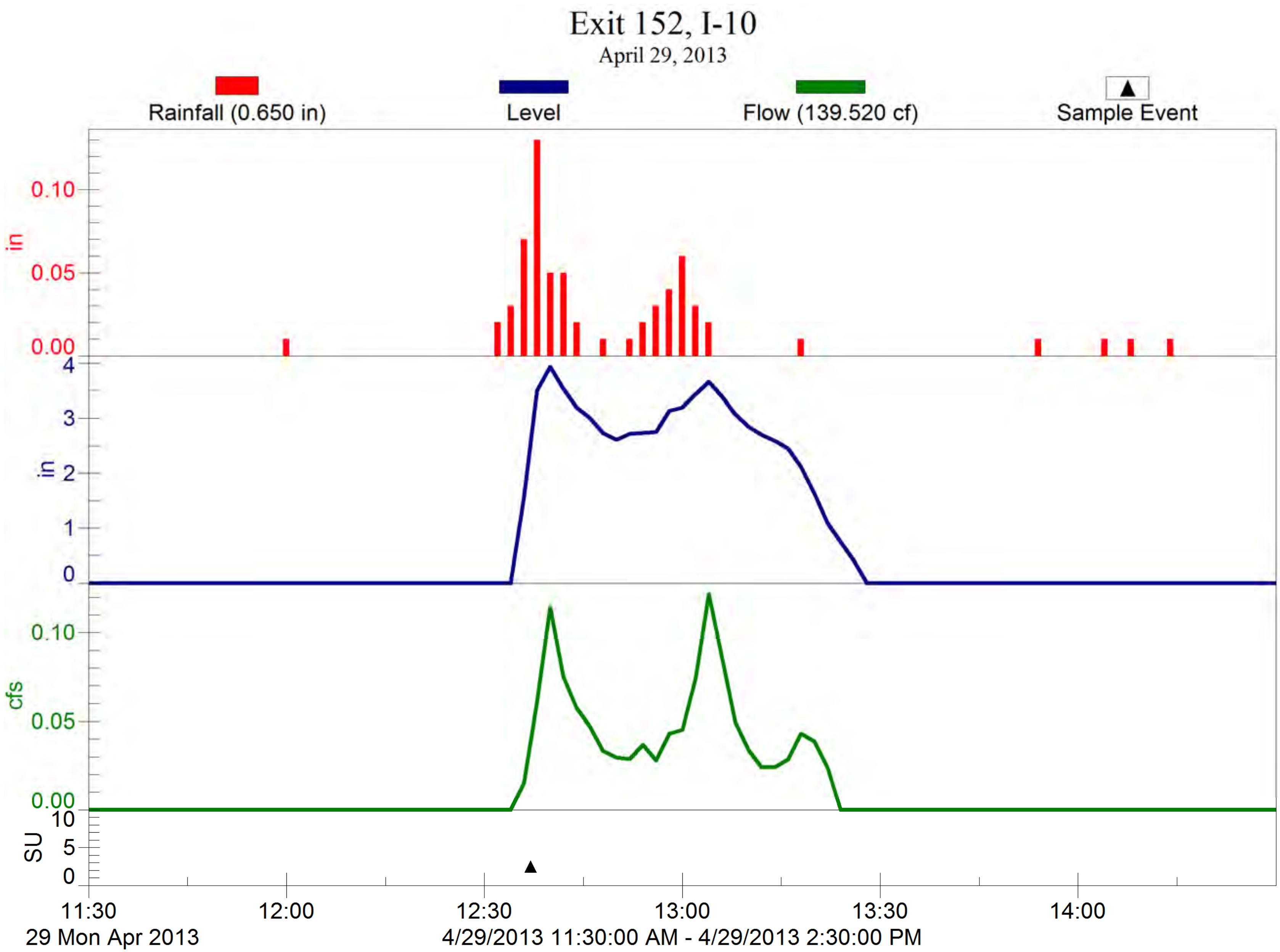
Exit 152, I-10
February 25, 2013
Rainfall (1.980 in)
Level
Flow (3486.49 cf)
Sample Event
in
0.08
0.06
0.04
0.02
0.00
in
6
4
2
0
cfs
1.5
1.0
0.5
0.0
SU
10
5
0
12PM
3PM
25 Mon Feb 2013
2/25/2013 9:00:00 AM - 2/25/2013 4:00:00 PM


Exit 152, I-10
February 25-26, 2013
Rainfall (1.820 in)
Level
Flow (7667.79 cf)
Sample Event
0.06
0.04
0.02
0.00
in
8
6
4
2
0
in
2.5
2.0
1.5
1.0
0.5
0.0
cfs
10
5
0
SU
26 Tue
3AM
6AM
Feb 2013
2/25/2013 9:00:00 PM - 2/26/2013 7:00:00 AM



Exit 152, I-10
March 18-19, 2013
Rainfall (1.030 in)
Level
Flow (1004.40 cf)
Sample Event
in
0.06
0.04
0.02
0.00
in
4
3
2
1
0
cfs
0.4
0.3
0.2
0.1
0.0
SU
10
5
0
19 Tue
3AM
6AM
Mar 2013
3/18/2013 10:00:00 PM - 3/19/2013 7:00:00 AM

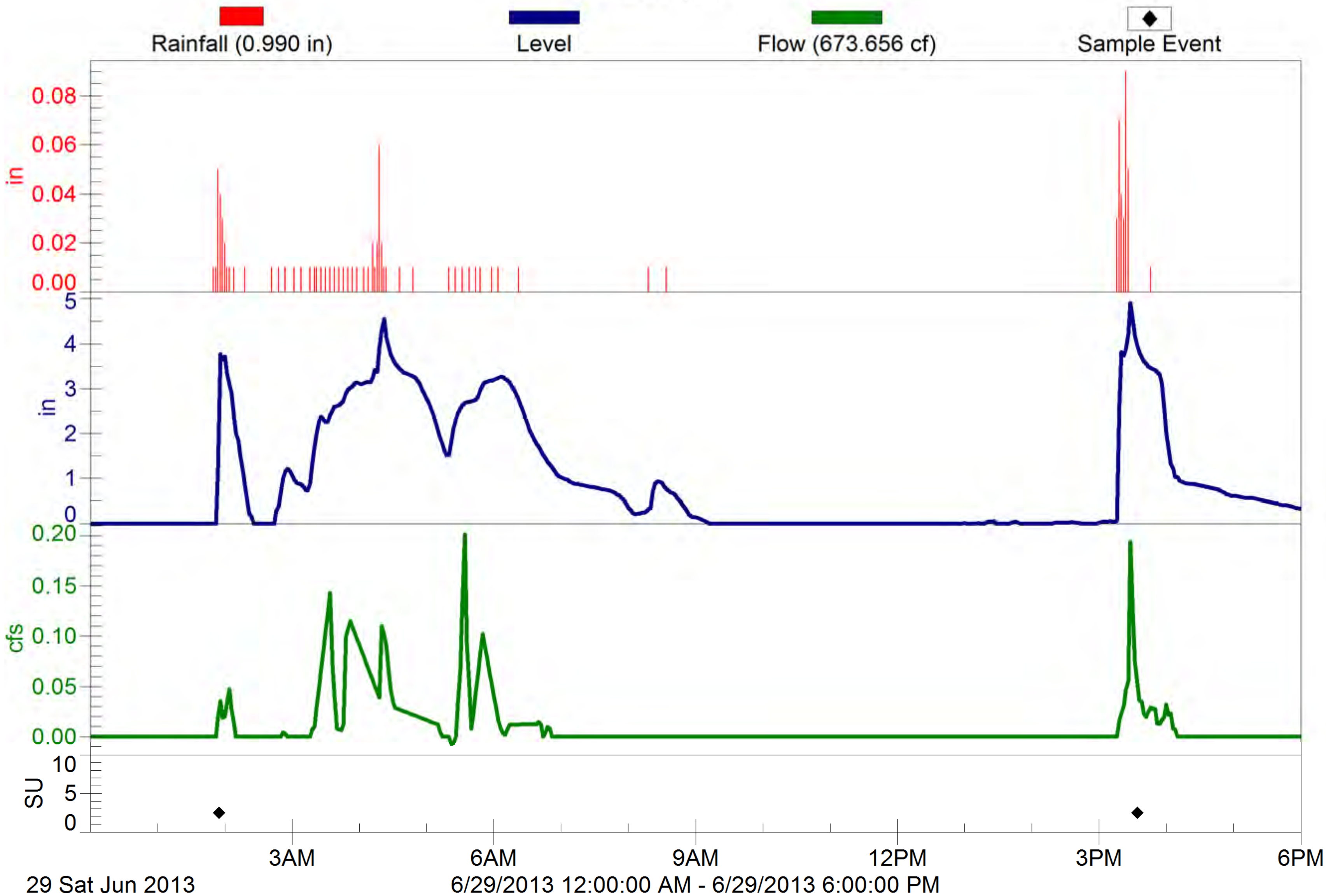

Exit 152, I-10
March 23-24, 2013
Rainfall (1.530 in)
Level
Flow (3900.44 cf)
Sample Event
in
0.15
0.10
0.05
0.00
in
4
2
cfs
1.0
0.8
0.6
0.4
0.2
0.0
SU
10
5
0
9AM
12PM
3PM
6PM
9PM
24 Sun
3AM
6AM
9AM
23 Sat Mar 2013
3/23/2013 7:00:00 AM - 3/24/2013 10:00:00 AM

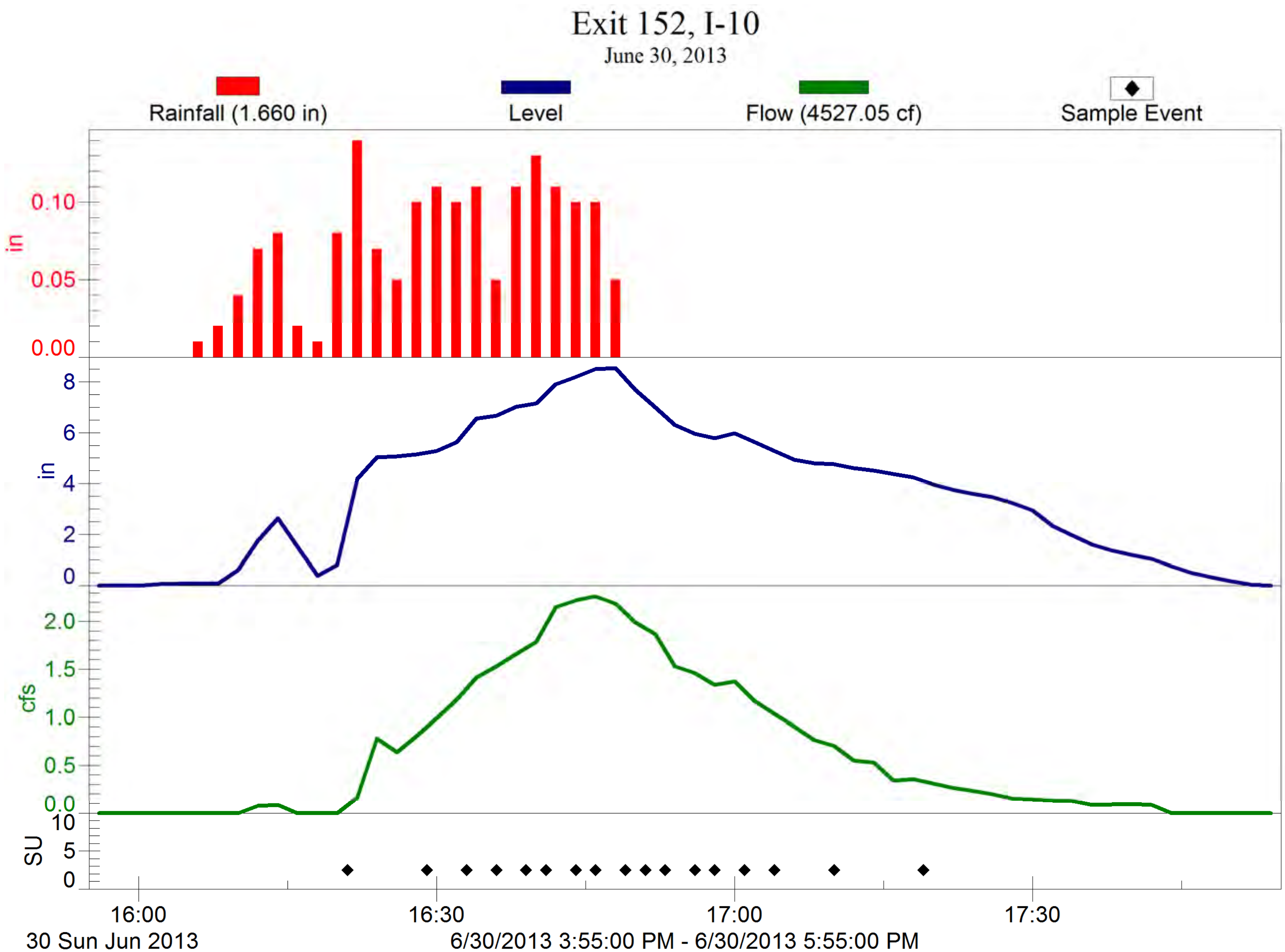


Exit 152, I-10
April 29, 2013
Rainfall (0.650 in)
Level
Flow (139.520 cf)
Sample Event
in
0.10
0.05
0.00
in
4
3
2
1
0
cfs
0.10
0.05
0.00
SU
10
5
0
11:30
29 Mon Apr 2013
12:00
12:30
13:00
13:30
14:00
4/29/2013 11:30:00 AM - 4/29/2013 2:30:00 PM

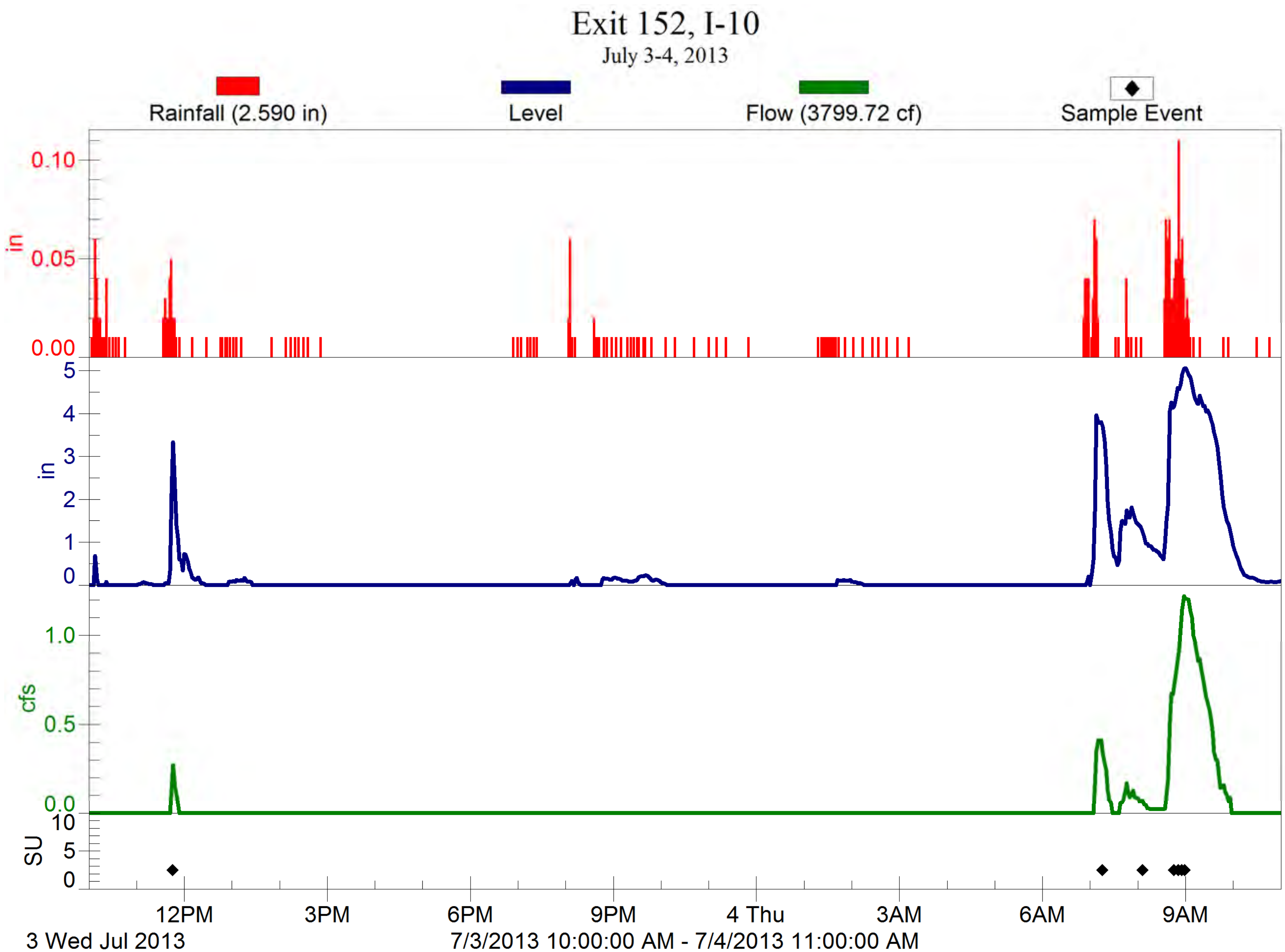
Exit 152, I-10

June 29, 2013

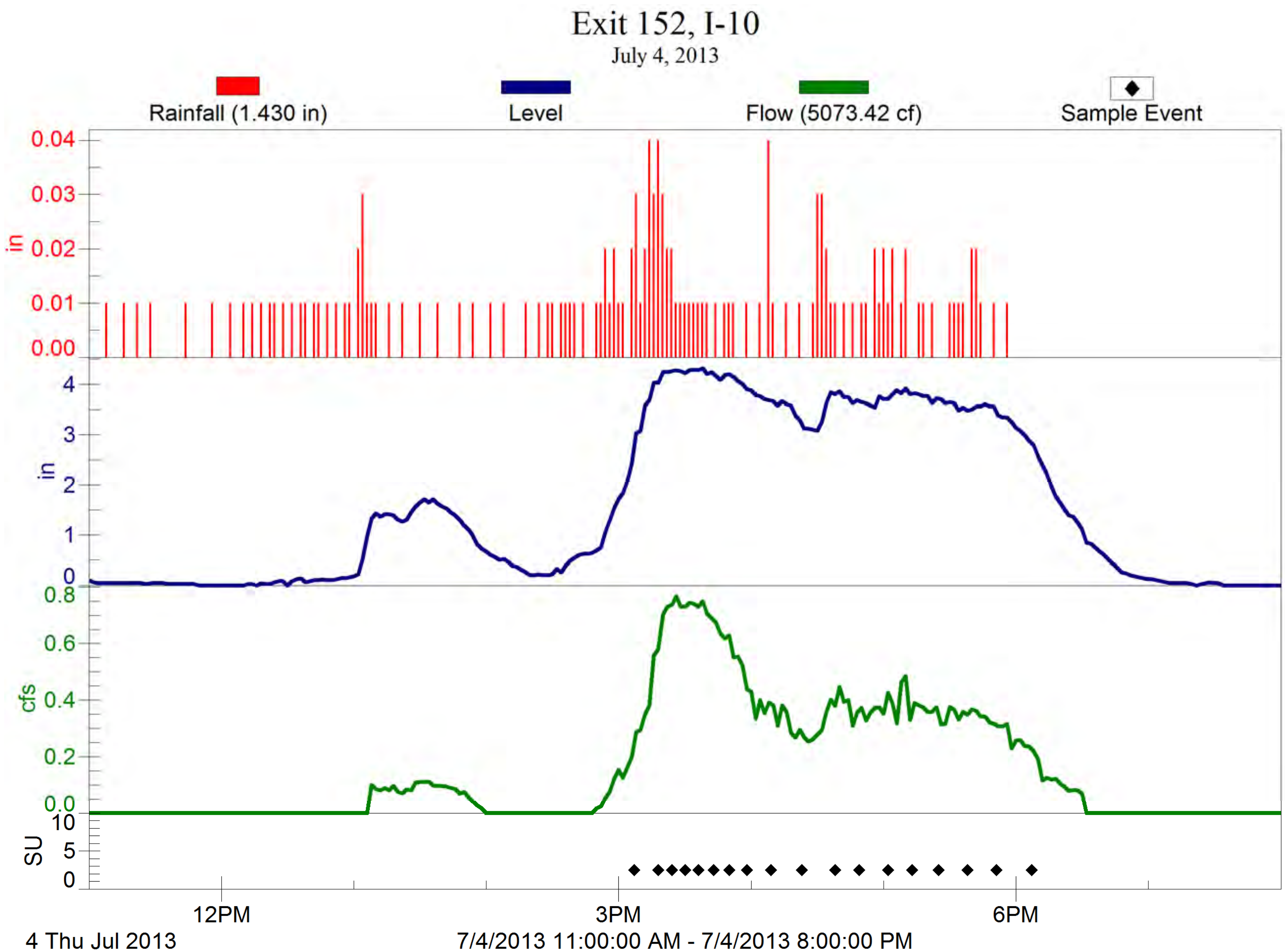


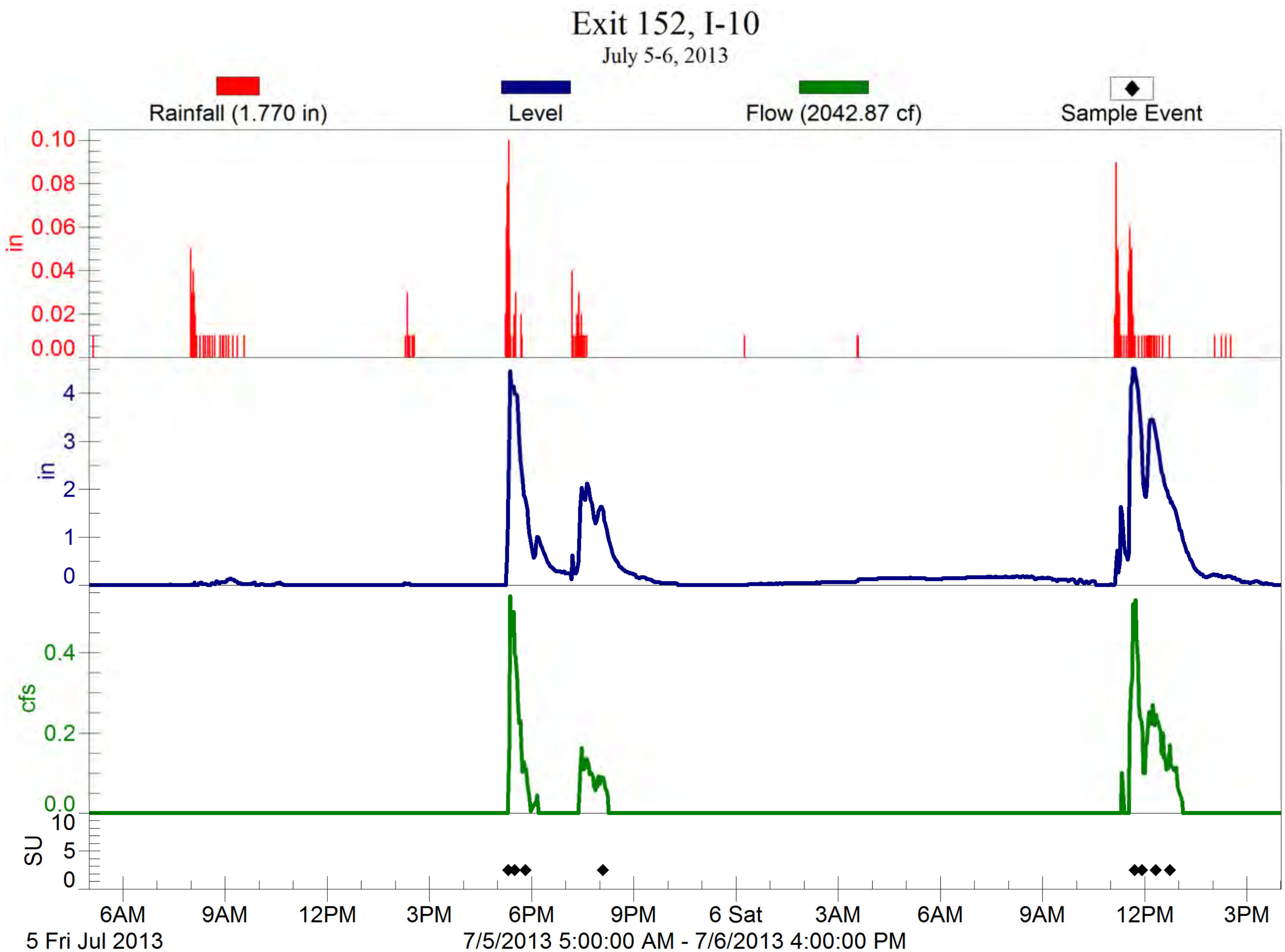


Exit 152, I-10
June 30, 2013
Rainfall (1.660 in)
Level
Flow (4527.05 cf)
Sample Event
in
0.10
0.05
0.00
in
8
6
4
2
0
cfs
2.0
1.5
1.0
0.5
0.0
SU
10
5
0
16:00
16:30
17:00
17:30
30 Sun Jun 2013
6/30/2013 3:55:00 PM - 6/30/2013 5:55:00 PM



Exit 152, I-10
July 3-4, 2013
Rainfall (2.590 in)
Level
Flow (3799.72 cf)
Sample Event
in
0.10
0.05
0.00
in
5
4
3
2
1
0
cfs
1.0
0.5
0.0
SU
10
5
0
12PM
3PM
6PM
9PM
4 Thu
3AM
6AM
9AM
3 Wed Jul 2013
7/3/2013 10:00:00 AM - 7/4/2013 11:00:00 AM

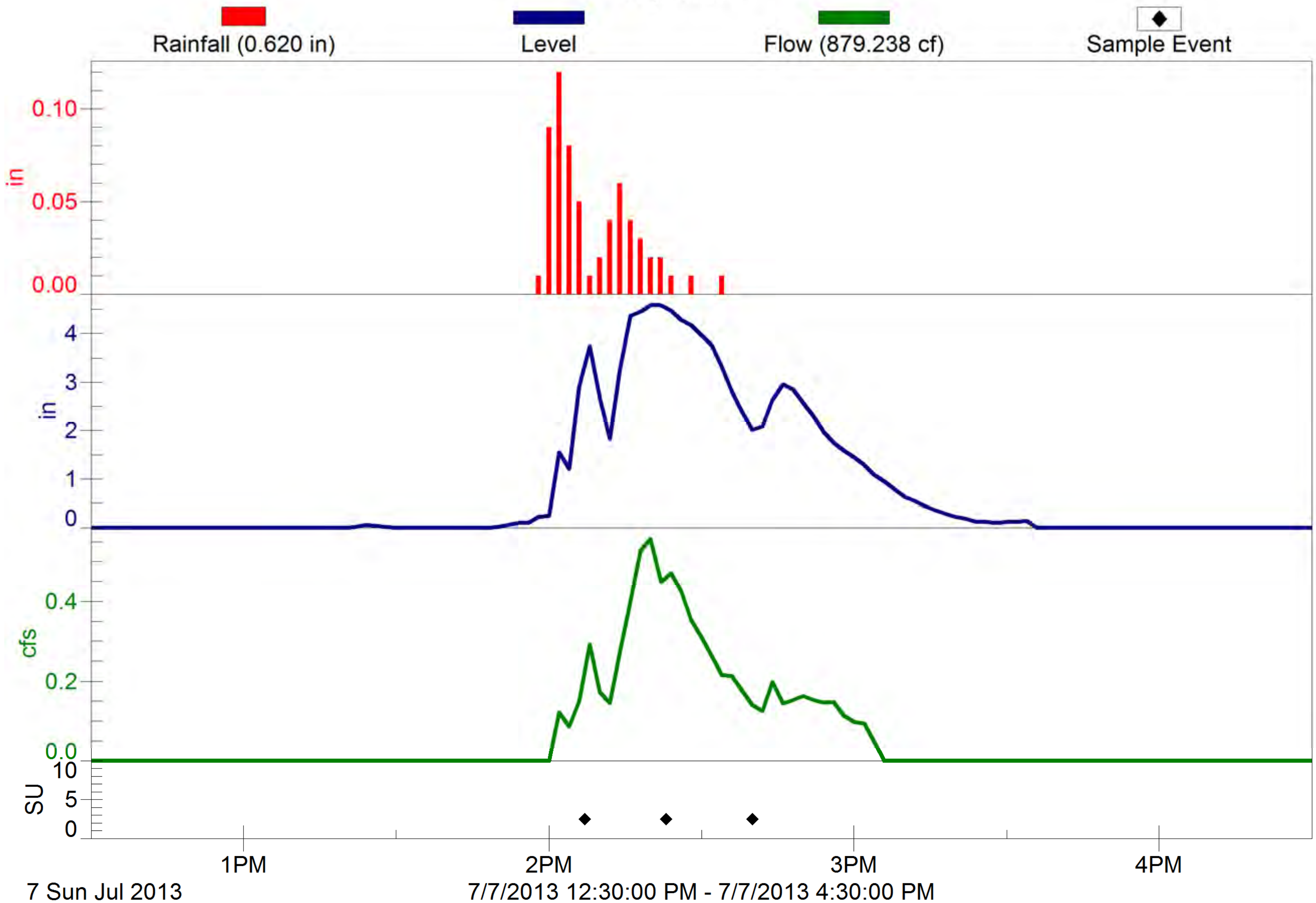

Exit 152, I-10
July 4, 2013
Rainfall (1.430 in)
Level
Flow (5073.42 cf)
Sample Event
0.04
0.03
0.02
0.01
0.00
in
4
3
2
1
0
in
0.8
0.6
0.4
0.2
0.0
cfs
10
5
0
SU
12PM
3PM
6PM
4 Thu Jul 2013
7/4/2013 11:00:00 AM - 7/4/2013 8:00:00 PM

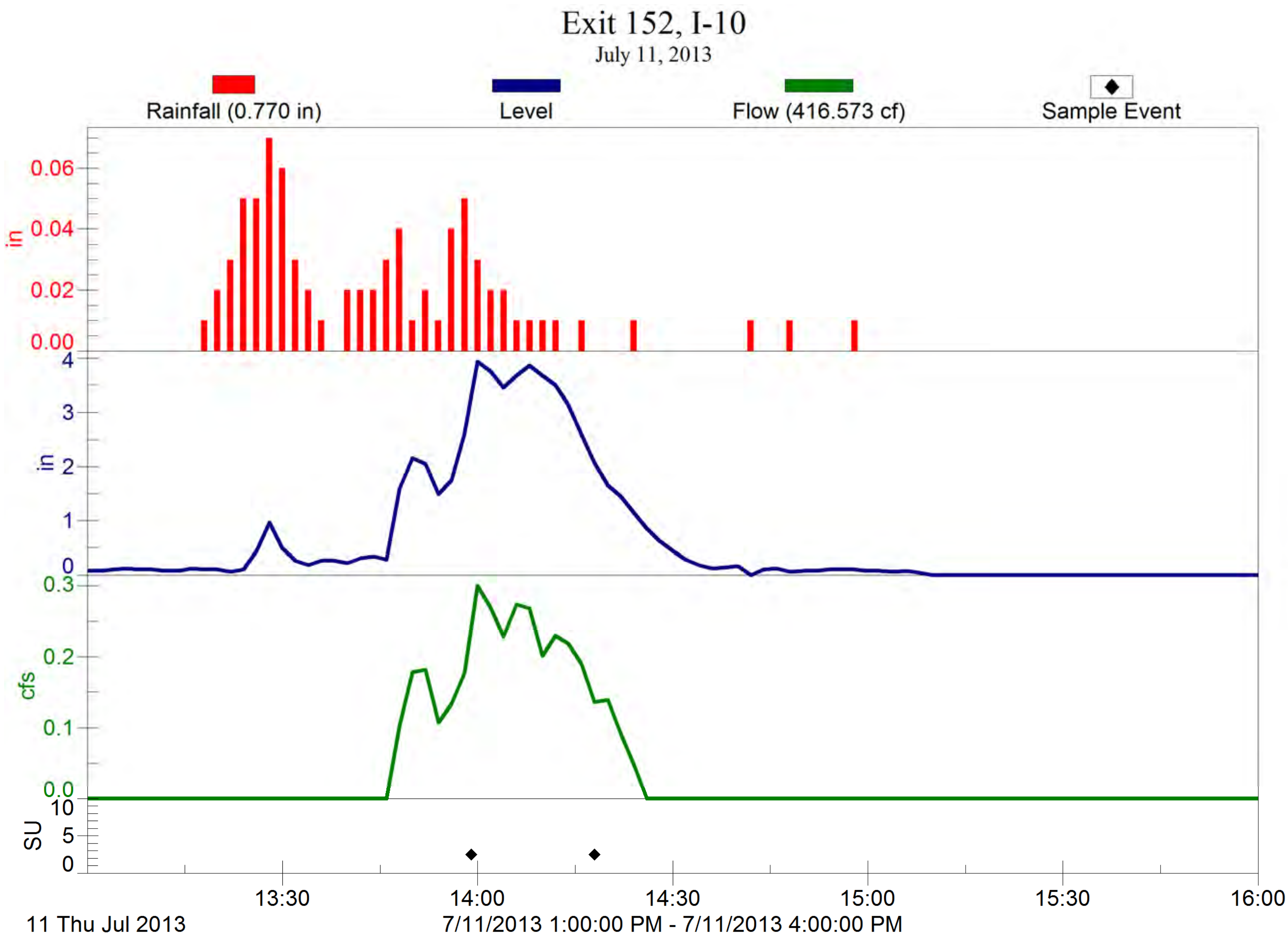


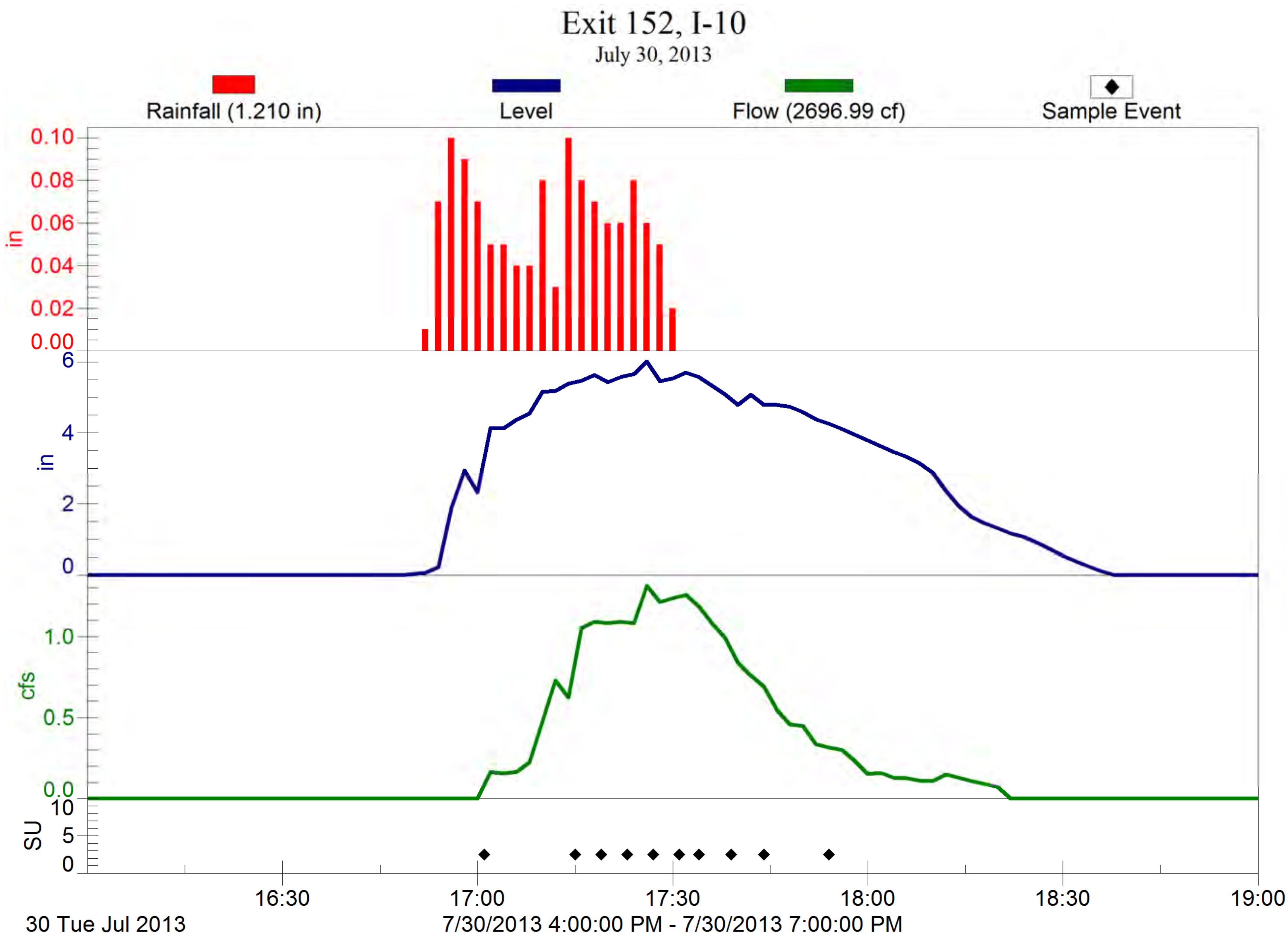
Exit 152, I-10
July 5-6, 2013
Rainfall (1.770 in)
Level
Flow (2042.87 cf)
Sample Event
0.10
0.08
0.06
0.04
0.02
0.00
in
4
3
2
1
0
in
0.4
0.2
0.0
cfs
10
5
0
SU
6AM
9AM
12PM
3PM
6PM
9PM
6 Sat
3AM
6AM
9AM
12PM
3PM
5 Fri Jul 2013
7/5/2013 5:00:00 AM - 7/6/2013 4:00:00 PM

Exit 152, I-10

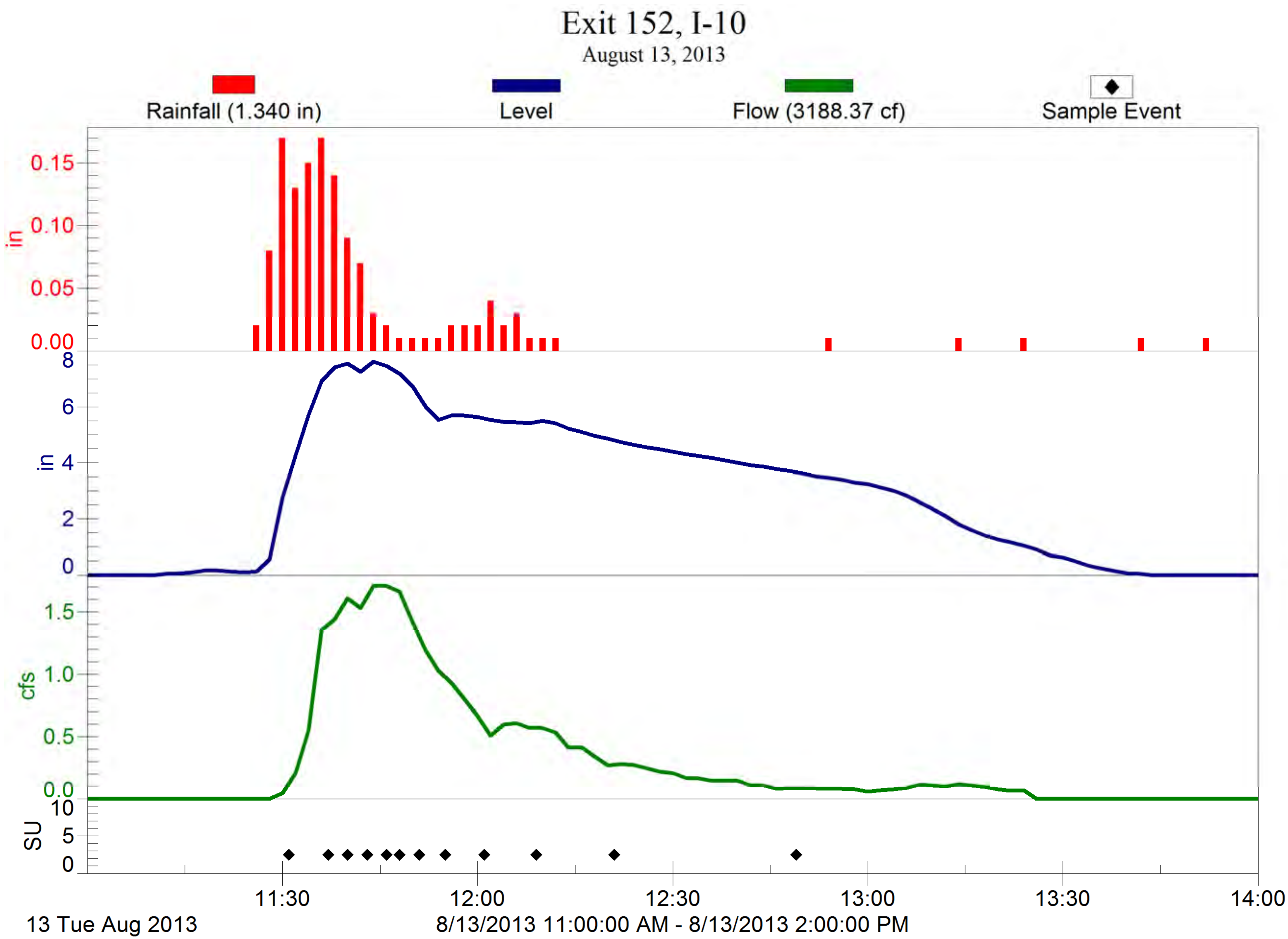
July 7, 2013

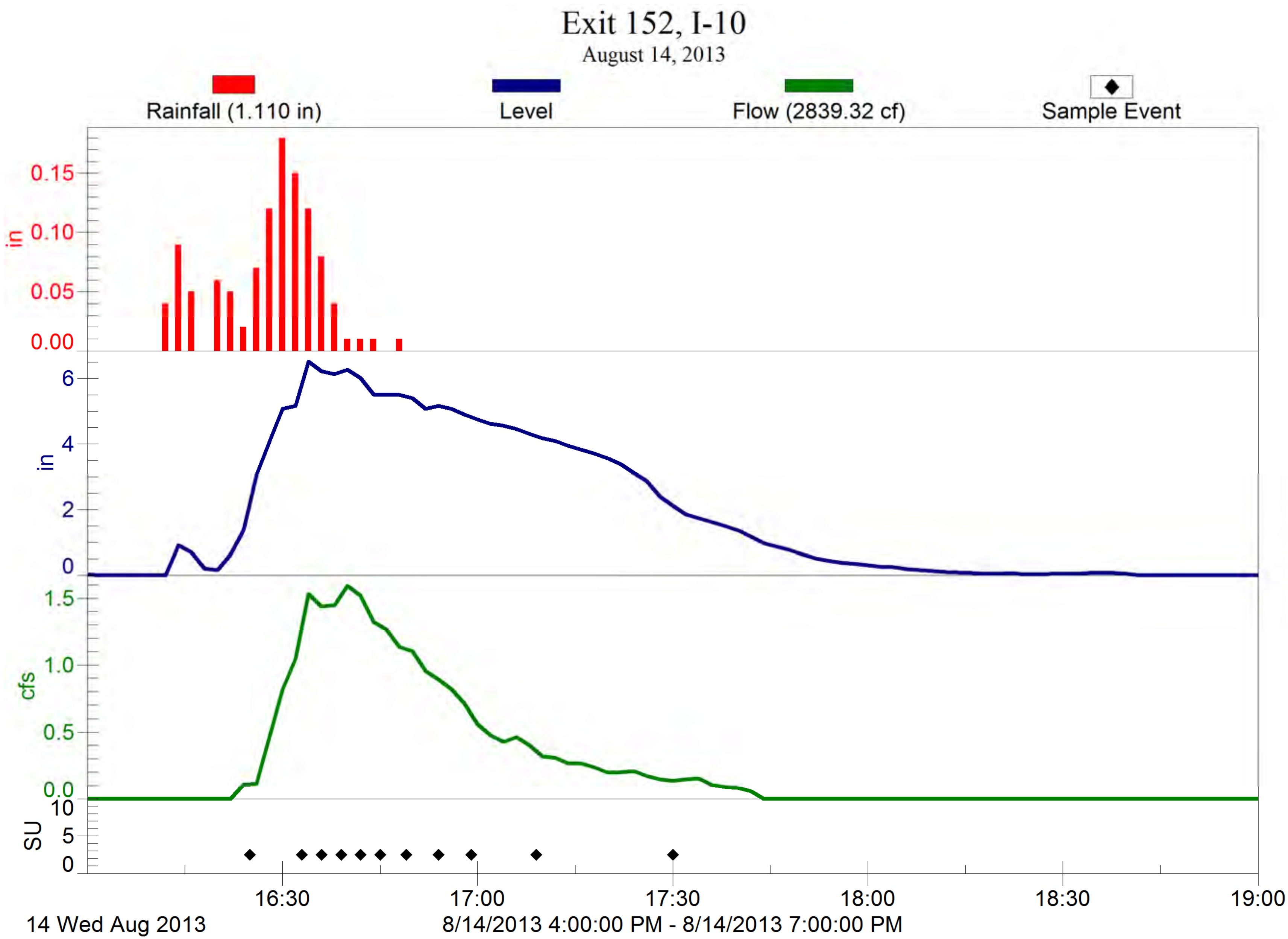



Exit 152, I-10
July 11, 2013
Rainfall (0.770 in)
Level
Flow (416.573 cf)
Sample Event
in
0.06
0.04
0.02
0.00
in
4
3
2
1
0
cfs
0.3
0.2
0.1
0.0
SU
10
5
0
13:30
14:00
14:30
15:00
15:30
16:00
11 Thu Jul 2013
7/11/2013 1:00:00 PM - 7/11/2013 4:00:00 PM

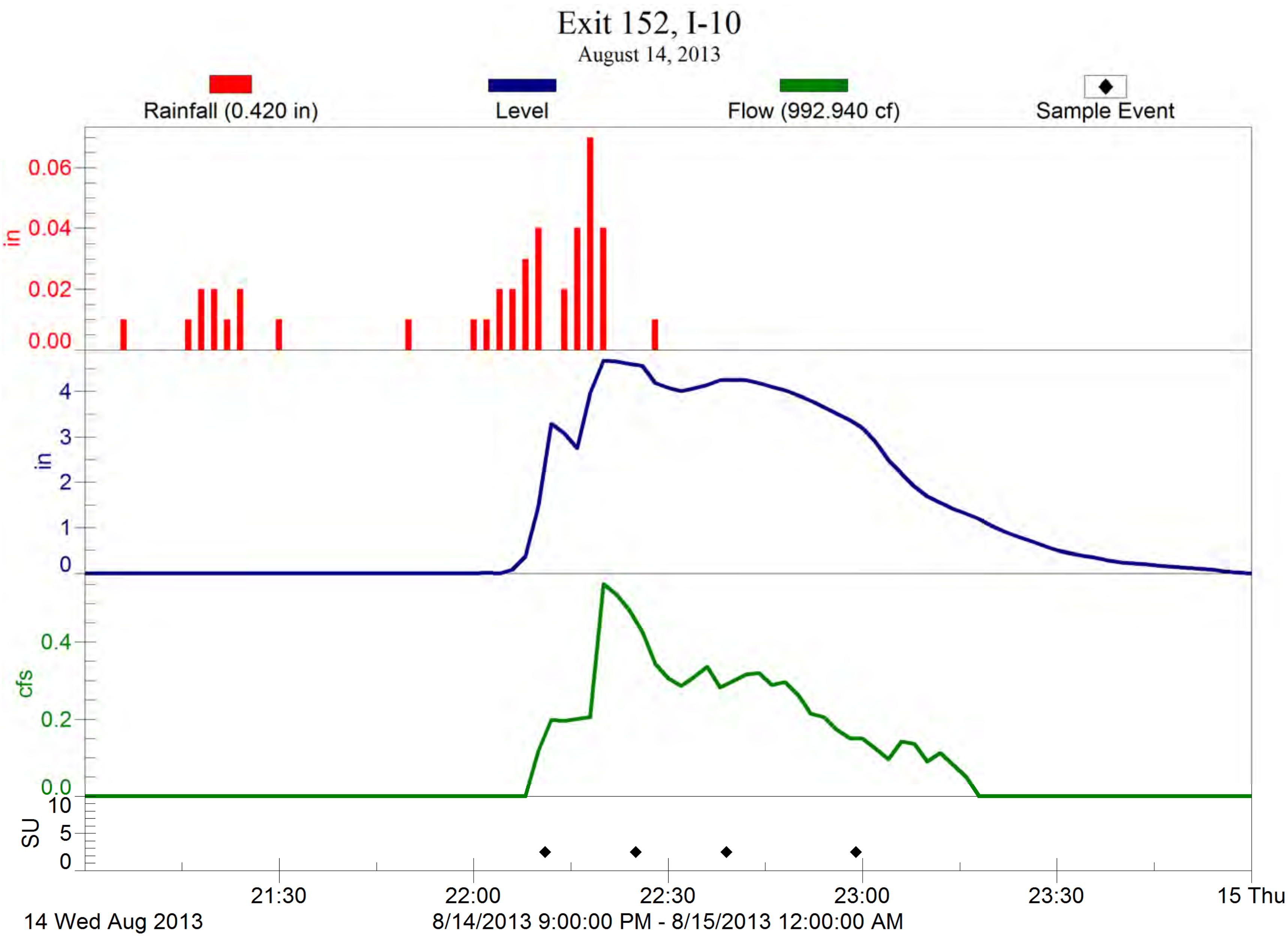


Exit 152, I-10
July 30, 2013
Rainfall (1.210 in)
Level
Flow (2696.99 cf)
Sample Event
in
0.10
0.08
0.06
0.04
0.02
0.00
in
6
4
2
0
cfs
1.0
0.5
0.0
SU
10
5
0
16:30
17:00
17:30
18:00
18:30
19:00
30 Tue Jul 2013
7/30/2013 4:00:00 PM - 7/30/2013 7:00:00 PM

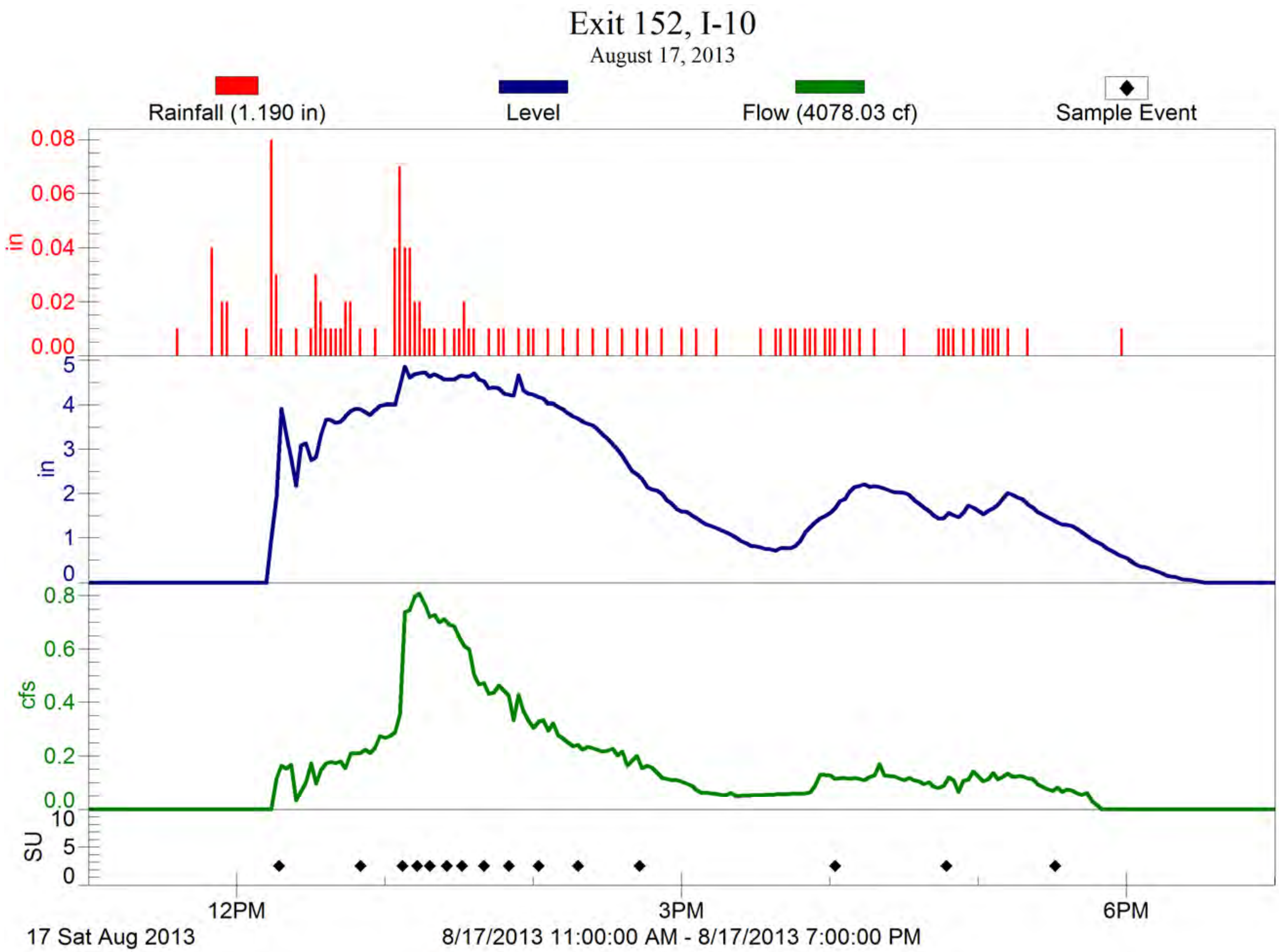

Exit 152, I-10
August 13, 2013
Rainfall (1.340 in)
Level
Flow (3188.37 cf)
Sample Event
in
0.15
0.10
0.05
0.00
8
6
4
2
0
cfs
1.5
1.0
0.5
0.0
SU
10
5
0
11:30
12:00
12:30
13:00
13:30
14:00
13 Tue Aug 2013
8/13/2013 11:00:00 AM - 8/13/2013 2:00:00 PM



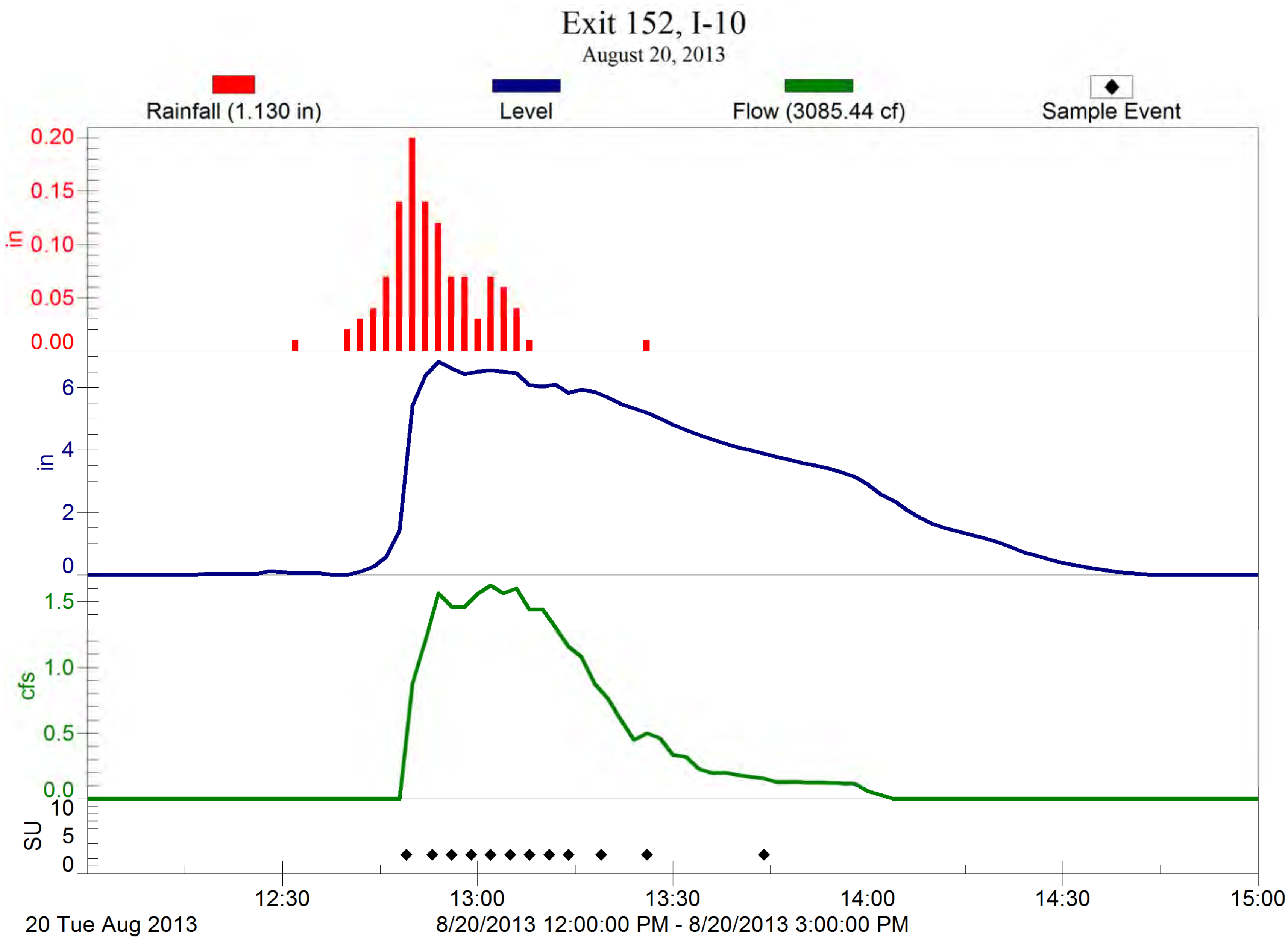
Exit 152, I-10
August 14, 2013
Rainfall (1.110 in)
Level
Flow (2839.32 cf)
Sample Event
in
0.15
0.10
0.05
0.00
in
6
4
2
0
cfs
1.5
1.0
0.5
0.0
SU
10
5
0
16:30
17:00
17:30
18:00
18:30
19:00
14 Wed Aug 2013
8/14/2013 4:00:00 PM - 8/14/2013 7:00:00 PM



Exit 152, I-10
August 14, 2013
Rainfall (0.420 in)
Level
Flow (992.940 cf)
Sample Event
in
0.06
0.04
0.02
0.00
in
4
3
2
1
0
cfs
0.4
0.2
0.0
SU
10
5
0
21:30
22:00
22:30
23:00
23:30
15 Thu
14 Wed Aug 2013
8/14/2013 9:00:00 PM - 8/15/2013 12:00:00 AM



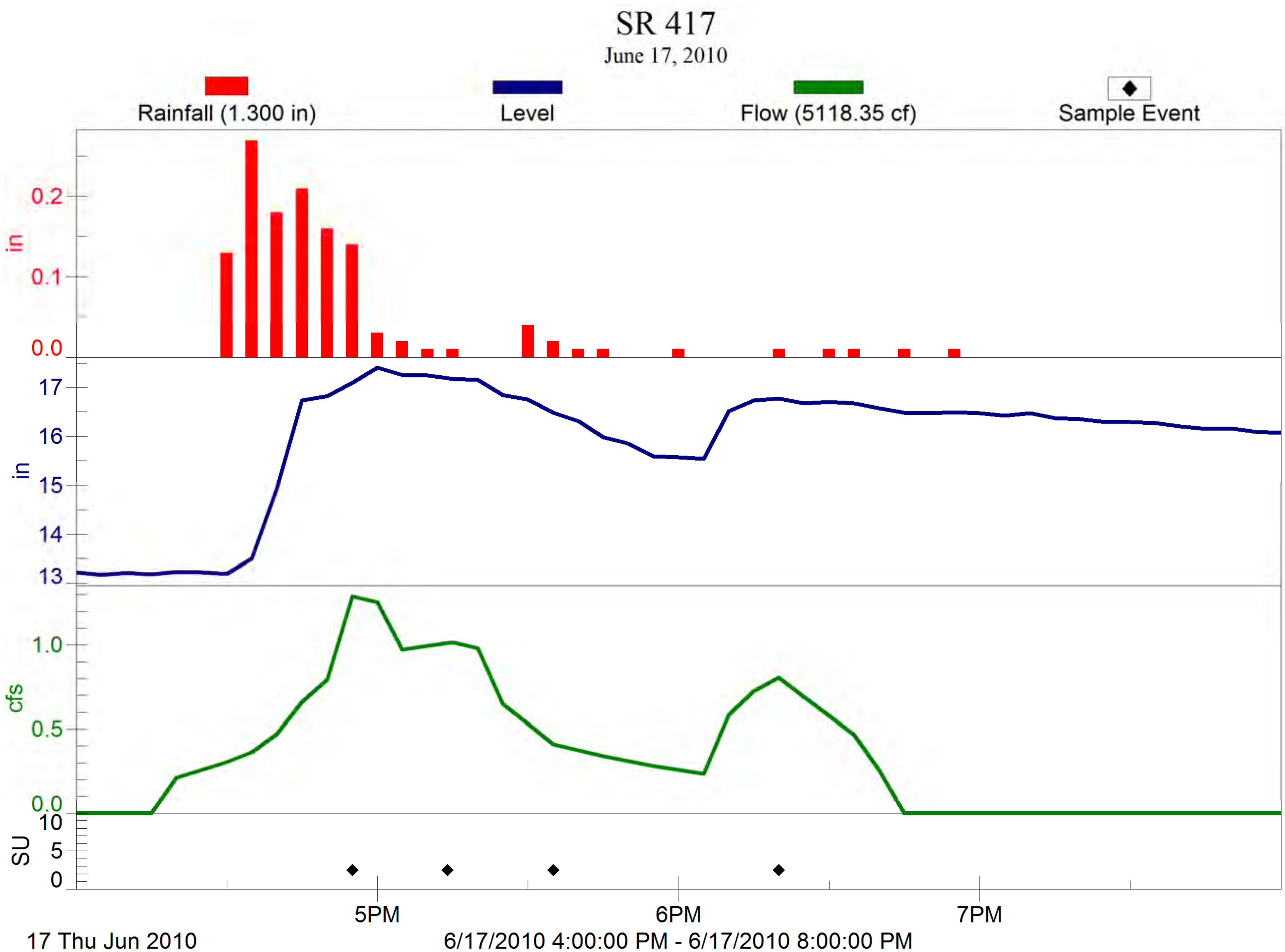
Exit 152, I-10
August 17, 2013
Rainfall (1.190 in)
Level
Flow (4078.03 cf)
Sample Event
0.08
0.06
0.04
0.02
0.00
in
5
4
3
2
1
0
in
0.8
0.6
0.4
0.2
0.0
cfs
10
5
0
SU
12PM
3PM
6PM
17 Sat Aug 2013
8/17/2013 11:00:00 AM - 8/17/2013 7:00:00 PM


Exit 152, I-10
August 20, 2013
Rainfall (1.130 in)
Level
Flow (3085.44 cf)
Sample Event
in
0.20
0.15
0.10
0.05
0.00
in
6
4
2
0
cfs
1.5
1.0
0.5
0.0
SU
10
5
0
12:30
13:00
13:30
14:00
14:30
15:00
20 Tue Aug 2013
8/20/2013 12:00:00 PM - 8/20/2013 3:00:00 PM

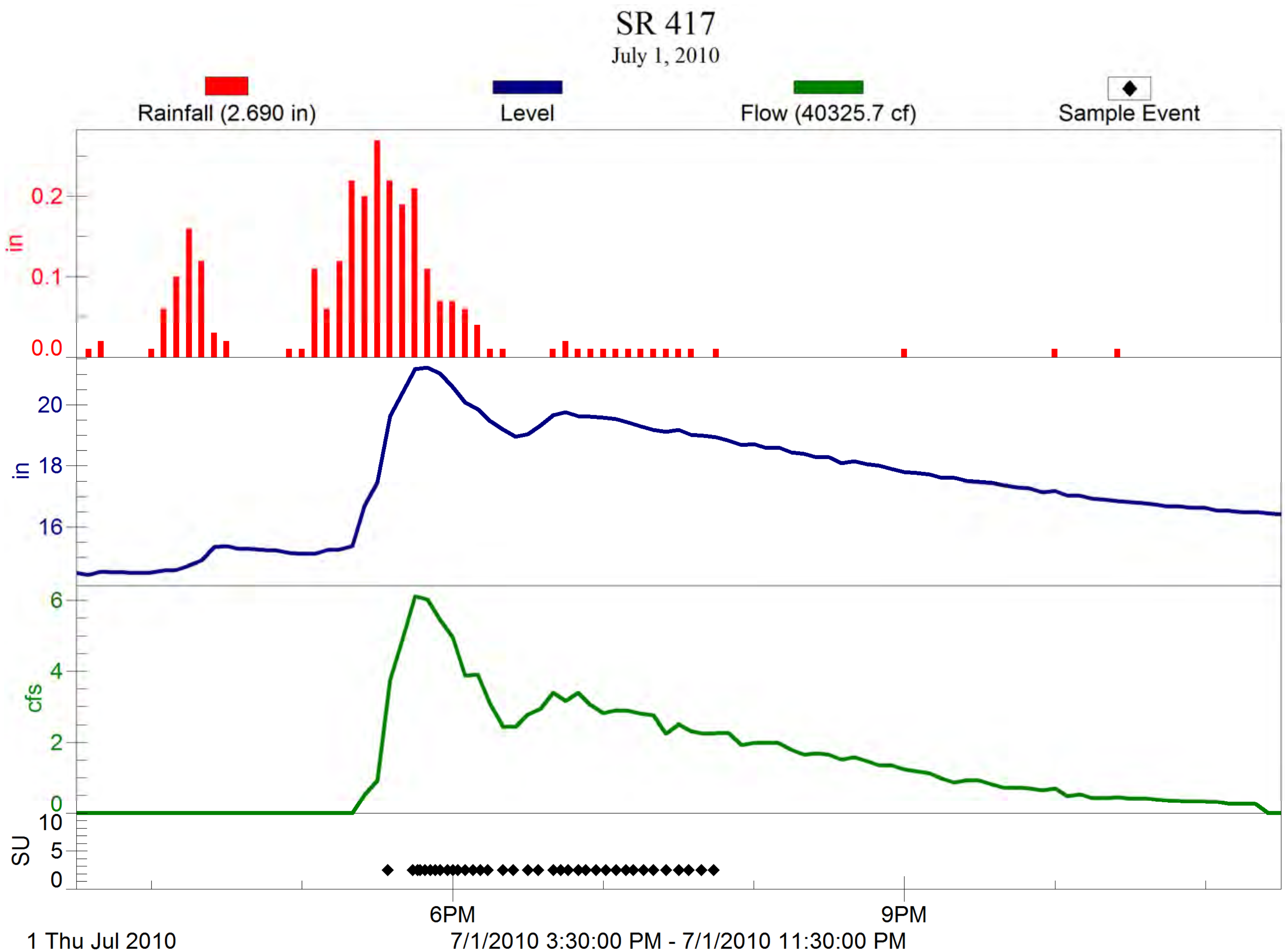
Appendix D

Storm Event Data for SR 417 Sampling Location

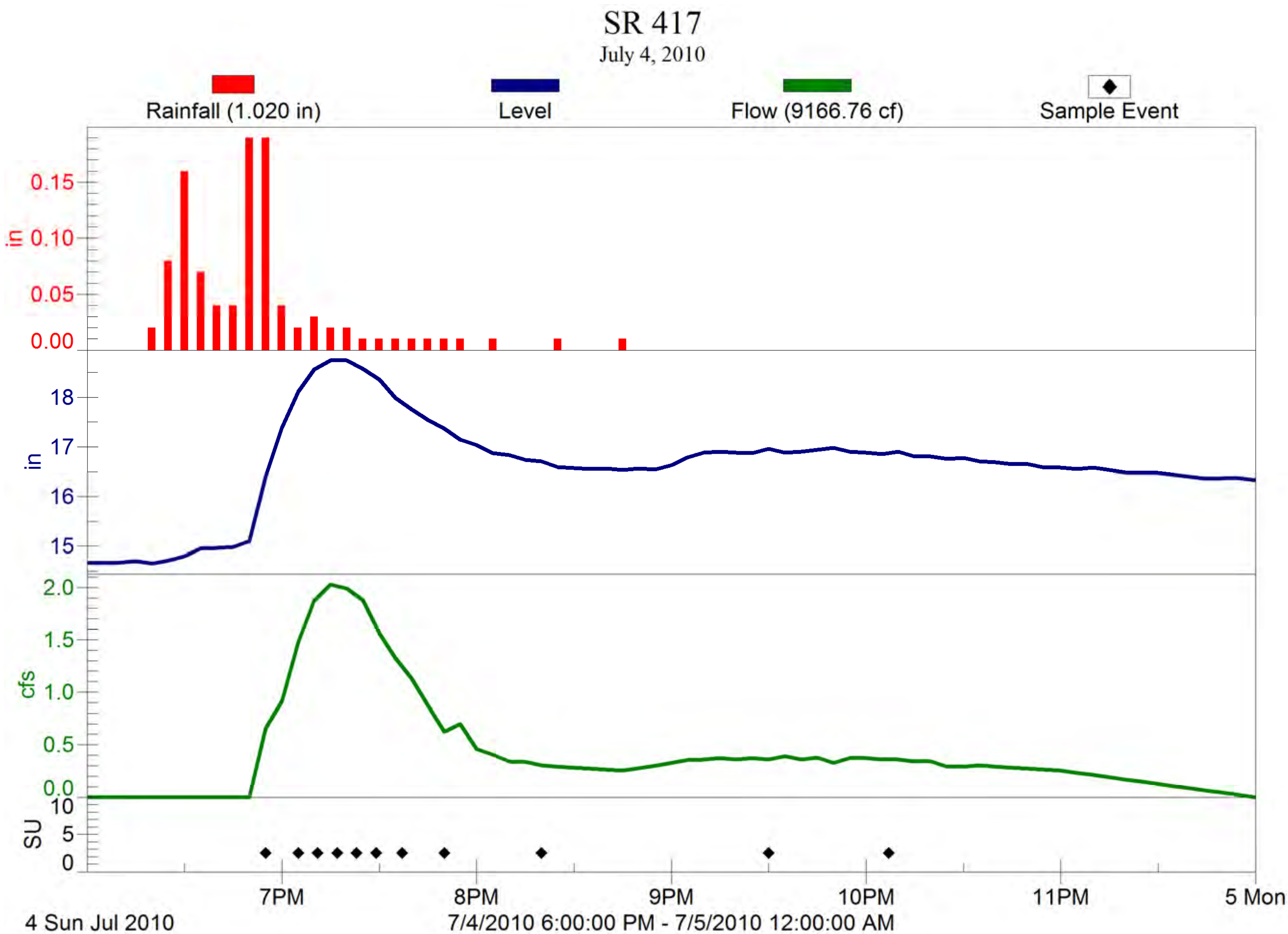
(Laboratory results included on the accompanying CD)

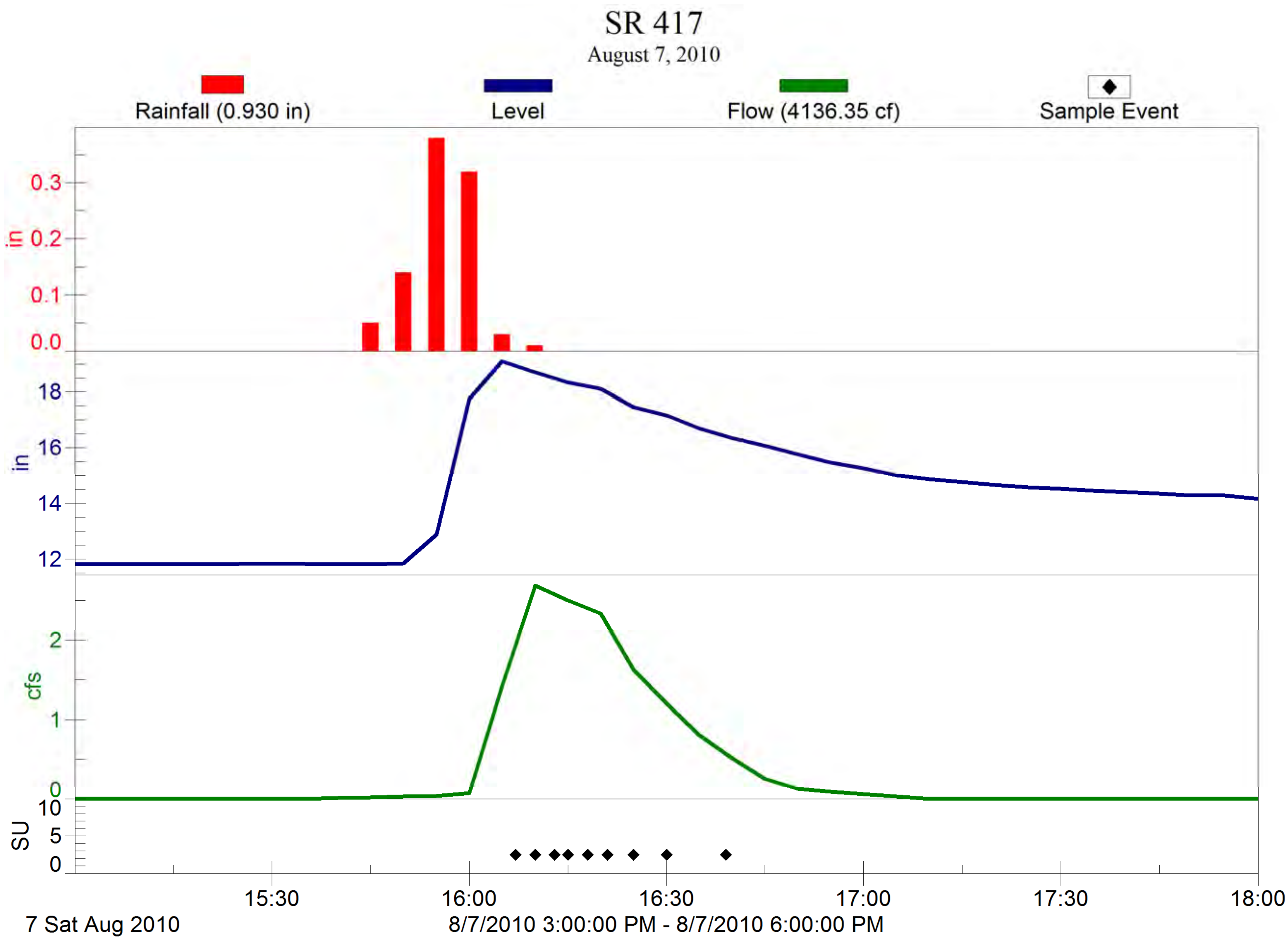


SR 417
June 17, 2010
Rainfall (1.300 in)
Level
Flow (5118.35 cf)
Sample Event
0.2
0.1
0.0
in
17
16
15
14
13
in
1.0
0.5
0.0
cfs
10
5
0
SU
5PM
6PM
7PM
17 Thu Jun 2010
6/17/2010 4:00:00 PM - 6/17/2010 8:00:00 PM

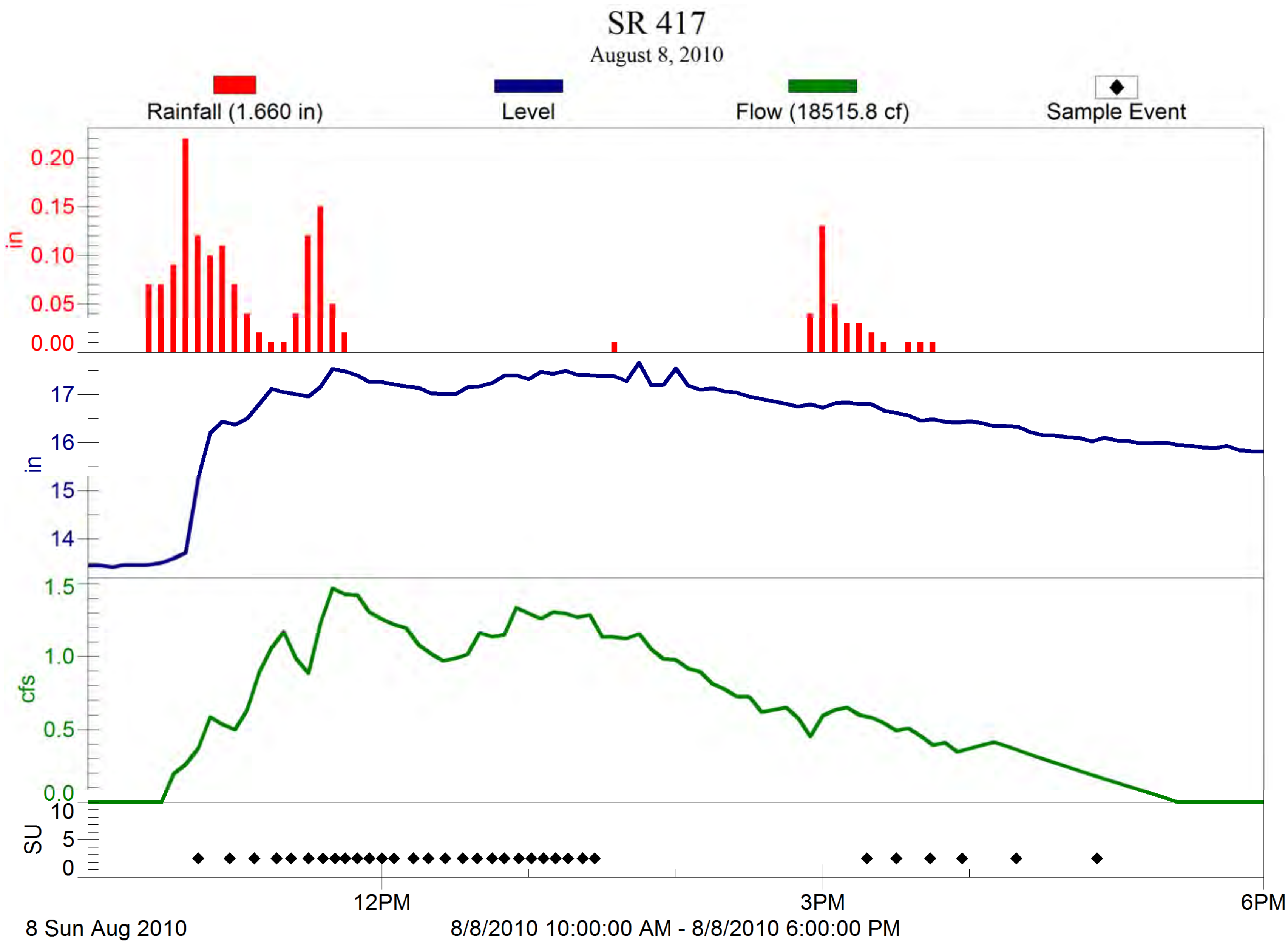


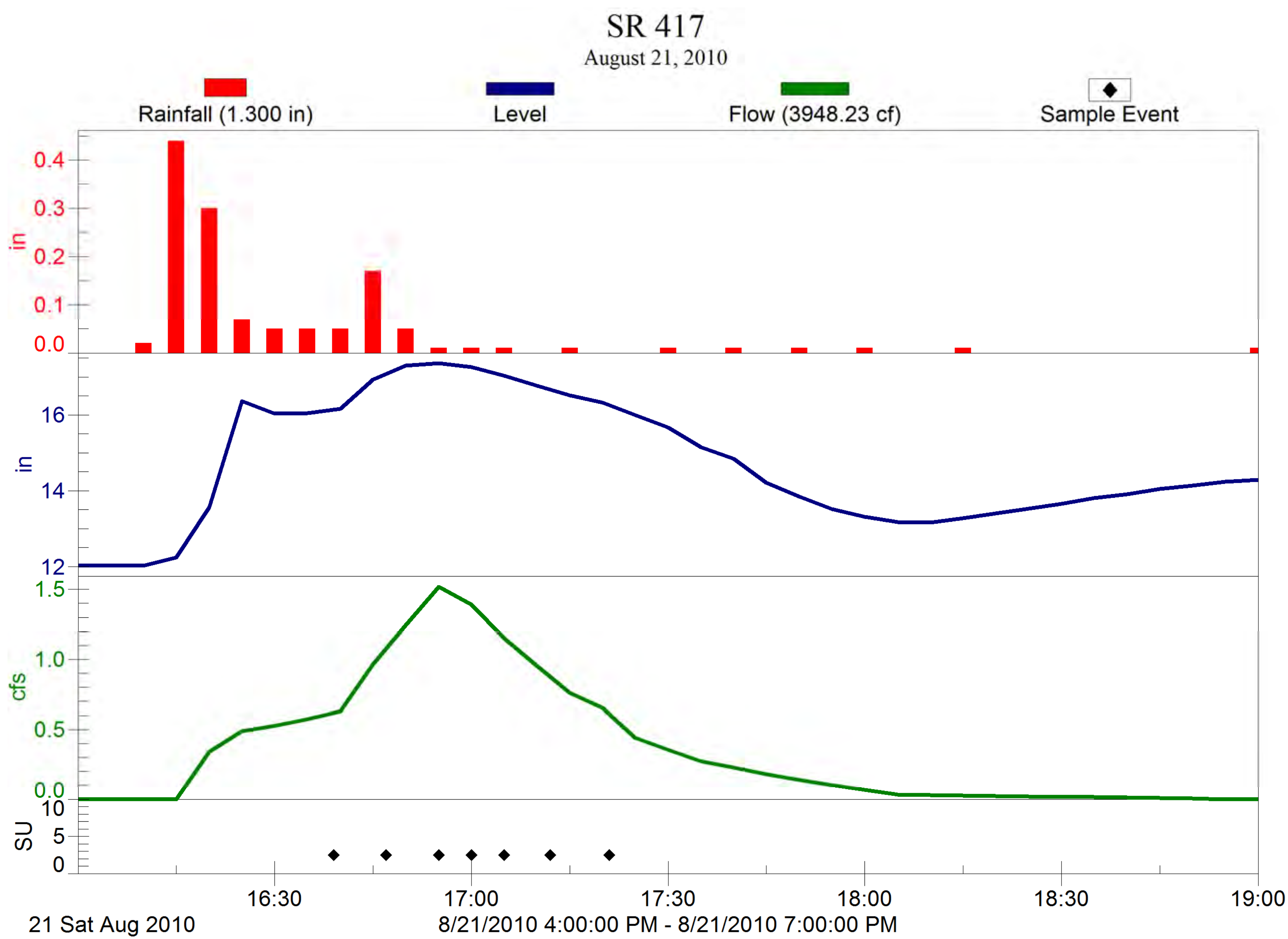
SR 417
July 1, 2010
Rainfall (2.690 in)
Level
Flow (40325.7 cf)
Sample Event
in
0.2
0.1
0.0
in
20
18
16
cfs
6
4
2
0
SU
10
5
0
6PM
9PM
1 Thu Jul 2010
7/1/2010 3:30:00 PM - 7/1/2010 11:30:00 PM


SR 417
July 4, 2010
Rainfall (1.020 in)
Level
Flow (9166.76 cf)
Sample Event
in
0.15
0.10
0.05
0.00
in
18
17
16
15
cfs
2.0
1.5
1.0
0.5
0.0
SU
10
5
0
7PM
8PM
9PM
10PM
11PM
5 Mon
4 Sun Jul 2010
7/4/2010 6:00:00 PM - 7/5/2010 12:00:00 AM

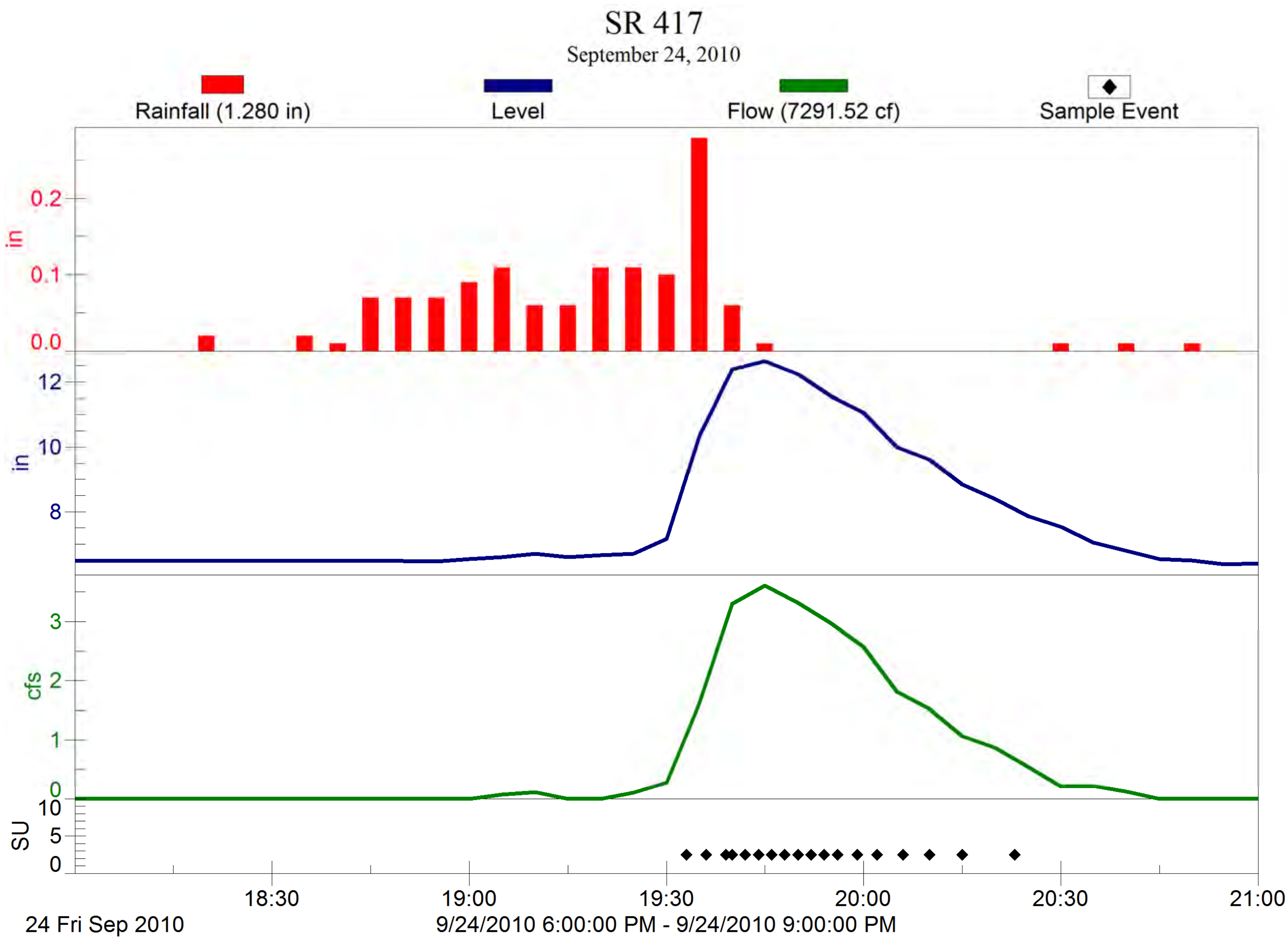


SR 417
August 7, 2010
Rainfall (0.930 in)
Level
Flow (4136.35 cf)
Sample Event
in
0.3
0.2
0.1
0.0
in
18
16
14
12
cfs
2
1
0
SU
10
5
0
15:30
16:00
16:30
17:00
17:30
18:00
7 Sat Aug 2010
8/7/2010 3:00:00 PM - 8/7/2010 6:00:00 PM


SR 417
August 8, 2010
Rainfall (1.660 in)
Level
Flow (18515.8 cf)
Sample Event
0.20
0.15
0.10
0.05
0.00
in
17
16
15
14
in
1.5
1.0
0.5
0.0
cfs
10
5
0
SU
12PM
3PM
6PM
8 Sun Aug 2010
8/8/2010 10:00:00 AM - 8/8/2010 6:00:00 PM



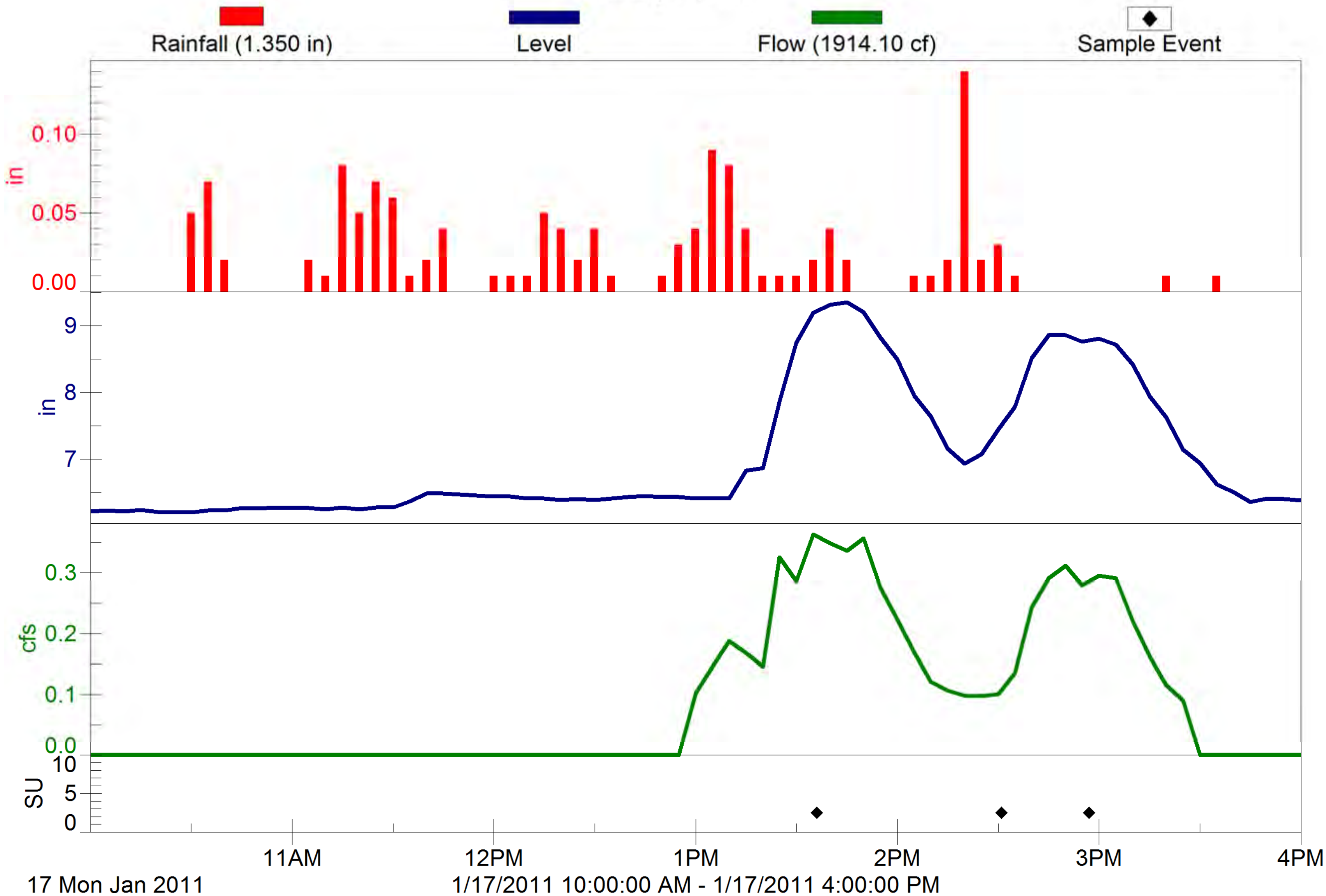
SR 417
August 21, 2010
Rainfall (1.300 in)
Level
Flow (3948.23 cf)
Sample Event
in
0.4
0.3
0.2
0.1
0.0
in
16
14
12
cfs
1.5
1.0
0.5
0.0
SU
10
5
0
16:30
17:00
17:30
18:00
18:30
19:00
21 Sat Aug 2010
8/21/2010 4:00:00 PM - 8/21/2010 7:00:00 PM

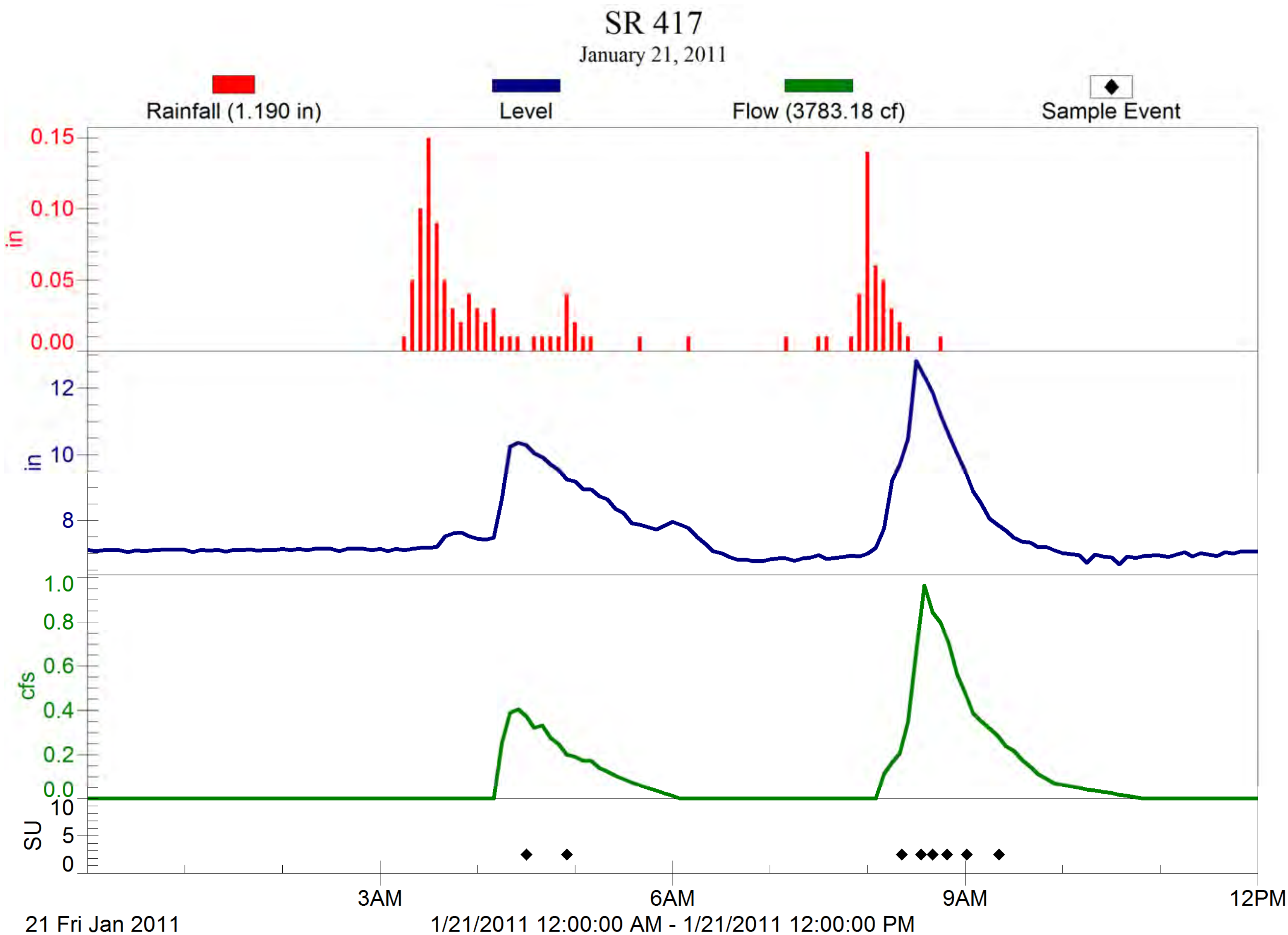


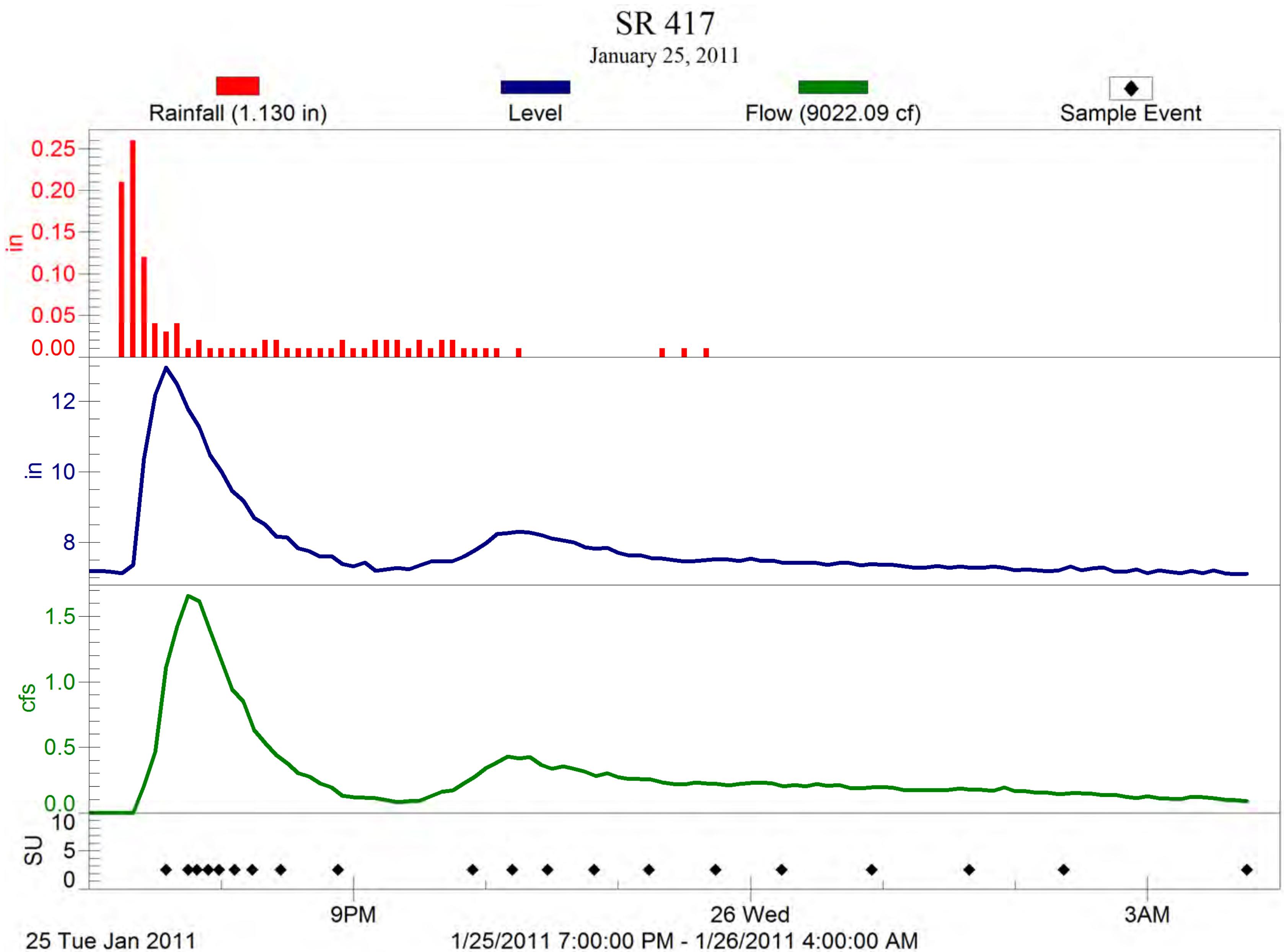
SR 417
September 24, 2010
Rainfall (1.280 in)
Level
Flow (7291.52 cf)
Sample Event
in
0.2
0.1
0.0
in
12
10
8
cfs
3
2
1
0
SU
10
5
0
18:30
19:00
19:30
20:00
20:30
21:00
24 Fri Sep 2010
9/24/2010 6:00:00 PM - 9/24/2010 9:00:00 PM

SR 417

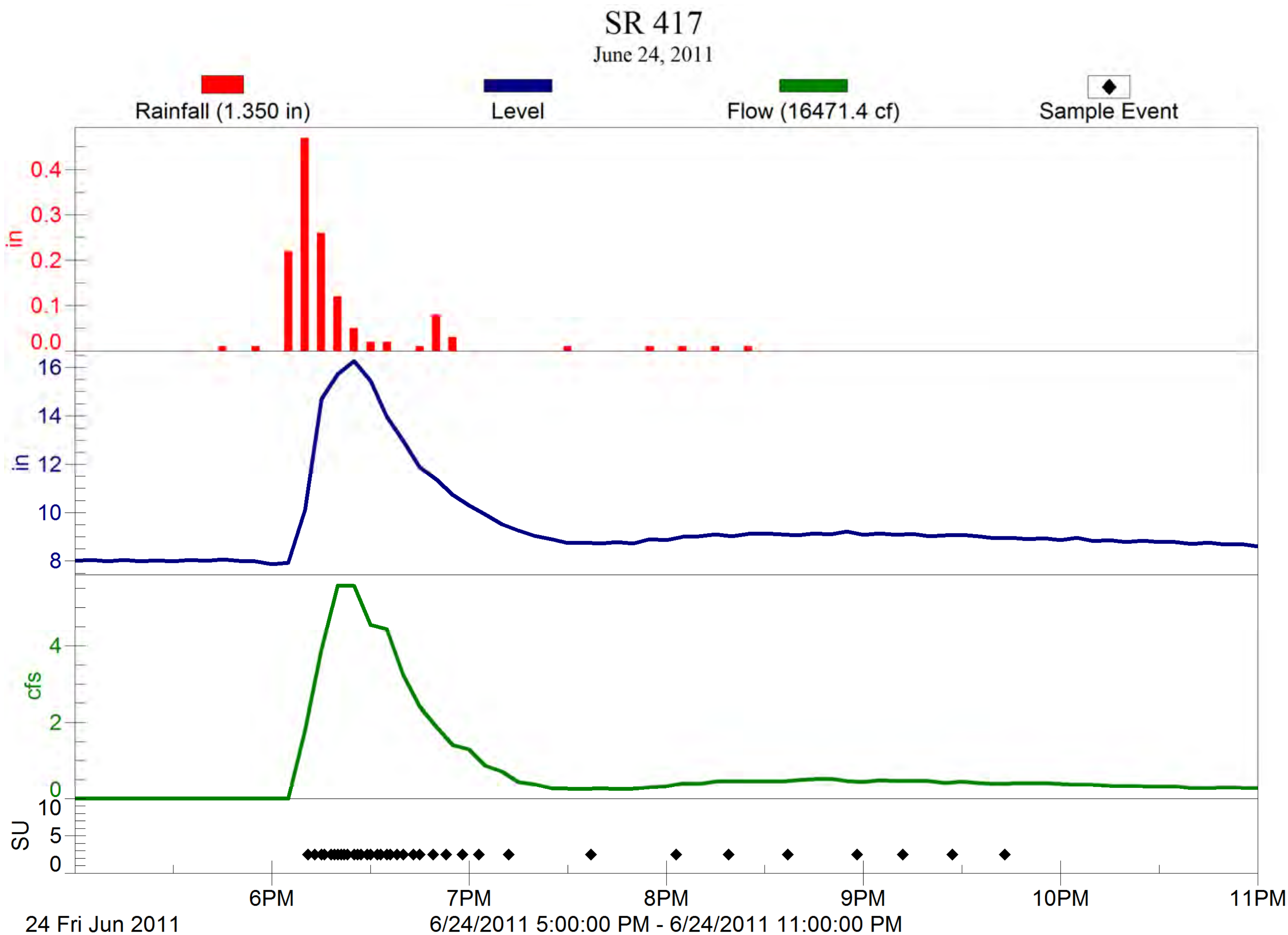
January 17, 2011




SR 417
January 21, 2011
Rainfall (1.190 in)
Level
Flow (3783.18 cf)
Sample Event
0.15
0.10
0.05
0.00
in
12
10
8
in
1.0
0.8
0.6
0.4
0.2
0.0
cfs
10
5
0
SU
3AM
6AM
9AM
12PM
21 Fri Jan 2011
1/21/2011 12:00:00 AM - 1/21/2011 12:00:00 PM

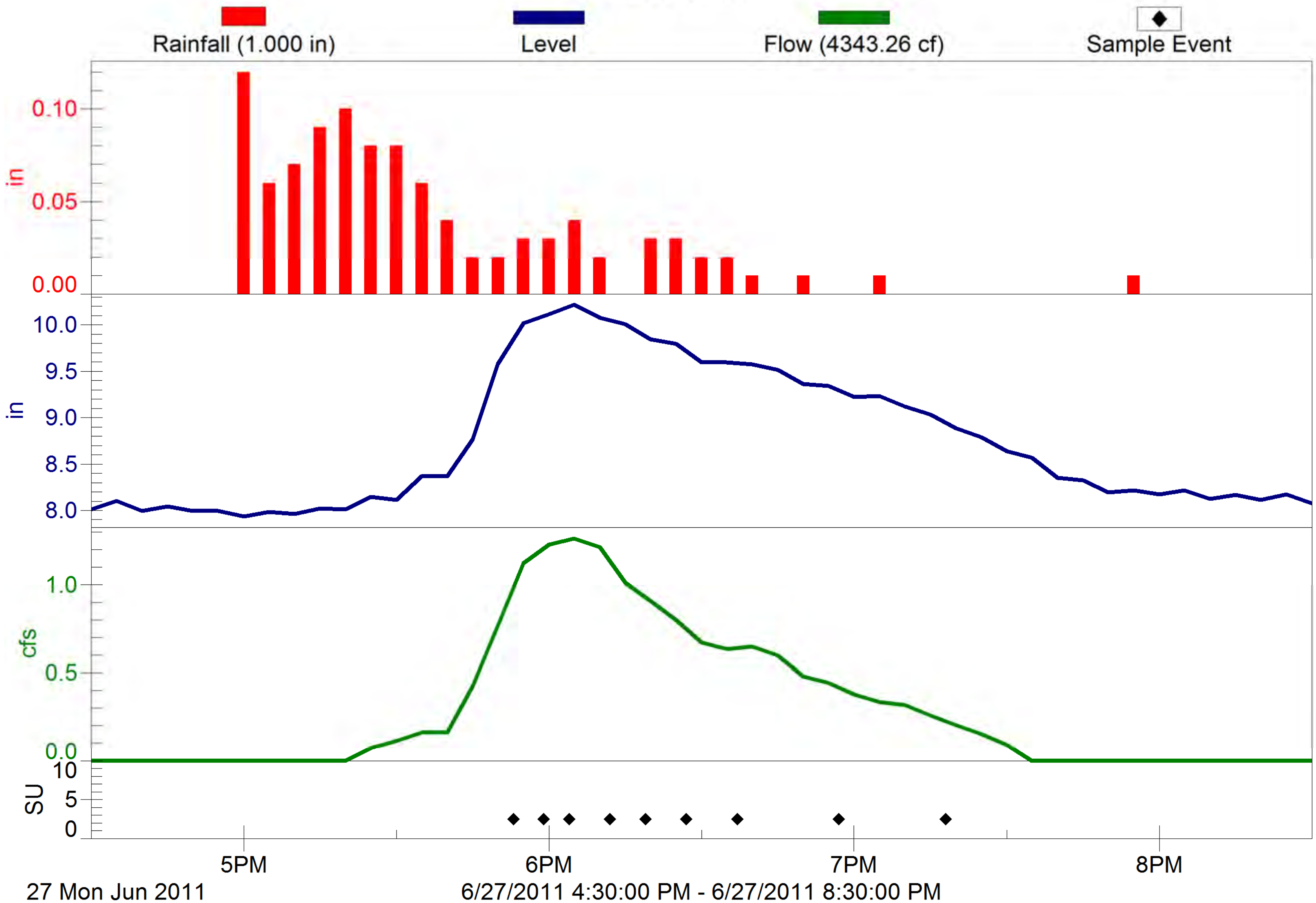


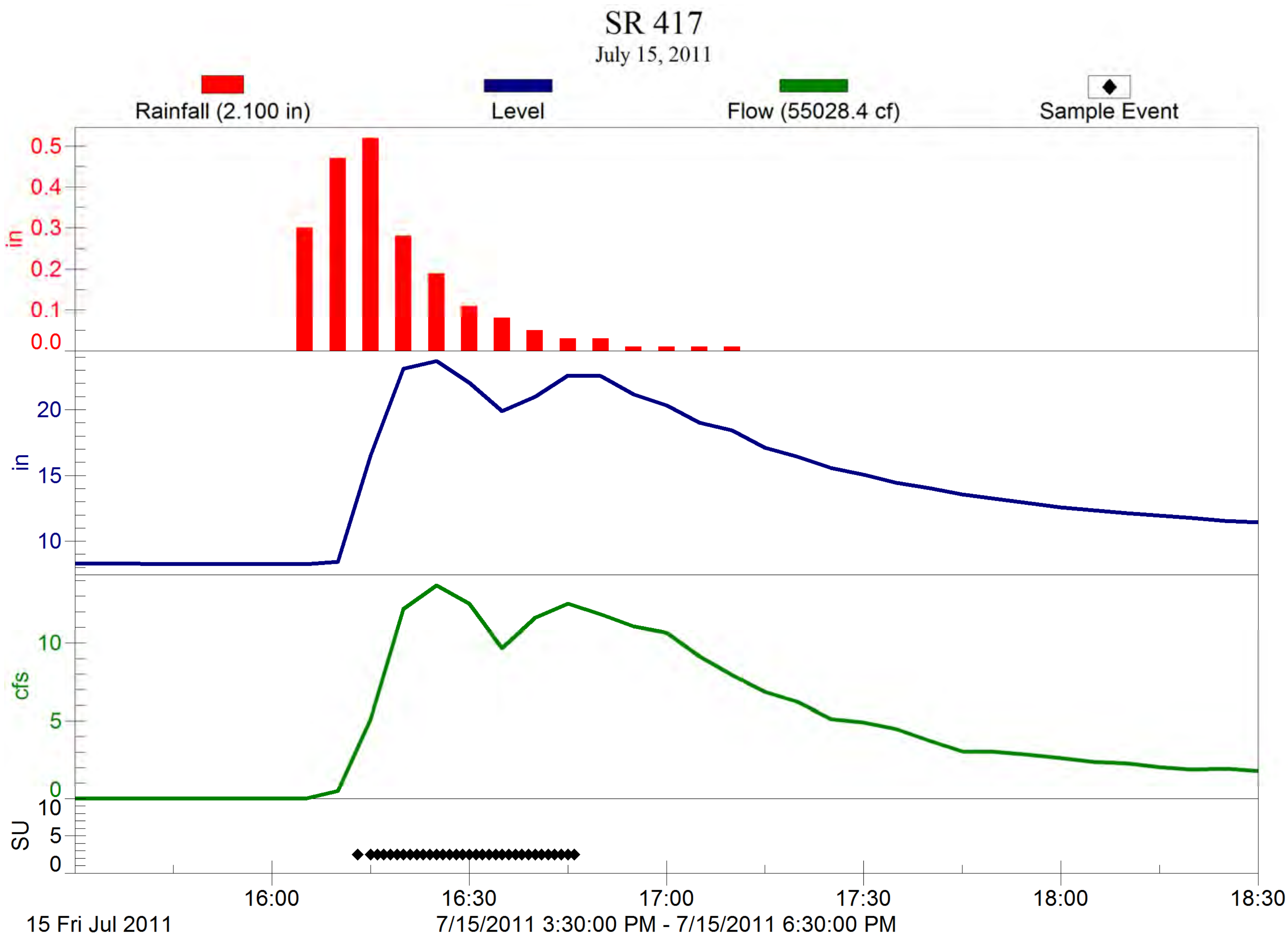
SR 417
January 25, 2011
Rainfall (1.130 in)
Level
Flow (9022.09 cf)
Sample Event
in
0.25
0.20
0.15
0.10
0.05
0.00
in
12
10
8
cfs
1.5
1.0
0.5
0.0
SU
10
5
0
9PM
26 Wed
3AM
25 Tue Jan 2011
1/25/2011 7:00:00 PM - 1/26/2011 4:00:00 AM


SR 417
June 24, 2011
Rainfall (1.350 in)
Level
Flow (16471.4 cf)
Sample Event
in
0.4
0.3
0.2
0.1
0.0
16
14
12
10
8
cfs
4
2
0
SU
10
5
0
6PM
7PM
8PM
9PM
10PM
11PM
24 Fri Jun 2011
6/24/2011 5:00:00 PM - 6/24/2011 11:00:00 PM

SR 417

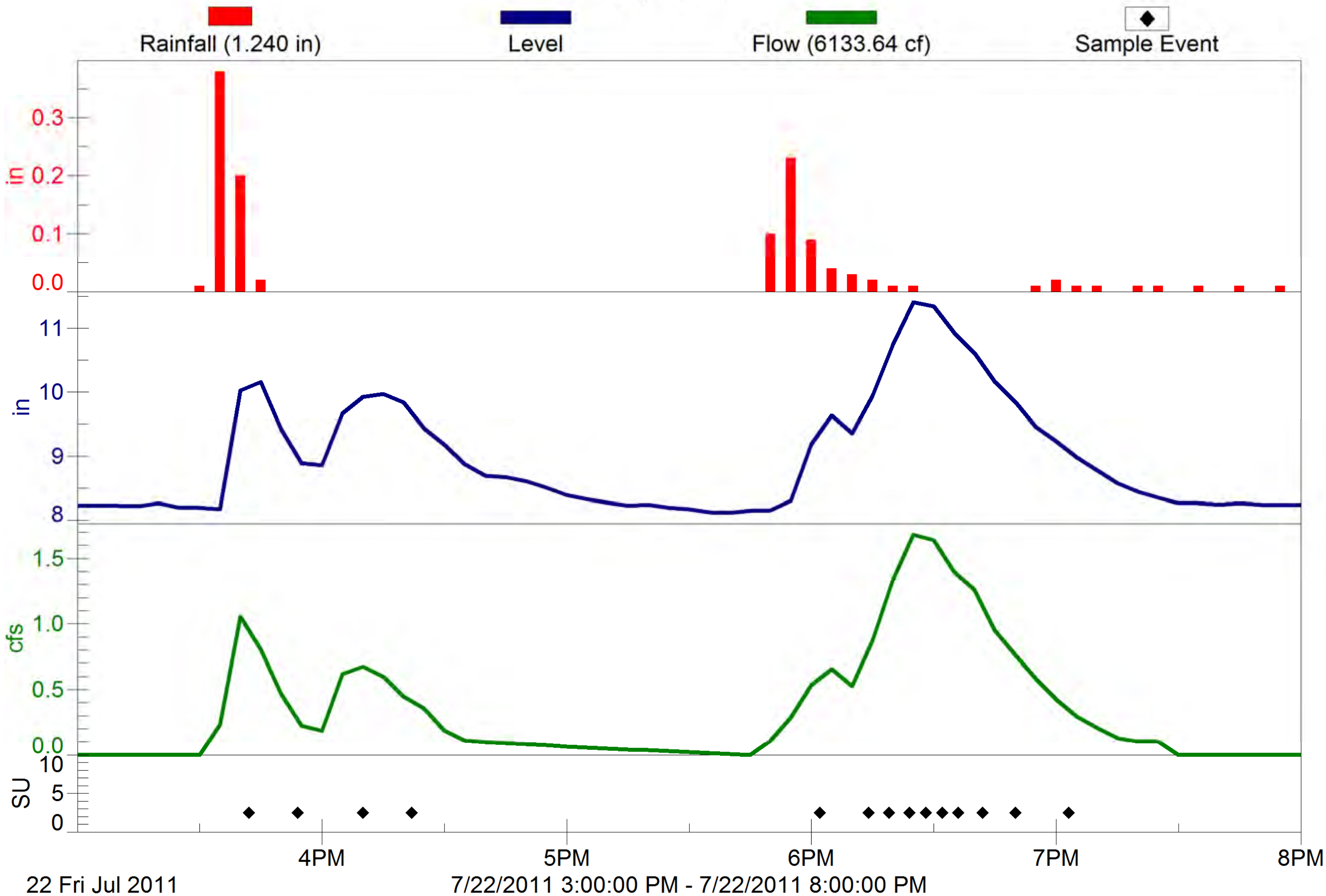
June 27, 2011

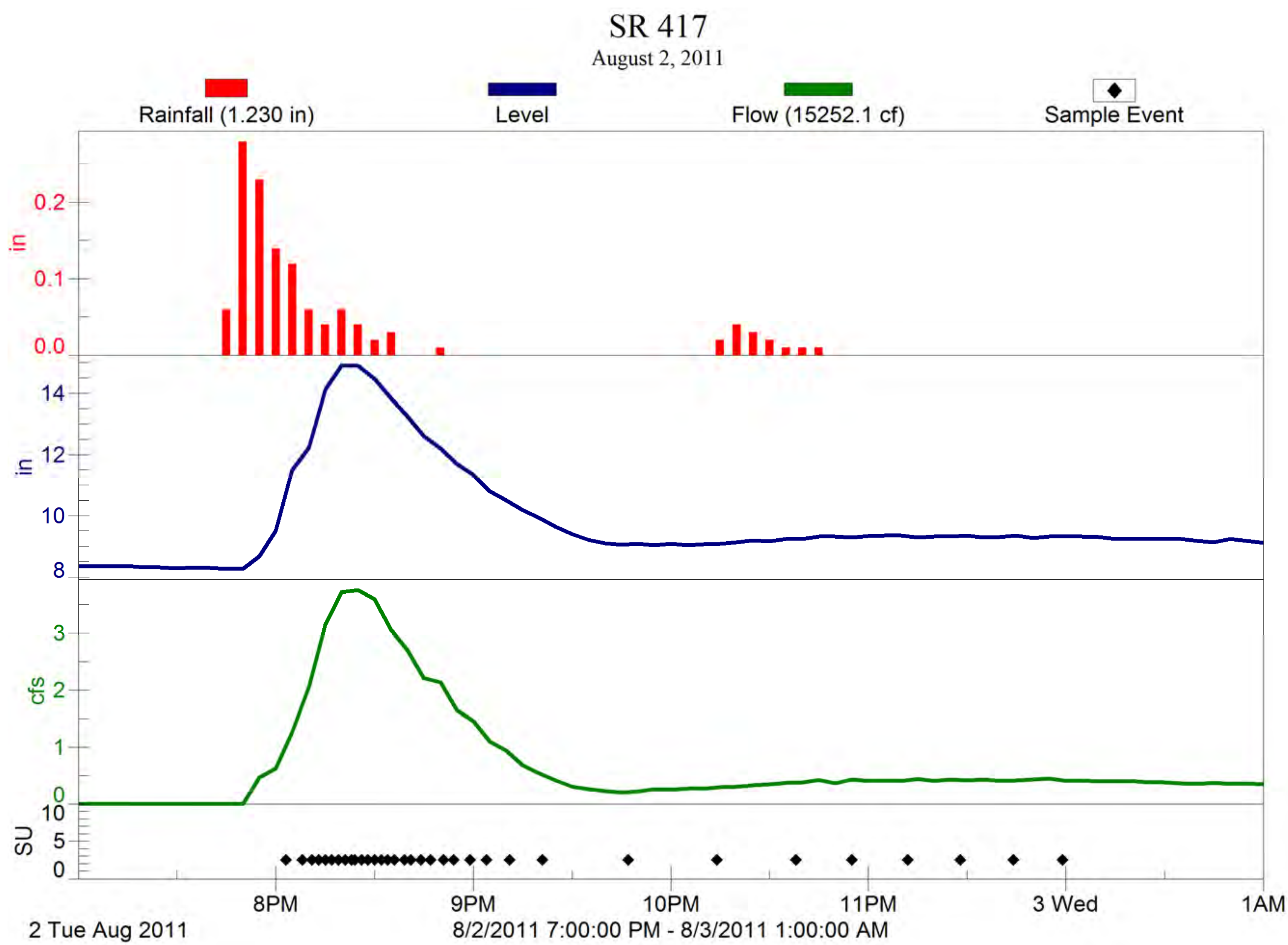



SR 417
July 15, 2011
Rainfall (2.100 in)
Level
Flow (55028.4 cf)
Sample Event
in
0.5
0.4
0.3
0.2
0.1
0.0
in
20
15
10
cfs
10
5
0
SU
10
5
0
16:00
16:30
17:00
17:30
18:00
18:30
15 Fri Jul 2011
7/15/2011 3:30:00 PM - 7/15/2011 6:30:00 PM

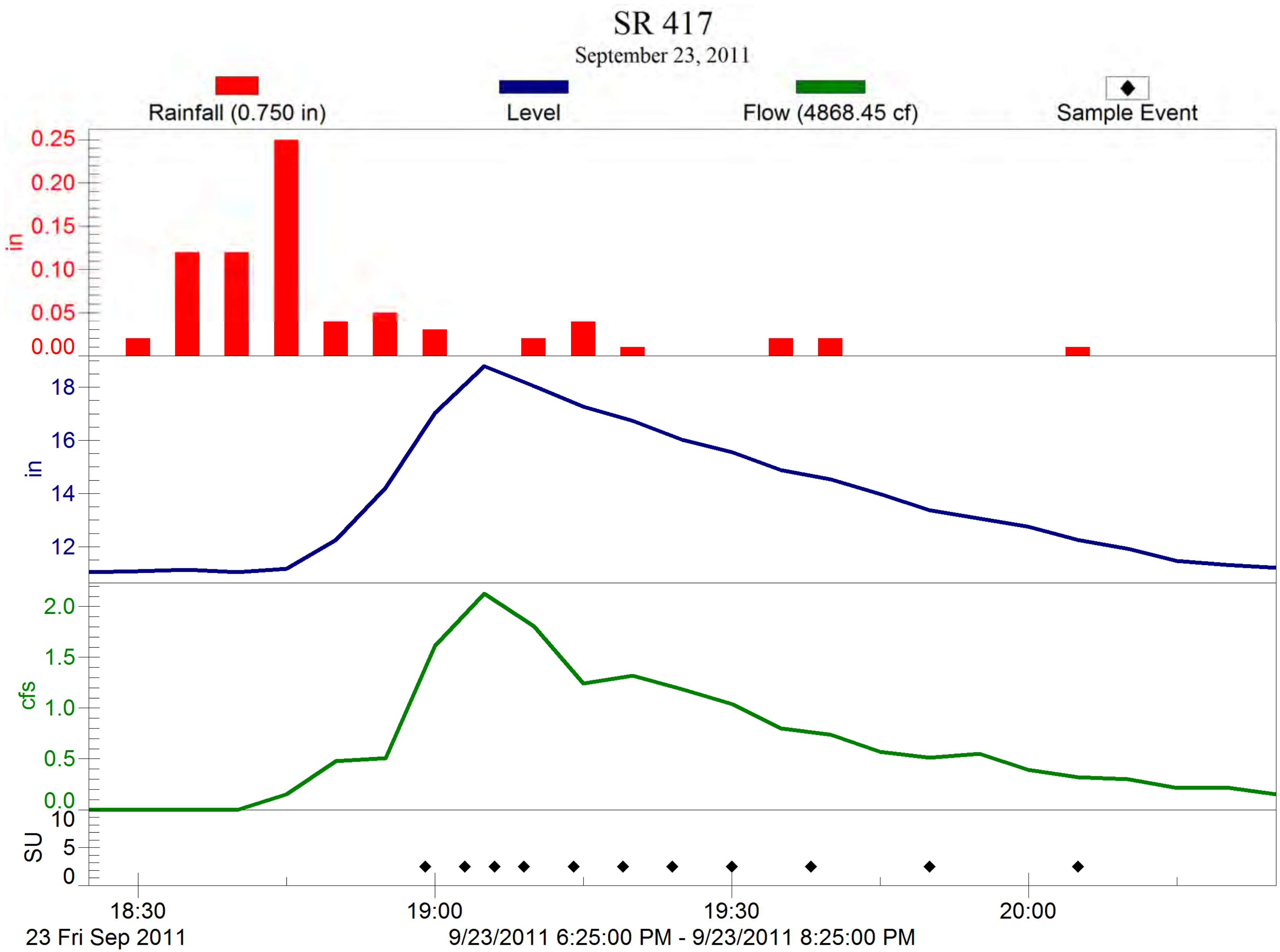
SR 417

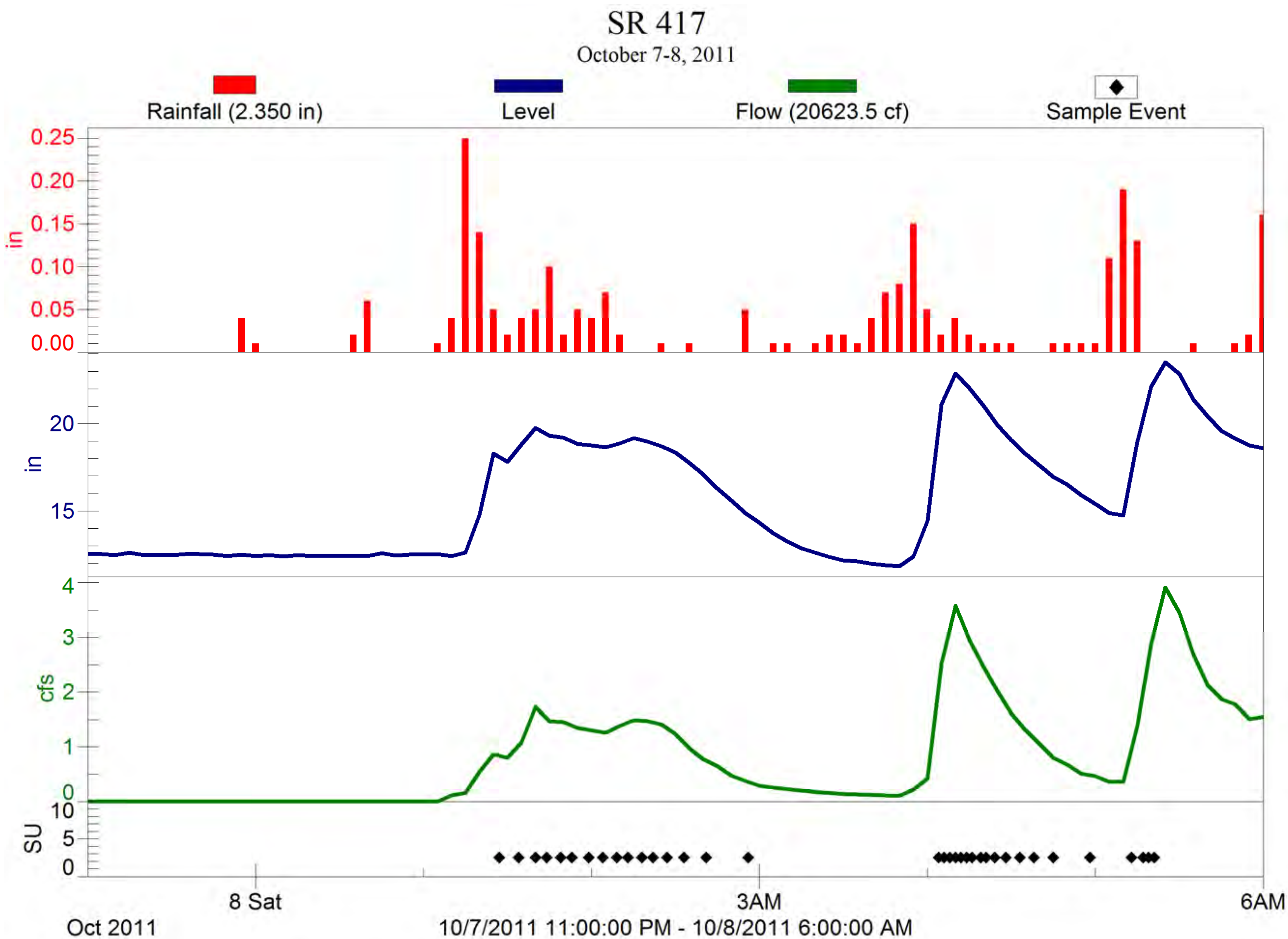
July 22, 2011





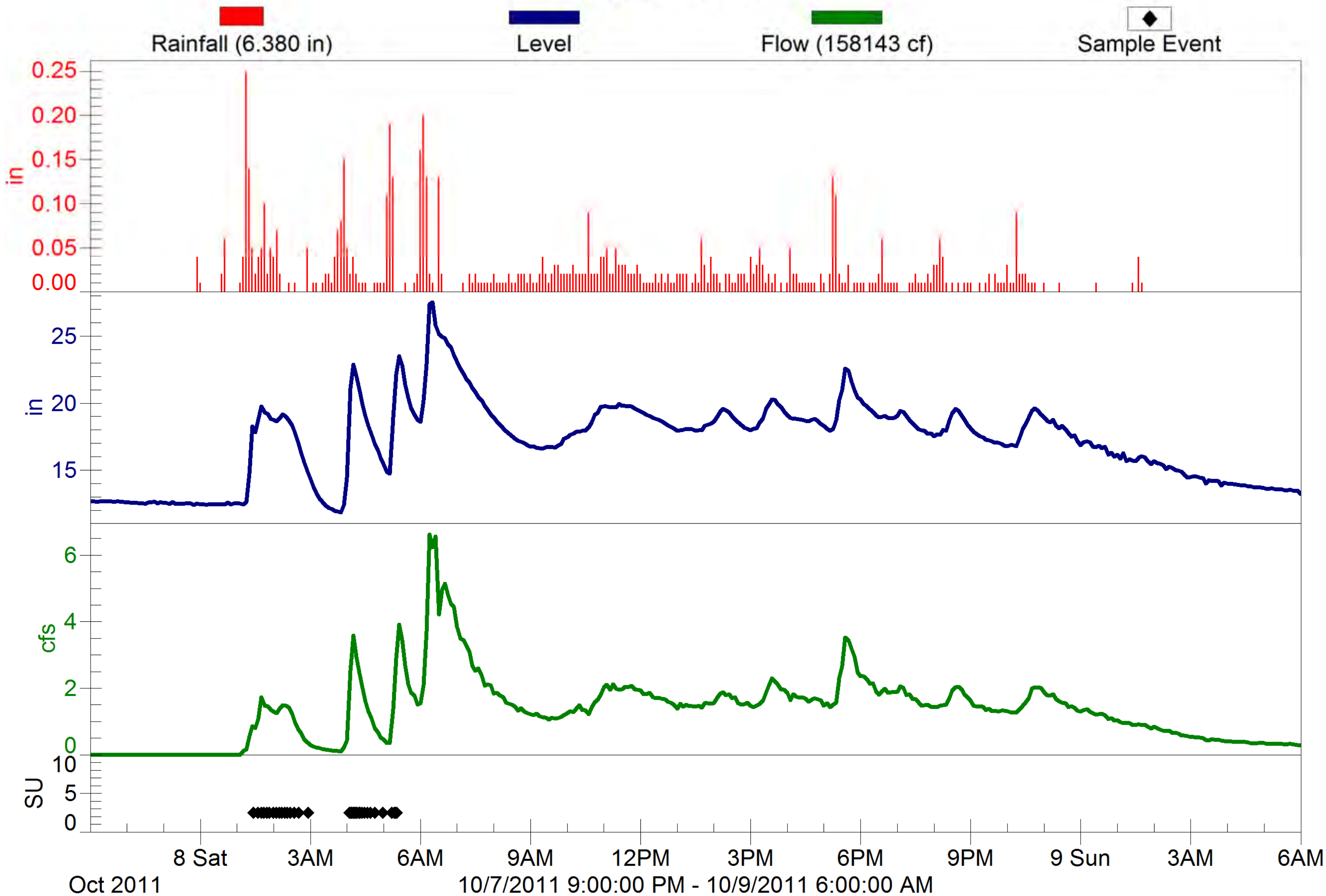
SR 417
August 2, 2011
Rainfall (1.230 in)
Level
Flow (15252.1 cf)
Sample Event
in
0.2
0.1
0.0
in
14
12
10
8
cfs
3
2
1
0
SU
10
5
0
8PM
9PM
10PM
11PM
3 Wed
1AM
2 Tue Aug 2011
8/2/2011 7:00:00 PM - 8/3/2011 1:00:00 AM

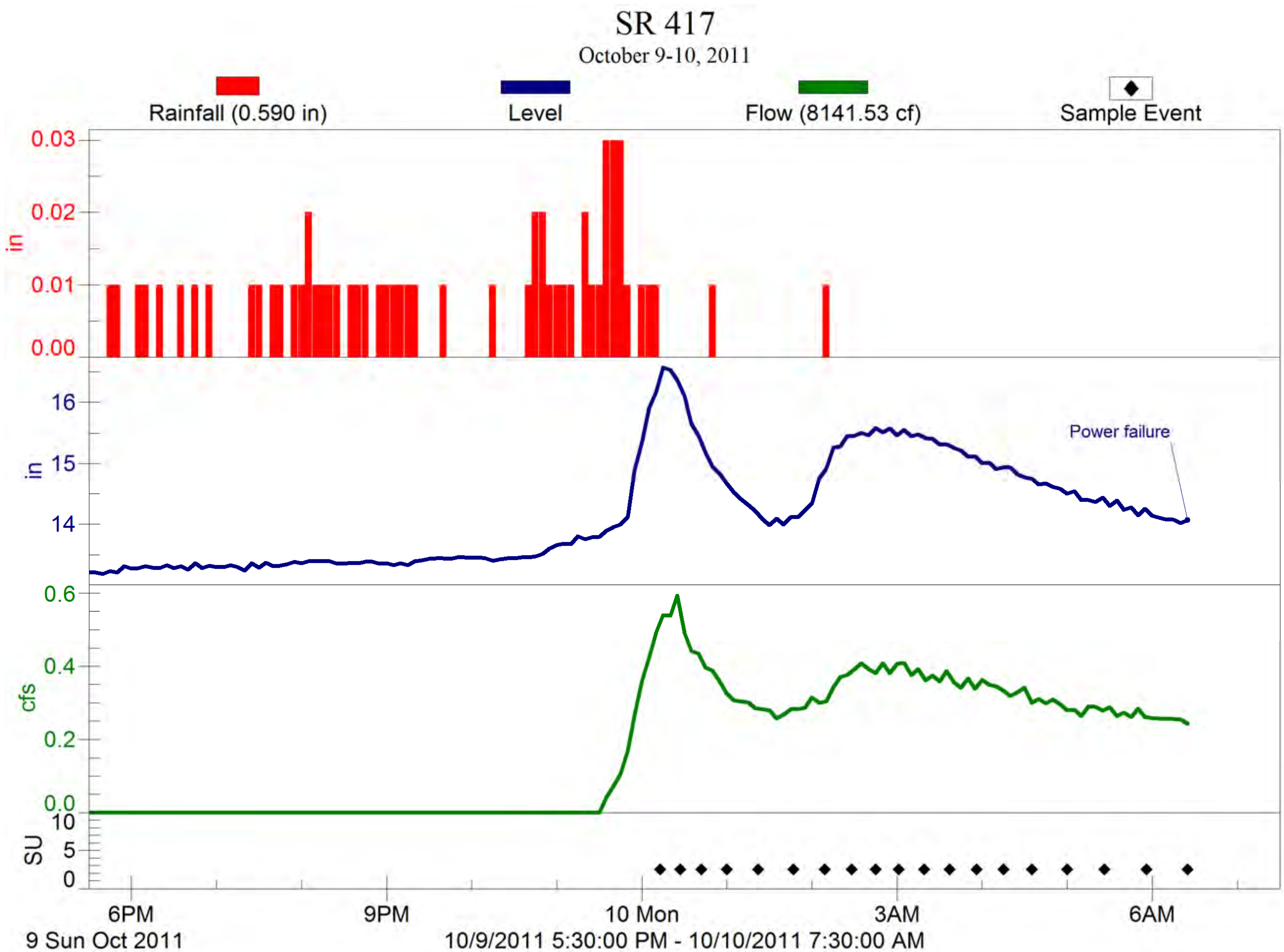

SR 417
September 23, 2011
Rainfall (0.750 in)
Level
Flow (4868.45 cf)
Sample Event
in
0.25
0.20
0.15
0.10
0.05
0.00
in
18
16
14
12
cfs
2.0
1.5
1.0
0.5
0.0
SU
10
5
0
18:30
19:00
19:30
20:00
23 Fri Sep 2011
9/23/2011 6:25:00 PM - 9/23/2011 8:25:00 PM

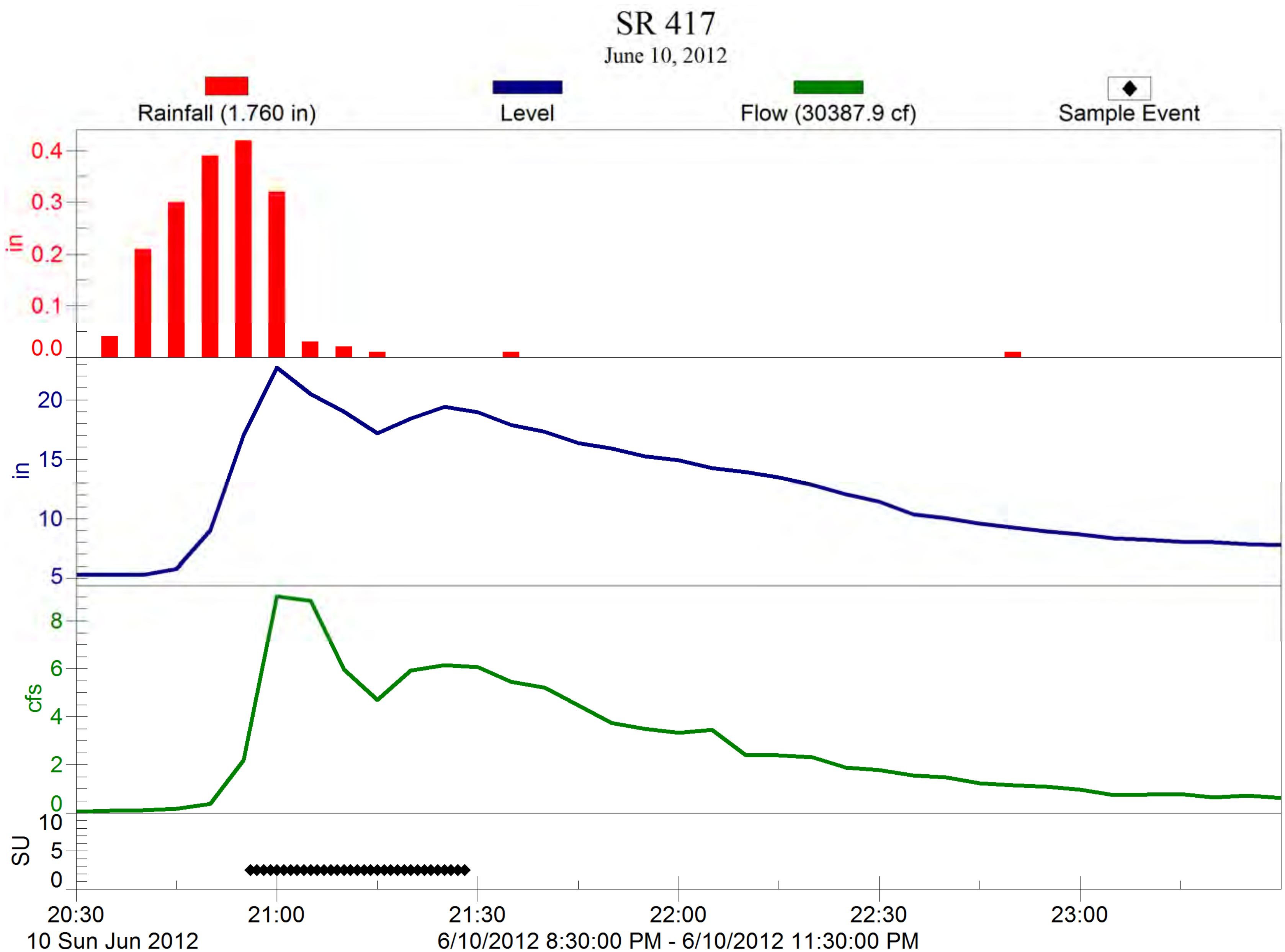

SR 417
October 7-8, 2011
Rainfall (2.350 in)
Level
Flow (20623.5 cf)
Sample Event
0.25
0.20
0.15
0.10
0.05
0.00
in
20
15
in
4
3
2
1
0
cfs
10
5
0
SU
8 Sat
3AM
6AM
Oct 2011
10/7/2011 11:00:00 PM - 10/8/2011 6:00:00 AM

SR 417

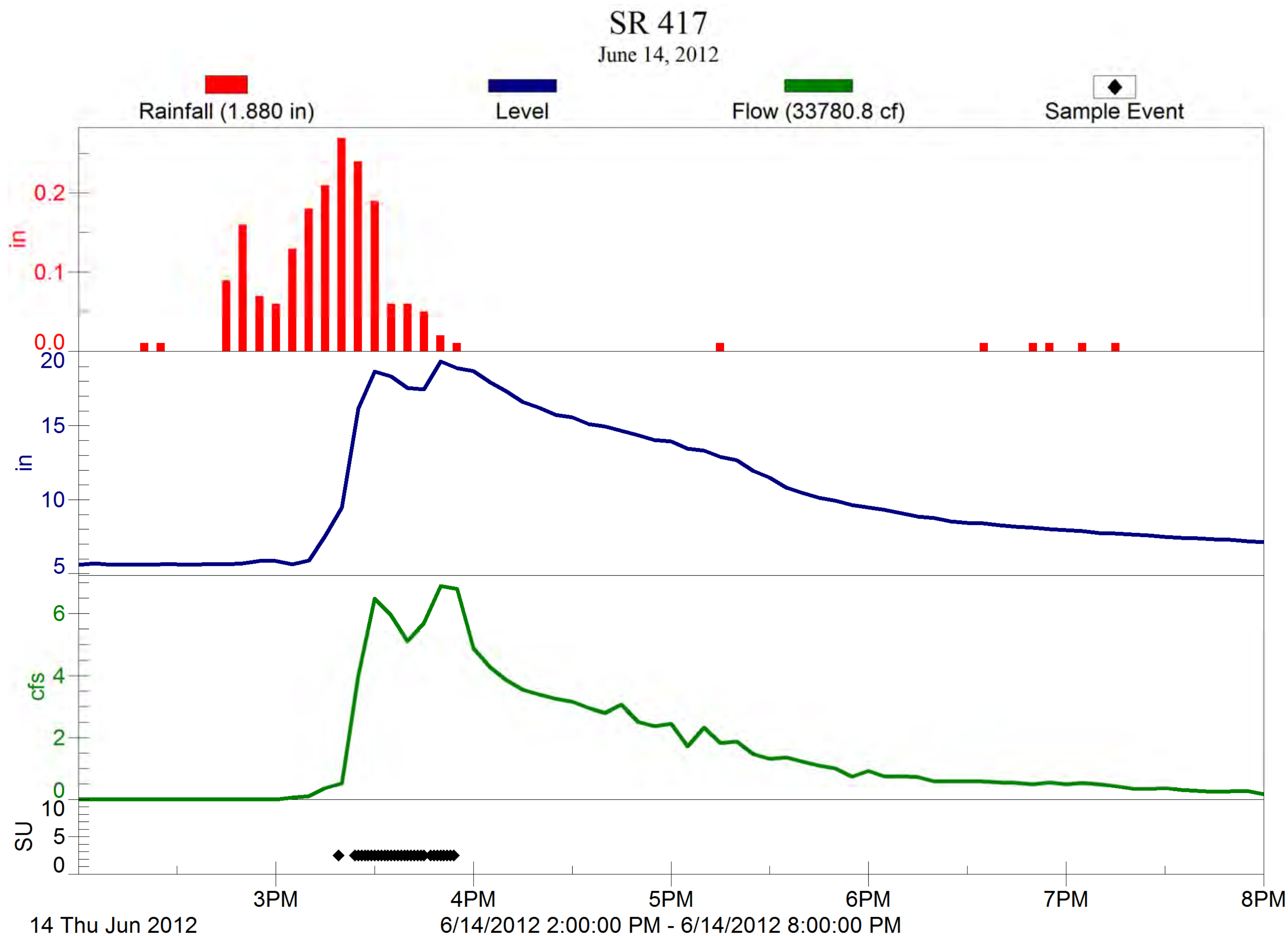
October 7-9, 2011



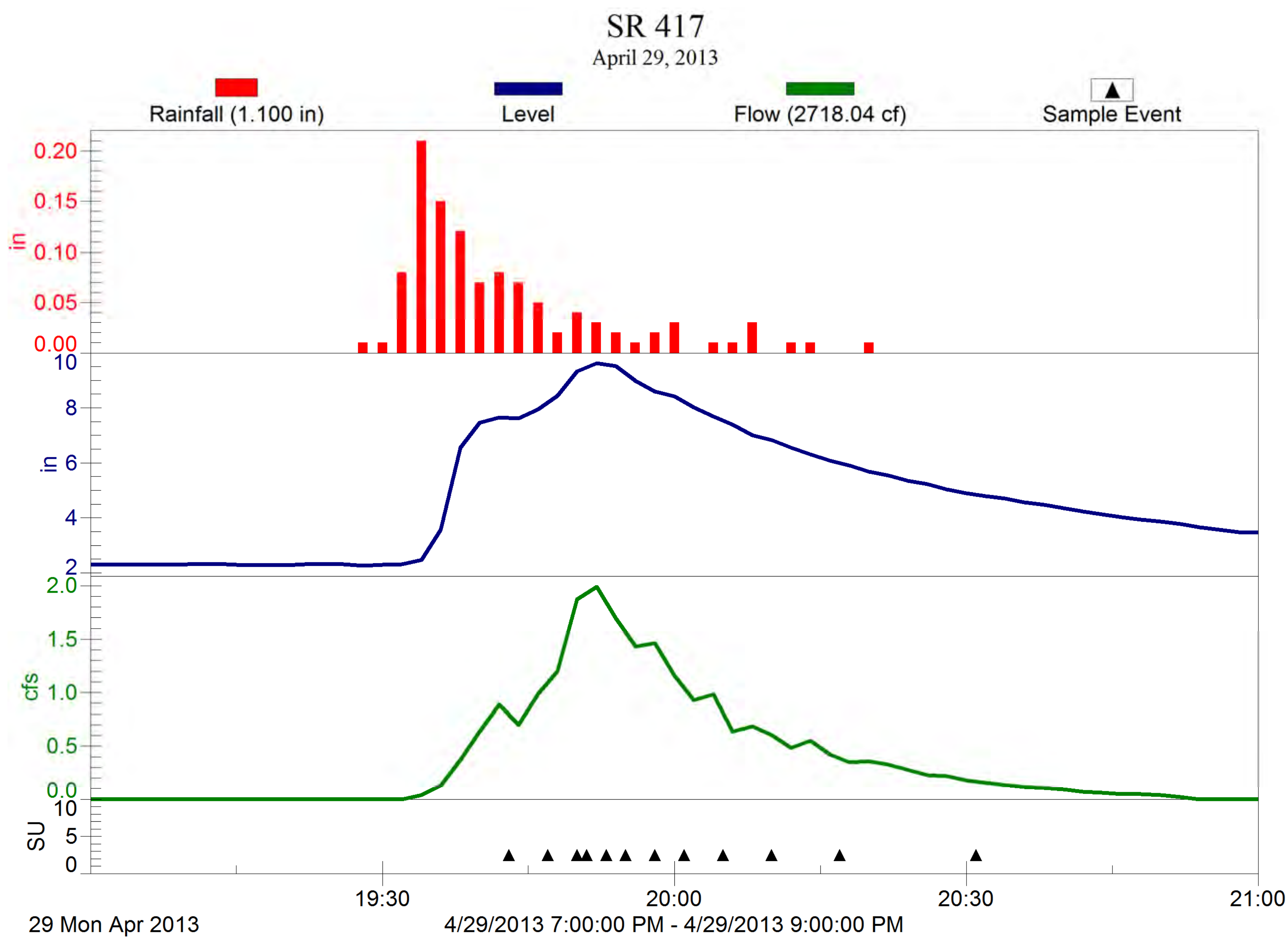

SR 417
October 9-10, 2011
Rainfall (0.590 in)
Level
Flow (8141.53 cf)
Sample Event
0.03
0.02
0.01
0.00
in
16
15
14
in
Power failure
0.6
0.4
0.2
0.0
cfs
10
5
0
SU
6PM
9 Sun Oct 2011
9PM
10 Mon
3AM
6AM
10/9/2011 5:30:00 PM - 10/10/2011 7:30:00 AM

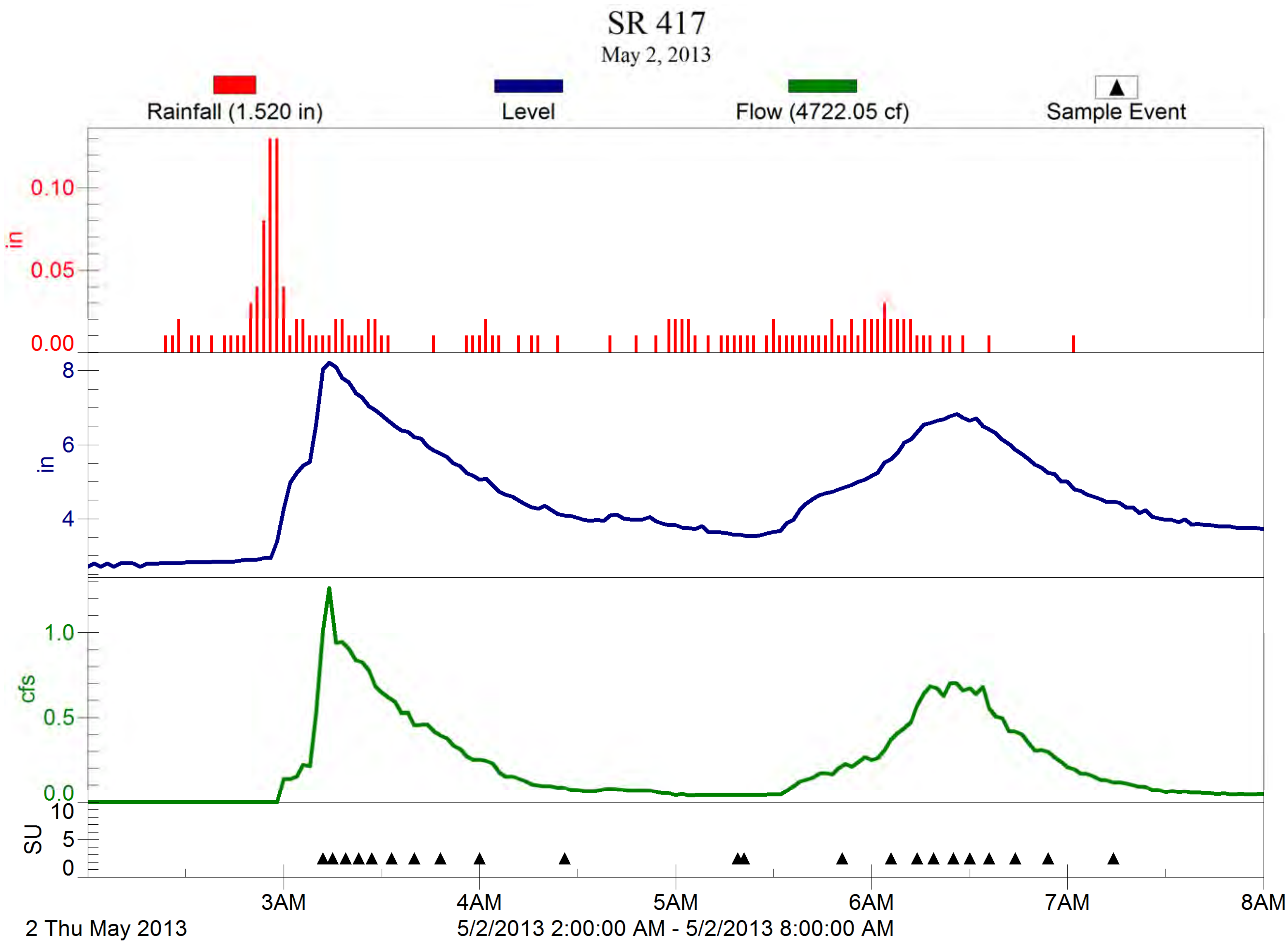


SR 417
June 10, 2012
Rainfall (1.760 in)
Level
Flow (30387.9 cf)
Sample Event
0.4
0.3
in
0.2
0.1
0.0
20
15
in
10
5
8
6
cfs
4
2
0
10
SU
5
0
20:30
10 Sun Jun 2012
21:00
21:30
22:00
22:30
23:00
6/10/2012 8:30:00 PM - 6/10/2012 11:30:00 PM



SR 417
June 14, 2012
Rainfall (1.880 in)
Level
Flow (33780.8 cf)
Sample Event
0.2
0.1
0.0
in
20
15
10
5
in
6
4
2
0
cfs
10
5
0
SU
3PM
4PM
5PM
6PM
7PM
8PM
14 Thu Jun 2012
6/14/2012 2:00:00 PM - 6/14/2012 8:00:00 PM

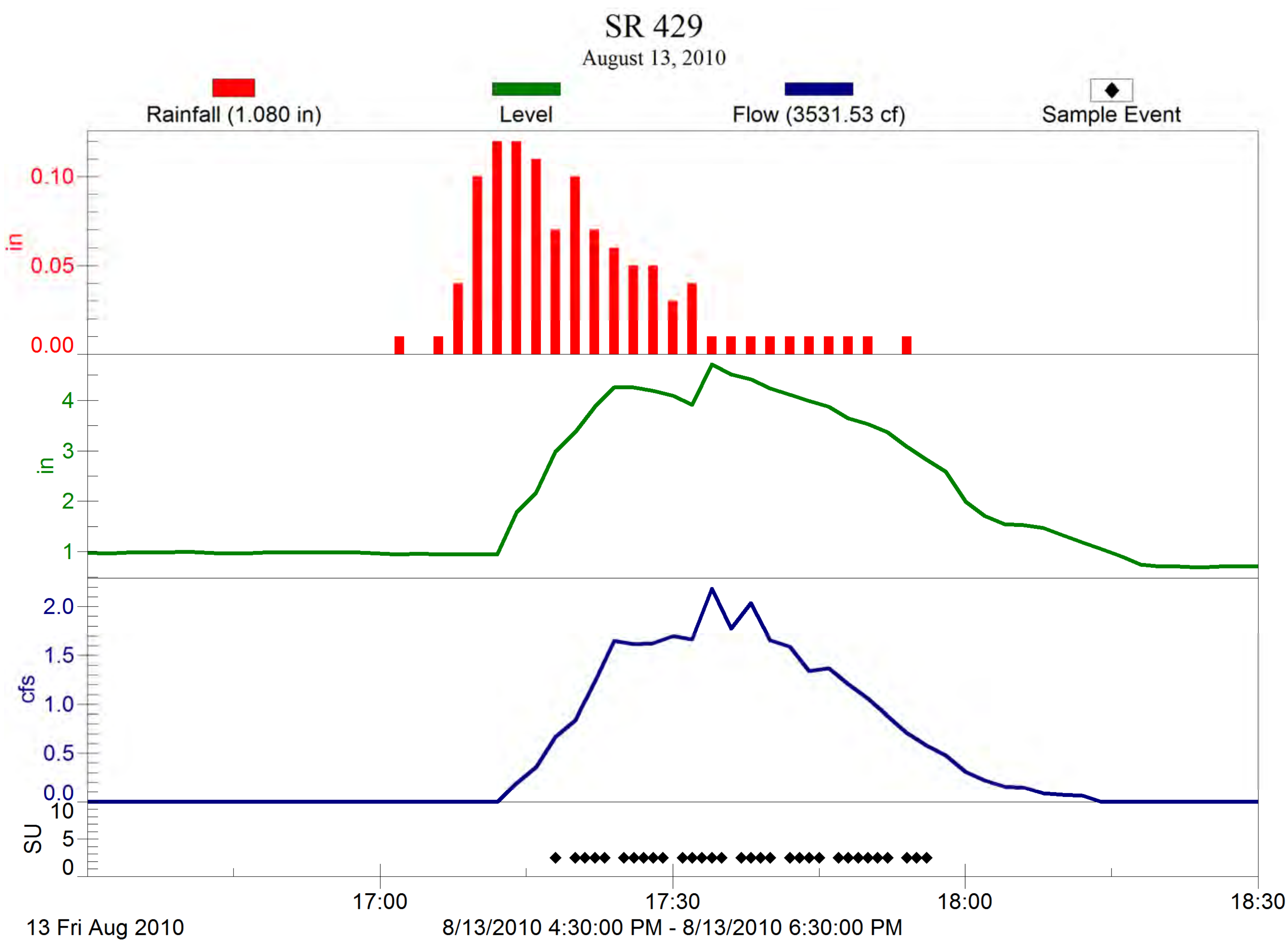

SR 417
April 29, 2013
Rainfall (1.100 in)
Level
Flow (2718.04 cf)
Sample Event
in
0.20
0.15
0.10
0.05
0.00
in
10
8
6
4
2
cfs
2.0
1.5
1.0
0.5
0.0
SU
10
5
0
19:30
20:00
20:30
21:00
29 Mon Apr 2013
4/29/2013 7:00:00 PM - 4/29/2013 9:00:00 PM

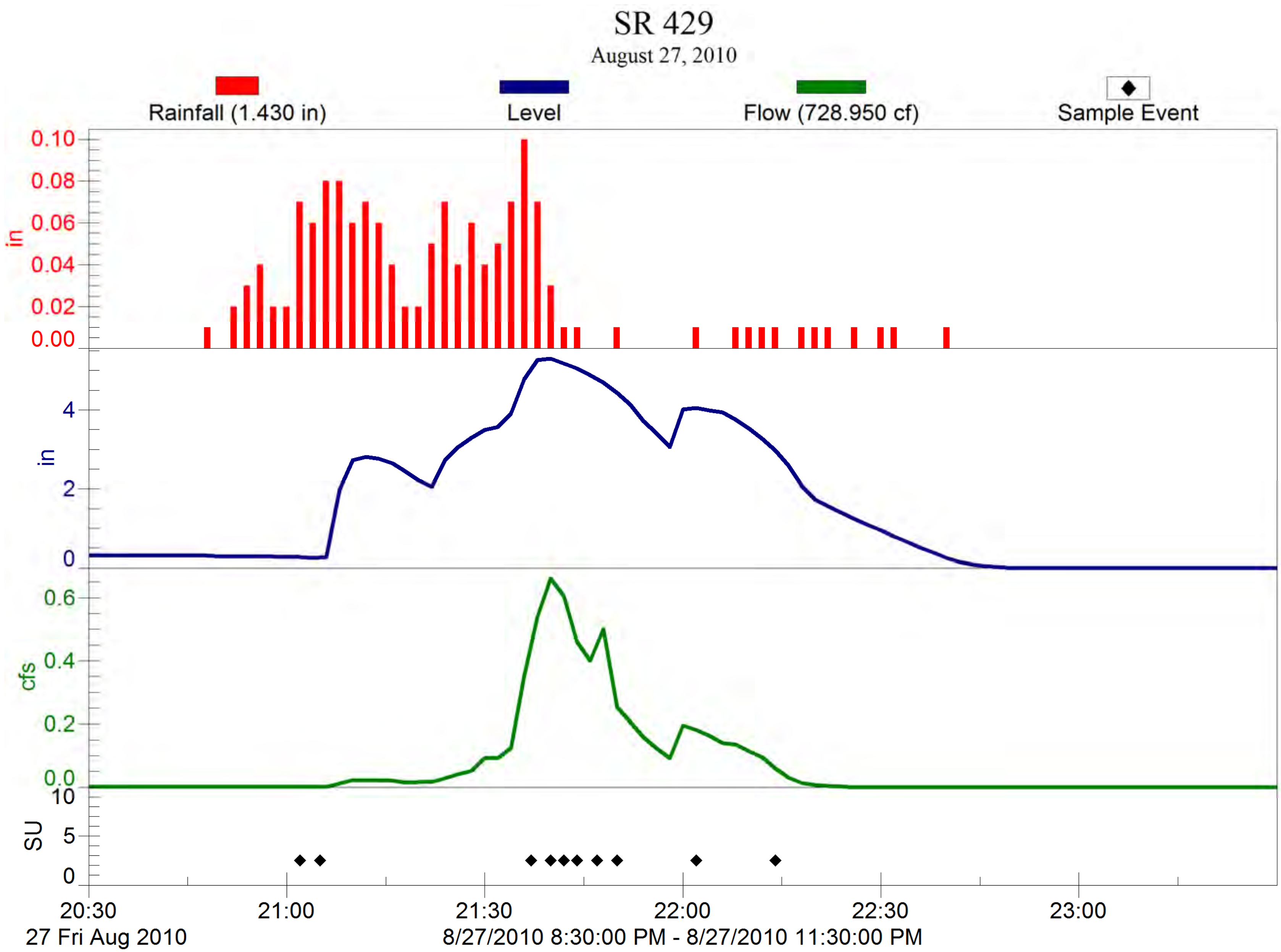

SR 417
May 2, 2013
Rainfall (1.520 in)
Level
Flow (4722.05 cf)
Sample Event
0.10
0.05
0.00
in
8
6
4
in
1.0
0.5
0.0
cfs
10
5
0
SU
3AM
4AM
5AM
6AM
7AM
8AM
2 Thu May 2013
5/2/2013 2:00:00 AM - 5/2/2013 8:00:00 AM

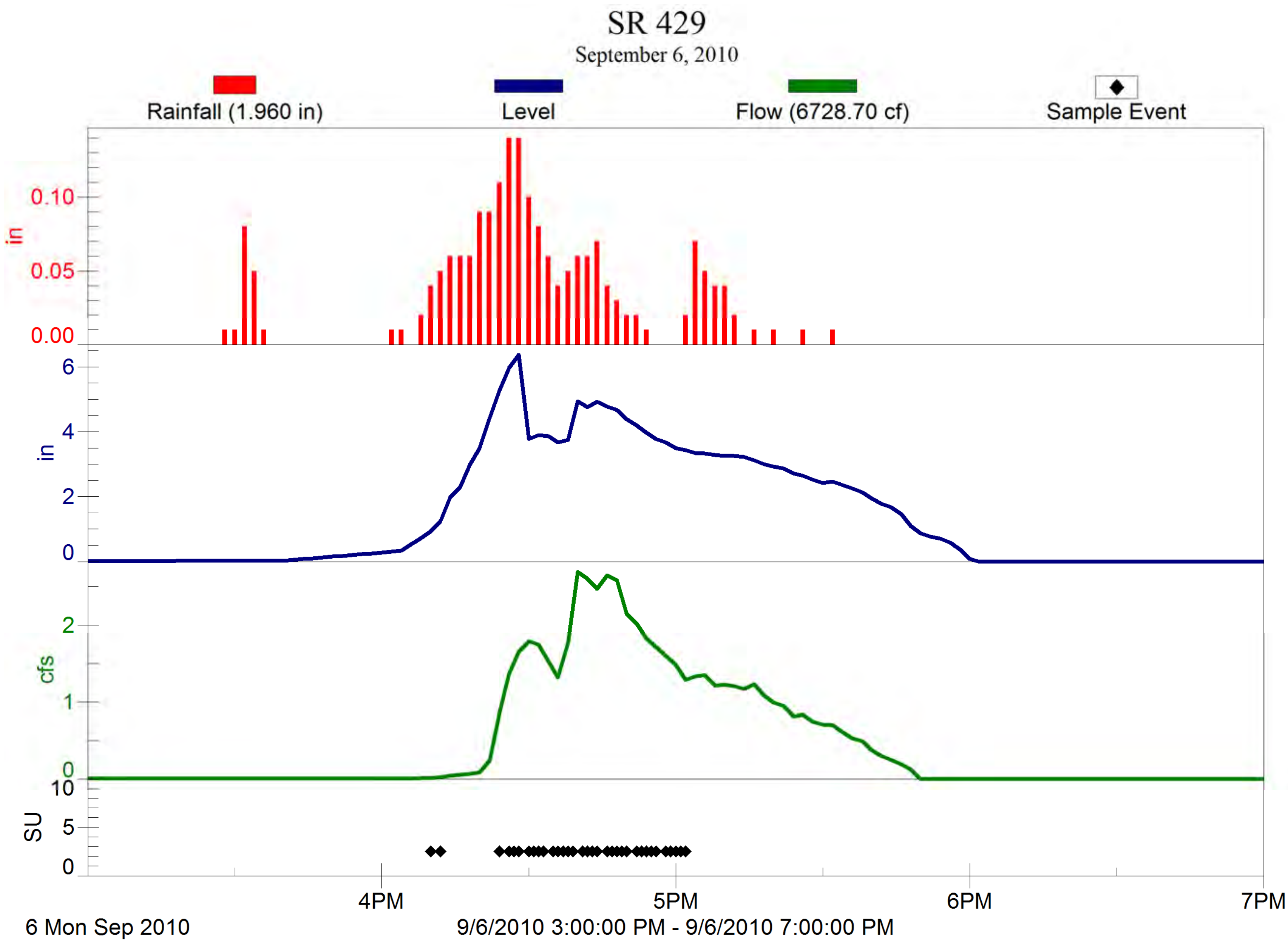
Appendix E

Storm Event Data for SR 429 Sampling Location

(Laboratory results included on the accompanying CD)

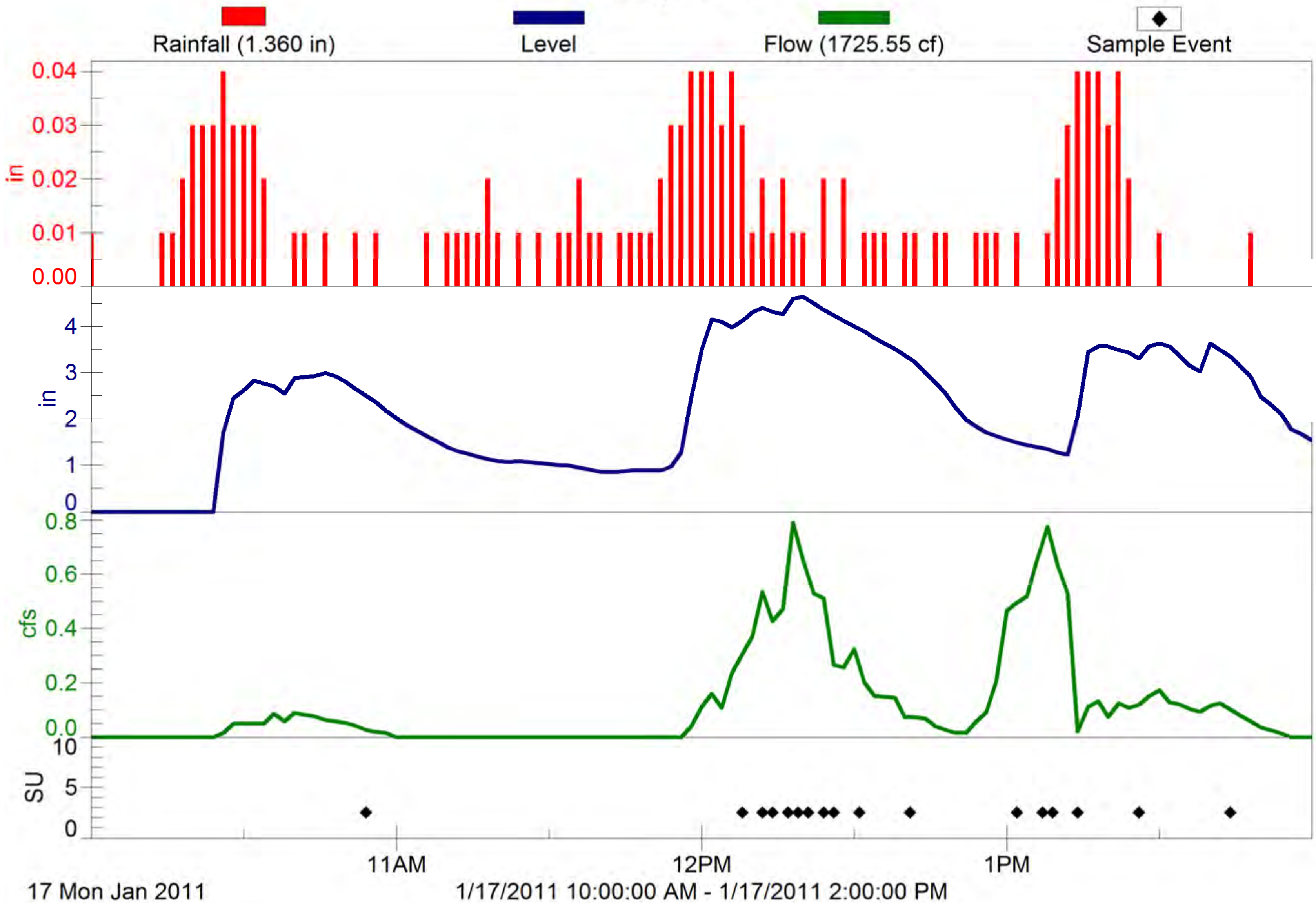

SR 429
August 13, 2010
Rainfall (1.080 in)
Level
Flow (3531.53 cf)
Sample Event
in
0.10
0.05
0.00
in
4
3
2
1
cfs
2.0
1.5
1.0
0.5
0.0
SU
10
5
0
17:00
17:30
18:00
18:30
13 Fri Aug 2010
8/13/2010 4:30:00 PM - 8/13/2010 6:30:00 PM

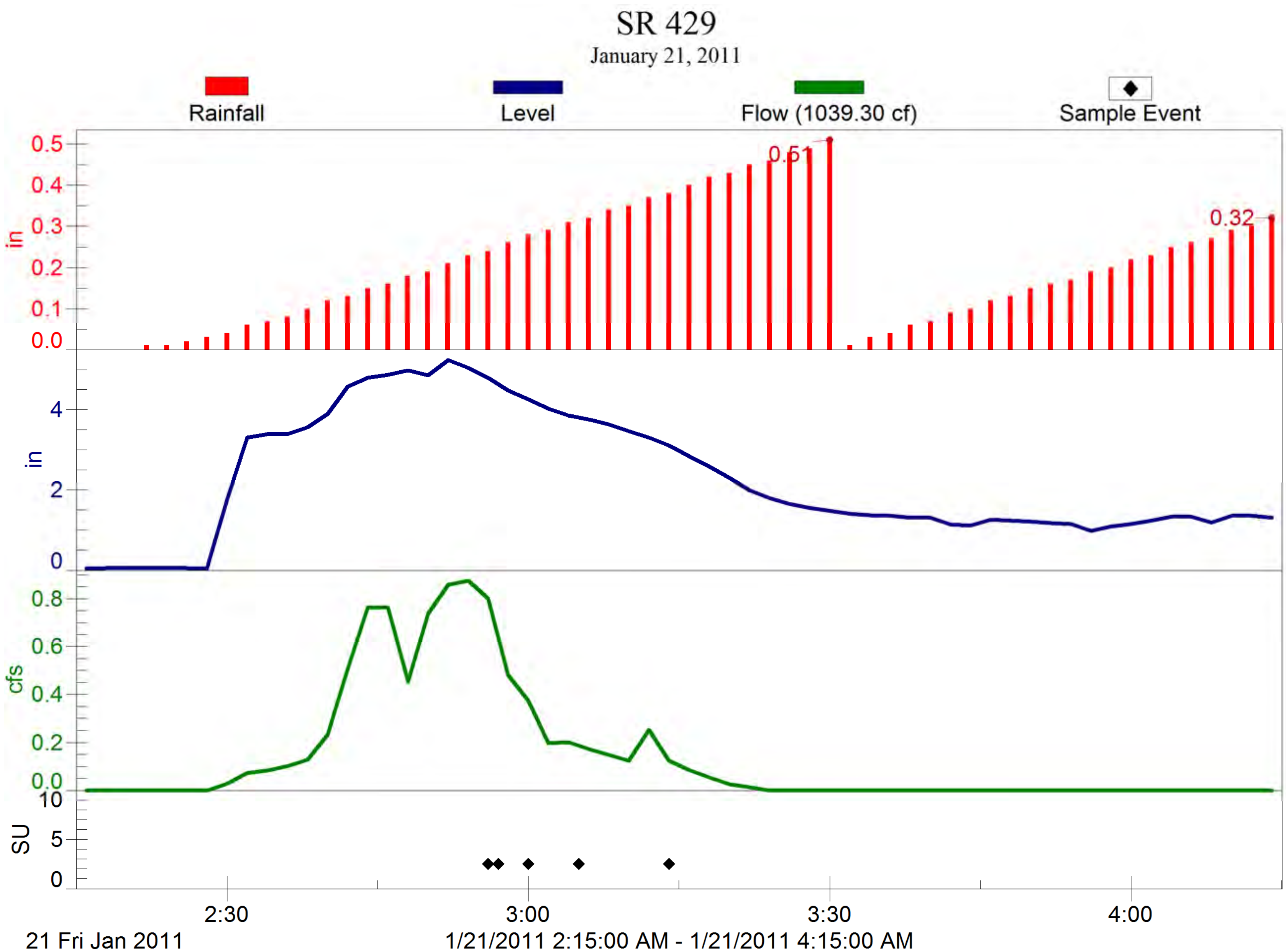

SR 429
August 27, 2010
Rainfall (1.430 in)
Level
Flow (728.950 cf)
Sample Event
in
0.10
0.08
0.06
0.04
0.02
0.00
in
4
2
0
cfs
0.6
0.4
0.2
0.0
SU
10
5
0
20:30
27 Fri Aug 2010
21:00
21:30
22:00
22:30
23:00
8/27/2010 8:30:00 PM - 8/27/2010 11:30:00 PM


SR 429
September 6, 2010
Rainfall (1.960 in)
Level
Flow (6728.70 cf)
Sample Event
in
0.10
0.05
0.00
in
6
4
2
0
cfs
2
1
0
SU
10
5
0
4PM
5PM
6PM
7PM
6 Mon Sep 2010
9/6/2010 3:00:00 PM - 9/6/2010 7:00:00 PM

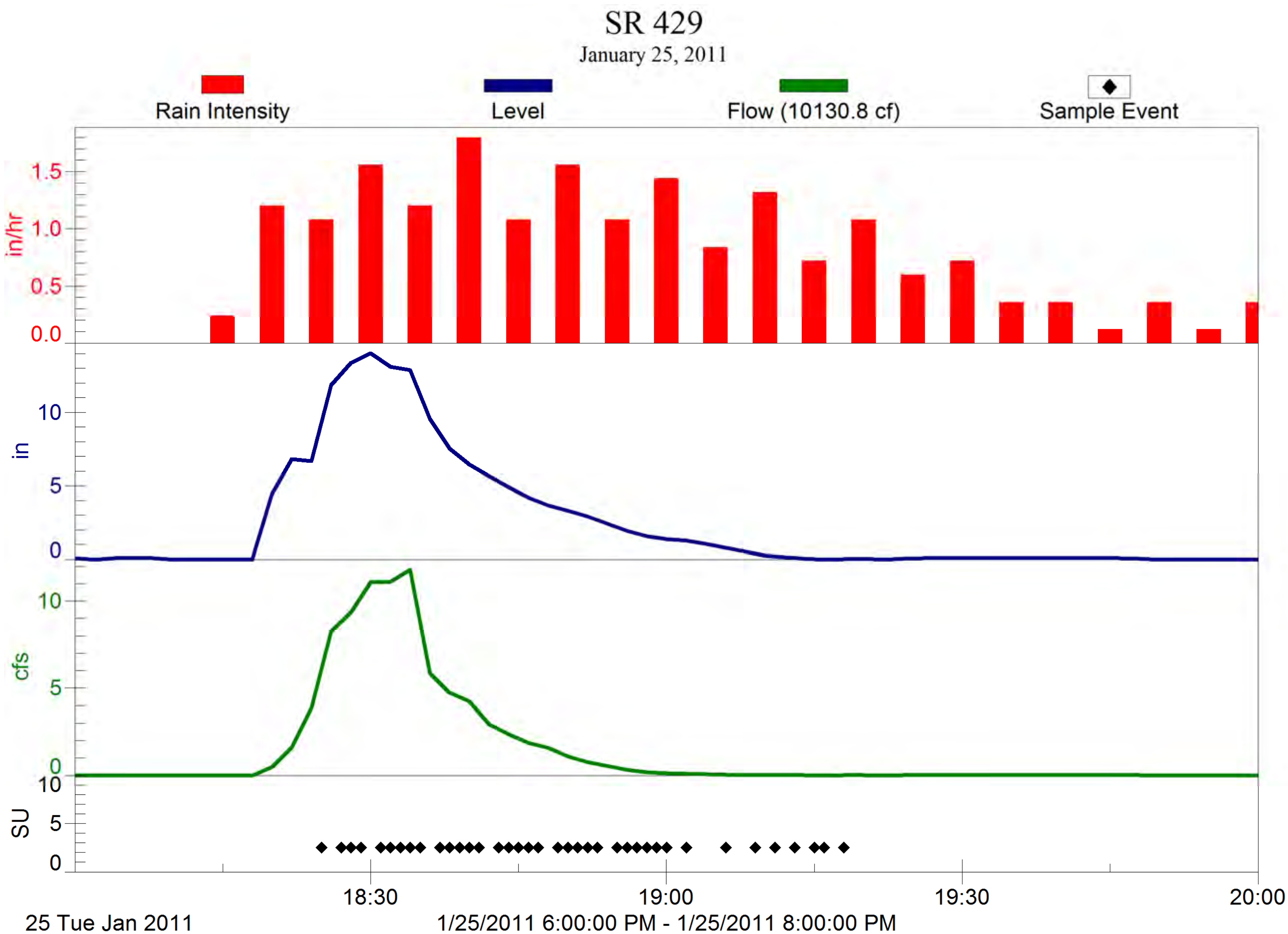
SR 429

January 17, 2011

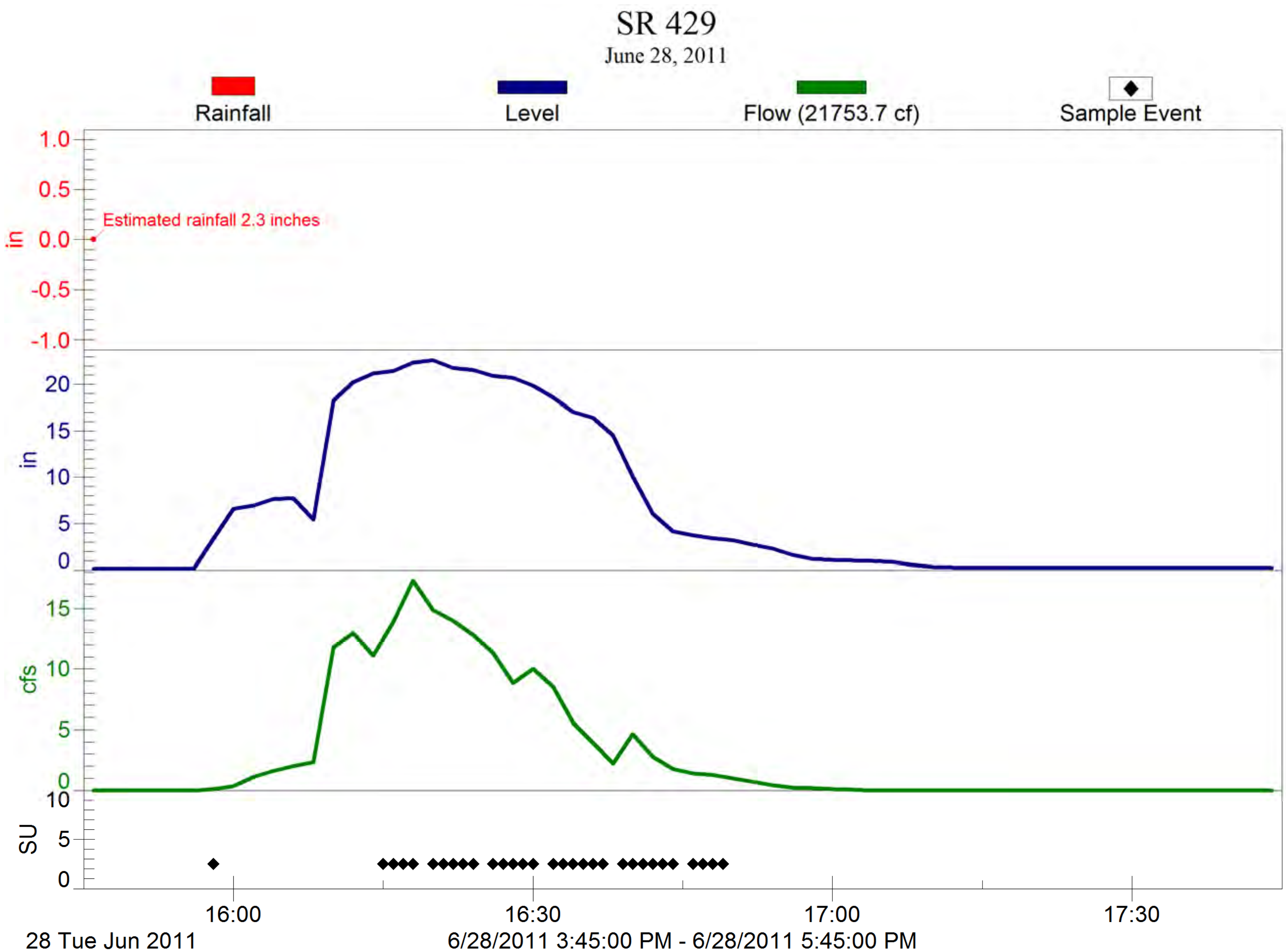


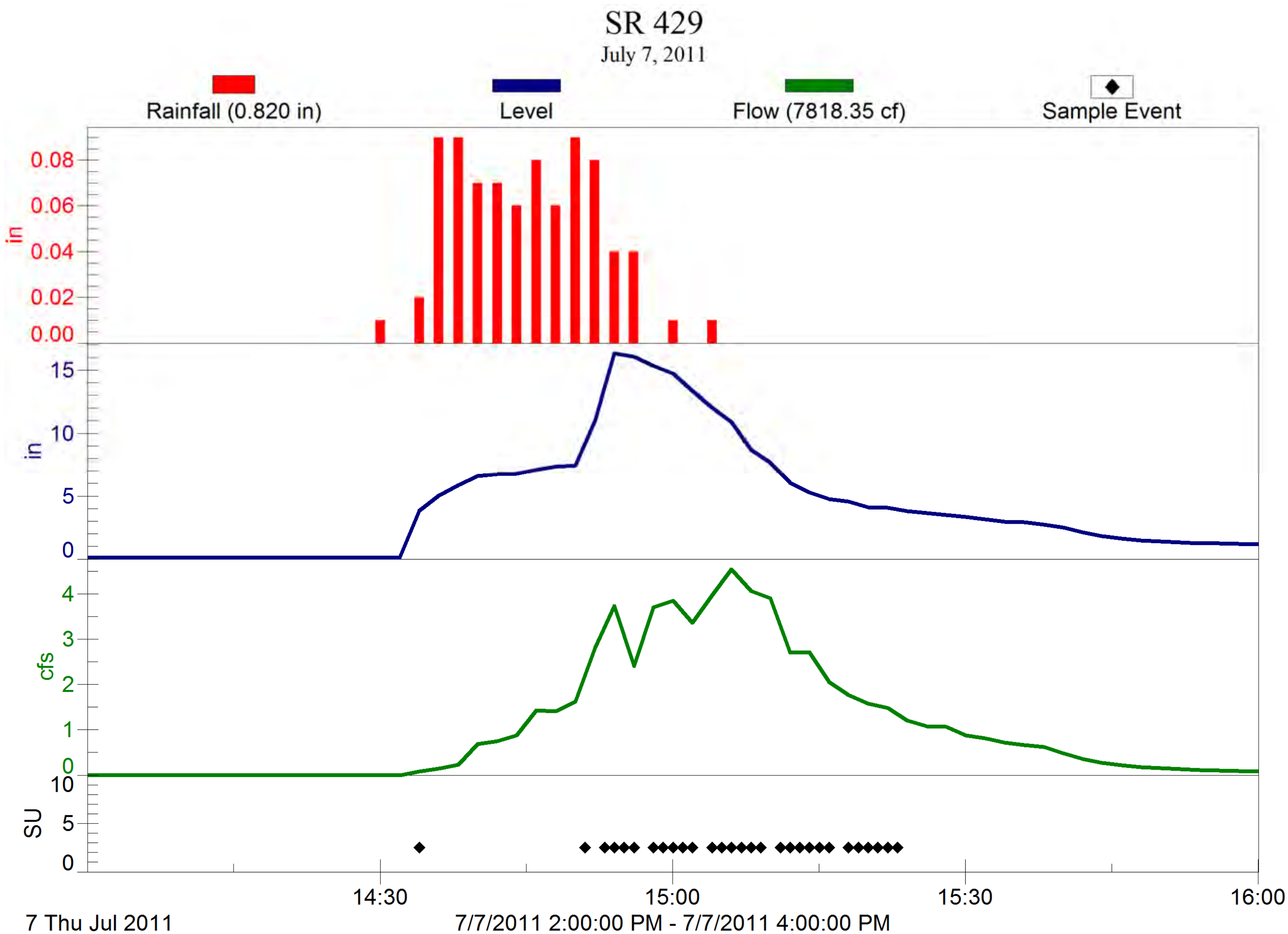


SR 429
January 21, 2011
Rainfall
Level
Flow (1039.30 cf)
Sample Event
0.5
0.4
0.3
0.2
0.1
0.0
in
0.51
0.32
4
2
0
in
0.8
0.6
0.4
0.2
0.0
cfs
10
5
0
SU
2:30
3:00
3:30
4:00
21 Fri Jan 2011
1/21/2011 2:15:00 AM - 1/21/2011 4:15:00 AM

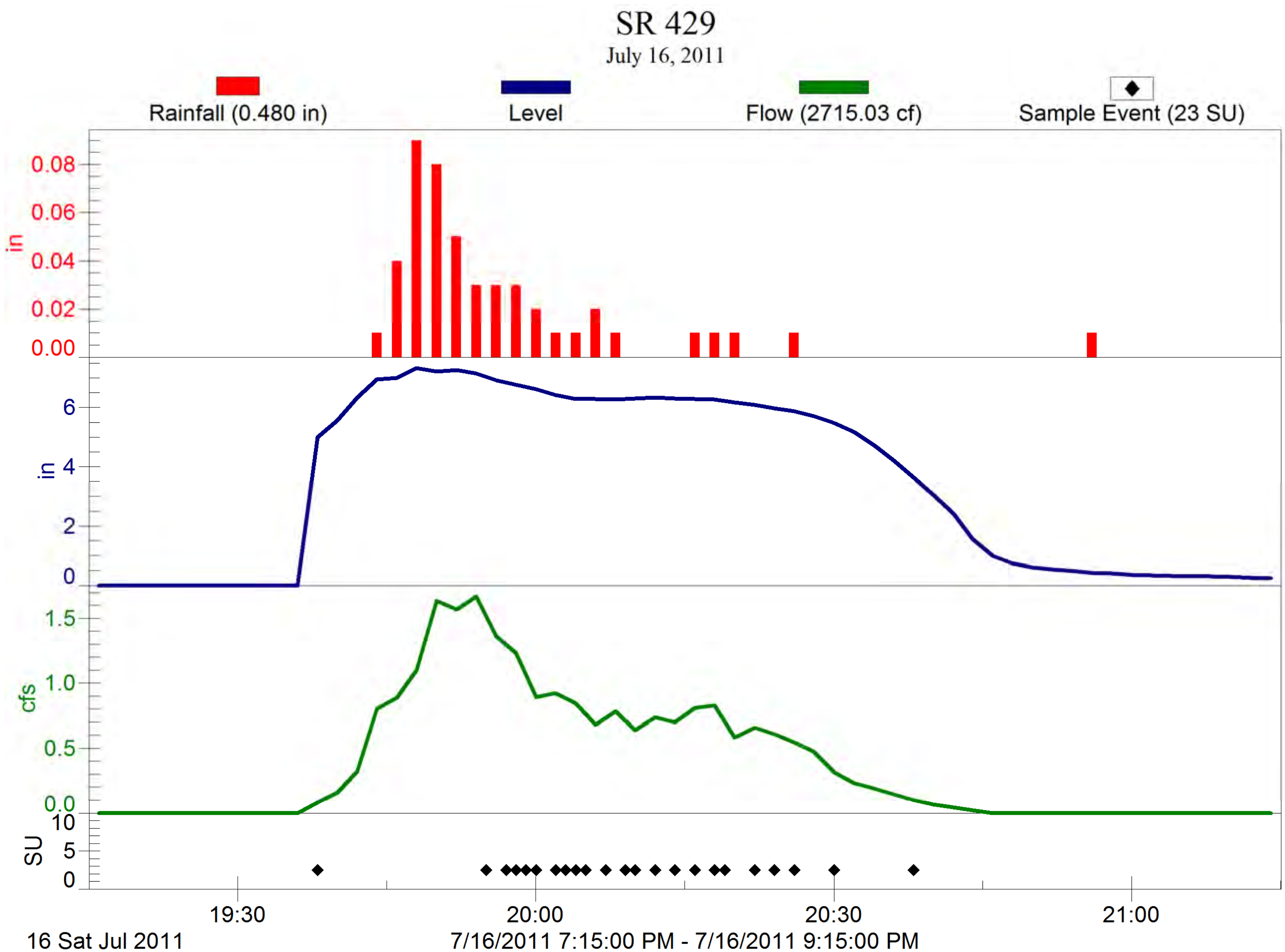


SR 429
January 25, 2011
Rain Intensity
Level
Flow (10130.8 cf)
Sample Event
in/hr
1.5
1.0
0.5
0.0
in
10
5
0
cfs
10
5
0
SU
10
5
0
18:30
19:00
19:30
20:00
25 Tue Jan 2011
1/25/2011 6:00:00 PM - 1/25/2011 8:00:00 PM


SR 429
June 28, 2011
Rainfall
Level
Flow (21753.7 cf)
Sample Event
Estimated rainfall 2.3 inches
in
1.0
0.5
0.0
-0.5
-1.0
in
20
15
10
5
0
cfs
15
10
5
0
SU
10
5
0
16:00
16:30
17:00
17:30
28 Tue Jun 2011
6/28/2011 3:45:00 PM - 6/28/2011 5:45:00 PM



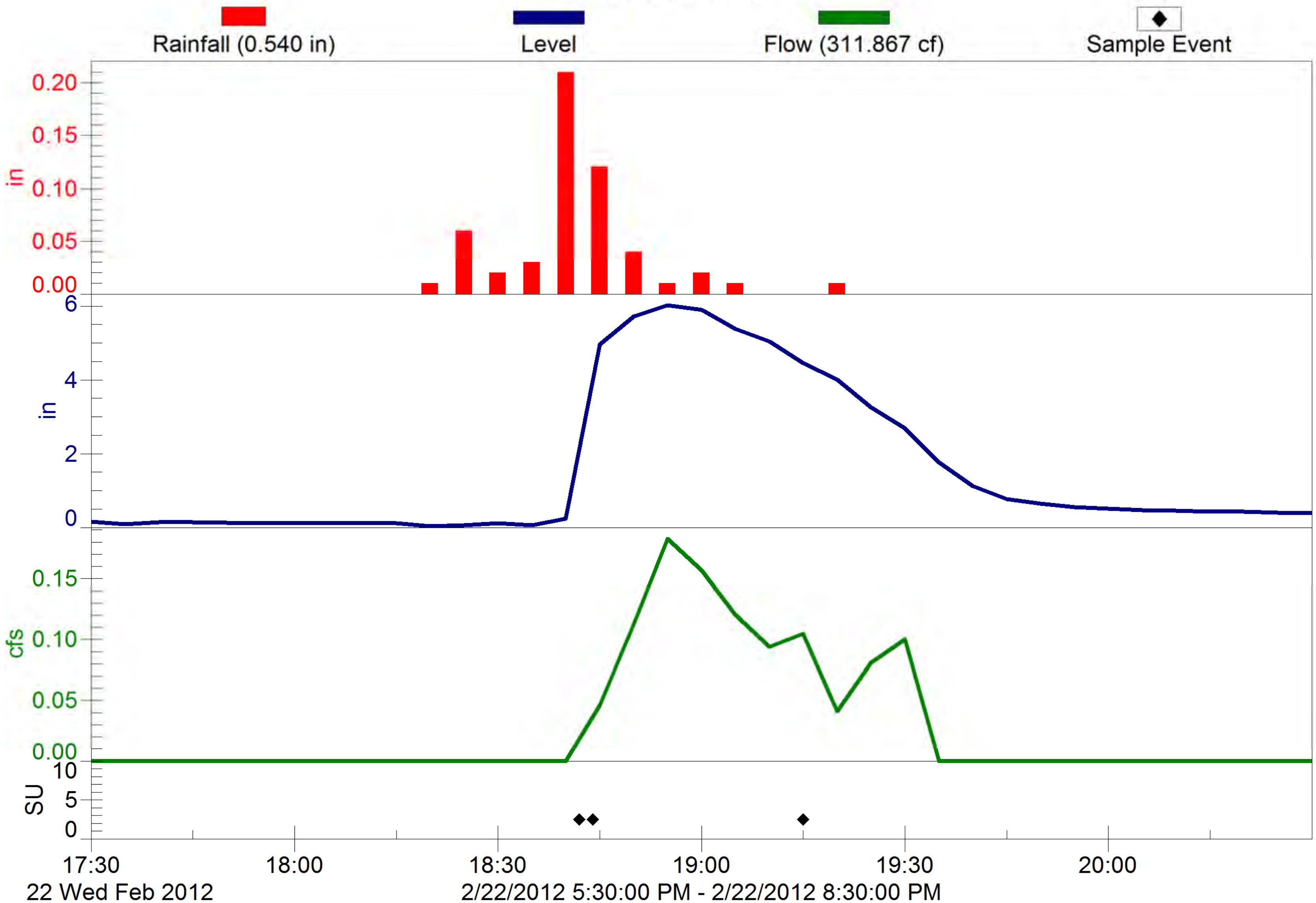
SR 429
July 7, 2011
Rainfall (0.820 in)
Level
Flow (7818.35 cf)
Sample Event
0.08
0.06
0.04
0.02
0.00
in
15
10
5
0
in
4
3
2
1
0
cfs
10
5
0
SU
14:30
15:00
15:30
16:00
7 Thu Jul 2011
7/7/2011 2:00:00 PM - 7/7/2011 4:00:00 PM

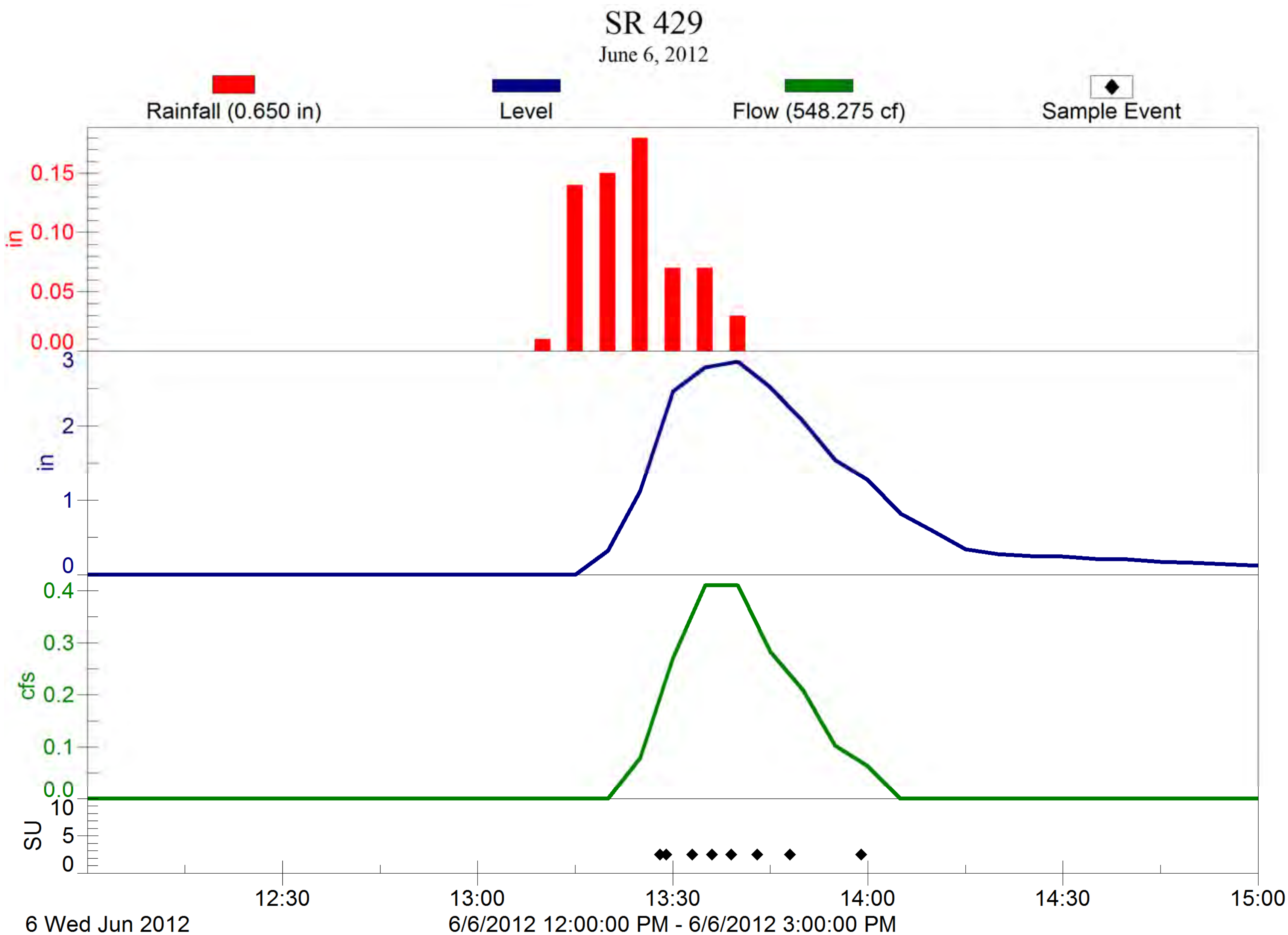


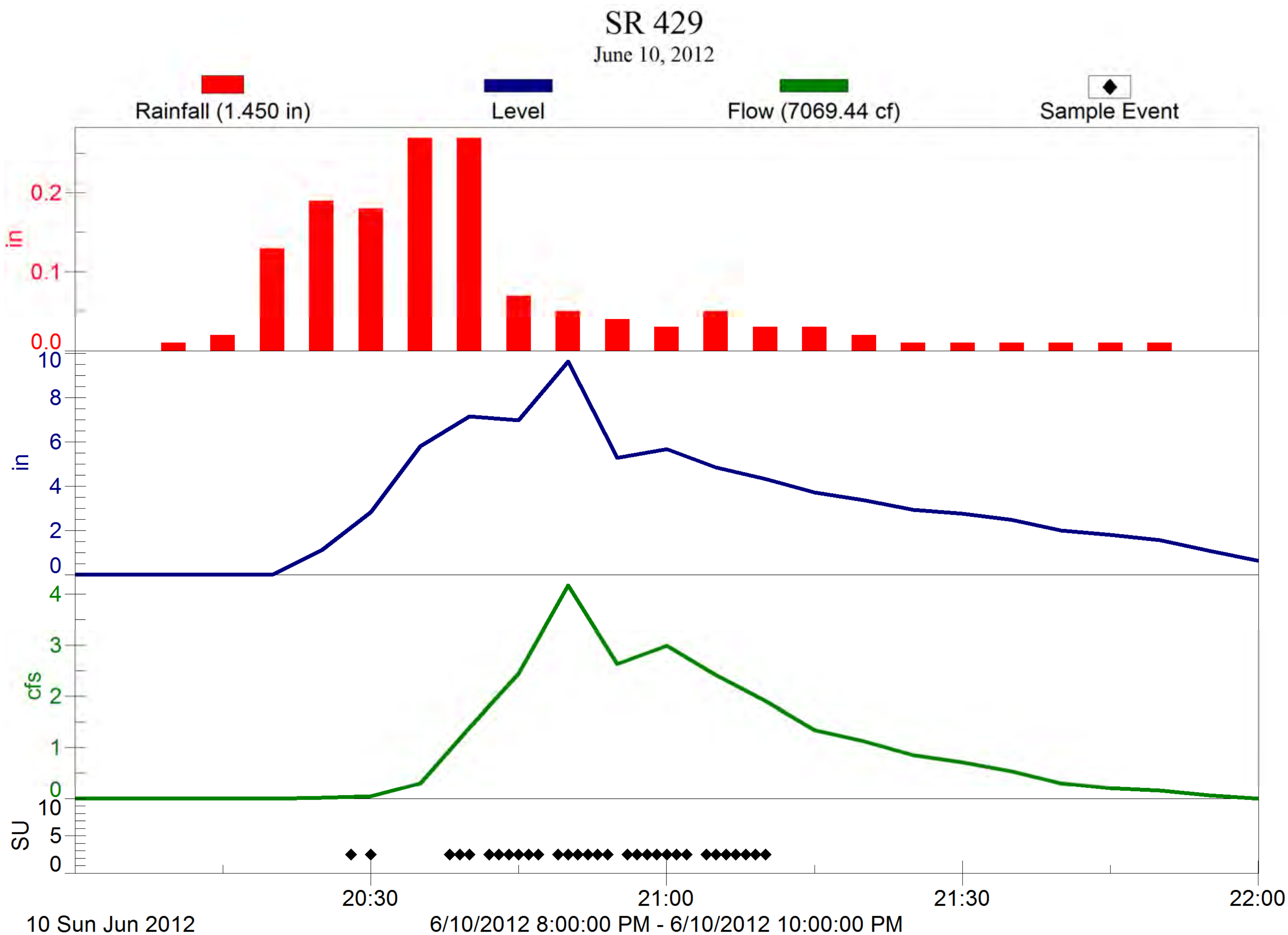
SR 429
July 16, 2011
Rainfall (0.480 in)
Level
Flow (2715.03 cf)
Sample Event (23 SU)
in
0.08
0.06
0.04
0.02
0.00
in
6
4
2
0
cfs
1.5
1.0
0.5
0.0
SU
10
5
0
19:30
20:00
20:30
21:00
16 Sat Jul 2011
7/16/2011 7:15:00 PM - 7/16/2011 9:15:00 PM

SR 429

February 22, 2012



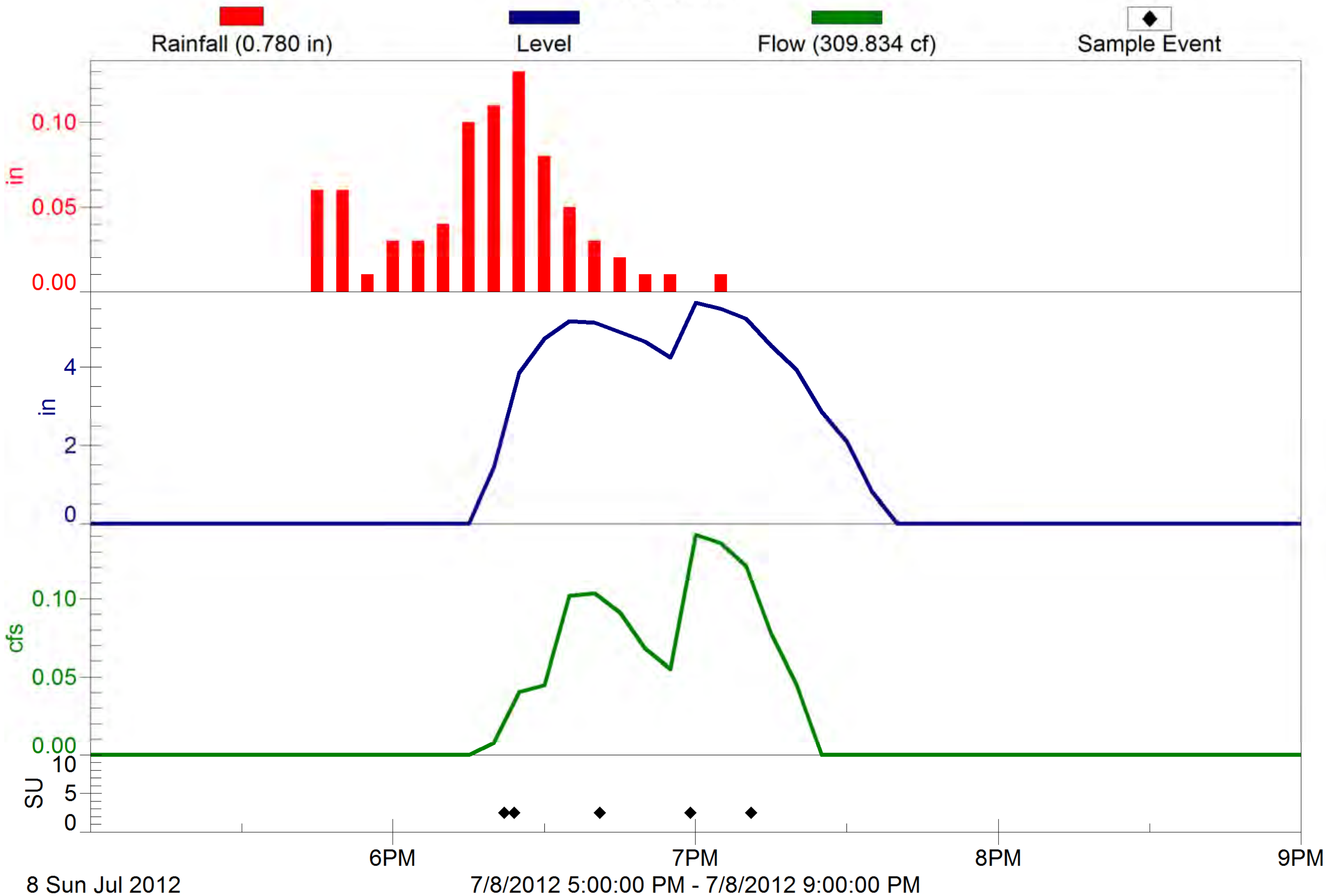

SR 429
June 6, 2012
Rainfall (0.650 in)
Level
Flow (548.275 cf)
Sample Event
in
0.15
0.10
0.05
0.00
3
2
1
0
0.4
0.3
cfs
0.2
0.1
0.0
10
SU
5
0
12:30
13:00
13:30
14:00
14:30
15:00
6 Wed Jun 2012
6/6/2012 12:00:00 PM - 6/6/2012 3:00:00 PM

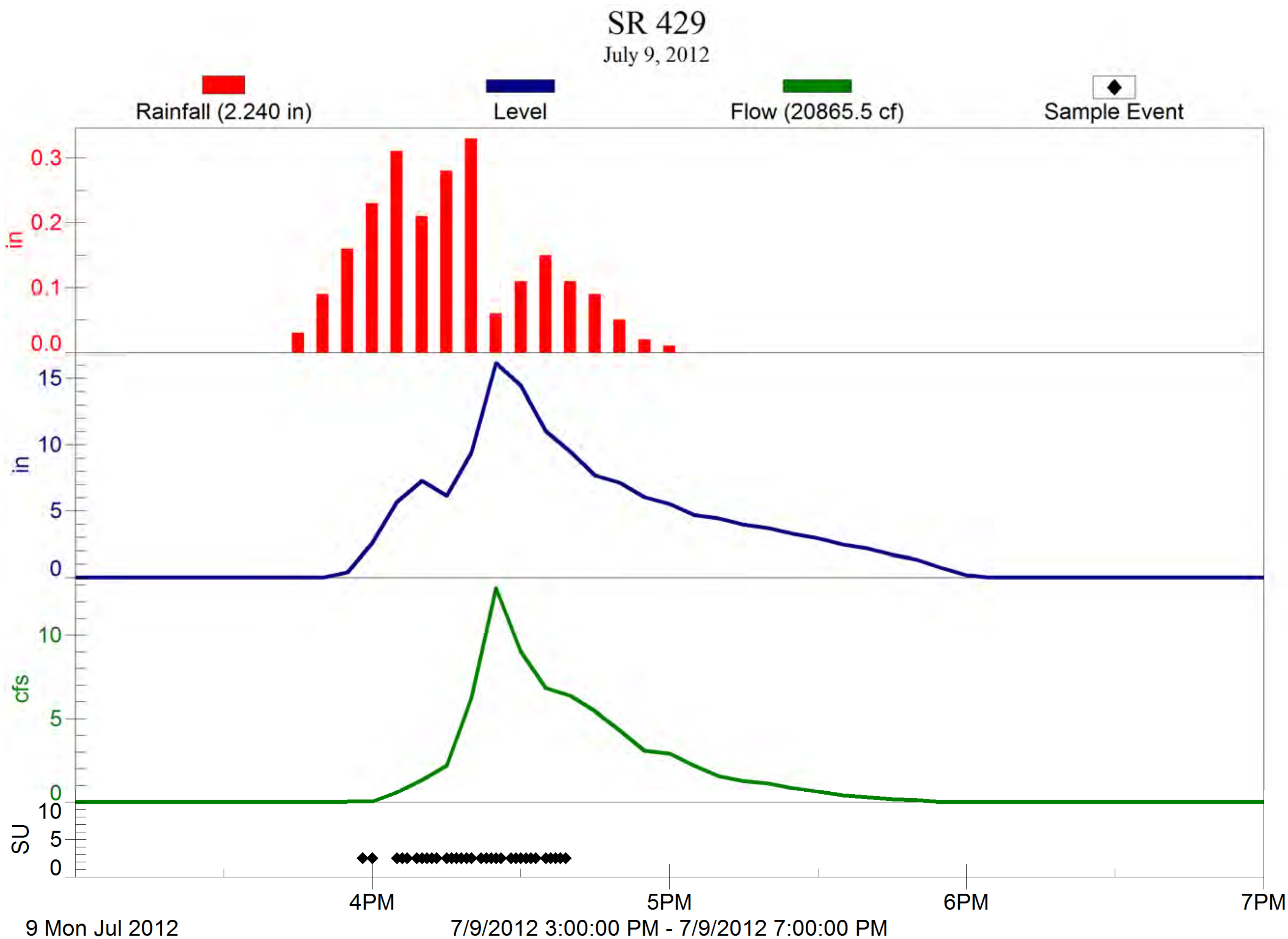


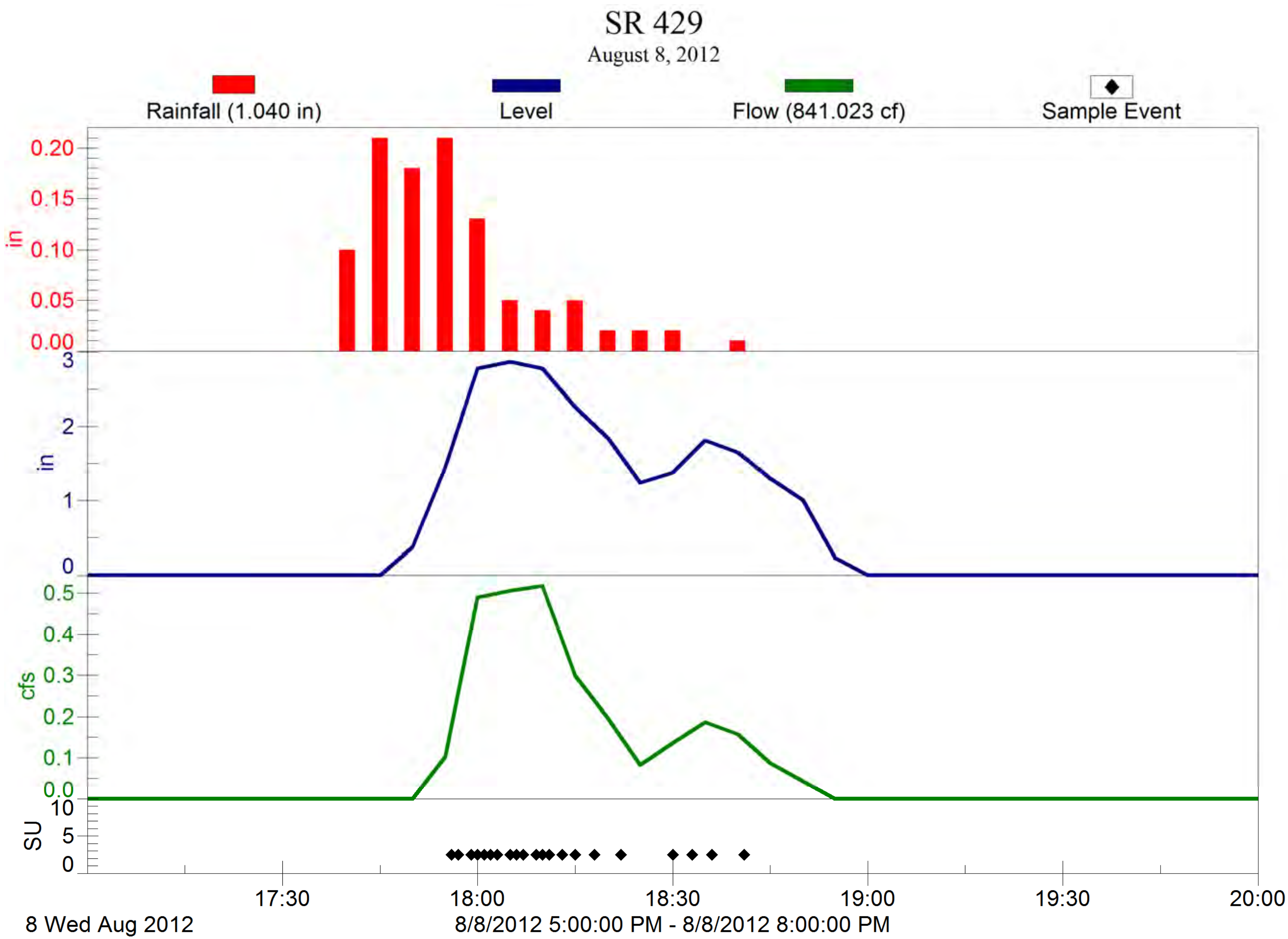
SR 429
June 10, 2012
Rainfall (1.450 in)
Level
Flow (7069.44 cf)
Sample Event
in
0.2
0.1
0.0
in
10
8
6
4
2
0
cfs
4
3
2
1
0
SU
10
5
0
20:30
21:00
21:30
22:00
10 Sun Jun 2012
6/10/2012 8:00:00 PM - 6/10/2012 10:00:00 PM

SR 429

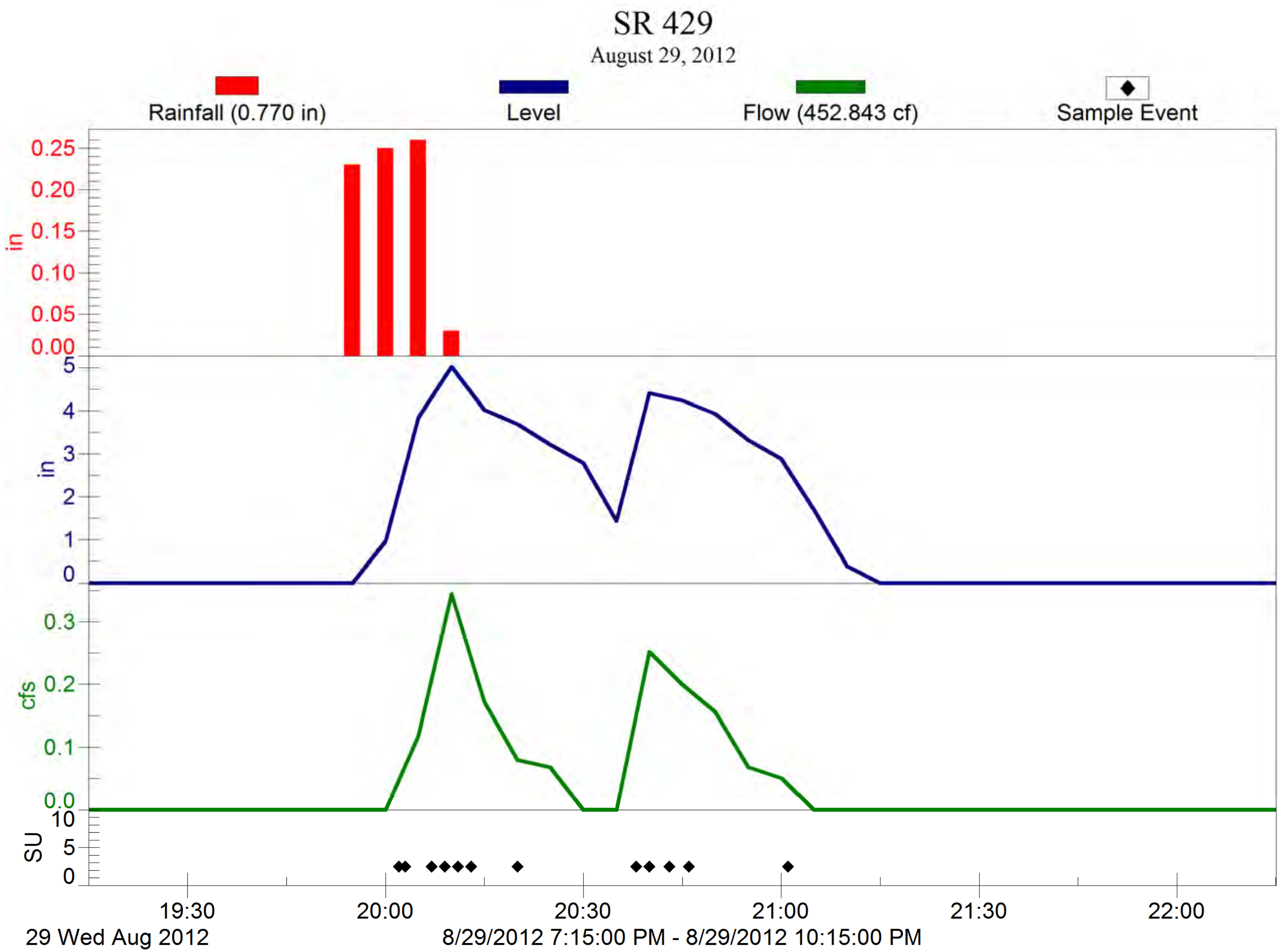
July 8, 2012

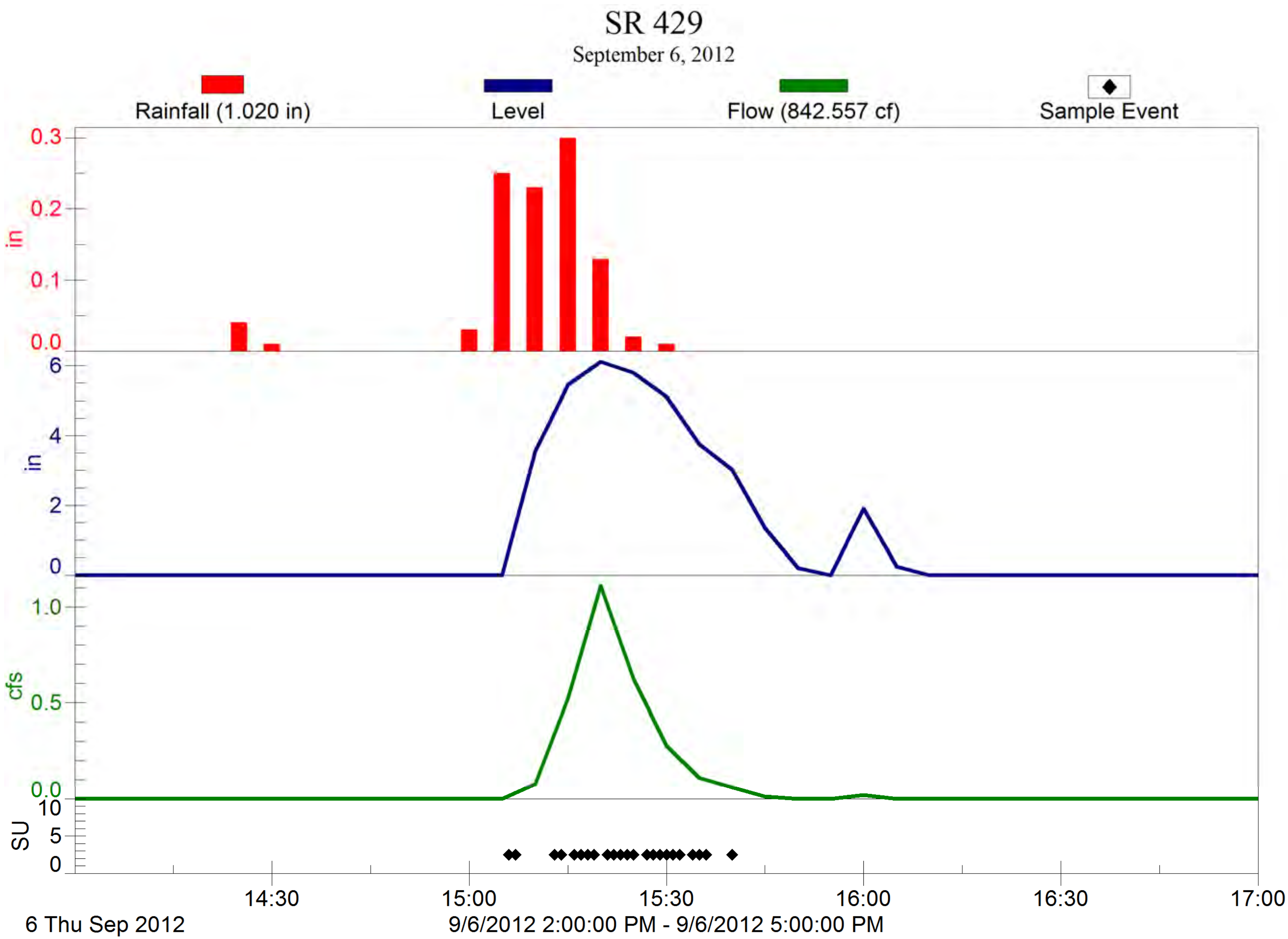



SR 429
July 9, 2012
Rainfall (2.240 in)
Level
Flow (20865.5 cf)
Sample Event
0.3
0.2
0.1
0.0
in
15
10
5
0
in
10
5
0
cfs
10
5
0
SU
4PM
5PM
6PM
7PM
9 Mon Jul 2012
7/9/2012 3:00:00 PM - 7/9/2012 7:00:00 PM

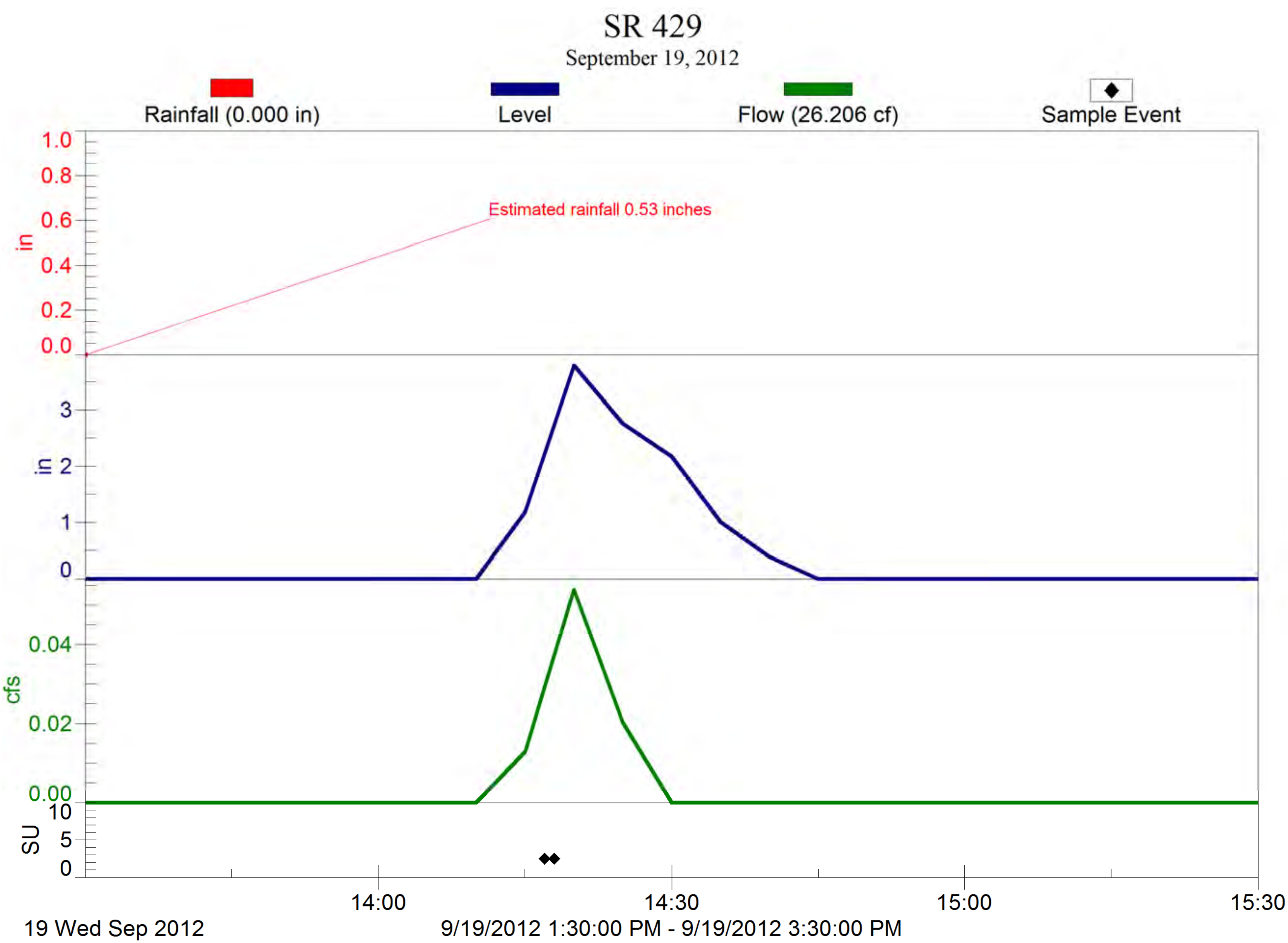


SR 429
August 8, 2012
Rainfall (1.040 in)
Level
Flow (841.023 cf)
Sample Event
in
0.20
0.15
0.10
0.05
0.00
in
3
2
1
0
cfs
0.5
0.4
0.3
0.2
0.1
0.0
SU
10
5
0
17:30
18:00
18:30
19:00
19:30
20:00
8 Wed Aug 2012
8/8/2012 5:00:00 PM - 8/8/2012 8:00:00 PM


SR 429
August 29, 2012
Rainfall (0.770 in)
Level
Flow (452.843 cf)
Sample Event
0.25
0.20
0.15
0.10
0.05
0.00
in
5
4
3
2
1
0
in
0.3
0.2
0.1
0.0
cfs
10
5
0
SU
19:30
20:00
20:30
21:00
21:30
22:00
29 Wed Aug 2012
8/29/2012 7:15:00 PM - 8/29/2012 10:15:00 PM



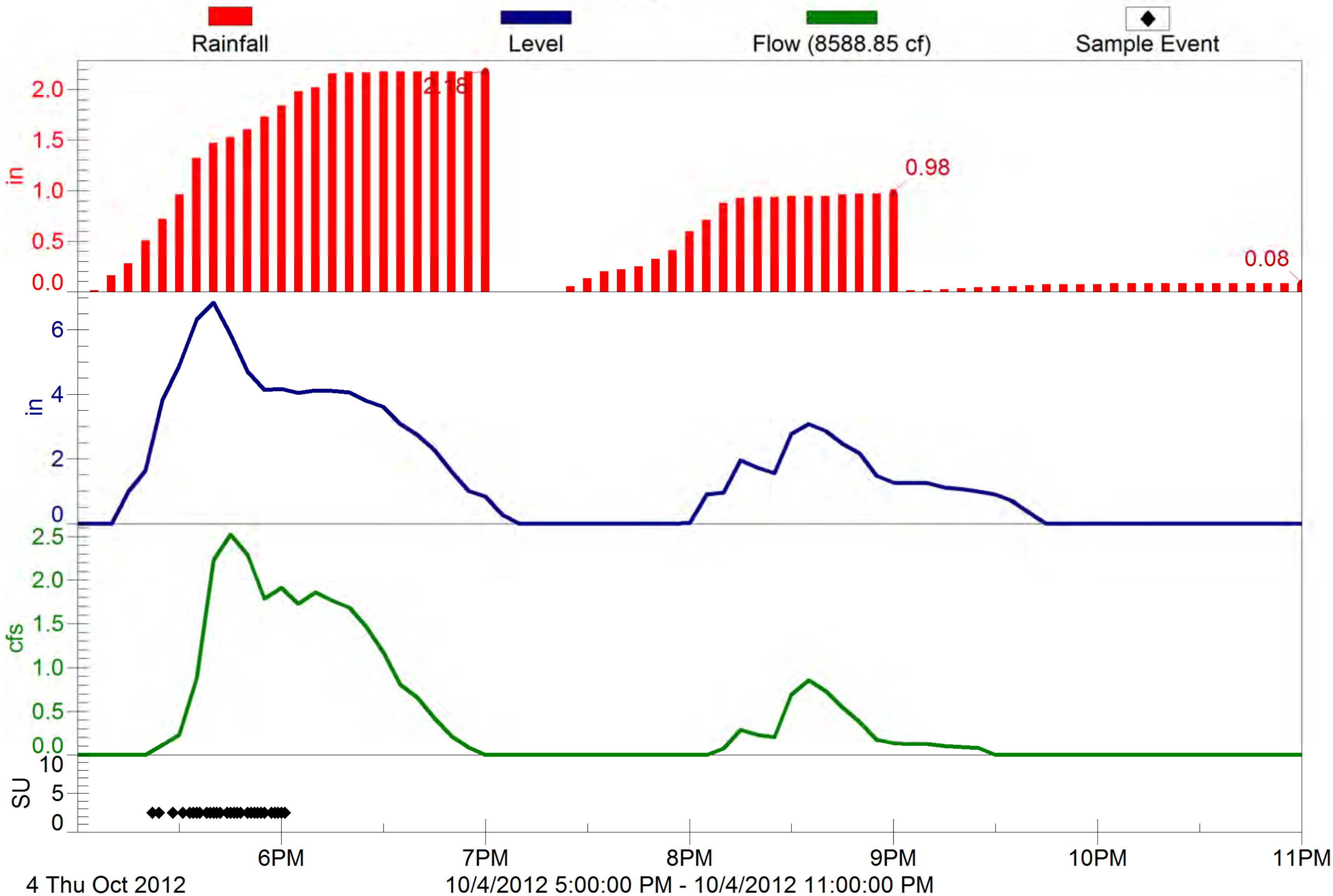
SR 429
September 6, 2012
Rainfall (1.020 in)
Level
Flow (842.557 cf)
Sample Event
in
0.3
0.2
0.1
0.0
in
6
4
2
0
cfs
1.0
0.5
0.0
SU
10
5
0
14:30
15:00
15:30
16:00
16:30
17:00
6 Thu Sep 2012
9/6/2012 2:00:00 PM - 9/6/2012 5:00:00 PM

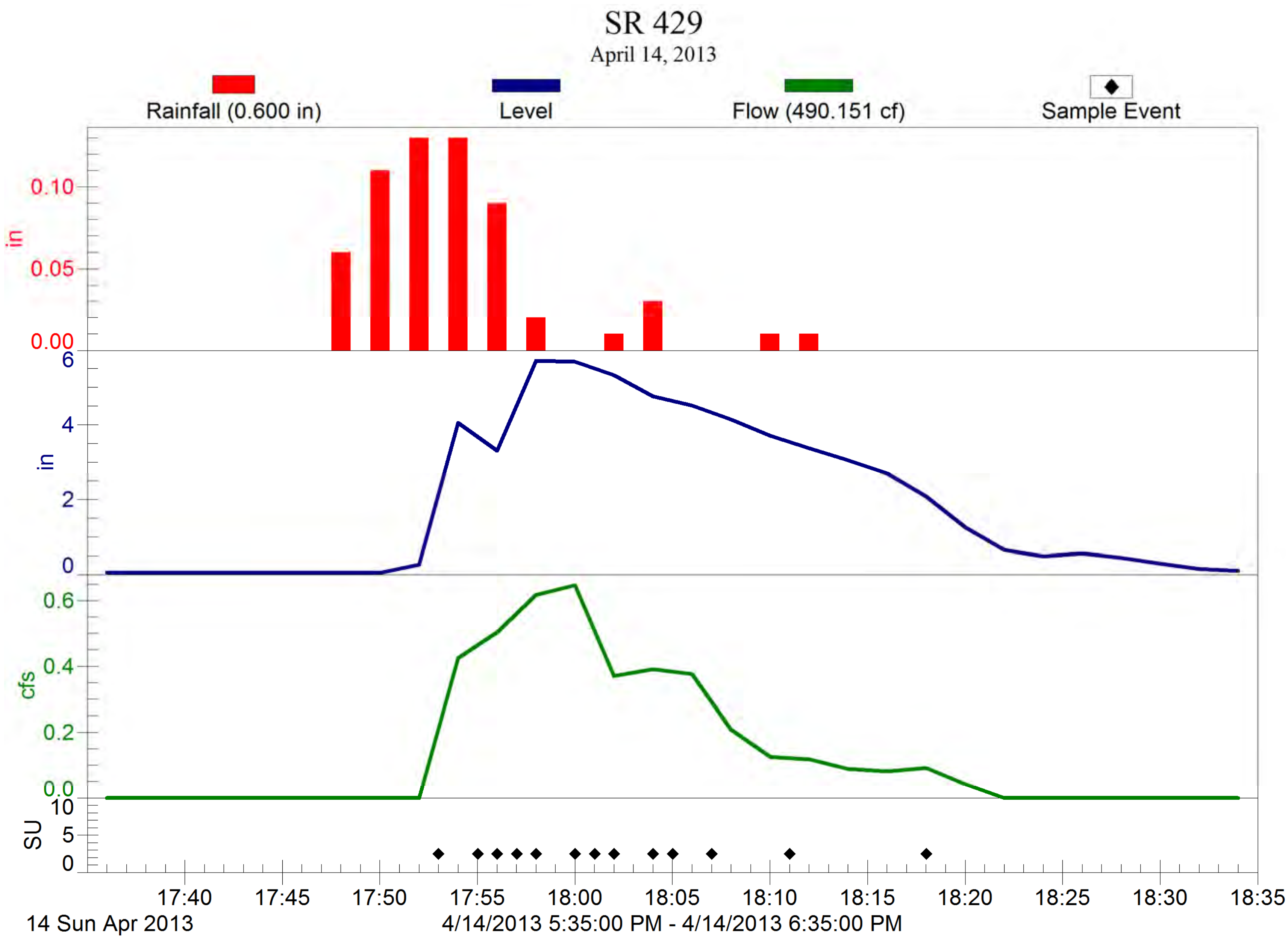


SR 429
September 19, 2012
Rainfall (0.000 in)
Level
Flow (26.206 cf)
Sample Event
Estimated rainfall 0.53 inches
in
cfs
SU
14:00
14:30
15:00
15:30
19 Wed Sep 2012
9/19/2012 1:30:00 PM - 9/19/2012 3:30:00 PM

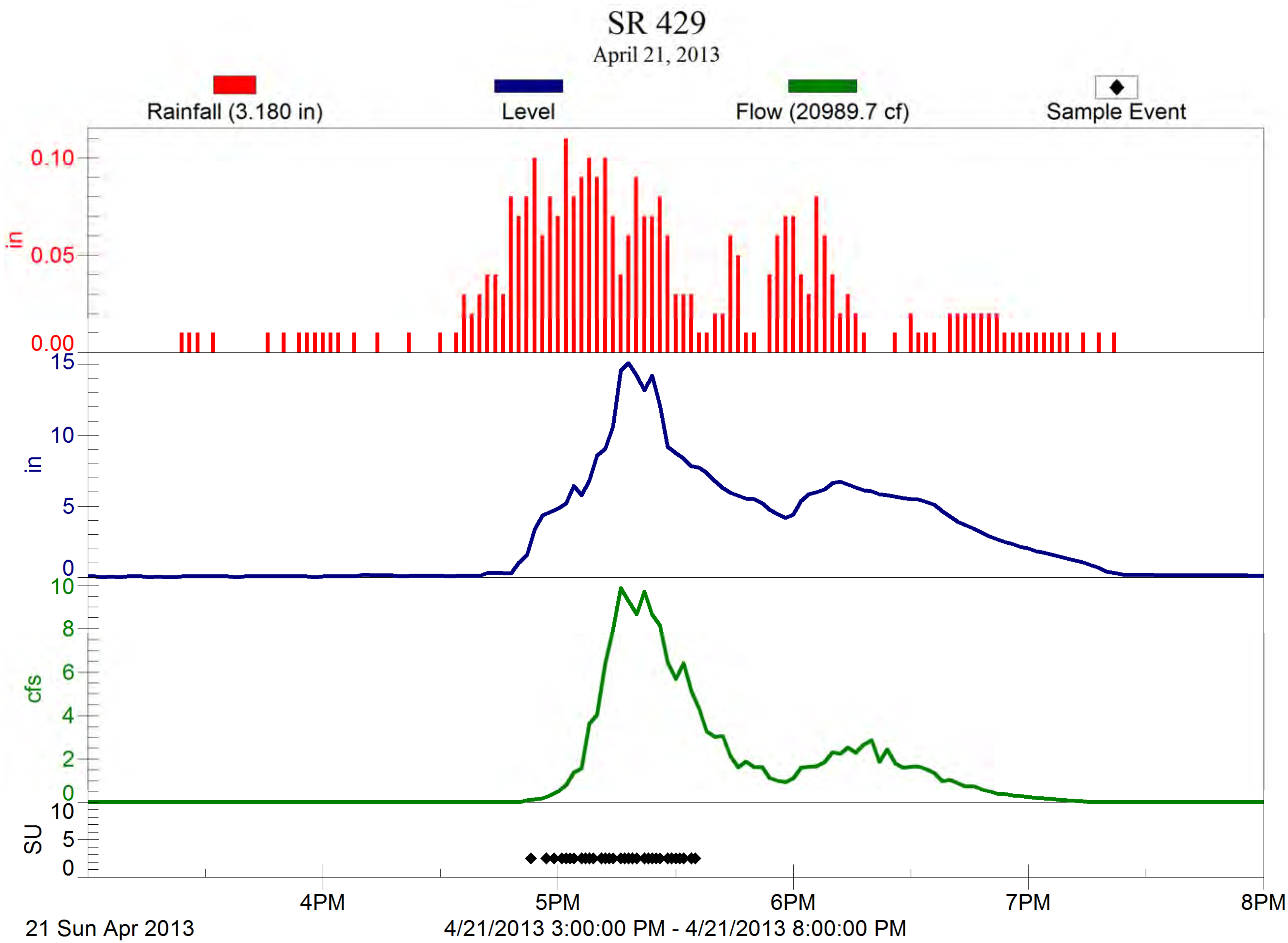
SR 429

October 4, 2012

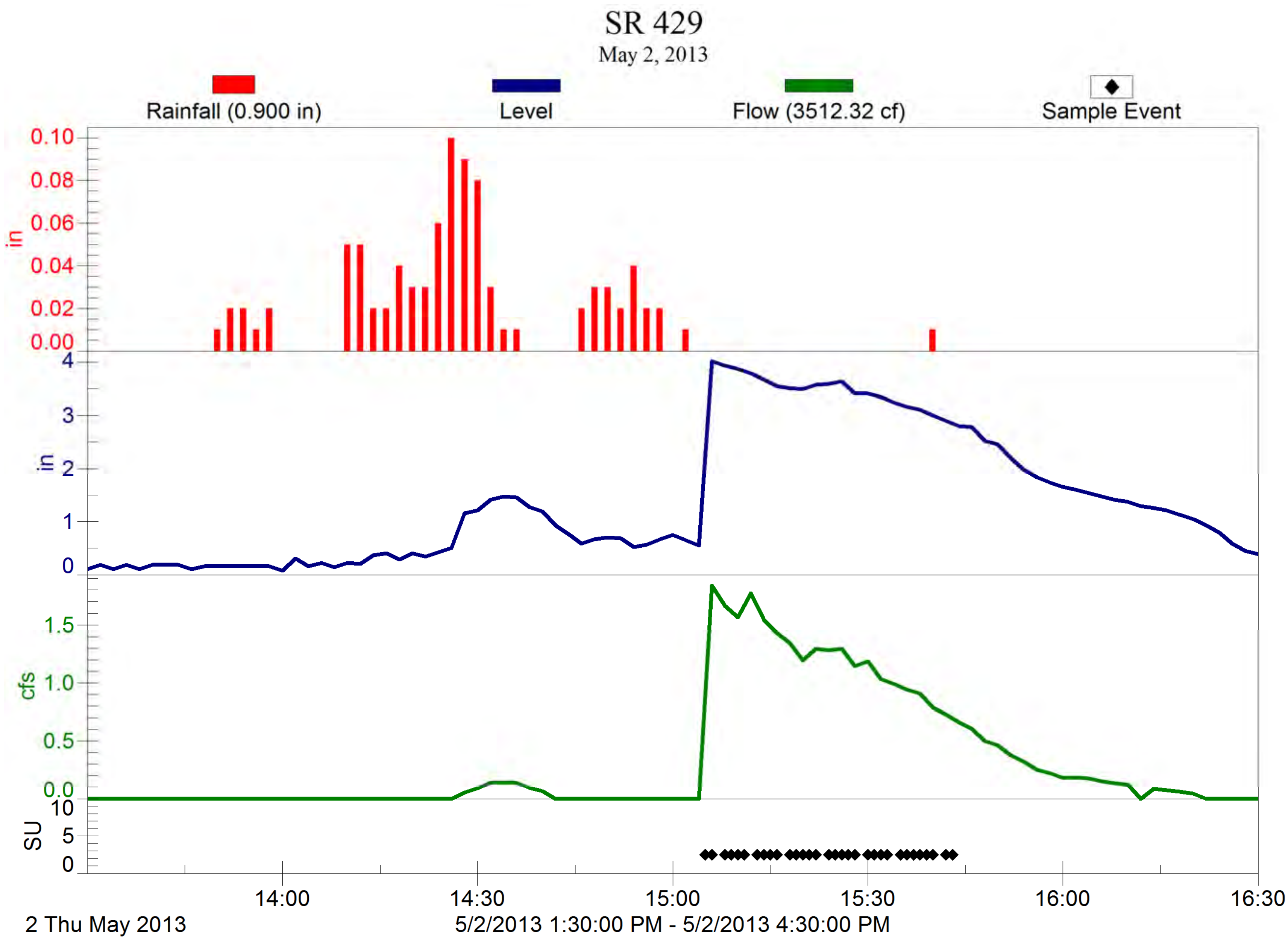




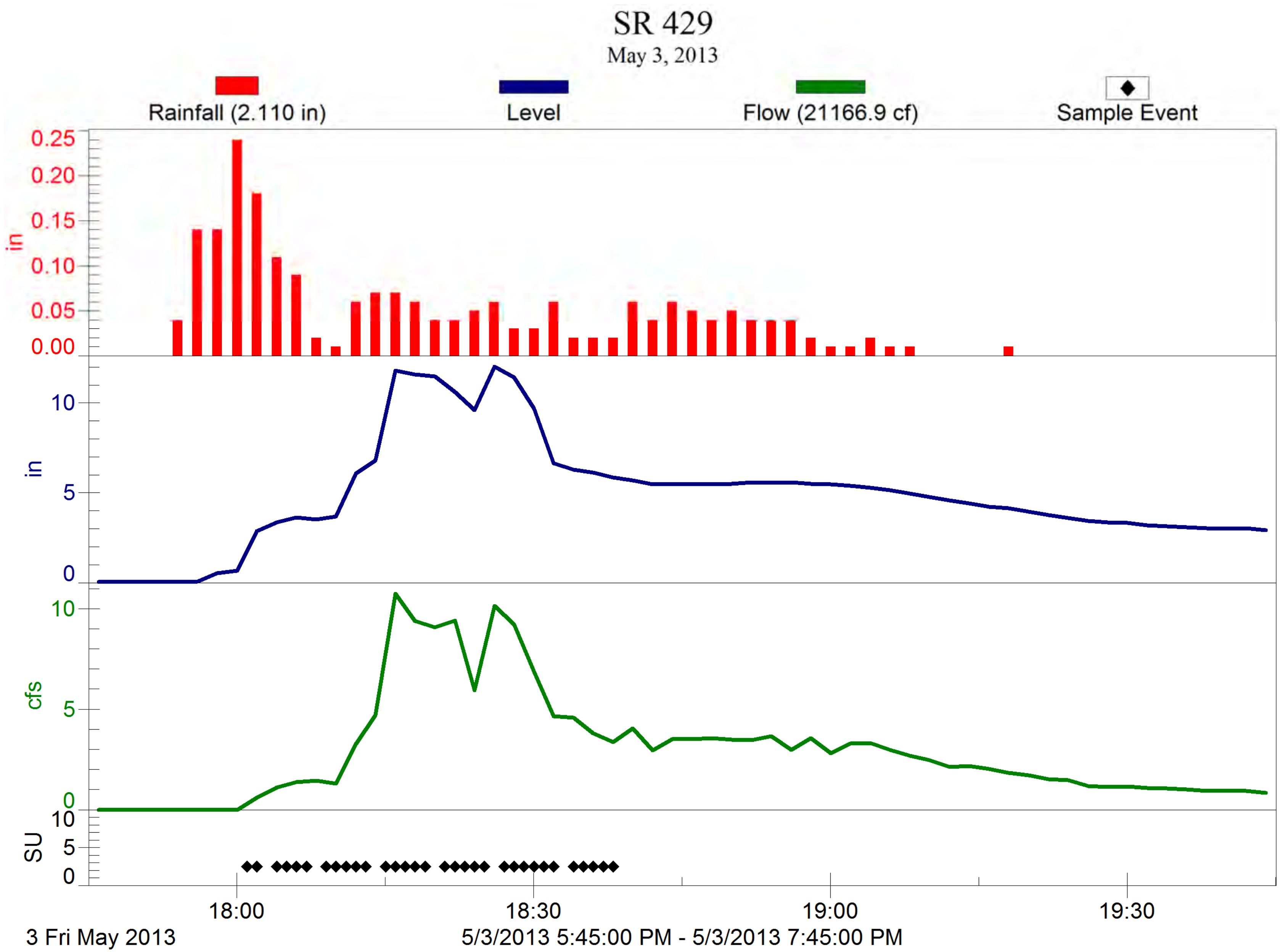
SR 429
April 14, 2013
Rainfall (0.600 in)
Level
Flow (490.151 cf)
Sample Event
in
0.10
0.05
0.00
in
6
4
2
0
cfs
0.6
0.4
0.2
0.0
SU
10
5
0
17:40
17:45
17:50
17:55
18:00
18:05
18:10
18:15
18:20
18:25
18:30
18:35
14 Sun Apr 2013
4/14/2013 5:35:00 PM - 4/14/2013 6:35:00 PM



SR 429
April 21, 2013
Rainfall (3.180 in)
Level
Flow (20989.7 cf)
Sample Event
in
0.10
0.05
0.00
in
15
10
5
0
cfs
10
8
6
4
2
0
SU
10
5
0
4PM
5PM
6PM
7PM
8PM
21 Sun Apr 2013
4/21/2013 3:00:00 PM - 4/21/2013 8:00:00 PM



SR 429
May 2, 2013
Rainfall (0.900 in)
Level
Flow (3512.32 cf)
Sample Event
0.10
0.08
0.06
0.04
0.02
0.00
in
4
3
2
1
0
in
1.5
1.0
0.5
0.0
cfs
10
5
0
SU
14:00
14:30
15:00
15:30
16:00
16:30
2 Thu May 2013
5/2/2013 1:30:00 PM - 5/2/2013 4:30:00 PM

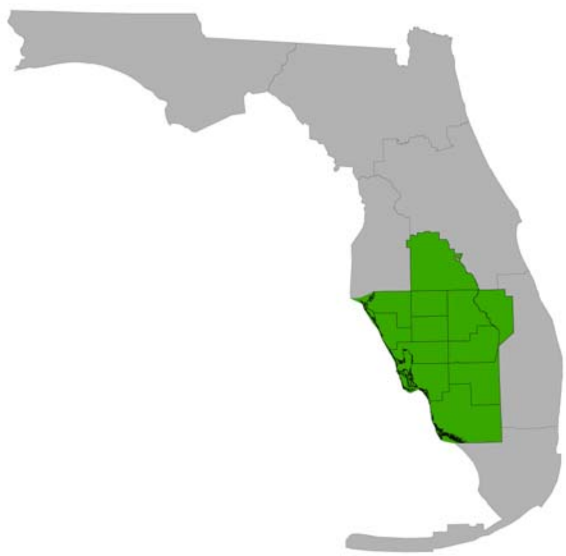


SR 429
May 3, 2013
Rainfall (2.110 in)
Level
Flow (21166.9 cf)
Sample Event
0.25
0.20
0.15
0.10
0.05
0.00
in
10
5
0
in
10
5
0
cfs
10
5
0
SU
18:00
18:30
19:00
19:30
3 Fri May 2013
5/3/2013 5:45:00 PM - 5/3/2013 7:45:00 PM

Appendix F

Determination of Appropriate Highway EMC Values For Use within FDOT District 1

DETERMINATION OF APPROPRIATE HIGHWAY EMC VALUES FOR USE WITHIN FDOT DISTRICT 1



PREPARED FOR FDOT DISTRICT 1
BARTOW, FLORIDA

AUGUST 2010

APPLIED TECHNOLOGY AND MANAGEMENT, INC.
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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION AND PURPOSE

The Florida Department of Environmental Protection (FDEP) is the state agency responsible for implementing the Federal Clean Water Act (CWA), including the development and implementation of Total Maximum Daily Loads (TMDLs). TMDLs are established and implemented in accordance with F.S. 403.067. Once a TMDL is adopted, there are several routes by which FDEP can choose to implement the TMDL. The most formal of these is the Basin Management Action Plan (BMAP). The BMAP process is intended to include the broadest possible range of interested parties, or stakeholders, with the objective of encouraging the greatest amount of cooperation and consensus possible. Through the BMAP process, FDEP determines how much of the pollutant of concern each individual stakeholder is allowed to discharge in order for the water body to meet its TMDL. Then, based upon a calculation of stakeholders' existing pollutant loads, each stakeholder must make appropriate reductions to reach their target. The BMAP is adopted by secretarial order and is an enforceable document.

The Florida Department of Transportation (FDOT), by virtue of its wide geographic coverage area, has been, is, or will be a stakeholder in nearly every BMAP that is developed in the State. As there can be significant capital costs associated with mandated reductions, FDOT has a strong interest in ensuring that the road and highway pollutant loading calculations for each BMAP reflect actual site conditions as accurately as possible.

FDEP currently determines annual highway pollutant loadings statewide using literature values of event mean concentrations (EMC) from 15 sampling sites in Florida based on studies dating from 1975 through 2007. Studies include seven sites in the Orlando area, two sites on the southeast coast, one site in Tallahassee, one site in Tampa, and four sites in southwest Florida. The purpose of this paper is to review the data and methods used in these studies and, based upon this review, to provide recommendations with regard to EMC values that are most appropriate for use within FDOT District 1.

2.0 BACKGROUND

FDOT District 1 manages more than 2,200 miles of roadway within 12 counties in the southwestern portion of the state. The roads and highways traverse both rural and urban areas, including populated jurisdictional areas regulated by the National Pollutant Discharge Elimination System (NPDES) program. The NPDES program is authorized under the CWA and is administered in Florida by FDEP. Municipal separate storm sewer systems (MS4s) are permitted under the NPDES program and as such MS4 stormwater discharges are effectively regulated as a point source. FDOT District 1 is an MS4 co-permittee with Polk, Sarasota, Manatee, and Lee Counties. In addition, District 1 holds an MS4 permit in Charlotte County.

MS4 permits contain specific conditions related to TMDLs and BMAPs. Once a BMAP or other TMDL implementation plan is adopted for a water body into which the MS4 discharges the pollutant of concern, the MS4 operator must comply with the adopted provisions of the BMAP. BMAPs typically include specific activities that are to be undertaken by the MS4 permittee during the permit cycle. BMAP stakeholders outside an MS4 permit area are also required to comply with BMAP provisions. Stakeholders who fail to comply are subject to enforcement action by FDEP or a water management district.

District 1 is currently a stakeholder in nutrient BMAPs for the Caloosahatchee River and tributaries (Lee and Charlotte Counties), Hendry Creek marine and freshwater segments (Lee County), and the Imperial River (Lee County). As such, District 1 will have allocations for each BMAP and will be required to demonstrate reductions in loads of total nitrogen (TN) and total phosphorus (TP) in order to meet their allocations.

3.0 REVIEW OF LITERATURE EMC VALUES

Data used by FDEP to determine highway EMC values are based in part upon summary information provided in Table 4-10 of *Evaluation of Current Stormwater Design Criteria within the State of Florida* (Harper and Baker 2007). In addition, between 2004 and 2007, FDOT District 1 conducted water quality investigations at four wet/dry detention ponds in Lee, Hendry, and Collier Counties (Johnson Engineering 2006; 2008; 2009a; 2009b). The primary objective of the District 1 studies was to evaluate the quality of stormwater runoff from state-managed roadways in southwest Florida. Data were used to develop regionally appropriate EMCs for nutrients, metals, and total suspended solids.

The District 1 reports were recently submitted to FDEP for review. Subsequent to FDEP review, the data were incorporated into the state's generalized EMC table for highway runoff for inclusion in *the Environmental Resource Permit Applicant's Handbook for Stormwater Treatment Systems in Florida*. EMC values for many land uses, including highways, are summarized in Table 3-4 of the draft handbook and will be incorporated into the Statewide Stormwater Rule once the rule is adopted. Appendix C of the handbook is currently being revised to reflect the additional data.

The EMC sampling site locations are shown in Figure 1 and characteristics of each of the sites and studies utilized to develop the statewide EMCs are shown in Table 1. TP and TN data for all but the Johnson Engineering studies for District 1 are based upon the information provided in Table 4-10 in Harper and Baker (2007). Additional data on rainfall, number of events sampled, average daily traffic counts, and percent impervious is based upon a review of the original studies or related journal articles. The ERD (2000) report and 2005 unpublished data were unavailable for review, so additional details cannot be provided for these studies.

The data presented in Table 1 and Figure 1 are notable in several respects. First, the data set is heavily weighted towards studies conducted in the Orlando area along the I-4 corridor. Seven of the 15 site investigations are within 20 miles of one another, and six of those are within eight miles of one another. In addition, the data suggest (and ATM later confirmed) that two of the cited Orlando area studies were from the same interchange. In fact, detailed review of both the Harper (1985) and Yousef et al. (1986) reports confirmed that the results

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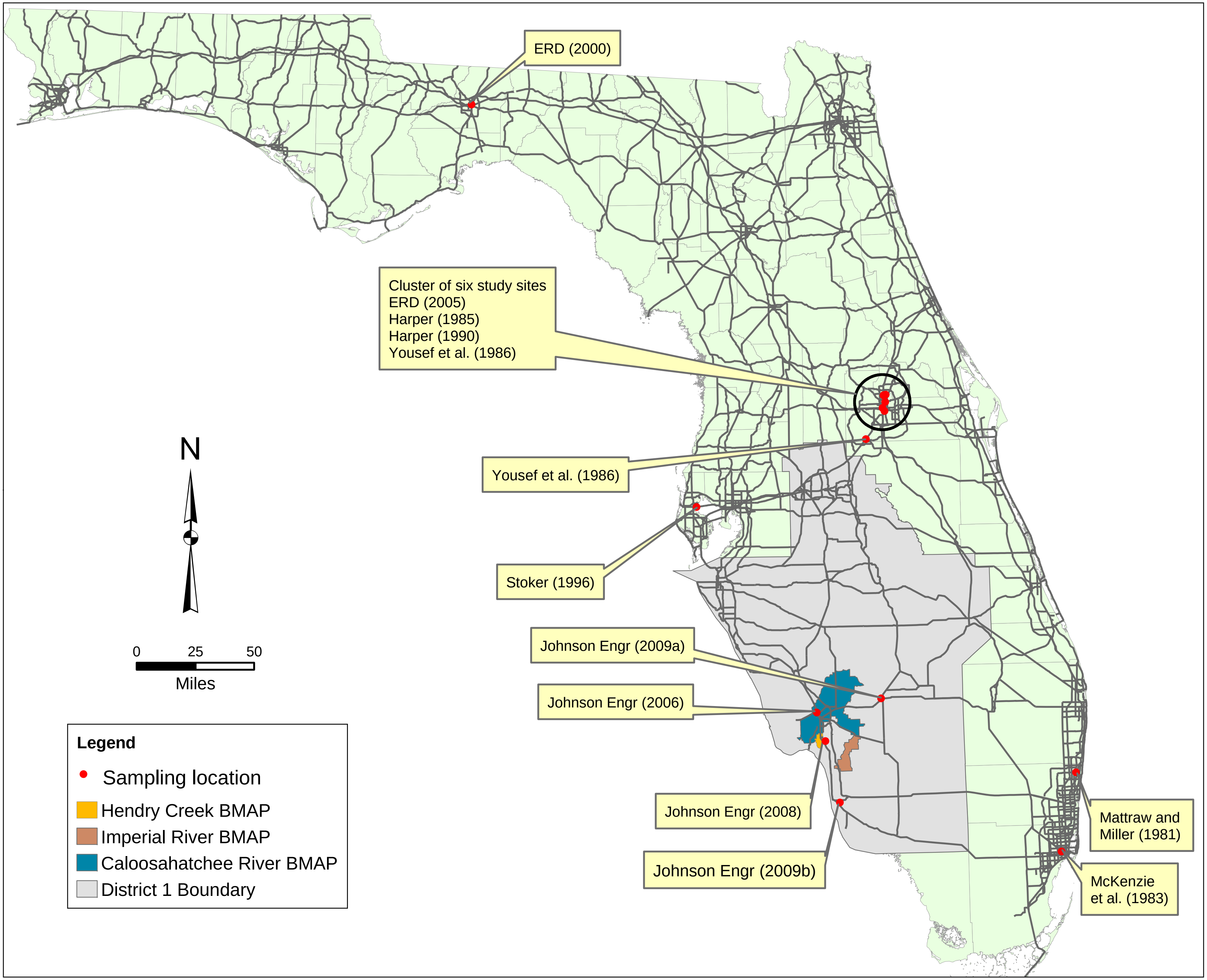

APPLIED TECHNOLOGY & MANAGEMENT

Figure 1
Distribution of Stormwater Sampling Sites Used to Determine Statewide EMC Values

Revision Date: 5 August 2010

Table 1. Characteristics of Stormwater Sampling Sites Used to Determine Highway EMCs (based in part on Table 4-10, Harper and Baker [2007])

Location	Reference	Dates of Sample Collection	# of events sampled	Drainage area (acres)	% Impervious	Average Daily Traffic	Range of Rainfall for Events Sampled (inches)	TN (mg/L)	TP (mg/L)
Broward County (6-lane)	Mattraw and Miller (1981)	April 1975-July 1977	42	58.3	36%	20,000	0.06-2.50	0.96	0.077
I-95 Miami bridge	McKenzie et al. (1983)	Nov 1979 (1 event); Mar 1981 (1 event); May 1981 (2 events)	4	1.43	100%	70,000	0.08-0.65	3.20	0.160
Maitland Blvd	German (1983)	April 1975-April 1979 (Samples collected in April, August, and December)	13-18	16.8[1]	Not specified	Not specified	Not specified	1.30	0.240
I-4 Maitland Interchange	Harper (1985)	April 1983-May 1984	16	3.95[2]	Not specified	31,400[4]	0.33-3.23	1.40	0.170
I-4 Maitland Interchange	Yousef et al. (1986)	April 1983-May 1984	16	48.9[3]	Not specified	15,000	0.33-3.23	1.40	0.170
I-4 Epcot Interchange	Yousef et al. (1986)	June 1983 - November 1984	14	20.5	Not specified	Not specified	Not specified	3.16	0.420
Winter Park I-4	Harper (1990)	January 1987-January 1988	10	1.17	100%	60-70,000	0.08-2.19	1.60	0.230
Orlando I-4	Harper (1990)	January 1987-December 1987	13	1.30	70%	60-70,000	0.04-2.77	2.15	0.550
Bayside Bridge - Tampa	Stoker (1996)	April 1993 - September 1996	24	12.9	100%	36-56,000	0.12-3.15	1.10	0.100
Tallahassee	ERD (2000)	NA	NA	NA	NA	NA	NA	1.10	0.166
Orlando - US 441	ERD (2005) - unpublished data	NA	NA	NA	NA	NA	NA	0.683	0.085
Richard Road (Lee County)	Johnson Engineering (2006)	Dec 2004-Nov 2005	9	7.56	49%	33,000	0.32-3.21	1.56	0.279
US 41 (Lee County)	Johnson Engineering (2008)	Sept 2005-August 2006	6	6.89	62%	61,000	0.25-1.03	0.832	0.121
Labelle (Hendry County)	Johnson Engineering (2009a)	August 2006-Oct 2007	7	6.80	84%	9,000	0.16-4.40	1.306	0.17
Flamingo Drive (Collier County)	Johnson Engineering (2009b)	April 2007-Sept 2007	8	16.95	65%	28,500	0.19-2.47	0.937	0.060
Geometric Mean								1.37	0.17

NA - Report and data were not available for review

[1] Drainage area is estimated

[2] Represents just the area draining to the sampling point at the retention pond

[3] Includes total area draining to the retention pond

[4] Includes both east and westbound traffic

presented from the I-4/Maitland Boulevard interchange are from the same field investigation in 1983-1984. A third study was conducted along Maitland Boulevard at holding ponds within 2 miles of the I-4/Maitland interchange (German 1983).

Secondly, there are considerable differences between the 15 studies with respect to number of events sampled, range of total rainfall per event and overall study length. Ideally, each stormwater study should include at least an entire year of sampling, with both small and large rain events represented.

Mattraw and Miller (1981), the earliest study in the data set, is also one of the most rigorous. Flow-weighted water quality samples were collected over a 27-month period from 45 events. Events sampled include storms as small as 0.06 inch up to events of 2.5 inches. The highway watershed in this study, which included 3,000 feet of 6-lane road, was chosen to determine the impact of moderate traffic (approximately 20,000 vehicles per day) on stormwater quality, so the study designers located a drainage with negligible runoff from adjacent commercial and residential areas. The TN and TP values reported in Table 1 are the averages of 436 individual sample aliquots collected over the course of the study. Corresponding median values for TN and TP are 0.600 mg/L and 0.060 mg/L, respectively. Data from this study are included in Appendix A.

In contrast, McKenzie et al. (1983) was a reconnaissance study of a small bridge area on I-95 in Miami and includes data from just four events, with rainfall ranging from 0.08 inch to just 0.65 inch. For the four storms sampled, a total of 35 individual sample aliquots were collected at approximately 3.8-minute intervals. The TN and TP values reported in Table 1 represent the medians of these individual samples. Data from this study are included in Appendix B.

The absence of higher rainfall events from the I-95/Miami Bridge biases the data toward higher EMCs since much of the pollutant load is often contained in the earlier portions of runoff. In addition, the authors note that a portion of the stormwater runoff from the I-95/Miami Bridge study was discharged before reaching the sample outfall point so the samples collected do not give a true picture of the actual concentrations of pollutants in the runoff. The total bridge drainage area comprised a 1,387-ft section along which some of the stormwater was intercepted and discharged through downdrains and a 339-ft section without downdrains that ended at the sample point. Because of these flow losses, estimated to be as high as 93 percent, and the limited number of events sampled, it is recommended that these data be removed from the database for use in calculating the statewide EMCs.

German (1983) conducted an investigation of water quality of four lakes in central Florida before, during, and after construction of an interchange at I-4 and a four-lane section of road connecting the interchange to US 17/92. The multi-purpose water quality monitoring program began in April 1971 and went through June 1979. The following study objectives were identified:

- Document lake water quality before, during, and after the start of road construction
- Determine quality and quantity of runoff entering the lakes and bulk precipitation falling on the surface of the lakes
- Determine water quality in the surficial aquifer around the lakes
- Determine loads of materials carried into the lakes by runoff and precipitation
- Determine the quality and quantity of bulk precipitation falling on the surface of the lakes

Water quality monitoring of direct runoff from residential areas into the lakes, highway runoff from Maitland Boulevard into two holding ponds, groundwater, precipitation, lake water, and holding pond water was conducted. Sampling of roadway runoff was started in April 1975 at one holding pond and in December 1977 at a second holding pond. Highway runoff samples were collected approximately three times per year in April, August, and December until April 1979. Road construction started in 1974 and was completed in April 1977. Runoff at each holding pond was sampled once during each rainfall event, i.e., samples were not flow-weighted over the duration of the storm). The author notes that initial sampling of runoff from residential areas into the lakes (August 1971 to August 1973) included collection of samples near the beginning and near the end of each storm. This was based upon the assumption that the early samples would contain the bulk of the pollutants. This did not turn out to be consistently true, however, so the method was modified to include just one sample at each site per event. Median values of TN and TP for highway runoff are represented in Table 1.

Harper (1985) investigated roadway runoff from Maitland Boulevard into one of three ponds at the I-4/Maitland Boulevard interchange with the primary objective of determining the fate and movement of heavy metals from highway runoff. Flow weighted samples were collected for sixteen events during a 13-month period from April 1983 to May 1984. Samples were collected at an outfall to one of three retention ponds at the interchange. The outfall drained a 3.95 acre area of Maitland Boulevard. Nutrient data were also collected at the outfall pipe, but the results of nutrient sample analyses are not presented in Harper's dissertation.

Yousef et al. (1986) presents results of highway runoff investigations at the I-4/Maitland Boulevard interchange and the Epcot/I-4 interchange. The data from the Maitland Boulevard study location are taken from the Harper (1985) study, but additional nutrient parameters not presented by Harper as part of his dissertation are also included.

Nitrogen values for the Maitland site are presented by Yousef et al. (1986) as averages of organic nitrogen (55 samples), ammonia nitrogen (108 samples), nitrate nitrogen (111 samples), and nitrite nitrogen (117 samples). For purposes of inclusion in the calculation of the statewide EMC value, the value of total nitrogen for this site is computed as the sum of the averages of each of these species of nitrogen (see Harper and Baker 2007). If there were equal numbers of samples for each of the constituents, this method would be equivalent to computing TN for each sample and then taking the average. However, since there is such a wide disparity in the numbers of samples used to determine each of the four nitrogen numbers, in particular organic nitrogen, it is incorrect to simply add up the averages. The correct approach is to take all of the samples for which all four constituents are known, compute TN for each sample and then average those values. The problem with this approach, however, is that the full range of events is not included and the average may not be representative of the actual long term average. No additional details about the nutrient samples are presented in either report, so additional review of the data could not be completed.

Harper and Baker (2007) also present two different sets of EMC values for the metals evaluated by Harper (1985) from the I-4/Maitland Boulevard interchange. Since the numbers come from the same study, they should be the same. The differences come about because the numbers presented under the Harper (1985) reference are flow-weighted averages, and the numbers presented under the Yousef et al. (1986) reference are simply averages of each individual sample collected over the course of the study. For purposes of determining EMCs, the flow-weighted averages should be used.

The objective of the study conducted at the Epcot interchange was to investigate and quantify the amount and character of nutrients and heavy metals at a succession of points in a stormwater treatment train consisting of swales, retention/detention ponds, and wetlands. Water quality data were collected at seven locations within the treatment train. Sample point #1 drained a median section of the connector road and was located in a grassy swale approximately 40 ft downstream from the exit from a 15-in culvert. Sample point #2 was located at the exit to a 15-in culvert that received direct runoff from the connector road. Sample point #3 received direct runoff from the I-4 interchange overpass that discharged through a 15-in culvert. Sample points #4 through #7 were all located downstream of the sites receiving direct roadway runoff at various locations along the treatment train.

Water samples at the Epcot stations were collected using open plexiglass trays connected to a Tygon tube that allowed collected flow to discharge into a 1-gallon bottle placed below the collection tray. The samples collected in this manner were not flow-weighted, but were instead representative of first flush conditions, or the first gallon of runoff. Because the samples represent the first flush and not EMC values, these data are not appropriate for inclusion in the calculation of statewide EMC values. Although these samples are referred to at one point in the report as “composites,” they are more accurately described as grab samples collected over a period of time. Collection of runoff begins at the start of the event and stops when the bottle is full.

It is also noted that although three of the stations directly drain roadway areas, only the data for Station #2 was selected for inclusion in the statewide EMC calculations. TN values for Stations #1 and #3 are 1.91 and 1.00 mg/L, respectively. TP values for Stations #1 and #3 are 0.36 and 0.19 mg/L, respectively. These values are substantially less than the TN and TP values of 3.16 and 0.42 mg/L used in the statewide EMC calculations. Averaging the results from the three stations yields TN and TP values of 2.02 and 0.32 mg/L, respectively.

In conjunction with an investigation on the effects of stormwater management systems on groundwater quality, Harper (1990) investigated water quality of runoff from two small road areas (1.17 and 1.30 acres) on I-4. Flow-weighted samples of highway runoff were collected from 10 events at one site and 13 events at the second site. These sites are both similar to the I-95/Miami bridge site in that all three are small drainage areas with high traffic volumes. For this study, Harper used a collection system similar to that used at the Epcot site, but the system was modified to enable collection of flow-weighted samples of up to 2 gallons. Data collection and analyses were conducted in accordance with approved Quality Assurance Plans. The TN and TP values in Table 1 are averages.

As part of an investigation into the effectiveness of a detention pond for reducing pollutants in bridge runoff, Stoker (1996) collected flow-weighted runoff samples from 24 rain events for a 12.9 acre impervious area of Bayside Bridge near Tampa. Up to 8 individual aliquots were collected over a period of up to 87 minutes. Sample collection started after the bridge opened in 1993 and continued for two years. During this time, the average daily traffic count was estimated to grow from approximately 36,000 to 56,000. The TN and TP values in Table 1 are the medians of 182 individual samples.

The four sample locations included in the District 1 EMC study included roadways with a range of characteristics representative of many of the roadways within District 1. Details of the areas sampled are included in Table 1, with additional information summarized in Table 2. Sample site locations are shown in Figure 2. The sites are all within 50 miles of one another and collectively include sampling from 30 different events ranging from 0.16 to 4.40 inches of rainfall. The sites are representative of both lightly traveled and more heavily traveled roadways in District 1. In addition, all four sites are located within the boundaries of or in proximity to the three BMAPs in which District 1 is a stakeholder.

Pond inflow EMCs for the District 1 studies were determined by compositing flow-weighted samples collected with an automated sampler. All samples were collected and analyzed in accordance with FDEP Standard Operating Procedures, including sample analyses by a laboratory accredited by the National Environmental Laboratory Accreditation Conference (NELAC). Details of the TN and TP data collected at each of the sites is presented in Table 3. The average TN value for the four sites ranged from 0.832 mg/L at US 41 to 1.56 mg/L at Richard Road. TP ranged from 0.06 mg/L at Flamingo Drive to 0.279 mg/L at Richard Road. The overall TN and TP averages for all sites are 1.16 and 0.157 mg/L, respectively. Except for TN at Richard Road, the median values were consistently less than the average values. TN and TP values included in Table 1 are averages.

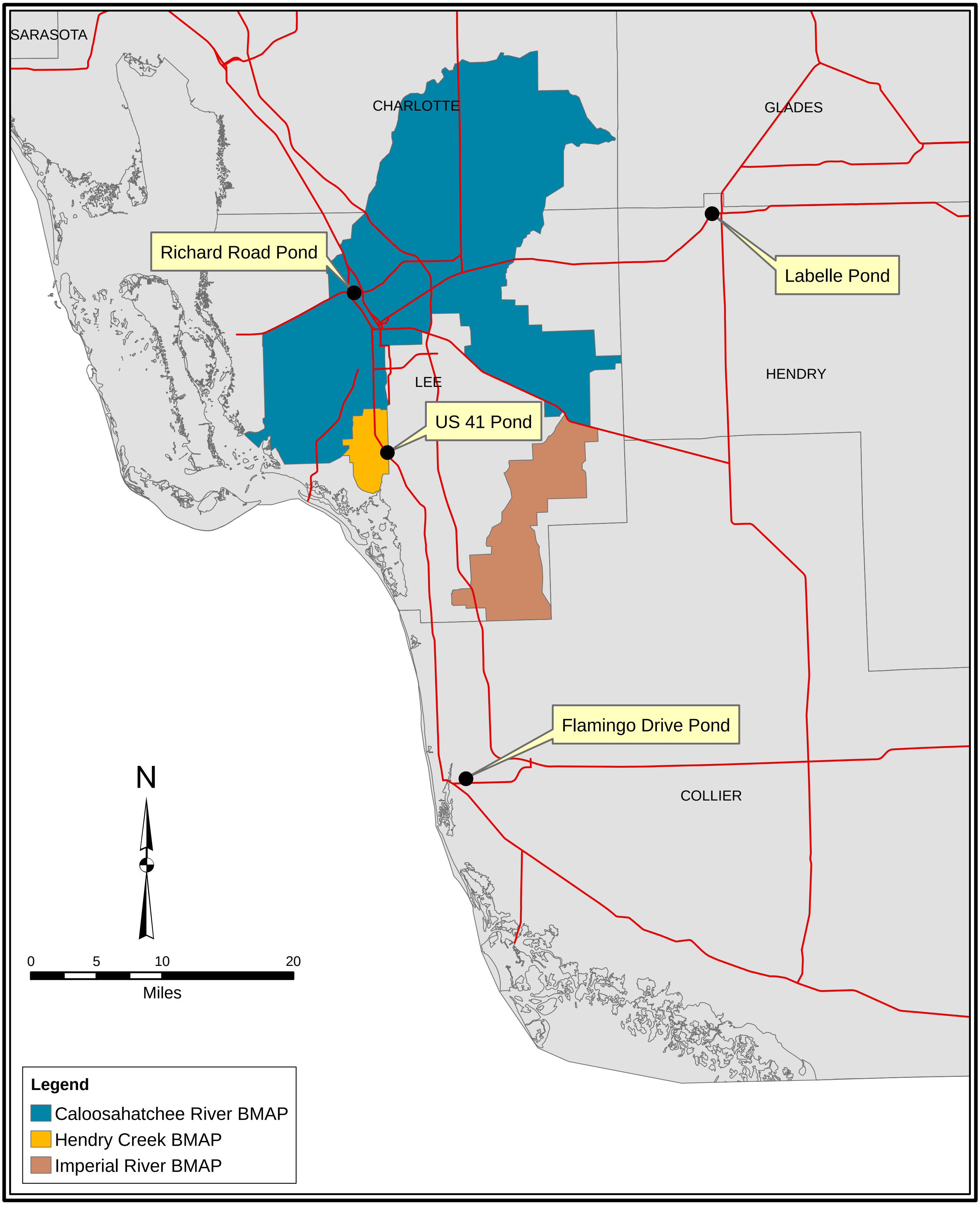

Figure 2. Locations of District 1 EMC Sampling Sites
Relative to Ongoing BMAPs

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Revision Date: 5 August 2010

Table 2. Summary of Roadway Segment Characteristics

Characteristic	Roadway Segment Richard Road (Lee Co.)	U.S. 41 (Lee Co.)	LaBelle (Hendry Co.)	Flamingo Dr. (Collier Co.)
Age of Facility (Years)	11	11	12	10
Drainage Area (Acres)	7.56	6.89	6.8	16.95
Drainage Basin Impervious (%)	49	62	84	65
Average Daily Traffic (2003) (Vehicles)	33,000	61,000	9,000	28,500
Roadway Section	4 Lanes w/ Bike Lanes, Sidewalks	6 Lanes, Extensive Turn Lane, Sidewalks	4 Lanes, Sidewalks	4 Lanes w/ Bike Lanes, Sidewalk
Drainage	Curb/Gutter	Curb/Gutter	Curb/Gutter	Curb/Gutter
Median	Wide, MinorLandscaping	Narrow	Center Turn Lane	Wide, Heavily Landscaped
Adjacent Landuse	Commercial	Commercial	Commercial	Commercial, Golf Course, SFRa, HDRb

Notes:

a) SFR = single family residential

b) HDR = high density residential

Sources: Johnson Engineering, Inc. (2006, 2008, 2009a, 2009b)

FDOT District 1 (percent impervious)

Table 3. EMC Data Collected in Conjunction with the FDOT District 1 Stormwater Study

Location	Date	Rainfall	TN (mg/L)	TP (mg/L)
Richard Road				
	12/25/2004	1.42	2.00	0.339
	3/17/2005	3.21	2.09	0.461
	3/23/2005	0.32	1.22	0.218
	4/27/2005	2.41	1.03	0.247
	5/31/2005	1.06	2.39	0.355
	7/8/2005	3.8	1.73	0.360
	8/16/2005	0.87	1.68	0.239
	9/26/2005	1.35	1.20	0.174
	11/29/2005	1.05	0.714	0.117
Mean			**1.56**	**0.279**
Median			**1.68**	**0.247**
US 41				
	11/29/2005	1.03	0.328	0.136
	2/3/2006	0.82	2.16	0.241
	7/2/2006	0.54	0.694	0.079
	7/6/2006	0.65	0.471	0.055
	7/19/2006	0.25	0.637	0.102
	8/14/2006	0.99	0.704	0.115
Mean			**0.832**	**0.121**
Median			**0.666**	**0.109**
Labelle				
	8/7/2006	0.16	0.428	0.055
	8/30/2006	4.4	2.54	0.129
	9/6/2006	0.27	1.33	0.075
	9/14/2006	0.47	0.927	0.156
	4/12/2007	0.18	1.10	0.358
	5/6/2007	0.4	1.73	0.109
	10/23/2007	0.4	1.08	0.292
Mean			**1.31**	**0.168**
Median			**1.10**	**0.129**
Flamingo Dr.				
	4/12/2007	0.20	1.04	0.042
	5/14/2007	2.47	1.50	0.138
	6/27/2007	0.87	0.973	0.066
	7/3/2007	0.24	0.788	0.060
	8/27/2007	0.19	1.09	0.055
	9/5/2007	2.46	0.664	0.039
	9/8/2007	0.37	0.675	0.043
	9/16/2007	1.44	0.767	0.040
Mean			**0.937**	**0.060**
Median			**0.881**	**0.049**
OVERALL AVERAGE			**1.16**	**0.157**

4.0 CONCLUSIONS AND RECOMMENDATIONS

Researchers have investigated the water quality of highway runoff in Florida for more than 35 years in conjunction with a variety of research objectives, including studies specifically designed to determine highway EMC values. Runoff data consistently show a high degree of variability between different events, so it is important whenever possible for individual sample sets to include a sufficient number and variety of rainfall events such that the calculated EMC values are representative of average annual conditions.

EMC data from 15 site investigations, including four studies conducted by District 1, are being used by FDEP to define highway EMC values to be used for loading calculations for BMAPs and by applicants for Environmental Resource Permits. Data and methods for 13 of these 15 site investigations were reviewed in order to better understand the data sets and methodologies used to determine the EMCs. While limited in many respects, and except for McKenzie et al. (1983) and the Epcot Interchange site investigated by Yousef et al. (1986), the studies reviewed appear to be acceptable for use in calculating the statewide EMCs where adequate site specific EMC data are not available.

Based upon an assessment of the available EMC data, the following actions are recommended:

1. Remove the duplicate data for the I-4/Maitland Boulevard interchange from the statewide EMC calculations.
2. Remove the EMC values from McKenzie et al. (1983) from the calculation of the overall statewide EMCs. There are sufficient studies with more robust data sets on which to base the EMCs. The manner in which the calculations are currently being done gives the McKenzie EMC values, with just four sample events collected over a short time frame and for a small range of events, the same weight as EMC values from other more rigorous studies, e.g., Mattraw and Miller (1981) with 45 events with representative rainfall collected in all seasons over a period of more than 2 years. This introduces an unreasonable bias into the overall calculation. Since the authors themselves describe their study as reconnaissance in nature, it is not appropriate to include the data in calculation of a number that has such far-reaching impacts. Removal of the duplicate data and the McKenzie values does not affect TP, but reduces TN to 1.28 mg/L.

3. Remove the EMC values for the Epcot Interchange (Youset et al. 1986) from the calculation of the overall statewide EMCs. The data from this investigation are representative of first flush values and are not appropriate for use in the statewide EMC calculations. Removal of the duplicate data, the McKenzie data, and the Epcot data yields TN and TP values of 1.19 and 0.155 mg/L, respectively.
4. Utilize the flow-weighted total metals EMC values computed by Harper (1985) for the I-4/Maitland Boulevard interchange.
5. Utilize the site-specific EMC data from the District 1 studies for calculation of the BMAP loadings in the ongoing Caloosahatchee, Hendry Creek, and Imperial River BMAPs. Collectively, these studies provide a more reasonable representation of conditions in the BMAP area than a generalized average that incorporates a plethora of data from regions that are not as representative of the roads in District 1. The recommended values for TN and TP are 1.16 and 0.157 mg/L, respectively.
6. Continue to update the statewide EMC values as additional data become available and promote the use of regional values in lieu of generalized statewide values whenever sufficient data are available.

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Appendix A. TN and TP data from Mattraw and Miller (1981)

Rainfall (inches)	Date	Total Nitrogen (MG/L)	Total Phosphorous (MG/L)
0.06	4/15/1975	4.72	0.53
		4.12	0.26
		2.94	0.39
		2.7	0.32
		3.43	0.23
		3.23	0.21
		2.91	0.26
		4.82	0.4
		4.07	0.28
		3.46	0.22
		4.68	0.26
0.23	5/5/1975	6.48	0.17
		5.47	0.17
		4.9	0.2
		5.04	0.16
		4.44	0.15
		5.05	0.15
		5.21	0.2
		5.21	0.18
0.38	5/9/1975	3.36	0.12
		3.53	0.16
		3.27	0.13
		2.89	0.1
		3.24	0.13
		3.52	0.11
		2.83	0.13
		3.07	0.13
		3.54	0.1
		3.1	0.12
		3.31	0.18
		3.5	0.24
0.11	5/22/1975	1.78	0.09
		2.45	0.12
		2.7	0.16
		1.8	0.11
		2.11	0.12
		2.35	0.1
		1.78	0.1
		1.7	0.09
		2.16	0.09
		1.98	0.08
		1.5	0.08

Appendix A. TN and TP data from Mattraw and Miller (1981)

Rainfall (inches)	Date	Total Nitrogen (MG/L)	Total Phosphorous (MG/L)
		2.52	0.09
0.88	5/29/1975	0.58	0.03
		0.58	0.04
		0.59	0.03
		0.52	0.04
		0.56	0.04
		0.39	0.12
		0.42	0.03
		0.41	0.04
		0.39	0.04
		0.32	0.04
		0.33	0.04
		0.38	0.03
0.22	7/14/1975	0.62	0.02
		0.4	0.03
		0.4	0.04
		0.39	0.03
		0.32	0.04
		0.32	0.04
		0.3	0.04
		0.3	0.05
		0.25	0.04
		0.31	0.03
		0.32	0.03
		0.32	0.03
1.23	8/23/1975	1.2	0.1
		1.11	0.05
		0.83	0.04
		0.84	0.03
		0.8	0.04
0.27	8/29/1975	0.66	0.06
		0.65	0.05
		0.5	0.06
		0.52	0.05
		0.45	0.05
		0.97	0.05
		0.51	0.05
		0.35	0.04
		0.38	0.05
		0.33	0.05
		0.37	0.05
		0.26	0.05

Appendix A. TN and TP data from Mattraw and Miller (1981)

Rainfall (inches)	Date	Total Nitrogen (MG/L)	Total Phosphorous (MG/L)
0.45	9/17/1975	0.69	0.06
		0.71	0.04
		0.57	0.06
		0.65	0.06
		0.58	0.06
		0.5	0.05
		1.24	0.06
		0.49	0.06
		0.69	0.05
		0.45	0.06
		~	0.06
		0.7	0.06
0.36	10/22/1975	0.47	0.04
		0.5	0.06
		0.86	0.39
		0.98	0.48
		0.62	0.36
		0.61	0.3
		0.5	0.26
		0.47	0.25
		0.54	0.27
0.38	10/31/1975	0.51	0.03
		0.48	0.04
		0.53	0.03
		0.58	0.03
		0.6	0.03
		0.56	0.03
		0.54	0.03
		0.53	0.03
		0.55	0.03
		0.57	0.03
		0.54	0.03
		0.58	0.03
0.3	1/5/1976	1.6	0.12
		1.65	0.09
		1.57	0.09
		1.49	0.08
		1.15	0.07
		1.2	0.07
		1.13	0.07
		1.09	0.08
		1.07	0.08

Appendix A. TN and TP data from Mattraw and Miller (1981)

Rainfall (inches)	Date	Total Nitrogen (MG/L)	Total Phosphorous (MG/L)
		0.95	0.08
		0.96	0.08
		0.9	0.08
0.63	5/15/1976	1.17	0.09
		0.93	0.07
		0.94	0.06
		0.9	0.06
		0.82	0.08
		0.72	0.06
		0.83	0.07
		0.67	0.06
		0.66	0.08
		0.62	0.06
		0.61	0.06
		0.57	0.06
0.3	5/17/1976	1.61	0.11
		1.68	0.08
		1.14	0.06
		1.05	0.05
		0.96	0.05
		0.88	0.05
		1.12	0.05
		1.07	0.05
		1.29	0.09
		0.98	0.05
		0.91	0.05
		0.9	0.05
0.63	5/21/1976	1.37	0.08
		0.73	0.06
		0.59	0.06
		0.5	0.05
		0.19	0.05
		0.23	0.04
		0.15	0.04
		0.15	0.04
		0.09	0.04
		0.12	0.04
		0.12	0.04
		0.13	0.04
		1.15	0.07
		0.43	0.06
		1.06	0.07

Appendix A. TN and TP data from Mattraw and Miller (1981)

Rainfall (inches)	Date	Total Nitrogen (MG/L)	Total Phosphorous (MG/L)
2.09	5/28/1976	0.67	0.07
		0.67	0.07
		0.59	0.06
		0.48	0.05
		0.26	0.05
		0.23	0.04
		0.23	0.04
		0.33	0.04
		0.3	0.05
0.38	6/4/1976	1.13	0.05
		0.76	0.04
		0.74	0.04
		0.65	0.03
		0.45	0.03
		0.44	0.03
		0.32	0.03
		0.33	0.03
		0.31	0.16
		0.28	0.03
		0.29	0.04
		0.3	0.03
		0.27	0.03
		0.26	0.03
		0.27	0.03
		0.27	0.03
		0.32	0.03
		0.29	0.04
		0.27	0.03
		0.28	0.03
		0.29	0.03
		0.26	0.03
		0.34	0.04
		0.36	0.04
0.65	6/7/1976	0.85	0.06
		0.58	0.05
		0.47	0.04
		0.42	0.04
		0.4	0.04
		0.42	0.04
		0.41	0.04
		0.41	0.04
		0.44	0.05

Appendix A. TN and TP data from Mattraw and Miller (1981)

Rainfall (inches)	Date	Total Nitrogen (MG/L)	Total Phosphorous (MG/L)
		0.46	0.05
		0.45	0.05
		0.48	0.05
0.84	6/11/1976	0.2	0.04
		0.12	0.04
0.29	6/11/1976	0.22	0.07
0.08	6/16/1976	0.66	0.08
		0.5	0.05
		0.4	0.06
		0.41	0.07
		0.37	0.07
		0.34	0.06
		0.33	0.8
		0.4	0.8
1.36	6/19/1976	0.5	0.07
		0.45	0.06
		0.37	0.06
		0.39	0.08
		0.19	0.04
		0.15	0.04
		0.17	0.04
		0.2	0.03
		0.37	0.04
		0.44	0.05
		0.31	0.04
0.95	6/23/1976	0.46	0.06
		0.55	0.05
		0.42	0.01
		0.39	0.07
		0.34	0.07
0.58	6/25/1976	0.23	0.03
		0.17	0.03
		0.12	0.03
		0.22	0.05
0.2	6/27/1976	0.57	0.06
		0.52	0.04
		0.34	0.04
		0.22	0.03
0.18	7/6/1976	1.9	0.09
		1.61	0.07
		1.63	0.07
		1.28	0.07

Appendix A. TN and TP data from Mattraw and Miller (1981)

Rainfall (inches)	Date	Total Nitrogen (MG/L)	Total Phosphorous (MG/L)
		1.65	0.07
		1.53	0.08
0.53	7/7/1976	0.53	0.05
		0.45	0.04
		0.3	0.03
		0.31	0.04
		0.29	0.04
0.12	7/13/1976	1.59	0.1
		2.31	0.07
		1.49	0.05
1.92	7/22/1976	1.66	0.09
		1.19	0.06
		1.71	0.06
		1.37	0.06
		1.48	0.07
		0.55	0.06
		0.91	0.06
		0.79	0.06
		0.76	0.05
		0.71	0.06
		0.4	0.05
		0.68	0.05
1.39	8/16/1976	0.72	0.08
		0.87	0.07
		0.76	0.07
		0.63	0.07
		0.66	0.07
		0.55	0.06
		0.49	0.06
		0.53	0.04
		0.57	0.05
		0.56	0.05
		0.64	0.05
0.56	8/18/1976	0.6	0.04
		0.49	0.06
		0.33	0.05
		0.29	0.05
		0.35	0.06
		2.31	0.08
		1.53	0.07
		1.41	0.08
		1.17	0.08

Appendix A. TN and TP data from Mattraw and Miller (1981)

Rainfall (inches)	Date	Total Nitrogen (MG/L)	Total Phosphorous (MG/L)
0.37	10/9/1976	1.13	0.08
		0.86	0.08
		0.86	0.08
		0.82	0.07
		1.26	0.07
2.42	11/2/1976	1.37	0.08
		1.23	0.11
		2.06	0.11
		0.76	0.08
		0.33	0.06
		0.2	0.06
1.07	11/17/1976	3.31	0.07
		3.01	0.07
		0.46	0.05
		0.91	0.05
		0.89	0.05
		0.28	0.05
		0.21	0.05
		0.16	0.04
		0.17	0.04
		0.25	0.04
		0.21	0.04
		0.23	0.05
2.50	12/13/1976	0.63	0.03
		0.59	0.03
		0.66	0.03
		0.39	0.03
		0.34	0.03
		0.41	0.03
		0.58	0.04
		0.6	0.04
		0.63	0.06
		0.64	0.07
		0.74	0.07
0.71	2/8/1977	1.37	0.07
		0.97	0.07
		0.71	0.06
		0.35	0.04
		0.34	0.04
		0.27	0.04
		0.39	0.04
		0.25	0.04

Appendix A. TN and TP data from Mattraw and Miller (1981)

Rainfall (inches)	Date	Total Nitrogen (MG/L)	Total Phosphorous (MG/L)
0.32	4/10/1977	1.32	0.1
		1.21	0.09
		0.96	0.07
		0.78	0.06
		0.79	0.07
		0.55	0.06
		0.56	0.06
		0.59	0.06
		0.58	0.06
		0.83	0.06
		0.61	0.06
		0.53	0.06
		0.56	0.06
		0.5	0.06
		0.5	0.06
		0.57	0.06
		0.51	0.06
		0.51	0.06
		0.51	0.06
		0.5	0.06
		0.61	0.06
		0.53	0.06
		0.56	0.07
0.27	4/12/1977	1	0.11
		1.03	0.09
		0.99	0.09
		0.7	0.08
		0.58	0.06
		0.55	0.06
		0.49	0.06
		0.57	0.06
1.14	4/13/1977	0.62	0.07
		0.75	0.05
		1.02	0.04
		0.63	0.05
		0.43	0.05
		0.36	0.05
		0.39	0.05
		0.38	0.05
		1.13	0.12
		0.91	0.05
		0.83	0.06

Appendix A. TN and TP data from Mattraw and Miller (1981)

Rainfall (inches)	Date	Total Nitrogen (MG/L)	Total Phosphorous (MG/L)
0.16	4/24/1977	0.99	0.06
		0.87	0.05
		1.37	0.05
		1.21	0.06
		0.88	0.04
		0.84	0.04
		1.16	0.05
		1.26	0.06
		1.08	0.06
		0.87	0.06
		0.7	0.05
		0.63	0.05
		0.72	0.05
		0.71	0.05
		0.74	0.05
		0.75	0.06
		0.61	0.05
		0.59	0.05
		0.6	0.05
2.08	5/4/1977	2.75	0.23
		2.7	0.21
		1.93	0.18
		1.17	0.15
		0.8	0.14
		0.67	0.12
		0.55	0.11
		0.51	0.1
		0.5	0.1
		0.35	0.08
0.88	5/9/1977	1.47	0.12
		0.74	0.06
		0.71	0.06
		0.45	0.03
		0.39	0.05
		0.28	0.03
		0.2	0.04
		0.22	0.04
		2.17	0.12
		0.59	0.03
		0.88	0.05
		0.76	0.04
		0.66	0.06

Appendix A. TN and TP data from Mattraw and Miller (1981)

Rainfall (inches)	Date	Total Nitrogen (MG/L)	Total Phosphorous (MG/L)
1.04	5/10/1977	0.58	0.05
		0.44	0.04
		0.43	0.04
		0.5	0.05
		0.54	0.06
		0.81	0.08
		0.68	0.07
		0.66	0.08
1.48	6/1/1977	0.98	0.17
0.29	7/1/1977	1.35	0.06
		1.23	0.06
		1.3	0.08
		1.09	0.06
		0.78	0.08
		0.52	0.09
		0.58	0.05
Mean		0.961	0.077
Median		0.600	0.060

Appendix B. TN and TP data from McKenzie et al. (1983)

Rainfall (inches)	Date	Total Nitrogen (MG/L)	Total Phosphorous (MG/L)
0.4	11/3/1979	7.7	0.35
		8.2	0.23
		8	0.23
		7.6	0.23
		7.7	0.23
		7.7	0.23
		8.1	0.22
		7.8	0.22
		7.8	0.23
		7.9	0.23
		7.7	0.23
0.12	3/23/1981	6.2	0.66
		6.9	0.02
		3.2	0.15
		3.6	0.34
		2.9	0.18
		2.1	0.14
		1.5	0.08
		-	0.0
0.08	5/1/1981	5.8	0.26
		3.7	0.18
		3.3	0.15
		0.8	0.18
		1.1	0.1
		1.3	0.08
		1.4	0.09
		1.9	0.09
		2.6	0.1
		-	0.02
0.65	5/20/1981	2	0.14
		0.55	0.05
		0.59	0.06
		0.49	0.04
		0.59	0.05
		0.69	0.05
		0.91	0.06
Mean		4.1	0.16
Median		3.3	0.15