ATTACHMENT C

CITY OF SEATTLE

NPDES PHASE I MUNICIPAL STORMWATER PERMIT

WY2012 STORMWATER MONITORING REPORT

Prepared by
Seattle Public Utilities

March 20, 2013

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1 INTRODUCTION

1.1 Introduction

This document serves as the City of Seattle's (City) water year 2012 monitoring report as required by Special Conditions S8.H and S9 of the 2007 National Pollutant Discharge Elimination System (NPDES) Phase I Municipal Stormwater Permit (Permit). The Permit became effective on February 16, 2007 and was modified on June 17, 2009 and September 1, 2010 by the Washington Department of Ecology (Ecology) under the NPDES and State Waste Discharge General Permits for discharges from Large and Medium Municipal Separate Storm Sewer Systems (MS4s). On August 1, 2012 Ecology reissued the Permit with limited changes, effective September 1, 2012 – July 31, 2013. This "one year" permit extends the timeline for some of the monitoring requirements in 2007 Permit until the new five year permit becomes effective on August 1, 2013. The one year permit is included when the term "Permit" is used in this report.

The City was required to fully implement the monitoring program as described in Special Condition 8 (S8) of the Permit on February 16, 2009. Special Condition S8.H of the Permit requires the City to provide a report annually on the monitoring that occurred during the previous water year (WY). A water year starts on October 1 and ends on September 30 of the following year. This report summarizes monitoring activities performed during the third complete water year stipulated in the 2007 Permit which began on October 1, 2011 and ended on September 30, 2012.

1.2 Background

The Permit requires three types of monitoring under section S8, which are summarized below and discussed in detail in Sections 2-4.

Stormwater Characterization (S8.D) – Stormwater characterization is monitoring which is intended to characterize stormwater runoff quantity and quality to allow analysis of loadings and changes in conditions over time within the Permittee's jurisdiction. Ecology stated in the Permit Fact Sheet that the purpose of requiring Permittees to engage in stormwater characterization monitoring is to gain knowledge of pollutant loads from areas within the municipality.

The City's implementation of this requirement consists of three in-pipe stormwater monitoring locations that are considered to be representative of the land uses that they are intended to characterize. The first monitoring location is located in northwest Seattle in the Venema neighborhood and represents predominantly residential land use. The second monitoring location is in northeast Seattle located adjacent to the University of Washington and represents predominantly commercial land use. The third monitoring location is in south Seattle near the City's border with Tukwila and represents predominantly industrial land use.

Under the current one year Permit, stormwater characterization monitoring was concluded on September 30, 2012 with the completion of the third complete water year of monitoring per the terms of the Permit. WY2012 stormwater characterization monitoring results are documented in Section 2 of this report.

Program Effectiveness (S8.E) – Program effectiveness monitoring is intended to improve stormwater management efforts by providing a feedback loop to help determine if a stormwater management program element is meeting the desired environmental outcome. The Permit requires the City to select two specific aspects of the Stormwater Management Program to evaluate; the effectiveness of a targeted action and the effectiveness of achieving a targeted environmental outcome.

The potential impact of urban stormwater runoff on the water quality of receiving waters is of great concern in the Seattle area. While new development and redevelopment may have a large number of options for providing water quality treatment through structural controls, existing developed areas have limited choices for retrofitting their stormwater systems. Thus, nonstructural measures, also known as source control, offer perhaps the greatest potential for improvement of water quality. Roads and other transportation related surfaces make up 26 percent of the land use within the City. Street sweeping is one of the source control tools available to meet this Permit requirement and the City has recently expanded its sweeping program, with a focus on removing pollutants from roadways that discharge to the City's Municipal Separate Storm Sewer System (MS4). Because of this, the City has chosen to evaluate the program effectiveness of street sweeping for both required aspects:

- **Targeted action** - *Does street sweeping result in improvements in stormwater quality and quality of sediments in stormwater discharges or both*? This aspect evaluated the effectiveness of regenerative air street sweeping technology at a frequency of every two weeks to potentially provide treatment at a level similar to structural stormwater best management practices (BMPs) by reducing the quarterly average street dirt pollutant load 60 percent for fine particles (less than 250 microns in diameter).
- **Targeted outcome** - *Does street sweeping reduce the discharge of certain pollutants below a targeted annual load amount*? This was evaluated through development of a spreadsheet model that predicts a targeted annual load reduction, using total suspended

solids as a surrogate pollutant, for varying conditions, such as sweeping frequency, sweeping velocity and parking enforcement compliance.

The program effectiveness study was completed in WY2011 and two deliverables were submitted to satisfy the Permit requirements for Section S8.E: 1) the targeted action work is documented in a report titled "Program Effectiveness Report - Sweet Sweeping for Water Quality" dated March 2012 and submitted concurrent with the WY2011 annual report; and 2) the targeted outcome work's deliverable was a spreadsheet model named "Sweeping to Reduce Contaminants" (STORC) which was submitted to Ecology on compact disc on May 30, 2012.

BMP Effectiveness (S8.F) – The Permit's best management practice (BMP) effectiveness monitoring requires the City to monitor two types of structural stormwater controls required for use by project proponents in new development and re-development projects that trigger the Stormwater Code requirement for water quality treatment or flow control of stormwater. Ecology designed the Permit requirement so that full scale field monitoring would evaluate the effectiveness and operation and maintenance requirements of stormwater treatment and hydrologic management BMPs applied in Phase I jurisdictions.

The first treatment BMP monitored by the City is the Stormwater Management StormFilter® (StormFilter) configured in two CatchBasin StormFilter™ (CBSFs) stormwater treatment systems utilizing zeolite-perlite-granular activated carbon (ZPG™) cartridges installed in West Seattle. The CBSF treatment BMP is frequently installed by the Seattle Department of Transportation (SDOT) to treat roadway stormwater runoff. The City was interested in monitoring the effectiveness of this BMP because the cartridge technology (the "StormFilter") has received a basic treatment General Use Level Designation (GULD) by Ecology via testing within a larger vault configuration, not in the smaller catch basin configuration. The study was conducted from February 2009 through September 2011 with a total of 37 storm events sampled across the two CBSFs monitored. The complete results of this study are documented in a report titled "CatchBasin StormFilter Performance Evaluation Report" dated March 5, 2012 and submitted to Ecology concurrent with the WY2011 annual report.

For the second treatment BMP, the City is partnering with Washington State University (WSU) to satisfy the Permit obligations for stormwater treatment BMP monitoring as allowed by special condition S3.B of the Permit. The City is participating in a WSU Low Impact Development (LID) research effort where WSU is monitoring the pollutant removal capacity of various bioretention soil mixes. The City has developed a Memorandum of Agreement (MOA) with WSU to obtain the monitoring results from four bioretention mesocosms at the WSU Puyallup LID research facility to meet the S8.F.2 Permit monitoring requirements for a basic/metals/phosphorus treatment BMP. The MOA specifies that WSU will conduct water quality monitoring on four mesocosms, which are identical in size and all contain a 60/40 mix of aggregate/compost, which is the current soil mix for bioretention facilities specified in the City's Stormwater Code (SMC 22.800-22.808). During WY2011, WSU completed installation and testing of monitoring equipment which took longer than anticipated, and stormwater sampling began in early WY2012. WY2012 monitoring conducted by WSU on the four mesocosms funded by the City is documented in Section 4 of this report.

In addition to the two water quality treatment BMPs, the Permit requires the City to monitor a flow reduction strategy that is in use or planned for installation within the city in a paired study or against a predicted outcome. To meet this requirement, the City has monitored one bioretention swale located in the High Point community in southwest Seattle. Flow was monitored in the swale continuously for two years. The results of this work were summarized in the City's WY2009 Annual Report submitted to Ecology on March 29, 2010.

2 S8.D Stormwater Monitoring

2.1 Overview

As stated in the introduction, stormwater characterization monitoring is a requirement of the 2007 NPDES Phase I Municipal Stormwater Permit (Permit) Special Condition 8 (S8). Ecology designed the stormwater characterization monitoring requirements to characterize stormwater runoff quantity and quality to allow analysis of loadings and changes in conditions over time and generalization across the Permittees' jurisdiction.

The monitoring work as described in the Permit was performed by Seattle Public Utilities (SPU) or contractors under the direction of SPU in accordance with a draft Quality Assurance Project Plan (QAPP) dated February 10, 2008, and approved by Ecology on September 26, 2008. The final QAPP was submitted to Ecology on February 12, 2009 with a revised final QAPP submitted on March 31, 2011. A brief summary of information provided in the QAPP is presented below.

WY2012 represents the third and final full water year of stormwater characterization monitoring conducted by the City under the Permit. As part of the characterization monitoring, the City was required to conduct first-flush toxicity tests once during the five year Permit cycle. Toxicity monitoring was successfully completed in WY2010 at each of the three monitoring locations. Toxicity results were presented in the WY2010 Annual Report.

2.1.1 Monitoring Goals and Objectives

The goal of the stormwater characterization monitoring is to meet the requirements of Section S8.D of the Permit. Ecology's purpose for requiring the City to conduct stormwater characterization monitoring is to obtain knowledge of average event mean concentrations (EMCs) and pollutant loads from representative areas drained by municipal storm sewer systems. In addition, Ecology hopes that the information will be useful for determining whether the comprehensive stormwater management programs are making progress toward the goal of reducing the amount of pollutants discharged and protecting water quality.

2.2 Sampling Location Descriptions

The Permit requires each Permittee to select three monitoring sites within the municipal storm sewer system that represent the three types of land uses: residential, commercial and industrial. As required by the Permit, the City proposed, and received approval from Ecology in December 2007, for the three monitoring sites to meet these requirements. A summary of the three monitoring basins is presented below in Table 2.2 and displayed visually in the Vicinity Map – Figure 2.2.

Table 2.2. Stormwater Characterization Basin Summary

Land Use Category	Station ID (Basin Name)	Storm Sewer System Type
Residential	R1 (Venema)	Separated, ditch & culvert system
Commercial	C1 (University District)	Partially separated
Industrial	I1 (Norfolk)	Partially separated

To determine locations for stormwater monitoring, the City's geographic information system (GIS) was used to display the stormwater infrastructure and identify possible catchments in the separated areas of the city that represent a discernible type of land use. Field visits were then conducted to evaluate hydrology (base flow, turbulent flow, tidal influence, etc.), the feasibility of monitoring (access, potential for vandalism, safety of monitoring personnel, equipment installation needs, etc.) and the suitability of the site for long-term monitoring.

Following the initial site selection, a walking survey of each basin was performed to confirm or correct the drainage area maps.

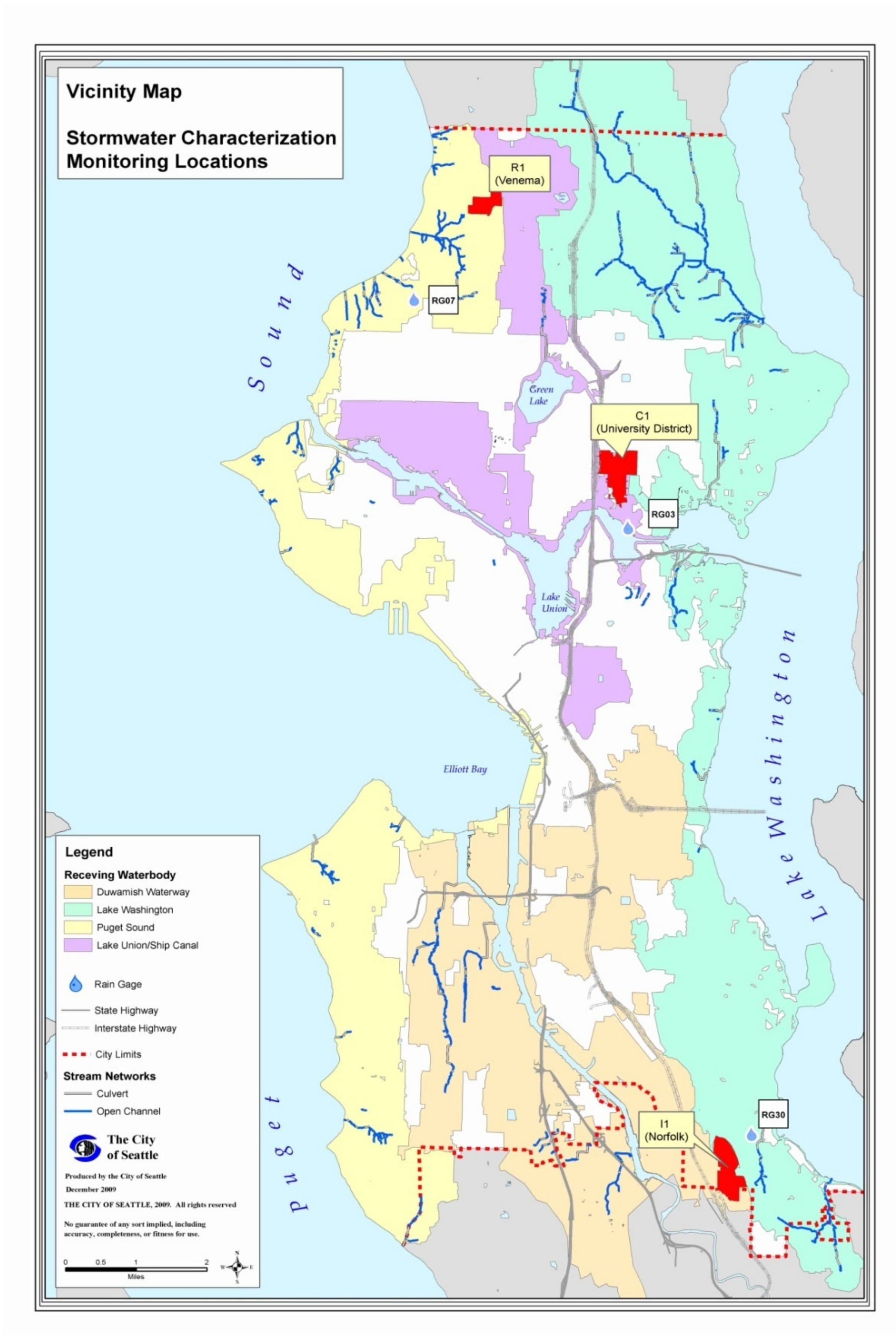
2.2.1 Basin Descriptions

Information about the basins monitored is summarized in Table 2.2.1 below.

Table 2.2.1. Stormwater Characterization Monitoring Location Summary

Represented Land Use	Residential	Commercial	Industrial
Basin	**R1 (Venema)**	**C1 (U- District)**	**I1 (Norfolk)**
Surface Area Distribution			
Total Area (acres)	85.3	181.0	164.2
Area Draining to MS4 Estimate (acres)	85.3	152.0	137.2
Area Draining to Combined System Estimate (acres)	0.0	29.0	27.0
Impervious Area Estimate (%) - for area draining to MS4	50.2	61.1	51.2
Land Use Distribution Estimate- for area draining to MS4			
Residential (%)	95	37	32
Industrial (%)	0	0	37
Commercial (%)	5	61	13
Open Space (%)	0	2	18
Hydrologic Information			
Rain Gauge	RG07	RG03	RG30
Receiving Water Body	Venema/Piper's Creek	Lake Union	Duwamish River

Figure 2.2. Vicinity Map – Stormwater Characterization Monitoring Locations



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The Permit set the following goal for stormwater characterization monitoring locations: "ideally, to represent a particular land use, no less than 80 percent of the area served by the conveyance will be classified as having that land use." The City was unable to find basins that met this goal due to the ultra-urban, mixed land use nature of Seattle. The City selected basins that best represented the land use type in the City and had infrastructure suitable for installation of monitoring equipment. The information on land use percentages for each monitoring sampling location was provided to Ecology in the Permit-required summary description of the monitoring program (S8.G.1.a) in October 2007 and approved by Ecology in December 2007.

SPU used the following method to determine the land use area for each stormwater characterization monitoring basin. Land use data are derived using GIS from the King County Parcel Database, which classifies each parcel into one of the eight general following categories: single family, multi-family, commercial, schools, other/NA, government/public facility, industrial, parks/open space and vacant. Land that is not classified as a parcel is considered right-of-way.

The King County Parcel Database further groups land use into four general categories: (1) residential which includes single family and multi-family and may include other/not applicable (NA); (2) commercial which includes commercial, schools, government/public facility and may include other/NA; (3) industrial which includes industrial and may include vacant; and (4) open which includes parks/open space and may include vacant.

SPU used GIS to determine the percentage of each land use type that drains to the MS4. The impervious area for each land use category is estimated using citywide averages based on GIS analysis. For basins that are partially separated, the equivalent area draining to the MS4 is less than the total basin area because some stormwater in the basin is conveyed via the combined sewer system.

The three monitoring basins are briefly described below. A description of each related monitoring station is described in Section 2.2.2.

2.2.1.1 R1 (Venema)

The R1 basin represents a typical residential area in the separated portion of the City. This basin is located in the northwest portion of Seattle and discharges to Venema Creek which flows into Piper's Creek and then Puget Sound. The basin is approximately 85.3 acres in size with 95 percent residential land use. The basin's sewer system is 100 percent separated. The R1 basin is delineated on Figure 2.2.1.1.

2.2.1.2 C1 (University District)

The C1 basin is located in a partially separated area of the northeast portion of Seattle and represents a mix of commercial uses such as the University of Washington and neighborhood businesses that serve the surrounding residential population. This basin is located north of Lake Union and east of I-5 and drains to Lake Union. The majority land use in the 181-acre basin is commercial which represents approximately 61 percent of the basin. The C1 basin is delineated on Figure 2.2.1.2.

2.2.1.3 I1 (Norfolk)

The I1 industrial basin is served by the partially separated stormwater system and contains business activities typical of industrial land uses in Seattle. It is one of the few industrial basins in Seattle that is not tidally influenced and therefore is considered the best industrial land use basin in the City for meeting the monitoring requirements even though the percent of industrial land use in this basin does not meet the Permit goal of ideally "no less than 80 percent" industrial land use. The I1 basin is located in southern Seattle adjacent and immediately north of the border between the City of Seattle and the City of Tukwila and drains under I-5 to the west into the Duwamish waterway. The 164.2-acre basin is 37 percent industrial, 32 percent residential, 13 percent commercial and 18 percent open space. The I1 basin is delineated on Figure 2.2.1.3.

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Figure 2.2.1.1. Site Map – R1 (Venema)

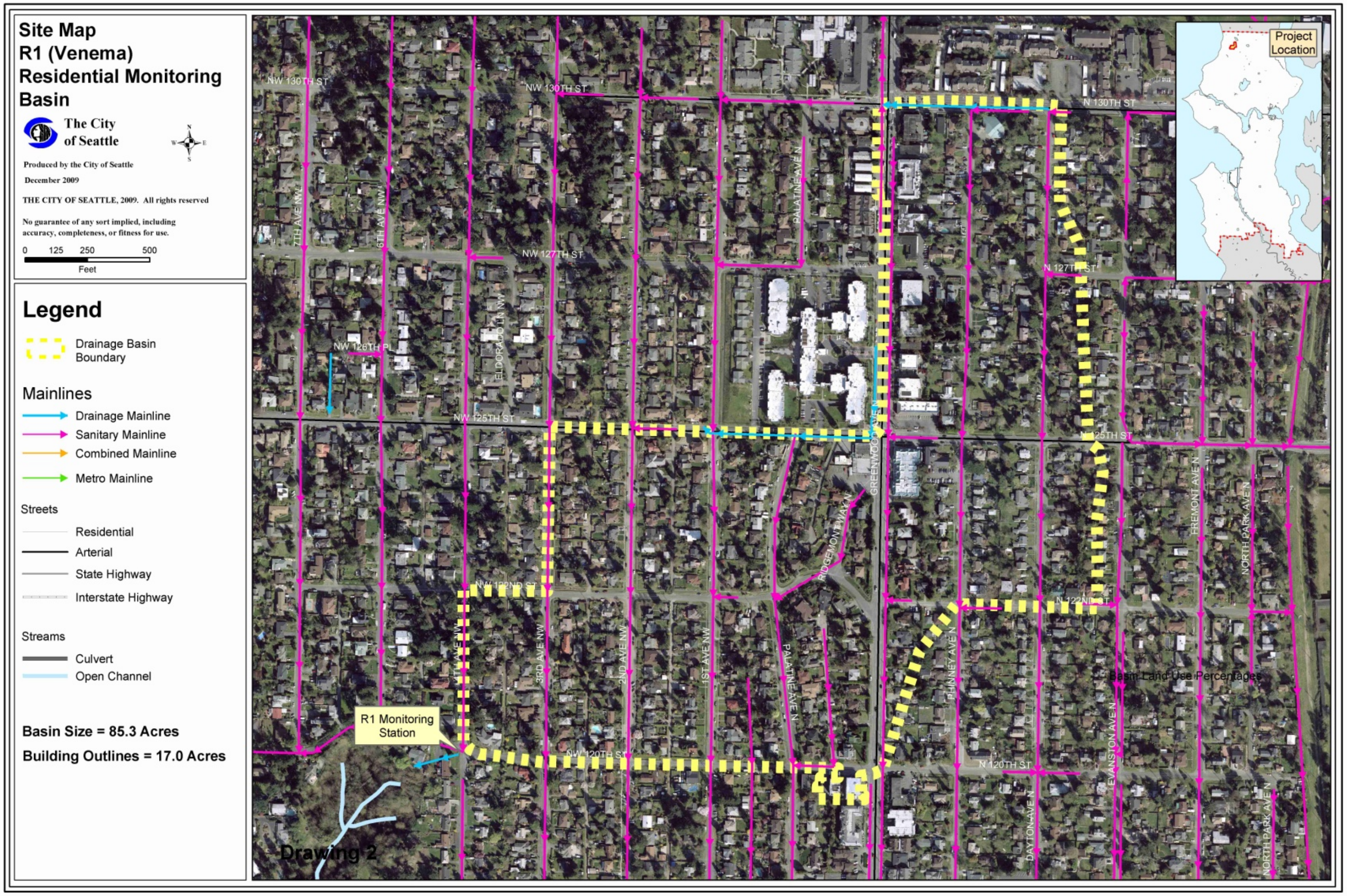

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Figure 2.2.1.2. Site Map – C1 (University District)

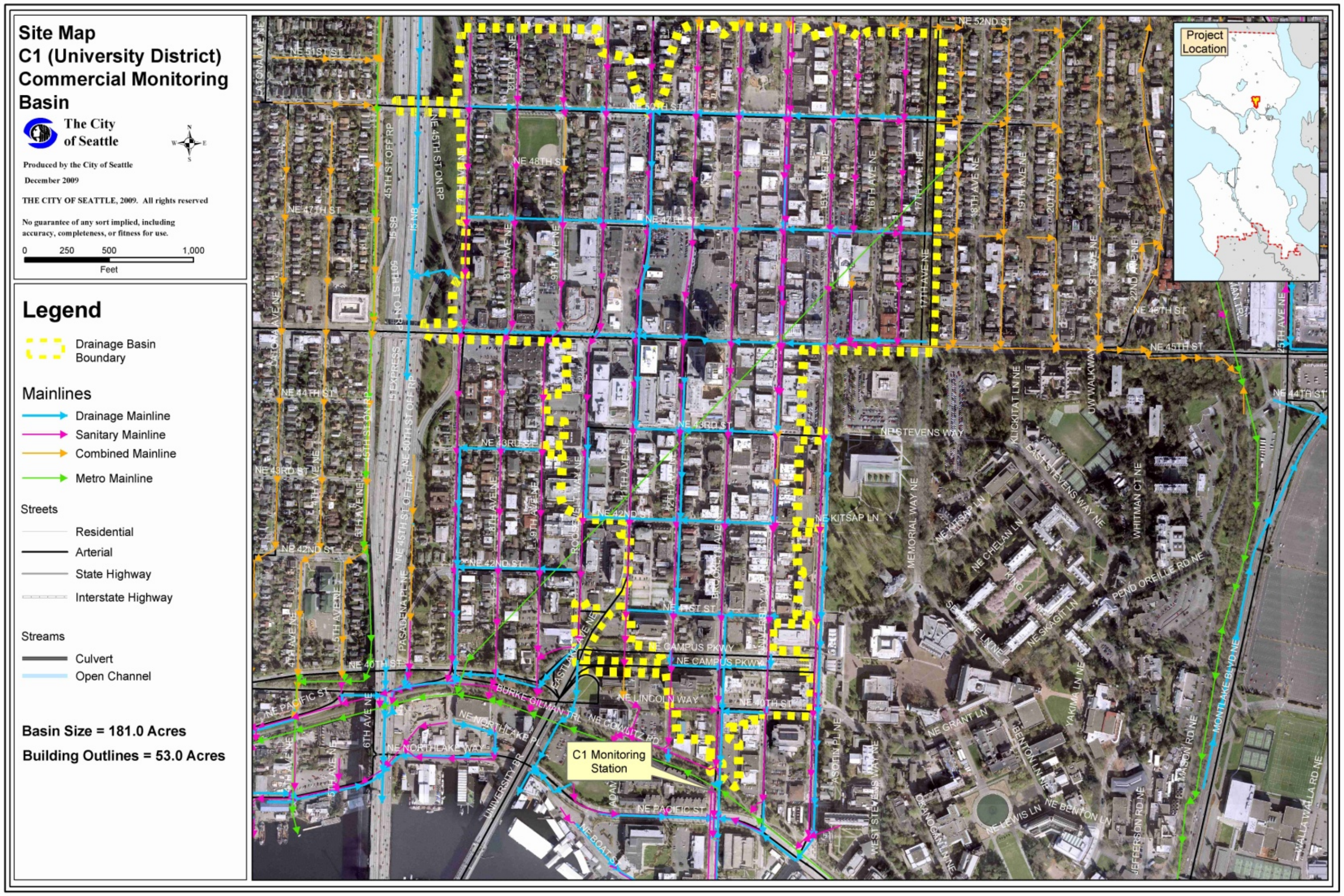

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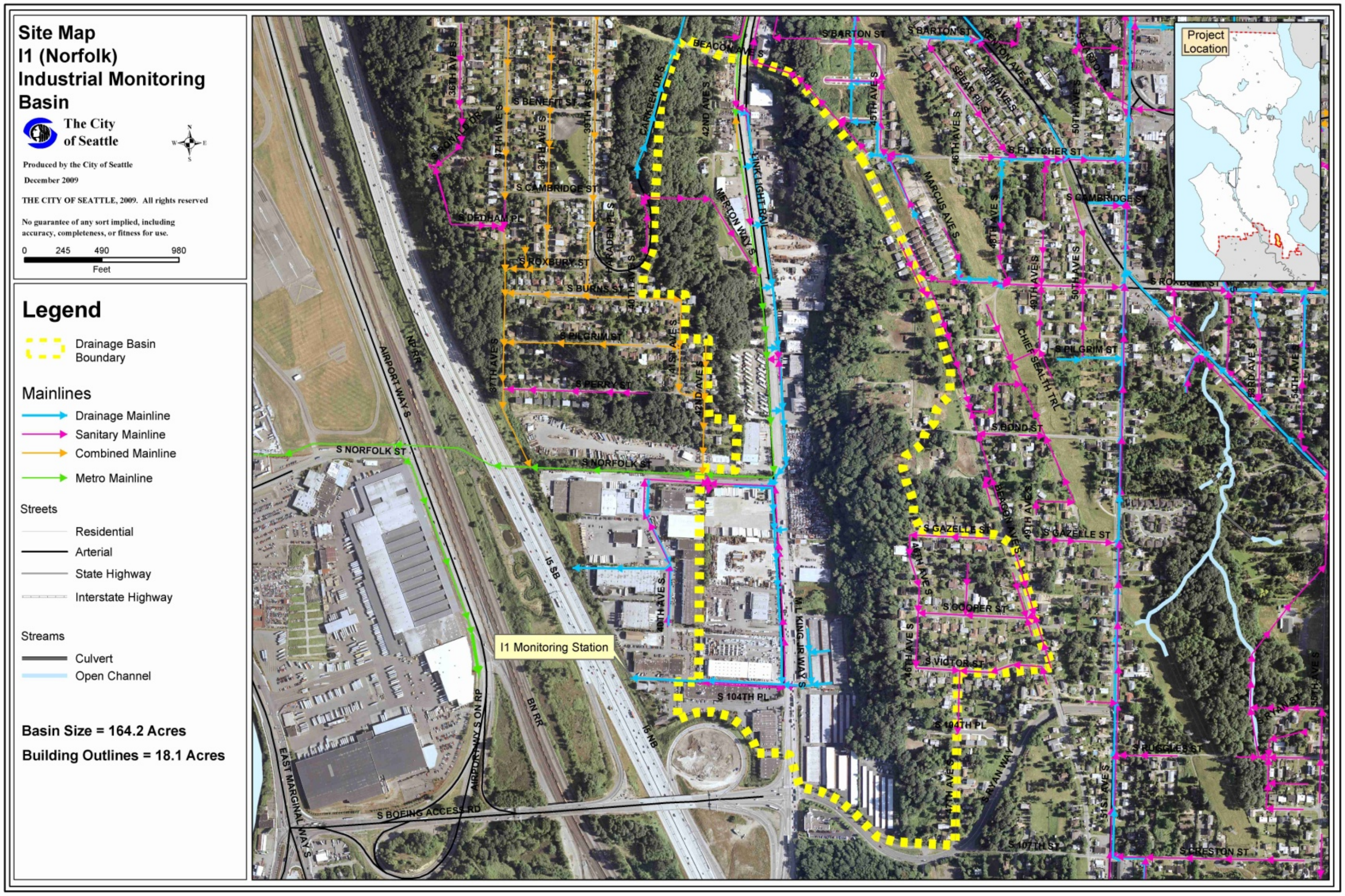
Figure 2.2.1.3. Site Map – I1 (Norfolk)



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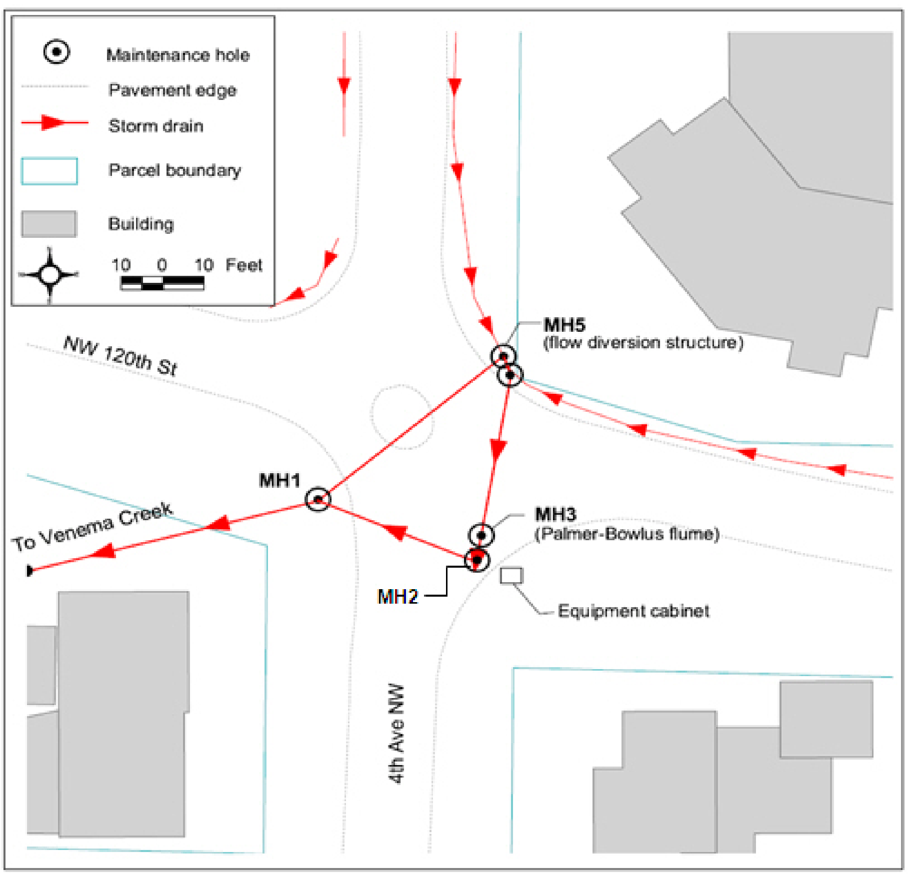
2.2.2 Monitoring Station Descriptions

Each of the three stormwater monitoring stations is configured with a flow monitor, automatic sampler, wireless telemetry and sediment traps. The specific monitor locations and equipment used at each site are detailed below with additional details being listed in the QAPP.

2.2.2.1 R1 (Venema)

The monitoring station R1 is composed of several maintenance holes, related storm drain piping, buried conduit and equipment enclosure at the intersection of NW 120th Street and 4th Avenue NW. The drainage system at this intersection was modified in June 2008 so that hydrologic conditions would be conducive to monitoring. Upgrades included adding a flow control weir (which acts as a diversion structure) and installing a 24-inch Palmer-Bowlus flume as a primary flow measurement device in a new section of storm drain piping with reduced slope (refer to Figure 2.2.1.1a).

Figure 2.2.2.1a. R1 Monitoring Station Overview



All stormwater flows into Maintenance Hole (MH) 5. Most flows are directed to the 24-inch Palmer-Bowlus flume in MH3 and then flow back to the original storm pipe via MH2 and MH1. High flows, exceeding rates of 14.6 cubic feet second (cfs), overtop the sharp crested flow-control weir in MH5 and flow directly to MH1 via the original section of storm pipe.

The Palmer-Bowlus flume is a hydraulic structure of rectangular cross-section that constricts and reshapes the flow, developing a hydraulic head proportional to flow. These flumes consist of a converging section at the inlet, a throat and diverging section at the outlet.

Figure 2.2.2.1b. Photograph of R1 Palmer-Bowlus Flume

Flow is monitored at two points at this monitoring location:

- The primary flow measurement point is a 24-inch Palmer-Bowlus flume installed in MH3. The water level in the flume is measured using a Campbell Scientific, Inc (CSI) CS408 pressure transducer (sensor).
- The secondary flow measurement point utilizes the weir in MH5. A portion of the highest flows could overtop the weir, thus bypassing the flume in MH3. The water level behind the weir is measured using a CSI CS448 pressure transducer.

A CSI CR1000 data logger records level and flow at five minute intervals. The data logger calculates flow from the level data using flume and weir equations. The flow in the flume and the flow over the weir (if any) are summed into one overall flow rate for the residential site. The two pressure transducer cables are routed to MH3 and MH5, respectively, through buried conduits connecting the maintenance holes to the equipment cabinet.

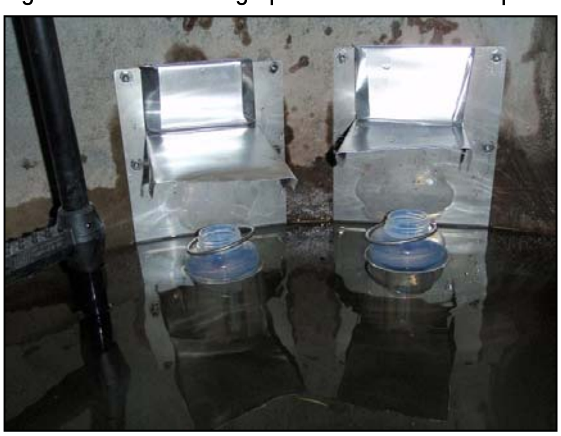
Water quality samples are collected at a single location in MH2. A modified Isco 6712 sampler collects volume-proportional stormwater composite samples as controlled by the CR1000 data logger. The sampler is enabled by a change in water level in the flume, and the sampler pacing is based on the flow calculated from the flume. The data logger and Isco sampler are installed in the equipment cabinet and the sampler tubing is run to MH2 through buried conduit. The sample intake tubing and strainer are mounted in MH2 and collect water quality samples from the sump just below the invert of the outlet pipe.

Figure 2.2.2.1c. Photograph of R1 Equipment Cabinet

Wireless telemetry provides remote communications with the CR1000 and both the data logger and sampler are powered by AC power.

Two sediment traps are installed in MH-2 with the mouths of the bottles located approximately 1-inch above the invert of the outlet pipe.

Figure 2.2.2.1d. Photograph of R1 Sediment Traps

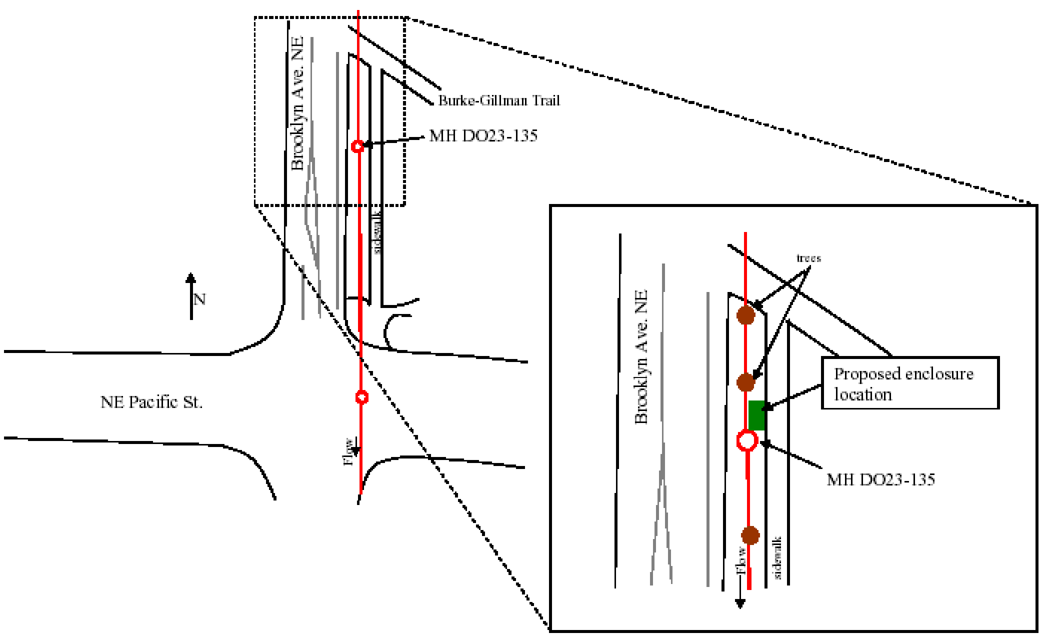


SPU rain gauge RG07 (45-S007) is used to represent rainfall in the R1 basin. RG07 is located at Whitman Middle School which is located near the corner of 15th Avenue NW and NW 92nd Street, roughly 1.5 miles southwest of the monitoring station.

2.2.2.2 C1 (University District)

Monitoring station C1 is accessed via MH D023-135 on the east side of Brooklyn Ave NE, which is situated on a relatively straight section of 36-inch diameter concrete reinforced pipe installed in 1972. The straightness of the pipe produces a relatively linear flow path through the maintenance hole. The pipe has a steep gradient with the upstream pipe slope at approximately 6.4 percent and the downstream pipe slope at approximately 7.6 percent.

Figure 2.2.2.2a. C1 Monitoring Station Overview



Flow is measured using an Isco 2150 area-velocity (AV) type flow monitor. The AV sensor is mounted upstream of the MH, at the invert of the 36-inch concrete pipe using stainless steel mounting rings. Flow is calculated at five minute intervals based on measured level and velocity data and site-specific information (pipe size and pipe shape) using the continuity equation. This is the only stormwater characterization monitoring station where non-stormwater base flow is present.

A modified Isco 6712 sampler collects volume-proportional stormwater composite samples. The sampler's strainer is affixed to the AV sensor mounting ring, with the intake being positioned in the pipe invert just downstream of the AV sensor.

Figure 2.2.2.2b. Photograph of C1 Equipment Cabinet

Note – monitoring MH D023-135 visible behind cabinet under truck bumper.

Wireless telemetry provides remote communications to both the flow meter and sampler via a CSI CR1000 data logger. The CR1000 controls the collection of samples by pacing the automatic sampler.

The sampler, logger and modem are housed in an enclosure installed in the parking strip adjacent to MH D023-135.

Two sediment traps are installed downstream of the MH with the traps' housing mounted to the pipe's invert.

Figure 2.2.2.2c. Photograph of C1 Sediment Traps

SPU rain gauge RG03 (45-S003) is used to represent rainfall in the C1 basin. RG03 located on the roof of the Harris Hydraulics Laboratory on the University of Washington Campus near Lake Union. It is approximately 0.3 miles southeast of the monitoring site.

2.2.2.3 I1 (Norfolk)

The I1 monitoring station is located within a new pipe and flow diversion structure vault that was constructed as part of an upgrade to the drainage system in this basin. The former 36-inch storm drain pipe, which partially collapsed, was replaced during a construction project that was started in the winter of 2008/09 and finished in July 2009. The new storm drain pipe is located between Martin Luther King Jr. Way and the Washington Department of Transportation (WSDOT) ditch located on the east side of Interstate 5. This pipeline runs along the south property boundary of the Papé Material Handling property (9892 40th Avenue South, Seattle, WA 98118) and parallels the boundary between the City of Seattle and the City of Tukwila.

The new pipe is a 64-inch, ductile-iron pipe (DIP). A 6-foot by 10-foot precast vault is installed at the downstream end of the new storm pipe. A high-flow outlet weir is installed at the downstream end of the vault with a crest elevation of 11.75 feet (NAVD88 datum). The purpose of the weir is to divert low flow to an oil control structure located under the Papé drive north of the new pipe. The weir, which discharges to the WSDOT ditch, also helps to dissipate flow energy of higher flows by spreading flow over the length of the weir. The following two figures present the I1 monitoring station layout in plan and side view, respectively.

Figure 2.2.2.3a. I1 Monitoring Station Overview

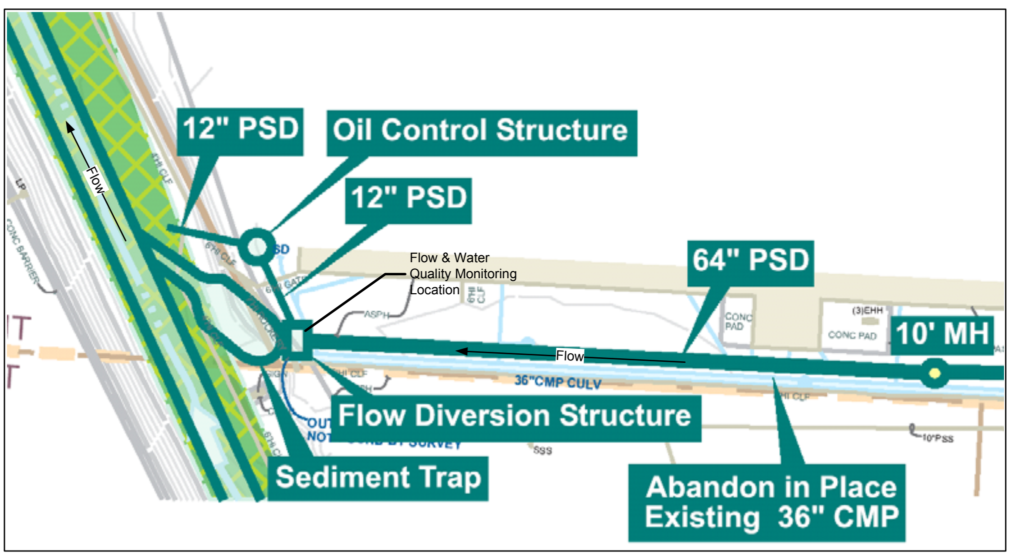
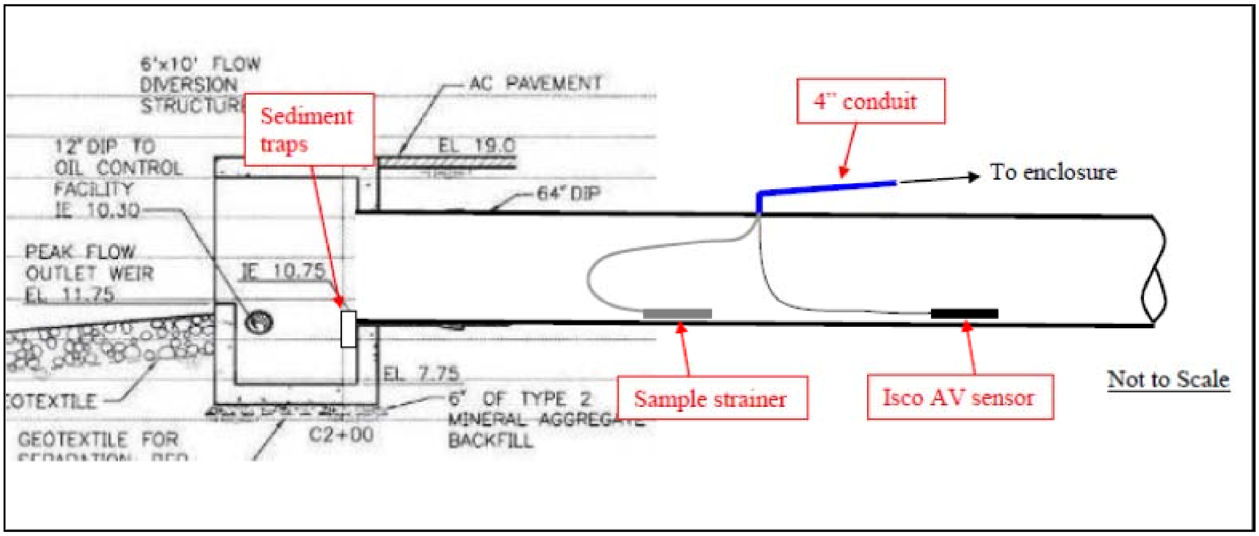


Figure 2.2.2.3b. I1 Station Cross Section View



Flow at the I1 station is measured using an Isco 2150 AV-type meter. The AV sensor is mounted upstream of the flow diversion vault, at the invert of the 64-inch DIP pipe using stainless steel mounting rings. Flow is calculated at five minute intervals based on measured level and velocity data and site-specific information (pipe size and pipe shape) using the continuity equation.

Figure 2.2.2.3c. Photograph of I1 Diversion Structure and Outfall

A modified Isco 6712 sampler collects volume-proportional stormwater composite samples. The sampler's strainer is affixed to the AV sensor mounting ring, with the intake being positioned in the pipe invert just downstream of the sensor.

Wireless telemetry provides remote communications to both the flow meter and sampler via a CSI CR1000 data logger. The CR1000 controls the collection of samples by pacing the automatic sampler.

The sampling equipment, logger and modem are housed in an enclosure installed in the Pape drive adjacent to the top of the diversion vault.

Figure 2.2.2.3d. Photograph of I1 Equipment Cabinet

Two sediment traps are installed in diversion structure vault with the mouths of the bottles located approximately 2-inches above the standing water level inside the structure.

Figure 2.2.2.3e. Photograph of I1 Sediment Traps

SPU rain gauge RG30 (45-S030) is used to represent rainfall in the I1 basin. RG30 is located on the roof of the Seattle Public Library at 9125 Rainier Ave. S. It is approximately miles 0.5 northeast of the monitoring site.

2.3 Sampling and Monitoring Procedures

CardnoTEC Inc. [(CardnoTEC), formerly Taylor Associates, Inc.], under contract with the City, performed all weather tracking, flow monitoring, stormwater sampling and sediment sampling activities.

2.3.1 Weather Tracking/Storm Criteria

Weather and rainfall data were continuously monitored using multiple forecasting, radar and satellite sources to target storms that meet the criteria for a qualifying event, listed in the table below.

Table 2.3.1. Qualifying Event Criteria

Criteria	Wet season	Dry season	Base Flow	Toxicity
Period	October 1 through April 30	May 1 through September 30	October 1 through September 30	August or September (ideally)
Rainfall volume	0.20" minimum, no fixed maximum	0.20" minimum, no fixed maximum	NA - none	No fixed minimum or maximum
Rainfall duration	No fixed minimum or maximum	No fixed minimum or maximum	NA	No fixed minimum or maximum
Antecedent dry period	≤ 0.02" rain in the previous 24 hours	≤ 0.02" rain in the previous 72 hours	≤ 0.02" rain in the previous 24 hours	One week
Storm capture coverage	75% (for storms longer than 24 hours, 75% of first 24 hours)	75% (for storms longer than 24 hours, 75% of first 24 hours)	100%/24 hrs	75% (for storms longer than 24 hours, 75% of first 24 hours)
Inter-event dry period	6 hours	6 hours	NA	NA

Notes-
NA – not applicable, no criteria

CardnoTEC made recommendations for storms to target for sampling with the final "go/no-go" decision made by the City's stormwater monitoring lead.

2.3.2 Precipitation Monitoring Procedures

SPU collects precipitation data from a network of 17 tipping bucket rain gages located throughout Seattle. Precipitation data are collected over one-minute intervals and transmitted via wireless telemetry to a centralized server. The rain gage network is operated and maintained under contract by ADS Environmental Services, Inc. (ADS).

Rain gage inspection and maintenance is performed on a quarterly basis. Maintenance includes: checking the levelness of the gage and re-leveling, if necessary; and cleaning of filter screens, drain holes and siphons. Gages are verified and calibrated annually by sending a known volume of water through the gage a minimum of two times, averaging the gage's measurement and comparing the average to the known volume. If the measurement is greater than +/- 2 percent of the actual volume, the gage is adjusted in the field until it reads within 2 percent or replaced with another gage, with the inaccurate gage sent back to the manufacturer for calibration.

All maintenance and calibration activities and any observed problems are recorded on a data sheet to be used to edit data raw rain data (discussed in Section 2.3.8.1).

2.3.3 Flow Monitoring Procedures

Flow monitoring equipment type and configuration per each station are described in Section 2.2.2. Level, velocity (if applicable) and flow data are logged at five-minute intervals. Flow monitoring quality assurance/quality control procedures are discussed in Section 2.3.8.2.

2.3.4 Stormwater Grab Sampling Procedures

Grab samples were collected by lowering a decontaminated stainless steel bailer, utilizing a swing arm sampler mounted on a telescoping pole, into the flow stream and pouring the contents into analyte-specific bottles. Ideally, all grab samples were collected between the first and last volume-proportional composite sample aliquot at each site. However, if the rain/runoff ended before the field crew could be present to collect the grab sample; a makeup grab sample was collected for that event during another event that met the storm criteria.

2.3.5 Stormwater Composite Sampling Procedures

Volume-proportioned stormwater composite samples were collected using modified Isco 6712 automatic samplers. The samplers utilize a peristaltic pump to draw stormwater from a strainer (a perforated stainless steel sample head affixed to the end of the sampler tube) installed in the flow channel and distribute it to composite bottles in the sampler base. The samplers' bases and distribution arms were modified to allow the use of eight discrete 2.5-gallon [9.46 Liter (L)] glass bottles which increases the volume of stormwater that can be collected. This increases the chances of obtaining sufficient volume, increases flexibility if storm sizes change and reduces staffing needed to visit stations to replace bottles as they fill during a sampling event.

Figure 2.3.5a. Photograph of Modified Automatic Sampler

The data loggers were programmed to trigger the samplers every time a specified volume (referred to as the "trigger volume") passes the monitoring location. Each trigger sent results in the collection of one stormwater aliquot deposited in the composite bottle. As each bottle is filled (after a discrete number of aliquots), the sampler's distributor arm advances to the next bottle. Bottles were removed and replaced as necessary over the course of the event.

Since stormwater samples, specifically stormwater solids concentrations and related contaminants, are readily biased without proper processing procedures; all composite samples were composited and split in the project analytical laboratory [Analytical Resources Inc. (ARI) in Tukwila, WA] using a combination of polytetrafluoroethylene (PTFE) cone splitters and 14L PTFE churn splitters for all events. The cone splitters were used to evenly split the original composite samples into subsamples that are theoretically equal in chemical quality and sediment concentration to any other subsample. One of the subsamples from the cone splitter was then poured into the churn splitter to split the sample into analyte-specific containers.

Figure 2.3.5b. Photograph of Compositing Samples Using Cone Splitter

2.3.6 Sediment Trap Samples

Two sediment traps were installed at each monitoring location by bolting the stainless steel trap mounting assembly directly to the pipe invert (C1), or wall of the catch basin or diversion structure (R1 and I1, respectively). One PTFE, 1L, wide-mouth sample bottle is placed in each mounting assembly and held in place by a retainer ring. When installed to the pipe invert (C1), the mouth of the bottle was approximately 9-inches above the invert. When the traps were installed in structures with standing water (R1 and I1), the mouths of the bottles were positioned 1-2 inches above the static water level.

Sediment traps were inspected on a monthly basis following installation, checking for damage, blockage or under- or over-accumulation. Inspections were adjusted to an as-needed basis when site characteristics were known. As bottles become partially full with sediment, there is a risk that new sediment will not be effectively captured by the trap. If sediment was observed to be over half full in any of the bottles, they were removed and replaced with new bottles. The removed bottles were archived in a secure refrigerator for processing with the newer bottles at the end of the water year.

Bottles were removed at the end of the water year and replaced with clean bottles for the following water year (until the final removal in October 2012). The removed bottles, including any archived bottles, were delivered to ARI where laboratory personnel separate the solids and water by centrifuging. The solids from all bottles collected at each location over the water year were composited in the laboratory to form one sample from each monitoring location and then transferred to analyte-specific containers for testing. The priority list in the Permit was used to determine which analytical tests to perform if insufficient sediment quantity was captured to run all tests.

2.3.7 Decontamination Procedures

All water quality sampling equipment and sediment trap bottles - which includes stainless steel beakers, sampler tubing/strainers, sample bottles, and churn/cone splitters - were decontaminated with the following procedure:

1. Wash in a solution of laboratory-grade, non-phosphate soap and tap (city) water.
2. Rinse in tap water.
3. Wash in a 10 percent nitric acid/deionized water solution.*
4. Rinse in deionized water.
5. Wash with 10% methanol/isopropyl alcohol
6. Final rinse in deionized water.

** Nitric wash omitted for stainless steel beakers*

Sampling equipment was decontaminated prior to every use with the exception of sampler tubing. Following the initial wash, sampler tubing was rinsed with deionized water immediately prior to each sampling event and is replaced at the start of each water year.

2.3.8 Sampling and Monitoring Quality Assurance/Quality Control (QA/QC) Procedures

2.3.8.1 Precipitation Monitoring QA/QC Procedures

All raw rainfall data was reviewed by ADS on a monthly basis. Data was reviewed for errors such as periods of no recorded rainfall when nearby rain gages record rain, excessive or unrealistic measured rainfall, periods of non-rain tips due to calibration or other activity and other indicators of inaccurate data. Field maintenance and calibration data sheets were reviewed to inform the data evaluation. Raw rainfall data were edited to remove erroneous or test tips which are recorded on a monthly edit log. Areas of missing data were either filled using transposed data from the nearest working gage or data is replaced with "*". All rain data were flagged with one of the four following qualifiers: 1) "*" - no data, 2) "R" – raw, unedited data, 3) "T" – data transposed from the nearest rain gage with validated data and 4) "V" – validated data (confirmed accurate or made accurate by deletion of erroneous data). Only finalized rain data are presented in this report.

2.3.8.2 Flow Monitoring QA/QC Procedures

Routine flow monitor maintenance visits were performed on a monthly or as-needed based on remote real-time monitor checks or data reviews. Each maintenance visit included visual inspection and cleaning of the sensors, calibration checks and calibration of the level sensor, if necessary. If the actual and measured level values differed more than 0.02 feet, the level sensor was calibrated. If level drift continued after correction, the level sensor was removed and replaced.

Level, flow and velocity data were downloaded on a weekly basis for maintenance purposes and on an as-needed basis around storm events. During each weekly data download, the data were inspected for any significant trends in reliability and/or accuracy (i.e., substantial level jump, spikes, flat-line data or no data). If anomalies were observed, a maintenance team was sent to the monitoring site to test and troubleshoot any issues found.

After each routine monthly maintenance visit, a thorough review of the data was completed for the preceding period between maintenance visits. Because each maintenance visit included an actual measurement of the water level, level data were corrected for level drift if the difference between the actual and measured level was greater than 0.02 ft. The adjusted level data were then used to recalculate the flow using sensed velocity data or the level-flow relationship at each site.

Both raw and edited/finalized flow data are stored in the City's time-series database. Only finalized data are used for calculations and presented in this report.

2.3.8.3 Field QC Sample Collection Procedures

During WY2012, numerous field QC samples were collected to evaluate the sampling operation and to quantify and document bias that can occur in the field. QC samples provide the ability to assess the quality of the data produced by field sampling and a means for quantifying sampling bias.

The following table lists the types of QC samples collected, description of how the QC samples were collected, the purpose and information provided by each sample and the number of samples collected during WY2012.

Table 2.3.8.3. QC Sample Summary

QC Sample Type	Code	Description	Purpose/Info Provided	Number Collected WY2012	Collected on
Field Duplicate Sample	FDS	Simultaneous sample collected at same location as Primary Environmental Sample (PES)	Quantify variability from field sampling activities Quantify variability from laboratory procedures	4	Stormwater grab samples
Field Split Sample	FSS	PES split by field staff	Quantify variability from laboratory procedures	4	Stormwater composite samples
Field Blank Sample	FBS	Blank water passed through decontaminated or new equipment in lab	Tests cleaning procedures or cleanliness of new, disposable equipment in a controlled environment	5	Stainless steel bailers, composite bottle and splitting equipment (churn and cone splitters)
Field Residual Blank	FRB	Blank water passed through equipment after sampling but without decontamination	Quantifies cross-contamination between samples and quantifies contamination from field sampling activities	6	Sampler tubing
Trip Blank	TRB	Sample container filled with blank water by lab that accompanies sample bottles from lab to field and back	Identify sample handling and transport bias Quantify sample cross-contamination	22	Used to accompany NWTPH-G grab samples

The field duplicate samples were collected in the field by lowering two analyte-specific bottles into the stormwater channel and filling simultaneously. The field split samples were generated in the laboratory by field staff by filling two identical analyte-specific containers simultaneously from the churn splitter. Field duplicates and split samples were collected at frequency of approximately 10 percent of the stormwater samples collected.

Excluding the trip blanks, all other field blanks were made by field staff passing reagent grade deionized water over or through new or decontaminated sample equipment and capturing the blank water in analyte-specific bottles. The sampler tubing was not fully decontaminated but rinsed with deionized water (consistent with Ecology's *Standard Operating Procedure for Automatic Sampling for Stormwater Monitoring – ECY002*, dated September 16, 2009) prior to sample or blank collection.

The trip blanks were generated by the primary environmental laboratory (ARI) by filling 40-milliter (mL) volatile organic analysis (VOA) vials with reagent grade deionized water. The trip blanks accompanied all sample bottles used for Northwest Total Petroleum Hydrocarbon –

Gasoline range (NWTPH-G) analyses from the time the empty bottles left the laboratory until the filled bottles were relinquished to the laboratory.

2.4 Analytical QA/QC Procedures, Methods and Reporting Limits

2.4.1 Analytical Data QA/QC Procedures

All laboratory data packages received included a hardcopy report and an electronic data deliverable (EDD). The laboratory case narratives were reviewed with each sample delivery group for quality control issues and corrective action taken. The data were evaluated for required method, reporting limit (RL), package completeness, holding time, blank contamination, accuracy and precision.

Each EDD was imported into a validation and review database, where deviations from the Measurement Quality Objectives (MQOs – in QAPP) were identified and associated samples were qualified accordingly. Qualification details are included in the QA/QC report in Appendix C.1.

2.4.2 Analytical Methods and Reporting Limits

Refer to Appendix C.1 for a list of analytical parameters, methods and reporting limits used for this project and a related discussion. Note – although the Permit allows for the removal of any parameter that was non-detect for two years of sampling, the City elected to continue to analyze for all water and sediment parameters in WY2012 for comparability with previous years.

2.5 Pollutant Load Calculation Procedures

The primary goal of the stormwater characterization monitoring is to gain knowledge of stormwater pollutant loads from areas within the municipality. Specifically, the Permit requires that *"for each stormwater monitoring site calculate the Event Mean Concentrations (EMCs), total annual pollutant load, the seasonal pollutant load, for the wet and dry seasons based on the water year. The loading shall be expressed as pounds and pounds per acre, and must take into account the potential pollutant load from base flow."*

The EMC for each event is the analyte concentration reported by the laboratory as analyzed on the event's composite sample since each composite consists of multiple subsamples (aliquots) representing the runoff of the entire event. The basic concept of a pollutant load calculation is deceptively simple, but it can be problematic to perform and requires several decisions to be made to resolve problems inherent in any load calculation. Due to these problems, most literature referred to this calculation as pollutant load *estimation* and many different methods can be employed to estimate the load using the same data set, resulting in a range of loads calculated from the same data. Below is a summary of load calculation methods to help explain why the City selected methods used in this report.

The load is simply the mass or weight of a pollutant that passes a point in the stormwater sewer system (e.g., a monitoring station) over a specific amount of time. To calculate load, the mass concentration of a pollutant is multiplied by the total volume of water passing the monitoring location over a period (i.e., seasonally or annually). The total flow volume is calculated by aggregating the flow measured by the continuous flow monitoring equipment. Although flow is essentially measured continuously, the pollutant concentration is only measured several times over a period (e.g., 11 times annually from the 11 events sampled) so the concentrations for the majority of the periods when the stormwater is not measured must be estimated using one of several methods.

The total pollutant load, whether seasonal or annual, is the sum of base flow load (where present) and stormwater load. Since the end result of the calculation as specified in the Permit is to determine the stormwater load, the base flow contribution is essential “removed” (or subtracted) from the total load to derive the stormwater load. For the purposes of this analysis, base flow loading is defined as the annual mass of a chemical constituent from non-stormwater sources that passes a point in the stormwater sewer system. These non-stormwater flows can include groundwater and shallow subsurface stormwater flow, or surface flows such as irrigation or springs. A practical measure of the presence of base flow is to review the continuous flow record from each monitoring site to determine if flows do not return to zero during dry periods. Of the City’s three monitoring sites, only the commercial site (C1) has base flow.

Of the five or more estimator methods commonly used for load estimation, SPU used two for this report which are discussed below: 1) the mean method; which is also referred to as “the Ecology method” since it is the method outlined in Ecology’s Standard Operating Procedure (SOP) and 2) the volume-proportional method – which is the method outlined in the City’s QAPP and thus will be referred to as the “QAPP method.” The two methods used by SPU are summarized in Sections 2.5.1 and 2.5.2.

In addition to selecting a method to estimate loads, a method of substituting values for analytes not detected at or above laboratory reporting limits (“non-detects”) must also be chosen. Methods for non-detect substitutions used by SPU are discussed in Section 2.5.3

Lastly, the method to remove the base flow load from the total load that SPU used is discussed in Section 2.5.4.

2.5.1 Ecology Method

The method described in Ecology's SOP – which is typically referred to as the mean concentration estimator method - simply averages all EMCs from storms sampled in the period to create one period mean EMC. The period mean EMC is multiplied by total flow volume during that period to calculate period load. This method assumes there is no correlation between stormwater volume and concentration so it weighs all EMCs equally and assumes the resulting mean concentration represents average concentration of stormwater discharged over a period. This method is detailed in the Ecology SOP ECY004 - *Standard Operating Procedure for Calculating Pollutant Loads for Stormwater Discharges*, dated September 16, 2009. This is the method used to calculate the base flow loads in this report since the base flow volume is relatively constant during dry weather sampling events so there is no relationship between measured concentration and volume.

2.5.2 QAPP Method

The method outlined in the City's stormwater characterization QAPP – the volume-weighted method - assumes there is a correlation between concentration and volume of flow. This estimator calculates a volume weighted concentration (VWC) representing the storms sampled in the period (dry season or wet season) and then multiplies the VWC times the storm volume over that period. The VWC is derived by dividing the sum of loads for each sampled event by the sum of flow volumes from each sampled event. The VWC of each period is multiplied by total flow volume during the period to calculate period load. Equations and stepwise procedures for this method are detailed in the City's QAPP. The City selected this method because our literature review indicated it was considered the best overall estimator for stormwater concentrations since it attained smaller biases when compared to other estimator methods. This is the method used in this report to estimate stormwater loads.

2.5.3 Non-Detect Substitution

Most types of environmental monitoring data, including stormwater data, contain analytical results reported as non-detect (ND) at or above the laboratory reporting limit (RL), rather than a specific numerical value. These non-detected values are statistically known as "left-censored" measurements because the actual concentrations are unknown and are assumed to fall within a range between 0 and the RL. Environmental data have been historically reported with inconsistent treatment of non-detects with many, both simple and complex, substitution methods used. Non-detect substitution is required when performing statistical analysis or loading calculations since an actual numerical value is required.

The City's QAPP states the following regarding non-detect substitutions: *In the event an estimated value below the reporting limit is not provided, the value will be estimated at half of the reporting limit.*

Since the QAPP was finalized, several discussions have occurred between the Phase I Permittees and Ecology regarding non-detect substitution with no formal agreement on the best method. With large data sets, complex statistical substitutions have been proven to yield less bias than simple substitutions but no complex substitutions work when sample numbers become small such as for this project where the maximum sample number for a wet season is 7-9 and the dry season is 2-4. To allow for a consistent comparison with other Permittees, the City has elected to expand on the method stated in our QAPP and use three non-detect substitution methods for load. Each non-detect value will be substituted with 0.0, 0.5 and 1.0 times the RL for that analyte. The three different substitutions result in a range of loads for each analyte which we consider more accurate than a single load and demonstrate some of the error that is inherent in load estimation. The range of loads estimated becomes larger as the ratio of non-detects to detected values increases.

If an analyte was non-detect across the entire period's data set, no load will be calculated for that analyte since the load would be based entirely on a theoretical presence of an analyte based on an arbitrary substitution.

2.5.4 Removal of Base Flow Load

Since the Permit requires that the load from stormwater-only is determined; any load from base flow, if present, must be subtracted from the stormwater load. Only the City's commercial monitoring site (C1) has base flow present. A total of four base flow events, two in the wet season and two in the dry season, were sampled during WY2012. The EMCs from each season's events were averaged to calculate a seasonal base flow concentration for each analyte. Each seasonal concentration was multiplied by the average base flow volume recorded for each of the stormwater events sampled during each season to calculate a seasonal base flow load (per the Ecology method). The base flow load was then subtracted from the total pollutant load (which is a combination of stormwater load and base flow load) to estimate the stormwater load.

2.6 Sampling Event Summary

This section presents a summary of events sampled during WY2012. This was the fourth year collecting stormwater samples under the 2007 Permit and the third (and final) complete water year. WY2012 began on October 1, 2011 and ended on September 30, 2012. The City was very successful at collecting all routine storm, base flow and sediment samples required by the Permit with no qualifications.

2.6.1 Precipitation Summary

The table below summarizes precipitation data for each of the three sampling locations for WY2012 based on a review of rain gage data.

Table 2.6.1. Total Precipitation – October 1, 2011 to September 30, 2012

Monitoring Station	R1	C1	I1
Rain Gage	RG07	RG03	RG30
Precipitation (inches)	35.74	34.72	40.21

2.6.2 Stormwater Sampling Summary

The stormwater monitoring frequency required by the Permit is "*sixty-seven percent of the forecasted qualifying storms which result in actual qualifying are required to be sampled, up to a maximum of eleven (11) storm events per water year. Qualifying storm event sampling must be distributed throughout the year, approximately reflecting the distribution of rainfall between wet and dry seasons (with a goal of 60-80% of the samples collected during the wet season and a goal of 20-40% of the sample collected in the dry season).*"

Eleven stormwater events, evenly distributed across the water year, were successfully sampled at each of the three stations. Nine samples were collected during the wet season and two samples were collected from each station during the dry season. The storm hydrologic data for each event, including precipitation, flow and sample information are presented in Table 2.6.2. All criteria for all events were met were met with no exceptions.

Although there are no criteria that state that grab samples must be collected during the same period that a composite sample is collected at a monitoring site, every attempt was made to collect grab samples during composite sample collection time period. During two events during WY2012, field crews were unable to collect the grab samples within the composite sample period so the missing grabs were collected during similar event conditions (i.e., during qualifying storm events) at a later date. The missed grab from C1 during storm event SE-24 on October 2-3, 2011 was collected during a storm on December 27, 2011. The missed grab from I1 during storm event SE-23 on October 2-3, 2011 was collected during a storm on February 13, 2012. All other grab samples were collected within the time period of the composite sample.

Annual and event specific flow, rainfall and aliquot information are graphically presented on hydrographs in Appendix C.2. Analytical results from stormwater samples are presented in the *Sampling Results* section of this report.

2.6.3 Base Flow Sampling Summary

Base flow is present at only one of the three monitoring stations – C1. To quantify the chemical concentration in the base flow for the purposes of removing the base flow load from the total load, two wet season and two dry season base flow sampling events were sampled at C1. The base flow was sampled using the samplers to collect a time-proportional composite sample by collecting aliquots at 15 minute intervals over a 24-hour period when no rainfall occurred. Analytical results from base flow events are presented in the *Sampling Results* section of this report.

2.6.4 Sediment Sampling Summary

The sediment trap bottles representing WY2012 were deployed on September 30, 2011 during the removal and replacement of the bottles from the previous water year. The traps were inspected monthly for debris or rapid accumulations of sediment. The frequent accumulation of trash (plastic bags, food wrappers, etc.) and organic debris on the traps in C1, which would often partially or completely cover the mouths of the bottles, has been observed over the duration of this project. Debris was removed during every confined space entry made for flow monitoring maintenance, storm setup and routine sediment trap checks; but debris accumulation continued to be a chronic problem at this site even with frequent site visits.

During the monthly visit on February 16, 2012, one of the two sediment bottles at C1 along with the retainer ring was found missing. The bottle and ring were replaced. During the monthly visit on May 23, 2012 the second (original) C1 bottle was found missing (likely from peak flows during a very intense storm two days earlier). This second bottle was also replaced.

Bottles from all three locations were removed for analysis on October 3, 2012. The bottles at R1 were about 75 percent full of sediment at the time of removal; the bottles are C1 were about 10 percent full; and the bottles at I1 were about 15 percent full. The sediment analyses priority list in the Permit was used to prioritize chemical analysis for sediment samples at C1 since there was insufficient quantity to analyze for all parameters.

2.7 Sampling Results

The following section discusses results for samples collected during WY2012. All analytical work for the stormwater characterization project was performed by ARI or their subcontractors: Pacific Agricultural Lab, Am Test and Spectra Laboratories.

2.7.1 Stormwater Samples

The analytical results for all the stormwater events sampled are summarized in site specific tables on the following pages (refer to Tables 2.7.1a to c).

2.7.2 Base Flow Samples

The main purpose for the collection of base flow samples at C1 is to generate a seasonal average base flow concentration for each analyte to calculate a base flow load. The base flow load is then subtracted from the total load to calculate the stormwater load for that site. Base flow analytical data from C1 is presented in Table 2.7.2.

Table 2.6.2. Stormwater Characterization Event Hydrologic Summary

Analyte Name	Goal	SE-23	SE-24	SE-25	SE-26	SE-27	SE-28	SE-29	SE-30	SE-31	SE-32	SE-33	SE-34	SE-35
Residential Zone (R1)														
Storm Event Start	NA	WY2011	WY2011	02-NOV-2011 16:35	11-NOV-2011 11:35	16-NOV-2011 10:15	26-DEC-2011 16:40	24-JAN-2012 06:40	29-JAN-2012 03:00	20-FEB-2012 17:10	24-FEB-2012 14:45	28-FEB-2012 16:40	20-MAY-2012 08:45	22-JUN-2012 09:25
Storm Event End	NA	WY2011	WY2011	02-NOV-2011 20:05	11-NOV-2011 18:00	16-NOV-2011 23:40	28-DEC-2011 05:00	24-JAN-2012 23:55	30-JAN-2012 06:00	21-FEB-2012 19:00	25-FEB-2012 15:00	29-FEB-2012 16:00	21-MAY-2012 19:00	23-JUN-2012 05:50
Storm Event Duration (hrs)	>1	WY2011	WY2011	3.5	5.2	13.4	36.3	17.3	27	25.8	24.3	23.3	34.2	20.4
24-hour Antecedent Rainfall (inches)(a)	<= 0.02	WY2011	WY2011	0	0	0	0.01	0	0	0	0	0	NA	NA
72-hour Antecedent Rainfall (inches)(b)	<= 0.02	WY2011	WY2011	NA	NA	NA	NA	NA	NA	NA	NA	NA	0	0
Storm Event Rainfall (inches)	>= 0.20	WY2011	WY2011	0.36	0.23	0.5	0.61	0.26	0.44	0.22	0.57	0.48	0.5	0.9
Storm Event Rainfall Max (in/hr)	NA	WY2011	WY2011	0.14	0.1	0.13	0.1	0.06	0.15	0.03	0.11	0.14	0.06	0.15
Storm Event Rainfall Mean (in/hr)	NA	WY2011	WY2011	0.12	0.02	0.04	0.02	0.01	0.02	0.01	0.02	0.02	0.01	0.04
Storm Event Baseflow Volume (cf)	NA	WY2011	WY2011	0	0	0	0	0	0	0	0	0	0	0
Storm Event Total Flow Max (cfs)	NA	WY2011	WY2011	1.09	0.25	0.60	0.59	0.36	1.25	0.29	1.74	0.92	0.15	1.29
Storm Event Total Flow Mean (cfs)	NA	WY2011	WY2011	0.33	0.05	0.10	0.05	0.05	0.07	0.05	0.19	0.08	0.01	0.16
Storm Event Total Flow Volume (cf)	NA	WY2011	WY2011	4203	875	4652	7136	2826	7074	4766	16310	6913	1589	11567
Composite Sample Aliquots Number	>= 10(c)	WY2011	WY2011	88	20	52	84	24	112	40	80	42	16	134
Event Storm Flow Volume Sampled (%)	>= 75(d)	WY2011	WY2011	97.3	90.2	98.5	96.6	97.3	77.5	99.7	99.6	97.5	87.9	96.8
Commerical Zone (C1)														
Storm Event Start	NA	WY2011	02-OCT-2011 16:00	10-OCT-2011 07:30	28-OCT-2011 12:25	02-NOV-2011 16:45	11-NOV-2011 11:35	16-NOV-2011 10:10	04-JAN-2012 08:45	24-JAN-2012 06:30	17-FEB-2012 11:35	20-MAY-2012 09:45	22-JUN-2012 09:15	Not sampled
Storm Event End	NA	WY2011	03-OCT-2011 12:00	11-OCT-2011 07:55	28-OCT-2011 23:00	02-NOV-2011 22:25	12-NOV-2011 00:30	17-NOV-2011 03:30	05-JAN-2012 06:00	24-JAN-2012 23:00	17-FEB-2012 21:40	21-MAY-2012 18:00	23-JUN-2012 06:00	Not sampled
Storm Event Duration (hrs)	>1	WY2011	20	24.4	10.6	5.7	12.9	17.3	21.3	16.5	10.1	32.3	20.8	Not sampled
24-hour Antecedent Rainfall (inches)(a)	<= 0.02	WY2011	0	0.01	0	0.01	0	0	0.02	0	0.01	NA	NA	Not sampled
72-hour Antecedent Rainfall (inches)(b)	<= 0.02	WY2011	NA	NA	NA	NA	NA	NA	NA	NA	NA	0	0	Not sampled
Storm Event Rainfall (inches)	>= 0.20	WY2011	0.21	0.56	0.4	0.24	0.25	0.39	0.72	0.27	0.37	0.68	0.97	Not sampled
Storm Event Rainfall Max (in/hr)	NA	WY2011	0.09	0.2	0.1	0.1	0.12	0.12	0.17	0.06	0.16	0.24	0.13	Not sampled
Storm Event Rainfall Mean (in/hr)	NA	WY2011	0.01	0.02	0.04	0.05	0.02	0.02	0.03	0.02	0.04	0.02	0.05	Not sampled
Storm Event Baseflow Volume (cf)	NA	WY2011	15120	17580	7239	4080	10230	13728	11475	11880	6897	18576	5229	Not sampled
Storm Event Total Flow Max (cfs)	NA	WY2011	13.88	52.72	14.90	20.16	14.05	9.78	39.88	13.62	61.98	89.99	20.76	Not sampled
Storm Event Total Flow Mean (cfs)	NA	WY2011	0.83	2.15	2.12	3.59	1.34	1.78	4.86	2.33	8.45	2.31	3.19	Not sampled
Storm Event Total Flow Volume (cf)	NA	WY2011	59890	189290	80783	73230	62148	111100	372030	138360	306800	268560	238350	Not sampled
Composite Sample Aliquots Number	>= 10(c)	WY2011	42	108	56	42	48	32	114	54	76	70	74	Not sampled
Event Storm Flow Volume Sampled (%)	>= 75(d)	WY2011	97.9	98.9	99.6	82	99.3	98.9	98	84.6	98.3	100/6.15 (e)	98.8	Not sampled

Analyte Name	Goal	SE-23	SE-24	SE-25	SE-26	SE-27	SE-28	SE-29	SE-30	SE-31	SE-32	SE-33	SE-34	SE-35
Industrial Zone (I1)														
Storm Event Start	NA	02-OCT-2011 16:00	28-OCT-2011 12:25	02-NOV-2011 17:00	11-NOV-2011 11:45	16-NOV-2011 08:55	26-DEC-2011 20:15	04-JAN-2012 09:10	29-JAN-2012 03:00	17-FEB-2012 14:15	22-JUN-2012 09:00	20-JUL-2012 02:15	Not sampled	Not sampled
Storm Event End	NA	03-OCT-2011 01:05	28-OCT-2011 17:00	02-NOV-2011 22:00	11-NOV-2011 19:55	17-NOV-2011 02:40	27-DEC-2011 21:30	05-JAN-2012 01:10	30-JAN-2012 03:35	18-FEB-2012 15:20	23-JUN-2012 05:25	20-JUL-2012 10:45	Not sampled	Not sampled
Storm Event Duration (hrs)	>1	9.1	4.6	5	8.2	17.8	25.2	16	24.6	25.1	20.4	8.5	Not sampled	Not sampled
24-hour Antecedent Rainfall (inches)(a)	<= 0.02	0	0	0	0	0	0	0.02	0	0	NA	NA	Not sampled	Not sampled
72-hour Antecedent Rainfall (inches)(b)	<= 0.02	NA	NA	NA	NA	NA	NA	NA	NA	NA	0	0	Not sampled	Not sampled
Storm Event Rainfall (inches)	>= 0.20	0.34	0.42	0.4	0.38	0.42	0.72	0.98	1.01	0.96	0.87	0.92	Not sampled	Not sampled
Storm Event Rainfall Max (in/hr)	NA	0.22	0.12	0.16	0.11	0.09	0.13	0.2	0.19	0.16	0.13	0.33	Not sampled	Not sampled
Storm Event Rainfall Mean (in/hr)	NA	0.04	0.08	0.08	0.05	0.02	0.03	0.06	0.04	0.04	0.04	0.11	Not sampled	Not sampled
Storm Event Baseflow Volume (cf)	NA	0	0	0	0	0	0	0	0	0	0	0	Not sampled	Not sampled
Storm Event Total Flow Max (cfs)	NA	5.29	5.60	4.05	2.57	2.02	3.64	8.62	5.31	8.56	4.35	9.92	Not sampled	Not sampled
Storm Event Total Flow Mean (cfs)	NA	0.44	2.18	1.83	0.76	0.51	0.11	0.56	1.54	1.51	0.75	1.71	Not sampled	Not sampled
Storm Event Total Flow Volume (cf)	NA	14424	35973	32952	22460	32672	10215.9	32471	136090	136400	55411	52376	Not sampled	Not sampled
Composite Sample Aliquots Number	>= 10(c)	40	96	88	56	22	18	58	168	140	110	102	Not sampled	Not sampled
Event Storm Flow Volume Sampled (%)	>= 75(d)	98.8	98.3	99.1	97.7	93.5	92.3	99.2	98.7	97.7	96.7	97.9	Not sampled	Not sampled

Notes:
NA - not applicable
j - did not meet storm criteria goal, conditional use only.
(a) - applies to wet season (Oct 1 to Apr 30)
(b) - applies to dry season (May 1 to Sept 30)
(c) - 10 aliquots is the goal but greater than 7 is acceptable
(d) - if storm exceeds 24 hours, required to sample 75% of the first 24 hours. Percent runoff sampled in first 24 hours displayed. Unless otherwise noted, percent runoff sampled over entire storm shown.
(e) C1, SE-33 - 100% runoff sampled during first 24 hrs, 61.5% over the entire storm.
WY2011 = event sampled during prior water year.
Not Sampled = Not sampled during WY2012.

Table 2.7.1a. Stormwater Analytical Summary – Residential Site (R1)

		SE-25	SE-26	SE-27	SE-28	SE-29	SE-30	SE-31	SE-32	SE-33	SE-34	SE-35
		R1	R1	R1	R1	R1	R1	R1	R1	R1	R1	R1
Analyte	Units	11/02/2011	11/11/2011	11/16/2011	12/26/2011	01/24/2012	01/29/2012	02/20/2012	02/24/2012	02/28/2012	05/20/2012	06/22/2012
Flow-weighted composite - automatic												
Nutrients												
Nitrate + Nitrite	mg-N/L	0.14 J	0.383	0.127 J	0.175 J	0.724	0.361	0.179	0.118 J	0.305	0.461	0.156
Nitrogen, Total Kjeldahl	mg-N/L	1.36	1.51	0.789	0.79	1.08	1.87	0.57	0.93	0.76	1.02	1
Phosphorus, Total	mg-P/L	0.208 J	0.19 J	0.266 J	0.156 J	0.304	0.322 J	0.085 J	0.224 J	0.134 J	0.107	0.12
Ortho-phosphate	mg-P/L	0.028	0.036	0.011	0.013	0.011	0.012	0.019	0.009	0.011	0.014	0.024
Semivolatile Organics												
bis(2-Ethylhexyl)phthalate	ug/L	1.2	1.3	1 U	1.2	3.1	1 UJ	1 U	1 U	1 U	9.5	1 U
Butylbenzylphthalate	ug/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 UJ	1 U	1 U
Diethylphthalate	ug/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Dimethylphthalate	ug/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Di-n-Butylphthalate	ug/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Di-n-Octyl phthalate	ug/L	1 U	1 U	1 U	1 U	1 U	1 UJ	1 U	1 UJ	1 U	1 U	1 U
1-Methylnaphthalene	ug/L	0.1 U	0.1 UJ	0.1 U	0.1 U	0.1 U	0.1 U	1.1 U	0.1 U	0.5 U	0.1 U	0.1 U
2-Methylnaphthalene	ug/L	0.1 U	0.1 UJ	0.1 U	0.1 U	0.1 U	0.1 U	1.1 U	0.1 U	0.5 U	0.1 U	0.1 U
Acenaphthene	ug/L	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	1.1 U	0.1 U	0.5 UJ	0.1 U	0.1 U
Acenaphthylene	ug/L	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	1.1 U	0.1 U	0.5 U	0.1 U	0.1 U
Anthracene	ug/L	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	1.1 U	0.1 U	0.5 U	0.1 U	0.1 U
Benzo(a)anthracene	ug/L	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	1.1 U	0.1 U	0.5 U	0.1 UJ	0.1 U
Benzo(a)pyrene	ug/L	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	1.1 U	0.1 U	0.5 U	0.1 U	0.1 U
Benzo(g,h,i)perylene	ug/L	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	1.1 U	0.09 J	0.5 UJ	0.1 UJ	0.1 U
Benzofluoranthenes, Total	ug/L	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	2.2 U	0.2 U	1 U	0.2 U	0.2 U
Chlorpyrifos	ug/L	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.25 U	0.2 U
Chrysene	ug/L	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	1.1 U	0.08 J	0.5 U	0.1 UJ	0.1 U
Diazinon	ug/L	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.25 U	0.2 U
Dibenz(a,h)anthracene	ug/L	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 UJ	1.1 UJ	0.1 UJ	0.5 U	0.1 U	0.1 U
Dibenzofuran	ug/L	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	1.1 U	0.1 U	0.5 U	0.1 U	0.1 U
Dichlobenil	ug/L	0.057	0.093 J	0.051	0.041 J	0.024 U	0.024 U	0.024 U	0.026	0.024	0.045	0.32
Fluoranthene	ug/L	0.1 U	0.1 UJ	0.1 U	0.1	0.07 J	0.07 J	1.1 U	0.09 J	0.5 U	0.1 U	0.1 U
Fluorene	ug/L	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	1.1 U	0.1 U	0.5 U	0.1 U	0.1 U
Indeno(1,2,3-cd)pyrene	ug/L	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	1.1 U	0.1 UJ	0.5 UJ	0.1 UJ	0.1 U
Malathion	ug/L	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U	0.49 U	0.4 U
Naphthalene	ug/L	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	1.1 U	0.1 U	0.5 UJ	0.06 UJ	0.1 U
Pentachlorophenol	ug/L	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	5.6 U	0.5 U	2.5 U	0.5 UJ	0.5 U
Phenanthrene	ug/L	0.1 U	0.1 U	0.1 U	0.1 U	0.06 J	0.1 U	1.1 U	0.06 J	0.5 U	0.1 U	0.1 U
Prometon	ug/L	0.024 U	0.024 U	0.024 U	0.024 U	0.024 U	0.024 U	0.024 U	0.024 U	0.024 U	0.024 U	0.8
Pyrene	ug/L	0.1 U	0.09 U	0.1 U	0.11	0.09 J	0.1	1.1 U	0.09 J	0.5 U	0.1 UJ	0.1 U

		SE-25	SE-26	SE-27	SE-28	SE-29	SE-30	SE-31	SE-32	SE-33	SE-34	SE-35
		R1	R1	R1	R1	R1	R1	R1	R1	R1	R1	R1
Analyte	Units	11/02/2011	11/11/2011	11/16/2011	12/26/2011	01/24/2012	01/29/2012	02/20/2012	02/24/2012	02/28/2012	05/20/2012	06/22/2012
Metals												
Cadmium, Total	ug/L	0.2	0.2	0.1 U	0.2	0.2	0.2	0.1 U	0.2	0.1	0.1 U	0.1
Cadmium, Dissolved	ug/L	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Copper, Total	ug/L	18.1	17.4	11.4	14.1	18.2	27.8	7.8	16	12.1	16.1	11.7
Copper, Dissolved	ug/L	5.6	7.5	4.8	4.5	4.9	4.4	3.8	2.6	4.1	12.2	6.6
Lead, Total	ug/L	19.1	14.3	10.5	14.6	19.4	37.4	6	21.6	11.8	4.6	7.6
Lead, Dissolved	ug/L	0.5	0.7	0.8	0.6	0.6	0.6	0.6	0.4	0.6	0.7	0.5
Zinc, Total	ug/L	54	44 J	33	45	68	94	24	53	41	25	32
Zinc, Dissolved	ug/L	18	14	15	14	16	14	11	9	16	14	13
Hardness	mg/L CaCO3	19	15	11	15	22	24	12	15	15	27	9.7
Miscellaneous Organics												
2,4-D	ug/L	0.08 U	0.08 UJ	0.088 UJ	0.08 U	0.08 U	0.08 U	0.08 U	0.08 U	0.08 U	0.21	0.23
MCPP	ug/L	0.08 U	0.08 UJ	0.088 UJ	0.08 U	0.08 U	0.08 U	0.08 U	0.08 U	0.08 U	0.08 U	0.083
Triclopyr	ug/L	0.08 U	0.08 UJ	0.088 UJ	0.08 U	0.08 U	0.08 U	0.08 U	0.08 U	0.08 U	0.08 U	0.08 U
Conventionals												
Conductivity	umho/cm	37.3	38.4	26.8	32.1	111	91.9	45.9	31.6	50.5	84.2	30.1
pH	std units	7.12	6.51	6.2	6.79	6.87	6.64	6.83	6.47	6.55	6.27 J	6.21
Solids, Total Suspended	mg/L	91.7	51.7	40.7	48.8	56.1	188	16.7	51.9	42.3	14.3	25.7
Turbidity	NTU	54	37	28	53.1	76	110	21	62	31	16.3	24
Chloride	mg/L	4.9	2.5	1.4	1.7	18.6	14.7	3.6	2.4	5	5.2	1.7
Biological Oxygen Demand	mg/L	8.9	12.8	4.7	3.5	2.6	5.2	2 U	2.9	3.1 J	5.3	3.6
Surfactants	mg/L	0.044	0.059 J	0.043	0.048	0.025 U	0.025 U	0.048 J	0.046	0.055	0.166	0.031
Grab - manual												
Petroleum Hydrocarbons												
Diesel Range Hydrocarbons	mg/L	0.42	0.93	0.58	0.36	0.41	0.38	0.28	0.48	0.42	0.39	0.63
Gasoline Range Hydrocarbons	mg/L	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U
Motor Oil	mg/L	0.7	1.3	0.95	0.93	1.3	1.1	0.71	1.6	0.98	0.87	1
Bacteria												
Fecal Coliform	CFU/100 mL	2100 J	600	470	600	360	530	500	273 J	81	4100	5800

Notes:
U - Analyte was not detected above the reported result.
J- Analyte was positively identified. The reported result is an estimate.
UJ- Analyte was not detected above the reported estimate.

Table 2.7.1b. Stormwater Analytical Summary – Commercial Site (C1)

		SE-24	SE-25	SE-26	SE-27	SE-28	SE-29	SE-30	SE-31	SE-32	SE-33	SE-34
		C1	C1	C1	C1	C1	C1	C1	C1	C1	C1	C1
Analyte	Units	10/02/2011*	10/10/2011	10/28/2011	11/02/2011	11/11/2011	11/16/2011	01/04/2012	01/24/2012	02/17/2012	05/20/2012	06/22/2012
Flow-weighted composite - automatic												
Nutrients												
Nitrate + Nitrite	mg-N/L	0.616	0.248 J	0.31	0.171 J	0.383	0.254 J	0.098 J	0.213 J	0.183 J	0.217	0.185
Nitrogen, Total Kjeldahl	mg-N/L	2.58	1.93	1.75	1.9	2.65	1.22	1.39	1.4	3.07	3.39	1.45
Phosphorus, Total	mg-P/L	0.464	0.336	0.241 J	0.26 J	0.393	0.24 J	0.212 J	0.28	0.535	0.387	0.2
Ortho-phosphate	mg-P/L	0.082	0.038	0.056	0.063	0.114	0.057	0.018	0.018	0.033	0.004 U	0.009
Semivolatile Organics												
bis(2-Ethylhexyl)phthalate	ug/L	7 J	4.6	2.8	4	2.7	2.2 U	2.4 J	3.2 J	6.9	3.9	3.9
Butylbenzylphthalate	ug/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Diethylphthalate	ug/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	0.7 J	1 U
Dimethylphthalate	ug/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Di-n-Butylphthalate	ug/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Di-n-Octyl phthalate	ug/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1-Methylnaphthalene	ug/L	0.1 U	0.1 U	0.1 U	0.1 U	0.1 UJ	0.1 U	0.1 U	0.1 U	0.1 U	0.5 U	0.1 U
2-Methylnaphthalene	ug/L	0.1 U	0.1 U	0.1 U	0.1 U	0.1 UJ	0.1 U	0.1 U	0.06 J	0.1 U	0.5 U	0.1 U
Acenaphthene	ug/L	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.5 U	0.1 U
Acenaphthylene	ug/L	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.5 U	0.1 U
Anthracene	ug/L	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.5 U	0.1 U
Benzo(a)anthracene	ug/L	0.1 U	0.1 U	0.1 U	0.1 U	0.08 U	0.1 U	0.1 U	0.1 U	0.12	0.5 U	0.1 U
Benzo(a)pyrene	ug/L	0.1 U	0.1 U	0.1 U	0.1 U	0.09 U	0.1 U	0.1 U	0.1 U	0.21	0.5 U	0.1 U
Benzo(g,h,i)perylene	ug/L	0.1	0.1 U	0.1 U	0.1 U	0.07 U	0.1 U	0.1 U	0.1 U	0.23	0.5 U	0.1 U
Benzofluoranthenes, Total	ug/L	0.2	0.16	0.2 U	0.2 U	0.23	0.2 U	0.2 UJ	0.2 U	0.31	1 U	0.2 U
Chlorpyrifos	ug/L	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.6 U	0.2 U	0.2 U
Chrysene	ug/L	0.15	0.11	0.1 U	0.1 U	0.13	0.1 U	0.1 U	0.1 U	0.23	0.5 U	0.1 U
Diazinon	ug/L	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.6 U	0.2 U	0.2 U
Dibenz(a,h)anthracene	ug/L	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 UJ	0.1 U	0.1 U	0.5 U	0.1 U
Dibenzofuran	ug/L	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.5 U	0.1 U
Dichlobenil	ug/L	0.024 UJ	0.024 U	0.024 U	0.024 U	0.024 UJ	0.024 U	0.024 U	0.024 U	0.07	0.03	0.027
Fluoranthene	ug/L	0.22	0.16	0.1 U	0.11	0.23 J	0.1 U	0.1 U	0.12	0.3	0.5 U	0.1 U
Fluorene	ug/L	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.5 U	0.1 U
Indeno(1,2,3-cd)pyrene	ug/L	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 UJ	0.1 U	0.1 U	0.5 U	0.1 U
Malathion	ug/L	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U	1.2 U	0.4 U	0.4 U
Naphthalene	ug/L	0.1 U	0.1 U	0.1 U	0.1 U	0.06 U	0.1 U	0.1 U	0.05 J	0.08 UJ	0.5 U	0.1 U
Pentachlorophenol	ug/L	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	2.5 U	0.5 U
Phenanthrene	ug/L	0.11	0.11	0.1 U	0.1 U	0.14	0.1 U	0.1 U	0.14	0.21	0.5 U	0.1 U
Prometon	ug/L	0.024 U	0.024 U	0.024 U	0.024 U	0.024 U	0.024 U	0.024 U	0.024 U	0.024 U	0.024 U	0.026 U
Pyrene	ug/L	0.21	0.17	0.1 U	0.17	0.18	0.1 U	0.1 U	0.21	0.35	0.5 U	0.1 U

		SE-24	SE-25	SE-26	SE-27	SE-28	SE-29	SE-30	SE-31	SE-32	SE-33	SE-34
		C1	C1	C1	C1	C1	C1	C1	C1	C1	C1	C1
Analyte	Units	10/02/2011*	10/10/2011	10/28/2011	11/02/2011	11/11/2011	11/16/2011	01/04/2012	01/24/2012	02/17/2012	05/20/2012	06/22/2012
Metals												
Cadmium, Total	ug/L	0.3	0.3	0.2	0.2	0.2	0.1	0.1	0.3	0.3	0.3	0.2
Cadmium, Dissolved	ug/L	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Copper, Total	ug/L	52.8	40.7	40.2	43.8	45.9	36.8	35.4	61.9	67.9	67.1	31.5
Copper, Dissolved	ug/L	19.8	8.7	16	14.4	14.8	14.2	5.8	10.2	9.5	28.1	11.4
Lead, Total	ug/L	21.5	30.2	14.6	18.4	21	10	21.8	30.3	46.5	17	14.8
Lead, Dissolved	ug/L	1.3	0.8	1.7	1.9	2.3	1.7	0.6	0.7	0.5	1.1	0.6
Mercury, Total	ug/L	0.0361	0.0346	0.0262	0.0336	0.0268	0.02 U	0.023	0.0212	0.0434	0.0497	0.02 U
Mercury, Dissolved	ug/L	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U
Zinc, Total	ug/L	202	178	230	143	183 J	213	118	190	250	205	111
Zinc, Dissolved	ug/L	59	33	49	45	70	130	26	26	20	100	37
Hardness	mg/L CaCO3	51	32	30	25	63	36	24	39	40	49	22
Miscellaneous Organics												
2,4-D	ug/L	0.08 U	0.08 U	0.08 U	0.08 U	0.08 UJ	0.094 UJ	0.08 U	0.08 U	0.08 U	0.2	0.08 U
MCPP	ug/L	0.08 U	0.08 U	0.08 U	0.08 U	0.08 UJ	0.094 UJ	0.08 U	0.08 U	0.08 U	0.08 U	0.08 U
Triclopyr	ug/L	0.08 U	0.08 U	0.08 U	0.08 U	0.08 UJ	0.094 UJ	0.08 U	0.08 U	0.08 U	0.08 U	0.087
Conventionals												
Conductivity	umho/cm	127	68.3	74	59.4	164	95.7	46.5	146	80.3	120	48.2
pH	std units	6.74	6.81	7	6.93	7.22	6.68	7.02	7.21	7.15	6.65 J	6.36
Solids, Total Suspended	mg/L	65	80.7	54	78.8	77	41	72.3 J	121	215	79.3	49.1
Turbidity	NTU	23	33	20	34	38	26	32	90	96	46	24
Chloride	mg/L	5.1	2.5	3	2.8	22.2	8.8	1.9	21.7	4.3	6.4	1.5
Biological Oxygen Demand	mg/L	13.2	7.8	18.9	18.1	35.9	17.6	6.7	6.9	19.5	38.4	6.9
Surfactants	mg/L	0.17	0.074	0.13 J	0.073	0.061 J	0.066	0.05	0.14	0.92 J	0.298	0.038
Grab - manual												
Petroleum Hydrocarbons												
Diesel Range Hydrocarbons	mg/L	0.83	0.7 J	0.52	0.77	0.92	0.98	0.64	0.8	0.66	0.73	0.68
Gasoline Range Hydrocarbons	mg/L	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U
Motor Oil	mg/L	2.2	1.6 J	1.5	1.6 J	1.9	1.5	2.2	2.6	2.4	1.5	1.7
Bacteria												
Fecal Coliform	CFU/100 mL	4100	12400	4800	3100	2900	3300	1600	3550 J	273 J	19700	6820

Notes:
U - Analyte was not detected above the reported result.
J- Analyte was positively identified. The reported result is an estimate.
UJ- Analyte was not detected above the reported estimate.
* - The grab sample for SE-24 on 10/2-3/2011 was not collected during the composite period, but collected on 12/27/2011 at 17:15.

Table 2.7.1c. Stormwater Analytical Summary – Industrial Site (I1)

		SE-23	SE-24	SE-25	SE-26	SE-27	SE-28	SE-29	SE-30	SE-31	SE-32	SE-33
		I1	I1	I1	I1	I1	I1	I1	I1	I1	I1	I1
Analyte	Units	10/02/2011*	10/28/2011	11/02/2011	11/11/2011	11/16/2011	12/26/2011	01/04/2012	01/29/2012	02/17/2012	06/22/2012	07/20/2012
Flow-weighted composite - automatic												
Nutrients												
Nitrate + Nitrite	mg-N/L	0.428	0.195 J	0.16 J	0.316	0.195 J	0.188 J	0.265 J	0.446	0.232 J	0.246	0.568
Nitrogen, Total Kjeldahl	mg-N/L	1.53	0.9	0.71	1.06	0.468	0.92	1.14	0.92	0.98	0.88	2.05
Phosphorus, Total	mg-P/L	0.386	0.145 J	0.152 J	0.171 J	0.136 J	0.177 J	0.327	0.201 J	0.299 J	0.137	0.496
Ortho-phosphate	mg-P/L	0.011 J	0.019 J	0.03 J	0.029 J	0.02 J	0.039 J	0.09	0.09	0.089	0.012	0.037
Semivolatile Organics												
bis(2-Ethylhexyl)phthalate	ug/L	6.3 J	1 U	1.4	2.3	1 U	3.1	3.1 J	1.5	1.3	1.4	2.6
Butylbenzylphthalate	ug/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Diethylphthalate	ug/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Dimethylphthalate	ug/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Di-n-Butylphthalate	ug/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Di-n-Octyl phthalate	ug/L	1.9	1 U	1 U	1.3	1 U	1 U	1 U	1 U	1 U	1 U	2.4
1-Methylnaphthalene	ug/L	0.1 U	0.1 U	0.1 U	0.1 UJ	0.1 U	0.94	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
2-Methylnaphthalene	ug/L	0.1 U	0.1 U	0.1 U	0.1 UJ	0.1 U	1.4	0.1 U	0.1 U	0.09 UJ	0.1 U	0.1 U
Acenaphthene	ug/L	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Acenaphthylene	ug/L	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Anthracene	ug/L	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Benzo(a)anthracene	ug/L	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.08 U
Benzo(a)pyrene	ug/L	0.1 U	0.1 U	0.1	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1
Benzo(g,h,i)perylene	ug/L	0.12	0.1	0.11	0.07 U	0.1 U	0.1 U	0.1 U	0.1 U	0.09 UJ	0.1 U	0.11
Benzofluoranthenes, Total	ug/L	0.25	0.2	0.2 U	0.2 U	0.2 U	0.2 U	0.2 UJ	0.2 U	0.2 U	0.2 U	0.19 U
Chlorpyrifos	ug/L	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	1 U
Chrysene	ug/L	0.13	0.1	0.12	0.08 U	0.1 U	0.12	0.1 U	0.1 U	0.1 U	0.1 U	0.14
Diazinon	ug/L	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	1 U
Dibenz(a,h)anthracene	ug/L	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 UJ	0.1 U	0.1 U	0.1 U	0.1 U
Dibenzofuran	ug/L	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Dichlobenil	ug/L	0.024 UJ	0.024 U	0.53	0.42 J	0.33	0.17 J	0.084	0.069	0.067		0.024 U
Fluoranthene	ug/L	0.18	0.14	0.15	0.14 J	0.1 U	0.14	0.1 U	0.06 J	0.1	0.1 U	0.21
Fluorene	ug/L	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.22	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Indeno(1,2,3-cd)pyrene	ug/L	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 UJ	0.1 U	0.1 U	0.1 U	0.08 U
Malathion	ug/L	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U	2 U
Naphthalene	ug/L	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.38	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Pentachlorophenol	ug/L	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Phenanthrene	ug/L	0.1 U	0.1 U	0.1	0.08 U	0.1 U	0.33	0.1 U	0.1 U	0.1	0.1 U	0.13
Prometon	ug/L	0.024 U	0.024 U	0.024 U	0.024 U	0.024 U	0.024 U	0.024 U	0.024 U	0.024 U		0.024 U
Pyrene	ug/L	0.2	0.19	0.18	0.14	0.1 U	0.19	0.1 U	0.1 U	0.17	0.1 U	0.22

		SE-23	SE-24	SE-25	SE-26	SE-27	SE-28	SE-29	SE-30	SE-31	SE-32	SE-33
		I1	I1	I1	I1	I1	I1	I1	I1	I1	I1	I1
Analyte	Units	10/02/2011*	10/28/2011	11/02/2011	11/11/2011	11/16/2011	12/26/2011	01/04/2012	01/29/2012	02/17/2012	06/22/2012	07/20/2012
Metals												
Cadmium, Total	ug/L	0.4	0.2	0.2	0.2	0.1	0.2	0.3	0.1 U	0.2	0.2	0.4
Cadmium, Dissolved	ug/L	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Copper, Total	ug/L	36.7	23	21.6	22.7	12.9	35.8	23.1	12.6	19.6	17.5	53.3
Copper, Dissolved	ug/L	4.4	5.4	6	6.2	5.4	6	3.7	5	4.1	7.6	6.4
Lead, Total	ug/L	18.2	11	8	10	4	8.9	14.1	4.9	9.9	5.3	25.7
Lead, Dissolved	ug/L	0.6	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.4	0.5
Mercury, Total	ug/L	0.025	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.0454
Mercury, Dissolved	ug/L	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U
Zinc, Total	ug/L	252	150	129	147 J	123	172	181	88	128	132	350
Zinc, Dissolved	ug/L	39	32	36	35	56	50	34	46	29	58	36
Hardness	mg/L CaCO3	57	46	52	65	51	34	49	72	68	45	80
Miscellaneous Organics												
2,4-D	ug/L	0.08 U	0.08 U	0.08 U	0.08 UJ	0.083 UJ	0.08 U	0.08 U	0.08 U	0.08 U	0.08 U	0.27
MCPP	ug/L	0.08 U	0.08 U	0.08 U	0.08 UJ	0.083 UJ	0.08 U	0.08 U	0.08 U	0.08 U	0.08 U	0.08 U
Triclopyr	ug/L	0.08 U	0.08 U	0.08 U	0.08 UJ	0.083 UJ	0.08 U	0.08 U	0.08 U	0.08 U	0.08 U	0.08 U
Conventionals												
Conductivity	umho/cm	126	93.6	100	139	121	71.3	97.4	176	155	98.9	137
pH	std units	6.88 J	7.07	7.2	7.68	7.15	6.93	7.18	7.18	7.44	6.73	7.59
Solids, Total Suspended	mg/L	147	17.6	72	65.7	29.8	56.3	109	32.8	85	39.3	213
Turbidity	NTU	68	46	60	56	31	60	46.8	31	72	37	125
Chloride	mg/L	2.9	1.8	2	2.8	2.7	2.4	2.6	13.2	6.6	1.9	3
Biological Oxygen Demand	mg/L	7.1 J	5.8	8.2	10.1	5.3	6.9	4	3.1	3.7	5.3	13.1
Surfactants	mg/L	0.83	0.043 J	0.046	0.056 J	0.075	0.11	0.032	0.025 U	0.052	0.1	0.26
Grab - manual												
Petroleum Hydrocarbons												
Diesel Range Hydrocarbons	mg/L	0.91	0.44	0.56	1.2	0.82	2.4	0.5	0.42	0.47	1	0.92
Gasoline Range Hydrocarbons	mg/L	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.44	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U
Motor Oil	mg/L	3	1.4	1.1	3.3	1.6	1.8	1.4	1.2	1.6	1.7	2
Bacteria												
Fecal Coliform	CFU/100 mL	104	2500	1520 J	507	760	400	627	480	991 J	6550	12000

Notes:
U - Analyte was not detected above the reported result.
J- Analyte was positively identified. The reported result is an estimate.
UJ- Analyte was not detected above the reported estimate.
* - The grab sample for SE-23 on 10/2-3/2011 was not collected during the composite period, but collected on 2/13/2012 at 09:30.

Table 2.7.2. Base Flow Analytical Summary – Commercial Site (C1)

		BF-09		BF-10		BF-11		BF-12	
		C1		C1		C1		C1	
Analyte	Units	12/05/2011		01/11/2012		05/10/2012		07/09/2012	
Time-weighted composite - automatic									
Nutrients									
Nitrate + Nitrite	mg-N/L	1.2		1.86		2.43		1.53	
Nitrogen, Total Kjeldahl	mg-N/L	0.43		0.67		2.6		1.3	
Phosphorus, Total	mg-P/L	0.113	J	0.191	J	2.32		0.118	
Ortho-phosphate	mg-P/L	0.052		0.166		2.06		0.134	
Semivolatile Organics									
bis(2-Ethylhexyl)phthalate	ug/L	1.4		0.7	J	1	U	2.2	
Butylbenzylphthalate	ug/L	1	U	1	U	1	U	1	U
Diethylphthalate	ug/L	1	U	1	U	1	U	1	U
Dimethylphthalate	ug/L	1	U	1	U	1	U	1	U
Di-n-Butylphthalate	ug/L	1	U	1	U	1	U	1	U
Di-n-Octyl phthalate	ug/L	1	U	1	U	1	U	1	U
1-Methylnaphthalene	ug/L	0.1	U	0.1	U	0.1	U	0.1	U
2-Methylnaphthalene	ug/L	0.1	U	0.1	U	0.1	U	0.1	U
Acenaphthene	ug/L	0.1	U	0.1	U	0.1	U	0.1	U
Acenaphthylene	ug/L	0.1	U	0.1	U	0.1	U	0.1	U
Anthracene	ug/L	0.1	U	0.1	U	0.1	U	0.1	U
Benzo(a)anthracene	ug/L	0.1	U	0.1	U	0.1	U	0.1	U
Benzo(a)pyrene	ug/L	0.1	U	0.1	U	0.1	U	0.1	U
Benzo(g,h,i)perylene	ug/L	0.1	U	0.1	U	0.1	U	0.1	U
Benzofluoranthenes, Total	ug/L	0.2	U	0.2	U	0.2	U	0.2	U
Chlorpyrifos	ug/L	0.2	U	0.2	U	0.2	U	0.2	U
Chrysene	ug/L	0.1	U	0.1	U	0.1	U	0.1	U
Diazinon	ug/L	0.2	U	0.2	U	0.2	U	0.2	U
Dibenz(a,h)anthracene	ug/L	0.1	U	0.1	U	0.1	U	0.1	U
Dibenzofuran	ug/L	0.1	U	0.1	U	0.1	U	0.1	U
Dichlobenil	ug/L	0.024	U	0.024	U	0.024	U	0.025	U
Fluoranthene	ug/L	0.1	U	0.1	U	0.1	U	0.1	U
Fluorene	ug/L	0.1	U	0.1	U	0.1	U	0.1	U
Indeno(1,2,3-cd)pyrene	ug/L	0.1	U	0.1	U	0.1	U	0.1	U
Malathion	ug/L	0.4	U	0.4	U	0.4	U	0.4	U
Naphthalene	ug/L	0.1	U	0.1	U	0.1	U	0.1	U
Pentachlorophenol	ug/L	0.5	U	0.5	U	0.5	U	0.5	U
Phenanthrene	ug/L	0.1	U	0.1	U	0.1	U	0.1	U

		BF-09		BF-10		BF-11		BF-12	
		C1		C1		C1		C1	
Analyte	Units	12/05/2011		01/11/2012		05/10/2012		07/09/2012	
Prometon	ug/L	0.024	U	0.024	U	0.024	U	0.025	U
Pyrene	ug/L	0.1	U	0.1	U	0.1	U	0.1	U
Metals									
Cadmium, Total	ug/L	0.1	U	0.6		0.1	U	0.1	U
Cadmium, Dissolved	ug/L	0.1	U	0.6		0.1	U	0.1	U
Copper, Total	ug/L	7.6		36.9		9.1		16.7	
Copper, Dissolved	ug/L	5.6		36.6		6.3		12.2	
Lead, Total	ug/L	1.9		11.3		1.5		1.4	
Lead, Dissolved	ug/L	0.4	J	7.3		0.3		0.5	
Mercury, Total	ug/L	0.02	U	0.0408		0.02	U	0.02	U
Mercury, Dissolved	ug/L	0.02	U	0.02	U	0.02	U	0.02	U
Zinc, Total	ug/L	30		750		63		102	
Zinc, Dissolved	ug/L	23		730		41		88	
Hardness	mg/L CaCO3	95		220		150		130	
Miscellaneous Organics									
2,4-D	ug/L	0.08	UJ	0.08	U	0.08	U	0.08	U
MCPP	ug/L	0.08	UJ	0.08	U	0.08	U	0.08	U
Triclopyr	ug/L	0.08	UJ	0.08	U	0.08	U	0.08	U
Conventionals									
Conductivity	umho/cm	235		524		433		349	
pH	std units	7.59		6.73		7.56		7.79	
Solids, Total Suspended	mg/L	3.9		11.4		10.7		6.7	
Turbidity	NTU	3.9		7.1		16.6		8.1	
Chloride	mg/L	15.9		79.7		33.7		16.2	
Biological Oxygen Demand	mg/L	2	U	15.4		14.5		16.6	
Surfactants	mg/L	0.039		0.025	U	0.039		0.07	
Grab - manual									
Petroleum Hydrocarbons									
Diesel Range Hydrocarbons	mg/L	0.1	U	0.12		0.73		0.19	
Gasoline Range Hydrocarbons	mg/L	0.25	U	0.25	U	0.25	U	0.00025	U
Motor Oil	mg/L	0.2	U	0.2	U	0.33		0.26	
Bacteria									
Fecal Coliform	CFU/100 mL	320		3000		2	U	1350	

Notes:
U - Analyte was not detected above the reported result.
J- Analyte was positively identified. The reported result is an estimate.
UJ- Analyte was not detected above the reported estimate.

2.7.3 Sediment Samples

The results of sediment trap samples collected from the three monitoring stations are summarized in Table 2.7.3. Insufficient sediment quantity was captured at site C1 to analyze for all the permit sediment parameters so parameters were prioritized according to Section S8.D of the permit. The permit allows that if insufficient sediment is available for grain size analysis per the Ecology sieve and pipette method (ASTM 1997) or PSEP 1986/2003, then the grain size can be characterized qualitatively. Below is the qualitative soil classification performed for sediment from C1 by ARI per ASTM method D2488/D4427.

C1: "The Sample is estimated to be a Sandy Silt made up predominantly of organic material. The estimated percentages of the major constituents are as follows: Gravel – 0%, Sand – 30%, Silt – 60%, Clay – 10%."

2.8 Stormwater Sample Statistics

Two sets of tables containing stormwater sample summary statistics are presented in this report: 1) statistics for WY2012 data for each of the monitoring locations are displayed in Tables 2.8a-c; and 2) statistics for all data collected under the Permit for each of the monitoring locations are displayed in Tables 2.8d-f. For R1, data ranges from WY2009 through WY2012. For C1 and I1, data ranges from WY2010 through WY2012.

The substitution factor for non-detects is 0.5 times the reporting limit in the summary statistics reports.

Table 2.7.3. Sediment Analytical Summary (all sites)

Analyte	Units	R1 10/03/2012		C1 10/03/2012		I1 10/03/2012	
Semivolatile Organics							
Chlorpyrifos	ug/kg	190	U	200	U	210	U
Chrysene	ug/kg	1100		1400		1000	
Diazinon	ug/kg	190	U	200	U	210	U
Dibenz(a,h)anthracene	ug/kg	240		350		240	
Dibenzofuran	ug/kg	220		80	J	160	U
Fluoranthene	ug/kg	2500		2100		1400	
Fluorene	ug/kg	260		120	J	160	U
Indeno(1,2,3-cd)pyrene	ug/kg	540		620		530	
Malathion	ug/kg	250	U	250	U	270	U
Naphthalene	ug/kg	100		80	J	130	J
Phenanthrene	ug/kg	2100		1200		740	
Pyrene	ug/kg	1700		1800		1200	
bis(2-Ethylhexyl)phthalate	ug/kg	1400		11000		14000	
Butylbenzylphthalate	ug/kg	64	U	260		330	U
Diethylphthalate	ug/kg	64	U	200	U	330	U
Dimethylphthalate	ug/kg	64	U	200	U	330	U
Di-n-Butylphthalate	ug/kg	64	U	150	J	330	U
Di-n-Octyl phthalate	ug/kg	64	U	200	U	10000	
Pentachlorophenol	ug/kg	430	U	670	U	800	U
1-Methylnaphthalene	ug/kg	86	U	130	U	160	U
2-Methylnaphthalene	ug/kg	52	J	67	J	80	J
Acenaphthene	ug/kg	210		67	J	160	U
Acenaphthylene	ug/kg	86	U	67	J	160	U
Anthracene	ug/kg	270		210		160	
Benzo(a)anthracene	ug/kg	800		800		530	
Benzo(a)pyrene	ug/kg	800		1000		820	
Benzo(g,h,i)perylene	ug/kg	640	J	840	J	720	J
PCBs							
Aroclor 1016	ug/kg	NR		33	U	33	U
Aroclor 1242	ug/kg	NR		33	U	33	U
Aroclor 1248	ug/kg	NR		49	U	33	U
Aroclor 1254	ug/kg	NR		160		52	
Aroclor 1260	ug/kg	NR		66		41	
Aroclor 1221	ug/kg	NR		33	U	33	U
Aroclor 1232	ug/kg	NR		33	U	33	U

Analyte	Units	R1 10/03/2012	C1 10/03/2012	I1 10/03/2012
Metals				
Cadmium, Total	mg/kg	0.565	1.13	1.32
Copper, Total	mg/kg	57.9	207	137
Lead, Total	mg/kg	124	195	84.2
Mercury, Total	mg/kg	NR	0.12	0.13
Zinc, Total	mg/kg	236	9250	1010
Conventionals				
Total Organic Carbon	%	18.9	14.3	9.12
Solids, Total	%	43.4	40.9	41.7
Grain Size				
Gravel	%	24.2	NM	0.7
Very Coarse Sand	%	16.7	NM	1.9
Coarse Sand	%	16.1	NM	2
Fine Sand	%	7.4	NM	2.1
Medium Sand	%	13.3	NM	1.9
Very Fine Sand	%	4.7	NM	2.7
Coarse Silt	%	5.2	NM	6.7
Medium Silt	%	3.7	NM	29.9
Fine Silt	%	2.9	NM	28.5
Very Fine Silt	%	2.4	NM	14.8
9-10 Phi Clay	%	1	NM	2.9
8-9 Phi Clay	%	1.9	NM	4.4
>10 Phi Clay	%	0.7	NM	1.5
Total Fines	%	17.7	NM	88.7

Notes:
U - Analyte was not detected above the reported result.
J- Analyte was positively identified. The reported result is an estimate.
UJ- Analyte was not detected above the reported estimate.
NR – Not required. PCB and mercury analysis are not required at the Residential site.
NM – Not measured. Insufficient sample quantity to perform all analysis. Grain size characterized qualitatively – see report text.

Table 2.8a. WY2012 Summary Statistics – Residential Site (R1) Stormwater

Analyte Name	Units	n	# D	Min	Avg	Max	Std Dev	Var	5th Pctile	25th Pctile	Med	75th Pctile	95th Pctile
Petroleum Hydrocarbons													
TPH-D	mg/L	11	11	0.28	0.48	0.93	0.179	0.032	0.32	0.385	0.42	0.53	0.78
TPH-G	mg/L	11	0	0.125	0.13	0.125	0	0	0.125	0.125	0.125	0.125	0.125
Motor Oil	mg/L	11	11	0.7	1.04	1.6	0.27	0.0731	0.705	0.9	0.98	1.2	1.45
Bacteria													
Fecal Coliform	CFU/100 mL	11	11	81	6903 (a)	5800	1869	3E+06	177	415	530	1350	4950
Nutrients													
Nitrate + Nitrite	mg-N/L	11	11	0.118	0.28	0.724	0.188	0.0353	0.1225	0.148	0.179	0.372	0.593
TKN	mg-N/L	11	11	0.57	1.06	1.87	0.38	0.1448	0.665	0.7895	1	1.22	1.69
Orthophosphate	mg-P/L	11	11	0.009	0.02	0.036	0.009	8E-05	0.01	0.011	0.013	0.0215	0.032
Phosphorus, Total	mg-P/L	11	11	0.085	0.19	0.322	0.08	0.0065	0.096	0.127	0.19	0.245	0.313
Semivolatile Organics													
1-Methylnaphthalene	ug/L	11	0	0.05	0.11	0.55	0.157	0.0245	0.05	0.05	0.05	0.05	0.4
2-Methylnaphthalene	ug/L	11	0	0.05	0.11	0.55	0.157	0.0245	0.05	0.05	0.05	0.05	0.4
Acenaphthene	ug/L	11	0	0.05	0.11	0.55	0.157	0.0245	0.05	0.05	0.05	0.05	0.4
Acenaphthylene	ug/L	11	0	0.05	0.11	0.55	0.157	0.0245	0.05	0.05	0.05	0.05	0.4
Anthracene	ug/L	11	0	0.05	0.11	0.55	0.157	0.0245	0.05	0.05	0.05	0.05	0.4
Benzo(a)anthracene	ug/L	11	0	0.05	0.11	0.55	0.157	0.0245	0.05	0.05	0.05	0.05	0.4
Benzo(a)pyrene	ug/L	11	0	0.05	0.11	0.55	0.157	0.0245	0.05	0.05	0.05	0.05	0.4
Benzo(g,h,i)perylene	ug/L	11	1	0.05	0.12	0.55	0.156	0.0242	0.05	0.05	0.05	0.07	0.4
Benzofluoranthenes, Total	ug/L	11	0	0.1	0.23	1.1	0.313	0.0982	0.1	0.1	0.1	0.1	0.8
Butylbenzylphthalate	ug/L	11	0	0.5	0.5	0.5	0	0	0.5	0.5	0.5	0.5	0.5
Chlorpyrifos	ug/L	11	0	0.1	0.1	0.125	0.008	6E-05	0.1	0.1	0.1	0.1	0.113
Chrysene	ug/L	11	1	0.05	0.12	0.55	0.156	0.0242	0.05	0.05	0.05	0.065	0.4
Di-n-Butylphthalate	ug/L	11	0	0.5	0.5	0.5	0	0	0.5	0.5	0.5	0.5	0.5
Di-n-Octyl phthalate	ug/L	11	0	0.5	0.5	0.5	0	0	0.5	0.5	0.5	0.5	0.5
Diazinon	ug/L	11	0	0.1	0.1	0.125	0.008	6E-05	0.1	0.1	0.1	0.1	0.113
Dibenz(a,h)anthracene	ug/L	11	0	0.05	0.11	0.55	0.157	0.0245	0.05	0.05	0.05	0.05	0.4
Dibenzofuran	ug/L	11	0	0.05	0.11	0.55	0.157	0.0245	0.05	0.05	0.05	0.05	0.4
Dichlobenil	ug/L	11	8	0.012	0.06	0.32	0.089	0.0079	0.012	0.018	0.041	0.054	0.207
Diethylphthalate	ug/L	11	0	0.5	0.5	0.5	0	0	0.5	0.5	0.5	0.5	0.5
Dimethylphthalate	ug/L	11	0	0.5	0.5	0.5	0	0	0.5	0.5	0.5	0.5	0.5
Fluoranthene	ug/L	11	4	0.05	0.13	0.55	0.152	0.0232	0.05	0.05	0.07	0.095	0.4
Fluorene	ug/L	11	0	0.05	0.11	0.55	0.157	0.0245	0.05	0.05	0.05	0.05	0.4
Indeno(1,2,3-cd)pyrene	ug/L	11	0	0.05	0.11	0.55	0.157	0.0245	0.05	0.05	0.05	0.05	0.4
Malathion	ug/L	11	0	0.2	0.2	0.245	0.014	0.0002	0.2	0.2	0.2	0.2	0.223

Analyte Name	Units	n	# D	Min	Avg	Max	Std Dev	Var	5th Pctile	25th Pctile	Med	75th Pctile	95th Pctile
Naphthalene	ug/L	11	0	0.03	0.11	0.55	0.158	0.0248	0.04	0.05	0.05	0.05	0.4
Pentachlorophenol	ug/L	11	0	0.25	0.57	2.8	0.797	0.6357	0.25	0.25	0.25	0.25	2.025
Phenanthrene	ug/L	11	2	0.05	0.12	0.55	0.156	0.0243	0.05	0.05	0.05	0.06	0.4
Prometon	ug/L	11	1	0.012	0.08	0.8	0.238	0.0564	0.012	0.012	0.012	0.012	0.406
Pyrene	ug/L	11	4	0.045	0.13	0.55	0.151	0.0228	0.0475	0.05	0.09	0.105	0.4
bis(2-Ethylhexyl) phthalate	ug/L	11	5	0.5	1.75	9.5	2.685	7.2067	0.5	0.5	0.5	1.25	6.3
Metals													
Cadmium, Dissolved	ug/L	11	0	0.05	0.05	0.05	0	0	0.05	0.05	0.05	0.05	0.05
Cadmium, Total	ug/L	11	8	0.05	0.14	0.2	0.07	0.0049	0.05	0.075	0.2	0.2	0.2
Copper, Dissolved	ug/L	11	11	2.6	5.55	12.2	2.577	6.6407	3.2	4.25	4.8	6.1	9.85
Copper, Total	ug/L	11	11	7.8	15.5	27.8	5.231	27.362	9.6	11.9	16	17.75	23
Hardness	mg/L CaCO3	11	11	9.7	16.8	27	5.548	30.781	10.35	13.5	15	20.5	25.5
Lead, Dissolved	ug/L	11	11	0.4	0.6	0.8	0.11	0.012	0.45	0.55	0.6	0.65	0.75
Lead, Total	ug/L	11	11	4.6	15.2	37.4	9.253	85.622	5.3	9.05	14.3	19.25	29.5
Zinc, Dissolved	ug/L	11	11	9	14	18	2.45	6	10	13.5	14	15.5	17
Zinc, Total	ug/L	11	11	24	46.6	94	20.53	421.65	24.5	32.5	44	53.5	81
Miscellaneous Organics													
2,4-D	ug/L	11	2	0.04	0.07	0.23	0.073	0.0053	0.04	0.04	0.04	0.042	0.22
MCPP	ug/L	11	1	0.04	0.04	0.083	0.013	0.0002	0.04	0.04	0.04	0.04	0.064
Triclopyr	ug/L	11	0	0.04	0.04	0.044	0.001	1E-06	0.04	0.04	0.04	0.04	0.042
Conventionals													
BOD	mg/L	11	10	1	4.87	12.8	3.318	11.008	1.8	3	3.6	5.25	10.85
Chloride	mg/L	11	11	1.4	5.61	18.6	5.699	32.473	1.55	2.05	3.6	5.1	16.65
Conductivity	umho/cm	11	11	26.8	52.7	111	29.11	847.16	28.45	31.85	38.4	67.35	101.5
Solids, Total Suspended	mg/L	11	11	14.3	57.1	188	48.37	2339.6	15.5	33.2	48.8	54	139.9
Surfactants	mg/L	11	9	0.013	0.05	0.166	0.041	0.0017	0.0125	0.037	0.046	0.0515	0.113
Turbidity	NTU	11	11	16.3	46.6	110	28.26	798.38	18.65	26	37	58	93
pH	std units	11	11	6.2	6.59	7.12	0.297	0.0881	6.205	6.37	6.55	6.81	6.995

Notes: n – sample number, #D – number detected, min – minimum, avg – average, max – maximum, std dev – standard deviation, var – variance. pctile –percentile, med –median, (a) – geometric mean presented instead of average for bacteria data, NA – not applicable

Table 2.8b. WY2012 Summary Statistics – Commercial Site (C1) Stormwater

Analyte Name	Units	n	# D	Min	Avg	Max	Std Dev	Var	5th Pctile	25th Pctile	Med	75th Pctile	95th Pctile
Petroleum Hydrocarbons													
TPH-D	mg/L	11	11	0.52	0.75	0.98	0.13	0.017	0.58	0.67	0.73	0.815	0.95
TPH-G	mg/L	11	0	0.125	0.125	0.125	0	0	0.125	0.125	0.125	0.125	0.125
Motor Oil	mg/L	11	11	1.5	1.88	2.6	0.4	0.162	1.5	1.55	1.7	2.2	2.5
Bacteria													
Fecal Coliform	CFU/ 100 mL	11	11	273	3644 (a)	19700	5628	3E+07	936.5	3000	3550	5810	16050
Nutrients													
Nitrate + Nitrite	mg-N/L	11	11	0.1	0.26	0.616	0.14	0.019	0.135	0.184	0.22	0.282	0.5
TKN	mg-N/L	11	11	1.22	2.07	3.39	0.74	0.551	1.305	1.425	1.9	2.615	3.23
Orthophosphate	mg-P/L	11	10	0	0.04	0.114	0.03	0.001	0.006	0.018	0.04	0.06	0.098
Phosphorus, Total	mg-P/L	11	11	0.2	0.32	0.535	0.11	0.012	0.206	0.241	0.28	0.39	0.5
Semivolatile Organics													
1-Methylnaphthalene	ug/L	11	0	0.05	0.07	0.25	0.06	0.004	0.05	0.05	0.05	0.05	0.15
2-Methylnaphthalene	ug/L	11	1	0.05	0.07	0.25	0.06	0.004	0.05	0.05	0.05	0.05	0.155
Acenaphthene	ug/L	11	0	0.05	0.07	0.25	0.06	0.004	0.05	0.05	0.05	0.05	0.15
Acenaphthylene	ug/L	11	0	0.05	0.07	0.25	0.06	0.004	0.05	0.05	0.05	0.05	0.15
Anthracene	ug/L	11	0	0.05	0.07	0.25	0.06	0.004	0.05	0.05	0.05	0.05	0.15
Benzo(a)anthracene	ug/L	11	1	0.04	0.07	0.25	0.06	0.004	0.045	0.05	0.05	0.05	0.185
Benzo(a)pyrene	ug/L	11	1	0.05	0.08	0.25	0.07	0.005	0.048	0.05	0.05	0.05	0.23
Benzo(g,h,i)perylene	ug/L	11	2	0.04	0.09	0.25	0.08	0.006	0.043	0.05	0.05	0.075	0.24
Benzofluoranthenes, Total	ug/L	11	4	0.1	0.18	0.5	0.13	0.016	0.1	0.1	0.1	0.215	0.405
Butylbenzylphthalate	ug/L	11	0	0.5	0.5	0.5	0	0	0.5	0.5	0.5	0.5	0.5
Chlorpyrifos	ug/L	11	0	0.1	0.12	0.3	0.06	0.004	0.1	0.1	0.1	0.1	0.2
Chrysene	ug/L	11	4	0.05	0.11	0.25	0.08	0.006	0.05	0.05	0.05	0.14	0.24
Di-n-Butylphthalate	ug/L	11	0	0.5	0.5	0.5	0	0	0.5	0.5	0.5	0.5	0.5
Di-n-Octyl phthalate	ug/L	11	0	0.5	0.5	0.5	0	0	0.5	0.5	0.5	0.5	0.5
Diazinon	ug/L	11	0	0.1	0.12	0.3	0.06	0.004	0.1	0.1	0.1	0.1	0.2
Dibenz(a,h)anthracene	ug/L	11	0	0.05	0.07	0.25	0.06	0.004	0.05	0.05	0.05	0.05	0.15
Dibenzofuran	ug/L	11	0	0.05	0.07	0.25	0.06	0.004	0.05	0.05	0.05	0.05	0.15
Dichlobenil	ug/L	11	3	0.01	0.02	0.07	0.02	3E-04	0.012	0.012	0.01	0.02	0.05
Diethylphthalate	ug/L	11	1	0.5	0.52	0.7	0.06	0.004	0.5	0.5	0.5	0.5	0.6
Dimethylphthalate	ug/L	11	0	0.5	0.5	0.5	0	0	0.5	0.5	0.5	0.5	0.5
Fluoranthene	ug/L	11	6	0.05	0.14	0.3	0.09	0.009	0.05	0.05	0.12	0.225	0.275
Fluorene	ug/L	11	0	0.05	0.07	0.25	0.06	0.004	0.05	0.05	0.05	0.05	0.15
Indeno(1,2,3-cd)pyrene	ug/L	11	0	0.05	0.07	0.25	0.06	0.004	0.05	0.05	0.05	0.05	0.15
Malathion	ug/L	11	0	0.2	0.24	0.6	0.12	0.015	0.2	0.2	0.2	0.2	0.4

Analyte Name	Units	n	# D	Min	Avg	Max	Std Dev	Var	5th Pctile	25th Pctile	Med	75th Pctile	95th Pctile
Naphthalene	ug/L	11	1	0.03	0.07	0.25	0.06	0.004	0.035	0.05	0.05	0.05	0.15
Pentachlorophenol	ug/L	11	0	0.25	0.34	1.25	0.3	0.091	0.25	0.25	0.25	0.25	0.75
Phenanthrene	ug/L	11	5	0.05	0.11	0.25	0.07	0.005	0.05	0.05	0.11	0.14	0.23
Prometon	ug/L	11	0	0.01	0.01	0.013	0	9E-08	0.012	0.012	0.01	0.012	0.013
Pyrene	ug/L	11	6	0.05	0.16	0.35	0.1	0.01	0.05	0.05	0.17	0.21	0.3
bis(2-Ethylhexyl) phthalate	ug/L	11	10	1.1	3.86	7	1.8	3.233	1.75	2.75	3.9	4.3	6.95
Metals													
Cadmium, Dissolved	ug/L	11	0	0.05	0.05	0.05	0	0	0.05	0.05	0.05	0.05	0.05
Cadmium, Total	ug/L	11	11	0.1	0.23	0.3	0.08	0.006	0.1	0.2	0.2	0.3	0.3
Copper, Dissolved	ug/L	11	11	5.8	13.9	28.1	6.12	37.4	7.25	9.85	14.2	15.4	23.95
Copper, Total	ug/L	11	11	31.5	47.6	67.9	12.9	166.8	33.45	38.5	43.8	57.35	67.5
Hardness	mg/L CaCO3	11	11	22	37.4	63	12.8	164.1	23	27.5	36	44.5	57
Lead, Dissolved	ug/L	11	11	0.5	1.2	2.3	0.62	0.384	0.55	0.65	1.1	1.7	2.1
Lead, Total	ug/L	11	11	10	22.4	46.5	10.1	102.5	12.3	15.9	21	26	38.4
Mercury, Dissolved	ug/L	11	0	0.01	0.01	0.01	0	0	0.01	0.01	0.01	0.01	0.01
Mercury, Total	ug/L	11	9	0.01	0.03	0.05	0.01	2E-04	0.01	0.022	0.03	0.035	0.047
Zinc, Dissolved	ug/L	11	11	20	54.1	130	34.3	1173	23	29.5	45	64.5	115
Zinc, Total	ug/L	11	11	111	184	250	44.2	1952	114.5	160.5	190	209	240
Miscellaneous Organics													
2,4-D	ug/L	11	1	0.04	0.06	0.2	0.05	0.002	0.04	0.04	0.04	0.04	0.124
MCPP	ug/L	11	0	0.04	0.04	0.047	0	4E-06	0.04	0.04	0.04	0.04	0.044
Triclopyr	ug/L	11	1	0.04	0.04	0.087	0.01	2E-04	0.04	0.04	0.04	0.04	0.067
Conventionals													
BOD	mg/L	11	11	6.7	17.3	38.4	11.1	123.5	6.8	7.35	17.6	19.2	37.15
Chloride	mg/L	11	11	1.5	7.29	22.2	7.56	57.09	1.7	2.65	4.3	7.6	21.95
Conductivity	umho/cm	11	11	46.5	93.6	164	40.2	1617	47.35	63.85	80.3	123.5	155
Solids, Total Suspended	mg/L	11	11	41	84.8	215	48.1	2310	45.05	59.5	77	80	168
Surfactants	mg/L	11	11	0.04	0.18	0.92	0.26	0.065	0.044	0.064	0.07	0.155	0.609
Turbidity	NTU	11	11	20	42	96	26.3	692.2	21.5	25	33	42	93
pH	std units	11	11	6.36	6.89	7.22	0.27	0.072	6.505	6.71	6.93	7.085	7.215

Notes: n – sample number, # D– number detected, min – minimum, avg – average, max – maximum, std dev – standard deviation, var – variance. pctile –percentile, med – median, (a) – geometric mean presented instead of average for bacteria data, NA – not applicable

Table 2.8c. WY2012 Summary Statistics – Industrial Site (I1) Stormwater

Analyte Name	Units	n	# D	Min	Avg	Max	Std Dev	Var	5th Pctile	25th Pctile	Med	75th Pctile	95th Pctile
Petroleum Hydrocarbons													
TPH-D	mg/L	11	11	0.42	0.88	2.4	0.57	0.325	0.43	0.485	0.82	0.96	1.8
TPH-G	mg/L	11	1	0.125	0.15	0.44	0.09	0.009	0.125	0.125	0.125	0.125	0.283
Motor Oil	mg/L	11	11	1.1	1.83	3.3	0.70	0.498	1.15	1.4	1.6	1.9	3.15
Bacteria													
Fecal Coliform	CFU/ 100 mL	11	11	104	1033 (a)	12000	366	1E+07	252	493.5	760	2010	9275
Nutrients													
Nitrate + Nitrite	mg-N/L	11	11	0.16	0.29	0.568	0.13	0.017	0.174	0.195	0.246	0.372	0.507
TKN	mg-N/L	11	11	0.468	1.05	2.05	0.42	0.178	0.589	0.89	0.92	1.1	1.79
Orthophosphate	mg-P/L	11	11	0.011	0.04	0.09	0.03	0.001	0.011	0.0195	0.03	0.064	0.09
Phosphorus, Total	mg-P/L	11	11	0.136	0.24	0.496	0.12	0.014	0.136	0.1485	0.177	0.313	0.441
Semivolatile Organics													
1-Methylnaphthalene	ug/L	11	1	0.05	0.13	0.94	0.26	0.072	0.05	0.05	0.05	0.05	0.495
2-Methylnaphthalene	ug/L	11	1	0.045	0.17	1.4	0.40	0.165	0.047	0.05	0.05	0.05	0.725
Acenaphthene	ug/L	11	0	0.05	0.05	0.05	0	0	0.05	0.05	0.05	0.05	0.05
Acenaphthylene	ug/L	11	0	0.05	0.05	0.05	0	0	0.05	0.05	0.05	0.05	0.05
Anthracene	ug/L	11	0	0.05	0.05	0.05	0	0	0.05	0.05	0.05	0.05	0.05
Benzo(a)anthracene	ug/L	11	0	0.04	0.05	0.05	0.00	9E-06	0.045	0.05	0.05	0.05	0.05
Benzo(a)pyrene	ug/L	11	2	0.05	0.06	0.1	0.02	0.000	0.05	0.05	0.05	0.05	0.1
Benzo(g,h,i)perylene	ug/L	11	4	0.035	0.07	0.12	0.03	0.001	0.04	0.05	0.05	0.105	0.115
Benzofluoranthenes, Total	ug/L	11	2	0.095	0.12	0.25	0.05	0.002	0.097	0.1	0.1	0.1	0.225
Butylbenzylphthalate	ug/L	11	0	0.5	0.5	0.5	0	0	0.5	0.5	0.5	0.5	0.5
Chlorpyrifos	ug/L	11	0	0.1	0.14	0.5	0.12	0.014	0.1	0.1	0.1	0.1	0.3
Chrysene	ug/L	11	5	0.04	0.08	0.14	0.04	0.001	0.045	0.05	0.05	0.12	0.135
Di-n-Butylphthalate	ug/L	11	0	0.5	0.5	0.5	0	0	0.5	0.5	0.5	0.5	0.5
Di-n-Octyl phthalate	ug/L	11	3	0.5	0.87	2.4	0.68	0.468	0.5	0.5	0.5	0.9	2.15
Diazinon	ug/L	11	0	0.1	0.14	0.5	0.12	0.014	0.1	0.1	0.1	0.1	0.3
Dibenz(a,h)anthracene	ug/L	11	0	0.05	0.05	0.05	0	0	0.05	0.05	0.05	0.05	0.05
Dibenzofuran	ug/L	11	0	0.05	0.05	0.05	0	0	0.05	0.05	0.05	0.05	0.05
Dichlobenil	ug/L	11	8	0.012	0.16	0.53	0.18	0.033	0.012	0.025	0.069	0.25	0.475
Diethylphthalate	ug/L	11	0	0.5	0.5	0.5	0	0	0.5	0.5	0.5	0.5	0.5
Dimethylphthalate	ug/L	11	0	0.5	0.5	0.5	0	0	0.5	0.5	0.5	0.5	0.5
Fluoranthene	ug/L	11	8	0.05	0.12	0.21	0.05	0.003	0.05	0.055	0.14	0.145	0.195
Fluorene	ug/L	11	1	0.05	0.07	0.22	0.05	0.002	0.05	0.05	0.05	0.05	0.135
Indeno(1,2,3-cd)pyrene	ug/L	11	0	0.04	0.05	0.05	0.00	9E-06	0.045	0.05	0.05	0.05	0.05

Analyte Name	Units	n	# D	Min	Avg	Max	Std Dev	Var	5th Pctile	25th Pctile	Med	75th Pctile	95th Pctile
Malathion	ug/L	11	0	0.2	0.27	1	0.24	0.058	0.2	0.2	0.2	0.2	0.6
Naphthalene	ug/L	11	1	0.05	0.08	0.38	0.09 9	0.009	0.05	0.05	0.05	0.05	0.215
Pentachlorophenol	ug/L	11	0	0.25	0.25	0.25	0	0	0.25	0.25	0.25	0.25	0.25
Phenanthrene	ug/L	11	4	0.04	0.09	0.33	0.08	0.007	0.045	0.05	0.05	0.1	0.23
Prometon	ug/L	11	0	0.012	0.01	0.013	3E-04	9E-08	0.012	0.012	0.012	0.012	0.013
Pyrene	ug/L	11	7	0.05	0.14	0.22	0.07	0.005	0.05	0.05	0.17	0.19	0.21
bis(2-Ethylhexyl) phthalate	ug/L	11	9	0.5	2.18	6.3	1.64	2.695	0.5	1.35	1.5	2.85	4.7
Metals													
Cadmium, Dissolved	ug/L	11	0	0.05	0.05	0.05	0	0	0.05	0.05	0.05	0.05	0.05
Cadmium, Total	ug/L	11	10	0.05	0.22	0.4	0.10	0.011	0.075	0.2	0.2	0.25	0.4
Copper, Dissolved	ug/L	11	11	3.7	5.47	7.6	1.13	1.288	3.9	4.7	5.4	6.1	7
Copper, Total	ug/L	11	11	12.6	25.3	53.3	12.1	146.3	12.75	18.55	22.7	29.45	45
Hardness	mg/L CaCO3	11	11	34	56.3	80	13.6	185.2	39.5	47.5	52	66.5	76
Lead, Dissolved	ug/L	11	11	0.2	0.32	0.6	0.13	0.017	0.2	0.2	0.3	0.35	0.55
Lead, Total	ug/L	11	11	4	10.9	25.7	6.41	41.17	4.45	6.65	9.9	12.55	21.95
Mercury, Dissolved	ug/L	11	0	0.01	0.01	0.01	0	0	0.01	0.01	0.01	0.01	0.01
Mercury, Total	ug/L	11	2	0.01	0.01	0.045	0.01	0.000	0.01	0.01	0.01	0.01	0.035
Zinc, Dissolved	ug/L	11	11	29	41	58	9.92	98.4	30.5	34.5	36	48	57
Zinc, Total	ug/L	11	11	88	168	350	73.4	5397.	105.5	128.5	147	176.5	301
Miscellaneous Organics													
2,4-D	ug/L	11	1	0.04	0.06	0.27	0.0	0.004	0.04	0.04	0.04	0.04	0.156
MCPP	ug/L	11	0	0.04	0.04	0.042	5E-04	2E-07	0.04	0.04	0.04	0.04	0.041
Triclopyr	ug/L	11	0	0.04	0.04	0.042	5E-04	2E-07	0.04	0.04	0.04	0.04	0.041
Conventionals													
BOD	mg/L	11	11	3.1	6.6	13.1	2.98	8.884	3.4	4.65	5.8	7.65	11.6
Chloride	mg/L	11	11	1.8	3.81	13.2	3.37	11.41	1.85	2.2	2.7	2.95	9.9
Conductivity	umho/cm	11	11	71.3	120	176	30.7	947.0	82.45	98.15	121	138	165.5
Solids, Total Suspended	mg/L	11	11	17.6	78.9	213	58.4	3415.	23.7	36.05	65.7	97	180
Surfactants	mg/L	11	10	0.013	0.15	0.83	0.23	0.055	0.022	0.0445	0.056	0.105	0.545
Turbidity	NTU	11	11	31	57.5	125	26.3	696.3	31	41.5	56	64	98.5
pH	std units	11	11	6.73	7.18	7.68	0.29	0.085	6.805	7	7.18	7.32	7.635

Notes: n – sample number, # D– number detected, min – minimum, avg – average, max – maximum, std dev – standard deviation, var – variance. pctile –percentile, med – median, (a) – geometric mean presented instead of average for bacteria data, NA – not applicable

Table 2.8d. WY2009-2012 Summary Statistics – Residential Site (R1) Stormwater

Analyte Name	Units	n	# D	Min	Avg	Max	Std Dev	Var	5th Pctile	25th Pctile	Med	75th Pctile	95th Pctile
Petroleum Hydrocarbons													
TPH-D	mg/L	35	33	0.125	0.387	1.2	0.22	0.048	0.136	0.25	0.36	0.44	0.72
TPH-G	mg/L	35	0	0.125	0.125	0.12	0	0	0.125	0.125	0.125	0.125	0.125
Motor Oil	mg/L	35	32	0.25	1.035	3.2	0.6	0.361	0.25	0.685	0.98	1.25	2.01
Bacteria													
Fecal Coliform	CFU/100 mL	35	35	6	636 (a)	35300	6747	5E+07	32.5	296.5	530	2380	13270
Nutrients													
Nitrate + Nitrite	mg-N/L	35	35	0.071	0.258	0.724	0.18	0.0314	0.106	0.132	0.179	0.338	0.674
TKN	mg-N/L	35	35	0.57	1.269	4.2	0.77	0.5897	0.594	0.789	1	1.35	2.794
Orthophosphate	mg-P/L	35	35	0.006	0.021	0.15	0.03	0.0009	0.007	0.01	0.013	0.017	0.064
Phosphorus, Total	mg-P/L	35	35	0.052	0.229	0.643	0.14	0.0187	0.098	0.139	0.19	0.284	0.494
Semivolatile Organics													
1-Methylnaphthalene	ug/L	35	0	0.05	0.071	0.55	0.09	0.0081	0.05	0.05	0.05	0.05	0.145
2-Methylnaphthalene	ug/L	35	0	0.05	0.071	0.55	0.09	0.0081	0.05	0.05	0.05	0.05	0.145
Acenaphthene	ug/L	35	0	0.05	0.071	0.55	0.09	0.0081	0.05	0.05	0.05	0.05	0.145
Acenaphthylene	ug/L	35	0	0.05	0.071	0.55	0.09	0.0081	0.05	0.05	0.05	0.05	0.145
Anthracene	ug/L	35	0	0.05	0.071	0.55	0.09	0.0081	0.05	0.05	0.05	0.05	0.145
Benzo(a)anthracene	ug/L	35	1	0.05	0.073	0.55	0.09	0.0082	0.05	0.05	0.05	0.05	0.159
Benzo(a)pyrene	ug/L	35	0	0.05	0.071	0.55	0.09	0.0081	0.05	0.05	0.05	0.05	0.145
Benzo(b)fluoranthene	ug/L	2	0	0.05	0.05	0.05	0	0	0.05	0.05	0.05	0.05	0.05
Benzo(g,h,i)perylene	ug/L	35	5	0.05	0.082	0.55	0.09	0.0084	0.05	0.05	0.05	0.05	0.194
Benzo(k)fluoranthene	ug/L	2	0	0.05	0.05	0.05	0	0	0.05	0.05	0.05	0.05	0.05
Benzofluoranthenes, Total	ug/L	33	5	0.05	0.127	1.1	0.19	0.0377	0.05	0.05	0.1	0.1	0.356
Butylbenzylphthalate	ug/L	35	0	0.5	0.529	1.5	0.17	0.0286	0.5	0.5	0.5	0.5	0.5
Chlorpyrifos	ug/L	35	0	0.04	0.097	0.125	0.01	0.0002	0.082	0.1	0.1	0.1	0.101
Chrysene	ug/L	35	7	0.05	0.087	0.55	0.09	0.0088	0.05	0.05	0.05	0.09	0.229
Di-n-Butylphthalate	ug/L	35	0	0.5	0.529	1.5	0.17	0.0286	0.5	0.5	0.5	0.5	0.5
Di-n-Octyl phthalate	ug/L	35	0	0.5	0.529	1.5	0.17	0.0286	0.5	0.5	0.5	0.5	0.5
Diazinon	ug/L	35	0	0.04	0.097	0.125	0.01	0.0002	0.082	0.1	0.1	0.1	0.101
Dibenz(a,h)anthracene	ug/L	35	0	0.05	0.071	0.55	0.09	0.0081	0.05	0.05	0.05	0.05	0.145
Dibenzofuran	ug/L	35	1	0.05	0.074	0.55	0.09	0.0082	0.05	0.05	0.05	0.05	0.166
Dichlobenil	ug/L	33	17	0.012	0.119	1.1	0.2	0.0416	0.012	0.024	0.057	0.093	0.334
Diethylphthalate	ug/L	35	0	0.5	0.529	1.5	0.17	0.0286	0.5	0.5	0.5	0.5	0.5
Dimethylphthalate	ug/L	35	0	0.5	0.529	1.5	0.17	0.0286	0.5	0.5	0.5	0.5	0.5
Fluoranthene	ug/L	35	13	0.05	0.105	0.55	0.1	0.01	0.05	0.05	0.05	0.115	0.262
Fluorene	ug/L	35	1	0.05	0.073	0.55	0.09	0.0082	0.05	0.05	0.05	0.05	0.152

Analyte Name	Units	n	# D	Min	Avg	Max	Std Dev	Var	5th Pctile	25th Pctile	Med	75th Pctile	95th Pctile
Indeno(1,2,3-cd)pyrene	ug/L	35	1	0.05	0.073	0.55	0.09	0.0082	0.05	0.05	0.05	0.05	0.152
Malathion	ug/L	35	0	0.1	0.141	0.245	0.05	0.0027	0.1	0.1	0.1	0.2	0.2
Naphthalene	ug/L	35	0	0.03	0.071	0.55	0.09	0.0082	0.05	0.05	0.05	0.05	0.145
Pentachlorophenol	ug/L	35	0	0.25	0.359	2.8	0.46	0.2104	0.25	0.25	0.25	0.25	0.725
Phenanthrene	ug/L	35	4	0.05	0.075	0.55	0.09	0.0081	0.05	0.05	0.05	0.05	0.152
Prometon	ug/L	33	5	0.012	0.083	0.8	0.17	0.0289	0.012	0.012	0.012	0.06	0.404
Pyrene	ug/L	35	14	0.045	0.108	0.55	0.1	0.0098	0.05	0.05	0.05	0.115	0.259
bis(2-Ethylhexyl)phthalate	ug/L	35	15	0.5	1.964	9.5	2.33	5.4076	0.5	0.5	1.1	2.4	7.17
Metals													
Cadmium, Dissolved	ug/L	35	0	0.05	0.081	0.1	0.02	0.0006	0.05	0.05	0.1	0.1	0.1
Cadmium, Total	ug/L	35	16	0.05	0.147	0.4	0.08	0.0068	0.05	0.1	0.1	0.2	0.3
Copper, Dissolved	ug/L	35	35	1.8	5.554	25.7	4.48	20.051	2.37	3.25	4.4	5.3	13.34
Copper, Total	ug/L	35	35	7.8	16.33	35	6.97	48.535	8	11.55	14.8	19.3	31.13
Hardness	mg/L CaCO3	35	35	9.7	17.24	28	5.25	27.567	9.91	12.5	16	20.55	26.3
Lead, Dissolved	ug/L	35	15	0.4	0.646	2.6	0.43	0.1884	0.47	0.5	0.5	0.6	1.3
Lead, Total	ug/L	35	35	3	18.48	56	11.5	131.85	5.58	11	15	22	39.2
Zinc, Dissolved	ug/L	35	35	9	15.14	34	5.96	35.538	9.7	11	14	16	27.8
Zinc, Total	ug/L	35	35	24	52.89	114	22	482.34	25.7	38	49	63	94.9
Miscellaneous Organics													
2,4-D	ug/L	35	4	0.04	0.414	3	0.58	0.3341	0.04	0.04	0.5	0.5	0.95
MCPP	ug/L	35	2	0.04	64.35	125	63.3	4010	0.04	0.04	125	125	125
Triclopyr	ug/L	35	1	0.04	0.046	0.25	0.04	0.0013	0.04	0.04	0.04	0.04	0.041
Conventionals													
BOD	mg/L	35	34	1	4.897	17.6	3.6	12.941	1.87	2.75	3.6	5.35	12.45
Chloride	mg/L	35	35	0.6	14.42	349	58.7	3446.3	0.7	1.5	2.4	4.35	25.74
Conductivity	umho/cm	35	35	19.3	75.82	1060	174	30362	21.43	30.5	36	51.5	132.6
Solids, Total Suspended	mg/L	33	33	6.2	63.74	288	55.3	3062.3	15.74	36.4	48.8	68.3	173
Surfactants	mg/L	35	14	0.013	0.035	0.166	0.03	0.0012	0.013	0.012	0.025	0.044	0.094
Turbidity	NTU	35	35	9.7	48.39	158	31.7	1007.2	17.49	26	38	58	104.4
pH	std units	35	35	6.12	6.772	7.61	0.37	0.1367	6.207	6.53	6.79	7.02	7.303

Notes: n – sample number, # D– number detected, min – minimum, avg – average, max – maximum, std dev – standard deviation, var – variance. pctile –percentile, med – median, (a) – geometric mean presented instead of average for bacteria data, NA – not applicable

Table 2.8e. WY2010-2012 Summary Statistics – Commercial Site (C1) Stormwater

Analyte Name	Units	n	# D	Min	Avg	Max	Std Dev	Var	5th Pctile	25th Pctile	Med	75th Pctile	95th Pctile
Petroleum Hydrocarbons													
TPH-D	mg/L	33	33	0.19	0.875	2.7	0.56	0.315	0.27	0.53	0.77	0.98	2.22
TPH-G	mg/L	33	0	0.125	0.125	0.125	0	0	0.125	0.125	0.125	0.125	0.125
Motor Oil	mg/L	33	33	0.73	2.164	5.8	1.05	1.103	0.92	1.5	1.8	2.6	3.56
Bacteria													
Fecal Coliform	CFU/100 mL	33	32	0.5	2701 (a)	40300	8516	7E+07	367.2	1730	3100	4910	2274
Nutrients													
Nitrate + Nitrite	mg-N/L	33	33	0.067	0.353	1.08	0.24	0.059	0.094	0.208	0.254	0.448	0.811
TKN	mg-N/L	33	33	1.02	2.639	25	4.09	16.74	1.104	1.39	1.75	2.62	3.85
Orthophosphate	mg-P/L	33	31	0.002	0.047	0.275	0.05	0.002	0.004	0.018	0.033	0.057	0.119
Phosphorus, Total	mg-P/L	33	33	0.16	0.289	0.698	0.11	0.013	0.169	0.216	0.26	0.314	0.492
Semivolatile Organics													
1-Methylnaphthalene	ug/L	34	4	0.05	0.123	1.6	0.28	0.076	0.05	0.05	0.05	0.05	0.355
2-Methylnaphthalene	ug/L	34	6	0.05	0.169	2.5	0.45	0.202	0.05	0.05	0.05	0.05	0.547
Acenaphthene	ug/L	34	1	0.05	0.062	0.25	0.04	0.001	0.05	0.05	0.05	0.05	0.131
Acenaphthylene	ug/L	34	1	0.05	0.061	0.25	0.04	0.001	0.05	0.05	0.05	0.05	0.128
Anthracene	ug/L	34	2	0.05	0.064	0.25	0.05	0.002	0.05	0.05	0.05	0.05	0.167
Benzo(a)anthracene	ug/L	34	2	0.04	0.065	0.27	0.05	0.002	0.05	0.05	0.05	0.05	0.165
Benzo(a)pyrene	ug/L	34	3	0.045	0.069	0.25	0.05	0.002	0.05	0.05	0.05	0.05	0.220
Benzo(g,h,i)perylene	ug/L	34	13	0.035	0.094	0.3	0.07	0.004	0.05	0.05	0.05	0.12	0.237
Benzofluoranthenes, Total	ug/L	34	12	0.05	0.141	0.62	0.14	0.018	0.05	0.05	0.1	0.175	0.415
Butylbenzylphthalate	ug/L	34	0	0.5	0.514	1	0.09	0.007	0.5	0.5	0.5	0.5	0.5
Chlorpyrifos	ug/L	34	0	0.1	0.105	0.3	0.03	0.001	0.1	0.1	0.1	0.1	0.1
Chrysene	ug/L	34	13	0.05	0.098	0.28	0.07	0.004	0.05	0.05	0.05	0.138	0.237
Di-n-Butylphthalate	ug/L	34	0	0.5	0.514	1	0.09	0.007	0.5	0.5	0.5	0.5	0.5
Di-n-Octyl phthalate	ug/L	34	0	0.5	0.514	1	0.09	0.007	0.5	0.5	0.5	0.5	0.5
Diazinon	ug/L	34	0	0.1	0.105	0.3	0.03	0.001	0.1	0.1	0.1	0.1	0.1
Dibenz(a,h)anthracene	ug/L	34	1	0.05	0.062	0.25	0.04	0.001	0.05	0.05	0.05	0.05	0.138
Dibenzofuran	ug/L	34	2	0.05	0.067	0.33	0.06	0.003	0.05	0.05	0.05	0.05	0.159
Dichlobenil	ug/L	34	6	0.012	0.037	0.3	0.05	0.002	0.012	0.012	0.012	0.06	0.075
Diethylphthalate	ug/L	34	5	0.5	0.670	3.7	0.57	0.327	0.5	0.5	0.5	0.5	1.17
Dimethylphthalate	ug/L	34	1	0.5	0.582	2.8	0.4	0.160	0.5	0.5	0.5	0.5	0.675
Fluoranthene	ug/L	34	22	0.05	0.154	0.59	0.11	0.011	0.05	0.05	0.135	0.218	0.280
Fluorene	ug/L	34	2	0.05	0.067	0.3	0.06	0.003	0.05	0.05	0.05	0.05	0.178
Indeno(1,2,3-cd)pyrene	ug/L	34	2	0.05	0.064	0.25	0.05	0.002	0.05	0.05	0.05	0.05	0.155
Malathion	ug/L	34	0	0.1	0.15	0.6	0.09	0.008	0.1	0.1	0.1	0.2	0.2

Analyte Name	Units	n	# D	Min	Avg	Max	Std Dev	Var	5th Pctile	25th Pctile	Med	75th Pctile	95th Pctile
Naphthalene	ug/L	34	7	0.03	0.162	2.2	0.39	0.155	0.047	0.05	0.05	0.05	0.534
Pentachlorophenol	ug/L	34	1	0.25	0.297	1.25	0.18	0.034	0.25	0.25	0.25	0.25	0.545
Phenanthrene	ug/L	34	17	0.05	0.108	0.36	0.07	0.005	0.05	0.05	0.11	0.138	0.237
Prometon	ug/L	34	0	0.012	0.033	0.3	0.05	0.002	0.012	0.012	0.012	0.048	0.075
Pyrene	ug/L	34	22	0.05	0.163	0.52	0.11	0.011	0.05	0.05	0.16	0.225	0.330
bis(2-Ethylhexyl) phthalate	ug/L	34	24	0.5	3.683	7.2	2.08	4.315	1.048	1.787	3.25	5.25	7
Metals													
Cadmium, Dissolved	ug/L	34	0	0.05	0.077	0.1	0.03	0.000	0.05	0.05	0.1	0.1	0.1
Cadmium, Total	ug/L	34	27	0.1	0.214	0.4	0.09	0.008	0.1	0.125	0.2	0.3	0.4
Copper, Dissolved	ug/L	34	34	5.8	16.93	47.3	9.69	93.81	7.33	9.675	14.6	20.18	35.16
Copper, Total	ug/L	34	34	22.6	48.88	80.7	16.1	257.6	26.45	35.57	44.85	61.88	73.33
Hardness	mg/L CaCO3	34	34	21	38.20	69	13.9	194.1	21.65	27.5	34.5	46.25	68.35
Lead, Dissolved	ug/L	34	25	0.5	1.047	3	0.62	0.383	0.5	0.5	1	1.25	2.105
Lead, Total	ug/L	34	34	6	18.78	46.5	9.18	84.22	8.65	12.42	17.5	21.23	36.85
Mercury, Dissolved	ug/L	34	0	0.01	0.01	0.01	0	0	0.01	0.01	0.01	0.01	0.01
Mercury, Total	ug/L	34	20	0.01	0.022	0.05	0.01	0.0002	0.01	0.01	0.023	0.029	0.046
Zinc, Dissolved	ug/L	34	34	20	53.32	130	29.6	878.59	25.65	33	46	60.5	116.3
Zinc, Total	ug/L	34	34	78	154.8	270	50.5	2546.1	89.2	112.7	149	194.5	237
Miscellaneous Organics													
2,4-D	ug/L	34	1	0.04	0.274	0.5	0.23	0.0529	0.04	0.04	0.35	0.5	0.5
MCPP	ug/L	34	0	0.04	62.52	125	63.4	4022	0.04	0.04	62.52	125	125
Triclopyr	ug/L	34	1	0.04	0.041	0.087	0.01	7E-05	0.04	0.04	0.04	0.04	0.042
Conventionals													
BOD	mg/L	33	32	4.6	14.83	53.4	10.9	118.34	5.6	7.5	11.1	17.6	36.9
Chloride	mg/L	34	34	1.4	8.455	34	9.2	84.716	1.5	3	4.5	8.8	32.24
Conductivity	umho/cm	33	33	46.5	104.8	227	47.2	2230	52.34	68.3	95.1	127	184.4
Solids, Total Suspended	mg/L	34	34	23.1	71.28	215	41.7	1739.7	30.14	45.85	59.4	78.6	158.6
Surfactants	mg/L	34	24	0.013	0.113	0.92	0.16	0.0272	0.013	0.025	0.064	0.13	0.323
Turbidity	NTU	33	33	11.8	36.90	96	22.1	490.02	15.9	21	32	42.9	87.96
pH	std units	33	33	6.36	7.044	8.26	0.32	0.1045	6.65	6.88	7.05	7.21	7.344

Notes: n – sample number, # D– number detected, min – minimum, avg – average, max – maximum, std dev – standard deviation, var – variance. pctile –percentile, med – median, (a) – geometric mean presented instead of average for bacteria data, NA – not applicable

Table 2.8f. WY2010-2012 Summary Statistics – Industrial Site (I1) Stormwater

Analyte Name	Units	n	# D	Min	Avg	Max	Std Dev	Var	5th Pctile	25th Pctile	Med	75th Pctile	95th Pctile
Petroleum Hydrocarbons													
TPH-D	mg/L	32	32	0.15	0.8	2.4	0.417	0.1738	0.252	0.4675	0.77	0.933	1.2
TPH-G	mg/L	32	2	0.125	0.1	0.44	0.069	0.0048	0.125	0.125	0.125	0.125	0.2353
Motor Oil	mg/L	32	32	0.34	1.7	3.3	0.762	0.5812	0.823	1.175	1.6	2	3.245
Bacteria													
Fecal Coliform	CFU/100 mL	32	32	2	736 (a)	91900	16161	3E+08	105.1	430	730	1490	9002.5
Nutrients													
Nitrate + Nitrite	mg-N/L	33	33	0.135	0.3	0.568	0.108	0.0117	0.177	0.212	0.26	0.358	0.4848
TKN	mg-N/L	33	32	0.15	1.2	3.23	0.678	0.4603	0.523	0.88	1.06	1.37	2.79
Orthophosphate	mg-P/L	33	33	0.007	0.1	0.121	0.034	0.0012	0.009	0.02	0.051	0.074	0.1116
Phosphorus, Total	mg-P/L	33	33	0.106	0.3	0.972	0.175	0.0308	0.115	0.152	0.21	0.327	0.5504
Semivolatile Organics													
1-Methylnaphthalene	ug/L	33	6	0.05	0.1	0.94	0.211	0.0447	0.05	0.05	0.05	0.05	0.472
2-Methylnaphthalene	ug/L	33	6	0.045	0.2	1.9	0.391	0.1532	0.05	0.05	0.05	0.05	0.722
Acenaphthene	ug/L	33	0	0.05	0.1	0.1	0.009	8E-05	0.05	0.05	0.05	0.05	0.05
Acenaphthylene	ug/L	33	0	0.05	0.1	0.1	0.009	8E-05	0.05	0.05	0.05	0.05	0.05
Anthracene	ug/L	33	0	0.05	0.1	0.1	0.009	8E-05	0.05	0.05	0.05	0.05	0.05
Benzo(a)anthracene	ug/L	33	2	0.04	0.1	0.3	0.045	0.002	0.05	0.05	0.05	0.05	0.078
Benzo(a)pyrene	ug/L	33	5	0.05	0.1	0.36	0.063	0.004	0.05	0.05	0.05	0.05	0.162
Benzo(g,h,i)perylene	ug/L	33	9	0.035	0.1	0.36	0.061	0.0037	0.048	0.05	0.05	0.1	0.144
Benzofluoranthenes, Total	ug/L	33	8	0.05	0.1	0.72	0.129	0.0167	0.05	0.05	0.095	0.1	0.29
Butylbenzylphthalate	ug/L	33	0	0.5	0.5	1	0.121	0.0147	0.5	0.5	0.5	0.5	0.7
Chlorpyrifos	ug/L	33	0	0.1	0.1	0.5	0.07	0.0048	0.1	0.1	0.1	0.1	0.1
Chrysene	ug/L	33	11	0.04	0.1	0.44	0.075	0.0057	0.05	0.05	0.05	0.12	0.168
Di-n-Butylphthalate	ug/L	33	0	0.5	0.5	1	0.121	0.0147	0.5	0.5	0.5	0.5	0.7
Di-n-Octyl phthalate	ug/L	33	6	0.5	0.8	2.4	0.582	0.3384	0.5	0.5	0.5	0.5	2.24
Diazinon	ug/L	33	0	0.1	0.1	0.5	0.07	0.0048	0.1	0.1	0.1	0.1	0.1
Dibenz(a,h)anthracene	ug/L	33	0	0.05	0.1	0.1	0.009	8E-05	0.05	0.05	0.05	0.05	0.05
Dibenzofuran	ug/L	33	0	0.05	0.1	0.1	0.009	8E-05	0.05	0.05	0.05	0.05	0.05
Dichlobenil	ug/L	33	16	0.012	0.1	0.53	0.124	0.0154	0.012	0.024	0.06	0.075	0.366
Diethylphthalate	ug/L	33	3	0.5	0.8	8.9	1.48	2.1893	0.5	0.5	0.5	0.5	1.56
Dimethylphthalate	ug/L	33	0	0.5	0.5	1	0.121	0.0147	0.5	0.5	0.5	0.5	0.7
Fluoranthene	ug/L	33	17	0.05	0.1	0.6	0.116	0.0134	0.05	0.05	0.06	0.15	0.298
Fluorene	ug/L	33	1	0.05	0.1	0.22	0.031	0.0009	0.05	0.05	0.05	0.05	0.07
Indeno(1,2,3-cd)pyrene	ug/L	33	3	0.04	0.1	0.28	0.043	0.0018	0.05	0.05	0.05	0.05	0.112
Malathion	ug/L	33	0	0.1	0.2	1	0.158	0.025	0.1	0.1	0.1	0.2	0.2

Analyte Name	Units	n	# D	Min	Avg	Max	Std Dev	Var	5th Pctile	25th Pctile	Med	75th Pctile	95th Pctile
Naphthalene	ug/L	33	5	0.05	0.1	2.1	0.359	0.1288	0.05	0.05	0.05	0.05	0.26
Pentachlorophenol	ug/L	33	0	0.25	0.3	0.5	0.044	0.0019	0.25	0.25	0.25	0.25	0.25
Phenanthrene	ug/L	33	13	0.04	0.1	0.33	0.074	0.0054	0.05	0.05	0.05	0.12	0.266
Prometon	ug/L	33	0	0.012	0	0.3	0.053	0.0028	0.012	0.012	0.012	0.06	0.075
Pyrene	ug/L	33	21	0.05	0.2	0.74	0.142	0.02	0.05	0.05	0.11	0.19	0.414
bis(2-Ethylhexyl) phthalate	ug/L	33	20	0.5	2.2	11	2.043	4.1742	0.5	1.2	1.6	2.6	5.7
Metals													
Cadmium, Dissolved	ug/L	33	0	0.05	0.1	0.1	0.025	0.0006	0.05	0.05	0.1	0.1	0.1
Cadmium, Total	ug/L	33	22	0.05	0.2	0.7	0.146	0.0213	0.1	0.1	0.2	0.2	0.48
Copper, Dissolved	ug/L	33	33	2	5.7	19.2	2.897	8.3944	3.66	4.4	5	6.3	9.02
Copper, Total	ug/L	33	33	10.2	23	64.3	13.55	183.59	11.06	13.3	18.2	25.7	53.74
Hardness	mg/L CaCO3	33	33	27	102	1300	215.8	46574	40.6	52	65	80	92.4
Lead, Dissolved	ug/L	33	15	0.2	0.5	2	0.303	0.0918	0.2	0.3	0.5	0.5	0.54
Lead, Total	ug/L	33	33	2	10	43	9.007	81.134	3.72	4.8	8	11	29.82
Mercury, Dissolved	ug/L	33	0	0.01	0	0.01	0	0	0.01	0.01	0.01	0.01	0.01
Mercury, Total	ug/L	33	5	0.01	0	0.047	0.011	0.0001	0.01	0.01	0.01	0.01	0.0459
Zinc, Dissolved	ug/L	33	33	12	47	125	21.44	459.84	16.8	34	46	57	77.8
Zinc, Total	ug/L	33	33	71	155	420	79.23	6277.8	83.2	106	131	172	338
Miscellaneous Organics													
2,4-D	ug/L	33	1	0.04	0.3	0.5	0.23	0.0529	0.04	0.04	0.27	0.5	0.5
MCPP	ug/L	33	0	0.04	61	125	63.42	4022	0.04	0.04	0.042	125	125
Triclopyr	ug/L	33	3	0.04	0.1	0.59	0.131	0.0172	0.04	0.04	0.04	0.04	0.396
Conventionals													
BOD	mg/L	33	32	1	6.9	27.2	5.125	26.266	2.66	3.6	5.3	8.1	14.6
Chloride	mg/L	33	33	1.1	4.5	13.8	3.364	11.319	1.8	2.6	3	5.1	11.94
Conductivity	umho/cm	33	33	70.7	143	285	42.82	1833.3	84.68	117	141	169	199.2
Solids, Total Suspended	mg/L	33	33	16	87	455	98.49	9699.7	19.4	32.8	62.8	85	287
Surfactants	mg/L	33	18	0.013	0.1	0.83	0.15	0.0226	0.013	0.0125	0.043	0.1	0.242
Turbidity	NTU	33	33	14.4	57	200	44.47	1977.1	19.36	31	44	60	154
pH	std units	33	33	6.73	7.3	7.68	0.203	0.0412	6.91	7.18	7.26	7.44	7.578

Notes: n – sample number, # D– number detected, min – minimum, avg – average, max – maximum, std dev – standard deviation, var – variance. pctile –percentile, med – median, (a) – geometric mean presented instead of average for bacteria data, NA – not applicable

2.9 Annual Load Estimation Results

As discussed previously, the City will estimate annual load using three non-detect substitution methods. Each non-detect value will be substituted with 0.0, 0.5 and 1.0 times the RL.

If an analyte contained no non-detectable results throughout the entire data set at each monitoring site, then the substitution factor is not applicable which means the estimated load will be the same using each of the three substitution methods. If an analyte was non-detect across the entire period's data set, no load will be calculated for that analyte since the load would be based entirely on a theoretical presence of an analyte based on an arbitrary substitution. Thus, the non-detect substitution only applies to analytes which contain a mix of detects and non-detects.

No load is estimated for fecal coliform, hardness, conductivity, pH or turbidity since these analytes are not reported as concentration per volume so these values cannot be converted into pounds per acre. The area used for the load calculation for each basin is the area of that basin draining to the municipal separated storm sewer system (MS4) and does not include acreage draining to the combined sewer system.

2.9.1 Residential Site (R1) Load Estimation

The following analytes were not detected in any stormwater from any events at R1 so no load was calculated:

Gasoline Range Hydrocarbons	Butylbenzylphthalate	Fluorene
1-Methylnaphthalene	Chlorpyrifos	Indeno(1,2,3-cd)pyrene
2-Methylnaphthalene	Di-n-Butylphthalate	Malathion
Acenaphthene	Di-n-Octyl phthalate	Naphthalene
Acenaphthylene	Diazinon	Pentachlorophenol
Anthracene	Dibenz(a,h)anthracene	Cadmium, Dissolved
Benzo(a)anthracene	Dibenzofuran	Triclopyr
Benzo(a)pyrene	Diethylphthalate	
Benzofluoranthenes, Total	Dimethylphthalate	

R1 stormwater loads for WY2012 for detected parameters are presented in Table 2.9.1.

2.9.2 Commercial Site (C1) Load Estimation

The following analytes were not detected in any stormwater from any events at C1 so no load was calculated:

Gasoline Range Hydrocarbons	Di-n-Butylphthalate	Indeno(1,2,3-cd)pyrene
1-Methylnaphthalene	Di-n-Octyl phthalate	Malathion
Acenaphthene	Diazinon	Pentachlorophenol
Acenaphthylene	Dibenz(a,h)anthracene	Prometon
Anthracene	Dibenzofuran	Cadmium, Dissolved

Butylbenzylphthalate	Dimethylphthalate	Mercury, Dissolved
Chlorpyrifos	Fluorene	MCPP

C1 stormwater loads for WY2012 detected parameters are presented in Table 2.9.2a., which displays loads with the base flow load removed.

The following analytes were not detected in any base flow samples at C1 so no base flow load was calculated:

Gasoline Range Hydrocarbons	Chrysene	Malathion
1-Methylnaphthalene	Di-n-Butylphthalate	Naphthalene
2-Methylnaphthalene	Di-n-Octyl phthalate	Pentachlorophenol
Acenaphthene	Diazinon	Phenanthrene
Acenaphthylene	Dibenz(a,h)anthracene	Prometon
Anthracene	Dibenzofuran	Pyrene
Benzo(a)anthracene	Dichlobenil	Mercury, Dissolved
Benzo(a)pyrene	Diethylphthalate	2,4-D
Benzo(g,h,i)perylene	Dimethylphthalate	MCPP
Benzofluoranthenes, Total	Fluoranthene	Triclopyr
Butylbenzylphthalate	Fluorene	
Chlorpyrifos	Indeno(1,2,3-cd)pyrene	

C1 base flow loads for WY2012 are presented in Table 2.9.2b.

Note – for analytes detected in some or all of the stormwater samples from C1 but not detected in some or all of base flow samples, the stormwater loads can decrease as the non-detect substitution factor increases since more base flow load will be removed from the total load as the non-detect replacement value becomes higher.

2.9.3 Industrial Site (I1) Load Estimation

The following analytes were not detected in any stormwater from any events at I1 so no load was calculated:

Acenaphthene	Diazinon	Pentachlorophenol
Acenaphthylene	Dibenz(a,h)anthracene	Prometon
Anthracene	Dibenzofuran	Cadmium, Dissolved
Benzo(a)anthracene	Diethylphthalate	Mercury, Dissolved
Butylbenzylphthalate	Dimethylphthalate	MCPP
Chlorpyrifos	Indeno(1,2,3-cd)pyrene	Triclopyr
Di-n-Butylphthalate	Malathion	

I1 stormwater loads for WY2012 for detected parameters are presented in Table 2.9.3.

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Table 2.9.1. Load Estimation – Residential Site (R1) Stormwater

Analyte Name	Wet Period Storm Load (LB)	Wet Period Storm Load by Area (LB/acre)	Dry Period Storm Load (LB)	Dry Period Storm Load by Area (LB/acre)	Annual Storm Load (LB)	Annual Storm Load by Area (LB/acre)	Wet Period Storm Load (LB)	Wet Period Storm Load by Area (LB/acre)	Dry Period Storm Load (LB)	Dry Period Storm Load by Area (LB/acre)	Annual Storm Load (LB)	Annual Storm Load by Area (LB/acre)	Wet Period Storm Load (LB)	Wet Period Storm Load by Area (LB/acre)	Dry Period Storm Load (LB)	Dry Period Storm Load by Area (LB/acre)	Annual Storm Load (LB)	Annual Storm by Area (LB/acre)
Substitution Factor for Non-Detects	**0.0 x Reporting Limit**						**0.5 x Reporting Limit**						**1.0 x Reporting Limit**					
Petroleum Hydrocarbons																		
Diesel Range Hydrocarbons	14.64	0.17	3.03	0.04	17.68	0.21	14.64	0.17	3.03	0.04	17.68	0.21	14.64	0.17	3.03	0.04	17.68	0.21
Gasoline Range Hydrocarbons	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nutrients																		
Nitrate + Nitrite	7.55	0.09	0.97	0.01	8.52	0.10	7.55	0.09	0.97	0.01	8.52	0.10	7.55	0.09	0.97	0.01	8.52	0.10
Nitrogen, Total Kjeldahl	34.37	0.40	5.06	0.06	39.43	0.46	34.37	0.40	5.06	0.06	39.43	0.46	34.37	0.40	5.06	0.06	39.43	0.46
Ortho-phosphate	0.45	0.01	0.12	0.001	0.56	0.01	0.45	0.01	0.12	0.001	0.56	0.01	0.45	0.01	0.12	0.001	0.56	0.01
Phosphorus, Total	7.10	0.08	0.60	0.01	7.69	0.09	7.10	0.08	0.60	0.01	7.69	0.09	7.10	0.08	0.60	0.01	7.69	0.09
Semivolatile Organics																		
1-Methylnaphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-Methylnaphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acenaphthene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acenaphthylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(a)anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(a)pyrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(g,h,i)perylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Butylbenzylphthalate	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chlorpyrifos	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chrysene	0.001	0.00001	0.00	0.00	0.001	0.00001	0.004	0.0001	0.0003	0.000003	0.005	0.0001	0.01	0.0001	0.001	0.00001	0.01	0.0001
Di-n-Butylphthalate	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Di-n-Octyl phthalate	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Diazinon	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibenz(a,h)anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibenzofuran	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dichlobenil	0.001	0.00001	0.001	0.00002	0.002	0.00003	0.001	0.00001	0.001	0.00002	0.002	0.00003	0.001	0.00001	0.001	0.00002	0.003	0.00003
Diethylphthalate	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dimethylphthalate	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Fluoranthene	0.002	0.00002	0.00	0.00	0.002	0.00002	0.005	0.0001	0.0003	0.000003	0.01	0.0001	0.01	0.0001	0.001	0.00001	0.01	0.0001
Fluorene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Indeno(1,2,3-cd)pyrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Analyte Name	Wet Period Storm Load (LB)	Wet Period Storm Load by Area (LB/acre)	Dry Period Storm Load (LB)	Dry Period Storm Load by Area (LB/acre)	Annual Storm Load (LB)	Annual Storm Load by Area (LB/acre)	Wet Period Storm Load (LB)	Wet Period Storm Load by Area (LB/acre)	Dry Period Storm Load (LB)	Dry Period Storm Load by Area (LB/acre)	Annual Storm Load (LB)	Annual Storm Load by Area (LB/acre)	Wet Period Storm Load (LB)	Wet Period Storm Load by Area (LB/acre)	Dry Period Storm Load (LB)	Dry Period Storm Load by Area (LB/acre)	Annual Storm Load (LB)	Annual Storm by Area (LB/acre)
Substitution Factor for Non-Detects	**0.0 x Reporting Limit**						**0.5 x Reporting Limit**						**1.0 x Reporting Limit**					
Malathion	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Naphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Pentachlorophenol	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phenanthrene	0.001	0.00001	0.00	0.00	0.001	0.00001	0.004	0.00005	0.0003	0.000003	0.004	0.0001	0.01	0.0001	0.001	0.00001	0.01	0.0001
Prometon	0.00	0.00	0.004	0.00004	0.004	0.00004	0.0004	0.000005	0.004	0.00004	0.004	0.00005	0.001	0.00001	0.004	0.00004	0.004	0.0001
Pyrene	0.002	0.00002	0.00	0.00	0.002	0.00002	0.005	0.0001	0.0003	0.000003	0.01	0.0001	0.01	0.0001	0.001	0.00001	0.01	0.0001
bis(2-Ethylhexyl)phthalate	0.01	0.0002	0.01	0.0001	0.02	0.0002	0.03	0.0003	0.01	0.0001	0.03	0.0004	0.04	0.0005	0.01	0.0001	0.05	0.001
Metals																		
Cadmium, Dissolved	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cadmium, Total	0.01	0.0001	0.0004	0.00001	0.01	0.0001	0.01	0.0001	0.0005	0.00001	0.01	0.0001	0.01	0.0001	0.001	0.00001	0.01	0.0001
Copper, Dissolved	0.13	0.002	0.04	0.0004	0.17	0.002	0.13	0.002	0.04	0.0004	0.17	0.002	0.13	0.002	0.04	0.0004	0.17	0.002
Copper, Total	0.54	0.01	0.06	0.001	0.60	0.01	0.54	0.01	0.06	0.001	0.60	0.01	0.54	0.01	0.06	0.001	0.60	0.01
Lead, Dissolved	0.02	0.0002	0.003	0.00003	0.02	0.0002	0.02	0.0002	0.003	0.00003	0.02	0.0002	0.02	0.0002	0.003	0.00003	0.02	0.0002
Lead, Total	0.63	0.01	0.04	0.0004	0.67	0.01	0.63	0.01	0.04	0.0004	0.67	0.01	0.63	0.01	0.04	0.0004	0.67	0.01
Zinc, Dissolved	0.44	0.01	0.07	0.001	0.50	0.01	0.44	0.01	0.07	0.001	0.50	0.01	0.44	0.01	0.07	0.001	0.50	0.01
Zinc, Total	1.76	0.02	0.16	0.002	1.92	0.02	1.76	0.02	0.16	0.002	1.92	0.02	1.76	0.02	0.16	0.002	1.92	0.02
Miscellaneous Organics																		
2,4-D	0.00	0.00	0.001	0.00001	0.001	0.00001	0.001	0.00002	0.001	0.00001	0.003	0.00003	0.003	0.00003	0.001	0.00001	0.004	0.00005
MCPP	0.00	0.00	0.0004	0.000004	0.0004	0.000004	0.001	0.00002	0.0004	0.000005	0.002	0.00002	0.003	0.00003	0.0004	0.000005	0.003	0.00004
Triclopyr	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Conventionals																		
Biological Oxygen Demand	128.39	1.51	19.21	0.23	147.60	1.73	131.32	1.54	19.21	0.23	150.53	1.76	134.26	1.57	19.21	0.23	153.47	1.80
Chloride	178.02	2.09	10.72	0.13	188.74	2.21	178.02	2.09	10.72	0.13	188.74	2.21	178.02	2.09	10.72	0.13	188.74	2.21
Solids, Total Suspended	2265.10	26.55	122.79	1.44	2387.89	27.99	2265.10	26.55	122.79	1.44	2387.89	27.99	2265.10	26.55	122.79	1.44	2387.89	27.99
Surfactants	1.32	0.02	0.24	0.003	1.56	0.02	1.39	0.02	0.24	0.003	1.63	0.02	1.47	0.02	0.24	0.00	1.71	0.02

Notes-
Loads estimated by QAPP method.
LB - pounds
ND – Not detected. Analyte not detected in any samples from period so no load calculated.

Table 2.9.2a. Load Estimation – Commercial Site (C1) Stormwater (with Base Flow Load Removed)

Analyte Name	Wet Period Storm Load (LB)	Wet Period Storm Load by Area (LB/acre)	Dry Period Storm Load (LB)	Dry Period Storm Load by Area (LB/acre)	Annual Storm Load (LB)	Annual Storm Load by Area (LB/acre)	Wet Period Storm Load (LB)	Wet Period Storm Load by Area (LB/acre)	Dry Period Storm Load (LB)	Dry Period Storm Load by Area (LB/acre)	Annual Storm Load (LB)	Annual Storm Load by Area (LB/acre)	Wet Period Storm Load (LB)	Wet Period Storm Load by Area (LB/acre)	Dry Period Storm Load (LB)	Dry Period Storm Load by Area (LB/acre)	Annual Storm Load (LB)	Annual Storm Load by Area (LB/acre)
Substitution Factor for Non-Detects	**0.0 x Reporting Limit**						**0.5 x Reporting Limit**						**1.0 x Reporting Limit**					
Petroleum Hydrocarbons																		
Diesel Range Hydrocarbons	544.61	3.58	84.30	0.55	628.91	4.14	543.41	3.58	84.30	0.55	627.71	4.13	542.22	3.57	84.30	0.55	626.52	4.12
Gasoline Range Hydrocarbons	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nutrients																		
Nitrate + Nitrite	80.89	0.53	13.42	0.09	94.30	0.62	80.89	0.53	13.42	0.09	94.30	0.62	80.89	0.53	13.42	0.09	94.30	0.62
Nitrogen, Total Kjeldahl	1504.10	9.90	293.76	1.93	1797.86	11.83	1504.10	9.90	293.76	1.93	1797.86	11.83	1504.10	9.90	293.76	1.93	1797.86	11.83
Ortho-phosphate	24.11	0.16	-5.82	-0.04	18.29	0.12	24.11	0.16	-5.69	-0.04	18.42	0.12	24.11	0.16	-5.56	-0.04	18.55	0.12
Phosphorus, Total	249.53	1.64	29.77	0.20	279.30	1.84	249.53	1.64	29.77	0.20	279.30	1.84	249.53	1.64	29.77	0.20	279.30	1.84
Semivolatile Organics																		
1-Methylnaphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-Methylnaphthalene	0.005	0.00003	0.00	0.00	0.005	0.00003	0.04	0.0002	0.02	0.0001	0.06	0.0004	0.07	0.0005	0.04	0.0002	0.11	0.001
Acenaphthene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acenaphthylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(a)anthracene	0.02	0.0001	0.00	0.00	0.02	0.0001	0.05	0.0003	0.02	0.0001	0.07	0.0004	0.07	0.0005	0.04	0.0002	0.11	0.001
Benzo(a)pyrene	0.04	0.0002	0.00	0.00	0.04	0.0002	0.06	0.0004	0.02	0.0001	0.08	0.0005	0.09	0.001	0.04	0.0002	0.13	0.001
Benzo(g,h,i)perylene	0.04	0.0003	0.00	0.00	0.04	0.0003	0.07	0.0004	0.02	0.0001	0.09	0.001	0.09	0.001	0.04	0.0002	0.13	0.001
Butylbenzylphthalate	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chlorpyrifos	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chrysene	0.06	0.0004	0.00	0.00	0.06	0.0004	0.08	0.001	0.02	0.0001	0.10	0.001	0.10	0.001	0.04	0.0002	0.14	0.001
Di-n-Butylphthalate	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Di-n-Octyl phthalate	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Diazinon	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibenz(a,h)anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibenzofuran	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dichlobenil	0.01	0.0001	0.00	0.00002	0.02	0.00	0.02	0.0001	0.003	0.00002	0.02	0.0001	0.03	0.0002	0.00	0.00002	0.03	0.0002
Diethylphthalate	0.00	0.00	0.05	0.0003	0.05	0.0003	0.36	0.002	0.07	0.0005	0.43	0.003	0.72	0.005	0.10	0.0006	0.82	0.01
Dimethylphthalate	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Fluoranthene	0.10	0.0006	0.00	0.00	0.10	0.0006	0.11	0.001	0.02	0.0001	0.13	0.001	0.12	0.001	0.04	0.0002	0.16	0.001
Fluorene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Analyte Name	Wet Period Storm Load (LB)	Wet Period Storm Load by Area (LB/acre)	Dry Period Storm Load (LB)	Dry Period Storm Load by Area (LB/acre)	Annual Storm Load (LB)	Annual Storm Load by Area (LB/acre)	Wet Period Storm Load (LB)	Wet Period Storm Load by Area (LB/acre)	Dry Period Storm Load (LB)	Dry Period Storm Load by Area (LB/acre)	Annual Storm Load (LB)	Annual Storm Load by Area (LB/acre)	Wet Period Storm Load (LB)	Wet Period Storm Load by Area (LB/acre)	Dry Period Storm Load (LB)	Dry Period Storm Load by Area (LB/acre)	Annual Storm Load (LB)	Annual Storm Load by Area (LB/acre)
Substitution Factor for Non-Detects	**0.0 x Reporting Limit**						**0.5 x Reporting Limit**						**1.0 x Reporting Limit**					
Indeno(1,2,3-cd)pyrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Malathion	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Naphthalene	0.004	0.00003	0.00	0.00	0.004	0.00003	0.03	0.0002	0.02	0.0001	0.05	0.0003	0.06	0.0004	0.04	0.0002	0.10	0.001
Pentachlorophenol	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phenanthrene	0.07	0.0004	0.00	0.00	0.07	0.0004	0.08	0.001	0.02	0.0001	0.10	0.001	0.10	0.001	0.04	0.0002	0.13	0.001
Prometon	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Pyrene	0.11	0.0008	0.00	0.00	0.11	0.0008	0.13	0.001	0.02	0.0001	0.15	0.001	0.14	0.001	0.04	0.0002	0.18	0.001
bis(2-Ethylhexyl)phthalate	2.97	0.02	0.47	0.003	3.44	0.02	3.04	0.02	0.47	0.003	3.51	0.02	3.10	0.02	0.47	0.003	3.58	0.02
Metals																		
Cadmium, Dissolved	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cadmium, Total	0.15	0.00	0.03	0.0002	0.18	0.001	0.15	0.001	0.03	0.0002	0.18	0.001	0.15	0.001	0.03	0.0002	0.18	0.001
Copper, Dissolved	6.74	0.04	2.44	0.02	9.18	0.06	6.74	0.04	2.44	0.02	9.18	0.06	6.74	0.04	2.44	0.02	9.18	0.06
Copper, Total	36.02	0.24	6.12	0.04	42.15	0.28	36.02	0.24	6.12	0.04	42.15	0.28	36.02	0.24	6.12	0.04	42.15	0.28
Lead, Dissolved	0.52	0.00	0.10	0.001	0.62	0.004	0.52	0.003	0.10	0.00	0.62	0.004	0.52	0.003	0.10	0.001	0.62	0.004
Lead, Total	21.10	0.14	1.96	0.01	23.06	0.15	21.10	0.14	1.96	0.01	23.06	0.15	21.10	0.14	1.96	0.01	23.06	0.15
Mercury, Dissolved	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Mercury, Total	0.02	0.0001	0.00	0.00	0.02	0.0002	0.02	0.0001	0.004	0.00002	0.03	0.0002	0.02	0.0001	0.00	0.00003	0.03	0.0002
Zinc, Dissolved	10.17	0.07	8.29	0.05	18.46	0.12	10.17	0.07	8.29	0.05	18.46	0.12	10.17	0.07	8.29	0.05	18.46	0.12
Zinc, Total	121.72	0.80	19.32	0.13	141.04	0.93	121.72	0.80	19.32	0.13	141.04	0.93	121.72	0.80	19.32	0.13	141.04	0.93
Miscellaneous Organics																		
2,4-D	0.00	0.00	0.01	0.0001	0.01	0.0001	0.03	0.0002	0.02	0.0001	0.04	0.0003	0.06	0.0004	0.02	0.0001	0.08	0.0005
MCPP	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Triclopyr	0.00	0.00	0.01	0.00003	0.01	0.00003	0.03	0.0002	0.01	0.00005	0.04	0.0002	0.06	0.0004	0.01	0.0001	0.07	0.0005
Conventionals																		
Biological Oxygen Demand	10019.00	65.91	2813.80	18.51	12832.80	84.43	9991.60	65.73	2813.80	18.51	12805.40	84.25	9964.20	65.55	2813.80	18.51	12778.00	84.07
Chloride	2182.20	14.36	359.96	2.37	2542.16	16.72	2182.20	14.36	359.96	2.37	2542.16	16.72	2182.20	14.36	359.96	2.37	2542.16	16.72
Solids, Total Suspended	82189.00	540.72	7963.30	52.39	90152.30	593.11	82189.00	540.72	7963.30	52.39	90152.30	593.11	82189.00	540.72	7963.30	52.39	90152.30	593.11
Surfactants	205.88	1.35	21.32	0.14	227.20	1.49	205.54	1.35	21.32	0.14	226.86	1.49	205.20	1.35	21.32	0.14	226.52	1.49

Notes-
Loads estimated by Ecology method.
LB – Pounds.
ND – Not detected. Analyte not detected in any samples from period so no load calculated.
* - Area used for load calculation is basin area draining to MS4 (152.0 acres), not total basin area.

Table 2.9.2b. Load Estimation – Commercial Site (C1) Base Flow

Analyte Name	Wet Period Baseflow Load (LB)	Wet Period Baseflow Load by Area* (LB/acre)	Dry Period Baseflow Load (LB)	Dry Period Baseflow Load by Area* (LB/acre)	Annual Baseflow Load (LB)	Annual Baseflow by Area* (LB/acre)	Wet Period Baseflow Load (LB)	Wet Period Baseflow Load by Area* (LB/acre)	Dry Period Baseflow Load (LB)	Dry Period Baseflow Load by Area* (LB/acre)	Annual Baseflow Load (LB)	Annual Baseflow by Area* (LB/acre)	Wet Period Baseflow Load (LB)	Wet Period Baseflow Load by Area* (LB/acre)	Dry Period Baseflow Load (LB)	Dry Period Baseflow Load by Area* (LB/acre)	Annual Baseflow Load (LB)	Annual Baseflow by Area* (LB/acre)
Substitution Factor for Non-Detects	**0.0 x Reporting Limit**						**0.5 x Reporting Limit**						**1.0 x Reporting Limit**					
Petroleum Hydrocarbons																		
Diesel Range Hydrocarbons	13.57	0.09	43.64	0.29	57.21	0.38	19.22	0.13	43.64	0.29	62.86	0.41	24.87	0.16	43.64	0.29	68.51	0.45
Gasoline Range Hydrocarbons	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nutrients																		
Nitrate + Nitrite	345.99	2.28	187.85	1.24	533.84	3.51	345.99	2.28	187.85	1.24	533.84	3.51	345.99	2.28	187.85	1.24	533.84	3.51
Nitrogen, Total Kjeldahl	124.33	0.82	185.01	1.22	309.34	2.04	124.33	0.82	185.01	1.22	309.34	2.04	124.33	0.82	185.01	1.22	309.34	2.04
Ortho-phosphate	24.64	0.16	104.09	0.68	128.73	0.85	24.64	0.16	104.09	0.68	128.73	0.85	24.64	0.16	104.09	0.68	128.73	0.85
Phosphorus, Total	34.36	0.23	115.64	0.76	150.00	0.99	34.36	0.23	115.64	0.76	150.00	0.99	34.36	0.23	115.64	0.76	150.00	0.99
Semivolatile Organics																		
1-Methylnaphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-Methylnaphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acenaphthene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acenaphthylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(a)anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(a)pyrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(g,h,i)perylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Butylbenzylphthalate	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chlorpyrifos	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chrysene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Di-n-Butylphthalate	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Di-n-Octyl phthalate	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Diazinon	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibenz(a,h)anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibenzofuran	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dichlobenil	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Diethylphthalate	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dimethylphthalate	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Fluoranthene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Fluorene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Indeno(1,2,3-cd)pyrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Analyte Name	Wet Period Baseflow Load (LB)	Wet Period Baseflow Load by Area* (LB/acre)	Dry Period Baseflow Load (LB)	Dry Period Baseflow Load by Area* (LB/acre)	Annual Baseflow Load (LB)	Annual Baseflow by Area* (LB/acre)	Wet Period Baseflow Load (LB)	Wet Period Baseflow Load by Area* (LB/acre)	Dry Period Baseflow Load (LB)	Dry Period Baseflow Load by Area* (LB/acre)	Annual Baseflow Load (LB)	Annual Baseflow by Area* (LB/acre)	Wet Period Baseflow Load (LB)	Wet Period Baseflow Load by Area* (LB/acre)	Dry Period Baseflow Load (LB)	Dry Period Baseflow Load by Area* (LB/acre)	Annual Baseflow Load (LB)	Annual Baseflow by Area* (LB/acre)
Substitution Factor for Non-Detects	**0.0 x Reporting Limit**						**0.5 x Reporting Limit**						**1.0 x Reporting Limit**					
Malathion	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Naphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Pentachlorophenol	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phenanthrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Prometon	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Pyrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
bis(2-Ethylhexyl)phthalate	0.24	0.00156	0.10	0.00069	0.34	0.00225	0.24	0.00156	0.13	0.00084	0.37	0.00240	0.24	0.00156	0.15	0.00100	0.39	0.00256
Metals																		
Cadmium, Dissolved	0.07	0.00045	ND	ND	0.07	0.00045	0.07	0.0005	ND	ND	0.07	0.00048	0.08	0.00052	ND	ND	0.91	0.00598
Cadmium, Total	0.07	0.00045	ND	ND	0.07	0.00045	0.07	0.00048	ND	ND	0.07	0.00048	0.08	0.00052	ND	ND	1.63	0.01072
Copper, Dissolved	4.77	0.03139	0.88	0.00577	5.65	0.03716	4.77	0.03139	0.88	0.00577	5.65	0.03716	4.77	0.03139	0.88	0.00577	5.65	0.03716
Copper, Total	5.03	0.03309	1.22	0.00805	6.25	0.04114	5.03	0.03309	1.22	0.00805	6.25	0.04114	5.03	0.03309	1.22	0.00805	6.25	0.04114
Lead, Dissolved	0.87	0.00573	0.04	0.00025	0.91	0.00598	0.87	0.00573	0.04	0.00025	0.91	0.00598	0.87	0.00573	0.04	0.00025	0.91	0.00598
Lead, Total	1.49	0.00982	0.14	0.00091	1.63	0.01072	1.49	0.00982	0.14	0.00091	1.63	0.01072	1.49	0.00982	0.14	0.00091	1.63	0.01072
Mercury, Dissolved	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Mercury, Total	0.005	0.00003	ND	ND	0.00003	0.0000002	0.01	0.00004	ND	ND	0.01	0.00004	0.01	0.00005	ND	ND	0.01	0.00005
Zinc, Dissolved	85.12	0.56000	6.12	0.04026	91.24	0.60026	85.12	0.56000	6.12	0.04026	91.24	0.60026	85.12	0.56000	6.12	0.04026	91.24	0.60026
Zinc, Total	88.16	0.58002	7.83	0.05150	95.99	0.63152	88.16	0.58002	7.83	0.05150	95.99	0.63152	88.16	0.58002	7.83	0.05150	95.99	0.63152
Miscellaneous Organics																		
2,4-D	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MCPP	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Triclopyr	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Conventionals																		
Biological Oxygen Demand	1740.80	11.45	1475.50	9.71	3216.30	21.16	1853.70	12.20	1475.50	9.71	3329.20	21.90	1967.00	12.94	1475.50	9.71	3442.50	22.65
Chloride	10807.00	71.10	2367.30	15.57	13174.30	86.67	10807.00	71.10	2367.30	15.57	13174.30	86.67	10807.00	71.10	2367.30	15.57	13174.30	86.67
Solids, Total Suspended	1729.70	11.38	825.53	5.43	2555.23	16.81	1729.70	11.38	825.53	5.43	2555.23	16.81	1729.70	11.38	825.53	5.43	2555.23	16.81
Surfactants	4.41	0.03	5.17	0.03	9.58	0.06	5.82	0.04	5.17	0.03	10.99	0.07	7.23	0.05	5.17	0.03	12.41	0.08

Notes-
Base flow loads estimated by Ecology method.
LB – Pounds.
ND – Not detected. Analyte not detected in any samples from period so no load calculated.
* - Area used for load calculation is basin area draining to MS4 (152.0 acres), not total basin area.

Table 2.9.3. Load Estimation – Industrial Site (I1) Stormwater

Analyte Name	Wet Period Storm Load (LB)	Wet Period Storm Load by Area* (LB/acre)	Dry Period Storm Load (LB)	Dry Period Storm Load by Area* (LB/acre)	Annual Storm Load (LB)	Annual Storm Load by Area* (LB/acre)	Wet Period Storm Load (LB)	Wet Period Storm Load by Area* (LB/acre)	Dry Period Storm Load (LB)	Dry Period Storm Load by Area* (LB/acre)	Annual Storm Load (LB)	Annual Storm Load by Area* (LB/acre)	Wet Period Storm Load (LB)	Wet Period Storm Load by Area* (LB/acre)	Dry Period Storm Load (LB)	Dry Period Storm Load by Area* (LB/acre)	Annual Storm Load (LB)	Annual Storm Load by Area* (LB/acre)
Substitution Factor for Non-Detects	**0.0 x Reporting Limit**						**0.5 x Reporting Limit**						**1.0 x Reporting Limit**					
Petroleum Hydrocarbons																		
Diesel Range Hydrocarbons	97.44	0.71	22.50	0.16	119.94	0.87	97.44	0.71	22.50	0.16	119.94	0.87	97.44	0.71	22.50	0.16	119.94	0.87
Gasoline Range Hydrocarbons	1.72	0.01	0.00	0.00	1.72	0.01	22.50	0.16	2.93	0.02	25.43	0.19	43.28	0.32	5.85	0.04	49.13	0.36
Nutrients																		
Nitrate + Nitrite	50.56	0.37	9.42	0.07	59.98	0.44	50.56	0.37	9.42	0.07	59.98	0.44	50.56	0.37	9.42	0.07	59.98	0.44
Nitrogen, Total Kjeldahl	158.36	1.15	33.91	0.25	192.27	1.40	158.36	1.15	33.91	0.25	192.27	1.40	158.36	1.15	33.91	0.25	192.27	1.40
Ortho-phosphate	11.57	0.08	0.57	0.004	12.13	0.09	11.57	0.08	0.57	0.004	12.13	0.09	11.57	0.08	0.57	0.00	12.13	0.09
Phosphorus, Total	39.24	0.29	7.29	0.05	46.53	0.34	39.24	0.29	7.29	0.05	46.53	0.34	39.24	0.29	7.29	0.05	46.53	0.34
Semivolatile Organics																		
1-Methylnaphthalene	0.004	0.00003	0.00	0.00	0.004	0.00003	0.01	0.0001	0.001	0.00001	0.01	0.0001	0.02	0.0001	0.002	0.00002	0.02	0.0002
2-Methylnaphthalene	0.01	0.00004	0.00	0.00	0.01	0.00004	0.01	0.0001	0.001	0.00001	0.01	0.0001	0.02	0.0002	0.002	0.00002	0.02	0.0002
Acenaphthene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acenaphthylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(a)anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(a)pyrene	0.001	0.00001	0.001	0.00001	0.002	0.00002	0.01	0.0001	0.002	0.00001	0.01	0.0001	0.02	0.0001	0.002	0.00002	0.02	0.0001
Benzo(g,h,i)perylene	0.003	0.00002	0.001	0.00001	0.005	0.00003	0.01	0.0001	0.002	0.00001	0.01	0.0001	0.02	0.0001	0.002	0.00002	0.02	0.0001
Butylbenzylphthalate	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chlorpyrifos	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chrysene	0.004	0.00003	0.002	0.00001	0.01	0.00004	0.01	0.0001	0.002	0.00002	0.01	0.0001	0.02	0.0001	0.003	0.00002	0.02	0.0001
Di-n-Butylphthalate	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Di-n-Octyl phthalate	0.02	0.0002	0.03	0.0002	0.05	0.0004	0.10	0.001	0.03	0.0002	0.13	0.001	0.18	0.001	0.04	0.0003	0.22	0.002
Diazinon	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibenz(a,h)anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibenzofuran	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dichlobenil	0.02	0.0002	0.0005	0.000003	0.02	0.0002	0.02	0.0002	0.001	0.000004	0.02	0.0002	0.02	0.0002	0.001	0.00001	0.02	0.0002
Diethylphthalate	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dimethylphthalate	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Fluoranthene	0.01	0.0001	0.002	0.00002	0.02	0.0001	0.02	0.0001	0.003	0.00002	0.02	0.0001	0.02	0.0001	0.004	0.00003	0.02	0.0002
Fluorene	0.001	0.00001	0.00	0.00	0.001	0.00001	0.01	0.0001	0.001	0.00001	0.01	0.0001	0.02	0.0001	0.002	0.00002	0.02	0.0001
Indeno(1,2,3-cd)pyrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Analyte Name	Wet Period Storm Load (LB)	Wet Period Storm Load by Area* (LB/acre)	Dry Period Storm Load (LB)	Dry Period Storm Load by Area* (LB/acre)	Annual Storm Load (LB)	Annual Storm Load by Area* (LB/acre)	Wet Period Storm Load (LB)	Wet Period Storm Load by Area* (LB/acre)	Dry Period Storm Load (LB)	Dry Period Storm Load by Area* (LB/acre)	Annual Storm Load (LB)	Annual Storm Load by Area* (LB/acre)	Wet Period Storm Load (LB)	Wet Period Storm Load by Area* (LB/acre)	Dry Period Storm Load (LB)	Dry Period Storm Load by Area* (LB/acre)	Annual Storm Load (LB)	Annual Storm Load by Area* (LB/acre)
Substitution Factor for Non-Detects	**0.0 x Reporting Limit**						**0.5 x Reporting Limit**						**1.0 x Reporting Limit**					
Malathion	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Naphthalene	0.001	0.00001	0.00	0.00	0.001	0.00001	0.01	0.0001	0.001	0.00001	0.01	0.0001	0.02	0.0001	0.002	0.00002	0.02	0.0001
Pentachlorophenol	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phenanthrene	0.01	0.0001	0.001	0.00001	0.01	0.0001	0.01	0.0001	0.002	0.00002	0.01	0.0001	0.02	0.0001	0.003	0.00002	0.02	0.0001
Prometon	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Pyrene	0.02	0.0001	0.003	0.00002	0.02	0.0001	0.02	0.0001	0.003	0.00002	0.02	0.0002	0.02	0.0002	0.004	0.00003	0.03	0.0002
bis(2-Ethylhexyl)phthalate	0.26	0.002	0.05	0.0003	0.31	0.002	0.28	0.002	0.05	0.0003	0.32	0.002	0.29	0.002	0.05	0.0003	0.34	0.002
Metals																		
Cadmium, Dissolved	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cadmium, Total	0.02	0.0002	0.01	0.0001	0.03	0.0002	0.03	0.0002	0.01	0.0001	0.03	0.0003	0.03	0.0002	0.01	0.0001	0.04	0.0003
Copper, Dissolved	0.82	0.01	0.16	0.001	0.99	0.01	0.82	0.01	0.16	0.001	0.99	0.01	0.82	0.01	0.16	0.001	0.99	0.01
Copper, Total	3.19	0.02	0.82	0.006	4.01	0.03	3.19	0.02	0.82	0.01	4.01	0.03	3.19	0.02	0.82	0.01	4.01	0.03
Lead, Dissolved	0.04	0.00	0.01	0.0001	0.05	0.0004	0.04	0.0003	0.01	0.0001	0.05	0.0004	0.04	0.0003	0.01	0.0001	0.05	0.0004
Lead, Total	1.44	0.01	0.36	0.003	1.80	0.01	1.44	0.01	0.36	0.003	1.80	0.01	1.44	0.01	0.36	0.003	1.80	0.01
Mercury, Dissolved	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Mercury, Total	0.0001	0.000001	0.001	0.000004	0.001	0.000005	0.002	0.00001	0.001	0.000005	0.002	0.00002	0.003	0.00003	0.001	0.00001	0.004	0.00003
Zinc, Dissolved	6.51	0.05	1.11	0.008	7.61	0.06	6.51	0.05	1.11	0.01	7.61	0.06	6.51	0.05	1.11	0.01	7.61	0.06
Zinc, Total	21.63	0.16	5.57	0.041	27.20	0.20	21.63	0.16	5.57	0.04	27.20	0.20	21.63	0.16	5.57	0.04	27.20	0.20
Miscellaneous Organics																		
2,4-D	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MCPP	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Triclopyr	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Conventionals																		
Biological Oxygen Demand	790.69	5.76	212.77	1.55	1003.46	7.31	790.69	5.76	212.77	1.55	1003.46	7.31	790.69	5.76	212.77	1.55	1003.46	7.31
Chloride	1173.60	8.55	56.97	0.42	1230.57	8.97	1173.60	8.55	56.97	0.42	1230.57	8.97	1173.60	8.55	56.97	0.42	1230.57	8.97
Solids, Total Suspended	10406.00	75.85	2895.50	21.10	13301.50	96.95	10406.00	75.85	2895.50	21.10	13301.50	96.95	10406.00	75.85	2895.50	21.10	13301.50	96.95
Surfactants	10.50	0.08	4.16	0.03	14.66	0.11	11.14	0.08	4.16	0.03	15.30	0.11	11.78	0.09	4.16	0.03	15.94	0.12

Notes:
Loads estimated by QAPP method.
LB – pounds.
ND - Not detected. Analyte not detected in any samples from period so no load calculated.
* - Area used for load calculation is basin area draining to MS4 (137.2 acres), not total basin area.

2.10 QA/QC Results

Refer to Appendix C.1 for the full QA/QC report.

2.11 SWMP Activities

The City's Stormwater Management Program (SWMP) Activities are described in Attachment A of the 2012 NPDES Annual Report. The City applies all of the activities in the SWMP throughout the areas of the City that are served by the MS4, which includes the R1, C1 and I1 monitoring station drainage basins.

2.12 Summary of Stormwater Characterization Monitoring

The City was successful in meeting Permit sampling goals in Section S8.D for WY2012 which was the third and final year of stormwater characterization monitoring required to be performed under the 2007 Permit. The required number of routine stormwater events was captured with all events meeting all weather and sampling criteria. Continuous flow and rain data were collected for all sites.

Stormwater chemistry data were screened as they were received from the analytical laboratory looking for outliers or anomalies. No follow-up investigations were initiated in WY2012.

2.13 Acknowledgements

Stormwater sampling is very challenging environmental monitoring work due to, among other factors: the difficulties of forecasting weather and targeting storms; operating and maintaining automatic sampling equipment continuously within a drainage system; working in traffic and confined spaces at irregular hours in inclement weather, etc. Data in reports such as this are presented in a matter-of-fact style which typically does not acknowledge that sampling and laboratory personnel are constantly required to rearrange their work and personal schedules to prioritize capturing stormwater samples. Once samples are collected, laboratory personnel must be available to process and preserve samples to meet holding times, and then analyze and manage large amounts of samples and data. The Permit's requirements were very ambitious regarding the large number of samples required using restrictive storm event and sample criteria. During WY2012, the City's Stormwater Characterization project team met all storm event sampling and weather criteria without exception. This was due to the hard work of many dedicated scientists who collaborated very effectively on this project.

The City of Seattle would like to acknowledge the dedication of the following staff:

CardnoTEC Inc. – field sampling staff
Bryan Berkompas (project manager)

Peter Heltzel
James Packman
Joe Hamman
Dan O'Brien
Rebecca Powell
Brian Rupert
Jon Berg
Brad Kwasnowski
Suzanne Smith
Robert Thompson
Curtis Nickerson
Carla Milesi
Brian Tornow
Ian Sahlberg
Kim Nickerson
Heidi Wachter

Analytical Resources, Inc – primary project analytical laboratory
Mark Harris (project manager) and staff

Seattle Public Utilities
Doug Hutchinson (project manager, report author)
Amy Minichillo, Lea Beard (data validators)

3 S8.E Stormwater Management Program Effectiveness

The program effectiveness monitoring component requires the City to select two specific aspects of the Stormwater Management Program to evaluate. One aspect to be evaluated is to determine the effectiveness of a targeted action. A second aspect to be evaluated is the effectiveness of achieving a targeted environmental outcome. This monitoring is intended to improve stormwater management efforts by providing a feedback loop to help determine if a stormwater management program element is meeting the desired environmental outcome.

The potential impact of urban stormwater runoff on the water quality of receiving waters is of great concern in the Seattle area. While new development and redevelopment may have a large number of options for providing water quality treatment through structural controls, existing developed areas have limited choices for retrofitting their stormwater systems. Thus, nonstructural measures, also known as source control, offer perhaps the greatest potential for improvement of water quality. Roads and other transportation related surfaces make up 26 percent of the land use within the City. Street sweeping is one of the source control tools available to meet this permit requirement and the City has recently expanded its sweeping program, with a focus on removing pollutants from roadways that discharge to the City's MS4. The City has chosen to evaluate the program effectiveness of street sweeping for water quality for both required program effectiveness aspects:

- **Targeted action** - Does street sweeping result in improvements in stormwater quality and quality of sediments in stormwater discharges or both? This aspect evaluated the effectiveness of regenerative air street sweeping technology at a frequency of every two weeks to potentially provide treatment at a level similar to structural stormwater BMPs by reducing the quarterly average street dirt pollutant load 60 percent for fine particles (less than 250 microns in diameter).
- **Targeted outcome** - Does street sweeping reduce the discharge of certain pollutants below a targeted annual load amount? This aspect was evaluated with a spreadsheet model that predicts a targeted annual load reduction, using total suspended solids as a surrogate pollutant, for varying conditions, such as sweeping frequency, sweeping velocity, and parking enforcement compliance.

The program effectiveness study was completed in WY2011 and two deliverables were submitted to satisfy the Permit requirements for Section S8.E: 1) the targeted action work is documented in a report titled "Program Effectiveness Report - Sweet Sweeping for Water

Quality" dated March 2012 and submitted concurrent with the WY2011 annual report; and 2) the targeted outcome work's deliverable was a spreadsheet model named "Sweeping to Reduce Contaminants" (STORC) which was submitted to Ecology on compact disc on May 30, 2012.

4 S8.F Stormwater Treatment and Hydrologic Management BMP Evaluation

4.1 Overview

The Permit requires full scale field monitoring to evaluate the effectiveness and operation and maintenance requirements of stormwater treatment and hydrologic management best management practice (BMPs) applied in Permittee's jurisdiction. Specifically, the Permit requires that each Phase I Permittee select two treatment types that are standard technologies in their stormwater manuals, for detailed performance monitoring. Two BMP units per each BMP treatment type are required to be monitored. In addition, one hydrologic management (or "flow reduction") BMP is also required to be monitored.

4.1.1 Treatment BMP Number One Overview

One of the two selected treatment types that the City has monitored is the Stormwater Management StormFilter® (StormFilter) manufactured by Contech Construction Products Inc. (Contech) which is a proprietary stormwater treatment BMP. The specific configuration evaluated by the City was the CatchBasin StormFilter™ (CBSF).

The CBSF is a frequently installed BMP by the Seattle Department of Transportation (SDOT) to treat roadway stormwater runoff. The City was interested in monitoring the effectiveness of this BMP because the cartridge technology has received a basic treatment General Use Level Designation (GULD) by Ecology based on testing within a vault configuration not a catch basin device.

The City's CBSF monitoring was started during WY2009 and was completed during WY2012. The complete results of this study are presented in report titled "CatchBasin StormFilter Performance Evaluation Report" dated March 5, 2012 which was submitted to Ecology concurrent with the WY2011 annual reports.

4.1.2 Treatment BMP Number Two Overview

This section presents the background and an overview of the status of the City's second BMP project; see Section 4.3 for monitoring results and discussion. The second BMP project that the

City originally proposed to monitor consisted of two bioretention swales located in the High Point redevelopment project of West Seattle. The final QAPP for the High Point bioretention swales project was submitted to Ecology on February 12, 2009. The City began implementation of monitoring the bioretention swales prior to February 2009, with the intent to collect the first water quality samples with the start of the partial water year on February 16, 2009. However, factors such as the complexity of this monitoring project coupled with concerns over the numerous assumptions and models required to make performance estimates, and the lack of transferability of findings from the project, resulted in the City changing its approach to the second BMP.

The City was still interested in evaluating the performance of bioretention systems and soils and pursued an opportunity to partner with the Washington State University (WSU) Puyallup Research and Extension Center to have WSU conduct BMP evaluation monitoring on the City's behalf by using Special Condition S8.B of the Permit. WSU, with the City of Puyallup, has constructed a Low Impact Development (LID) research center at the WSU Puyallup Research and Extension Center. The LID center contains many full-scale BMPs including bioretention cells, water gardens and porous pavements.

The City will use monitoring and results from four bioretention cells, referred to as mesocosms, to meet Special Condition S8.F.2.b for monitoring a metals/phosphorus treatment BMP. The four mesocosms are identical (essentially one primary and three replicates) and all contain a 60/40 mix of aggregate/compost. The mix and configuration of the mesocosms is similar to the City's bioretention design standard. Stormwater will flow into each mesocosm and the water quality samples and flow data will be collected at the influent and effluent of each mesocosm to calculate pollutant reduction.

The City notified Ecology of its plan to replace the High Point BMP project with the WSU collaboration verbally and followed with a letter dated September 15, 2009. Ecology gave the City approval to proceed with this plan. The City signed a Memorandum of Agreement (MOA) with WSU on November 12, 2009. The MOA and related addendum are included in Appendix C.3. The WSU mesocosm QAPP was completed in September 2010 and Ecology approved the QAPP in a letter dated October 27, 2010. Construction of the research facility was completed in the fall of 2010 and the monitoring started in the fall of 2011.

After collecting samples from two events in November 2011 (presented later in this report), WSU determined that the influent concentration of the natural stormwater flowing off the contributing area was too low for a meaningful evaluation of the performance of the bioretention mixes. WSU decided to temporarily suspend the agreed monitoring under the City-WSU MOA and chose to focus on research and testing to generate higher concentration synthetic stormwater that would be used for the duration of the study. WSU verbally informed Ecology and SPU representatives of these WSU decisions and delays, and Ecology and SPU provided substantial feedback to WSU on target synthetic stormwater concentrations and application procedures.

Concurrent with its research on generating synthetic stormwater, WSU began revising the original City-WSU QAPP to document the revised monitoring approach using synthetic stormwater and pumped flows. The final QAPP was updated to reflect current monitoring practices after monitoring began in November 2011. A draft of the updated QAPP was distributed to Ecology in June 2012 for review and comment. Ecology's comments were incorporated into the updated final QAPP which is dated July 2012. SPU provided a written update to Ecology of the status of the WSU monitoring and QAPP revision in a letter dated August 20, 2012.

A summary of information provided in the QAPP and the results of the WY2012 monitoring are presented in Section 4.3 below.

4.1.3 Hydrologic Management BMP Overview

The Permit requires the City to monitor a flow reduction strategy that is in use in the city or planned for installation within the city in a paired study or against a predicted outcome. To meet this requirement, the City has monitored one bioretention swale located in the High Point community in West Seattle. Flow was monitored in the swale continuously for two years and the results were reported in the WY2009 annual report.

4.2 CatchBasin StormFilter™ Monitoring (Treatment BMP One)

The CatchBasin StormFilter monitoring work was performed from February 2009 through September 2011. The performance of the units was evaluated based on analyses of water quality, rainfall and flow data. A total of 37 stormwater events were sampled between both of the monitored CBSF units, which exceeded the required maximum storm event number of 35 required pursuant to the Permit. Because the maximum sample number has been achieved, this study is complete and SPU has fulfilled its monitoring obligation pursuant to Permit.

The complete results of this study, which spanned three water years, are presented in report titled "CatchBasin StormFilter Performance Evaluation Report" dated March 5, 2012 and submitted to Ecology concurrent with the WY2011 annual reports.

4.3 WSU Mesocosm Monitoring (Treatment BMP Two)

The City and Washington State University (WSU) have partnered to study bioretention soil mixes as the second stormwater treatment BMP that the City will monitor to meet Permit requirements. The location of Washington State University (WSU) Puyallup Research and Extension Center which houses the LID Research Center (labeled "Project site" on the figure) is shown on Figure 4.3. During WY2012, WSU began monitoring the bioretention mesocosms. The initial results of the monitoring led to additional research and laboratory- and field-scale testing which in turn led WSU to revise the project QAPP. The updated, final QAPP was approved by Ecology is dated September 2012. The following summarizes the monitoring plan detailed in the QAPP.

Figure 4.3. Vicinity Map – WSU LID Research Center

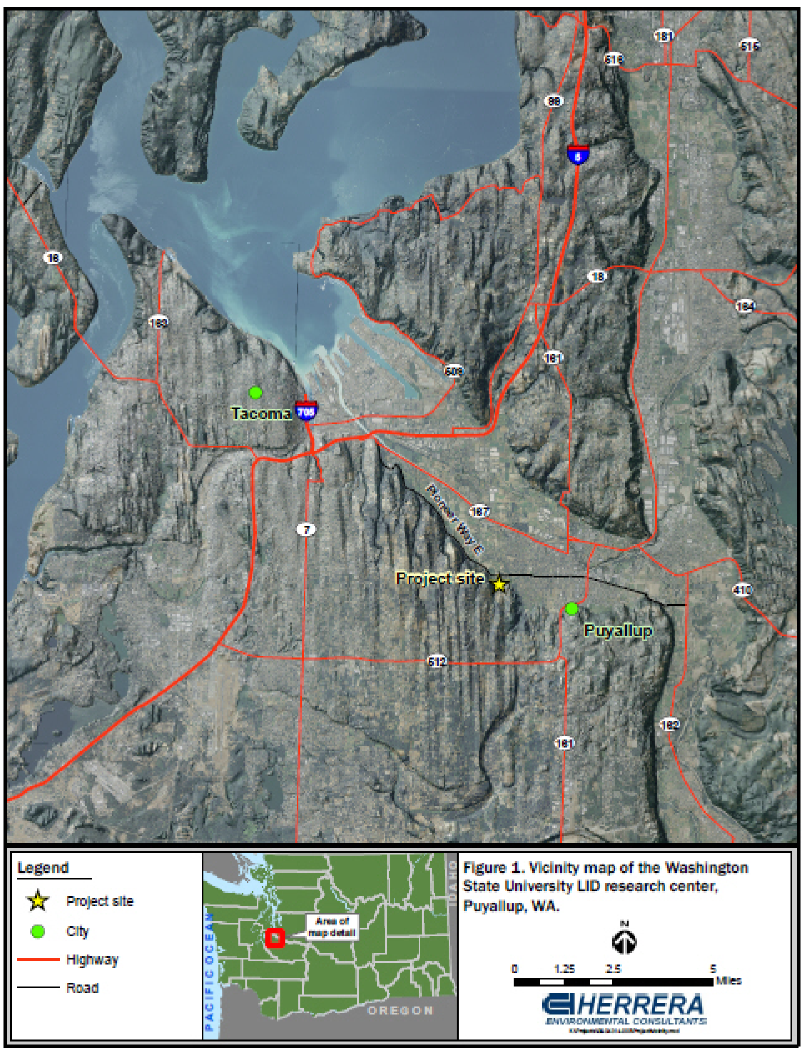
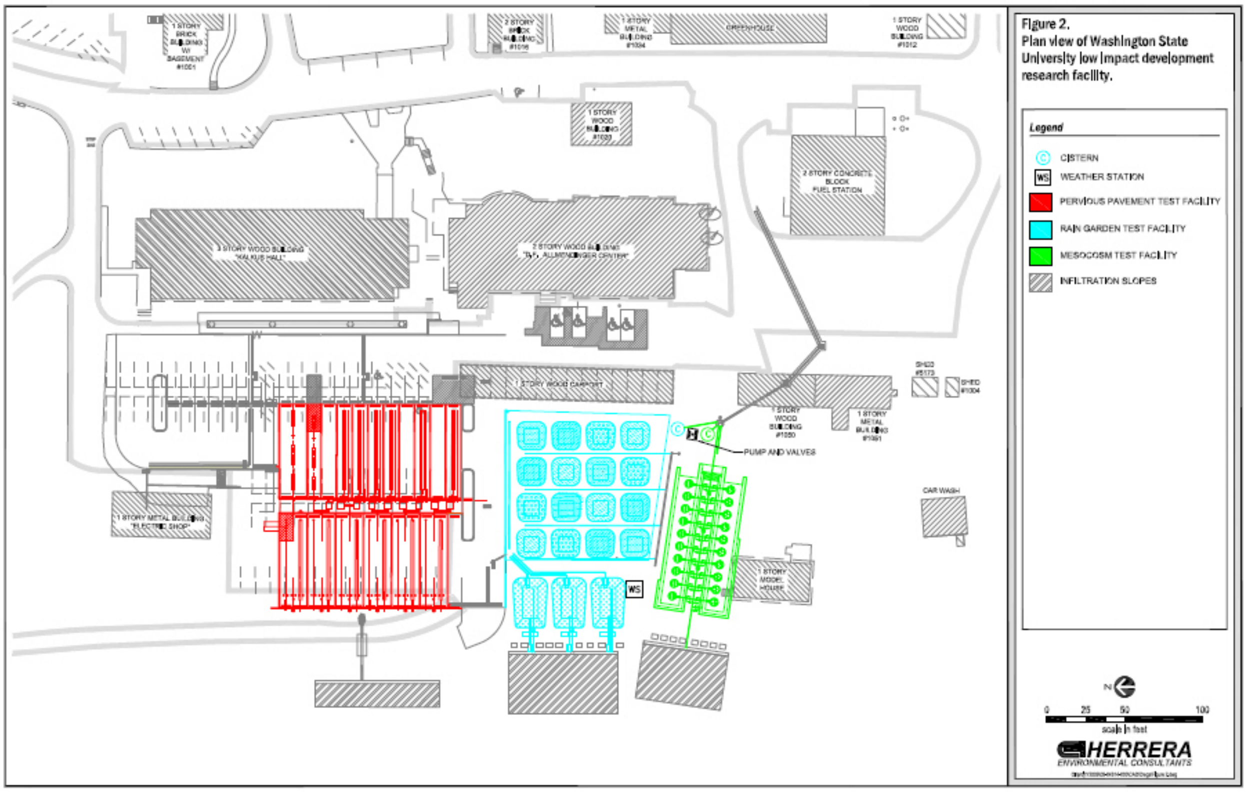


Figure 1. Vicinity map of the Washington State University LID research center, Puyallup, WA.

4.3.1 WSU Mesocosm Facility Summary

The LID research center contains many full-scale, structural stormwater BMPs including bioretention cells, water gardens and porous pavements. Figure 4.3.1a displays the plan view of the entire LID research center, which includes the mesocosms (shown in green) along with other LID elements not studied by the City.

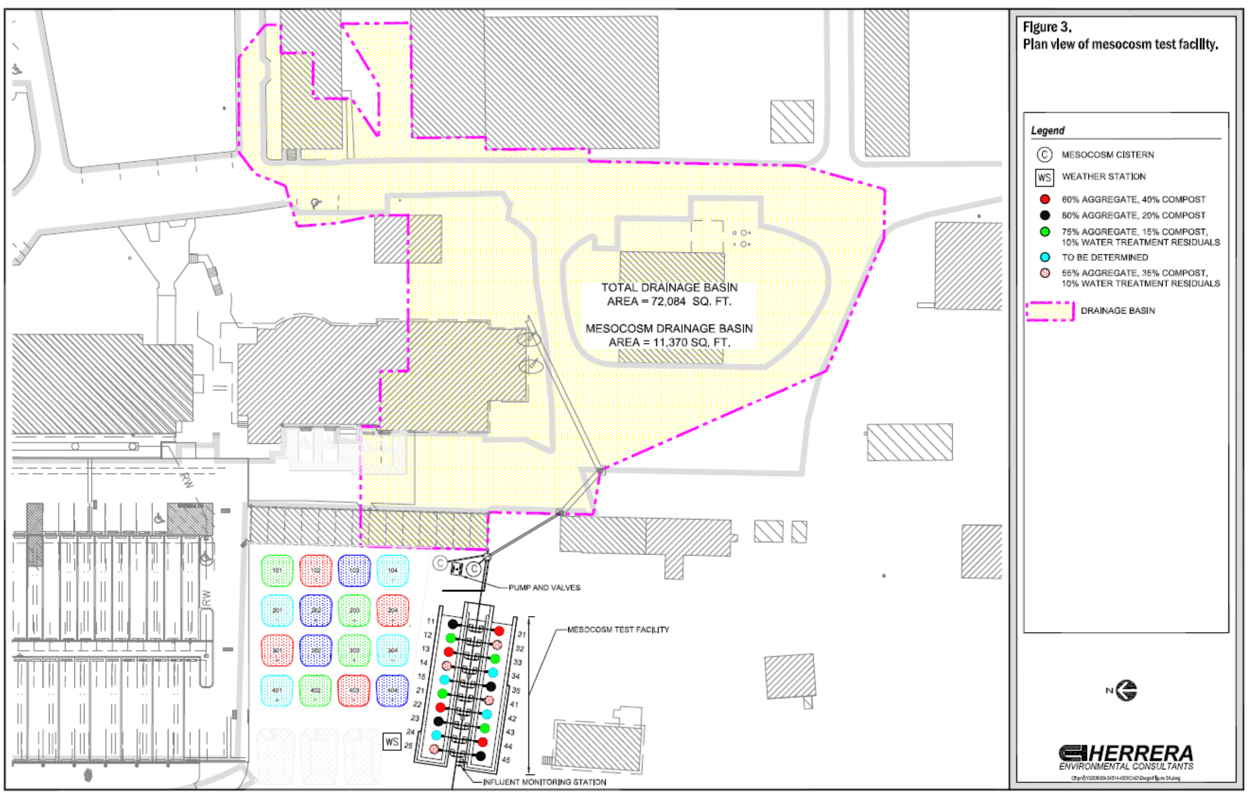
Figure 4.3.1a. Site Map – WSU LID Research Center



The City is analyzing data from a subset (four) of the twenty bioretention cells, referred to as mesocosms, to evaluate bioretention soil mixes as metals/phosphorus treatment BMPs. The four mesocosms of the City's study are identical (essentially one primary and three replicates) and all contain a soil mixture of 60 percent aggregate and 40 percent compost (approximately 8 percent organic matter by weight). The mix, configuration and sizing of the mesocosms are similar to the bioretention design standard in the City's stormwater code. The monitoring plan for this subset of mesocosms conforms to requirements in the Permit and is very similar the plan used for Treatment BMP Number One.

Runoff from an 18,021 square foot (SF) mesocosm drainage area is routed via gravity flow to all 20 mesocosms and one influent monitoring station. The runoff is first routed to an 11,370 liter (L) (3,000 gallon) cistern for storage and even delivery to each mesocosm. During WY2012, stormwater from the cistern was routed via gravity flow only to the mesocosms to assess treatment performance during “natural” storms. (Alternatively, for “synthetic storms” targeted for future water years, stormwater can also be pumped from the cistern). The cistern’s location on the campus and associated drainage area are shown in Figure 4.3.1b. Weir boxes constructed at the water surface elevation inside the cistern distribute flows evenly to each mesocosm, with one distribution line bypassing the mesocosms and terminating at a separate Influent Monitoring Station (IMS). The four 60 percent aggregate/40 percent compost mesocosms monitored for the City are colored red in the below figure and are numbered: 13, 22, 31 and 44. The 16 other mesocosms will also be monitored by WSU but not funded nor reported on by the City. Influent flows and chemistry for all the mesocosms will be generalized based on data collected at the IMS.

Figure 4.3.1b. WSU Mesocosm Drainage Area



The cistern is kept full of stormwater between sampled storm events. Therefore, any stormwater that enters the cistern from the associated drainage basin will flow directly to the mesocosms and Influent Monitoring Station via gravity without attenuation. Eductors (jet pump ejectors) installed inside the cistern are activated during sampled storm events to attempt to keep particulate bound pollutants from settling out in the cistern prior to reaching the mesocosms. The eductors were installed to minimize pretreatment that might occur in the cistern from solids settling.

Figure 4.3.1c is a photograph showing the empty cistern and weir boxes in the foreground. In the background are the 20 mesocosm tanks prior to the addition of the bioretention soil mixes.

Figure 4.3.1c. Photograph of Cistern and Mesocosm Tanks

Each mesocosm is constructed with a 152.4 centimeter (cm) (60 inches) diameter by 132 cm (52 inches) deep media tank to hold the bioretention soil mix. The bottom of each media tank is filled with coarse sand to a depth of 30.5 cm (12 inches) thick. Next, 61 cm (24 inches) of the bioretention soil mix was placed over the sand layer and hand packed before water is introduced to the system. A slotted under drain pipe within the sand layer serves as the drain for the mesocosm. Flow enters the tanks through a manifold constructed of plastic piping perforated with drilled holes that distributes water across the surface of the bioretention soil mix. Figure

4.3.1d shows the mesocosm tanks filled with bioretention soil mixes with the manifold suspended on the surface of the mix.

Figure 4.3.1d. Photograph of Mesocosms filled with Bioretention Mix

Each mesocosm has a surface area of 19.63 SF. Given flows from the impervious drainage area will be distributed equally to the 20 mesocosms and the IMS, the ratio of contributing basin area to surface area for the mesocosm is 2.3 percent ([19.63 SF × 21]/18,021 SF = 0.023 = 2.3 percent). For reference, SPU sizing criteria for water quality treatment using bioretention require the bottom area of the treatment system to represent 2.6 percent of the contributing area for 6 inches of ponding, and 2.0 percent of the contributing area for 12 inches of ponding. Pursuant to SPU design criteria, the maximum ponding depth for bioretention cells is 12 inches and in high density right-of-way applications the ponding depth shall be no greater than 6 inches. In general, these data indicate the mesocosms are appropriately sized for assessing the performance of systems that were constructed to meet SPU's sizing criteria for water quality treatment (larger sizing is required for facilities used for flow control).

4.3.2 Monitoring Design Summary

A Hydrological Services TB1-L tipping bucket flow gauge is installed at the IMS. The tipping bucket flow gauge is connected to a Campbell Scientific CR1000 data logger. The data logger measures each tip of the flow gauge bucket mechanism and converts the signal to a volume estimate. The volume estimates are totalized over a 5-minute logging interval, converted to an estimate of discharge for that period. The stored data are automatically downloaded on a daily basis via radio telemetry to a central server located in an adjacent campus building. The discharge data collected from the IMS is used to estimate influent discharge rates to all of the mesocosms.

Effluent discharge rates are measured at the point of discharge for each mesocosm's outlet flow control structure. Flow from each outlet flow control structure is routed into a separate Hydrological Services TB1-L tipping bucket flow gauge for each mesocosm. These flow gauges are connected to the same Campbell Scientific CR1000 datalogger described above. The discharge measurements from these flow gauges are stored and downloaded using procedures described above for the Influent Monitoring Station.

A weather station with two tipping bucket rain gauges is used to continuously monitor precipitation at the monitoring site. These data are used to delineate qualifying events for sampling and to assess mesocosm hydrologic performance relative to precipitation depth, duration, peak intensity and average intensity.

The automated sampler intake for the IMS is located just upstream of the station's tipping bucket flow gauge. The automated sampler intake for each mesocosm outlet is located immediately upstream of the tipping bucket flow gauges. In both cases, the sampler intakes are positioned to ensure the homogeneity and representativeness of the collected samples. Specifically, sampler intakes are installed to make sure adequate depth is available for sampling, and to avoid capture of litter, debris, gross solids, or floatables that might be present towards the bottom or top of flow stream.

Storm criteria and sampling goals are presented in the following table:

Table 4.3.1. Qualifying Event Criteria

Criteria	Requirements
Target storm depth	A minimum of 0.15 inches (3.81 millimeters) of precipitation over a 24-hour period
Rainfall duration	Target storms must have a duration of at least one hour
Antecedent dry period	A period of at least 6 hours preceding the event with less than 0.04 inches (1.02 millimeters) of precipitation.
Storm capture coverage	75 percent (for storms longer than 24 hours, 75 percent of first 24 hours)
End of storm	A continuous 6-hour period with less than 0.04 inches (1.02 millimeters) of precipitation.

Stormwater monitoring activities will occur in two phases: Phase 1 and Phase 2. Phase 1 monitoring (covered in this report) involves quantifying the treatment performance of the mesocosms using stormwater that is generated during natural storms and routed by gravity to the individual mesocosms via the cistern. Phase 2 will involve quantifying treatment performance of the mesocosms using synthetic stormwater that is mixed in the cistern to augment existing stormwater and pumped into the mesocosms. During WY2012, only Phase 1 monitoring was performed.

4.3.3 Initial Monitoring Results

Phase 1 monitoring for the four City-funded mesocosms was initiated in November 2011 with two events (starting on November 2, and November 16, 2011, respectively) sampled across these four mesocosms

All sampling activities were performed by WSU staff. All stormwater sample chemical analyses were performed by Analytical Resources, Inc. (ARI) in Tukwila, WA. The results presented below were taken from a report authored by WSU for the City titled "Bioretention Facility Stormwater Monitoring MOA DA 2009-39, Interim Monitoring Report 2012," dated December 10, 2012. The figures and tables presented below were copied directly from this report. Where applicable, sample IDs and formatting were streamlined and text was edited for clarity.

The following example presents the station and sample nomenclature employed by WSU:

Station 5-13EC2011

Year

"Error Corrected" data

Mesocosm Number

Mesocosm array

The four mesocosms monitored on behalf of the City are numbered 13, 22, 31 and 44 and the Influent Monitoring Station is identified as "MIC" (for "Mesocosm Influent Control"). Sample results and hydrologic data are presented for each event below. A general discussion of the results and next steps follows.

4.3.3.1 November 2, 2011 Event Results

The first event sampled a storm that occurred over November 2–3, 2011. The first figure below presents hydrographs from the event with upper graph displaying flow measured at the effluent of the four mesocosms and the lower graph displaying flow entering the Influent Monitoring Station (labeled "Station5- MIC" on the lower graph).

Figure 4.3.3.1. November 2, 2011 Event Hydrographs

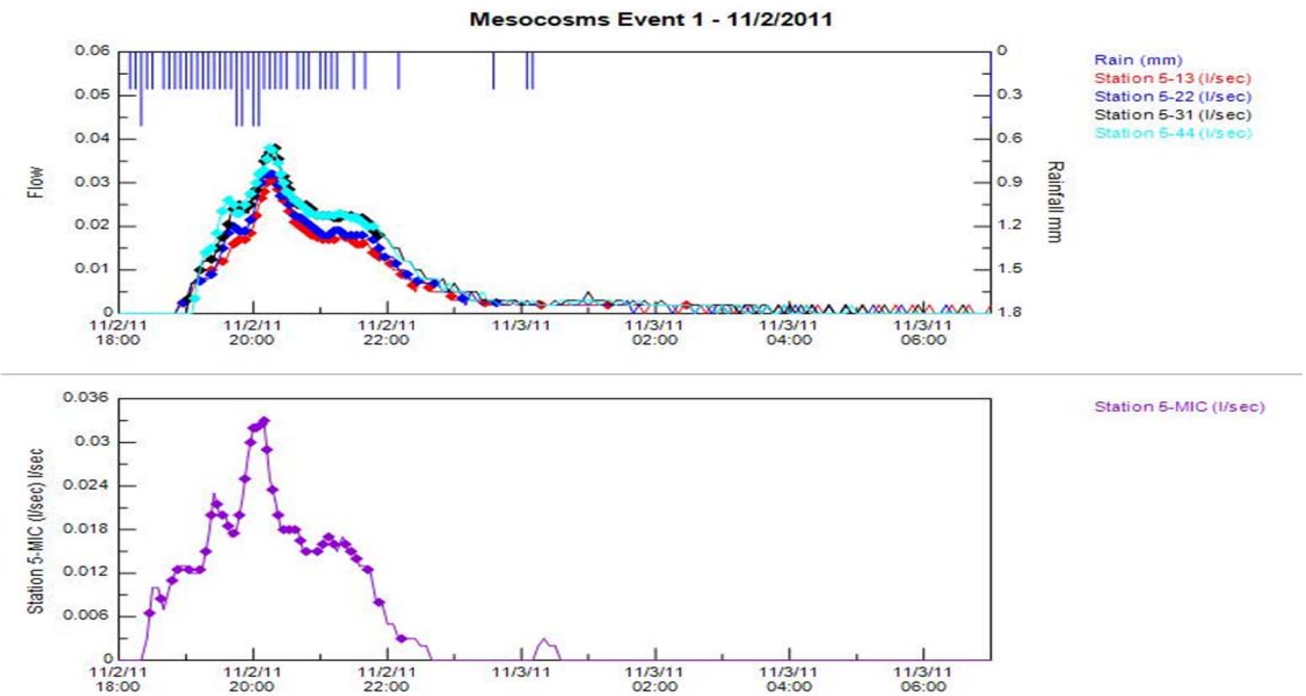


Table 4.3.3.1a. November 2, 2011 Event Hydrologic Summary

11-2-11 Sampling Event								
Rainfall Statistics			Flow/Sample Statistics					
Start	11/2/2011 18:10		Station	Station 5-13	Station 5-22	Station 5-31	Station 5-44	Station 5-MIC
Stop	11/3/2011 0:10		Start	11/2/2011 18:55	11/2/2011 18:55	11/2/2011 19:05	11/2/2011 19:10	11/2/2011 18:25
Duration (hrs)	6		Stop	11/3/2011 6:10	11/3/2011 6:10	11/3/2011 6:10	11/3/2011 5:00	11/3/2011 6:10
Depth (mm)	11.684		Duration (hrs)	9.08	8.75	9.25	8.33	4.58
Avg Intensity (mm/hr)	1.947		Avg (l/sec)	0.008	0.009	0.01	0.011	0.013
Max Reading (mm)	0.508		Max (l/sec)	0.032	0.032	0.038	0.038	0.033
Antecedent Dry Period (hrs)	59.42		Volume (liters)	249.6	270.3	327.3	319.8	222.3
			Aliquots	40	40	39	39	37
			First Aliquot	11/2/2011 18:57	11/2/2011 18:57	11/2/2011 19:12	11/2/2011 19:17	11/2/2011 18:27
			Last Aliquot	11/3/2011 2:27	11/2/2011 23:37	11/2/2011 21:52	11/2/2011 21:47	11/2/2011 22:12
			Duration (hrs)	7.5	4.7	2.7	2.5	3.8
			Pacing	5	5	5	5	5
			Sampled Volume (liters)	236.6999969	239.25	229.1999969	224.8500061	213.75
			% Coverage	94.83	88.51	70.03	70.31	96.15

The following tables present the analytical water quality from the November 2, 2011 event. The first table presents a summary of all analytes with a general statistical summary and the remaining tables present a summary by analyte (excluding pH and hardness).

Table 4.3.3.1b. November 2, 2011 Analytical Summary – All Analytes

Analyte	Units	Influent Concentration	Effluent Concentrations					Percent Removal*
			n	Min	Max	Mean	Median	
pH	std units	6.92	4	6.82	6.92	6.66	6.89	0.4
Total Suspend Solids	mg/L	5.7	4	4.3	7.9	5.75	5.4	5.3
Hardness	mg/L as CaCO	9.3	4	54	69	60.75	60	-545.2
Total Phosphorus	mg/L	0.063	4	0.358	0.408	0.374	0.364	-477.8
Ortho-phosphorus	mg/L	0.027	4	0.267	0.312	0.287	0.2845	-953.7
Total Copper	*ug/L*	*4.8 R*	*4*	*12.2 R*	*15.7 R*	*13.9 R*	*13.9 R*	*-189.6*
Dissolved Copper	*ug/L*	*2.3 R*	*4*	*8.6 R*	*11 R*	*9.8 R*	*9.8 R*	*-326.1*
Total Zinc	*ug/L*	*99 R*	*4*	*5 R*	*6 R*	*5.75 R*	*6 R*	*93.9*
Dissolved Zinc	*ug/L*	*49 R*	*4*	*4 R*	*6 R*	*4.5 R*	*4 R*	*91.8*

Notes: * Percent removal determined from median effluent value.
Italicized text – metal data rejected (flagged R), included for reference only.

Table 4.3.3.1c November 2, 2011 Analytical Summary – Total Suspended Solids

WSU Sample ID	Mesocosm No.	Units	Data Qualifier	Influent Concentration	Effluent Concentration	Percent Removal
LM11-02-0075	13	mg/L		5.7	4.3	24.6
LM11-02-0076	22	mg/L		5.7	7.9	-38.6
LM11-02-0077	31	mg/L		5.7	4.6	19.3
LM11-02-0078	44	mg/L		5.7	6.2	-8.8

Table 4.3.3.1d. November 2, 2011 Analytical Summary – Total Phosphorus

WSU Sample ID	Mesocosm No.	Units	Data Qualifier	Influent Concentration	Effluent Concentration	Percent Removal
LM11-02-0075	13	mg/L		0.063	0.358	-468.3
LM11-02-0076	22	mg/L		0.063	0.364	-477.8
LM11-02-0077	31	mg/L		0.063	0.364	-477.8
LM11-02-0078	44	mg/L		0.063	0.408	-547.6

Table 4.3.3.1e. November 2, 2011 Analytical Summary – Ortho-Phosphorus

WSU Sample ID	Mesocosm No.	Units	Data Qualifier	Influent Concentration	Effluent Concentration	Percent Removal
LM11-02-0075	13	mg/L		0.027	0.267	-889.0
LM11-02-0076	22	mg/L		0.027	0.29	-974.1
LM11-02-0077	31	mg/L		0.027	0.279	-933.3
LM11-02-0078	44	mg/L		0.027	0.312	-1055.6

Table 4.3.3.1f. November 2, 2011 Analytical Summary – Total Copper

WSU Sample ID	Mesocosm No.	Units	Data Qualifier	Influent Concentration	Effluent Concentration	Percent Removal
LM11-02-0075	13	ug/L	R	4.8	14.3	-197.9
LM11-02-0076	22	ug/L	R	4.8	13.4	-179.1
LM11-02-0077	31	ug/L	R	4.8	15.7	-227.0
LM11-02-0078	44	ug/L	R	4.8	12.2	-154.1

Table 4.3.3.1h. November 2, 2011 Analytical Summary – Dissolved Copper

WSU Sample ID	Mesocosm No.	Units	Data Qualifier	Influent Concentration	Effluent Concentration	Percent Removal
LM11-02-0075	13	ug/L	R	2.3	11	-378.2
LM11-02-0076	22	ug/L	R	2.3	9.4	-308.7
LM11-02-0077	31	ug/L	R	2.3	10.2	-343.4
LM11-02-0078	44	ug/L	R	2.3	8.6	-273.9

Table 4.3.3.1i. November 2, 2011 Analytical Summary – Total Zinc

WSU Sample ID	Mesocosm No.	Units	Data Qualifier	Influent Concentration	Effluent Concentration	Percent Removal
LM11-02-0075	13	ug/L	R	99	5	95.0
LM11-02-0076	22	ug/L	R	99	6	93.9
LM11-02-0077	31	ug/L	R	99	6	93.9
LM11-02-0078	44	ug/L	R	99	6	93.9

Table 4.3.3.1j. November 2, 2011 Analytical Summary – Dissolved Zinc

WSU Sample ID	Mesocosm No.	Units	Data Qualifier	Influent Concentration	Effluent Concentration	Percent Removal
LM11-02-0075	13	ug/L	UR	49	6	87.8
LM11-02-0076	22	ug/L	UR	49	4	91.8
LM11-02-0077	31	ug/L	UR	49	4	91.8
LM11-02-0078	44	ug/L	UR	49	4	91.8

Data Qualifiers: R – Result value was rejected and should not be used in analyses.
UR – Analyte was not detected above reporting limit but result value was rejected.

Table 4.3.3.1k. November 2, 2011 Analytical Summary – Particle Size Distribution

Concentration in each size fraction (mg/L)

Size Range (microns)	>500	500-250	250-125	125-62.5	62.5-3.9	3.9-1	<1
LM11-02-0075 (meso13)	0.2	0.2	0.0	0.0	0.0	1.7	6.7
LM11-02-0076 (meso22)	0.2	0.5	0.0	0.0	0.0	3.1	10.6
LM11-02-0077 (meso31)	0.2	0.4	0.0	0.0	0.0	3.0	12.5
LM11-02-0078 (meso44)	0.0	0.2	0.0	0.0	0.0	5.2	10.7
LM11-02-0079 (IMS)	0.0	0.2	0.0	0.0	5.2	1.6	0.7

Volume percent retained in each size fraction

Size Range (microns)	>500	500-250	250-125	125-62.5	62.5-3.9	3.9-1	<1
LM11-02-0075 (meso13)	2.4	2.4	0.0	0.0	0.0	19.3	75.9
LM11-02-0076 (meso22)	1.5	3.7	0.0	0.0	0.0	21.4	73.4
LM11-02-0077 (meso31)	1.3	2.6	0.0	0.0	0.0	18.5	77.5
LM11-02-0078 (meso44)	0.0	1.3	0.0	0.0	0.0	32.4	66.3
LM11-02-0079 (IMS)	0.0	2.7	0.0	0.0	67.6	20.1	9.5

4.3.3.2 November 16, 2011 Event Results

The second event sampled a storm that occurred on November 16, 2011. The following figures present hydrographs from the event with upper graph displaying flow measured at the effluent of the four mesocosms and the lower graph displaying flow entering the Influent Monitoring Station (labeled “Station5- MICE2011” on the lower graph).

Figure 4.3.3.2. November 16, 2011 Event Hydrographs

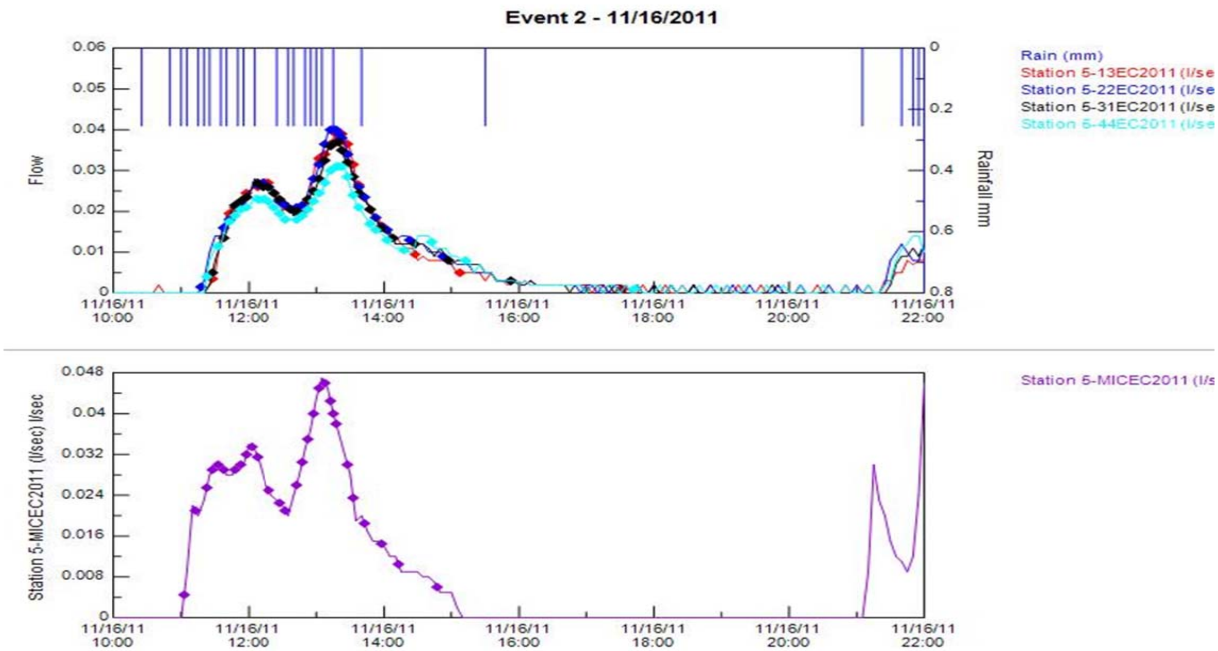


Table 4.3.3.2a. November 16, 2011 Event Hydrologic Summary

11-16-11 Sampling Event								
Rainfall Statistics			Flow/Sample Statistics					
Start	11/16/2011 10:25		Station	Station 5-13EC2011	Station 5-22EC2011	Station 5-31EC2011	Station 5-44EC2011	Station 5-MICEC2011
Stop	11/16/2011 15:30		Start	11/16/2011 10:40	11/16/2011 11:20	11/16/2011 11:25	11/16/2011 11:25	11/16/2011 11:05
Duration (hrs)	5.08		Stop	11/16/2011 20:55	11/16/2011 21:05	11/16/2011 19:50	11/16/2011 20:55	11/16/2011 15:10
Depth (mm)	5.588		Duration (hrs)	7.17	6.92	6.25	7.08	4.08
Avg Intensity (mm/hr)	1.099		Avg (l/sec)	0.012	0.012	0.013	0.011	0.022
Max Reading (mm)	0.254		Max (l/sec)	0.04	0.041	0.037	0.031	0.047
Antecedent Dry Period (hrs)	58		Volume (liters)	297.6	309.3	291.6	273.9	324.9
			Aliquots	24	26	29	31	28
			First Aliquot	11/16/2011 11:27	11/16/2011 11:37	11/16/2011 11:27	11/16/2011 11:32	11/16/2011 11:12
			Last Aliquot	11/16/2011 17:32	11/16/2011 15:52	11/16/2011 15:52	11/16/2011 17:42	11/16/2011 14:47
			Duration (hrs)	6.1	4.2	4.4	6.2	3.6
			Pacing	11	10	9	8	11
			Sampled Volume (liters)	287.8500061	277.3500061	277.0499878	258.8999939	308.25
			% Coverage	96.72	89.67	95.01	94.52	94.88

The following tables present the analytical water quality from the November 16, 2011 event. The first table presents a summary of all analytes with a general statistical summary and the remaining tables present a summary by analyte (excluding pH and hardness).

Table 4.3.3.2b. November 16, 2011 Analytical Summary – All Analytes

Analyte	Units	Influent Concentration	Effluent Concentrations n	Min	Max	Mean	Median	Percent Removal *
pH	std units	6.69	4	6.84	6.91	6.88	6.88	-2.8
Total Suspended Solids	mg/L	4.50	4	4.1	5.8	5.125	5.3	-17.8
Hardness	mg/L as CaCO	12.00	4	43	54	49.75	51	-325.0
Total Phosphorus	mg/L	0.064	4	0.35	0.452	0.391	0.381	-495.3
Ortho-phosphorus	mg/L	0.021	4	0.213	0.262	0.235	0.232	-1004.8
Total Copper	*ug/L*	*7.8 R*	*4*	*9.8 R*	*13.5 R*	*11.6 R*	*11.5 R*	*-47.4*
Dissolved Copper	*ug/L*	*3.7 R*	*4*	*7.7 R*	*9 R*	*8.28 R*	*8.2 R*	*-121.6*
Total Zinc	*ug/L*	*132.0 R*	*4*	*5 R*	*7 R*	*5.75 R*	*5.5 R*	*95.8*
Dissolved Zinc	*ug/L*	*103.0 R*	*4*	*4 R*	*4 R*	*4 R*	*4 R*	*96.1*

Notes: * Percent removal determined from median effluent value.
Italicized text – metal data rejected (flagged R), included for reference only.

Table 4.3.3.1c. November 16, 2011 Analytical Summary – Total Suspended Solids

WSU Sample ID	Mesocosm No.	Units	Data Qualifier	Influent Concentration	Effluent Concentration	Percent Removal
LM11-02-0083	13	mg/L		4.5	5.8	-28.9
LM11-02-0084	22	mg/L		4.5	4.1	8.9
LM11-02-0085	31	mg/L		4.5	5.3	-17.8
LM11-02-0086	44	mg/L		4.5	5.3	-17.8

Table 4.3.3.1d. November 16, 2011 Analytical Summary – Total Phosphorus

WSU Sample ID	Mesocosm No.	Units	Data Qualifier	Influent Concentration	Effluent Concentration	Percent Removal
LM11-02-0083	13	mg/L		0.064	0.370	-478.1
LM11-02-0084	22	mg/L		0.064	0.350	-446.9
LM11-02-0085	31	mg/L		0.064	0.452	-606.3
LM11-02-0086	44	mg/L		0.064	0.392	-512.5

Table 4.3.3.1e. November 16, 2011 Analytical Summary – Ortho-Phosphorus

WSU Sample ID	Mesocosm No.	Units	Data Qualifier	Influent Concentration	Effluent Concentration	Percent Removal
LM11-02-0083	13	mg/L		0.021	0.213	-914.29
LM11-02-0084	22	mg/L		0.021	0.239	-1038.10
LM11-02-0085	31	mg/L		0.021	0.225	-971.43
LM11-02-0086	44	mg/L		0.021	0.262	-1147.62

Table 4.3.3.1f. November 16, 2011 Analytical Summary – Total Copper

WSU Sample ID	Mesocosm No.	Units	Data Qualifier	Influent Concentration	Effluent Concentration	Percent Removal
LM11-02-0083	13	ug/L	R	7.8	12.0	-53.9
LM11-02-0084	22	ug/L	R	7.8	10.9	-39.7
LM11-02-0085	31	ug/L	R	7.8	13.5	-73.1
LM11-02-0086	44	ug/L	R	7.8	9.8	-25.6

Table 4.3.3.1h. November 16, 2011 Analytical Summary – Dissolved Copper

WSU Sample ID	Mesocosm No.	Units	Data Qualifier	Influent Concentration	Effluent Concentration	Percent Removal
LM11-02-0083	13	ug/L	R	3.7	9.0	-143.2
LM11-02-0084	22	ug/L	R	3.7	7.7	-108.1
LM11-02-0085	31	ug/L	R	3.7	8.6	-132.4
LM11-02-0086	44	ug/L	R	3.7	7.8	-110.8

Table 4.3.3.1i. November 16, 2011 Analytical Summary – Total Zinc

WSU Sample ID	Mesocosm No.	Units	Data Qualifier	Influent Concentration	Effluent Concentration	Percent Removal
LM11-02-0083	13	ug/L	R	132.0	5.0	96.2
LM11-02-0084	22	ug/L	R	132.0	6.0	95.5
LM11-02-0085	31	ug/L	R	132.0	7.0	94.7
LM11-02-0086	44	ug/L	R	132.0	5.0	96.2

Table 4.3.3.1j. November 16, 2011 Analytical Summary – Dissolved Zinc

WSU Sample ID	Mesocosm No.	Units	Data Qualifier	Influent Concentration	Effluent Concentration	Percent Removal
LM11-02-0083	13	ug/L	UR	103.0	4.0	96.12
LM11-02-0084	22	ug/L	UR	103.0	4.0	96.12
LM11-02-0085	31	ug/L	UR	103.0	4.0	96.12
LM11-02-0086	44	ug/L	UR	103.0	4.0	96.12

Data Qualifiers: R – Result value was rejected and should not be used in analyses.
UR – Analyte was not detected above reporting limit but result value was rejected.

Table 4.3.3.1k. November 16, 2011 Analytical Summary – Particle Size Distribution

Concentration in each size fraction (mg/L)

Size Range (microns)	>500	500-250	250-125	125-62.5	62.5-3.9	3.9-1	<1
LM11-02-0083 (meso13)	0.0	0.0	0.0	0.0	0.0	4.3	7.6
LM11-02-0084 (meso22)	0.0	0.0	0.0	0.0	0.0	2.5	4.5
LM11-02-0085 (meso31)	0.0	0.5	0.0	0.0	0.0	3.4	6.7
LM11-02-0086 (meso44)	0.0	0.6	0.0	0.0	0.0	3.7	6.1
LM11-02-0081 (IMS)	0.1	0.0	0.0	0.0	0.0	2.7	3.6

Volume percent retained in each size fraction

Size Range (microns)	>500	500-250	250-125	125-62.5	62.5-3.9	3.9-1	<1
LM11-02-0083 (meso13)	0.0	0.0	0.0	0.0	0.0	36.0	64.0
LM11-02-0084 (meso22)	0.0	0.0	0.0	0.0	0.0	35.9	64.1
LM11-02-0085 (meso31)	0.0	5.0	0.0	0.0	0.0	31.6	63.4
LM11-02-0086 (meso44)	0.0	6.2	0.0	0.0	0.0	35.7	58.1
LM11-02-0081 (IMS)	1.6	0.0	0.0	0.0	0.0	42.6	55.8

4.3.4 Quality Control Process and Data Quality Summary

Each storm event was checked by the WSU program director to determine if data meet method quality objectives outlined in the QAPP. The following is a summary of the data quality of the two WY2012 storms:

November 2, 2011 Event

- TSS, hardness and phosphorus met Method Quality Objective's (MQO's) with method blanks, matrix spikes and lab duplicates within stated goals.
- Metals samples were not filtered and preserved within stated holding time (12 hours) and were rejected.
- The storm capture coverage criteria of 75 percent was not met for two mesocosms (mesocosms 31 and 44) since the actual sampling coverage was 70 percent for both mesocosms. As this was the first storm event attempted and the coverage exceeded 75 percent for the two other mesocosms, the samples were submitted and are considered acceptable for the performance evaluation. Sampler pacing was adjusted so the percent coverage would be sufficient for the following storm events.

November 16, 2011 Event

- TSS, hardness and phosphorus met MQO's with method blanks, matrix spikes and lab duplicates within stated goals.

- Metals samples were not filtered and preserved within stated holding time (12 hours) and were rejected. Corrective actions were taken by the laboratory to avoid this from happening for subsequent storms.

4.3.5 Result Discussion

Natural stormwater at the WSU LID research facility, as measured at the influent monitoring station, contains concentrations for most analytes at levels well below those typically measured in stormwater from residential or commercial land uses. Zinc is the only stormwater constituent at the influent at levels representative of residential or commercial land use (total zinc concentrations ranged from 99-132 µg/L).

The concentrations in the natural stormwater for the first two events are considered too low for a meaningful evaluation of the performance of bioretention soil exposed to typical stormwater concentrations. However, the initial sampling results provide a useful examination of what constituents leach out of new bioretention media exposed to low concentration stormwater.

Using percent removal when evaluating effluent concentrations with low influent concentrations can be deceptive since removals will be very low or even negative, indicating no removal or an export (leaching) of constituents. However, looking at effluent concentrations only is likewise deceptive because effluent concentrations are below most water quality standards even though concentrations typically *increased* after passing through the bioretention media.

Total suspended solids performance could be considered neutral. Influent concentration were very low (4.5-5.7 mg/L) and effluent concentrations remained low ranging from 4.1 to 7.9 mg/L.

Influent concentrations for total phosphorus (TP) and ortho-phosphorus (ortho-P) were also low (0.063-0.064 mg/L and 0.021-0.027 mg/L respectively). Total and ortho-P were exported from the mesocosms at factors of 5 to 10 times influent concentration in both storms. Median effluent concentrations for TP were 0.364-0.381 mg/L and 0.232 to 0.285, respectively. The source of the phosphorus is likely the compost. Nutrient export from bioretention media is a documented and growing concern. It is important to note that one of WSU's goals of testing the various bioretention media blends in addition to 60/40 percent aggregate/compost blend discussed in this report is improving phosphorus retention.

Metals data were rejected for the first two storms because holding times were exceeded. However, the metals performance is discussed since the first two storms display similar concentrations and removals as the third storm (on October 15, 2012, not discussed in this report since it occurred in WY2013) with acceptable metals data. A low amount of leaching or export of total and dissolved copper was observed for all storm events. Influent concentrations were quite low for all storms (4.8-7.8 µg/L for total copper and 2.3-3.7 for dissolved copper). Median effluent concentrations for total copper ranged from 11.5-13.9 µg/L and for dissolved copper ranged from 8.2 to 9.8 µg/L. The source of the copper is not known and can be the compost, sand or potentially a fungicide used on the plants. Percent removal of total and dissolved zinc was high for both storms with removal ranging from 94-96 percent and 92-96 for total and dissolved zinc, respectively.

Particle size distribution (PSD) data also indicated a slight export of bioretention media since influent PSD were 97 percent or greater fines (i.e, in the clay and silt size ranges or <62.5 microns) whereas effluent PSD showed a slight increase in the >250 micron fractions and the fines percentages dropping to approximately 94-95 percent by volume.

4.3.6 QAPP Update

As discussed above, the sampled results from the two first events indicated that the stormwater from the contributing area has low levels of total suspended solids, nutrients and metals (except zinc) which are considered to be below acceptable levels for assessing water quality treatment facilities.

Based on the results of the first two events, Phase 1 monitoring (natural stormwater) was halted while Phase 2 monitoring design and synthetic storm production procedures were developed throughout the remainder of WY2012. Phase 2 monitoring is designed to provide supplemental performance data from different influent flow and concentration scenarios that cannot be achieved during natural storms in the Phase 1 monitoring alone. During WY2012, Ecology, Seattle and WSU agreed on acceptable ranges of pollutants for Phase 2. Initial small-scale batch tests were conducted during spring 2012. The testing and development of Phase 2 procedures resulted in a significant update to the final QAPP. The updated QAPP was approved by Ecology and is dated September 2012. Since no Phase 2 monitoring was performed in WY2012, the Phase 2 procedures and target concentration ranges are not presented in this Annual Report.

4.3.7 Future WSU Monitoring

WSU's goal is to sample four storm events annually (i.e., per water year) across all mesocosms. Two additional Phase 1 (natural stormwater) events will be sampled for a total of four Phase 1 storms. Following the collection of the fourth Phase 1 storm, WSU plans to commence Phase 2 sampling using synthetic stormwater.

4.4 Hydrologic Management BMP Monitoring

SPU completed the hydrologic management BMP assessment during WY2009. For a discussion of this work, refer to the WY2009 Annual Report.

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Appendix C.1: STORMWATER CHARACTERIZATION - QUALITY ASSURANCE/QUALITY CONTROL REPORT

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This Quality Assurance/Quality Control (QA/QC) report presents results of the QA/QC review of flow monitoring and analytical data generated for the Stormwater Characterization project (Permit Section S8.D) for Water Year (WY) 2012. The following discussion includes QA/QC practices and results for flow monitoring, laboratory analytical testing and field sample analysis.

Flow Monitoring QA/QC Results

Flow data were reviewed and edited according to the procedures outlined in Section 2.3.8.2. The following is a summary of any inconsistencies noted during data review at each of the three monitoring locations:

<u>Residential Monitoring Station (R1):</u> During each routine monthly maintenance visit, the two pressure transducers at the R1 station were removed, cleaned and reinstalled. A water level check was performed each time prior to sensor removal to provide a point of reference for correcting the level data. The water level checks indicated that the flume's pressure transducer readings drifted between -0.015 and -0.03 feet over each month. The drift was corrected in the finalized level data and the final flow was calculated using the corrected level data.

<u>Commercial Monitoring Station (C1)</u>: The storm drain pipe at C1 has a slope of 7 percent which results in very high velocities, often exceeding 10 feet per second (fps) (velocities above 10 fps are considered less than optimal) and relatively low water levels (base flow levels are less than 2 inches). Low water levels result in inaccurate velocity measurements (the velocity sensor requires approximately 3 inches of water level for accurate measurements) and during moderate to high flow conditions the high velocity can produce a turbulent "rooster tail" (flows hitting the front of sensor and ramping over the sensor in an aerated and turbulent manner) over the submerged area/velocity sensor which causes high variability in the water level measurement. To increase the accuracy of the flow data, a low flow dam was installed immediately downstream of the sensor to attempt to backup water over the sensor to enable velocity measurements at low to moderate flows and to mitigate the rooster tail effect during higher flows. The dam improves the accuracy of flow measurements during higher, storm flow conditions but can cause overestimation of flow during lower, base flow conditions. This is because level is measured within the backwater zone (because the level transducer is located near the back of the submerged sensor) but the Doppler velocity sensor is obtaining measurements just upstream of the backwater zone (since the velocity sensor is located at the very front of the sensor and the pipe is too steep to backup water over the entire sensor) so velocity measurements are largely unaffected by the backwater created by the dam. The combination of the backwatered, elevated level readings and unaffected velocity readings can lead to a general overestimation of the flow rate under base flow conditions. As the flow increases, the sensor becomes more completely submerged and flow measurement accuracy increases. Since the

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presence of the dam is considered to provide increased flow accuracy during storm flows, the storm flow data are considered as accurate as possible given the challenging site conditions.

Debris is commonly found in this pipe and there have been numerous occurrences of debris becoming entangled in or around the area/velocity sensor and the sediment traps located downstream. This debris is removed immediately upon discovery but may result in short periods of lower accuracy flow data as the debris obstructs the sensor's ability to measure velocity.

There were several notable data gaps that occurred at C1 during WY2012. An equipment error during a non-sampled storm on December 27, 2011 could not be corrected by interpolation and created a four and a half hour gap in the final data set. Two longer data gaps occurred from January 27 to January 30, 2012 and from January 30, to February 6, 2012. These longer data gaps were caused by instrument error and occurred during both dry and wet weather periods. These gaps could not be filled using interpolation and the periods were left as gaps with no final flow data.

There was also a four day data gap from June 11 to June 15, 2012. An intense storm on May 20-21, 2012 partially damaged the sensor and it was removed on June 11 and replaced with a new sensor on June 15, 2012. The data collected between the May 20 storm and the sensor removal on June 11 indicated the damaged sensor was not responding to rainfall like it did before the large storm and was also behaving erratically on the falling limb of storm event hydrographs. The data collected between May 23 and June 11, 2012 could not be adjusted or verified because the water level was not verified prior to the sensor being removed.

Industrial Monitoring Station (I1): This site experiences a backwater condition due to the pipe's low slope and backup from the downstream WSDOT swale which can result in below optimum flow velocities for the Doppler velocity sensor (velocities less than one foot per fps are difficult for the sensor to measure accurately. The standing water level in the pipe created by the backwater is always greater than 1 foot but averages around 2 feet during the wet season. Runoff from smaller storms enters the pipe and is slowed by the standing water. The diminished velocities are primarily a concern during small or low intensity events where the slow velocities may be undetected by the sensor which results in the flow being calculated as zero. During larger events, the backwater effect is less of a problem as the increased runoff creates higher velocities. Therefore, the confidence in the velocity and flow data is lower for small events than for the larger events where higher flow velocities and rates occur.

Anomalous spikes in level and flow were observed in the data throughout the year. The spikes typically occurred during periods with zero flow and were likely caused by inconsistent communication between the flow monitor and data logger (which are made by different manufacturers) and were not representative of actual flow conditions. These spikes were corrected in the final flow data.

A routine weekly data review identified that the velocity and flow rates seemed significantly lower than expected following a series of relatively strong storm events beginning on January 20, 2012. On January 27, 2012, a flow monitoring maintenance crew found the sensor obstructed with silt and cleaned the sensor and the velocity and flow measurements returned to normal. Flow data during periods of rainfall from January 14 through the January 27, 2012 cleaning are suspect due to sensor fouling but could not be corrected. Periods without rainfall and relatively flat level data were considered to have acceptable flow values as this is the normal operation of the site during dry periods.

To avoid future sensor fouling, a custom-made sensor washer was installed on March 23, 2012. The washer uses an air compressor to flush the sensor every five days to clear sediment to prevent fouling. There were no observed issues with velocity readings for the rest of the water year after the sensor washer was installed.

Analytical Data QA/QC Results

This analytical data quality QA/QC report addresses analytical data collected for the Stormwater Characterization project during WY2012.

Analytical Data QA/QC Procedures

All laboratory data packages were received with a hardcopy report and an electronic data deliverable (EDD). For each data package, laboratory case narratives were reviewed for quality control issues and corrective action(s) taken. Data were evaluated for required methods, holding times, reporting limits, accuracy, precision and blank contamination.

Each EDD was imported into a review template spreadsheet where deviations from the measurement quality objectives (MQOs) were identified and associated samples were qualified accordingly.

One result value per sample per analyte is reported. Where the laboratory performed dilutions or re-analyses that resulted in multiple valid values, the result with the lowest detection limit is reported.

Data qualifiers were applied to sample chemistry data based on the results of validation. Four data qualifier codes were used; U, J, UJ and R.

Data Qualifier Definitions

Data Qualifier	Definition
U	Analyte was analyzed for, but not detected above reported result.
J	Reported result is an estimated quantity.
UJ	Analyte was analyzed for, but not detected above reported estimate.
R	Result value was rejected. Result should not be used in analyses.

Analytical Methods and Reporting Limits

The following table is used to describe the methods and reporting limits (RL) used by the laboratory. Reporting limits represent the minimum concentration of an analyte in a specific matrix that can be identified and quantified above the method detection limit and within specified limits of precision and bias during routine analytical operating conditions. Reporting limits can vary by individual samples, particularly for sediments where the quantity and dilution analyzed affect the minimum detectable value.

Stormwater Samples - Analytes, Methods and Reporting Limits

Analyte Group	Analyte	Reporting Limit	Units	Lab Method
Bacteria	Fecal Coliform	2	CFU/ 100 mL	SM9222D
Conventionals	BOD	2	mg/L	SM5210B
	Conductivity	1	µmhos/cm	EPA120.1
	Hardness	0.33	mg/L $CaCO_3$	SM2340B
	pH	0.01	std units	SM4500H
	Solids, Total Suspended	1	mg/L	SM2540B
	Surfactants	0.025	mg/L	SM5540C
	Turbidity	0.05	NTU	EPA180.1
Metals	Cadmium - Dissolved	0.1	µg/L	EPA200.8
	Cadmium - Total	0.1	µg/L	EPA200.8
	Copper - Dissolved	0.5	µg/L	EPA200.8
	Copper - Total	0.5	µg/L	EPA200.8
	Lead - Dissolved	0.1	µg/L	EPA200.8
	Lead - Total	0.1	µg/L	EPA200.8
	Mercury - Dissolved	0.02	µg/L	SW7470A
	Mercury - Total	0.02	µg/L	SW7470A

Analyte Group	Analyte	Reporting Limit	Units	Lab Method
	Zinc - Dissolved	4	µg/L	EPA200.8
	Zinc - Total	4	µg/L	EPA200.8
Nutrients	Chloride	0.1	mg/L	EPA300.0
	Nitrate + Nitrite	0.01	mg-N/L	EPA353.2
	Nitrogen, Total Kjeldahl	0.3	mg-N/L	EPA351.2
	Orthophosphate	0.004	mg-P/L	SM4500-PE
	Phosphorus, Total	0.008	mg-P/L	SM4500-PE
SVOCs	2,4-D	0.08	µg/L	EPA8321B
	Diazinon	0.2	µg/L	SW8270DSIM
	Dichlobenil	0.024	µg/L	SW8270D
	Malathion	0.4	µg/L	SW8270DSIM
	MCPP	0.08	µg/L	EPA8321B
	Prometon	0.024	µg/L	SW8270D
	Triclopyr	0.08	µg/L	EPA8321B
	Chlorpyrifos	0.2	µg/L	SW8270DSIM
	Dibenzofuran	0.1	µg/L	SW8270DSIM
	PAHs	0.1	µg/L	SW8270DSIM
	Phthalates	1	µg/L	SW8270D
	Pentachlorophenol	0.5	µg/L	SW8270DSIM
TPH	Diesel Range	0.1	mg/L	NWTPH-DX
	Gasoline Range Hydrocarbons	0.25	mg/L	NWTPH-GX
	Motor Oil	0.2	mg/L	NWTPH-DX

Sediment Samples- Analytes, Methods and Reporting Limits

Analyte Group	Analyte	Reporting Limit	Units	Lab Method
Conventionals	Solids, Total	0.01	%	SM2540B
	Grain Size	0.1	%	PSEP-PS
	Total Organic Carbon	0.02	%	EPA9060
Metals	Cadmium	0.05	mg/kg	SW6020
	Copper	0.5	mg/kg	SW6020
	Lead	0.3	mg/kg	SW6020
	Mercury	0.02	mg/kg	SW7471

Analyte Group	Analyte	Reporting Limit	Units	Lab Method
	Zinc	1	mg/kg	SW6020
PCBs	Aroclors	33	µg/kg	SW8082A
Pesticides	Chlorpyrifos	10	µg/kg	SW8270DSIM
	Diazinon	10	µg/kg	SW8270DSIM
	Malathion	13	µg/kg	SW8270DSIM
PAHs	PAHs	5	µg/kg	SW8270DSIM
Phenolics	2,4,5-Trichlorophenol	1	µg/kg	SW8270DSIM
	2,4,6-Trichlorophenol	1	µg/kg	SW8270DSIM
	2,4-Dichlorophenol	1	µg/kg	SW8270DSIM
	2,4-Dimethylphenol	1	µg/kg	SW8270DSIM
	2,4-Dinitrophenol	1	µg/kg	SW8270DSIM
	2-Chlorophenol	1	µg/kg	SW8270DSIM
	2-Methylphenol	1	µg/kg	SW8270DSIM
	2-Nitrophenol	1	µg/kg	SW8270DSIM
	4,6-Dinitro-2-methylphenol	1	µg/kg	SW8270DSIM
	4-Chloro-3-methylphenol	1	µg/kg	SW8270DSIM
	4-Methylphenol	1	µg/kg	SW8270DSIM
	4-Nitrophenol	1	µg/kg	SW8270DSIM
	Pentachlorophenol	1	µg/kg	SW8270DSIM
	Phenol	1	µg/kg	SW8270DSIM
Phthalates	bis(2-Ethylhexyl)phthalate	67	µg/kg	SW8270D
	Butylbenzylphthalate	67	µg/kg	SW8270D
	Diethylphthalate	67	µg/kg	SW8270D
	Dimethylphthalate	67	µg/kg	SW8270D
	Di-n-Butylphthalate	67	µg/kg	SW8270D
	Di-n-Octyl phthalate	67	µg/kg	SW8270D

Laboratory Data QA/QC Evaluation Results

Holding Time

All sample results were assessed for holding time compliance in accordance with 40 Code of Federal Regulations (CFR) Part 136. For composite samples, the sample time used was the last aliquot in each composite.

Analytical results obtained outside of holding time, but within 2x the holding time have been qualified as estimated (J). Qualification based on holding time is only applied to the specific results described herein.

Holding times were met for all sediment samples. The following stormwater sample results were obtained outside of holding time:

One stormwater sample from C1, collected on 10/10/2011 was reanalyzed for diesel and motor oil range hydrocarbons due to poor surrogate recovery. The reanalysis took place outside of holding time and the results were qualified as estimated (J).

Seven stormwater samples (listed below) were analyzed 1 day past holding time for Surfactants. Results were qualified as estimated (J).

Surfactant Sample Holding Time Exceedances

Site	Sample Date
C1	10/28/2011
C1	11/12/2011
C1	2/17/2012
I1	10/28/2011
I1	11/11/2011
R1	11/11/2011
R1	2/21/2012

Laboratory Blanks

Laboratory method blanks were generated and analyzed by the laboratories in association with primary environmental samples. The following table lists the qualification actions resulting from the blank results.

Blank Validation Criteria

Blank Result	Blank Compared to Sample	Action
Blank > RL	Sample < RL	Qualify sample result as non-detect (U) at the Reporting Limit.
	RL < Sample < Blank	Qualify sample result as non-detect (U) at the reported concentration.
	Blank < Sample < 10x Blank	Qualify sample result as estimated (J).
	10x Blank < Sample	No qualification needed.
Blank < (-RL)	Sample < RL	Qualify sample result as estimated non-detect (UJ) at Reporting Limit.
	RL < Sample < 10x Blank	Qualify sample result as estimated (J).
	10x Blank < Sample	No qualification needed.
(-RL) < Blank < RL	Sample < RL	Qualify sample result as non-detect (U) at Reporting Limit.
	RL < Sample	No qualification needed.

RL – reporting limit

The following table illustrates the application of qualifiers to stormwater sample results based on the blank results per blank sample type.

Association of Blank QC Qualifiers to Results

Blank Sample Type	Associated Results
Method Blank	All results in prep batch
Filter Blank	All results from same sample delivery group
Trip Blank	All results from same sample delivery group
Tubing Blank	All composite results from project water year and
Bottle Blank/Splitter Blank/Bailer Blank	All composite results from project water year
Grab Sampler Equipment Blank	All grab results from project water year

All laboratory method blank results were within control limits with the exception of those listed below. For the method blanks exceedances listed below, corrective action has been taken and associated sample results were qualified accordingly.

Method Blank Exceedances for Stormwater Samples

Analyte	Reported Result	Units	Action
bis(2-Ethylhexyl)phthalate	2	µg/L	Sample results less than 20 qualified J

Field equipment blank samples were collected and analyzed in addition to laboratory method blanks. The results of these additional blanks can be found in the *Field Sample QC/QC Results* section later in this report.

No method blank exceedances were observed for blank samples associated with sediment samples.

Accuracy

Accuracy is the degree of agreement between an observed value and an accepted reference value. Accuracy was demonstrated by analysis of matrix spikes (MS), laboratory control samples (LCS), reference materials (RM) and surrogate compounds (SUR). Laboratory control limits were used when provided. The following table lists the qualification actions resulting from the accuracy analysis.

Accuracy Validation Criteria

Percent Recovery*	Sample Compared to RL	Action
%R < LowLimit	Sample ≤ RL	Qualify sample result as estimated non-detect (UJ).
	RL < Sample	Qualify sample result as estimated (J).
	Parent† > 4x spike added	No qualification needed.
UppLimit < %R	Sample ≤ RL	No qualification needed.
	RL < Sample	Qualify sample result as estimated (J).
	Parent > 4x spike added	No qualification needed.

RL – reporting limit

† Parent - The sample from which an aliquot is used to make the spiked QC sample.

* The percent recovery of the spiked compound and is calculated as:

$$\%R = \frac{(Spiked\ QC\ Sample\ Result - Parent\ Sample\ Result)}{Spike\ amount}$$

The following table illustrates the application of qualifiers to sample results based on the accuracy of QC sample types.

Association of Accuracy QC to Sample Results

QC Type	Associated Results
LCS/LCSD/RM	All results in prep batch
MS/MSD	All results in prep batch
Surrogate	Results for associated analyte in current sample only

All accuracy QC results were within control limits except as noted below. Sample results associated with QC exceedances have been qualified as appropriate.

Accuracy Exceedances for Stormwater Samples

Analyte	Type	Analysis Date	Out	Action
BOD	LCS	3/1/2012	Low	Associated Sample Qualified J
Diazinon	LCS	2/28/2012	High	All Associated Samples Non-Detect: No Qual.
Di-N-Octylphthalate	MS	2/3/2012	Low	Associated Sample Qualified UJ
Zinc (Total)	MS	11/23/2011	High	Associated Samples Qualified J

No accuracy exceedences were observed for QC samples associated with sediment samples.

Precision

Precision is the degree observed reproducibility of measurement results. Precision was demonstrated by analysis of laboratory sample duplicates (LD), field sample duplicates (FD), laboratory control sample duplicates (LCSD) and matrix spike duplicates (MSD). The following table lists the qualification actions resulting from the precision analysis.

Precision Validation Criteria

<table>
<tr><th rowspan="2">Matrix</th><th colspan="2">Original & Duplicate</th><th rowspan="2">Associated Sample</th><th rowspan="2">Action</th></tr>
<tr><th>Criteria 1</th><th>Criteria 2</th></tr>
<tr><td rowspan="3">Water</td><td rowspan="6">Both Original and Dup Results < 5x RL</td><td rowspan="2">|original - duplicate| > RL</td><td>Result < RL</td><td>Qualify sample results as estimated non-detect (UJ).</td></tr>
<tr><td>Result > RL</td><td>Qualify sample results as estimated (J).</td></tr>
<tr><td>|original - duplicate|≤ RL</td><td>All</td><td>No qualification needed.</td></tr>
<tr><td rowspan="3">Sed</td><td rowspan="2">|original - duplicate| > 2x RL</td><td>Result < RL</td><td>Qualify sample results as estimated non-detect (UJ).</td></tr>
<tr><td>Result > RL</td><td>Qualify sample results as estimated non-detect (UJ).</td></tr>
<tr><td>|original - duplicate|≤ 2x RL</td><td>All</td><td>No qualification needed.</td></tr>
<tr><td rowspan="3">Water</td><td rowspan="5">Either Original or Dup Results > 5x RL</td><td rowspan="2">RPD† > 20*%</td><td>Result < RL</td><td>Qualify sample results as estimated non-detect (UJ).</td></tr>
<tr><td>Result > RL</td><td>Qualify sample results as estimated (J).</td></tr>
<tr><td>RPD ≤ 20*%</td><td>All</td><td>No qualification needed.</td></tr>
<tr><td rowspan="2">Sed</td><td rowspan="2">RPD > 35%</td><td>Result < RL</td><td>Qualify sample results as estimated non-detect (UJ). Note in report.</td></tr>
<tr><td>Result > RL</td><td>Qualify sample results as estimated (J).</td></tr>
</table>

Matrix	Original & Duplicate		Associated Sample	Action
	Criteria 1	Criteria 2		
		RPD ≤ 35%	All	No qualification needed.

RL – Reporting Limit

† RPD – Relative Percent Difference between the original and the duplicate, calculated as follows:

$$RPD = 100 \times \left| \frac{(original - duplicate)}{Mean\,(original, duplicate)} \right|$$

*An RPD control limit of 25% was used when assessing field duplicate water samples.

The following table illustrates the application of qualifiers to sample results based on the precision QC sample types.

Association of Precision QC to Sample Results

QC Type	Associated Results
Lab Duplicate	All results in prep batch
Laboratory Control Sample Duplicate	All results in prep batch
Matrix Spike Duplicate	Parent sample results[1]
Field Duplicate/ Field Split	Parent sample results only[2]

Notes:

1. In cases where the only associated precision QC was the MSD, the MSD was used to evaluate all results in the prep batch.

2. In cases where the laboratory was deficient in providing laboratory precision QC, Field precision QC was used to evaluate all results in each prep batch.

All laboratory precision QC results were within control parameters except as noted below. Associated sample results have been qualified accordingly.

Laboratory Precision Exceedances for Stormwater Samples

Analyte	Type	Analysis Date	Action
1-Methylnaphthalene	LCS/LCSD	12/3/2011	Associated Samples Qualified J/UJ
2,4-D	LCS/LCSD	11/23/2011	Associated Samples Qualified UJ
2,4-D	LCS/LCSD	11/24/2011	Associated Sample Qualified UJ
2,4-D	LCS/LCSD	12/20/2011	Associated Sample Qualified UJ
2-Methylnaphthalene	LCS/LCSD	12/3/2011	Associated Samples Qualified J/UJ
Acenaphthene	LCS/LCSD	3/14/2012	Associated Sample Qualified UJ
Benzo(G,H,I)Perylene	MS/MSD	3/5/2012	Associated Sample Qualified J
Benzo(G,H,I)Perylene	LCS/LCSD	3/14/2012	Associated Sample Qualified UJ
Benzofluoranthenes, Total	MS/MSD	1/11/2012	Associated Samples Qualified UJ

Analyte	Type	Analysis Date	Action
Bis(2-ethylhexyl)phthalate	MS/MSD	1/11/2012	Associated Samples Qualified J
Bis(2-ethylhexyl)phthalate	MS/MSD	2/3/2012	Associated Sample Qualified UJ
Butylbenzylphthalate	LCS/LCSD	3/7/2012	Associated Sample Qualified UJ
Dibenzo(A,H)Anthracene	MS/MSD	1/11/2012	Associated Samples Qualified UJ
Dibenzo(A,H)Anthracene	MS/MSD	2/10/2012	Associated Sample Qualified UJ
Dibenzo(A,H)Anthracene	MS/MSD	3/5/2012	Associated Sample Qualified UJ
Dibenzo(A,H)Anthracene	LCS/LCSD	3/6/2012	Associated Sample Qualified UJ
Dichlobenil	LCS/LCSD	10/10/2011	Associated Samples Qualified UJ
Dichlobenil	LCS/LCSD	11/23/2011	Associated Samples Qualified J/UJ
Dichlobenil	LCS/LCSD	1/5/2012	Associated Samples Qualified J
Di-N-Octylphthalate	MS/MSD	2/3/2012	Associated Sample Qualified UJ
Di-N-Octylphthalate	MS/MSD	3/1/2012	Associated Sample Qualified UJ
Fecal Coliform	Lab Dup	2/18/2012	Associated Samples Qualified J
Fecal Coliform	Lab Dup	2/24/2012	Associated Sample Qualified J
Fluoranthene	LCS/LCSD	12/3/2011	Associated Samples Qualified J/UJ
Indeno(1,2,3-Cd)Pyrene	MS/MSD	1/11/2012	Associated Samples Qualified UJ
Indeno(1,2,3-Cd)Pyrene	MS/MSD	3/5/2012	Associated Sample Qualified UJ
Indeno(1,2,3-Cd)Pyrene	LCS/LCSD	3/14/2012	Associated Sample Qualified UJ
Lead (D)	Lab Dup	12/13/2011	Associated Sample Qualified J
MCPP	LCS/LCSD	11/23/2011	Associated Samples Qualified UJ
MCPP	LCS/LCSD	11/24/2011	Associated Sample Qualified UJ
MCPP	LCS/LCSD	12/20/2011	Associated Sample Qualified UJ
Naphthalene	LCS/LCSD	3/14/2012	Associated Sample Qualified UJ
Phosphorus, Total	Lab Dup	2/2/2012	Associated Sample Qualified J
Triclopyr	LCS/LCSD	11/23/2011	Associated Samples Qualified UJ
Triclopyr	LCS/LCSD	11/24/2011	Associated Sample Qualified UJ
Triclopyr	LCS/LCSD	12/20/2011	Associated Sample Qualified UJ
TSS	Lab Dup	1/6/2012	Associated Sample Qualified J

No precision exceedences were observed for QC samples associated with sediment samples.

The laboratory control sample and duplicate (LCS/LCSD) RPDs for the above compounds did not meet the control limits established by the project QAPP. However, the limits were considered in control by the laboratory. For this reason, the associated samples were qualified as estimated.

Field duplicates were collected and analyzed in addition to laboratory duplicates. The results of these additional blanks can be found in the *Field Results Sample QA/QC* results section below.

Data Completeness

Approximately 2,600 analytical results were required for the Stormwater Characterization project during WY2012. All samples were received by the laboratory and all required parameters were analyzed. Upon final QA/QC review, the amount of useable data reported for the project year exceeded the MQO of 90 percent.

Field Sample QA/QC Sample Results

The following section discusses the results of QA/QC samples generated in the field or laboratory by field staff.

Field Blank QC Samples

Trip Blanks

Trip blanks accompanied all sample bottles used for gasoline range hydrocarbon (TPH-G) analyses from the time the empty sample bottles left the laboratory until the filled bottles were relinquished to the laboratory. Trip blanks were analyzed for TPH-G and no TPH-G was detected in any of the trip blanks submitted. Trip blank dates and analytical results are shown in the table below.

Stormwater Sample Trip Blank Results

Sample Date	Reported Result	Qualifier	Units
10/28/2011	0.25	U	mg/L
11/2/2011	0.25	U	mg/L
11/11/2011	0.25	U	mg/L
11/16/2011	0.25	U	mg/L
12/6/2011	0.25	U	mg/L
12/27/2011	0.25	U	mg/L
1/4/2012	0.25	U	mg/L
1/12/2012	0.25	U	mg/L
1/24/2012	0.25	U	mg/L
1/29/2012	0.25	U	mg/L
2/13/2012	0.25	U	mg/L
2/17/2012	0.25	U	mg/L
2/20/2012	0.25	U	mg/L
2/24/2012	0.25	U	mg/L

Sample Date	Reported Result	Qualifier	Units
2/28/2012	0.25	U	mg/L
3/2/2012	0.25	U	mg/L
10/10/2011	0.25	U	mg/L
5/21/2012	0.25	U	mg/L
5/11/2012	0.25	U	mg/L
6/22/2012	0.25	U	mg/L
7/20/2012	0.25	U	mg/L
7/10/2012	0.25	U	mg/L

Bailer Blanks

One bailer blank was collected at each of the three monitoring locations and tested for all of the grab-sample analytes (stainless bailers are used to collect stormwater grab samples). Results of the bailer blank analyses are shown in the table below. No contamination was detected in any of the bailer blanks so no corrective action was needed.

Bailer Blank Results

		Site	I1	C1	R1
		Date	3/2/2012	3/2/2012	2/21/2012
Analyte	RL	Units			
Diesel Range Hydrocarbons	0.1	mg/L	0.1 U	0.1 U	0.1 U
Motor Oil Range Hydrocarbons	0.2	mg/L	0.2 U	0.2 U	0.2 U
Gasoline Range Hydrocarbons	0.25	mg/L	0.25 U	0.25 U	0.25 U
Fecal Coliform	1	cfu/100ml	1 U	1 U	2 U

Bottle and Splitter Blanks

Bottle blanks were collected from the composite glass bottles used in the auto samplers. Splitter blanks were collected from the cone and churn splitters used to process samples. These were tested for contamination by testing for all of the composite sample analytes.

After some contamination was found in the initial round of bottle and splitter blanks from January 2012; many investigations and corrective actions (discussed below) were pursued by the laboratory. A second round of bottle and splitter blanks were collected and analyzed in June 2012 to confirm the success of corrective actions taken.

Trace hits of copper in the initial splitter blank and bis(2-ethylhexyl)phthalate in the initial bottle blank were reported. Since detected amounts of these analytes in the associated samples was greater than ten (10) times the amount detected in the blanks, no corrective action was needed.

Nitrate + nitrite was detected in the splitter blanks and in the first bottle blank (collected in January). SPU observed the nitrate + nitrite contamination during data screening and requested that the field and laboratory staff investigate. After extensive testing, the source of contamination was determined to be a sodium hydroxide (NaOH) solution used by the lab to preserve samples immediately prior to analysis. Corrective action was taken by the lab, and they have since observed no recurrence of the contamination. Samples associated with the contaminated blanks have been qualified accordingly.

Total phosphorus contamination was also observed in the first bottle and splitter blanks. Further testing by the laboratory indicated that the contamination was a result of inconsistent digestion methods used between samples and standards. The laboratory has taken corrective action by insuring that samples and standards are always prepared by the same digestion methods. A second set of bottle and splitter blanks was collected in June 2012 and tested for total phosphorus to confirm that corrective action had resolved the contamination issue. The second round of blanks is free from phosphorus contamination and the corrective action is considered to have resolved the issue. Sample results associated with the contaminated blanks have been qualified accordingly.

Bottle and Splitter Blank Results

			Type	Bottle Blank		Splitter Blank	
			Sample Round	1	2	1	2
			Date	1/12/2012	6/1/2012	1/12/2012	6/1/2012
Analyte		RL	Units				
Cadmium	Dissolved	0.1	µg/L	0.1 U		0.1 U	
Cadmium	Total	0.1	µg/L	0.1 U		0.1 U	
Copper	Dissolved	0.5	µg/L	0.5 U		0.5 U	
Copper	Total	0.5	µg/L	0.5 U		**0.5**	
Lead	Dissolved	0.1	µg/L	0.1 U		0.1 U	
Lead	Total	0.1	µg/L	0.1 U		0.1 U	
Zinc	Dissolved	4	µg/L	4 U		4 U	
Zinc	Total	4	µg/L	4 U		4 U	
Nitrogen, Total Kjeldahl		0.3	mg/L	0.3 U	0.3 U	0.3 U	0.3 U
Nitrate + Nitrite		0.01	mg/L	**0.014**	0.01 U	**0.029**	**0.015**
Ortho-phosphate		0.004	mg/L	0.004 U	0.004 U	0.004 U	0.004 U
Phosphorus, Total		0.008	mg/L	**0.018**	0.008 U	**0.019**	0.008 U
Bis(2-ethylhexyl)phthalate		1	µg/L	**1.1**		1 U	
Butylbenzylphthalate		1	µg/L	1 U		1 U	
Diethylphthalate		1	µg/L	1 U		1 U	
Dimethylphthalate		1	µg/L	1 U		1 U	
Di-N-Butylphthalate		1	µg/L	1 U		1 U	
Di-N-Octylphthalate		1	µg/L	1 U		1 U	
1-Methylnaphthalene		0.1	µg/L	0.1 U		0.1 U	
2-Methylnaphthalene		0.1	µg/L	0.1 U		0.1 U	
Acenaphthene		0.1	µg/L	0.1 U		0.1 U	
Acenaphthylene		0.1	µg/L	0.1 U		0.1 U	
Anthracene		0.1	µg/L	0.1 U		0.1 U	

		Type	Bottle Blank		Splitter Blank	
		Sample Round	1	2	1	2
		Date	1/12/2012	6/1/2012	1/12/2012	6/1/2012
Analyte	RL	Units				
Benzo(A)Anthracene	0.1	µg/L	0.1 U		0.1 U	
Benzo(A)Pyrene	0.1	µg/L	0.1 U		0.1 U	
Benzo(G,H,I)Perylene	0.1	µg/L	0.1 U		0.1 U	
Benzofluoranthenes, Total	0.2	µg/L	0.2 U		0.2 U	
Chrysene	0.1	µg/L	0.1 U		0.1 U	
Dibenzo(A,H)Anthracene	0.1	µg/L	0.1 U		0.1 U	
Dibenzofuran	0.1	µg/L	0.1 U		0.1 U	
Fluoranthene	0.1	µg/L	0.1 U		0.1 U	
Fluorene	0.1	µg/L	0.1 U		0.1 U	
Indeno(1,2,3-Cd)Pyrene	0.1	µg/L	0.1 U		0.1 U	
Naphthalene	0.1	µg/L	0.1 U		0.1 U	
Pentachlorophenol	0.5	µg/L	0.5 U		0.5 U	
Phenanthrene	0.1	µg/L	0.1 U		0.1 U	
Pyrene	0.1	µg/L	0.1 U		0.1 U	

Tubing Blanks

A small amount of bis(2-ethylhexyl)phthalate was found in the first tubing blank from site C1. The detected amounts of this analyte in the associated samples was greater than ten (10) times the amount detected in the blank so no corrective action was needed.

The first tubing blank for site I1 contained a small hit for ortho-phosphate. Associated samples were qualified accordingly. As all other field blanks contained no discernible ortho-phosphate contamination, no further corrective action was needed.

Total phosphorus contamination was observed in the first round of tubing blanks for all three sites. Further testing by the laboratory indicates that the contamination was a result of inconsistent digestion methods used between samples and standards. The laboratory has taken corrective action by insuring that samples and standards are always prepared by the same digestion methods. A second set of tubing blanks was collected in July 2012 and tested for total phosphorus to confirm that corrective action had resolved the contamination issue. The second round of tubing blanks are free from phosphorus contamination and the corrective action is considered to have resolved the issue. Sample results associated with the contaminated blanks have been qualified accordingly.

Tubing Blank Results

			Site	R1		C1		I1	
			Sample Round	1	2	1	2	1	2
			Date	1/27/12	7/11/12	1/27/12	7/12/12	1/27/12	7/12/12
Analyte		RL	Units						
Cadmium	Dissolved	0.1	µg/L	0.1 U		0.1 U		0.1 U	
Cadmium	Total	0.1	µg/L	0.1 U		0.1 U		0.1 U	
Copper	Dissolved	0.5	µg/L	0.5 U		0.5 U		0.5 U	
Copper	Total	0.5	µg/L	0.5 U		0.5 U		0.5 U	
Lead	Dissolved	0.1	µg/L	0.1 U		0.1 U		0.1 U	
Lead	Total	0.1	µg/L	0.1 U		0.1 U		0.1 U	
Zinc	Dissolved	4	µg/L	4 U		4 U		4 U	
Zinc	Total	4	µg/L	4 U		4 U		4 U	
Nitrogen, Total Kjeldahl		0.3	mg/L	0.3 U	0.3 U	0.3 U	0.3 U	0.3 U	0.3 U
Nitrate + Nitrite		0.01	mg/L	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U
Ortho-phosphate		0.004	mg/L	0.004 U	0.004 U	0.004 U	0.004 U	**0.004**	0.004 U
Phosphorus, Total		0.008	mg/L	**0.03**	0.008 U	**0.028**	0.008 U	**0.03**	0.008 U
Bis(2-ethylhexyl)phthalate		1	µg/L	1 U		**1.1 J**		1 U	
Butylbenzylphthalate		1	µg/L	1 U		1 U		1 U	
Diethylphthalate		1	µg/L	1 U		1 U		1 U	
Dimethylphthalate		1	µg/L	1 U		1 U		1 U	
Di-N-Butylphthalate		1	µg/L	1 U		1 U		1 U	
Di-N-Octylphthalate		1	µg/L	1 U		1 U		1 U	
1-Methylnaphthalene		0.1	µg/L	0.1 U		0.1 U		0.1 U	
2-Methylnaphthalene		0.1	µg/L	0.1 U		0.1 U		0.1 U	
Acenaphthene		0.1	µg/L	0.1 U		0.1 U		0.1 U	
Acenaphthylene		0.1	µg/L	0.1 U		0.1 U		0.1 U	
Anthracene		0.1	µg/L	0.1 U		0.1 U		0.1 U	
Benzo(A)Anthracene		0.1	µg/L	0.1 U		0.1 U		0.1 U	
Benzo(A)Pyrene		0.1	µg/L	0.1 U		0.1 U		0.1 U	
Benzo(G,H,I)Perylene		0.1	µg/L	0.1 U		0.1 U		0.1 U	
Benzofluoranthenes, Total		0.2	µg/L	0.2 U		0.2 U		0.2 U	
Chrysene		0.1	µg/L	0.1 U		0.1 U		0.1 U	
Dibenzo(A,H)Anthracene		0.1	µg/L	0.1 U		0.1 U		0.1 U	
Dibenzofuran		0.1	µg/L	0.1 U		0.1 U		0.1 U	
Fluoranthene		0.1	µg/L	0.1 U		0.1 U		0.1 U	
Fluorene		0.1	µg/L	0.1 U		0.1 U		0.1 U	
Indeno(1,2,3-Cd)Pyrene		0.1	µg/L	0.1 U		0.1 U		0.1 U	
Naphthalene		0.1	µg/L	0.1 U		0.1 U		0.1 U	
Pentachlorophenol		0.5	µg/L	0.5 U		0.5 U		0.5 U	
Phenanthrene		0.1	µg/L	0.1 U		0.1 U		0.1 U	
Pyrene		0.1	µg/L	0.1 U		0.1 U		0.1 U	

Stormwater Duplicate and Split Samples

During WY2012, four duplicate grab samples and four composite split samples were analyzed as field precision QC samples. The duplicate and split sample results are summarized in the following tables.

The qualifier applied to the associated sample results, based on rules listed earlier in this report, is displayed after the RPD or absolute difference column. All field duplicate and split QC met control criteria, except those listed below:

- The nutrient field duplicate sample for site R1, collected on 2/21/2012, was mistakenly prepared with nitric acid by the laboratory analyst. This mistake resulted in an incongruously high result for nitrate + nitrite. The field duplicate result has been rejected. No further action was required.
- The field duplicate result for site C1 collected on 11/2/2011 exceeded control parameters for motor oil range hydrocarbons. The associated parent sample result was qualified as estimated (J).
- The field duplicate results for C1 (1/24/2012), I1 (11/2/2011) and R1 (11/2/2011) exceeded control parameters for fecal coliform. Associated sample results were qualified as estimated (J).
- The field split result for site C1 (1/24/2012) exceeded the control criteria for total mercury. The associated sample results were qualified as estimated (J).
- Field split results for C1 (1/24/2012) and I1 (1/5/2012) exceeded control criteria for bis(2-ethylhexyl)phthalate. Associated results were qualified as estimated (J).

Water Sample Grab Duplicate Results

			C1 Grab – 11/2/2011				C1 Grab – 1/24/2012				I1 Grab – 11/2/2011				R1 Grab – 11/2/2011			
Analyte	RL	Units	Parent	Dup	RPD or |Δ|	Qualifier	Parent	Dup	RPD or |Δ|	Qualifier	Parent	Dup	RPD or |Δ|	Qualifier	Parent	Dup	RPD or |Δ|	Qualifier
Diesel Range Hydrocarbons	0.1	mg/L	0.77	0.6	24.8		0.8	0.8	0		0.56	0.5	11.3		0.42	0.43	2.35	
Gasoline Range Hydrocarbons	0.25	mg/L	< 0.25	< 0.25	0		< 0.25	< 0.25	0		< 0.25	< 0.25	0		< 0.25	< 0.25	0	
Motor Oil Range	0.2	mg/L	1.6	1.2	**28.6**	J	2.6	2.6	0		1.1	1	9.52		0.7	0.66	5.88	
Fecal Coliform	40	CFU/100 mL	3100	2700	13.8		3550	2300	**42.7**	J	1520	1150	**27.7**	J	2100	1400	**40**	J

Water Sample Composite Split Results

			C1 Composite – 1/24/2012				I1 Composite – 11/2/2011				I1 Composite – 1/5/2012				R1 Composite – 2/21/2012			
Analyte	RL	Units	Parent	Split	RPD or |Δ|	Qualifier	Parent	Split	RPD or |Δ|	Qualifier	Parent	Split	RPD or |Δ|	Qualifier	Parent	Split	RPD or |Δ|	Qualifier
Conductivity	1	umhos/cm	146	146	0.00%		100	100	0.00%		97.4	98.3	0.920%		45.9	46.1	0.435%	
pH	0.01	pH	7.21	7.3	|0.09|		7.2	7.1	|0.1|		7.18	7.33	|0.15|		6.83	6.69	|0.14|	
Turbidity	0.1	NTU	90	77.5	14.93%		60	56	6.90%		46.8	43.3	7.77%		21	26	21.28%	
Biological Oxygen Demand	1	mg/L	6.9	7.2	4.26%		8.2	6.9	17.2%		4	4.4	|0.4|		< 2	2.2	|0.2|	
Chloride	0.1	mg/L	21.7	21.7	0.00%		2	2	0.00%		2.6	2.6	0.00%		3.6	3.6	0.00%	
Hardness	0.33	mg/L CaCO3	39	40	2.53%		52	54	3.77%		49	46	6.32%		12	12	0.00%	
Nitrate + Nitrite	0.01	mg-N/L	0.213	0.246	14.4%		0.16	0.161	0.623%		0.265	0.287	7.97%		0.179	**545**	**200%**	R
Nitrogen, Total Kjeldahl	0.3	mg-N/L	1.4	1.44	|0.04|		0.71	0.78	|0.71|		1.14	1.12	1.77%		0.57	< 0.3	|0.27|	
Ortho-Phosphate	0.004	mg-P/L	0.018	0.018	|0|		0.03	0.03	0.00%		0.09	0.09	0.00%		0.019	0.019	|0|	
Phosphorus, Total	0.008	mg-P/L	0.28	0.282	0.71%		0.152	0.173	12.92%		0.327	0.332	1.52%		0.085	0.092	7.91%	
Solids, Total Suspended	1	mg/L	121	111	8.62%		72	64.8	10.53%		109	110	0.91%		16.7	20	18.0%	
Surfactants	0.025	mg/L	0.14	0.13	7.41%		0.046	0.043	|0.003|		0.032	< 0.025	|0.007|		0.048	0.068	|0.025|	
Cadmium, Dissolved	0.1	ug/L	< 0.1	< 0.1	|0|		< 0.1	< 0.1	|0|		< 0.1	< 0.1	|0|		< 0.1	< 0.1	|0|	
Cadmium, Total	0.1	ug/L	0.3	0.3	|0|		0.2	0.2	|0|		0.3	0.2	|0.1|		< 0.1	< 0.1	|0|	
Copper, Dissolved	0.5	ug/L	10.2	10.5	2.90%		6	6.1	1.65%		3.7	3.6	2.74%		3.8	4.6	19.0%	
Copper, Total	0.5	ug/L	61.9	64.4	3.96%		21.6	21.8	0.92%		23.1	23.3	0.862%		7.8	8.2	5.00%	
Lead, Dissolved	0.1	ug/L	0.7	0.8	13.33%		0.3	0.3	|0|		0.2	0.2	|0|		0.6	0.6	0.00%	
Lead, Total	0.1	ug/L	30.3	29.2	3.70%		8	8	0.00%		14.1	14.2	0.707%		6	6.6	9.52%	
Zinc, Dissolved	4	ug/L	26	28	7.41%		36	37	2.74%		34	33	2.99%		11	12	|1|	
Zinc, Total	4	ug/L	190	190	0.00%		129	130	0.77%		181	183	1.10%		24	28	15.4%	
Mercury, Dissolved	20	ng/L	< 20	< 20	|0|		< 20	< 20	|0|		< 20	< 20	|0|					
Mercury, Total	20	ng/L	21.2	54.6	**|33.4|**	J	< 20	< 20	|0|		< 20	21.9	|1.9|					
Dichlobenil	0.024	ug/L	< 0.024	< 0.024	|0|		0.53	0.58	9.01%		0.084	0.079	|0.005|		< 0.024	< 0.024	|0|	
Prometon	0.024	ug/L	< 0.024	< 0.024	|0|		< 0.024	< 0.024	|0|		< 0.024	< 0.024	|0|		< 0.024	< 0.024	|0|	
Bis(2-ethylhexyl)phthalate	1	ug/L	3.2	5.1	**|1.9|**	J	1.4	1.3	|0.1|		3.1	1.4	**|1.7|**	J	< 1	< 1	|0|	
Di-N-Octylphthalate	1	ug/L	< 1	< 1	|0|		< 1	< 1	|0|		< 1	< 1	|0|		< 1	< 1	|0|	

Analyte	RL	Units	C1 Composite – 1/24/2012				I1 Composite – 11/2/2011				I1 Composite – 1/5/2012				R1 Composite – 2/21/2012			
			Parent	Split	RPD or |Δ|	Qualifier	Parent	Split	RPD or |Δ|	Qualifier	Parent	Split	RPD or |Δ|	Qualifier	Parent	Split	RPD or |Δ|	Qualifier
Dimethylphthalate	1	ug/L	< 1	< 1	|0|		< 1	< 1	|0|		< 1	< 1	|0|		< 1	< 1	|0|	
Diethylphthalate	1	ug/L	< 1	< 1	|0|		< 1	< 1	|0|		< 1	< 1	|0|		< 1	< 1	|0|	
Di-N-Butylphthalate	1	ug/L	< 1	< 1	|0|		< 1	< 1	|0|		< 1	< 1	|0|		< 1	< 1	|0|	
Butylbenzylphthalate	1	ug/L	< 1	< 1	|0|		< 1	< 1	|0|		< 1	< 1	|0|		< 1	< 1	|0|	
Chlorpyrifos	0.2	ug/L	< 0.2	< 0.2	|0|		< 0.2	< 0.2	|0|		< 0.2	< 0.2	|0|		< 0.2	< 0.24	|0|	
Diazinon	0.2	ug/L	< 0.2	< 0.2	|0|		< 0.2	< 0.2	|0|		< 0.2	< 0.2	|0|		< 0.2	< 0.24	|0|	
Malathion	0.4	ug/L	< 0.4	< 0.4	|0|		< 0.4	< 0.4	|0|		< 0.4	< 0.4	|0|		< 0.4	< 0.47	|0|	
1-Methylnaphthalene	0.1	ug/L	< 0.1	< 0.1	|0|		< 0.1	< 0.3	|0|		< 0.1	< 0.1	|0|		< 1.1	< 1.2	|0|	
2-Methylnaphthalene	0.1	ug/L	0.06	0.08	|0.02|		< 0.1	< 0.3	|0|		< 0.1	< 0.1	|0|		< 1.1	< 1.2	|0|	
Acenaphthene	0.1	ug/L	< 0.1	< 0.1	|0|		< 0.1	< 0.3	|0|		< 0.1	< 0.1	|0|		< 1.1	< 1.2	|0|	
Acenaphthylene	0.1	ug/L	< 0.1	< 0.1	|0|		< 0.1	< 0.3	|0|		< 0.1	< 0.1	|0|		< 1.1	< 1.2	|0|	
Anthracene	0.1	ug/L	< 0.1	< 0.1	|0|		< 0.1	< 0.3	|0|		< 0.1	< 0.1	|0|		< 1.1	< 1.2	|0|	
Benzo(A)Anthracene	0.1	ug/L	< 0.1	< 0.1	|0|		< 0.1	< 0.3	|0|		< 0.1	< 0.1	|0|		< 1.1	< 1.2	|0|	
Benzo(A)Pyrene	0.1	ug/L	< 0.1	< 0.1	|0|		0.1	< 0.3	|0.2|		< 0.1	< 0.1	|0|		< 1.1	< 1.2	|0|	
Benzo(G,H,I)Perylene	0.1	ug/L	< 0.1	< 0.1	|0|		0.11	< 0.3	|0.19|		< 0.1	< 0.1	|0|		< 1.1	< 1.2	|0|	
Benzofluoranthenes, Total	0.2	ug/L	< 0.2	< 0.2	|0|		< 0.2	< 0.6	|0|		< 0.2	< 0.2	|0|		< 2.2	< 2.4	|0|	
Chrysene	0.1	ug/L	< 0.1	< 0.1	|0|		0.12	< 0.3	|0.18|		< 0.1	< 0.1	|0|		< 1.1	< 1.2	|0|	
Dibenzo(A,H)Anthracene	0.1	ug/L	< 0.1	< 0.1	|0|		< 0.1	< 0.3	|0|		< 0.1	< 0.1	|0|		< 1.1	< 1.2	|0|	
Dibenzofuran	0.1	ug/L	< 0.1	< 0.1	|0|		< 0.1	< 0.3	|0|		< 0.1	< 0.1	|0|		< 1.1	< 1.2	|0|	
Fluoranthene	0.1	ug/L	0.12	0.12	|0|		0.15	< 0.3	|0.15|		< 0.1	< 0.1	|0|		< 1.1	< 1.2	|0|	
Fluorene	0.1	ug/L	< 0.1	< 0.1	|0|		< 0.1	< 0.3	|0|		< 0.1	< 0.1	|0|		< 1.1	< 1.2	|0|	
Indeno(1,2,3-Cd)Pyrene	0.1	ug/L	< 0.1	< 0.1	|0|		< 0.1	< 0.3	|0|		< 0.1	< 0.1	|0|		< 1.1	< 1.2	|0|	
Naphthalene	0.1	ug/L	0.05	0.06	|0.01|		< 0.1	< 0.3	|0|		< 0.1	< 0.1	|0|		< 1.1	< 1.2	|0|	
Pentachlorophenol	0.5	ug/L	< 0.5	< 0.5	|0|		< 0.5	< 1.5	|0|		< 0.5	< 0.5	|0|		< 5.6	< 6	|0|	
Phenanthrene	0.1	ug/L	0.14	0.13	|0.1|		0.1	< 0.3	|0.2|		< 0.1	< 0.1	|0|		< 1.1	< 1.2	|0|	
Pyrene	0.1	ug/L	0.21	0.2	|0.01|		0.18	< 0.3	|0.12|		< 0.1	< 0.1	|0|		< 1.1	< 1.2	|0|	
Aroclor 1016	0.01	ug/L	< 0.01	< 0.01	|0|										< 0.01	< 0.01	|0|	
Aroclor 1221	0.01	ug/L	< 0.01	< 0.01	|0|										< 0.01	< 0.01	|0|	
Aroclor 1232	0.01	ug/L	< 0.01	< 0.01	|0|										< 0.01	< 0.01	|0|	
Aroclor 1242	0.01	ug/L	< 0.01	< 0.01	|0|										< 0.01	< 0.01	|0|	
Aroclor 1248	0.02	ug/L	< 0.02	< 0.018	|0|										< 0.01	< 0.01	|0|	
Aroclor 1254	0.01	ug/L	0.032	0.031	|0.001|										< 0.01	< 0.01	|0|	
Aroclor 1260	0.02	ug/L	< 0.02	< 0.025	|0|										< 0.01	< 0.01	|0|	

Notes:

U - Analyte was not detected above the reported result.

J- Analyte was positively identified. The reported result is an estimate.

UJ- Analyte was not detected above the reported estimate.

RPD – Relative percent difference, |Δ| - Absolute difference. RPD may be calculated based on results with more significant figures than those shown in this table.

Appendix C.2: Stormwater Characterization - Annual, Storm And Base Flow Event Hydrographs

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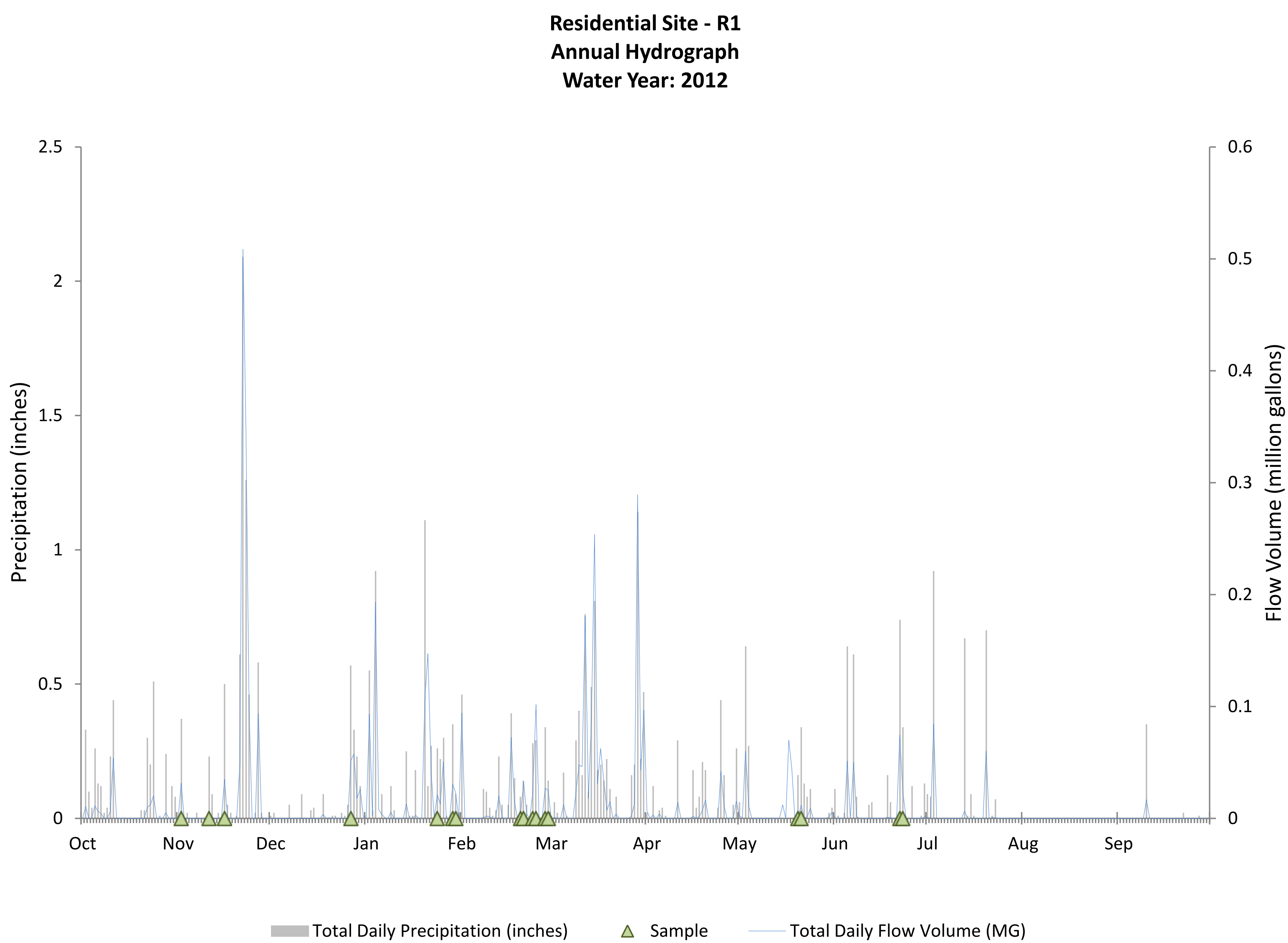
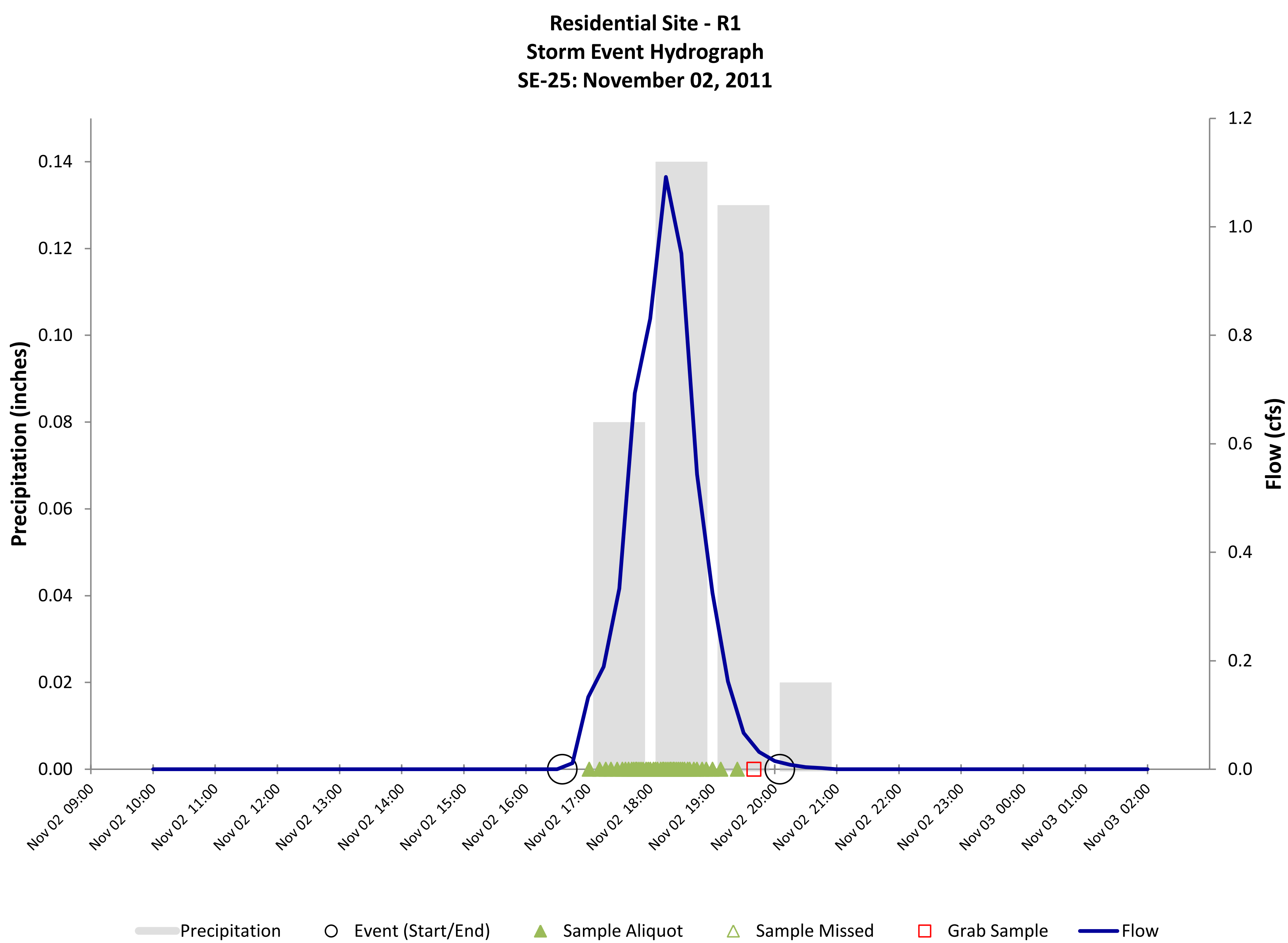
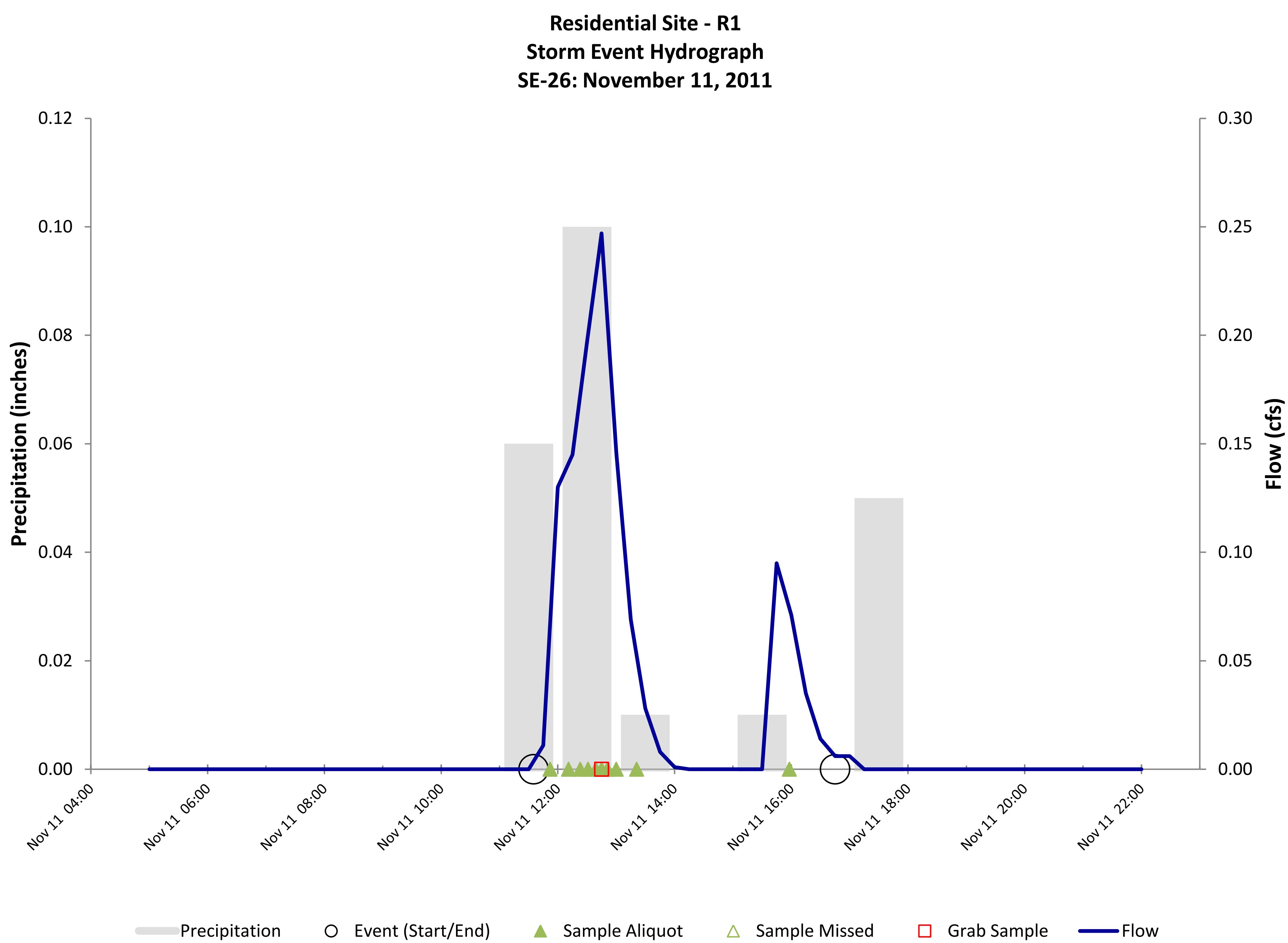
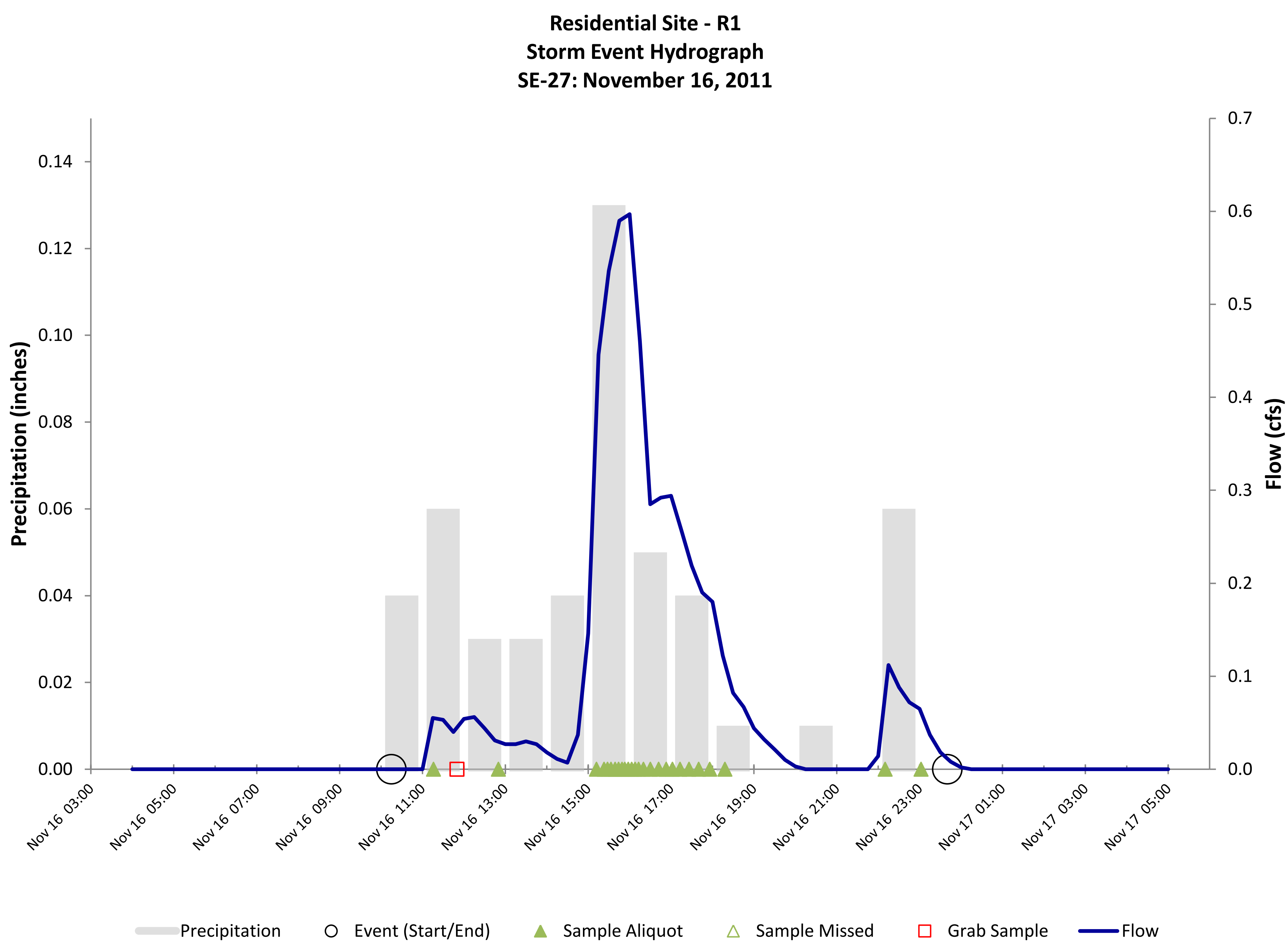


Residential Site - R1
Annual Hydrograph
Water Year: 2012
Precipitation (inches)
Flow Volume (million gallons)
2.5
2
1.5
1
0.5
0
0.6
0.5
0.4
0.3
0.2
0.1
0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Total Daily Precipitation (inches)
Sample
Total Daily Flow Volume (MG)

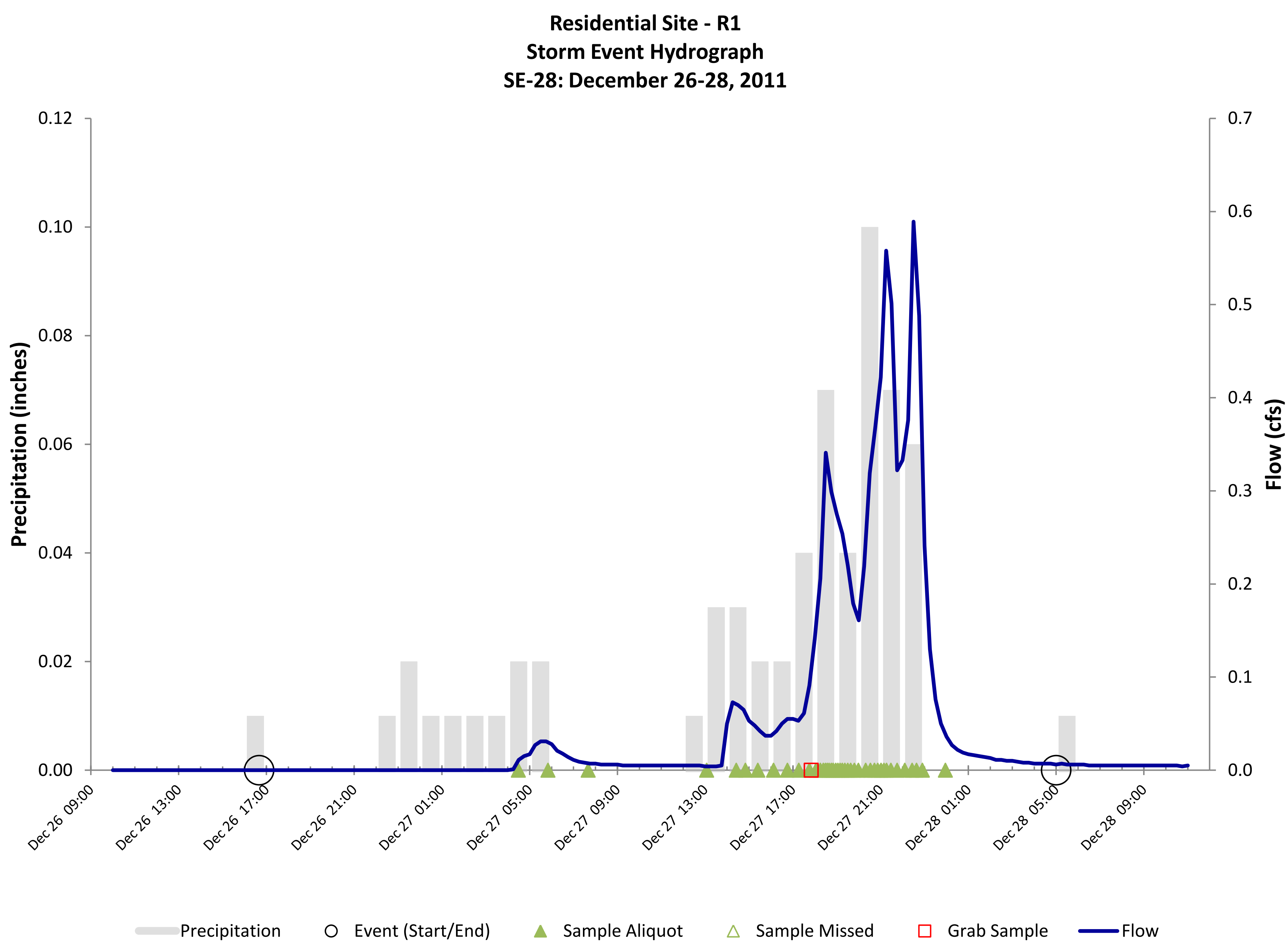


Residential Site - R1
Storm Event Hydrograph
SE-25: November 02, 2011
Precipitation (inches)
Flow (cfs)
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14
0.0
0.2
0.4
0.6
0.8
1.0
1.2
Nov 02 09:00
Nov 02 10:00
Nov 02 11:00
Nov 02 12:00
Nov 02 13:00
Nov 02 14:00
Nov 02 15:00
Nov 02 16:00
Nov 02 17:00
Nov 02 18:00
Nov 02 19:00
Nov 02 20:00
Nov 02 21:00
Nov 02 22:00
Nov 02 23:00
Nov 03 00:00
Nov 03 01:00
Nov 03 02:00
Precipitation
Event (Start/End)
Sample Aliquot
Sample Missed
Grab Sample
Flow

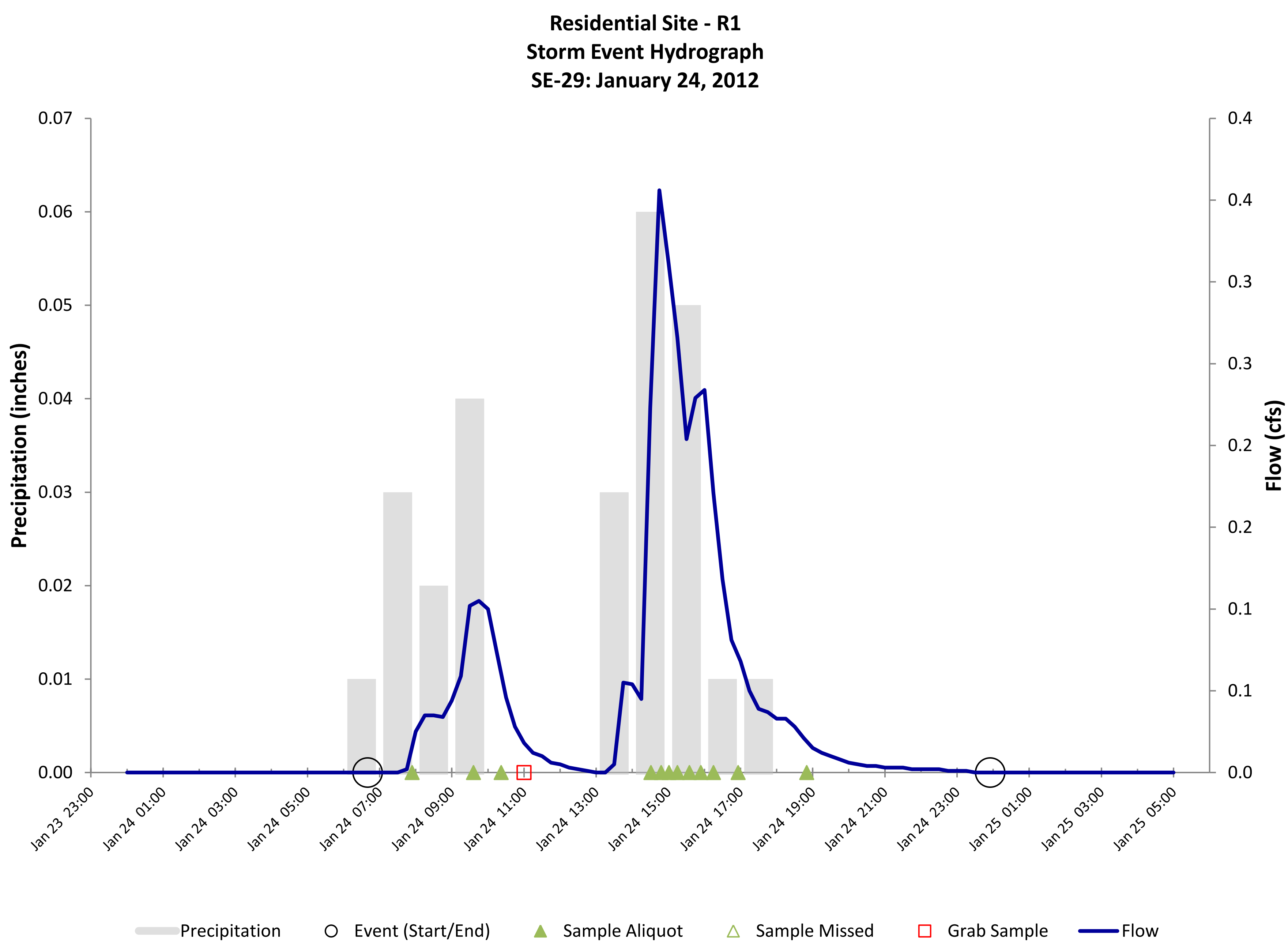

Residential Site - R1
Storm Event Hydrograph
SE-26: November 11, 2011
Precipitation (inches)
Flow (cfs)
0.12
0.10
0.08
0.06
0.04
0.02
0.00
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Nov 11 04:00
Nov 11 06:00
Nov 11 08:00
Nov 11 10:00
Nov 11 12:00
Nov 11 14:00
Nov 11 16:00
Nov 11 18:00
Nov 11 20:00
Nov 11 22:00
Precipitation
Event (Start/End)
Sample Aliquot
Sample Missed
Grab Sample
Flow



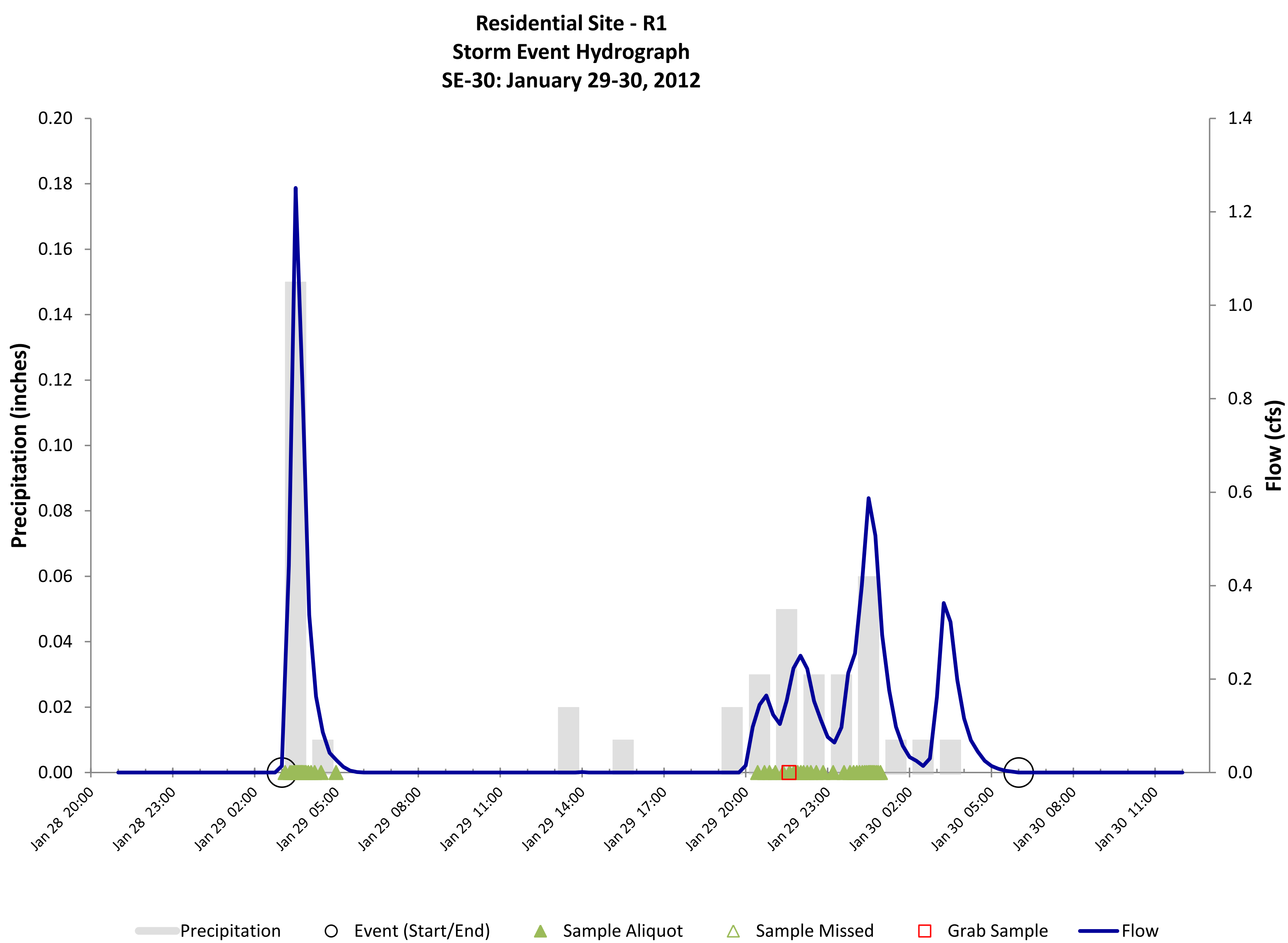
Residential Site - R1
Storm Event Hydrograph
SE-27: November 16, 2011
Precipitation (inches)
Flow (cfs)
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Nov 16 03:00
Nov 16 05:00
Nov 16 07:00
Nov 16 09:00
Nov 16 11:00
Nov 16 13:00
Nov 16 15:00
Nov 16 17:00
Nov 16 19:00
Nov 16 21:00
Nov 16 23:00
Nov 17 01:00
Nov 17 03:00
Nov 17 05:00
Precipitation
Event (Start/End)
Sample Aliquot
Sample Missed
Grab Sample
Flow



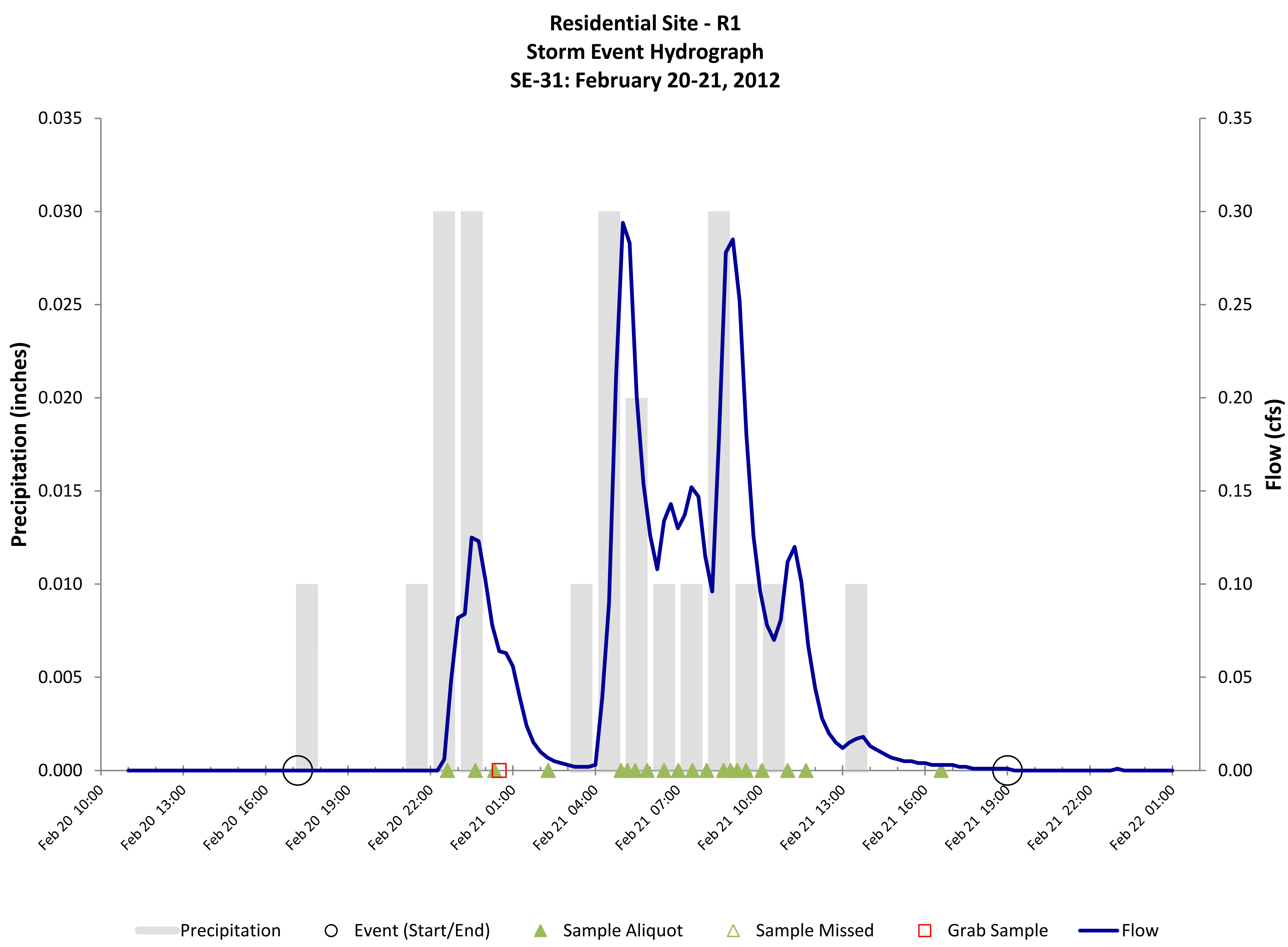
Residential Site - R1
Storm Event Hydrograph
SE-28: December 26-28, 2011
Precipitation (inches)
Flow (cfs)
0.12
0.10
0.08
0.06
0.04
0.02
0.00
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Dec 26 09:00
Dec 26 13:00
Dec 26 17:00
Dec 26 21:00
Dec 27 01:00
Dec 27 05:00
Dec 27 09:00
Dec 27 13:00
Dec 27 17:00
Dec 27 21:00
Dec 28 01:00
Dec 28 05:00
Dec 28 09:00
Precipitation
Event (Start/End)
Sample Aliquot
Sample Missed
Grab Sample
Flow



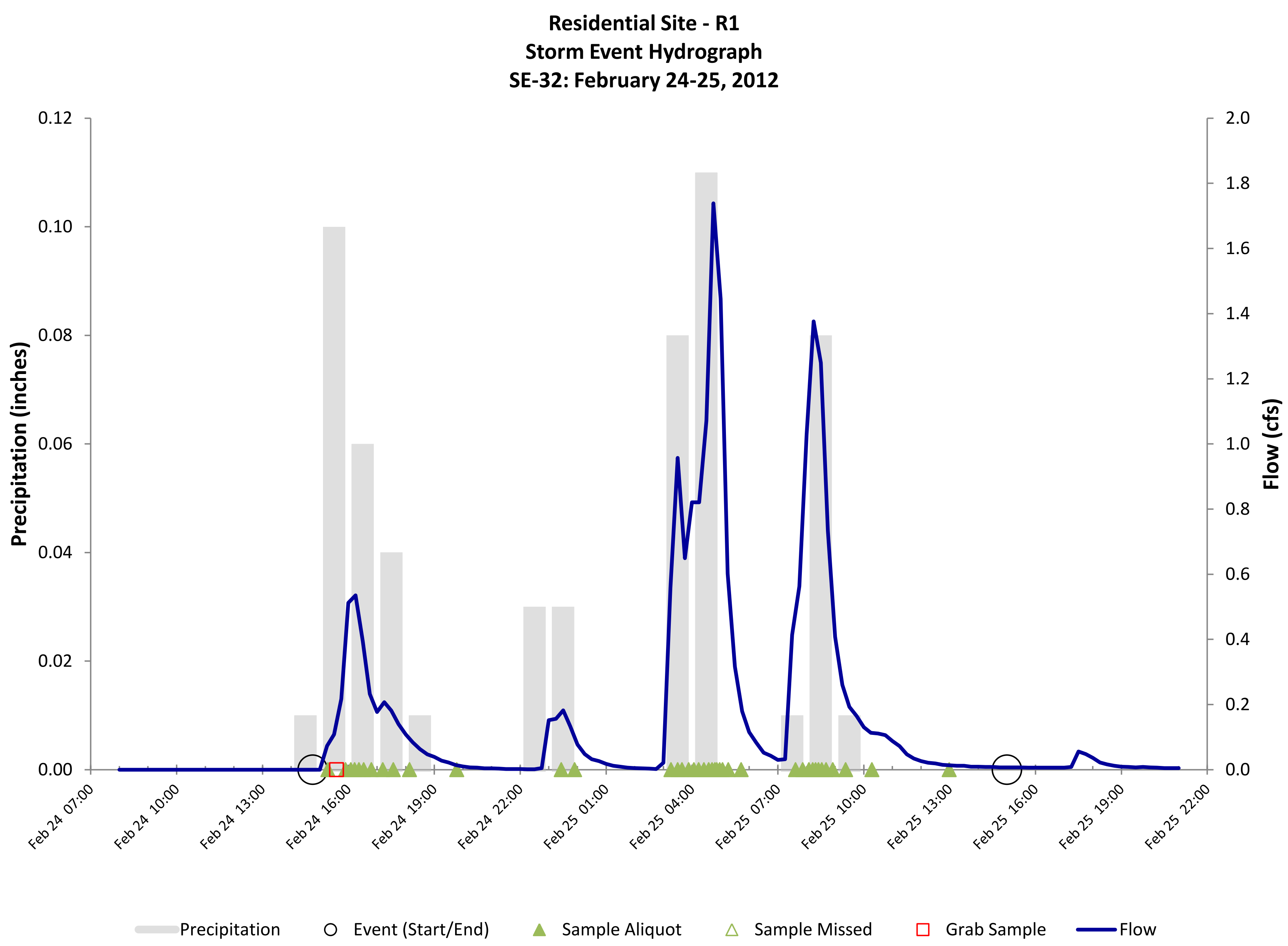
Residential Site - R1
Storm Event Hydrograph
SE-29: January 24, 2012
Precipitation (inches)
Flow (cfs)
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
0.4
0.4
0.3
0.3
0.2
0.2
0.1
0.1
0.0
Jan 23 23:00
Jan 24 01:00
Jan 24 03:00
Jan 24 05:00
Jan 24 07:00
Jan 24 09:00
Jan 24 11:00
Jan 24 13:00
Jan 24 15:00
Jan 24 17:00
Jan 24 19:00
Jan 24 21:00
Jan 24 23:00
Jan 25 01:00
Jan 25 03:00
Jan 25 05:00
Precipitation
Event (Start/End)
Sample Aliquot
Sample Missed
Grab Sample
Flow



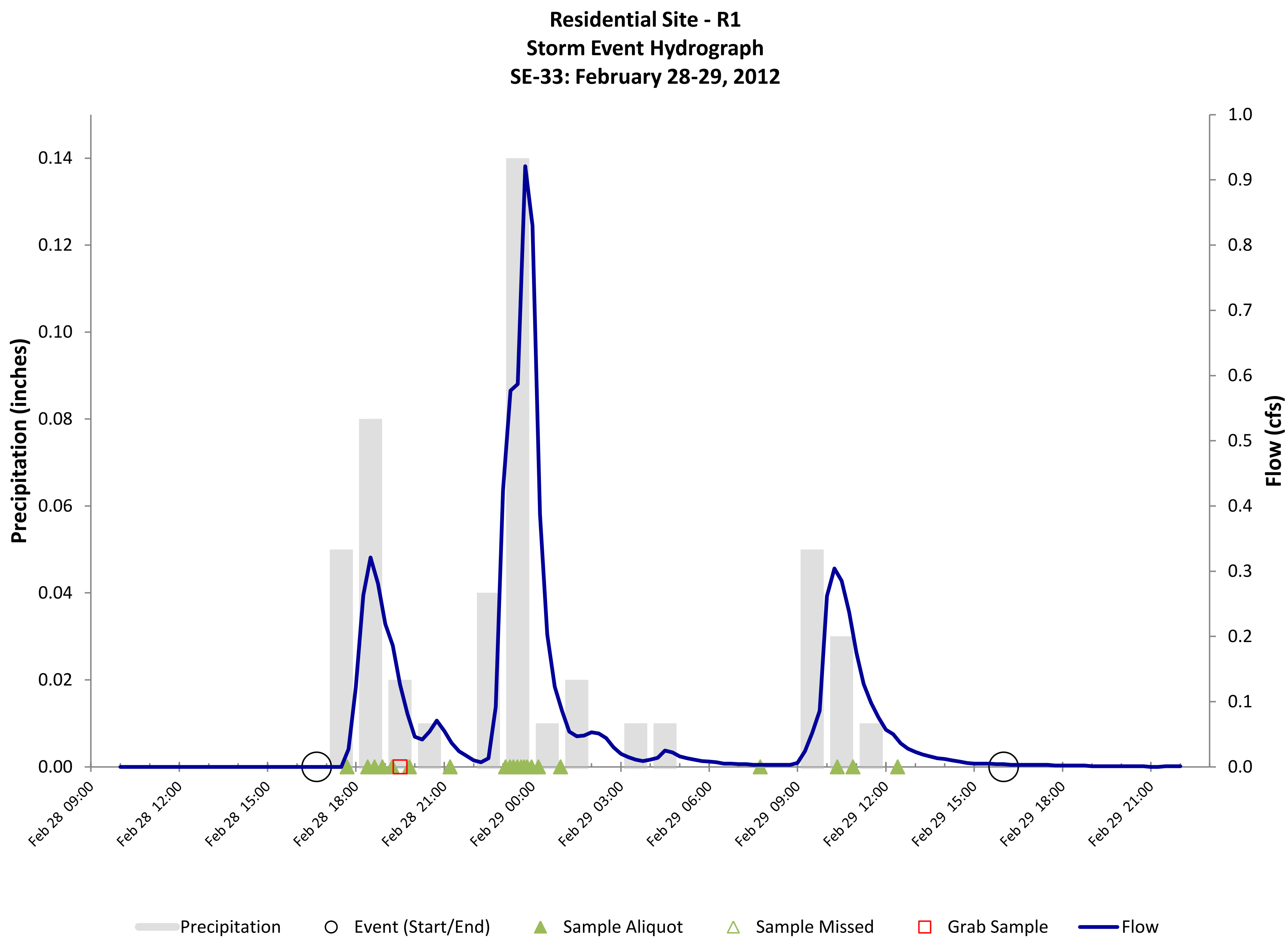
Residential Site - R1
Storm Event Hydrograph
SE-30: January 29-30, 2012
Precipitation (inches)
Flow (cfs)
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Jan 28 20:00
Jan 28 23:00
Jan 29 02:00
Jan 29 05:00
Jan 29 08:00
Jan 29 11:00
Jan 29 14:00
Jan 29 17:00
Jan 29 20:00
Jan 29 23:00
Jan 30 02:00
Jan 30 05:00
Jan 30 08:00
Jan 30 11:00
Precipitation
Event (Start/End)
Sample Aliquot
Sample Missed
Grab Sample
Flow

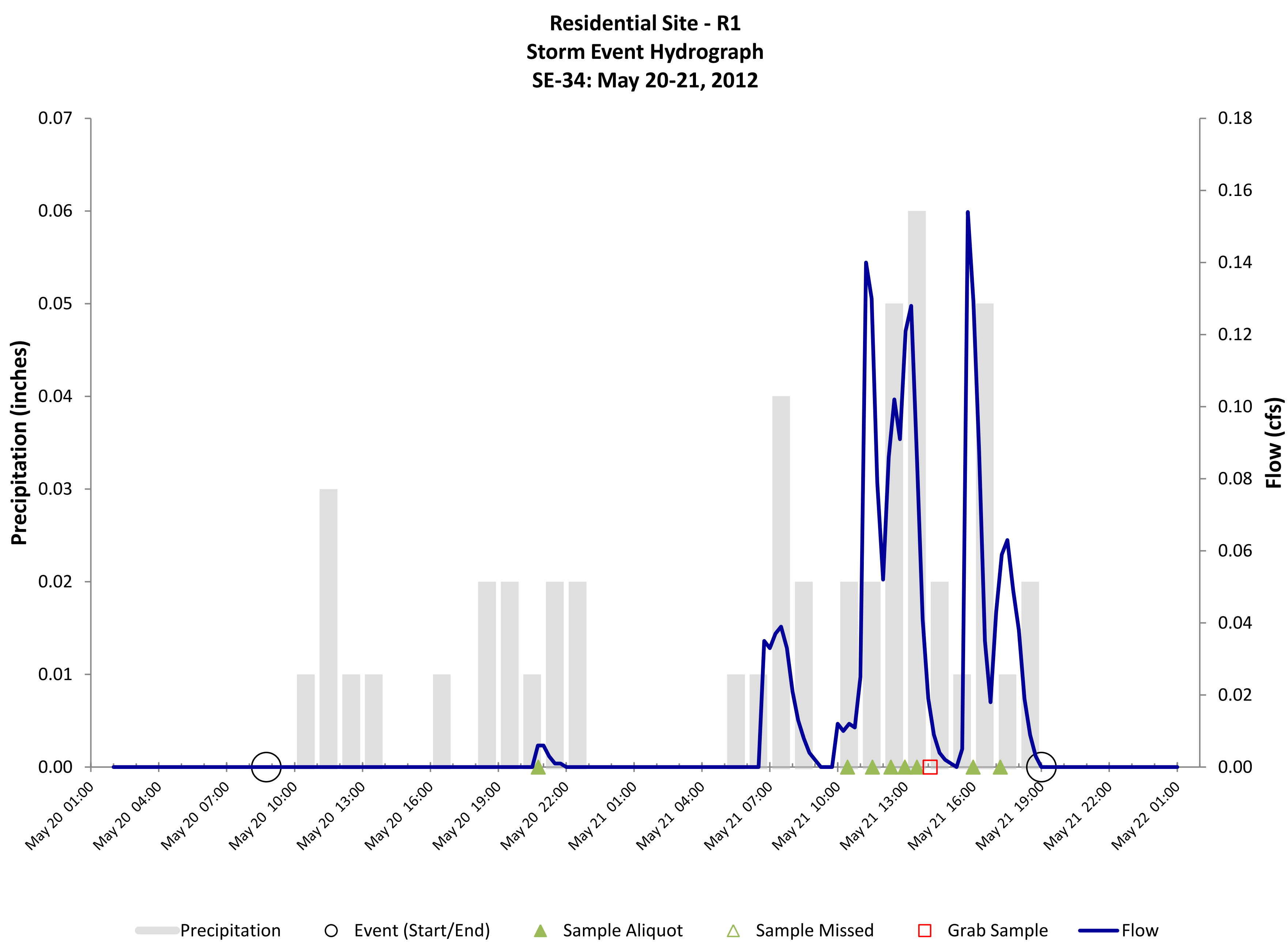


Residential Site - R1
Storm Event Hydrograph
SE-31: February 20-21, 2012
Precipitation (inches)
Flow (cfs)
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Feb 20 10:00
Feb 20 13:00
Feb 20 16:00
Feb 20 19:00
Feb 20 22:00
Feb 21 01:00
Feb 21 04:00
Feb 21 07:00
Feb 21 10:00
Feb 21 13:00
Feb 21 16:00
Feb 21 19:00
Feb 21 22:00
Feb 22 01:00
Precipitation
Event (Start/End)
Sample Aliquot
Sample Missed
Grab Sample
Flow

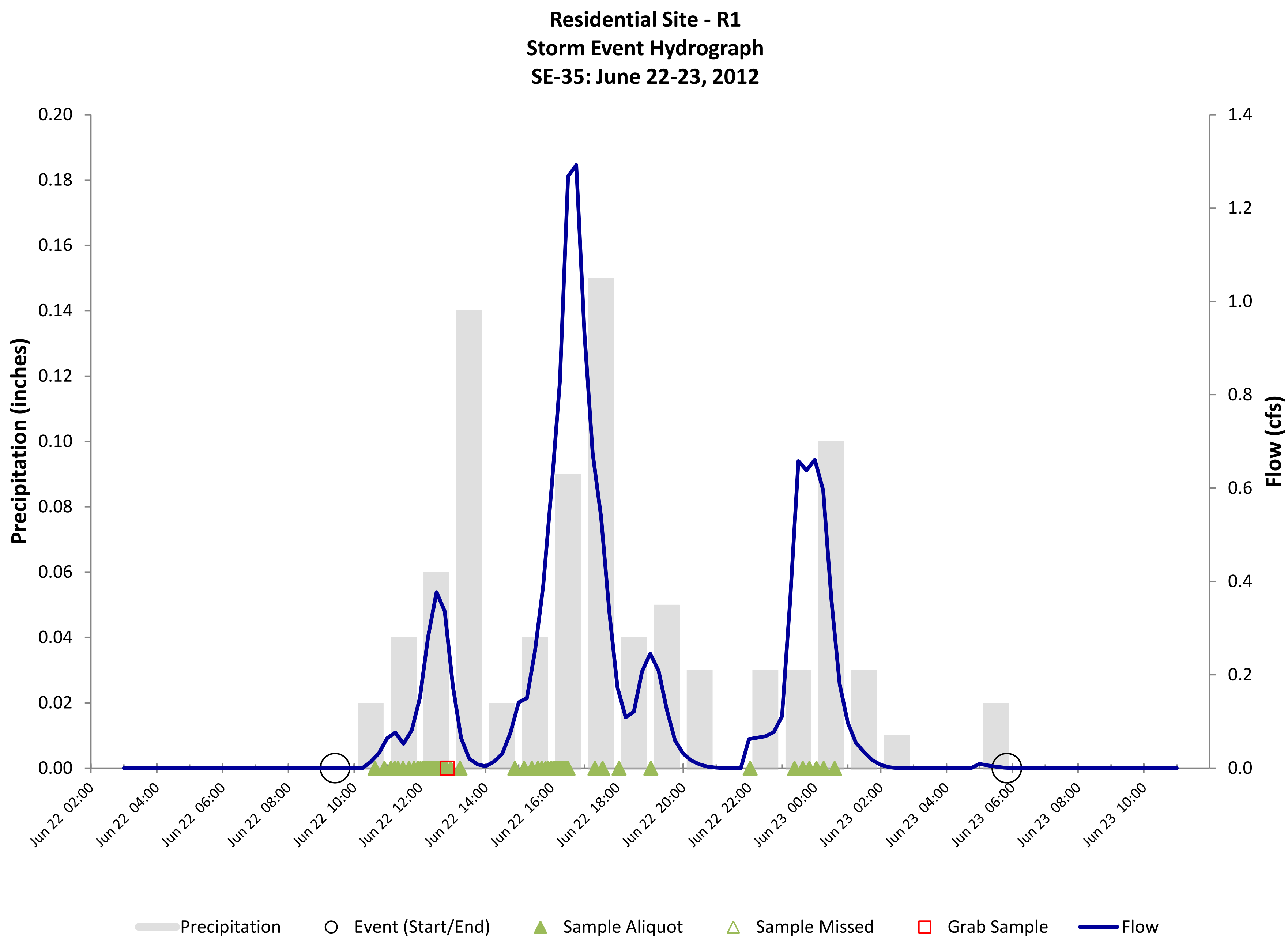


Residential Site - R1
Storm Event Hydrograph
SE-32: February 24-25, 2012
Precipitation (inches)
Flow (cfs)
0.12
0.10
0.08
0.06
0.04
0.02
0.00
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Feb 24 07:00
Feb 24 10:00
Feb 24 13:00
Feb 24 16:00
Feb 24 19:00
Feb 24 22:00
Feb 25 01:00
Feb 25 04:00
Feb 25 07:00
Feb 25 10:00
Feb 25 13:00
Feb 25 16:00
Feb 25 19:00
Feb 25 22:00
Precipitation
Event (Start/End)
Sample Aliquot
Sample Missed
Grab Sample
Flow

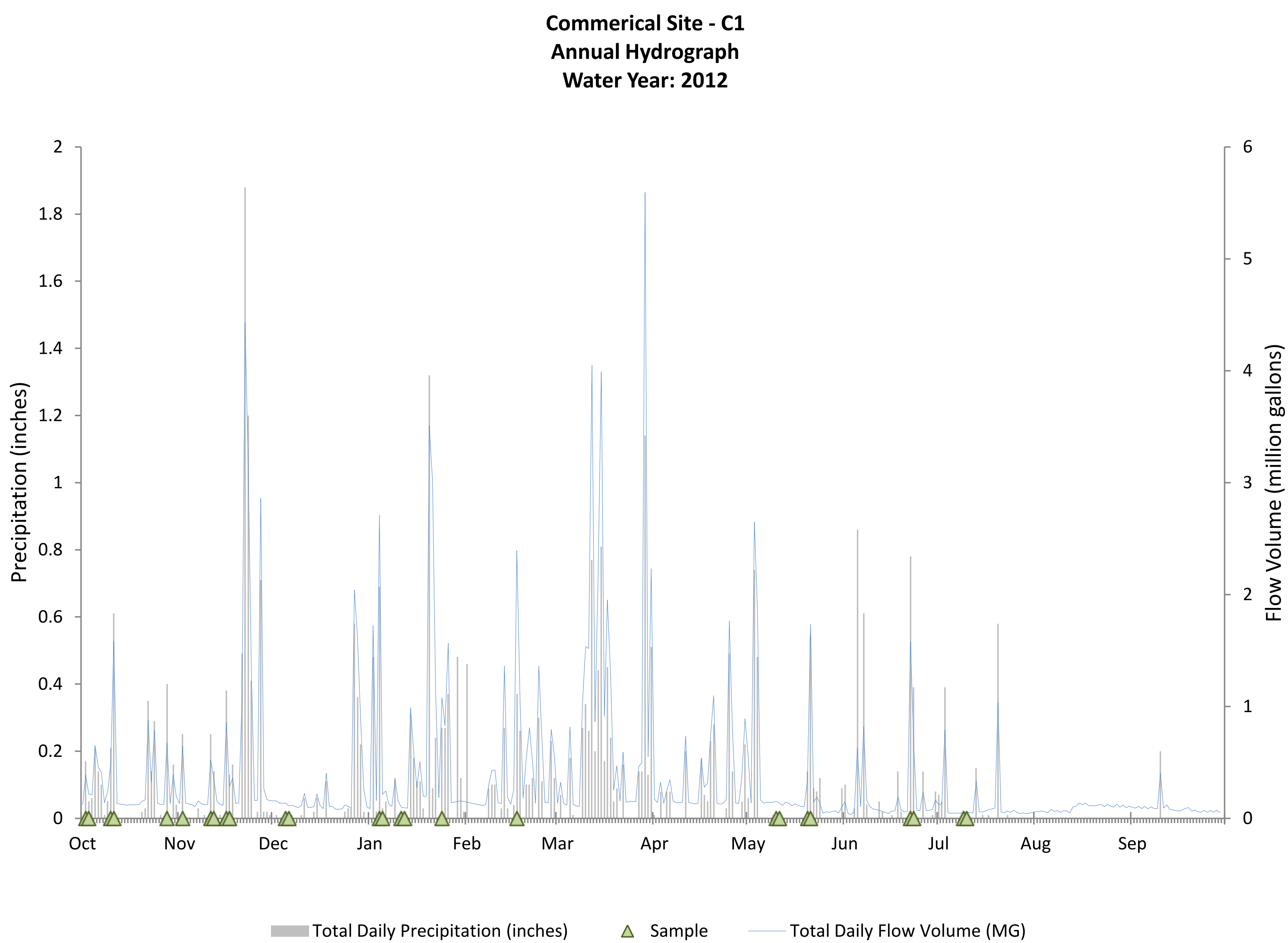

Residential Site - R1
Storm Event Hydrograph
SE-33: February 28-29, 2012
Precipitation (inches)
Flow (cfs)
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Feb 28 09:00
Feb 28 12:00
Feb 28 15:00
Feb 28 18:00
Feb 28 21:00
Feb 29 00:00
Feb 29 03:00
Feb 29 06:00
Feb 29 09:00
Feb 29 12:00
Feb 29 15:00
Feb 29 18:00
Feb 29 21:00
Precipitation
Event (Start/End)
Sample Aliquot
Sample Missed
Grab Sample
Flow



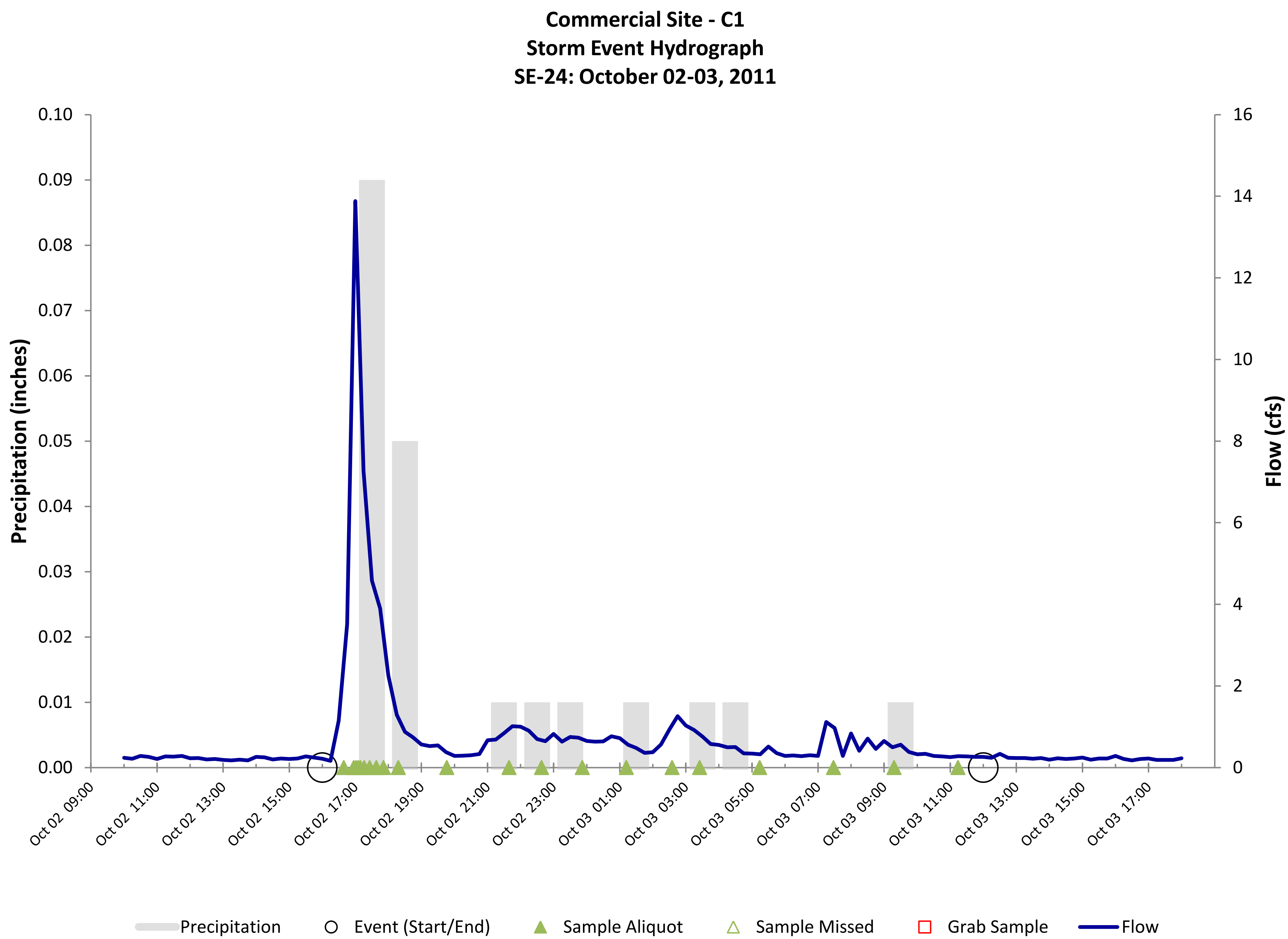
Residential Site - R1
Storm Event Hydrograph
SE-34: May 20-21, 2012
Precipitation (inches)
Flow (cfs)
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
May 20 01:00
May 20 04:00
May 20 07:00
May 20 10:00
May 20 13:00
May 20 16:00
May 20 19:00
May 20 22:00
May 21 01:00
May 21 04:00
May 21 07:00
May 21 10:00
May 21 13:00
May 21 16:00
May 21 19:00
May 21 22:00
May 22 01:00
Precipitation
Event (Start/End)
Sample Aliquot
Sample Missed
Grab Sample
Flow



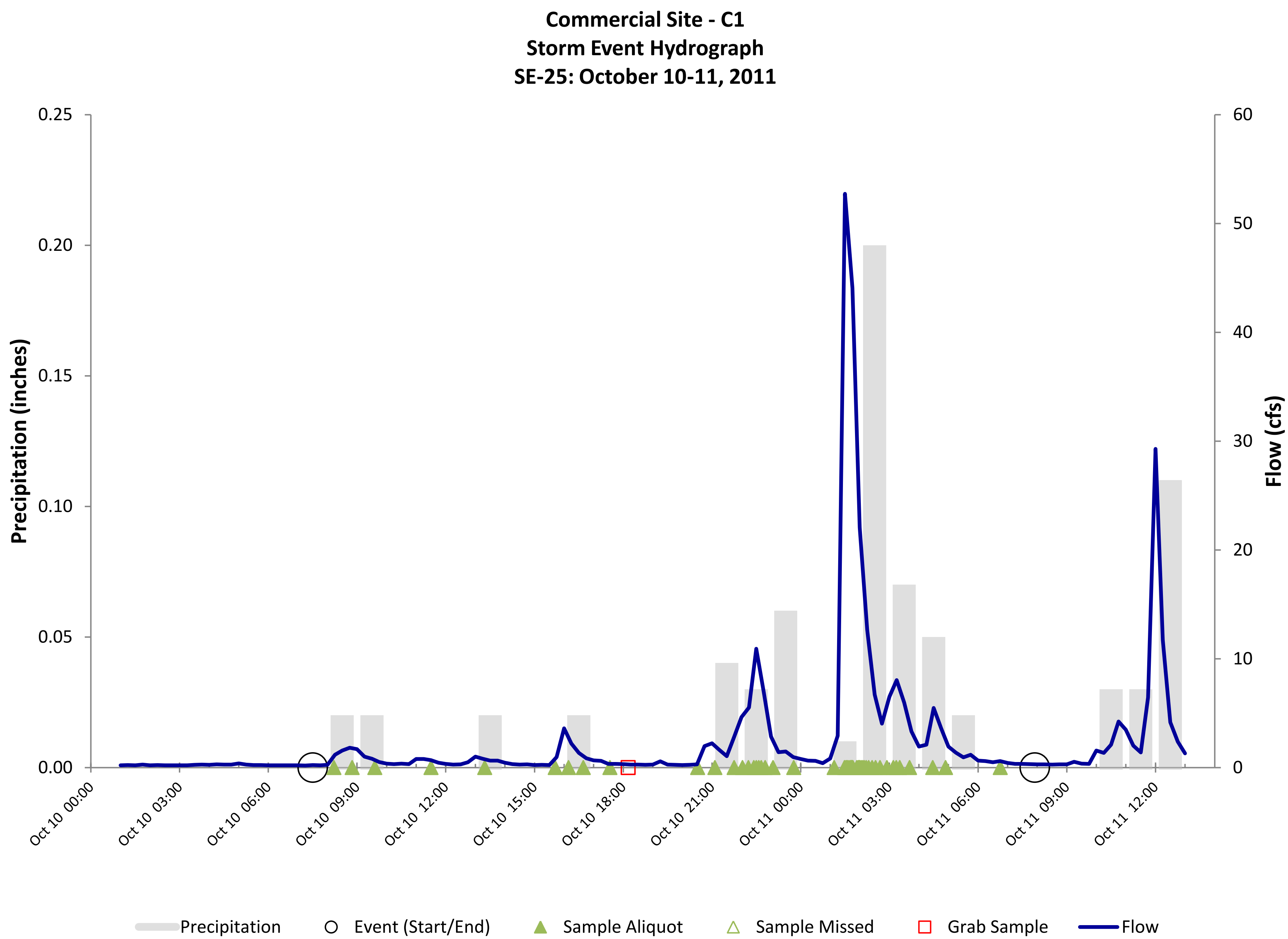
Residential Site - R1
Storm Event Hydrograph
SE-35: June 22-23, 2012
Precipitation (inches)
Flow (cfs)
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Jun 22 02:00
Jun 22 04:00
Jun 22 06:00
Jun 22 08:00
Jun 22 10:00
Jun 22 12:00
Jun 22 14:00
Jun 22 16:00
Jun 22 18:00
Jun 22 20:00
Jun 22 22:00
Jun 23 00:00
Jun 23 02:00
Jun 23 04:00
Jun 23 06:00
Jun 23 08:00
Jun 23 10:00
Precipitation
Event (Start/End)
Sample Aliquot
Sample Missed
Grab Sample
Flow



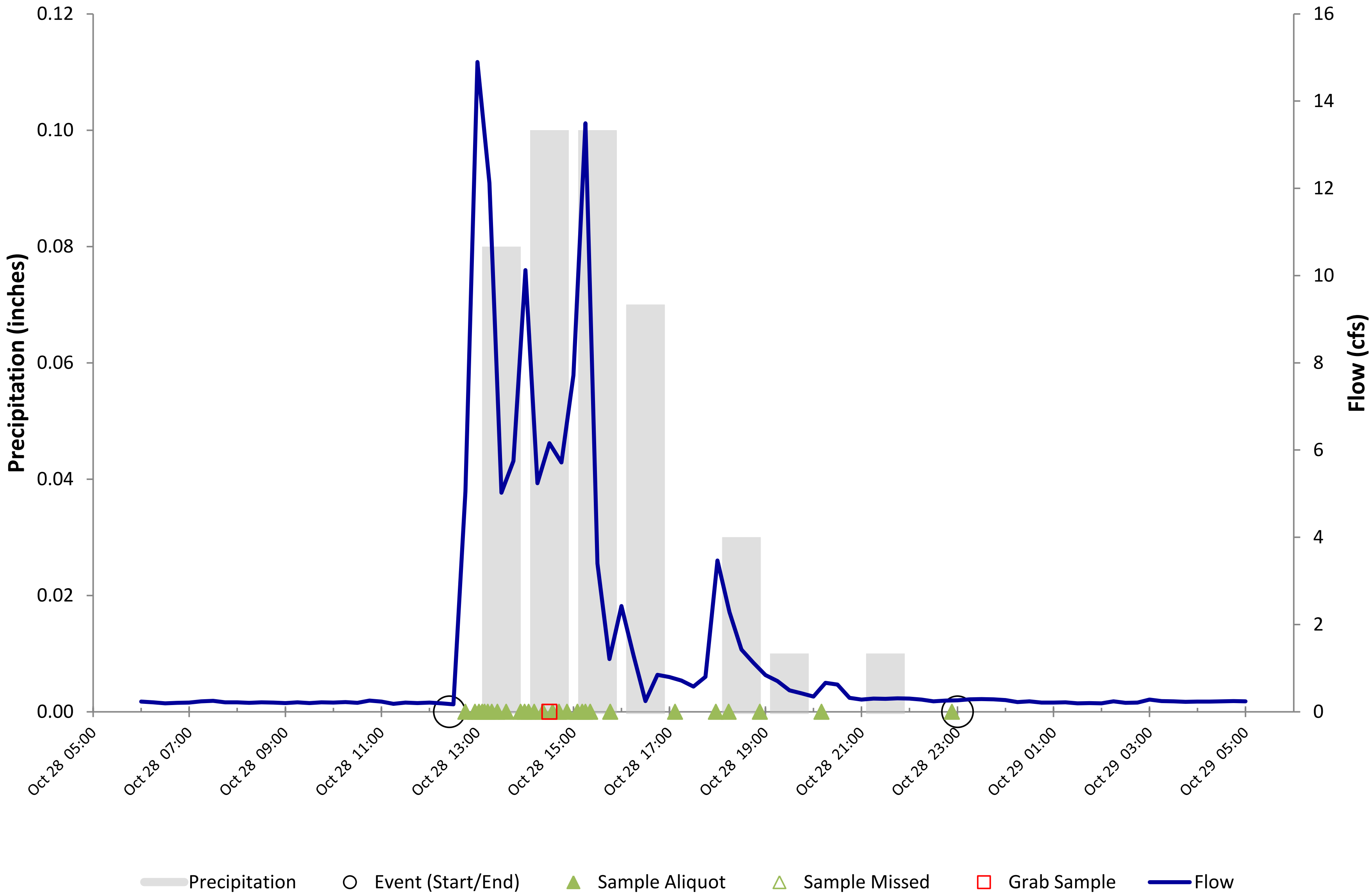
Commerical Site - C1
Annual Hydrograph
Water Year: 2012
Precipitation (inches)
Flow Volume (million gallons)
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
6
5
4
3
2
1
0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Total Daily Precipitation (inches)
Sample
Total Daily Flow Volume (MG)

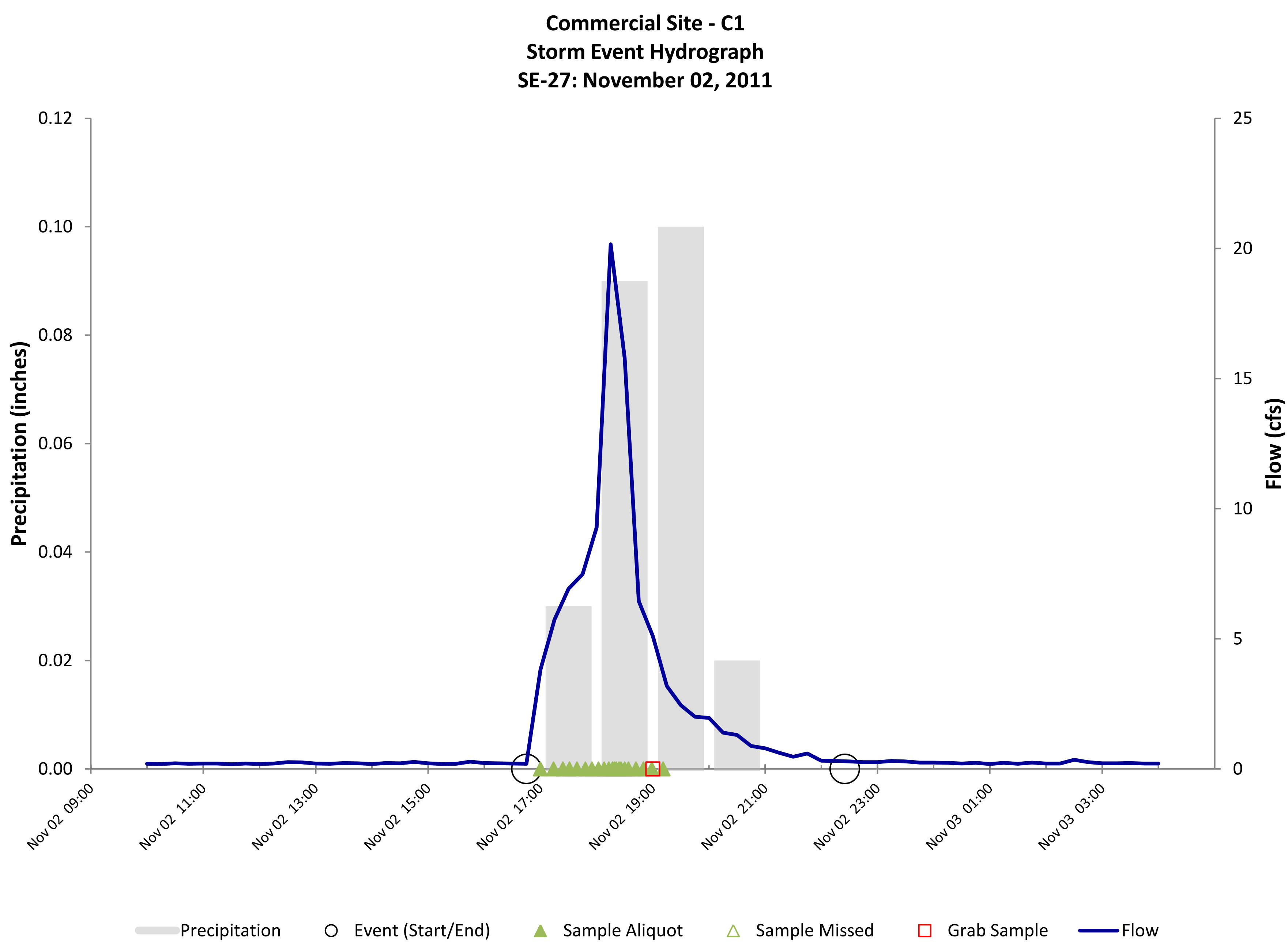


Commercial Site - C1
Storm Event Hydrograph
SE-24: October 02-03, 2011
Precipitation (inches)
Flow (cfs)
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
16
14
12
10
8
6
4
2
0
Oct 02 09:00
Oct 02 11:00
Oct 02 13:00
Oct 02 15:00
Oct 02 17:00
Oct 02 19:00
Oct 02 21:00
Oct 02 23:00
Oct 03 01:00
Oct 03 03:00
Oct 03 05:00
Oct 03 07:00
Oct 03 09:00
Oct 03 11:00
Oct 03 13:00
Oct 03 15:00
Oct 03 17:00
Precipitation
Event (Start/End)
Sample Aliquot
Sample Missed
Grab Sample
Flow

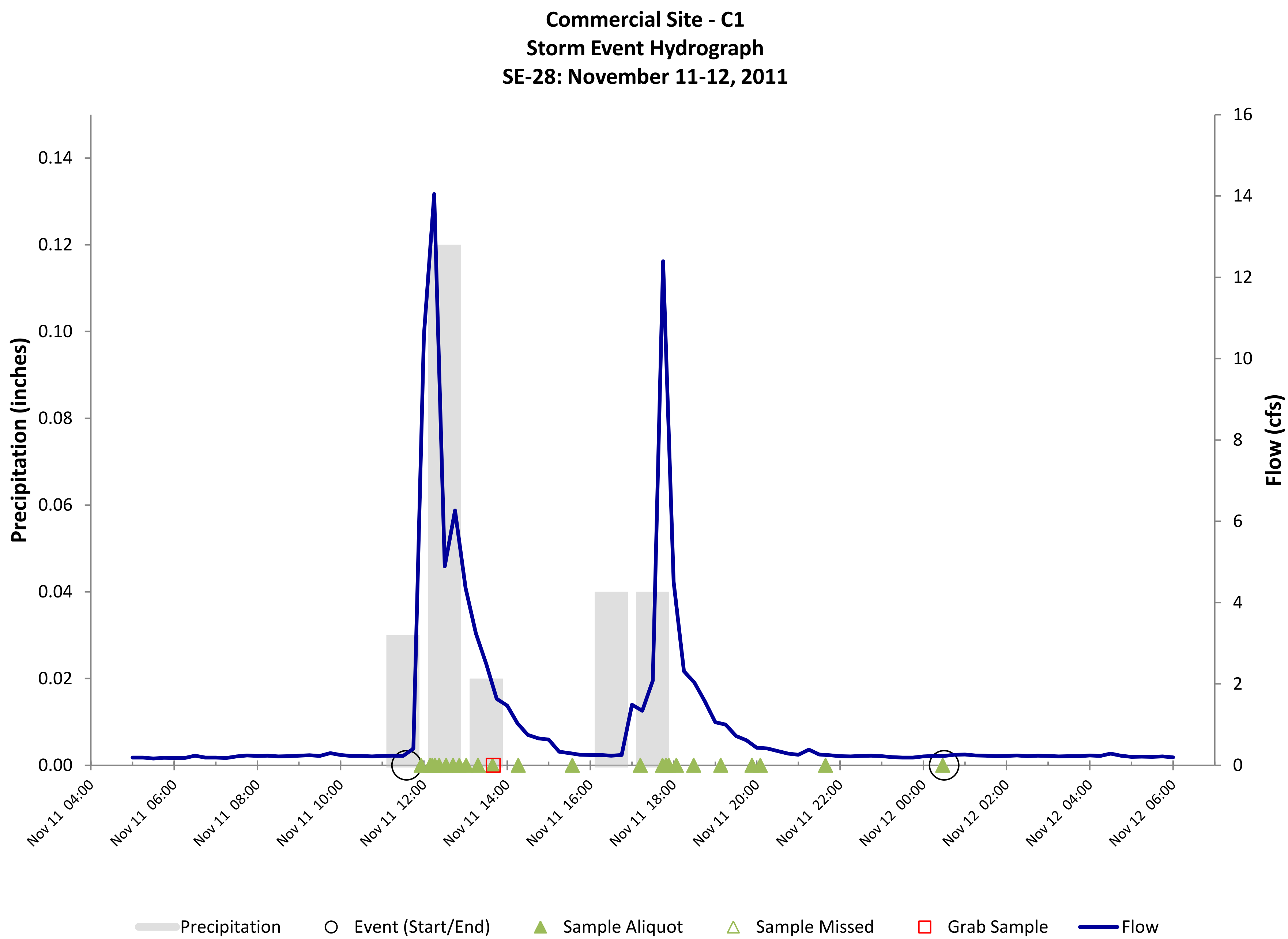

Commercial Site - C1
Storm Event Hydrograph
SE-25: October 10-11, 2011
Precipitation (inches)
Flow (cfs)
0.25
0.20
0.15
0.10
0.05
0.00
60
50
40
30
20
10
0
Oct 10 00:00
Oct 10 03:00
Oct 10 06:00
Oct 10 09:00
Oct 10 12:00
Oct 10 15:00
Oct 10 18:00
Oct 10 21:00
Oct 11 00:00
Oct 11 03:00
Oct 11 06:00
Oct 11 09:00
Oct 11 12:00
Precipitation
Event (Start/End)
Sample Aliquot
Sample Missed
Grab Sample
Flow

Commercial Site - C1
Storm Event Hydrograph
SE-26: October 28, 2011



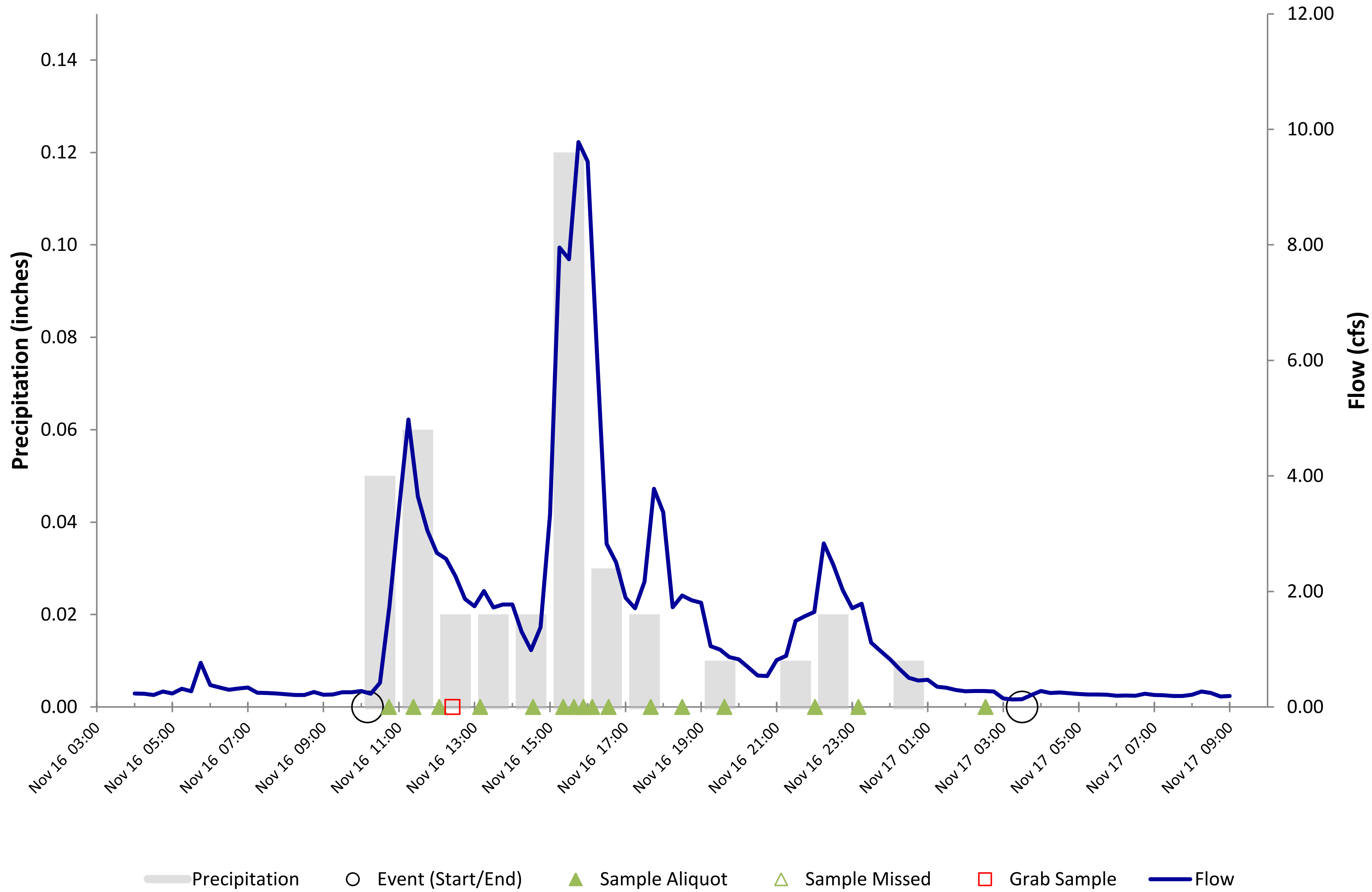


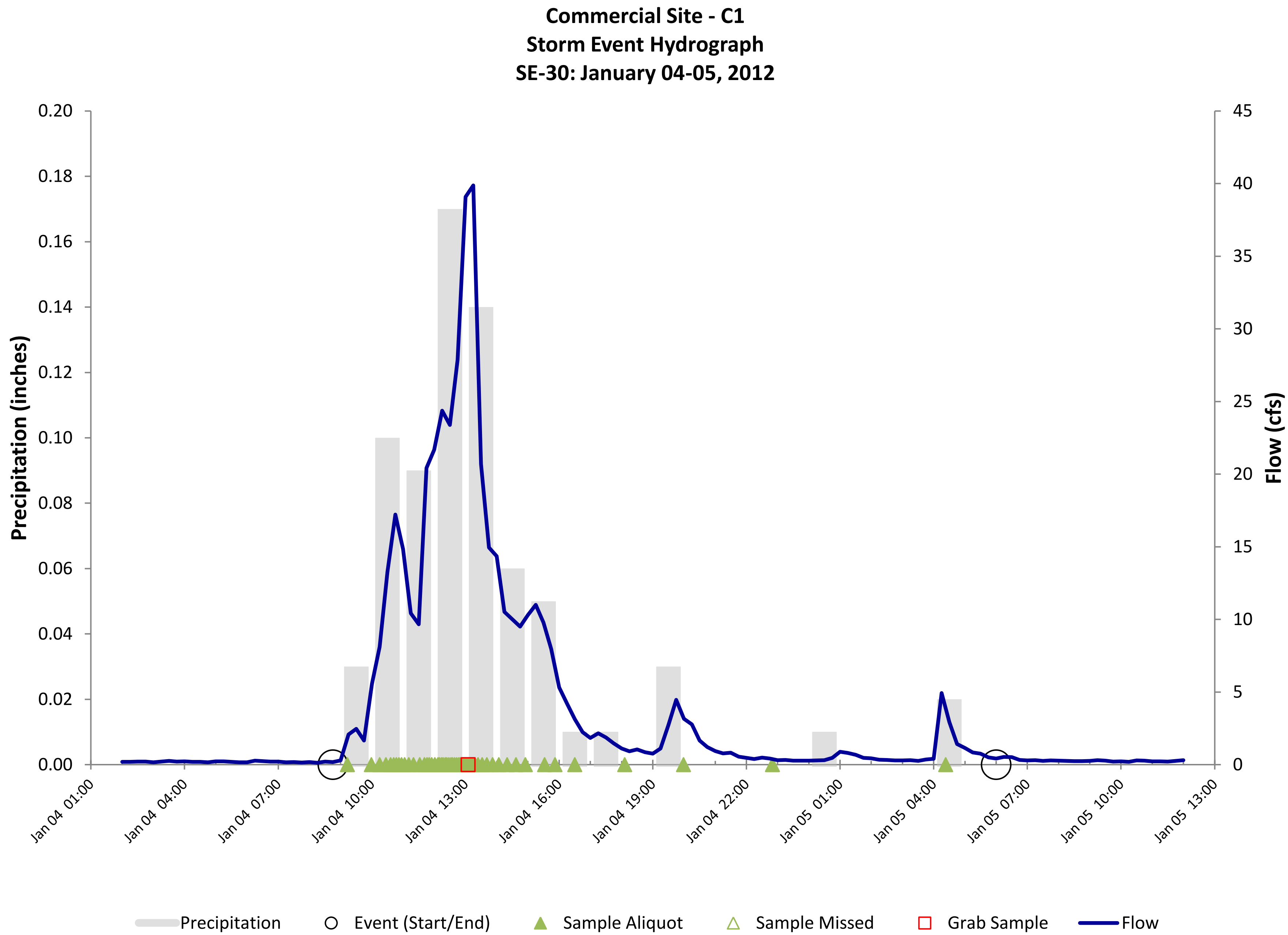
Commercial Site - C1
Storm Event Hydrograph
SE-27: November 02, 2011
Precipitation (inches)
Flow (cfs)
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0
5
10
15
20
25
Nov 02 09:00
Nov 02 11:00
Nov 02 13:00
Nov 02 15:00
Nov 02 17:00
Nov 02 19:00
Nov 02 21:00
Nov 02 23:00
Nov 03 01:00
Nov 03 03:00
Precipitation
Event (Start/End)
Sample Aliquot
Sample Missed
Grab Sample
Flow



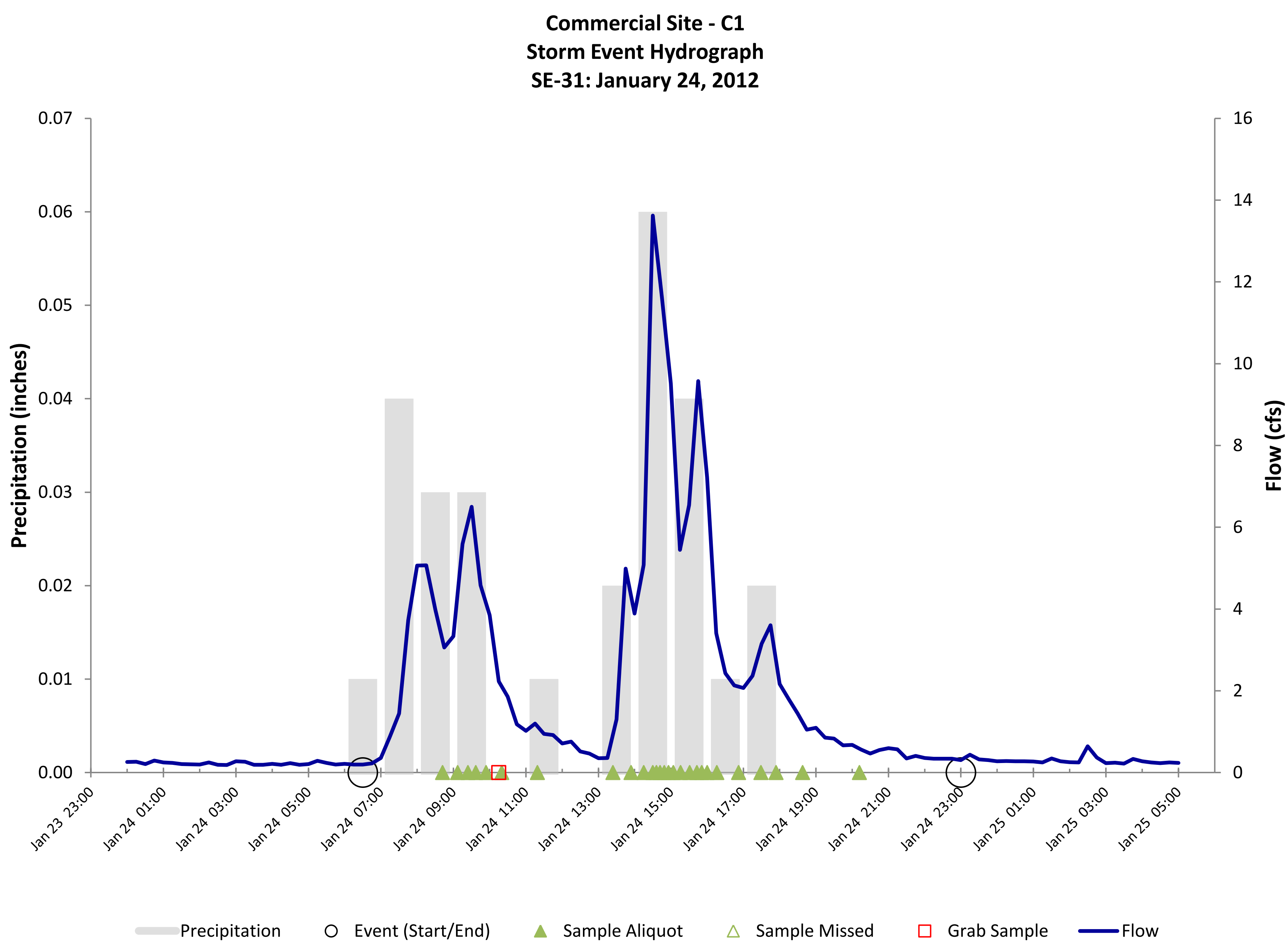
Commercial Site - C1
Storm Event Hydrograph
SE-28: November 11-12, 2011
Precipitation (inches)
Flow (cfs)
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
16
14
12
10
8
6
4
2
0
Nov 11 04:00
Nov 11 06:00
Nov 11 08:00
Nov 11 10:00
Nov 11 12:00
Nov 11 14:00
Nov 11 16:00
Nov 11 18:00
Nov 11 20:00
Nov 11 22:00
Nov 12 00:00
Nov 12 02:00
Nov 12 04:00
Nov 12 06:00
Precipitation
Event (Start/End)
Sample Aliquot
Sample Missed
Grab Sample
Flow

Commercial Site - C1
Storm Event Hydrograph
SE-29: November 16-17, 2011

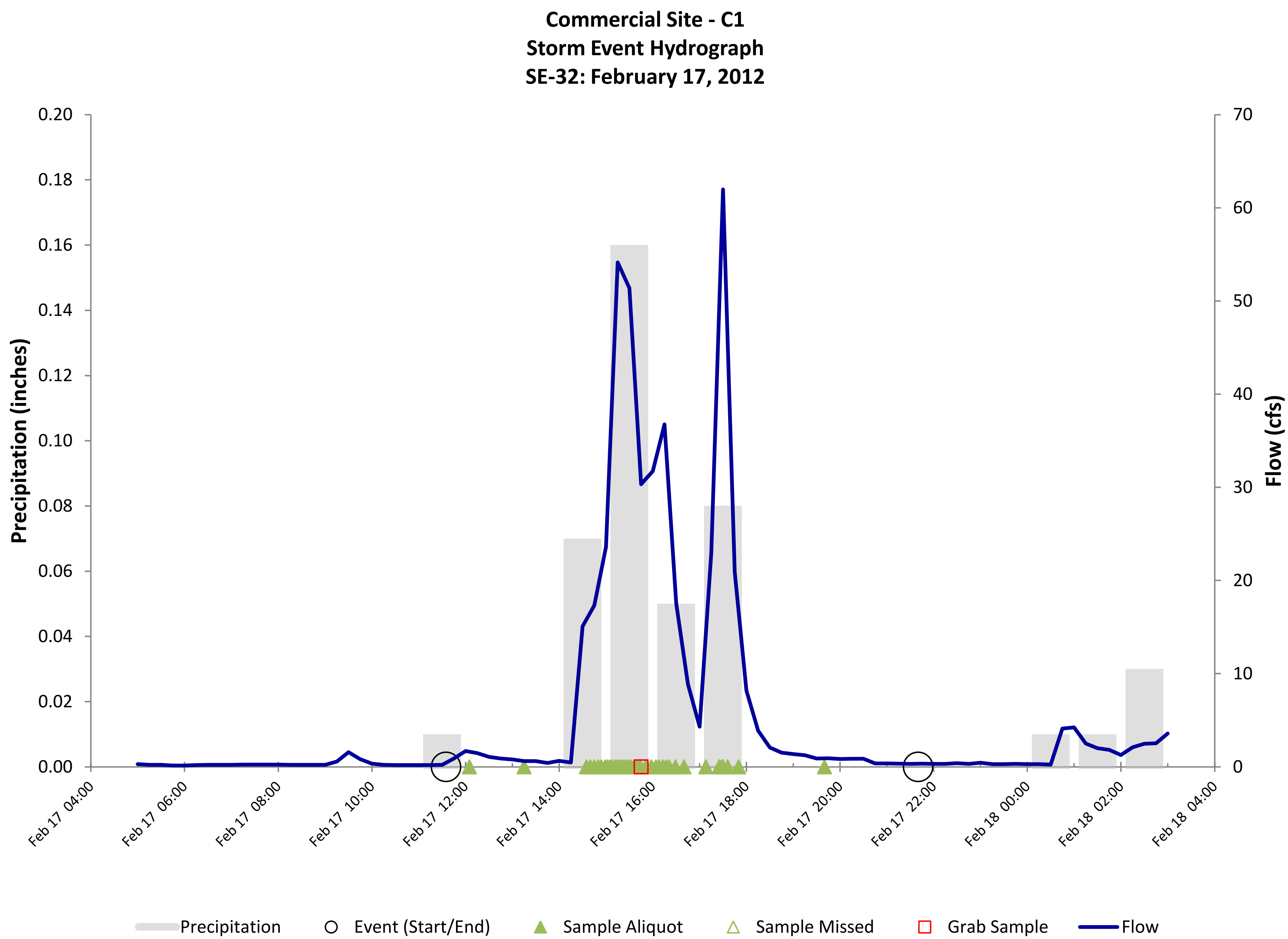




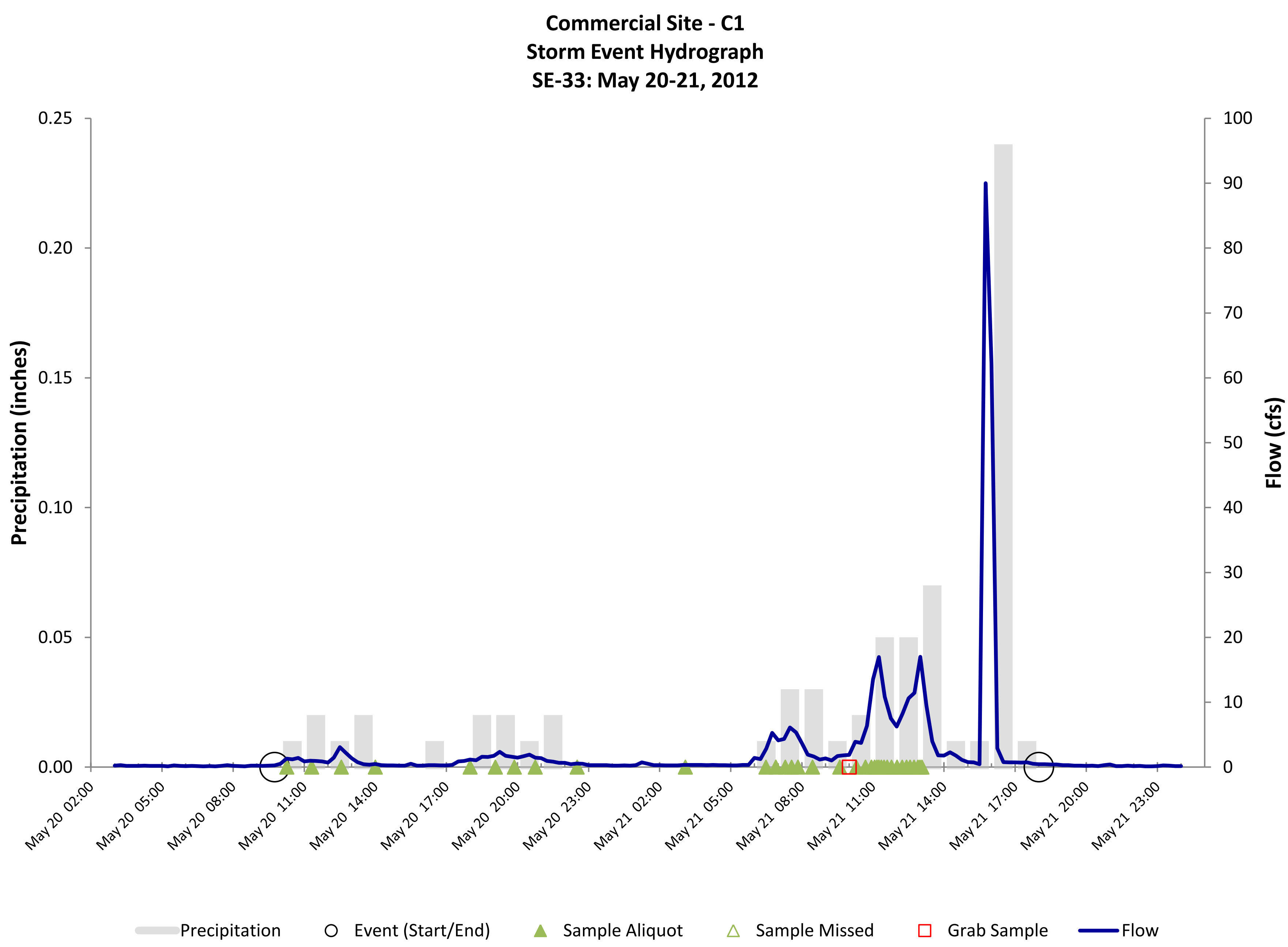
Commercial Site - C1
Storm Event Hydrograph
SE-30: January 04-05, 2012
Precipitation (inches)
Flow (cfs)
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
45
40
35
30
25
20
15
10
5
0
Jan 04 01:00
Jan 04 04:00
Jan 04 07:00
Jan 04 10:00
Jan 04 13:00
Jan 04 16:00
Jan 04 19:00
Jan 04 22:00
Jan 05 01:00
Jan 05 04:00
Jan 05 07:00
Jan 05 10:00
Jan 05 13:00
Precipitation
Event (Start/End)
Sample Aliquot
Sample Missed
Grab Sample
Flow

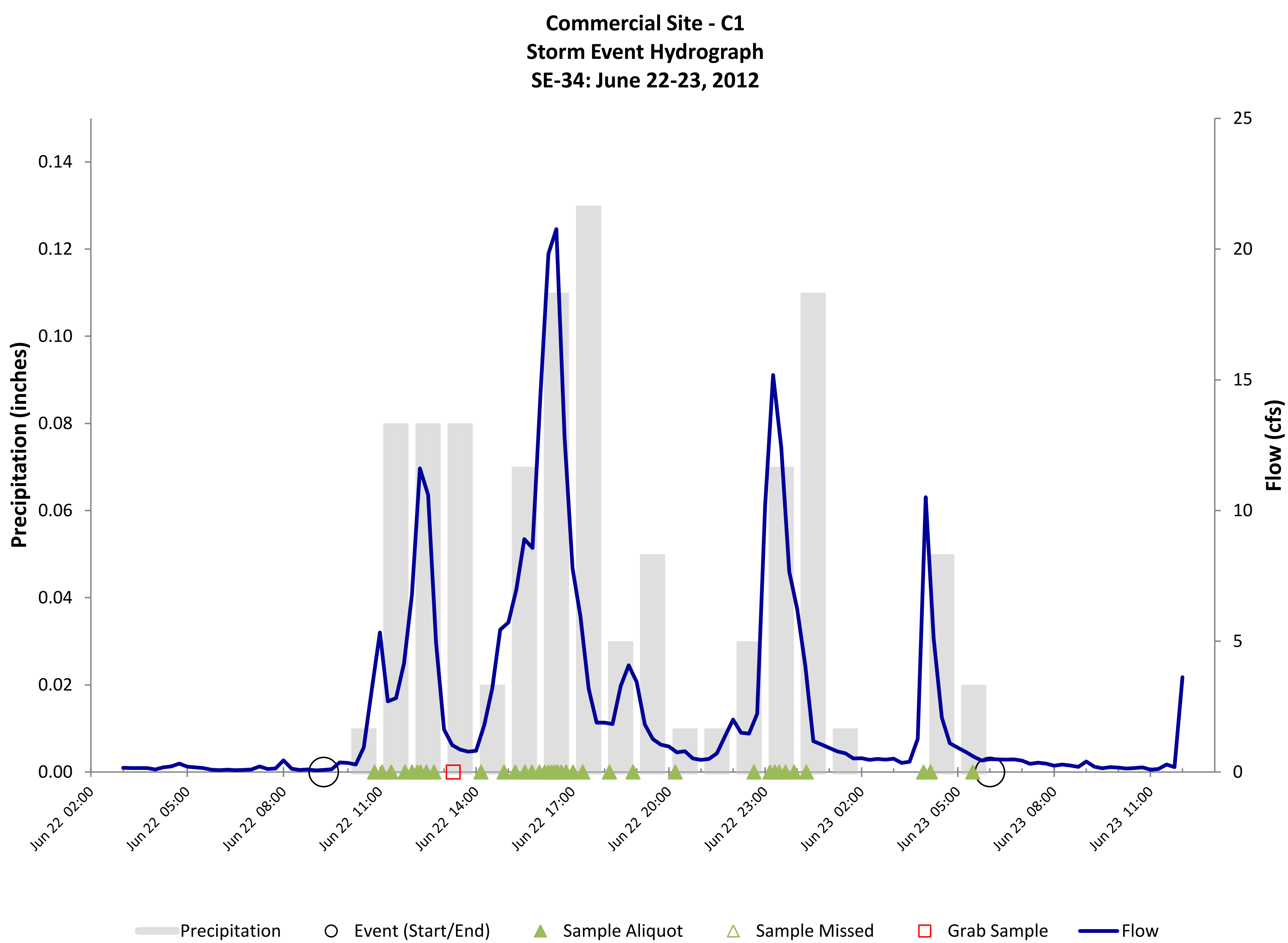


Commercial Site - C1
Storm Event Hydrograph
SE-31: January 24, 2012
Precipitation (inches)
Flow (cfs)
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
16
14
12
10
8
6
4
2
0
Jan 23 23:00
Jan 24 01:00
Jan 24 03:00
Jan 24 05:00
Jan 24 07:00
Jan 24 09:00
Jan 24 11:00
Jan 24 13:00
Jan 24 15:00
Jan 24 17:00
Jan 24 19:00
Jan 24 21:00
Jan 24 23:00
Jan 25 01:00
Jan 25 03:00
Jan 25 05:00
Precipitation
Event (Start/End)
Sample Aliquot
Sample Missed
Grab Sample
Flow

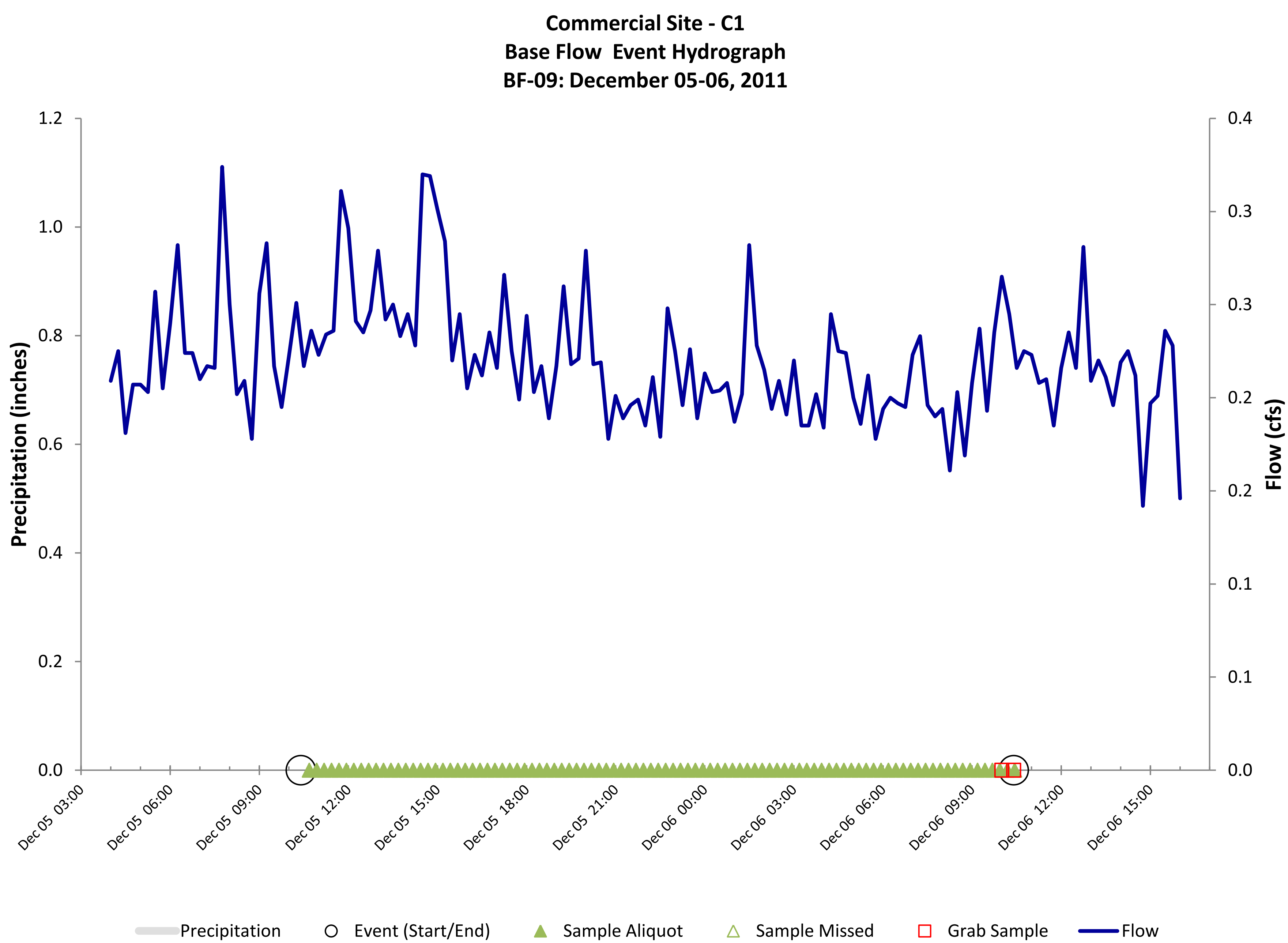


Commercial Site - C1
Storm Event Hydrograph
SE-32: February 17, 2012
Precipitation (inches)
Flow (cfs)
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14
0.16
0.18
0.20
0
10
20
30
40
50
60
70
Feb 17 04:00
Feb 17 06:00
Feb 17 08:00
Feb 17 10:00
Feb 17 12:00
Feb 17 14:00
Feb 17 16:00
Feb 17 18:00
Feb 17 20:00
Feb 17 22:00
Feb 18 00:00
Feb 18 02:00
Feb 18 04:00
Precipitation
Event (Start/End)
Sample Aliquot
Sample Missed
Grab Sample
Flow

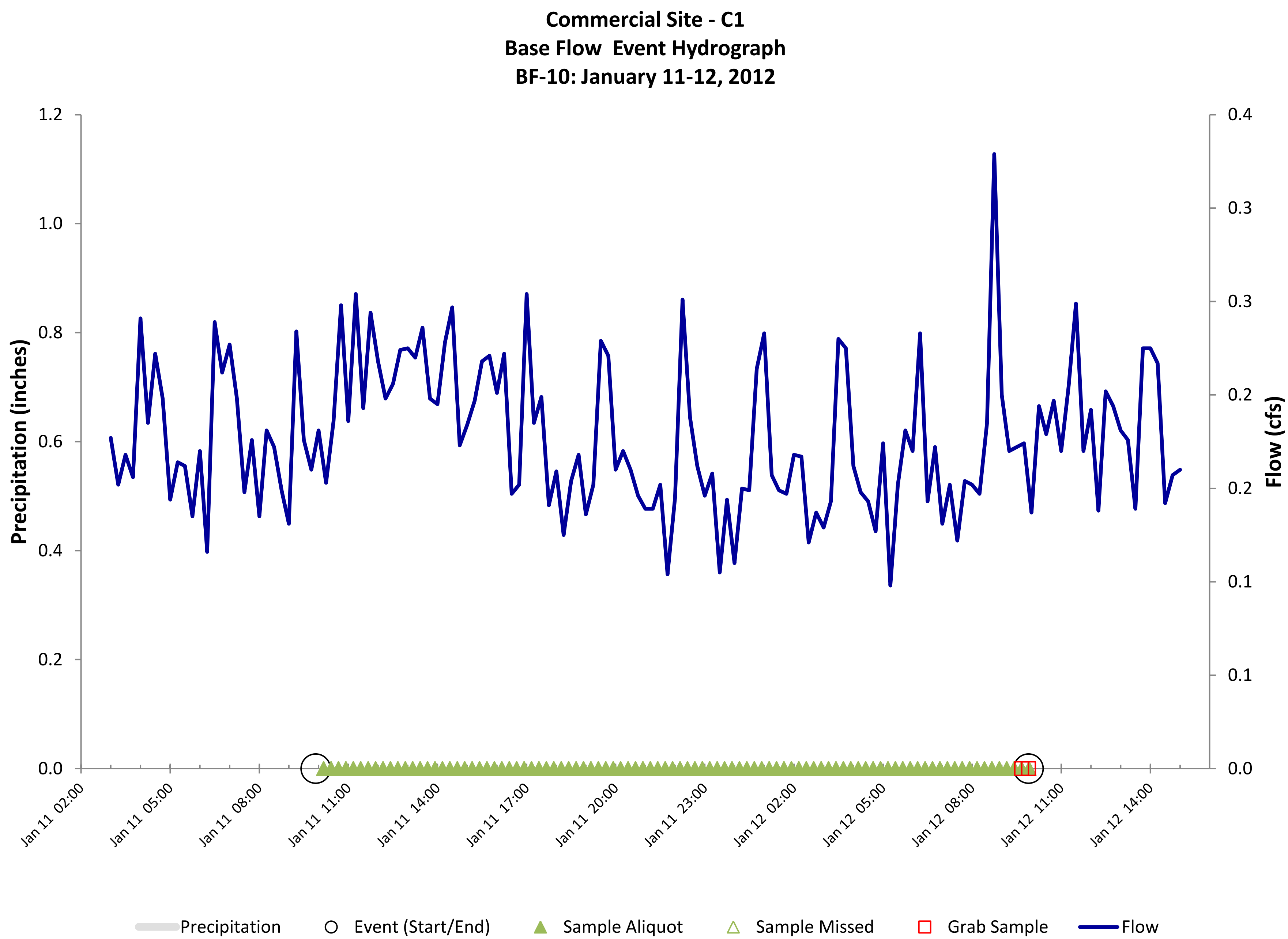

Commercial Site - C1
Storm Event Hydrograph
SE-33: May 20-21, 2012
Precipitation (inches)
Flow (cfs)
0.25
0.20
0.15
0.10
0.05
0.00
100
90
80
70
60
50
40
30
20
10
0
May 20 02:00
May 20 05:00
May 20 08:00
May 20 11:00
May 20 14:00
May 20 17:00
May 20 20:00
May 20 23:00
May 21 02:00
May 21 05:00
May 21 08:00
May 21 11:00
May 21 14:00
May 21 17:00
May 21 20:00
May 21 23:00
Precipitation
Event (Start/End)
Sample Aliquot
Sample Missed
Grab Sample
Flow



Commercial Site - C1
Storm Event Hydrograph
SE-34: June 22-23, 2012
Precipitation (inches)
Flow (cfs)
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14
0
5
10
15
20
25
Jun 22 02:00
Jun 22 05:00
Jun 22 08:00
Jun 22 11:00
Jun 22 14:00
Jun 22 17:00
Jun 22 20:00
Jun 22 23:00
Jun 23 02:00
Jun 23 05:00
Jun 23 08:00
Jun 23 11:00
Precipitation
Event (Start/End)
Sample Aliquot
Sample Missed
Grab Sample
Flow

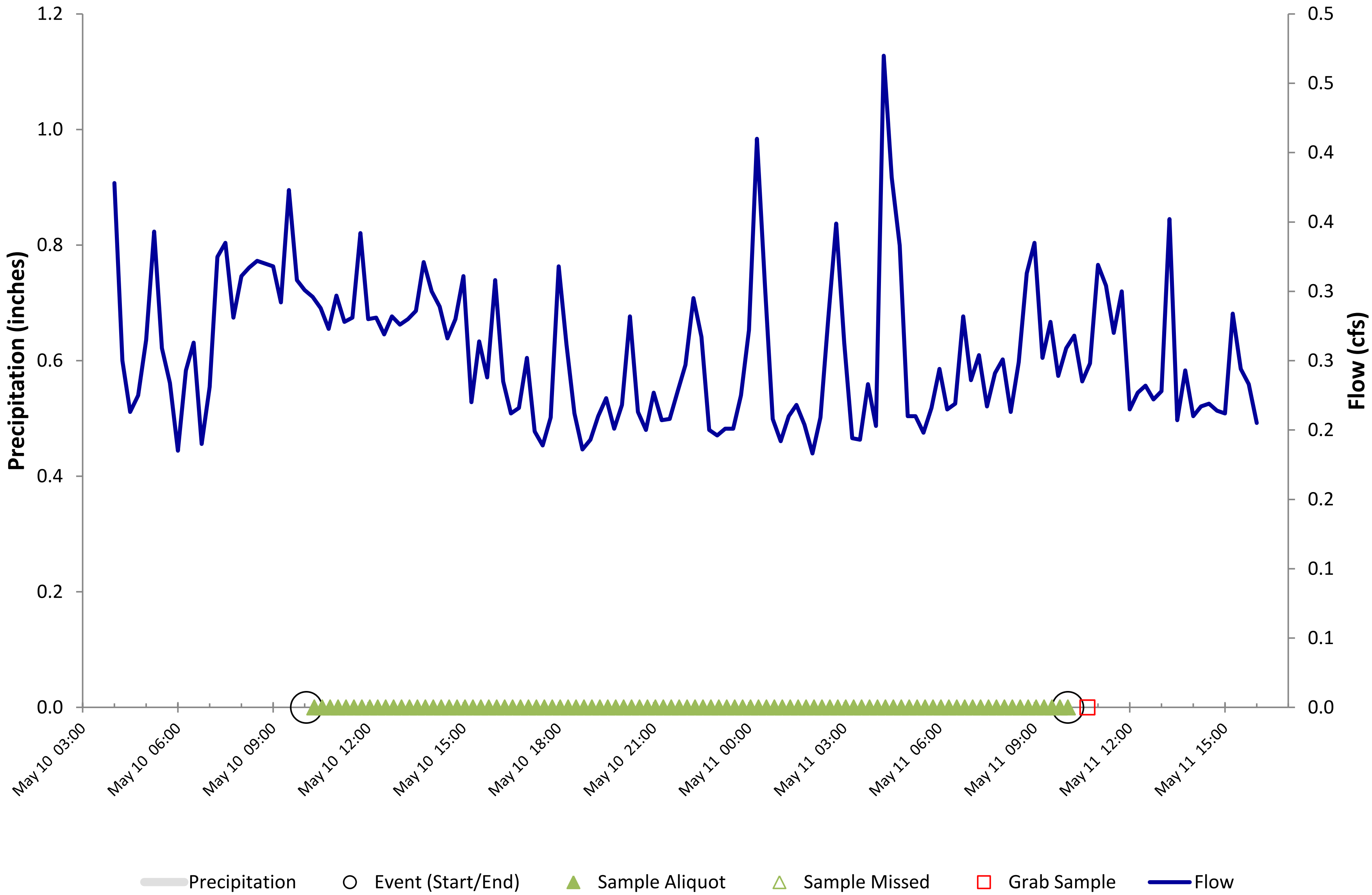


Commercial Site - C1
Base Flow Event Hydrograph
BF-09: December 05-06, 2011
Precipitation (inches)
Flow (cfs)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0.4
0.3
0.3
0.2
0.2
0.1
0.1
0.0
Dec 05 03:00
Dec 05 06:00
Dec 05 09:00
Dec 05 12:00
Dec 05 15:00
Dec 05 18:00
Dec 05 21:00
Dec 06 00:00
Dec 06 03:00
Dec 06 06:00
Dec 06 09:00
Dec 06 12:00
Dec 06 15:00
Precipitation
Event (Start/End)
Sample Aliquot
Sample Missed
Grab Sample
Flow

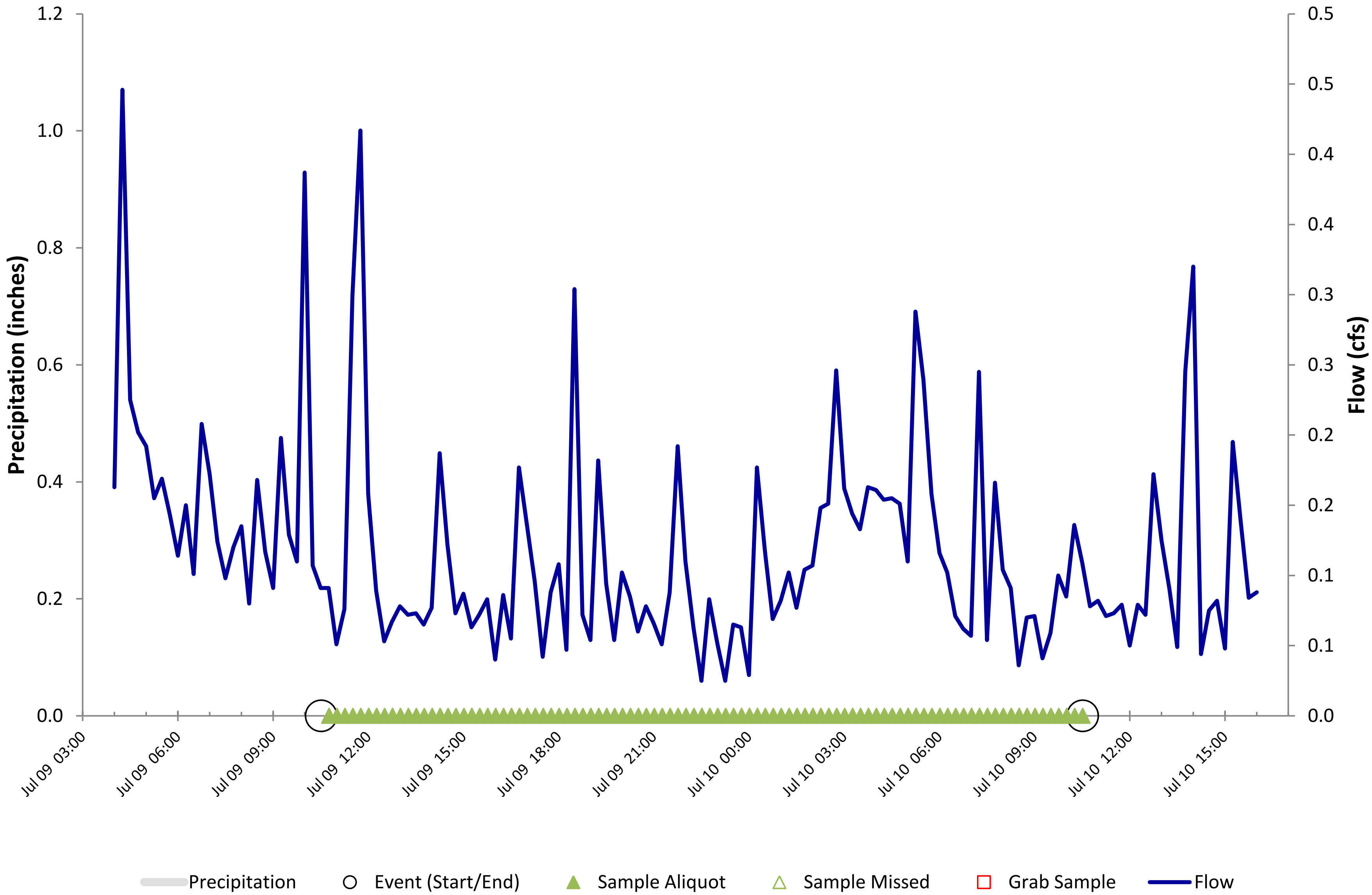


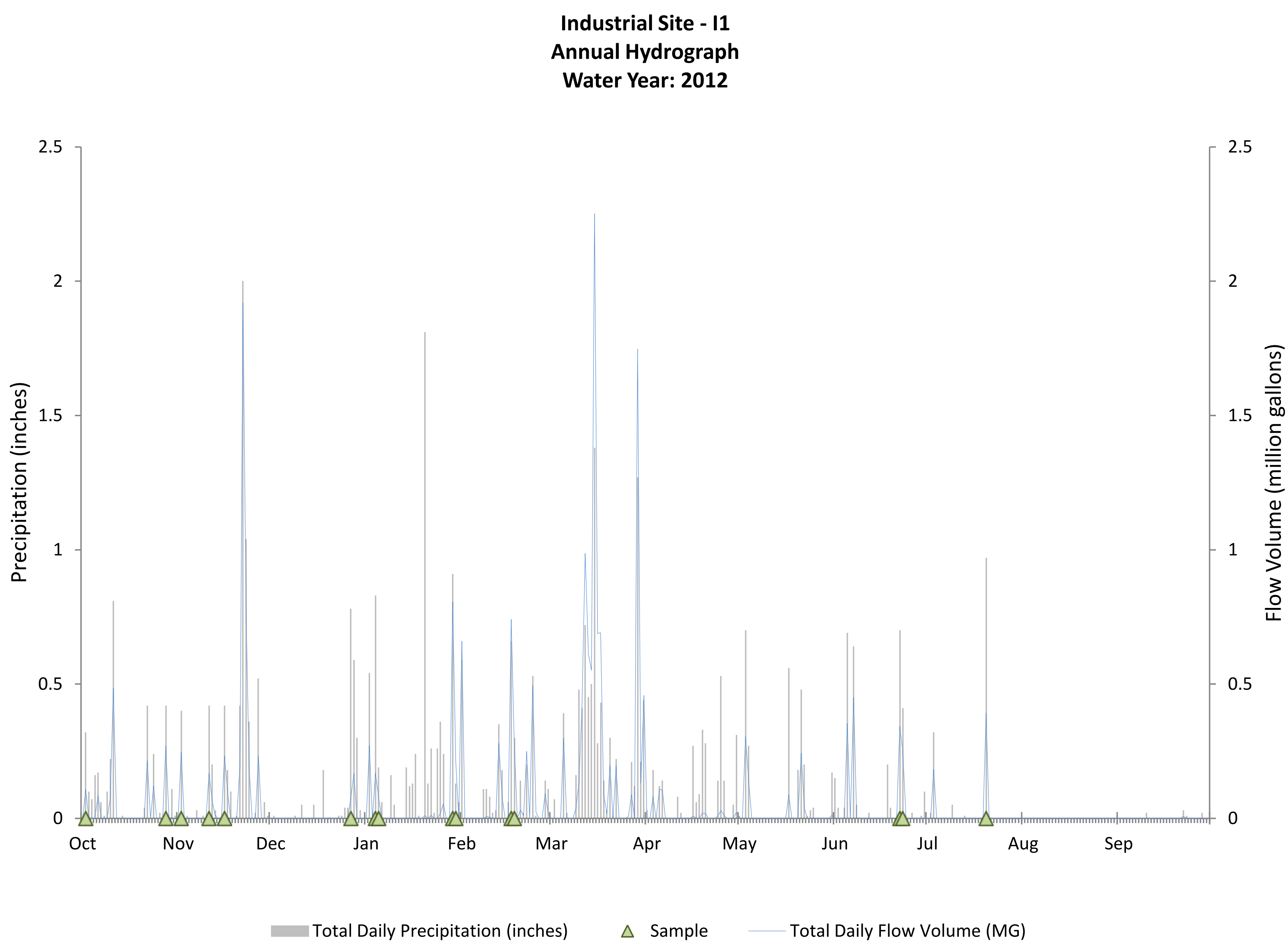
Commercial Site - C1
Base Flow Event Hydrograph
BF-10: January 11-12, 2012
Precipitation (inches)
Flow (cfs)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0.4
0.3
0.3
0.2
0.2
0.1
0.1
0.0
Jan 11 02:00
Jan 11 05:00
Jan 11 08:00
Jan 11 11:00
Jan 11 14:00
Jan 11 17:00
Jan 11 20:00
Jan 11 23:00
Jan 12 02:00
Jan 12 05:00
Jan 12 08:00
Jan 12 11:00
Jan 12 14:00
Precipitation
Event (Start/End)
Sample Aliquot
Sample Missed
Grab Sample
Flow

Commercial Site - C1
Base Flow Event Hydrograph
BF-11: May 10-11, 2012

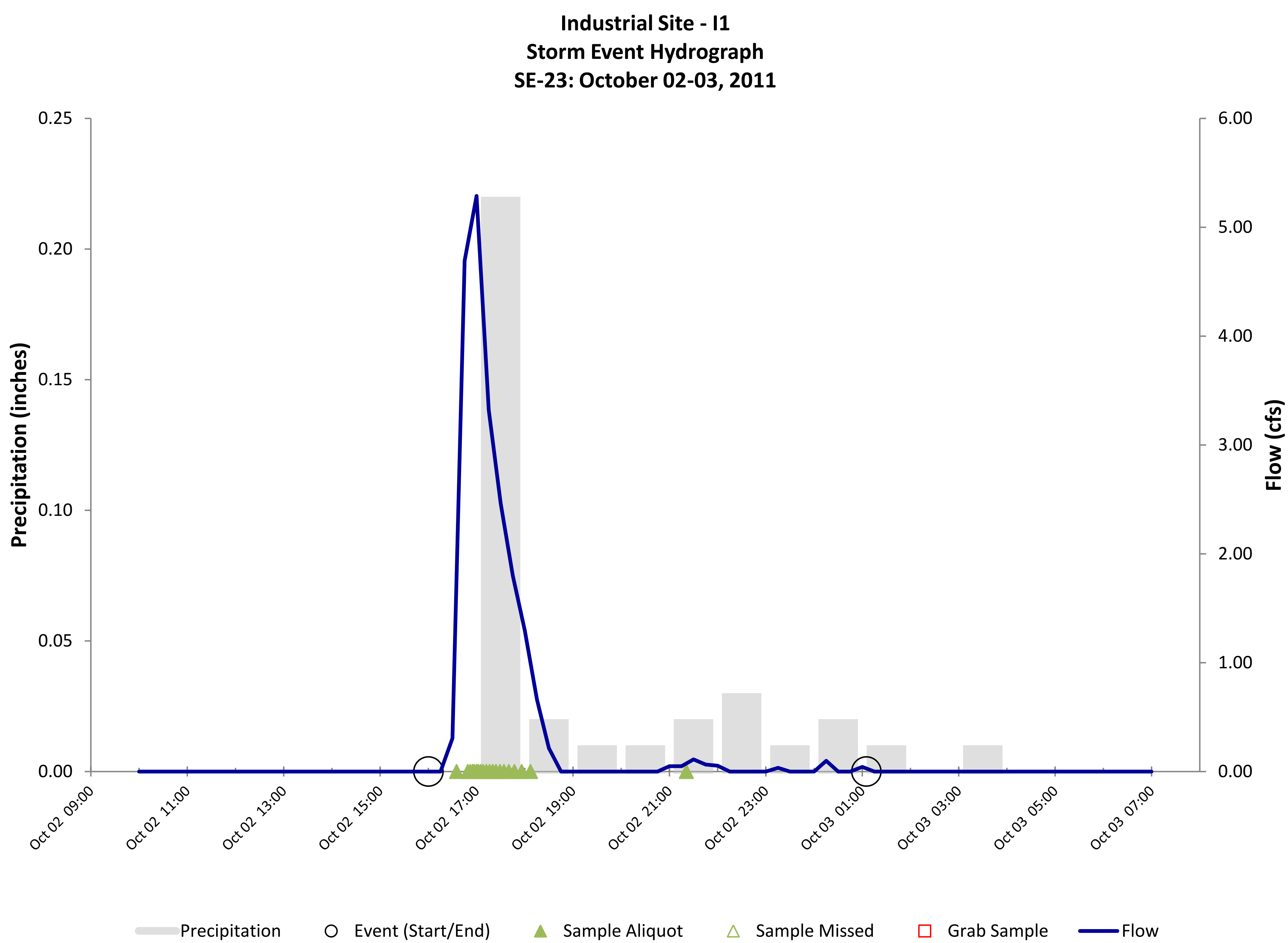


Commercial Site - C1
Base Flow Event Hydrograph
BF-12: July 09-10, 2012



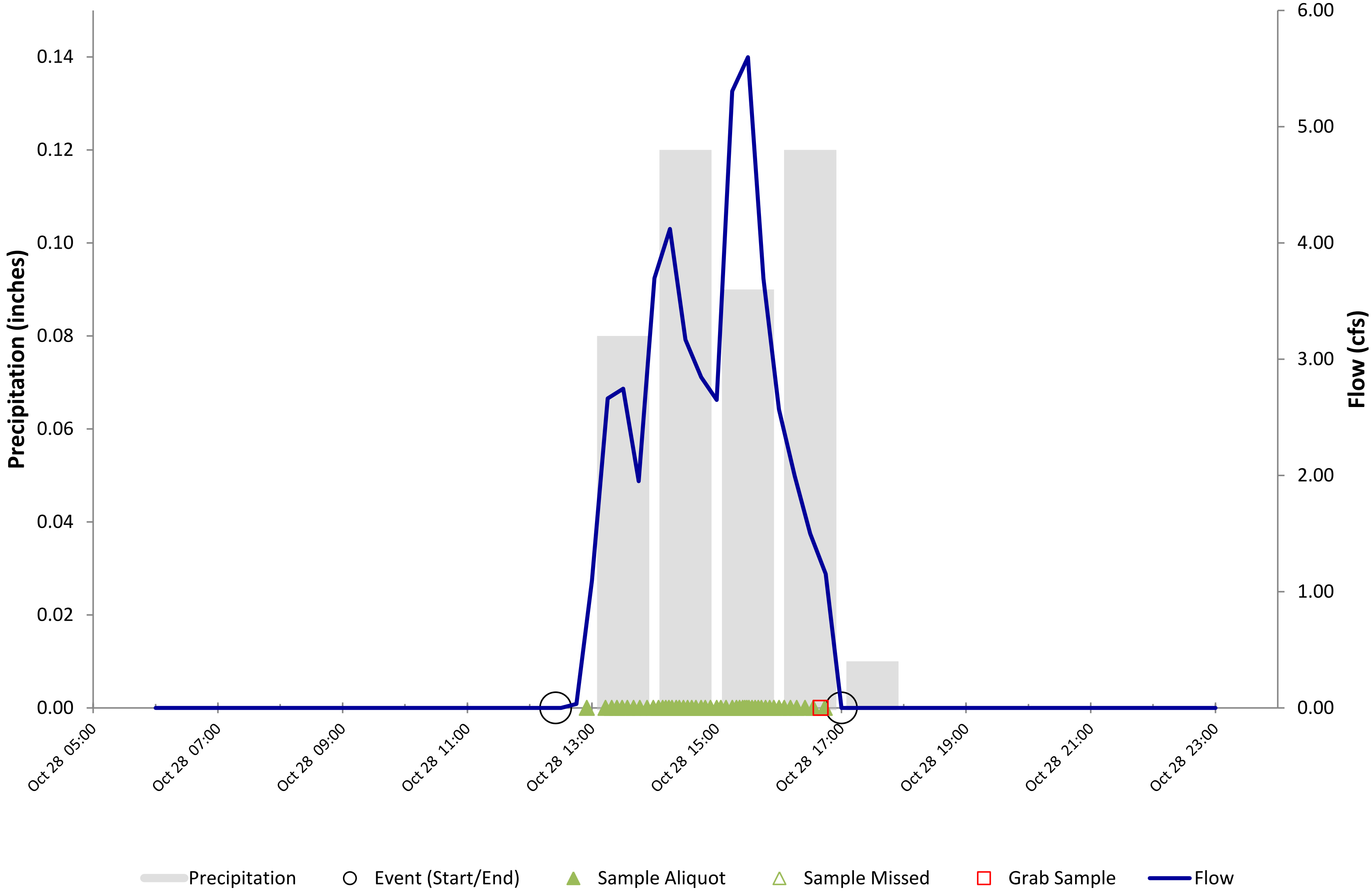


Industrial Site - I1
Annual Hydrograph
Water Year: 2012
Precipitation (inches)
Flow Volume (million gallons)
2.5
2
1.5
1
0.5
0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Total Daily Precipitation (inches)
Sample
Total Daily Flow Volume (MG)

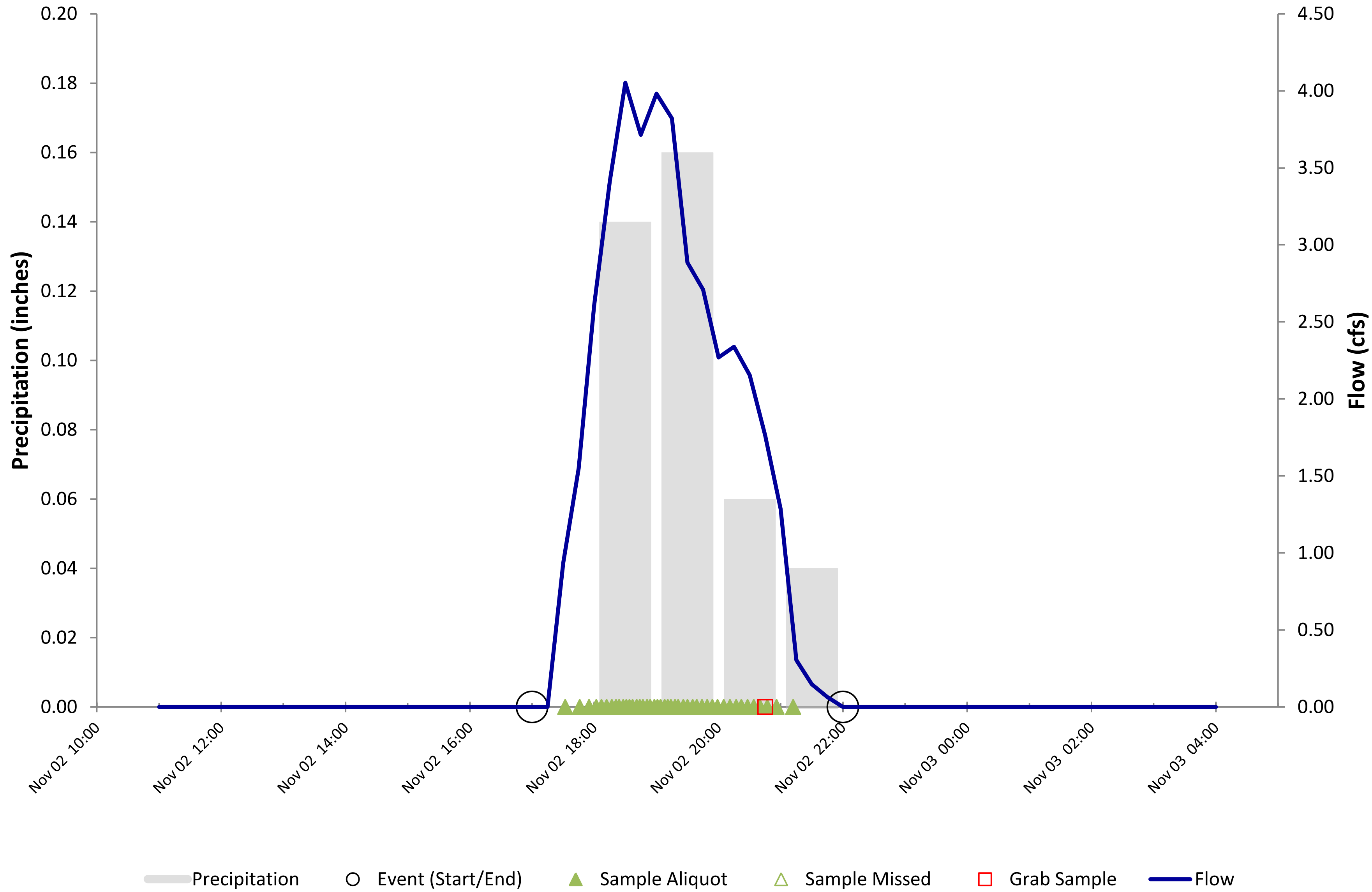


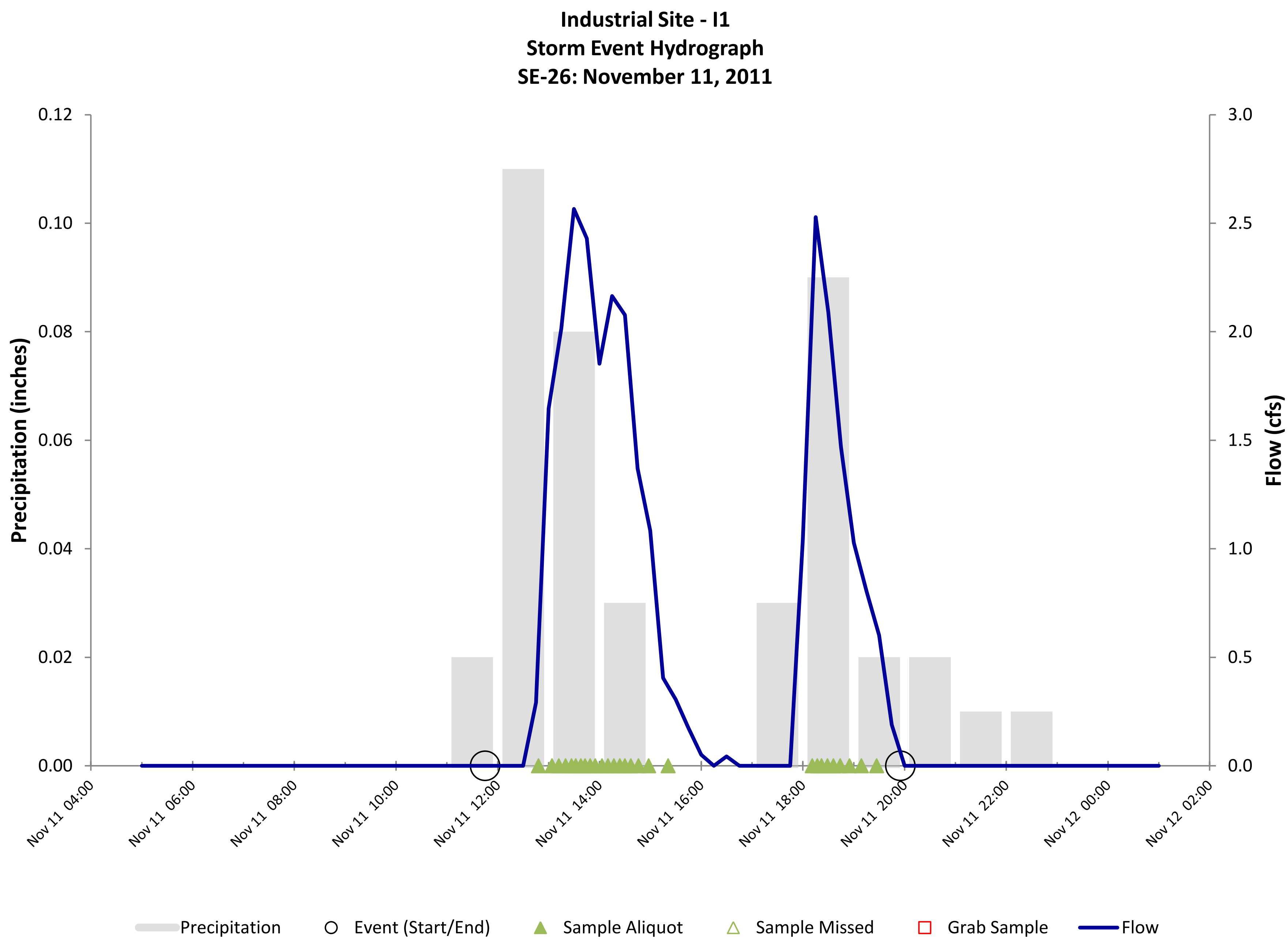
Industrial Site - I1
Storm Event Hydrograph
SE-23: October 02-03, 2011
Precipitation (inches)
Flow (cfs)
0.25
0.20
0.15
0.10
0.05
0.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Oct 02 09:00
Oct 02 11:00
Oct 02 13:00
Oct 02 15:00
Oct 02 17:00
Oct 02 19:00
Oct 02 21:00
Oct 02 23:00
Oct 03 01:00
Oct 03 03:00
Oct 03 05:00
Oct 03 07:00
Precipitation
Event (Start/End)
Sample Aliquot
Sample Missed
Grab Sample
Flow

Industrial Site - I1
Storm Event Hydrograph
SE-24: October 28, 2011



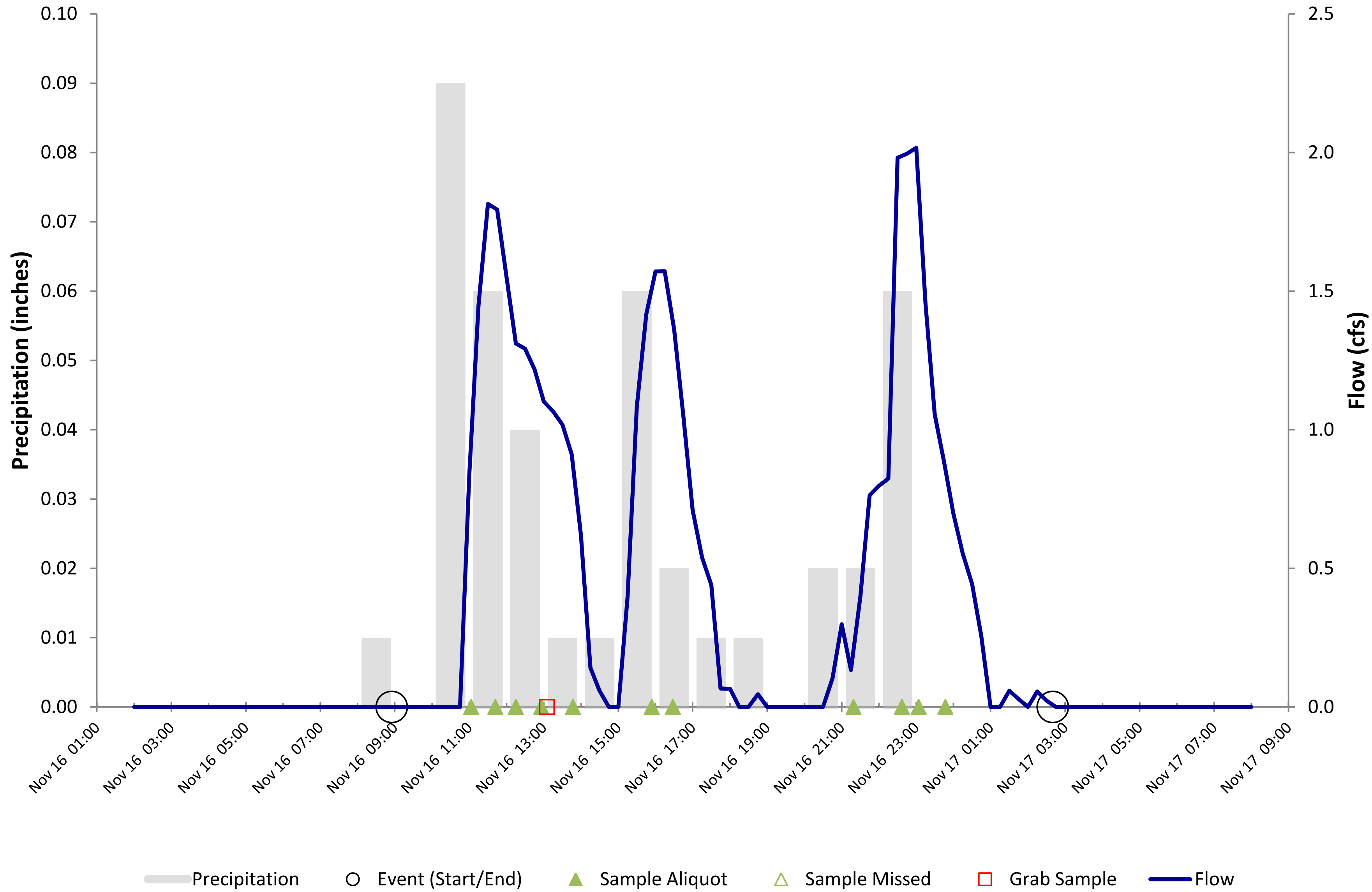
Industrial Site - I1
Storm Event Hydrograph
SE-25: November 02, 2011



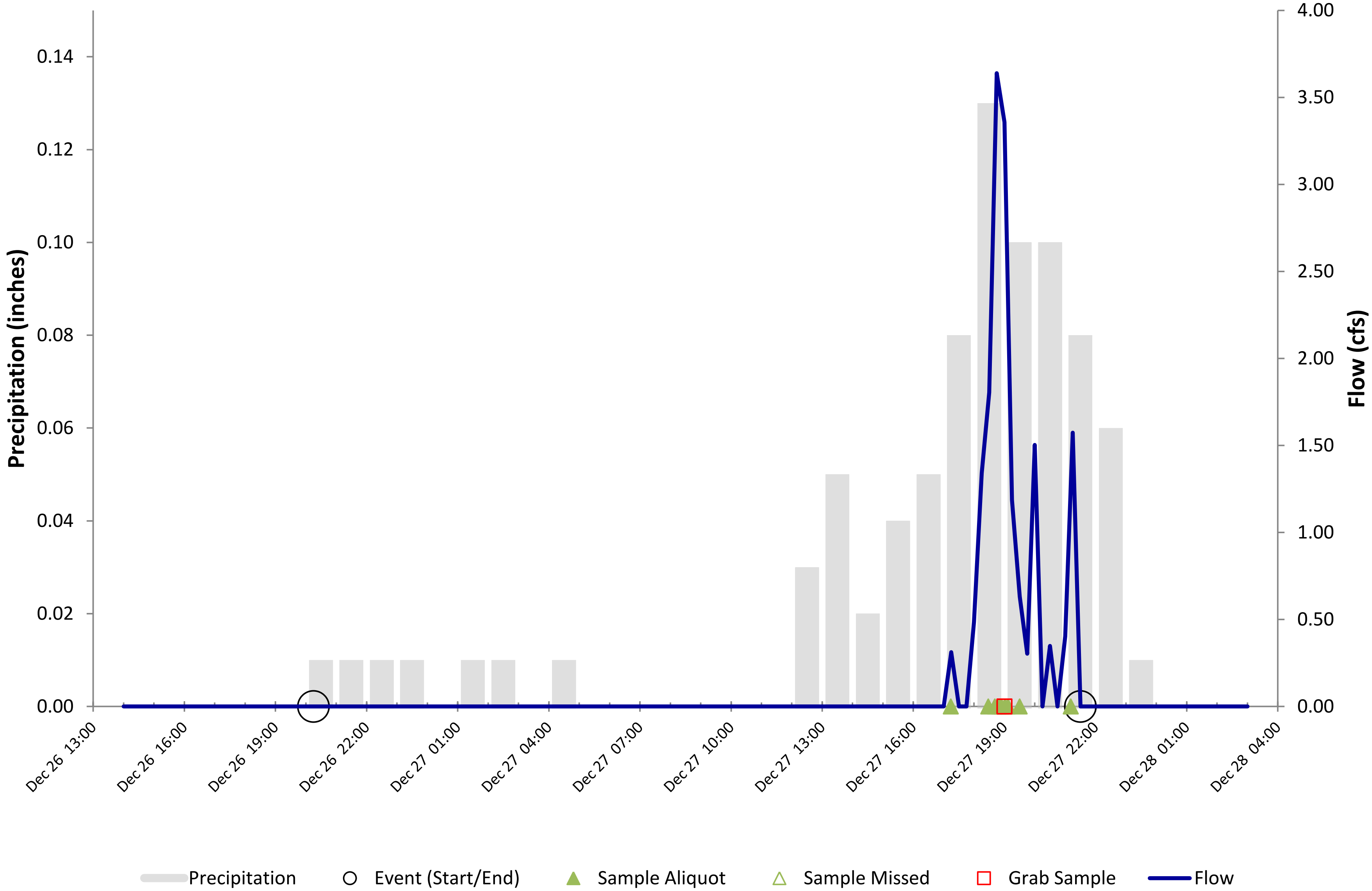


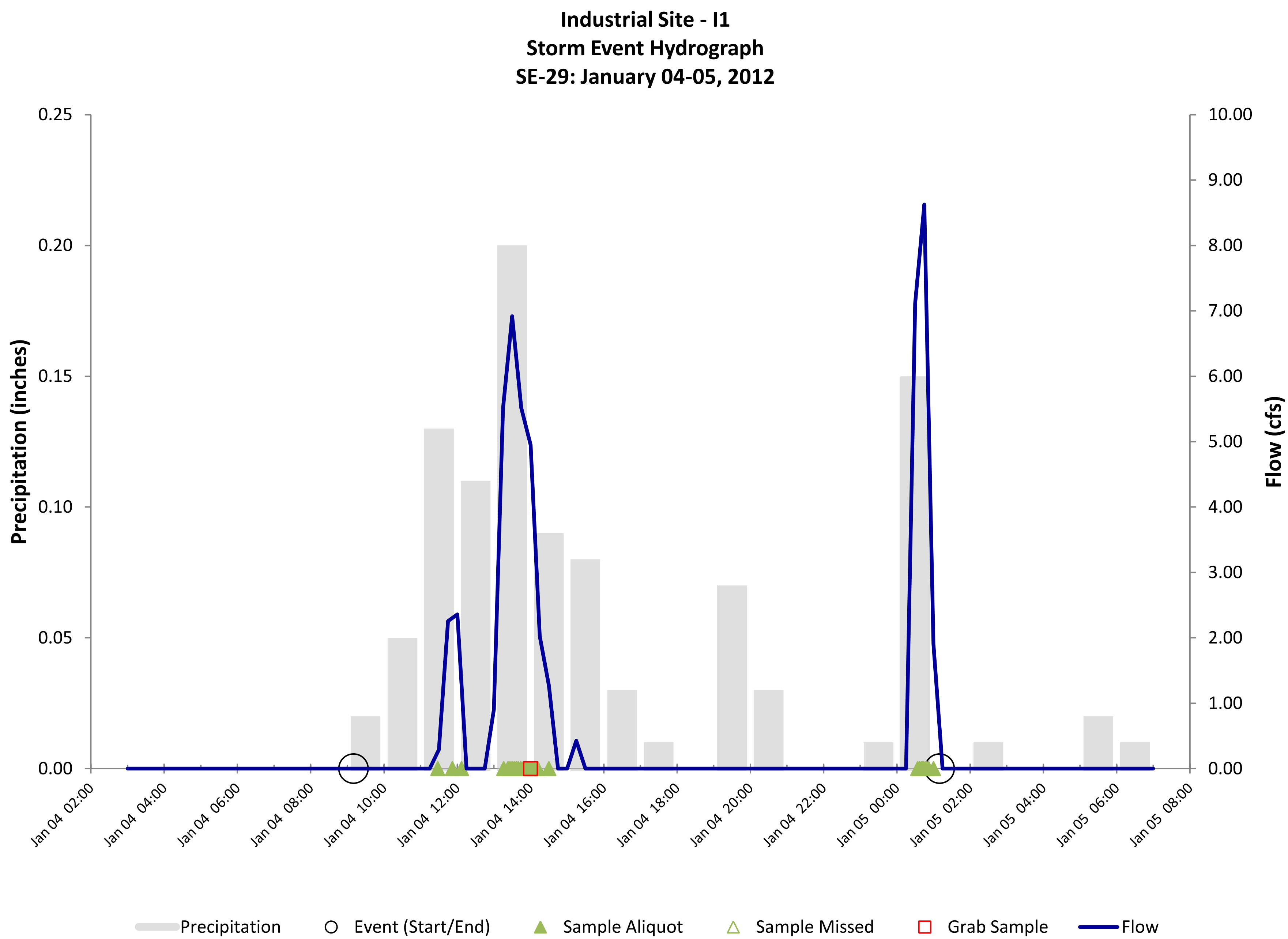
Industrial Site - I1
Storm Event Hydrograph
SE-26: November 11, 2011
Precipitation (inches)
Flow (cfs)
0.12
0.10
0.08
0.06
0.04
0.02
0.00
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Nov 11 04:00
Nov 11 06:00
Nov 11 08:00
Nov 11 10:00
Nov 11 12:00
Nov 11 14:00
Nov 11 16:00
Nov 11 18:00
Nov 11 20:00
Nov 11 22:00
Nov 12 00:00
Nov 12 02:00
Precipitation
Event (Start/End)
Sample Aliquot
Sample Missed
Grab Sample
Flow

Industrial Site - I1
Storm Event Hydrograph
SE-27: November 16-17, 2011



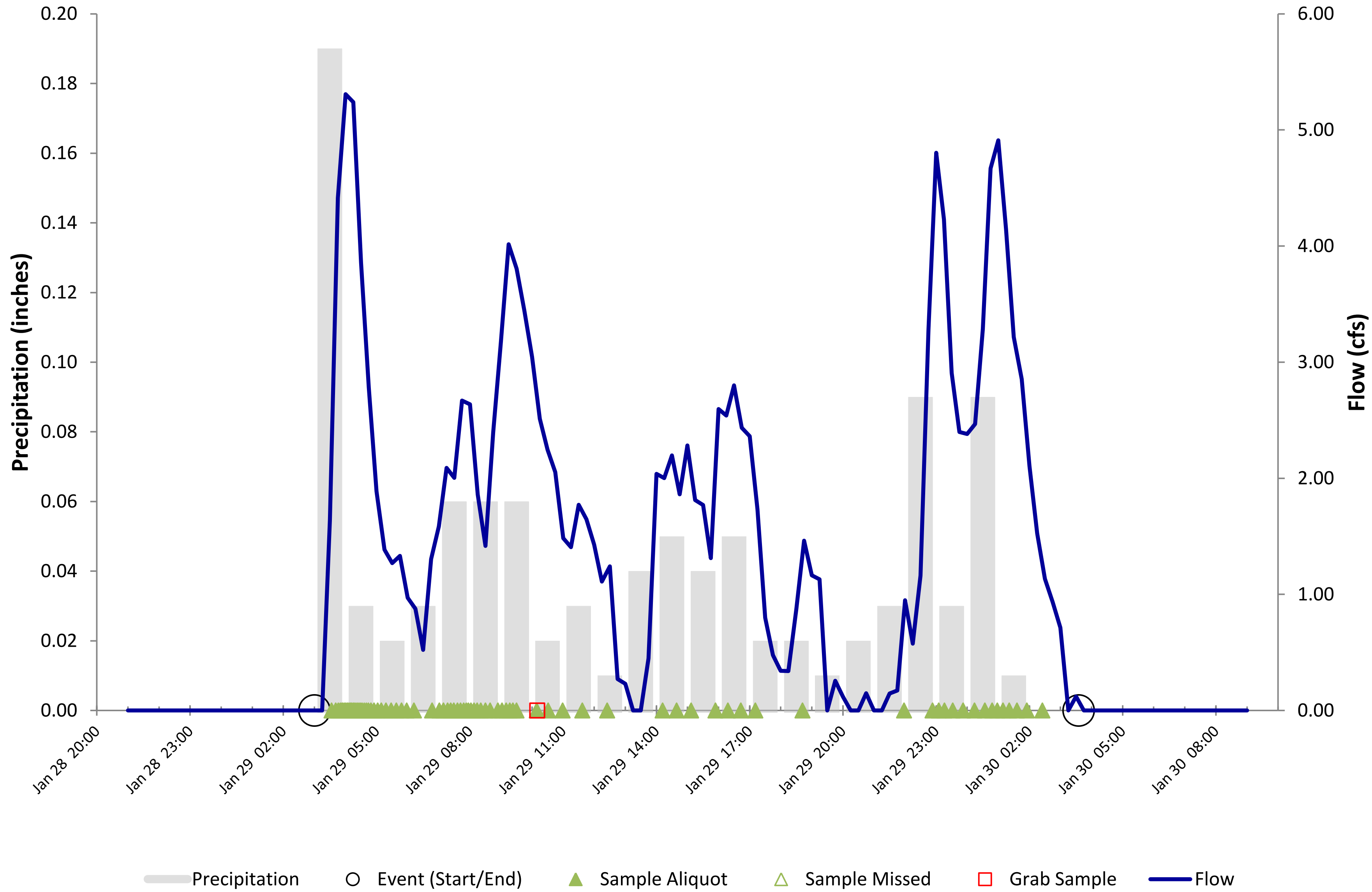
Industrial Site - I1
Storm Event Hydrograph
SE-28: December 26-27, 2011

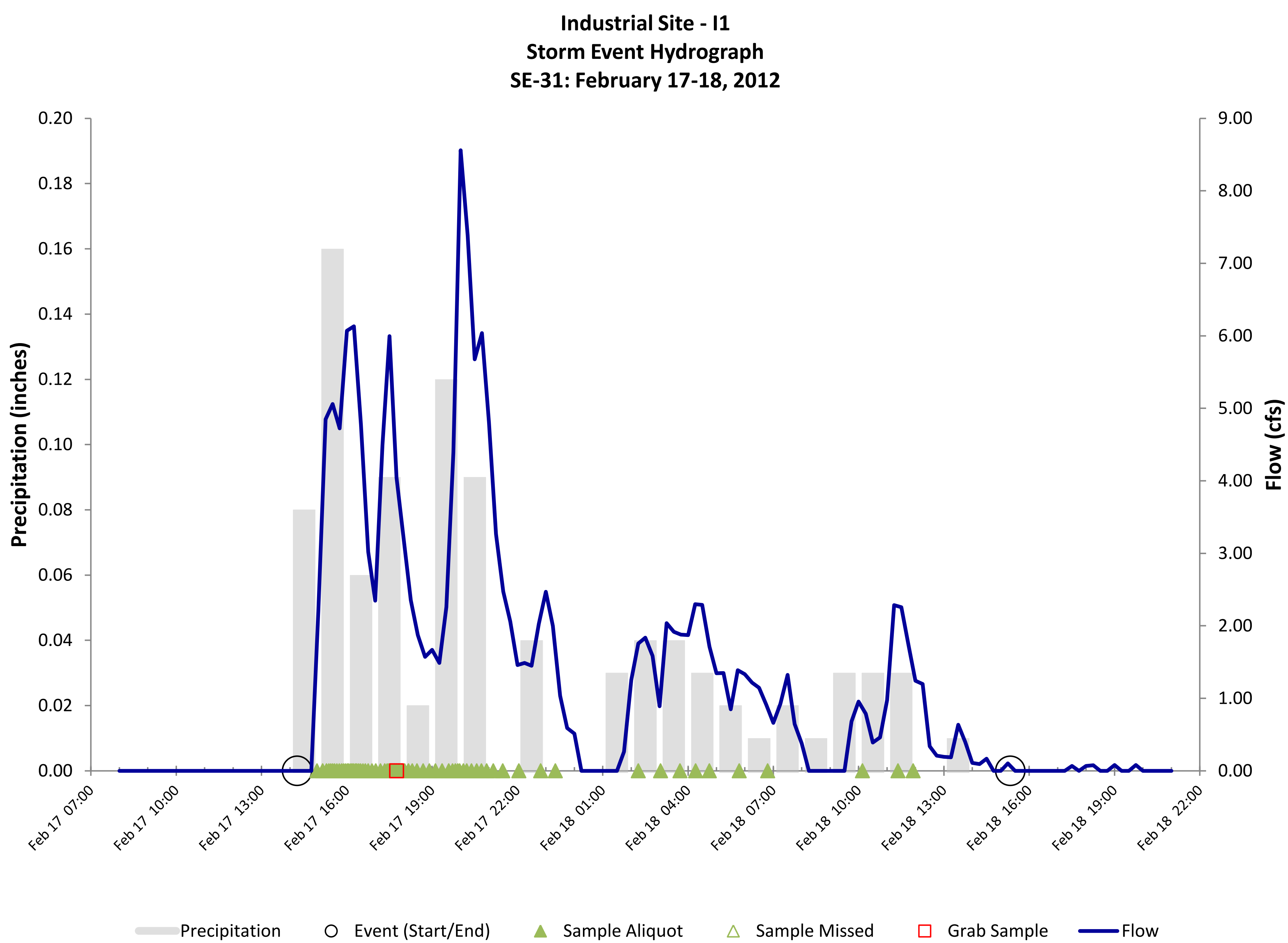




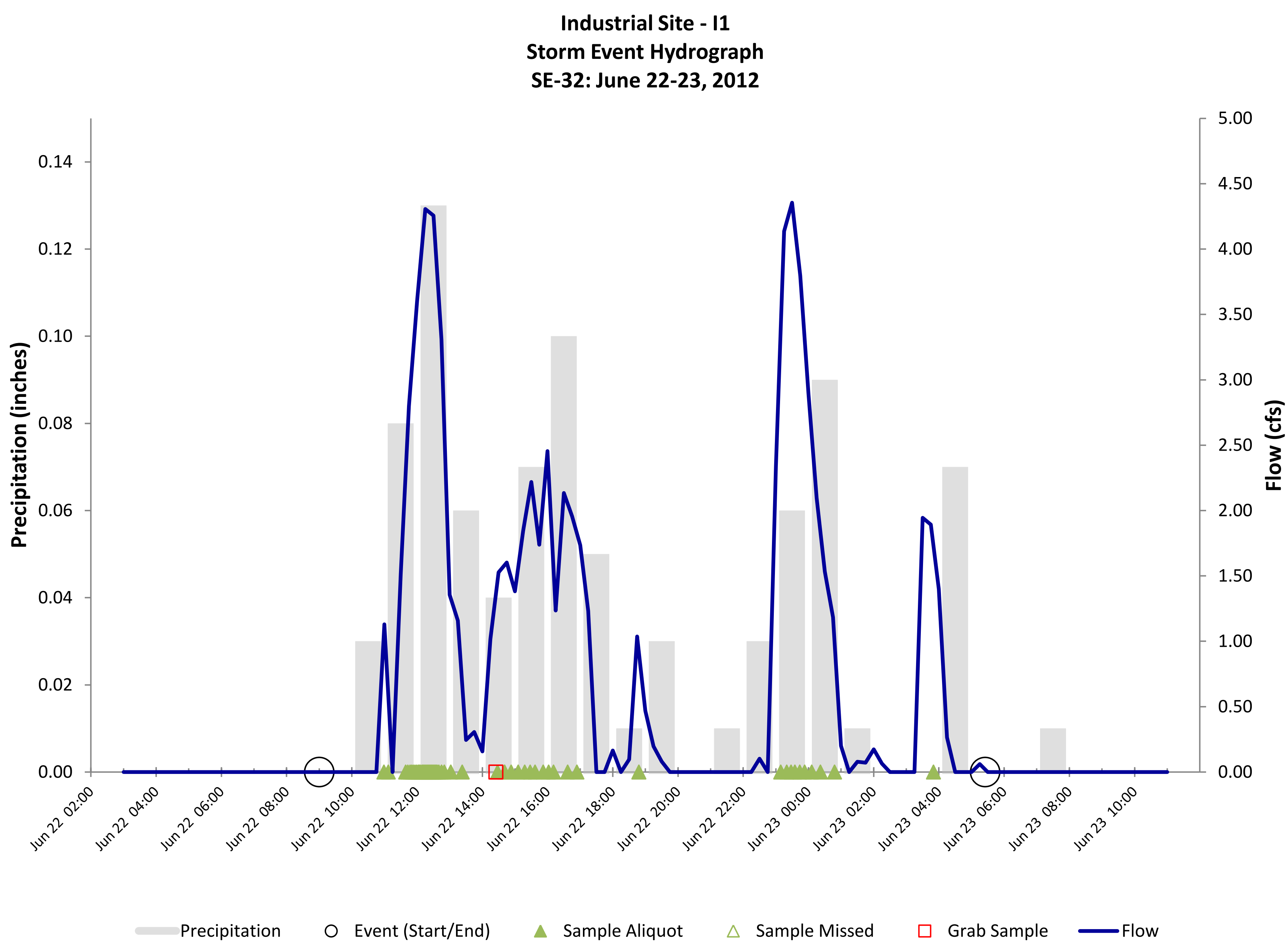
Industrial Site - I1
Storm Event Hydrograph
SE-29: January 04-05, 2012
Precipitation (inches)
Flow (cfs)
0.25
0.20
0.15
0.10
0.05
0.00
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Jan 04 02:00
Jan 04 04:00
Jan 04 06:00
Jan 04 08:00
Jan 04 10:00
Jan 04 12:00
Jan 04 14:00
Jan 04 16:00
Jan 04 18:00
Jan 04 20:00
Jan 04 22:00
Jan 05 00:00
Jan 05 02:00
Jan 05 04:00
Jan 05 06:00
Jan 05 08:00
Precipitation
Event (Start/End)
Sample Aliquot
Sample Missed
Grab Sample
Flow

Industrial Site - I1
Storm Event Hydrograph
SE-30: January 29-30, 2012

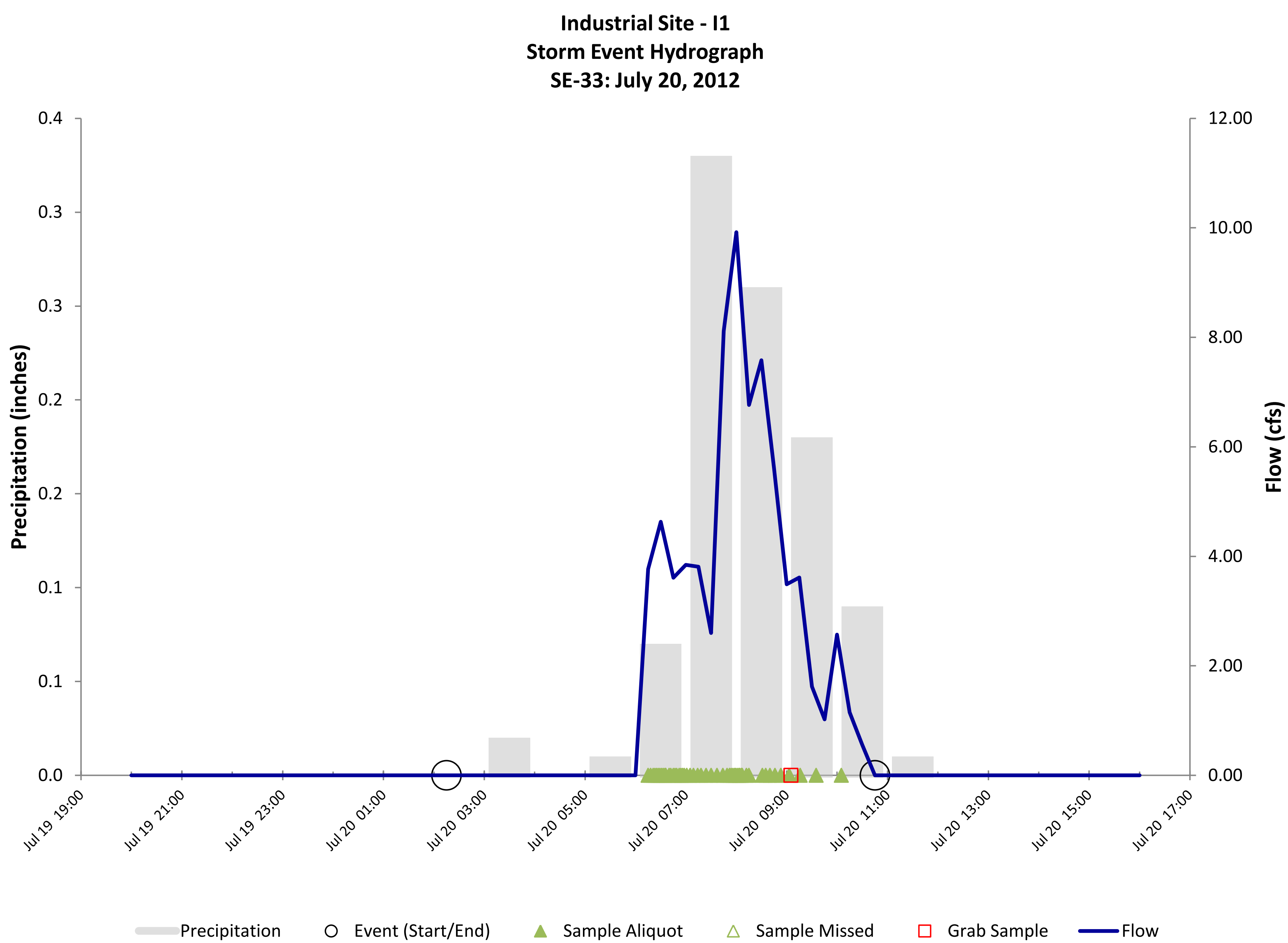




Industrial Site - I1
Storm Event Hydrograph
SE-31: February 17-18, 2012
Precipitation (inches)
Flow (cfs)
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Feb 17 07:00
Feb 17 10:00
Feb 17 13:00
Feb 17 16:00
Feb 17 19:00
Feb 17 22:00
Feb 18 01:00
Feb 18 04:00
Feb 18 07:00
Feb 18 10:00
Feb 18 13:00
Feb 18 16:00
Feb 18 19:00
Feb 18 22:00
Precipitation
Event (Start/End)
Sample Aliquot
Sample Missed
Grab Sample
Flow



Industrial Site - I1
Storm Event Hydrograph
SE-32: June 22-23, 2012
Precipitation (inches)
Flow (cfs)
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Jun 22 02:00
Jun 22 04:00
Jun 22 06:00
Jun 22 08:00
Jun 22 10:00
Jun 22 12:00
Jun 22 14:00
Jun 22 16:00
Jun 22 18:00
Jun 22 20:00
Jun 22 22:00
Jun 23 00:00
Jun 23 02:00
Jun 23 04:00
Jun 23 06:00
Jun 23 08:00
Jun 23 10:00
Precipitation
Event (Start/End)
Sample Aliquot
Sample Missed
Grab Sample
Flow


Industrial Site - I1
Storm Event Hydrograph
SE-33: July 20, 2012
Precipitation (inches)
Flow (cfs)
0.4
0.3
0.3
0.2
0.2
0.1
0.1
0.0
12.00
10.00
8.00
6.00
4.00
2.00
0.00
Jul 19 19:00
Jul 19 21:00
Jul 19 23:00
Jul 20 01:00
Jul 20 03:00
Jul 20 05:00
Jul 20 07:00
Jul 20 09:00
Jul 20 11:00
Jul 20 13:00
Jul 20 15:00
Jul 20 17:00
Precipitation
Event (Start/End)
Sample Aliquot
Sample Missed
Grab Sample
Flow

Appendix C.3: WSU Contract Documents

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13F-3743-5328(0327)
0182463

MEMORANDUM OF AGREEMENT NO. DA2009-39 BETWEEN THE CITY OF SEATTLE AND WASHINGTON STATE UNIVERSITY FOR BIORETENTION SOIL TESTING AND BIORETENTION FACILITY STORMWATER MONITORING

THIS MEMORANDUM OF AGREEMENT ("Agreement") is made by and between the City of Seattle ("City"), a municipal corporation of the State of Washington, acting through its Seattle Public Utilities Department ("SPU"), and Washington State University (WSU) ("Provider").

1. **EFFECTIVE DATE** This Agreement shall be effective on the date it is signed by both parties ("Effective Date").

2. **TERM OF AGREEMENT** The Provider is retroactively authorized to have begun work on the Scope of Work of this Agreement as of September 1, 2009. This retroactive authorization includes with it the Provider's obligation and agreement to the terms and conditions of this Agreement as they may apply to any work performed by the Provider prior to the execution of this Agreement and expire ("Completion Date") as stated in ATTACHMENT B – TERMS AND CONDITIONS, attached hereto and made a part of this Agreement.

3. **SCOPE OF SERVICES** Provider shall perform the services described in ATTACHMENT A – SCOPE OF SERVICES AND SCHEDULE, (the "Project") attached hereto and made a part of this Agreement. Digital Materials: Provider shall provide digital materials, including reports, data, maps, graphs and photos that are compatible with current Seattle Public Utilities file and data formats.

   Copyright in all material created by Provider and paid for by City as part of this agreement shall be the property of the State of Washington. Both City and Provider may use these materials, and permit others to use them, for any purpose consistent with their respective missions as agencies of the State of Washington. This material includes, but is not limited to: books, computer programs, documents, films, pamphlets, reports, sound reproductions, studies, surveys, tapes, and/or training materials. Material which Provider provides and uses to perform this agreement but which is not created for or paid for by City shall be owned by Provider or such other party as determined by Copyright Law and/or Provider's internal policies; however, for any such materials, Provider herby grants (or, if necessary and to the extent reasonably possible, shall obtain and grant) a perpetual, unrestricted, royalty free, non-exclusive license to City to use the material for City internal purposes.

4. **BILLING AND PAYMENT** Provider shall submit invoices to SPU and SPU shall pay Provider up to the Total Dollar Amount, all in accordance with ATTACHMENT B – TERMS AND CONDITIONS, attached hereto and made a part of this Agreement.

5. **NO JOINT UNDERTAKING** Nothing in this Agreement shall be construed to make or render the parties hereto partners, joint ventures or participants in any joint undertaking whatsoever.

6. **SCHEDULE** The parties shall comply with the schedule appearing in ATTACHMENT A – SCOPE OF SERVICES AND SCHEDULE. Compliance with the schedule is important to successful completion of the Project. The parties shall promptly and regularly notify each other of any occurrences affecting the schedule and shall attempt to agree upon an amended schedule if necessary or appropriate, to be effective upon execution of an Amendment to this Agreement in accordance with Section 19. Notwithstanding, failure to comply with the schedule shall constitute a Default and be grounds for termination unless or until any Amendment is executed.

7. **NO THIRD PARTY BENEFICIARIES** This Agreement is entered into solely for the mutual benefit of the parties hereto. This Agreement is not entered into with the intent that it shall benefit either party's agents, assigns, consultants or contractors, and no such other person or entity shall be a third party beneficiary of this Agreement.

8. **PUBLICATION** Each party may publish the results of the Project, and may acknowledge its respective role in and support of the Project.

9. **INDEMNIFICATION** To the extent permitted by Washington law, the Provider does hereby defend, indemnify and hold the City and its employees and agents harmless from all losses, liabilities, claims, actions or damages arising out of the Provider's performance of the services contemplated by this Agreement to the extent attributable to the negligent acts or omissions by the Provider, its agents or employees.

10. **INSURANCE** No insurance certification is required. However, Agency agrees that it will maintain premises and vehicle liability insurance in force with coverages and limits of liability that would generally be maintained by similarly situated Agencies and workers

compensation insurance as may be required by Washington State statutes.

11. **ASSIGNMENT** This Agreement shall not be assigned in whole or in part by either party without the prior written approval of the other party.

12. **COMPLIANCE WITH LAW** The parties to this Agreement shall comply with all Federal, State, and local laws and ordinances.

13. **DEFAULT AND TERMINATION** This Agreement may be terminated by either party hereto upon written notice delivered to the other party at least thirty (30) days prior to the intended date of termination. By such termination, neither party may nullify obligations already incurred prior to the date of termination. In the event of Termination for Convenience of this Agreement by City, City shall pay all reasonable costs and non-cancelable obligations incurred by Provider as of the date of termination.

14. **CITY ABILITY TO TERMINATE DUE TO LACK OF APPROPRIATIONS** It is understood that funds for the payment of the services to be provided hereunder are allocated out of monies received by the City from tax sources and/or other governmental entities and that funding for the services to be provided hereunder may by decreased or eliminated by executive or legislative action. Therefore, the parties agree that notwithstanding any other provision of this Agreement, if said funding is decreased or eliminated, or if in the judgment of the executive or legislative authority of the City, continuation of this Agreement would be an unnecessary expenditure of public funds, then the City may terminate this Agreement without further obligation to Provider after the City has given Provider written notice of such termination at least thirty (30) days prior to the effective date of termination and documentation of such executive or legislative action. City shall pay all reasonable costs and non-cancelable obligations incurred by Provider as of the date of termination.

15. **SEVERABILITY** If any provision of this Agreement or any provision of any law, rule or document incorporated by reference into this Agreement shall be held invalid, such invalidity shall not affect the other provisions of this Agreement which legally can be given effect without the invalid provision. To this end, the provisions of this Agreement are declared to be severable.

16. **APPLICABLE LAW** This Agreement shall be governed by and construed in accordance with the laws of the State of Washington. The jurisdiction and venue of any action brought hereunder shall be in the Superior Court of King County.

17. **AUDIT** During the progress of the Project and for a period of no less than three years from the Completion Date, each party will keep and make available for each other's inspection and audit all records pertaining to the Project, including accounting records. The parties shall furnish to each other copies of these records upon request and shall maintain the records in accordance with work order accounting procedures prescribed by the Division of Municipal Corporations of the State Auditor's Office.

18. **NOTICES** All notices to the parties to this Agreement shall be in writing and addressed to those persons identified on ATTACHMENT B – TERMS AND CONDITIONS.

19. **AMENDMENT** This MOA shall not be amended or modified except in writing and signed by both parties hereto.

20. **ENTIRE AGREEMENT** This Agreement and any written attachments or Amendments thereto, constitutes the complete contractual agreement of the parties and any oral representations or understandings not incorporated herein are excluded.

WASHINGTON STATE UNIVERSITY
PO Box 643140, Pullman, WA 99164-3140

By: ______________________ 11/2/09
Signature Date

for Dan Nordquist
Director, Authorized Inst. Official
Office of Grant and
Research Development
[Type or Print Name]

[Type or Print Title]

SEATTLE PUBLIC UTILITIES
The City of Seattle

By: ______________________ for Nancy Ahern 11/12/09
Signature Date

NANCY AHERN, DEPUTY DIRECTOR

By: ______________________ 11/19/09
Signature Date

RAY HOFFMAN, ACTING DIRECTOR

ATTACHMENTS:
A – SCOPE OF SERVICES AND SCHEDULE
B – TERMS AND CONDITIONS
C – BUDGET DETAILS

ATTACHMENT A
SCOPE OF SERVICES AND SCHEDULE

Provider:	WASHINGTON STATE UNIVERSITY
MOA Number:	DA2009-39
MOA Title	Bioretention Soil Testing and Bioretention Facility Stormwater Monitoring

Background: This Memorandum of Agreement (MOA) with Washington State University (WSU) is to have WSU conduct testing for the City of Seattle (City) for two tasks: 1) bioretention soils mix testing, and 2) bioretention facility monitoring.

Task 1 will be used by the City's Green Stormwater Infrastructure program to refine bioretention soil mix guidelines and assess availability of optimum aggregate material in the region. This task will be overseen by Shanti Colwell.

Task 2 will be used to meet the best management practices (BMP) evaluation monitoring requirements of the of the 2007 National Pollutant Discharge Elimination System (NPDES) Phase I Municipal Stormwater Permit. Special Condition S8.C.1.c of this permit requires the City to implement a long-term stormwater Best Management Practice (BMP) evaluation monitoring program that is intended to evaluate the effectiveness of stormwater treatment and hydrologic management BMPs. The City will use Special Condition S8.B.1 to meet this requirement which allows the City to have stormwater monitoring conducted on its behalf by another party. Specifically, the City will use monitoring results from four bioretention cells referred to as "mesocosms" at the WSU low impact development (LID) facility to meet the permit monitoring requirements for a metals/phosphorus ("enchanced") treatment BMP. The four mesocosms are identical (essentially one primary and three replicates) and all contain a 60/40 mix of aggregate/compost, which is the City's current specified mix for bioretention facilities. Stormwater will be pumped into each mesocosm and the water quality samples and flow data will be collected at the influent and effluent of each mesocosm to calculate pollutant reduction. This task will be overseen by Doug Hutchinson.

See Attachment A – Table 1 for Subcontractors Scope of Work Details

Task 1.0 - Bioretention Soil Testing

Task Summary - WSU Research Center in Puyallup shall collect and evaluate various bioretention soil mix aggregates to assist the City refine bioretention soil mix guidelines and assess availability of optimum aggregate material in the region.

Tasks

Task 1.1 Aggregate Evaluation

WSU shall contact selected aggregate sources and request copies of tests for some of their pits. Up to ten local aggregate suppliers will be contacted.

WSU shall compare sieve test information provided by the aggregate suppliers to the Seattle specification (draft from Shanti Colwell - June 11, 2009) and the WSU Bioretention Soil Mix Review and Recommendations (Curtis Hinman 2009). Up to 10 aggregates will be selected for sieve testing at WSU Puyallup.

WSU shall collect aggregate samples from the chosen suppliers. A sufficient volume of Cedar Grove fine compost will be obtained to conduct the entire survey.

WSU shall perform particle size (wet sieve) analysis on two replicate samples of each aggregate and on the Cedar Grove compost. Up to 22 particle size analyses will be performed in this phase of the project.

Task 1.2 - Bioretention Soil Mix Testing

WSU shall select from the 10 aggregates tested, five aggregates based on their coefficient of uniformity, mean particle size, and the existing Seattle and WSU guidelines. WSU shall mix these five aggregates with Cedar Grove compost at a ratio of 60% aggregate to 40% compost by volume and the saturated hydraulic conductivity and percent organic matter (%OM) of the resulting mixtures will be tested.

WSU shall conduct saturated hydraulic conductivity tests on all five mixtures. There will be four replicate samples of each mixture and permeability of each sample will be measured with consecutive water applications.

The following method will be used to evaluate saturated hydraulic conductivity:

- Compost and aggregate are combined in a mechanical mixer to obtain homogenous media.
- Twelve-inch soil columns are formed by adding media to 4-inch diameter PVC columns in 3-inch lifts with uniform compaction of each lift.
- Columns are saturated from the bottom overnight.
- Water is supplied to the column at constant head pressure.
- Volume of effluent per unit time is measured for calculation of saturated hydraulic conductivity.
- Measurements are taken at three different hydraulic gradients.

The following method will be used to assess percent organic matter content of the aggregate compost mixes (Loss on Ignition Method):

- Weigh a 50 mL crucible (tare).
- Place 10 to 20 g of air-dried soil into the tared crucible and place in a drying oven set at 100□ C for 2 to 3 hrs. Cool container in a desiccator and weigh (soil).
- Place the container plus sample in a muffle furnace set at 360□ C for 4 to 5 hrs. Cool container in a desiccator and weigh (burn).

Calculation:

$$\%OM = \frac{\text{soil} - \text{burn}}{\text{soil} - \text{tare}} \times 100$$

WSU shall deliver five gallons of each of the five mixtures to the City to be sent to an outside laboratory for hydraulic conductivity tests using the ASTM constant head permeameter test. The number of mixtures to be tested and the specific mixtures to be tested will be at the discretion of the City. The costs for this ASTM constant head permeameter testing will be paid for by the City outside of this MOA.

Deliverables

Task 1.1 Aggregate Evaluation

1. Comparisons of aggregate supplier particle size analyses with WSU particle size analyses for up to 10 aggregates plus Cedar Grove compost. A table of particle size distributions and uniformity coefficients will be developed.

Task 1.2 Bioretention Soil Mix Testing

1. Results of WSU permeability tests and %OM of five soil mixtures consisting of 60% aggregate and 40% Cedar Grove compost.
2. Five gallons of each of the five mixtures delivered to City.

Cost: Total cost for Task 1.1 and 1.2 is estimated to be $9,997, which includes a 49.5% Facilities and Administration charge.

Schedule: 9/1/2009 – 12/31/2009

Task 2 - Bioretention Facility Stormwater Monitoring

Task Summary - WSU Research Center in Puyallup shall conduct water quality testing in full-scale, replicated bioretention cells (referred to as "mesocosms") to assist the City meeting its NPDES stormwater monitoring requirement and provide defensible data for water quality treatment performance in bioretention systems to protect receiving waters.

Tasks

Task 2.1 – QAPP Development

WSU Research faculty and Herrera Environmental Consultants shall develop the Quality Assurance Project Plan (QAPP) for the Low Impact Development Research Program. Specifically, writing the QAPP will include:

- Initial meetings to discuss the research plan and specific experiments.
- Review of the TAPE protocol in context of the LID research program.
- Develop and review QAPP drafts.
- Develop an addendum to the QAPP that addresses specific requirements for monitoring required by the City.

Task 2.2 – Bioretention Facility Monitoring 2010

WSU shall collect and apply stormwater from a contributing area consisting of roads, parking and rooftops to bioretention mesocosms (155cm diameter X 133.35cm tall). The mesocosms will be planted with shrubs and grasses typical to western Washington bioretention facilities and in a soil mix consisting of 60% aggregate and 40% compost. The soil mix aggregate gradation, organic material content and chemical composition will be characterized before application of stormwater. Generally, the test procedures will be the following:

- The collected stormwater will be tested for pollutants of concern and additional chemicals will be mixed with the existing stormwater to achieve desired concentrations.
- The mixed stormwater will be applied at known rates and concentrations to reflect typical precipitation patterns for western Washington and stormwater concentrations.
- One sample representing the mixed stormwater that is applied will be collected to represent the influent sample for the four tested mesocosms.
- Effluent from each of the four mesocosms will be partitioned through a flow splitter to collect a flow-weighted sample. A sub-sample will be collected from the retained flow from each mesocosm to be submitted to the laboratory for analysis.
- Four water quality sampling events through four mesocosms will be conducted annually.
- Two duplicate water quality samples will be collected annually.
- One soil sample from each of the tested mesocosms will be collected annually at the end of the stormwater testing period for that year.
- Sampling procedures will follow protocol outlined in the QAPP for the Washington State University Low Impact Development Research Program (prepared under Task 2.1).

Task 2.3 – Bioretention Facility Monitoring Testing 2011

If necessary, based on statistical analysis of data from 2010; WSU shall repeat tasks detailed in Task 2.2 for up to four water quality events during 2011.

Deliverables

- WSU, through a subcontract with Herrera Environmental Consultants, shall complete the QAPP for the LID Research Program and an addendum to the QAPP that addresses specific requirements for City of Seattle experiments.
- WSU shall calibrate delivery and effluent collection systems.
- WSU shall conduct four water quality treatment experiments through four mesocosms annually, and collect and analyze one soil sample annually.
- WSU shall prepare reports for each sampling event and a summary report characterizing the bioretention system performance including statistical analysis.

WSU shall deliver the stormwater samples to an analytical laboratory for analysis of the following parameters:

- Hardness
- pH
- TSS
- Total Zn
- Dissolved Zn
- Total Cu
- Dissolve Cu
- Orthophosphate
- Total Phosphorus
- Particle Size Distribution

- WSU shall analyze the soil samples for the following parameters:
- Grain Size (wet sieve)
- Bulk Density
- Total solids
- Total volatile solids
- Total Cd
- Total Cu
- Total Pb
- Total Zn
- Digest for all metals
- Total Phosphorus
- TPH (diesel range)

WSU shall deliver the samples to the analytical laboratory and pay for the cost of the analytical work as part of the MOA.

Costs

Task 2.1 $39,253 (Note – WSU has agreed to waive all Facilities and Administration charges (Overhead) for this task)
Task 2.2 $35,573, which includes a 49.5% Facilities and Administration charge.
Task 2.3 $ 36,369, which includes a 49.5% Facilities and Administration charge.

Schedule:

Task 2.1 9/1/2009 – 12/31/2009 (QAPP to be delivered to SPU by 12/31/2009)
Task 2.2 1/1/2010 – 12/31/2010
Task 2.3 1/1/2011 – 12/31/2011

SUBCONTRACTOR

SCOPE OF WORK

Washington State University LID Research Facility Technical Support

In February 2009, Washington State University (WSU) authorized Herrera Environmental Consultants (Herrera) to prepare a scope of work and cost estimate to provide technical support in connection with the design of a new Low Impact Development (LID) research facility for WSU's Research and Extension Center in Puyallup. Monitoring at the research facility will be overseen by WSU, but other agencies, individuals, or entities will also conduct studies at the facility. Herrera will provide monitoring design consultation and author the Quality Assurance Project Plan (QAPP) for the facility and for a specific study to be designed and lead by Seattle Public Utilities (SPU). John Lenth is Herrera's project manager assigned to this project. Curtis Hinman is WSU's project representative for this project. Herrera's work on this project will be contracted through WSU; however, SPU is a significant stakeholder and will be having varying levels of involvement during each phase of the project.

This scope of work includes a discussion of the activities, assumptions, deliverables, and a schedule associated with this project:

- Task 1.0 – QAPP Production
- Task 2.0 – Project Management

Task 1.0 – QAPP Production

Herrera will prepare a Quality Assurance Project Plan (QAPP) for the LID research facility in accordance with Ecology's *Guidelines for Preparing Quality Assurance Project Plans for Environmental Studies* (Ecology Publication No. 01-03-003) and Technical Guidance for Assessing the Quality of Aquatic Environments, February 1994 (Ecology Publication No. 91-78). The QAPP will describe the monitoring and data quality objectives, and the associated procedures and methodologies that will be used to ensure that all environmental data generated will meet study objectives. The QAPP will include information on the water quality monitoring approach and laboratory protocols, including types of data and samples to be collected, sample location, general sampling procedures, analytical methods, method quality objectives, quality control procedures, data handling protocols, and data assessment procedures. Flow monitoring procedures will also be described with data quality objectives identified for instrument accuracy provided as necessary. Any discussion of the monitoring approach will include an explanation of how the project will yield sufficient information to achieve the purpose and intent of the monitoring. Finally, a discussion of data accuracy and statistical requirements will also be included.

The experimental design and sampling procedures sections of the QAPP will be organized into four primary sections, one for each of the four components of the LID research facility: pervious pavement, rain garden test plots, large rain garden test plots, and mesocosms. Each component will have unique requirements related to water quality and quantity data collection procedures.

SUBCONTRACTOR

SCOPE OF WORK

In addition to WSU's facility-wide monitoring, SPU will be conducting monitoring at 4 of the mesocosm cells. The QAPP will include any additional information that pertains to the SPU monitoring while clearly delineating which components of the monitoring plan are part of the larger WSU monitoring plan.

Assumptions

- The monitoring conducted by SPU and by WSU will be guided by the same QAPP. Any variance between the monitoring approaches will be noted in the QAPP.

Deliverables

- Herrera will submit an electronic copy (PDF file) of the draft QAPP to WSU and SPU by ~~October 16, 2009.~~ December 1, 2009
- Herrera will address consolidated comments received from WSU and SPU within three weeks of receiving their respective comments. Herrera will then submit an electronic copy (PDF file) of the revised QAPP to WSU, SPU, and Ecology.
- Herrera will address consolidated comments received from Ecology within three weeks of their receipt. Herrera will then submit 2 hard copies and an electronic copy of the final QAPP to WSU, SPU, and Ecology.

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Task 2.0 – Project Management/ Contract Administration

Herrera will be responsible for ongoing contract administration of this project, including preparing invoices and progress reports, as well as coordination of all work efforts with the designated client point of contact. Herrera's project manager will have phone and e-mail contact with WSU and SPU on an as-needed basis.

ATTACHMENT B
TERMS AND CONDITIONS

Provider:	WASHINGTON STATE UNIVERSITY	
MOA Number:	DA2009-39	
MOA Title	Bioretention Soil Testing and Bioretention Facility Stormwater Monitoring	
Effective Date	**Completion Date**	**Total Dollar Amount**
Effective on the date it is signed by both parties.	**12/31/2011**	**$133,191**

Basis of payment (hourly rate or lump sum at completion of task or scope) & intervals of payment
(See the budget details as provided on ATTACHMENT C: BUDGET DETAILS)

WSU will bill monthly for work completed.

Payments will be based on hourly rates as detailed in Attachment C.

This MOA includes a Management Reserve Fund which must be authorized in writing and reviewed by SPU Grants and Contract Section before proceeding with additional work.

Provider shall submit invoices to:	**Invoices shall include the following:**
Emmy Purainer, Accounts Payable Seattle Public Utilities PO Box 34018 Seattle WA 98124-4018	Invoice date and number SPU Agreement Number Period covered by the invoice Breakdown of charges Description of services performed

Subcontractors or sub-consultants authorized (Enter "NONE" if not applicable)

Herrera Environmental Consultants – John Lenth (Herrera Project Manager)

Name of Provider's Key Personnel Essential to the Project

Curtis Hinman – WSU Project Manager (for entire project)
Rita Hummel – WSU Project Manager for Task 1
Dan Nordquist, Director, Office of Grant and Research Development
Jackie Bolden, Grant & Contract Lead, Office of Grant and Research Development

Name of SPU's Key Personnel Essential to the Project (Including SPU's Project Manager)

Doug Hutchinson – overall Project Manager
Shanti Colwell – Project Manager for Task 1

Name and Address for Delivery of Notices

Provider:	**Seattle Public Utilities:**
Dan Nordquist, Director Office of Grant and Research Development, WSU PO BOX 643140 PULLMAN WA 99164-3140 Phone: 509-335-9661 Email: ogrd@wsu.edu	Doug Hutchinson Seattle Public Utilities PO Box 34018 Seattle WA 98124-4018 Phone: 206-233-7899 (Hutchinson)

Provider: WSU Puyallup Research and Extension Center
MOA Number: DA2009-39
MOA Title: Bioretention Soil Testing and Bioretention Facility Stormwater Monitoring

ATTACHMENT C
BUDGET DETAILS
PAGE 1

WSU Project Director(s): John Stark, Curtis Hinman, Rita Hummel

Personnel Costs			**Current**			**Total**
Salaries:	**Mos.**	**FTE**	**Mo. Rate**	**Yr 1**	**Yr 2**	**Amount**
Ag ResTech II	11	0.259	3,459	9,838	10,230	20,068
Grad Student RA	9	0.346	1,433	4,462		4,462
			Total Salaries	14,300	10,230	24,530
Wages Temporary timeslip				455		455
			Total Wages	455		455
Benefits						
ART II		36.0%		3,542	3,683	7,225
Grad Student		12.9%		576		576
				69		69
			Total Benefits	4,187	3,683	7,870
SUBTOTAL (Personnel Costs)				18,942	13,913	32,855
Goods & Services						
Water Samples Analysis				7,546	7,546	15,092
Chemicals				2,400	2,400	4,800
Sediment Analysis				468	468	936
Aggregate Gradation				850		850
SUBTOTAL (Goods & Services)				11,264	10,414	21,678
Travel						
Grad Student Travel				275		275
SUBTOTAL (Travel)				275	-	275
Subcontracts						
Herrara Environmental Consultants - QAPP development				39,253		39,253
SUBTOTAL for Subcontracts				39,253	-	39,253
Total Direct Costs				69,734	24,327	94,061
Exclusion - Total Herra Subcontract F&A waived per D. Nordquist				39,253		39,253
			F&A BASE	30,481	24,327	54,808
F&A @ 49.5%				15,088	12,042	27,130
TOTAL COSTS				84,822	36,369	121,191
*** Management Reserve Fund**						12,000
TOTAL AMOUNT OF MOA				124,075	36,369	133,191

*** The Management Reserve Fund must be authorized in writing and reviewed by SPU Grants and Contract Section before proceeding with additional work.**

DETAILS BY TASK	PAGE 2	TABLE 1	Task 1.1 and 1.2	$9,997.07
	PAGE 3	TABLE 2	Task 2.1	$39,253.00
	PAGE 4	TABLE 3	Task 2.2	$35,572.66
	PAGE 5	TABLE 4	Task 2.3	$36,368.66
			Project Total	$121,191.39

Provider: WSU Puyallup Research and Extension Center

MOA Number: DA2009-39

MOA Title: Bioretention Soil Testing and Bioretention Facility Stormwater Monitoring

ATTACHMENT C
PAGE 3
TABLE 2

TASK 2.1

HERRERA ENVIRONMENTAL CONSULTANTS

Cost Estimate for Washington State University LID Research Facility Technical Support
Herrera Proposal No. 09-04314-000

Washington State University LID Research Facility Technical Support *Number of Tasks: 2*			Task 1.0 *QAPP Production*		Task 2.0 *Project Management*		TOTAL	
COST SUMMARY								
Labor				$36,631		$2,556		$39,187
Travel and per diem				$66		$0		$66
Other direct costs (ODCs)				$0		$0		$0
GRAND TOTAL				**$36,697**		**$2,556**		**$39,253**
COST ITEMIZATION								
Labor		(2009 rates)						
Personnel		Rate/Hour	Hours	Cost	Hours	Cost	Hours	Cost
P6 Lenth, John	Principal Scientist	$170.43	60	$10,226	15	$2,556	75	$12,782
P4 Ahearn, Dylan	Senior Scientist	$136.84	120	$16,420	0	$0	120	$16,420
P2 Steinberg, Peter	Staff Scientist	$92.59	0	$0	0	$0	0	$0
P2 Bennett, Dan	Staff Scientist	$90.95	0	$0	0	$0	0	$0
P2 Catarra, Gina	Staff Scientist	$90.33	8	$723	0	$0	8	$723
P2 Yu, David	Staff Scientist	$83.38	0	$0	0	$0	0	$0
P2 Woodcock, Elizabeth	Staff Scientist	$76.20	60	$4,572	0	$0	60	$4,572
P1 Tomow, Brian	Scientist	$62.27	0	$0	0	$0	0	$0
P1 Rodriguez, Ruben	CAD/GIS Technician	$64.73	4	$259	0	$0	4	$259
P4 Gill, James	Senior Technical Editor	$91.77	30	$2,753	0	$0	30	$2,753
F3 Anderson, Jim	Contract Administrator	$98.62	0	$0	0	$0	0	$0
A5 Maxwell, Stuart	Technical Communications Manager	$111.44	8	$891	0	$0	8	$891
A2 Bradford, Andy	Administrative Staff	$65.55	12	$787	0	$0	12	$787
SUBTOTAL LABOR (Burdened Labor)			**302**	**$36,631**	**15**	**$2,556**	**317**	**$39,187**
TRAVEL AND PER DIEM COSTS	Unit	Cost	Units	Cost	Units	Cost	Units	Cost
Auto Use	Mile	$0.55	120	$66.00	0	$0.00	120	$66
SUBTOTAL TRAVEL AND PER DIEM				**$66**		**$0**		**$66**

Provider: WSU Puyallup Research and Extension Center
MOA Number: DA2009-39
MOA Title: Bioretention Soil Testing and Bioretention Facility Stormwater Monitoring

ATTACHMENT C
PAGE 2
TABLE 1

Task 1.1 and 1.2

Aggregate Gradation (wet sieve) and Saturated Hydraulic Conductivity Testing

Item	Cost
Graduate Student	
Salary	$4,462.00
Benefits	$576.00
Time-slip	
Wages	$455.00
Benefits	$69.00
Travel	$275.00
Supplies	$850.00
Subtotal	$6,687.00
Facilities and Administration @ 49.5%	$3,310.07
Total	**$9,997.07**

Provider: WSU Puyallup Research and Extension Center
MOA Number: DA2009-39
MOA Title: Bioretention Soil Testing and Bioretention Facility Stormwater Monitoring

ATTACHMENT C
PAGE 4
TABLE 3

TASK 2.2

2010 - Water Samples (4 sample events plus QC)

Analytical Parameter	Units	Unit Cost	Cost	Tasks and Miscellaneous Materials	Hours	Hrly Rate*	Cost	Total
Hardness	22	$29.00	$638.00	pressure sensor accuracy check	32	$27.14	$868.48	
pH	22	$22.00	$484.00	clean mixing tanks	32	$27.14	$868.48	
TSS	22	$28.00	$616.00	flush delivery lines	16	$27.14	$434.24	
Total Zn	22	$22.00	$484.00	prepare sample collection system	48	$27.14	$1,302.72	
Dissolved Zn	22	$25.00	$550.00	collect sample	32	$27.14	$868.48	
Total Cu	22	$22.00	$484.00	sample delivery (COC, paperwork etc.)	32	$27.14	$868.48	
Dissolve Cu	22	$25.00	$550.00	data entry	32	$27.14	$868.48	
Orthophosphate	22	$39.00	$858.00	sampling event report	256	$27.14	$6,947.84	
TP	22	$46.00	$1,012.00		**Units**	**Unit Cost**	**Cost**	
Particle Size Distribution	22	$85.00	$1,870.00	chemicals	16	$150.00	$2,400.00	
Subtotal			$7,546.00				$15,427.20	$22,973.20

2010 - Sediment Sample (once/year)

Analytical Parameter	Units	Unit Cost	Cost	Tasks and Miscellaneous Materials	Hours	Hrly Rate*	Cost	
Grain Size (wet sieve)	1	$110.20	$110.20	collect core sample	2	$27.14	$54.28	
Bulk Density	1	$110.20	$110.20	process core sample (pack & ship, COC)	2	$27.14	$54.28	
Total solids	1	$21.00	$21.00	data entry	1	$27.14	$27.14	
Total volatile solids	1	$26.00	$26.00	sampling event report	8	$27.14	$217.12	
Total Cd	1	$18.00	$18.00					
Total Cu	1	$18.00	$18.00					
Total Pb	1	$18.00	$18.00					
Total Zn	1	$18.00	$18.00					
Digest for all metals	1	$12.00	$12.00					
TP	1	$25.00	$25.00					
TPH (diesel range)	1	$92.00	$92.00					
Subtotal			$468.40				$352.82	$821.22
Subtotal (4 sampling events in 4 mesocosms and soil sampling)								$23,794.42
Facilities and Administration @ 49.5%								$11,778.24
Total								$35,572.66

* based on total monthly cost for Ag Technician II: $4,704/173.33 hrs per month = $27.14/hr
($3459 salary + $1245 benefits = $4704.47)

TASK 2.3

2011 - Water Samples (4 sample events plus QC)

Analytical Parameter	Units	Unit Cost	Cost	Tasks and Miscellaneous Materials	Hours	Hrly Rate*	Cost	Total
Hardness	22	$29.00	$638.00	pressure sensor accuracy check	32	$28.22	$903.04	
pH	22	$22.00	$484.00	clean mixing tanks	32	$28.22	$903.04	
TSS	22	$28.00	$616.00	flush delivery lines	16	$28.22	$451.52	
Total Zn	22	$22.00	$484.00	prepare sample collection system	48	$28.22	$1,354.56	
Dissolved Zn	22	$25.00	$550.00	collect sample	32	$28.22	$903.04	
Total Cu	22	$22.00	$484.00	sample delivery (COC, paperwork etc.)	32	$28.22	$903.04	
Dissolve Cu	22	$25.00	$550.00	data entry	32	$28.22	$903.04	
Orthophosphate	22	$39.00	$858.00	sampling event report	256	$28.22	$7,224.32	
TP	22	$46.00	$1,012.00		Units	Unit Cost	Cost	
Particle Size Distribution	22	$85.00	$1,870.00	chemicals	16	$150.00	$2,400.00	
			$7,546.00				$15,945.60	$23,491.60

2011 - Sediment Sample (once/year)

Analytical Parameter	Units	Unit Cost	Cost	Tasks and Miscellaneous Materials	Hours	Hrly Rate*	Cost	
Grain Size (wet sieve)	1	$110.20	$110.20	collect core sample	2	$28.22	$56.44	
Bulk Density	1	$110.20	$110.20	process core sample (pack & ship, COC)	2	$28.22	$56.44	
Total solids	1	$21.00	$21.00	data entry	1	$28.22	$28.22	
Total volatile solids	1	$26.00	$26.00	sampling event report	8	$28.22	$225.76	
Total Cd	1	$18.00	$18.00					
Total Cu	1	$18.00	$18.00					
Total Pb	1	$18.00	$18.00					
Total Zn	1	$18.00	$18.00					
Digest for all metals	1	$12.00	$12.00					
TP	1	$25.00	$25.00					
TPH (diesel range)	1	$92.00	$92.00					
Subtotal			$468.40				$366.86	$835.26
Subtotal (4 sampling events in 4 mesocosms and soil sampling)								$24,326.86
Facilities and Administration @ 49.5%								$12,041.80
Total								$36,368.66

* based on total monthly rate for 2011 Ag Technician II: $4,892/173.33 hrs per month = $28.22/hr
($3597 salary + $1295 benefits = $4892)

AMENDMENT NO. 1

TO

MEMORANDUM OF AGREEMENT NO. DA2009-39

BETWEEN

SEATTLE PUBLIC UTILITIES

AND

WASHINGTON STATE UNIVERSITY

FOR

BIORETENTION SOIL TESTING AND BIORETENTION FACILITY STORMWATER MONITORING

This Agreement is made and entered into by and between The City of Seattle ("the City"), a Washington municipal corporation, through its Seattle Public Utilities Department ("SPU"), and Washington State University (WSU) ("Provider").

The original Agreement for services for Bioretention Soil Testing and Bioretention Facility Stormwater Monitoring is amended as follows. All other terms and conditions of the original Agreement, as amended, remain in effect.

The Provider shall perform the tasks of the Scope of Work for this Amendment as described in Attachment A.1 and Attachment B.1 which are attached to and made a part of this Agreement.

The total dollar amount of this amendment is $5,172 increasing the Agreement total not to exceed amount to $138,362.

IN WITNESS WHEREOF, the parties have executed this Agreement Amendment by having their representatives affix their signatures below.

WASHINGTON STATE UNIVERSITY
PO Box 643140, Pullman, WA 99164-3140

By: Brendan R. Hoff 1/22/10
Signature Date

for Dan Nordquist
Director, Authorized Inst. Official
Office of Grant and
Research Development
[Type or Print Name]

[Type or Print Title]

SEATTLE PUBLIC UTILITIES
The City of Seattle

By: Ray Hoffman 2/11/10
Signature Date

RAY HOFFMAN, ACTING DIRECTOR

By: Nancy Ahern 2/10/10
Signature Date
Nancy Ahern, Deputy Director

ATTACHMENTS:
A.1 – SCOPE OF SERVICES AND SCHEDULE
B.1 – TERMS AND CONDITIONS
C.1 – BUDGET DETAILS
D – SUMMARY OF AGREEMENT DOLLAR AMOUNT TO DATE

ATTACHMENT A.1
SCOPE OF SERVICES AND SCHEDULE

Provider:	WASHINGTON STATE UNIVERSITY
MOA Number:	Amendment 1 to DA2009-39
MOA Title	Bioretention Soil Testing and Bioretention Facility Stormwater Monitoring

Background: This amendment reflects a revision to the scope of work for 'Task 1.0 – Bioretention Soil Testing'. The revision was requested by Seattle Public Utilities (SPU) and is specific to 'Task 1.2-Bioretention Soil Mix Testing'. In the original MOA, Task 1.2 called for WSU to select 5 aggregates from the 10 aggregates tested in 'Task 1.1-Aggregate Evaluation', mix them with Cedar Grove Compost at a ratio of 60% aggregate to 40% compost by volume and the test the saturated hydraulic conductivity and percent organic matter of the resulting mixtures. However, after reviewing the initial results, SPU determined that mixing aggregates on the outer boundaries of the aggregate specification with compost and testing those mixes would provide more valuable information on the performance of the existing soil specification. Since these aggregates did not exist in the samples collected, WSU was tasked with creating them.

Task 1.2a

The first paragraph of Task 1.2 shall be replaced with the following:
WSU shall select only 2 aggregates from the 10 aggregates tested in 'Task1.1- Aggregate Evaluation'. These 2 aggregates shall fall within the existing WSU specification. WSU shall create 3 "engineered" aggregates. Two of the engineered aggregates will fit the outer limits of the Seattle specification (Table 1, Upper and Lower) and the third engineered aggregate will be a Gap-graded material (Table 1). Hydraulic conductivity and OM content will be measured at WSU Puyallup on 60/40 (aggregate/compost) mixtures according to the original protocol. All engineered aggregates will contain 3% fines in order to directly examine the effects of manipulating the distribution of the larger particle sizes. The engineered aggregates will be created by blending sieved sand materials at the ratios listed in Table 1. In order to produce a sufficient quantity of individual particle sizes in a timely manner an 18" set of sieves will be purchased and utilized.

Sieve #	Upper		Lower		Gap-graded		Total (kg)
	% Retained	(kg)	% Retained	(kg)	% Retained	(kg)	
4	0	0	40	11.2	40	11.2	22.4
10	0	0	20	5.6	20	5.6	11.2
18	22	6.16	11	3.08	0	0	9.24
40	28	7.84	14	3.92	0	0	11.76
100	27	7.56	8	2.24	18	5.04	14.84
200	20	5.6	4	1.12	19	5.32	12.04
Fines	3	0.84	3	0.84	3	0.84	2.52

Table 1. Particle size percentages by weight for the engineered aggregates and total amounts of material needed.

Deliverables: Task 1.2 Bioretention Soil Mix Testing
1. Results of WSU permeability tests and %OM of five soil mixtures consisting of 60% aggregate and 40% Cedar Grove compost.
2. Five gallons of each of the five mixtures delivered to City.

Schedule: 9/1/2009 – 12/31/2009

ATTACHMENT B.1
TERMS AND CONDITIONS

Provider:	WASHINGTON STATE UNIVERSITY
MOA Number:	Amendment 1 to DA2009-39
MOA Title	Bioretention Soil Testing and Bioretention Facility Stormwater Monitoring

Effective Date	Completion Date	Total Dollar Amount For Amendment 1
Effective on the date it is signed by both parties.	12/31/2011	$5,172.00

Basis of payment (hourly rate or lump sum at completion of task or scope) & intervals of payment
(See the budget details as provided on ATTACHMENT C: BUDGET DETAILS)

WSU will bill monthly for work completed.
Payments will be based on hourly rates as detailed in Attachment C.1.

Provider shall submit invoices to:	Invoices shall include the following:
Emmy Purainer, Accounts Payable Seattle Public Utilities PO Box 34018 Seattle WA 98124-4018	Invoice date and number SPU Agreement Number Period covered by the invoice Breakdown of charges Description of services performed

Subcontractors or sub-consultants authorized (Enter "NONE" if not applicable)

Name of Provider's Key Personnel Essential to the Project

Curtis Hinman – WSU Project Manager (for entire project)
Rita Hummel – WSU Project Manager for Task 1
Dan Nordquist, Director, Office of Grant and Research Development
Jackie Bolden, Grant & Contract Lead, Office of Grant and Research Development

Name of SPU's Key Personnel Essential to the Project (Including SPU's Project Manager)

Doug Hutchinson – overall Project Manager
Shanti Colwell – Project Manager for Task 1

Name and Address for Delivery of Notices

Provider:	Seattle Public Utilities:
Dan Nordquist, Director Office of Grant and Research Development, WSU PO BOX 643140 PULLMAN WA 99164-3140 Phone: 509-335-9661 Email: ogrd@wsu.edu	Doug Hutchinson Seattle Public Utilities PO Box 34018 Seattle WA 98124-4018 Phone: 206-233-7899 (Hutchinson)

ATTACHMENT C.1
BUDGET DETAILS

Provider:	WASHINGTON STATE UNIVERSITY
MOA Number:	Amendment 1 to DA2009-39
MOA Title	Bioretention Soil Testing and Bioretention Facility Stormwater Monitoring

Additional Budget for Task 1.2: (as amended in Task 1.2a of this amendment)

				Total
Personnel Costs				
Salaries:	**Mos.**	**FTE**	**Current Mo. Rate**	**Amount**
Grad Student RA	1	0.480	1,432.67	687
Total Salaries				687
Wages Temporary employees				550
Total Wages				550
Benefits				
Grad Student		12.9%		89
Temporary employees				83
Total Benefits				172
Total Personnel Costs				1,409
Equipment				
One (1) 18" Sieve Set				1,950
Total Equipment				1,950
Travel				
Grad Student Travel				100
Total Travel				100
Total Direct Costs				3,459
F&A @ 49.5%				1,712
TOTAL COSTS				5,171

ATTACHMENT D
SUMMARY OF AGREEMENT DOLLAR AMOUNT TO DATE

Provider:	WASHINGTON STATE UNIVERSITY	
MOA Number:	Amendment 1 to DA2009-39	
MOA Title	Bioretention Soil Testing and Bioretention Facility Stormwater Monitoring	
DOCUMENT		**DOCUMENT AMOUNT**
Agreement No. DA2009-39		$133,191
Amendment No. 1		$5,171
TOTAL		$138,362

13F-3743-5328

AMENDMENT 2 TO
MEMORANDUM OF AGREEMENT #DA2009-39
BETWEEN
SEATTLE PUBLIC UTILITIES
AND
WASHINGTON STATE UNIVERSITY
FOR
BIORETENTION SOIL TESTING AND BIORETENTION FACILITY STORMWATER MONITORING

This Agreement is made and entered into by and between The City of Seattle ("the City"), a Washington municipal corporation, through its Seattle Public Utilities Department ("SPU"), and Washington State University (WSU) ("Provider").

WITNESSETH THAT:

WHEREAS, on November 19, 2009, the City engaged the services of the Provider under Agreement No. DA2009-39, hereinafter referred to as "Agreement" to perform services relating to Bioretention Soil Testing and Bioretention Facility Stormwater Monitoring; and

WHEREAS, SPU wishes to amend the Agreement due to unanticipated increases in laboratory costs and schedule delays due to start-up delays (no labor impacts are associated with the delays); and

WHEREAS, the additional time and budget are necessary and justified in order to complete the work;

NOW THEREFORE, the terms, conditions, covenants and performance contained in Agreement No. DA2009-39 and all subsequent Amendments shall be binding upon the parties hereto except insofar as amended and/or modified by this Amendment as follows:

Attachment B, Terms and Conditions, of the Agreement is hereby amended by changing the termination date to read as follows: "By this Amendment, the Completion date of the Agreement is extended to June 30, 2012 and the total dollar amount is increased by $9,878, for a new total not to exceed amount of $148,240.

Attachment C, Tables 3 and 4, of the Agreement are hereby amended as described in Attachment C.2 which is attached to and made a part of this Agreement.

IN WITNESS WHEREOF, the parties have executed this Amendment by having their representatives affix their signatures below.

WASHINGTON STATE UNIVERSITY
PO Box 643140, Pullman, WA 99164-3140

By: Dan Nordquist 6/8/11
Signature Date

Dan Nordquist
Director, Authorized Inst. Official
Office of Grant and Research Development
[Type or Print Name]

[Type or Print Title]

SEATTLE PUBLIC UTILITIES
The City of Seattle

By: Nancy Ahern 6/21/11
Signature Date

NANCY AHERN, DEPUTY DIRECTOR
UTILITY SYSTEMS MANAGEMENT BRANCH

ATTACHMENTS:
C.2 – BUDGET DETAILS (Revised Water Sample Lab Schedule and Costs)
D.1 – SUMMARY OF AGREEMENT DOLLAR AMOUNT TO DATE

ATTACHMENT C.2
Revised Water Sample Lab Schedule and Costs (SPU)

Provider: WSU Puyallup Research and Extension Center
SPU MOA #DA2009-39 Amendment #2
MOA Title: Bioretention Soil Testing and Bioretention Facility Stormwater Monitoring

Table 3.1

Lab Costs for Task 2.2: 4 Storms (February 15 to May 31, 2011)

Parameter	Analytical Method	Matrix	Number of Storms/Samples	Rinsate Blanks	Field Dups	Total Samples	Price	Total Cost/Parameter
pH	EPA 150 1	Water	4	0	1	5	$10 00	$50 00
Total Suspended Solids	EPA 160 2	Water	4	0	1	5	$18 00	$90 00
Suspended Sediment Concentration	ASTM D3977-97C	Water	4	0	1	5	$55 00	$275 00
Particle Size Distribution	Tape Appendix F	Water	4	0	1	5	$60 00	$300 00
Total Phosphorus	EPA 365 2	Water	4	1	1	6	$25 00	$150 00
Orthophosphorus	EPA 365 2	Water	4	1	1	6	$22 00	$132 00
Hardness	200 7 6010	Water	4	0	1	5	$60 00	$300 00
Total Cd Cu Zn	ICPMS	Water	4	1	1	6	$75 00	$450 00
Dissolved Cd Cu Zn			4	1	1	6	$75 00	$450 00
Filtering (metals/nutrients)	N/A	Water	8	1	1	10	$10 00	$100 00

total annual samples (4 storms x 5 sampling stations*) 4 x 5 = 20

New annual direct lab total/mesocosm (w/o F&A)	$2 297
New annual direct lab total/4 mesocosms + influent monitoring station (w/o F&A)	$11 485
Original Task 2.2 direct lab costs (w/o F&A)	$7 546
Total Task 2.2 Cost Increase Compared to MOA	$3 939
Original Total Task 2.2 Costs	$35 573
Revised Total Task 2.2 Costs	$39 512

Revised Schedule for Task 2.2: February 15 to May 31, 2011

Table 4.1

Lab Costs for Task 2.3: 5 Storms (October 1, 2011 to May 31, 2012)

Parameter	Analytical Method	Matrix	Number of Storms/Samples	Rinsate Blanks	Field Dups	Total Samples	Price	Total Cost/Parameter
pH	EPA 150 1	Water	5	0	1	6	$10 00	$60 00
Total Suspended Solids	EPA 160 2	Water	5	0	1	6	$18 00	$108 00
Suspended Sediment Concentration	ASTM D3977-97C	Water	5	0	1	6	$55 00	$330 00
Particle Size Distribution	Tape Appendix F	Water	5	0	1	6	$60 00	$360 00
Total Phosphorus	EPA 365 2	Water	5	1	1	7	$25 00	$175 00
Orthophosphorus	EPA 365 2	Water	5	1	1	7	$22 00	$154 00
Hardness	200 7 6010	Water	5	0	1	6	$60.00	$360 00
Total Cd Cu Zn	ICPMS	Water	5	1	1	7	$75 00	$525 00
Dissolved Cd Cu Zn			5	1	1	7	$75 00	$525 00
Filtering (metals/nutrients)	N/A	Water	8	1	1	10	$10 00	$100 00

total annual samples (5 storms x 5 sampling stations*) 5 x 5 = 25

New annual direct lab total/mesocosm (w/o F&A)	$2 697
New annual direct lab total/4 mesocosms + influent monitoring station (w/o F&A)	$13 485
Original Task 2.3 direct lab costs (w/o F&A)	$7 546
Total Task 2.3 Cost Increase Compared to MOA	$5 939
Original Total Task 2.3 Costs	$36 369
Revised Total Task 2.3 Costs	$42 308

Revised Schedule for Task 2.3: October 1, 2011 to May 31, 2012

* 4 mesocosms + influent monitoring station = 5 stations total per storm

Total Amendment related to revised lab costs (both tasks combined):	$9,878
Revised Project Total:	$148,240

ATTACHMENT D.1
SUMMARY OF AGREEMENT DOLLAR AMOUNT TO DATE

Provider:	WASHINGTON STATE UNIVERSITY
MOA Number:	Amendment 2 to DA2009-39
MOA Title	Bioretention Soil Testing and Bioretention Facility Stormwater Monitoring

DOCUMENT	DOCUMENT AMOUNT
Agreement No. DA2009-39	$133,191
Amendment No. 1	$5,171
Amendment No. 2	$9,878
TOTAL	$148,240

AMENDMENT 3 TO
MEMORANDUM OF AGREEMENT #DA2009-39
BETWEEN
SEATTLE PUBLIC UTILITIES
AND
WASHINGTON STATE UNIVERSITY
FOR
BIORETENTION SOIL TESTING AND BIORETENTION FACILITY STORMWATER MONITORING

This Agreement is made and entered into by and between The City of Seattle ("the City"), a Washington municipal corporation, through its Seattle Public Utilities Department ("SPU"), and Washington State University (WSU) ("Provider").

WITNESSETH THAT:

WHEREAS, on November 19, 2009, the City engaged the services of the Provider under Agreement No. DA2009-39, hereinafter referred to as "Agreement" to perform services relating to Bioretention Soil Testing and Bioretention Facility Stormwater Monitoring; and

WHEREAS, SPU wishes to extend the Agreement because the additional time is necessary and justified in order to complete the work;

NOW THEREFORE, the terms, conditions, covenants and performance contained in Agreement #DA2009-39 and all subsequent Amendments shall be binding upon the parties hereto except insofar as amended and/or modified by this Amendment as follows:

Attachment B, Terms and Conditions, of the Agreement is hereby amended by changing the termination date to read as follows: "By this Amendment, the Completion date of the Agreement is extended to March 31, 2015."

IN WITNESS WHEREOF, the parties have executed this Amendment by having their representatives affix their signatures below.

WASHINGTON STATE UNIVERSITY
PO Box 643140, Pullman, WA 99164-3140

By: [signature] 8/2/12
Signature Date

Dan Nordquist
Director, Authorized Inst. Official
Office of Grant and Research Development
[Type or Print Name]

[Type or Print Title]

SEATTLE PUBLIC UTILITIES
The City of Seattle

By: [signature] 8/21/12
Signature Date

NANCY AHERN, DEPUTY DIRECTOR
UTILITY SYSTEMS MANAGEMENT BRANCH