WSDOT NPDES Municipal Stormwater Permit Highway Runoff and BMP Effectiveness Stormwater Monitoring Report (S7.B, S7.C, and S7.E) Water Year 2012

October 2013

Prepared by

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Stormwater Monitoring Report

Highway Runoff and BMP Effectiveness
Water Year 2012

Approved by:

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Megan White, Director, WSDOT Environmental Services Office

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WSDOT = Washington State Department of Transportation

Acknowledgements

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1 Introduction

1.1 Permit Overview

In February 2009, the Washington State Department of Ecology (Ecology) issued a National Pollutant Discharge Elimination System (NPDES) and State Waste Discharge Permit (permit) (Ecology 2009a) to the Washington State Department of Transportation (WSDOT) (Permit #WAR043000A). Under Special Condition S7 of the permit, WSDOT must collect baseline stormwater monitoring data from its highways, rest areas, ferry terminals, and maintenance facilities. In addition, the department must evaluate the effectiveness of stormwater treatment and hydrologic (flow control) best management practices (BMPs) following guidelines from Ecology's *Guidance for Evaluating Emerging Stormwater Treatment Technologies, Technology Assessment Protocol* (TAPE) (Ecology 2008).[1]

Under Special Conditions S7.B-E and S8.F of the permit, a detailed monitoring report is required for data collected from the October 1, 2011 through September 30, 2012 water year 12 (WY 12). The following report satisfies this requirement and provides a summary of monitoring activities completed at WSDOT highway runoff and BMP effectiveness monitoring sites in WY 12. A separate report covers monitoring activities at WSDOT non-highway facilities (rest areas, maintenance facilities, and ferry terminals) in WY 12.

1.2 Monitoring Requirements

WSDOT is required by the permit to develop and implement a monitoring program to collect high-quality data that characterizes stormwater runoff from state highways. In addition, the permit requires a monitoring program to evaluate the effectiveness of stormwater treatment and hydrologic BMPs.

Baseline Monitoring of WSDOT Highways (S7.B and S7.C)

WSDOT is required to collect water quality and quantity data for stormwater runoff from the pavement edge at five highway locations across the state. The department must meet the following requirements:

1. WSDOT must establish highway monitoring stations at locations with the following annual average daily traffic (AADT) thresholds (S7.B.3):
    - Two highly urbanized western Washington sites (≥ 100,000 AADT)
    - One urbanized western Washington site (≤ 100,000 and ≥ 30,000 AADT)
    - One rural western Washington site (≤ 30,000 AADT)
    - One urbanized eastern Washington site (≤ 100,000 and ≥ 30,000 AADT)

[1] Ecology's *Technology Assessment Protocol* (TAPE) was updated and revised in 2011. However, the 2008 version of TAPE was in effect at the time the permit was implemented. This version of TAPE (2008) was used as guidance for implementation of the monitoring program.

2. WSDOT must collect and analyze sediments at highway sampling sites each year (S7.B.7).

3. WSDOT must collect seasonal first flush toxicity samples from three untreated highway runoff monitoring locations once each year (S7.C.3). Site locations are based on the following AADTs:
   - One highly urbanized site (≥ 100,000 AADT)
   - One urbanized site (≤ 100,000 and ≥ 30,000 AADT)
   - One rural site (≤ 30,000 AADT)

Monitoring Effectiveness of BMPs (S7.C and S7.E)

WSDOT must collect influent and effluent samples from at least two treatment BMPs, at no less than two sites per BMP. Monitoring must continue until statistical goals are met as defined by TAPE (Ecology 2008) (S7.E.2).

In addition, WSDOT is required to collect continuous rainfall and surface runoff data from one flow reduction BMP that is in use or planned for installation, such as a low-impact development (LID) BMP (S7.E.2).

Seasonal first flush toxicity sampling is required from three BMP effluent locations. At least one BMP location must be categorized as enhanced treatment for metals.

- One highly urbanized site (≥ 100,000 AADT)
- One urbanized site (≤ 100,000 and ≥ 30,000 AADT)
- One rural site (≤ 30,000 AADT)

1.3 Monitoring Schedule

In accordance with Special Condition S7.G.1.c, *Quality Assurance Project Plans (QAPPs) for Baseline Monitoring of WSDOT Highway Runoff* (WSDOT 2011a) and *WSDOT Roadway Stormwater Treatment Evaluation: Best Management Practices* (WSDOT 2011b) were submitted for approval to Ecology on September 2, 2011. The department received a QAPP approval letter from Ecology on September 16, 2011. These QAPPs describe the objectives of the highway runoff and BMP effectiveness monitoring programs and the procedures used to ensure the quality and integrity of collected data. The QAPPs also identify project timelines and schedules.

Under permit Special Condition S7.G.1.d, WSDOT was required to fully implement the monitoring program no later than September 6, 2011. The department recognized that developing a statewide highway runoff and best management practices (BMP) effectiveness stormwater monitoring program would take considerable time and planning. However, unanticipated challenges, including a statewide hiring freeze, forced WSDOT to delay the hiring and training necessary for essential monitoring support staff. Further, an equipment purchase freeze made it impossible to establish fully functional monitoring sites to meet permit-required implementation timelines.

On October 20, 2011, as required under General Condition G20 in the permit, WSDOT notified Ecology that it would be unable to fully comply with monitoring program implementation timelines and toxicity sampling would be deferred until the water year 2013 (WY 13) monitoring season.

In a letter to Ecology on January 13, 2012, WSDOT proposed a revised schedule and phased approach for initiating the highway and BMP effectiveness monitoring components of its program. The phased approach provided time for the iterative learning and adaptation necessary to fully and successfully implement the program. The letter proposed sampling at one highway and BMP monitoring site beginning May 1, 2012, with the remainder of the sites operational by June 15, 2012. Ecology concurred with the revised schedule, and WSDOT successfully met the revised timelines and schedule. Appendix A provides copies of the G20 notification letters to Ecology.

As a result of the schedule revision described above, this highways and BMP effectiveness monitoring report addresses the development and status of the monitoring program, but does not include monitoring data analyses which will be included in the report for WY 13.

2 Monitoring Program Implementation

2.1 Site Selection Strategy

To maximize resources and address logistical challenges in implementing the highway runoff and best management practices (BMP) effectiveness monitoring programs, WSDOT staff developed a strategy to optimize the number of monitoring locations needed to meet permit requirements. Whenever possible, staff co-located highway and BMP effectiveness monitoring stations to reduce the total number of sites required.

Clustering sites helps address logistical challenges and reduce team mobilization costs by minimizing staff travel time and associated costs. As a side benefit, field teams become familiar with the hazards of fewer sites, making fieldwork safer.

During the monitoring site selection process, opportunities to combine stormwater research interests at WSDOT with permit-required monitoring were carefully considered. As a result, the BMP effectiveness studies selected for this project support the department's stormwater research priorities.

Figure 1 shows the location of highway and BMP effectiveness monitoring sites across the state.

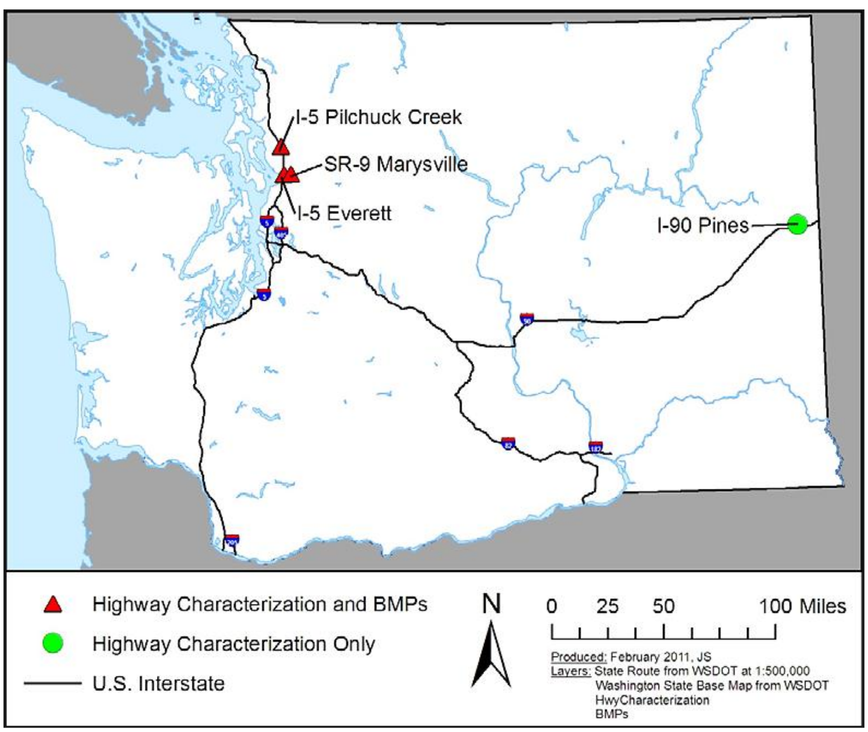

Figure 1 Highway and BMP Effectiveness Sites Selected for Monitoring

2.2 Highway Monitoring Sites

Four of five highway monitoring sites serve a dual purpose as highway runoff characterization and BMP effectiveness and toxicity testing sites. These sites are located in western Washington along Interstate 5 (I-5) north of Everett, and State Route 9 (SR 9) near Marysville. The remaining highway monitoring site is in Spokane on Interstate 90 (I-90). This site represents an "urbanized" highway monitoring location in eastern Washington.

Table 1 shows the selected highway runoff monitoring locations.

Table 1 Highway characterization monitoring sites.

Permit Traffic Designation	AADT[1]	Location[2]	Description
Highly urbanized[3]	120,500	NB I-5 at MP 197.27 Everett	Pavement edge (PE) interceptor on embankment
Highly urbanized	120,500	NB I-5 at MP 197.35 Everett	PE interceptor on embankment
Urbanized	78,500	SB I-5 at MP 210.71 Pilchuck Creek	PE interceptor on embankment
Rural[3]	16,500	SR 9 at MP 17.92 Marysville	PE interceptor on embankment
Urbanized (eastern WA)	87,168	I-90 at MP 289.54 Spokane	PE curb collector along highway shoulder

[1] Annual average daily traffic (AADT).
[2] Location: northbound (NB); southbound (SB); milepost (MP).
[3] Toxicity samples are collected from these sites and the pavement edge interceptor at the BMP effectiveness monitoring site at MP 210.85 along SB I-5 north of Pilchuck Creek.

I-5 Everett Highway Runoff Monitoring Sites

For the two monitoring stations along I-5 north of Everett, WSDOT staff installed interceptors along roadside embankments at the pavement edge (PE) on the east side of the highway at mileposts (MPs) 197.27 and 197.35. The interceptors are 40-foot long, high-density polyethylene (HDPE) half-pipes designed to capture stormwater runoff from three lanes of traffic and a paved shoulder for highway runoff characterization sampling. This represents a drainage area of 0.055 acre for each station. These interceptors also serve as influent sampling locations for BMP effectiveness evaluation.

The Everett highway runoff monitoring stations are just north of the Snohomish River in Snohomish County. Surrounding land uses include industrial and agricultural activities. Both sites satisfy the "highly urbanized" permit criterion, with annual average daily traffic (AADT) values of 120,500. Figure 2 shows their location along the highway.

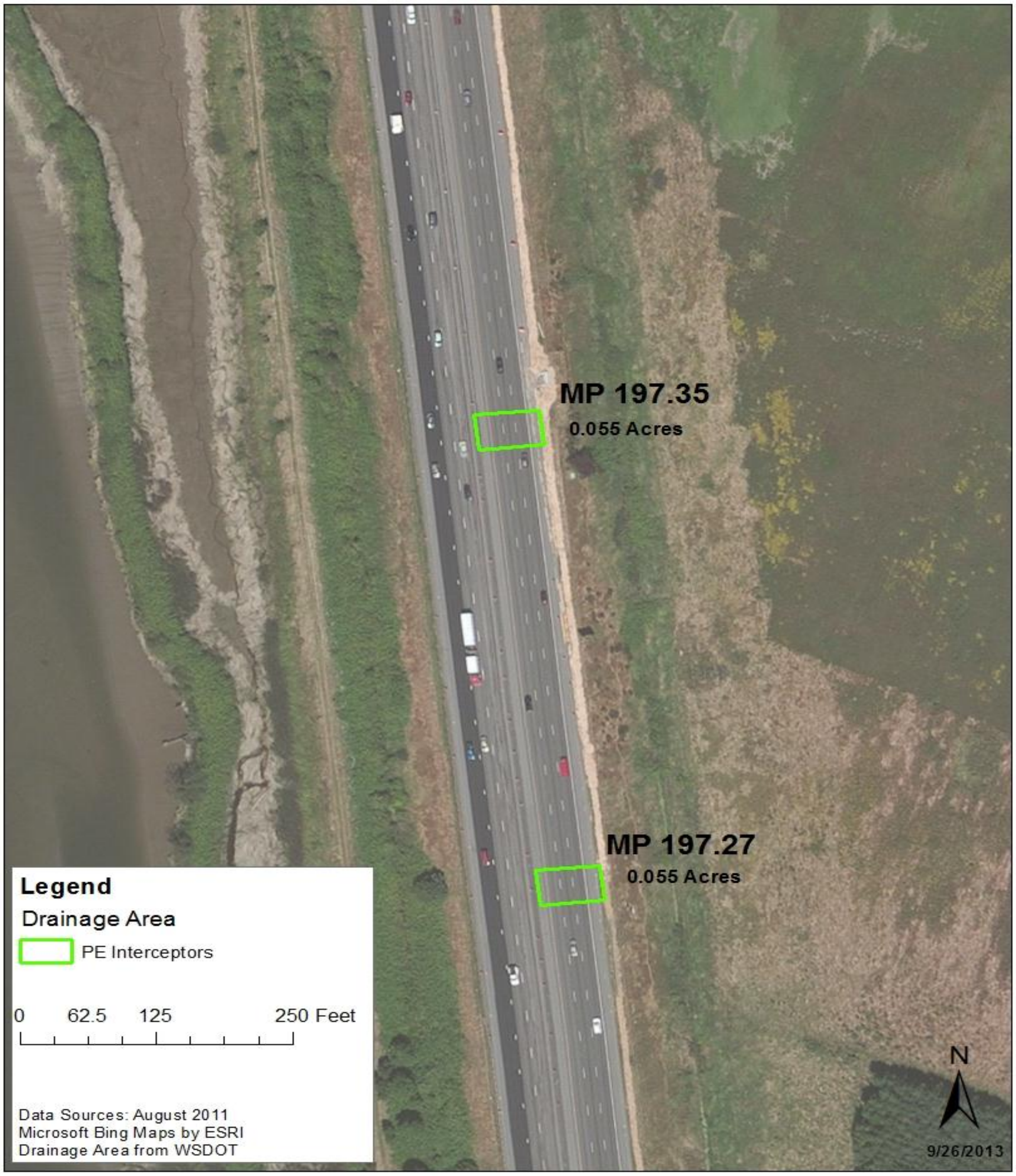

Figure 2 I-5 Everett “highly urbanized” highway runoff monitoring sites.

I-5 Pilchuck Creek Highway Runoff Monitoring Site

The I-5 Pilchuck Creek highway monitoring stations at MPs 210.71 and 210.85 include 40-foot long, HDPE half-pipe interceptors that are installed at the pavement edge (PE) along roadside embankments on the west side of the highway. In each case, the PE interceptors collect stormwater runoff from two of the three southbound lanes of traffic and the paved westernmost shoulder. This represents a drainage area of 0.031 acre for each station.

Both highway runoff monitoring stations at I-5 Pilchuck Creek serve a dual purpose as influent sampling locations for BMP effectiveness monitoring. Highway runoff characterization and BMP influent data are collected from the monitoring station at MP 210.71. Toxicity sampling and BMP influent data are collected from the station at MP 210.85.

The I-5 Pilchuck highway monitoring sites are just north of Pilchuck Creek in Snohomish County. Surrounding land uses include rural residential and agricultural activities. These sites satisfy the "urbanized" highway permit criterion with AADT values of 78,500. Figure 3 shows the location of the sites along the highway.

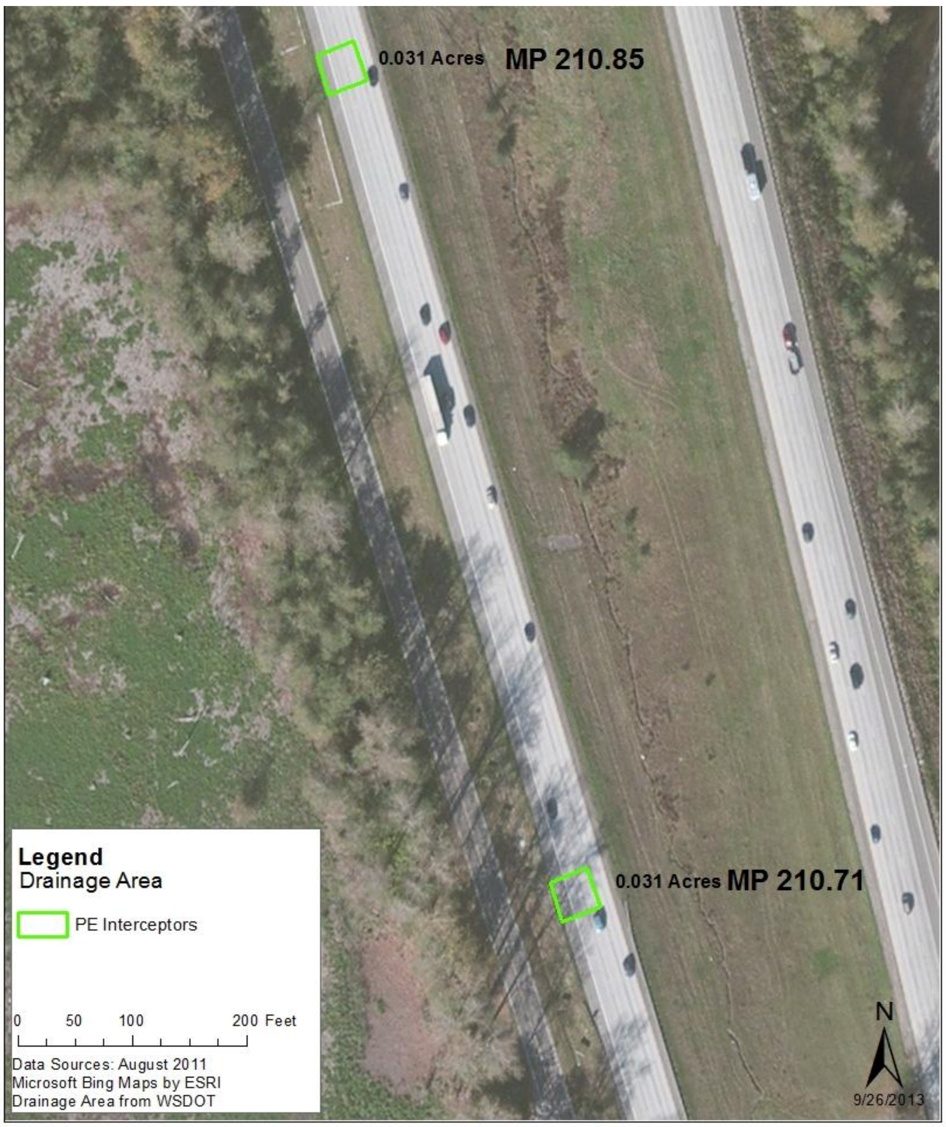

Figure 3 I-5 Pilchuck Creek "urbanized" highway runoff monitoring site.

SR 9 Marysville Highway Runoff Monitoring Site

The SR 9 Marysville highway runoff monitoring site includes a 40-foot long, HDPE half-pipe interceptor installed at the pavement edge (PE) along a roadside embankment on the west side of the highway at MP 17.92. The PE interceptor collects stormwater runoff from one and a half lanes of highway. This represents a drainage area of 0.038 acre.

The SR 9 Marysville highway runoff monitoring site is just north of Lake Stevens on the eastern edge of the city of Marysville in Snohomish County. The surrounding land uses include rural residential and light industrial activities. The site satisfies the "rural" permit criterion with an AADT value of 16,500. Figure 4 shows the location of the site along the highway.

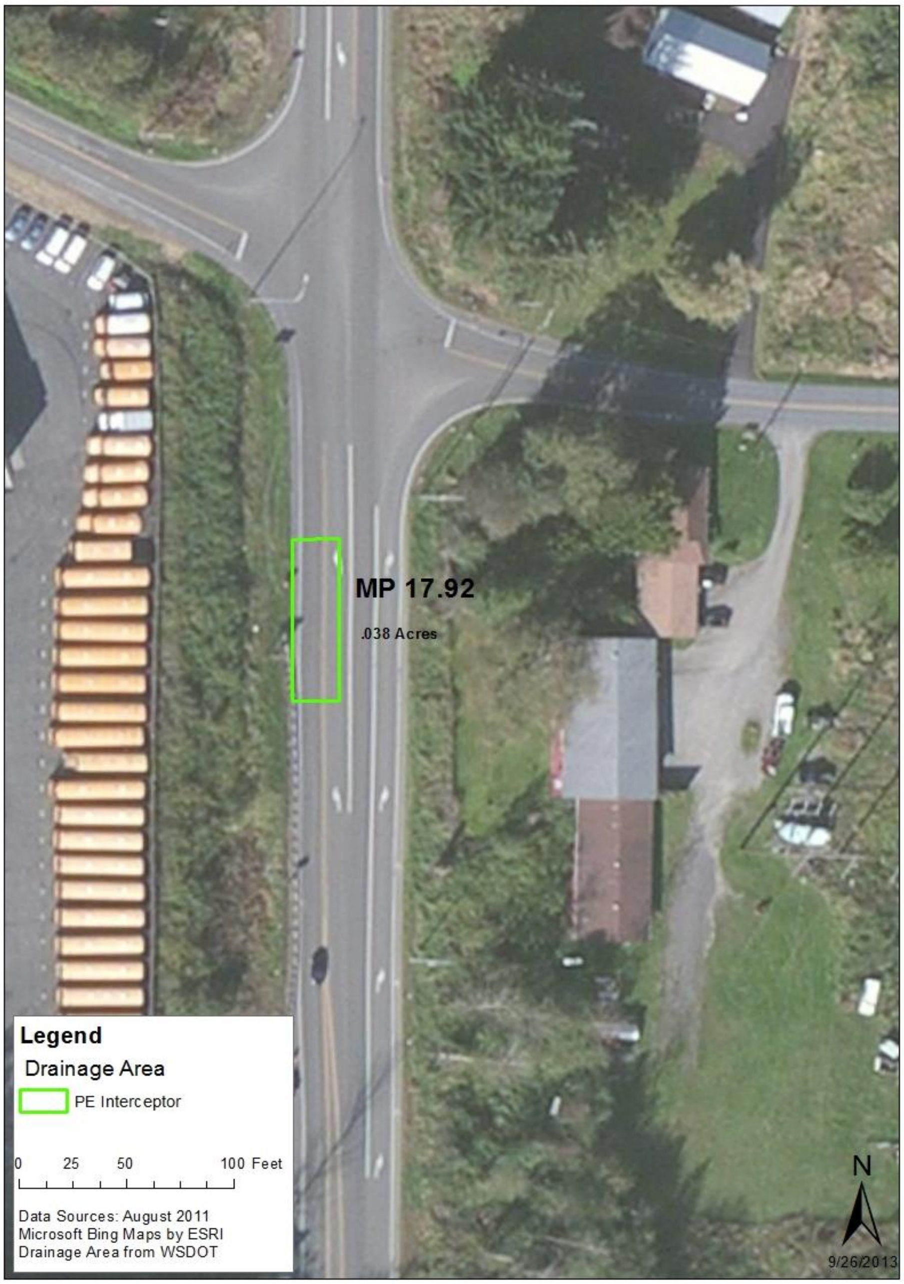

Figure 4 SR 9 Marysville "rural" highway characterization site.

I-90 Pines Highway Runoff Monitoring Site

The I-90 Pines highway runoff monitoring site is established along the westbound lanes of the highway at MP 289.55 in the City of Spokane Valley. An 80-foot long concrete curb behind a Jersey barrier intercepts stormwater runoff from three lanes of traffic and the westbound highway on-ramp. The monitoring station is established behind the curb and Jersey barrier between the Pines Maintenance Facility fence and the highway shoulder. This represents a drainage area of 0.132 acre.

Surrounding land uses include urban residential and industrial activities. This site satisfies the eastern Washington "urbanized" permit criterion, with an AADT of 87,168. Figure 5 shows the location of the site and sampling station along the north side of the interstate highway.

Figure 5 I-90 Pines "urbanized" highway characterization site.

2.3 BMP Effectiveness Monitoring Sites

The department combined permit-required highway runoff characterization and BMP effectiveness monitoring sites at two locations along I-5 and one location along SR 9. The following types of biofiltration BMPs were selected for monitoring:

- Vegetated filter strips (basic VFS)
- Compost-amended vegetated filter strips (CAVFS)
- Modified (experimental) VFS

Vegetated filter strips (VFSs) are sloping land areas with planted vegetation and amended soils used to treat stormwater sheet flow from roads and highways. These BMPs function by slowing runoff velocities, filtering sediment and other pollutants, and providing some biologic uptake and infiltration into underlying soils (WSDOT 2011c).

A basic VFS is a compacted roadside embankment that is hydroseeded with an established grass seed mix. A CAVFS is a variation of the basic VFS that incorporates soil amendments (compost) into the top 12 inches of soil to enhance infiltration characteristics, increase surface roughness, and improve plant growth and cover (WSDOT 2011c). *Basic VFSs* and *compost-amended VFSs* (CAVFS) are preferred filter strip designs. Both BMPs are also approved for use by the Washington State Department of Ecology (Ecology) and described in detail in the *Highway Runoff Manual* (WSDOT 2011c).

The *modified VFS* is an experimental BMP that has not yet received approval from Ecology. The modified VFS includes a 3-inch compost blanket that is applied to the surface of the soil. In comparison to CAVFS, the modified VFS does not require heavy equipment to till compost into the top 12 inches of the soil, making the cost of installation less expensive.

Modified VFS designs reduce costs for construction because compost blanket applications require minimal ground disturbance, fewer traffic impacts, and less traffic control. In addition, compost blankets may be applied on steeper slopes, over broader areas, and as erosion control earlier in the construction process. Finally, compost-blanket VFSs can be applied in confined spaces, such as urban areas, where CAVFS installations are usually not possible.

The department’s VFS effectiveness study sites are established along roadside embankments adjacent to the northbound lanes of I-5 (MPs 197.27 and 197.35) and southbound lanes of I-5 (MPs 210.71 and 210.85). These sites provide a paired study for comparison of a low-impact development (LID) treatment approach as required in Special Condition S7.E.2 of the permit. A CAVFS is installed along the southbound lanes of I-5 at MP 210.78 for additional comparison.

The SR 9 study site is different in that it addresses only one permit requirement – it provides a “rural” sampling location for BMP effluent toxicity testing. Highway runoff characterization is also collected from the edge of pavement at the SR 9 study site, but this data is not included in the VFS effectiveness evaluation.

Table 2 provides a list of the BMPs with their locations, average slopes, and average grades. Figure 6 shows the BMP effectiveness study site locations.

Table 2 BMP effectiveness monitoring sites.

BMP Study	Location	BMP Type	Traffic Designation	Average Slope (H:V)[1]	Average % Grade
I-5 VFS Study	I-5, Everett MP197.27	Basic VFS	Highly urban 120,500 AADT	3.70:1	27
	I-5, Everett MP 197.35[2]	Modified VFS		3.85:1	26
	I-5 Pilchuck MP 210.71	Basic VFS	Urban 78,500 AADT	4.00:1	25
	1-5 Pilchuck MP 210.78	CAVFS		3.85:1[3]	26
	I-5 Pilchuck MP 210.85[2]	Modified VFS		3.70:1	26
SR 9 Rural VFS Study	SR9 Marysville MP 17.92[2]	VFS	Rural 16,500 AADT	4.00:1	25

[1] Horizontal:Vertical (H:V)

[2] Toxicity samples collected from influent and effluent sampling points.

[3] Estimated slope.

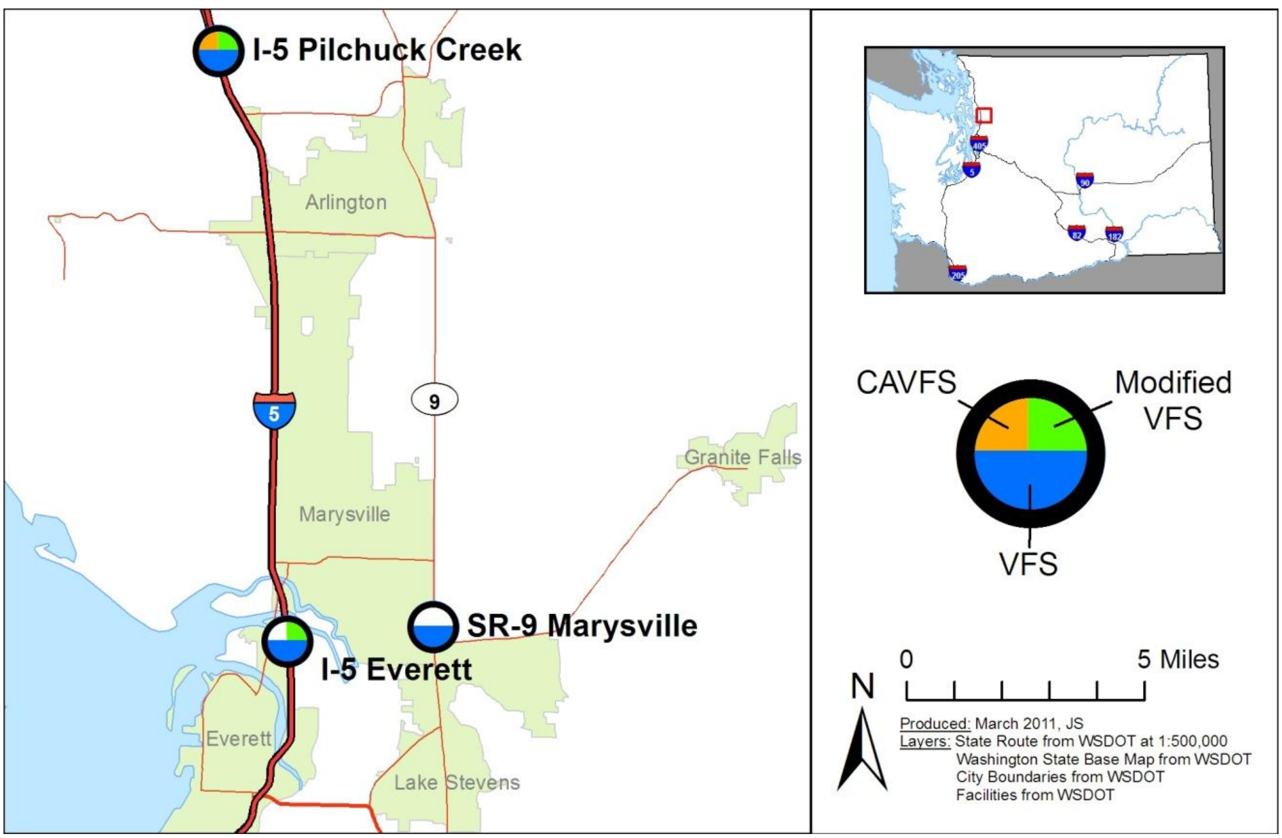

Figure 6 BMP locations and types for stormwater monitoring.

2.4 Highway Runoff Characterization and BMP Effectiveness Study Design

The I-5 BMP effectiveness studies evaluate and compare highway treatment performance of basic VFS, modified compost-blanket VFS and CAVFS designs. Stormwater interceptors (HDPE half-pipe collectors) are positioned along each VFS at the pavement edge, and at 6.6 feet (2 meters) and 13.1 feet (4 meters) downslope from the pavement edge. WSDOT staff will evaluate and compare treatment performance from the pavement edge (influent samples) and downslope collection points (effluent samples).

WSDOT staff established effluent sample collection points located 6.6 feet downslope as part of the study's sampling design because highways in highly urbanized areas may have limited space to locate stormwater treatment along the road shoulder. Some studies suggest much of the flow reduction and water quality treatment performance of VFSs may occur close to the edge of pavement (Ebihara et al., 2009; Kaighn and Yu 1996).

The effluent collection points located 13.1 feet downslope are included in this study to further evaluate the treatment performance of the BMPs on the road shoulder embankment. Sampling from the 6.6 and 13.1 feet locations will allow us to assess to what extent, if any, performance is enhanced by increasing the distance.

Aerial views of the I-5 Everett and I-5 Pilchuck Creek BMP effectiveness monitoring study sites are shown in Figures 7 and 8.

Figure 9 shows an aerial view of the SR 9 Marysville monitoring study site. This site provides a monitoring location for rural highway runoff and BMP effluent toxicity sampling. Thus, this site is not part of the BMP effectiveness evaluation.

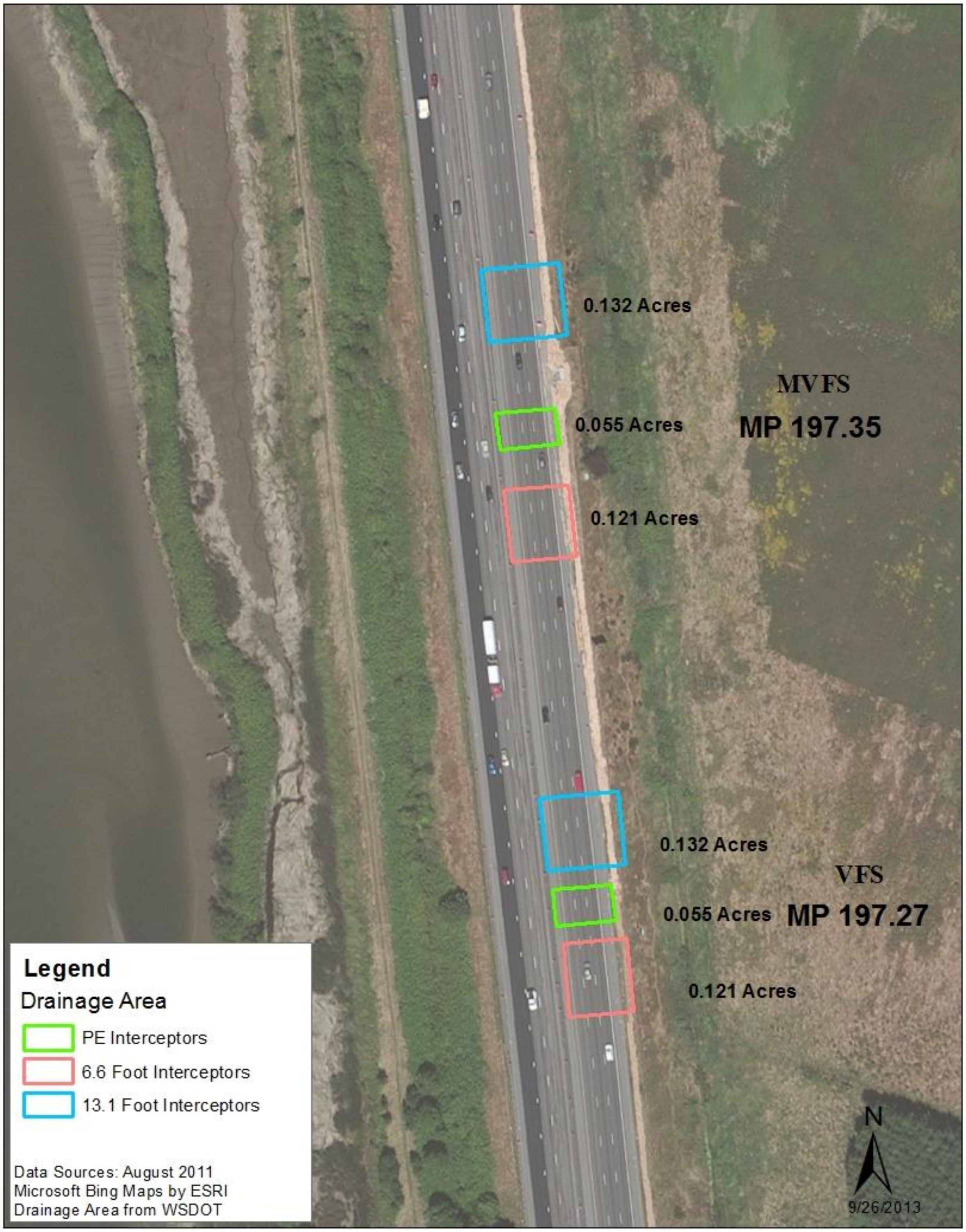

Figure 7 I-5 Everett BMP effectiveness monitoring study sites.

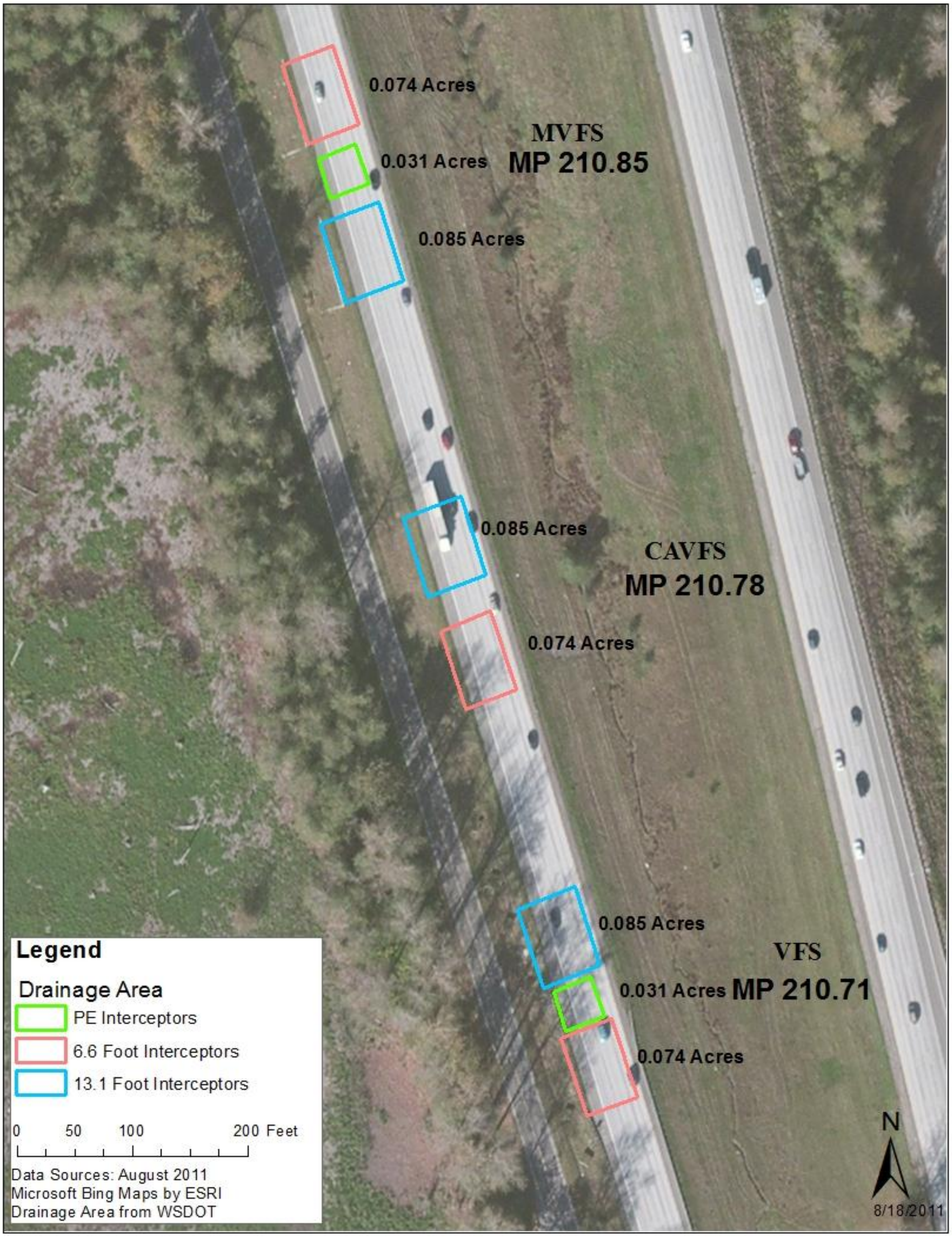

Figure 8 I-5 Pilchuck Creek BMP effectiveness monitoring study sites.

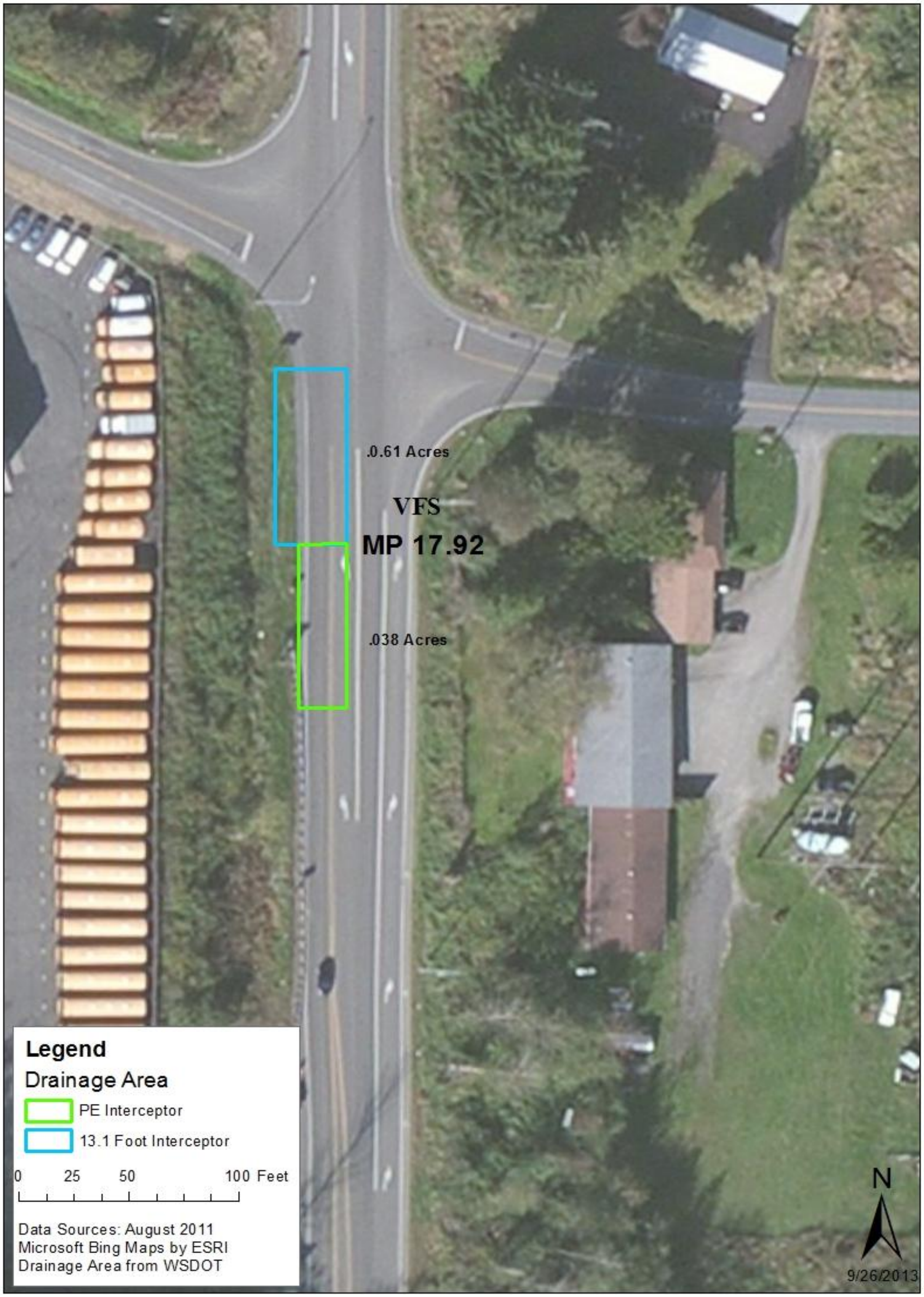

Figure 9 SR 9 Marysville highway and BMP effluent monitoring site.

Time of Concentration

WSDOT field staff programed automatic flow-weighted composite samplers to begin sampling as early in a storm runoff event as feasible and to continue sampling past the longest estimated time of concentration. For highway runoff characterization and BMP effectiveness monitoring sites, time of concentration is the time necessary for surface runoff to reach the edge of pavement interceptor from the hydraulically most distant point of each drainage area. Time of concentration provides a measure to ensure pacing of the monitoring equipment is set to obtain a representative sample and to evaluate whether contributions from the entire basin are represented.

Table 3 lists characteristics and calculated time of concentration for each monitoring site based on a range of rainfall depths typical in Washington State. Flow lengths were estimated from hydraulics reports, field estimates, as-built drawings, aerial photography, or WSDOT's GIS Workbench (WSDOT 2011d). Drainage areas were calculated by multiplying the flow length by the length of the pavement edge interceptors.

Table 3 Highway and BMP effectiveness monitoring site characteristics and times of concentration.

Site Location	Flow Length of Longest Path (ft)	Drainage Area (ac)	Rainfall at 0.15"		Rainfall at 2"	
			Tc (min)[1]	Qp (gal/min)[2]	Tc (min)	Qp (gal/min)
I-5 Everett, MP 197.27	136	0.05	5.78	0.12	2.42	1.63
I-5 Everett, MP 197.35	136	0.05	5.78	0.12	2.42	1.63
I-5 Pilchuck, MP 210.71	93	0.03	1.97	0.07	1.32	0.92
I-5 Pilchuck, MP 210.85	93	0.03	1.97	0.07	1.32	0.92
SR-9 Marysville, MP 18	121	0.04	3.93	0.08	2.59	1.14
I-90 Spokane, MP 289.54	172	0.13	5.48	0.29	1.87	3.91

[1] Tc: Time of concentration (minutes)

[2] Qp (gal/min): Peak flow (gallons/minute)

Monitoring Site Set-Up and Sampling Design Details

WSDOT staff installed high-density polyethylene (HDPE) half-pipe interceptors along the pavement at the I-5 Everett, I-5 Pilchuck Creek, and SR 9 Marysville highway runoff characterization and BMP effectiveness monitoring sites. Staff buried pipes and mortared them to the edge of the pavement at a level that allows the free flow of surface water runoff into the interceptor pipes. Interceptor pipes were sloped slightly downhill to promote directional flow for measurement. Figure 10 shows the pavement edge interceptor pipe and highway shoulder in cross section.

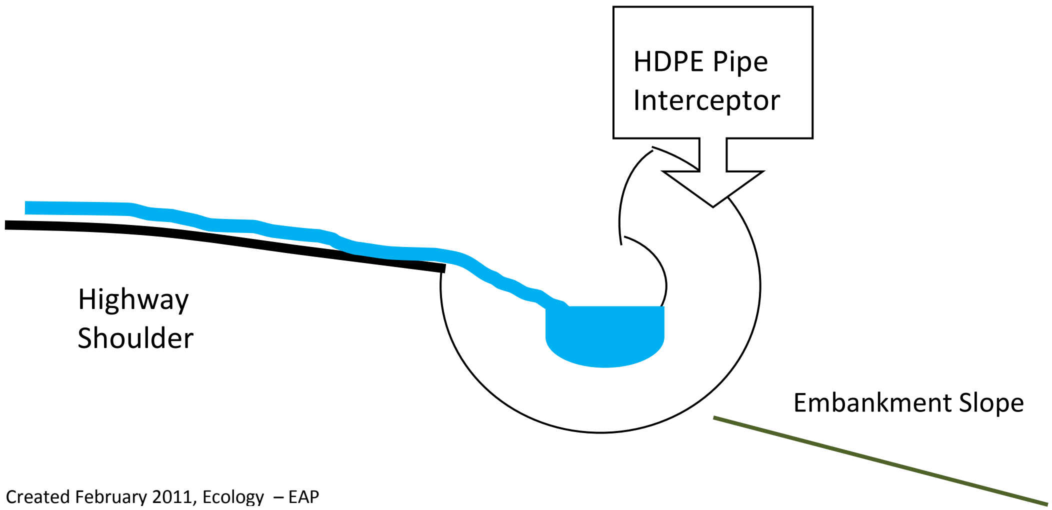

Figure 10 Cross section of the pavement edge interceptor.

Interceptor pipes installed at 6.6 feet and 13.1 feet along the VFS embankments were recessed into the surface of the soil and positioned to collect surface runoff flowing through the BMP from the edge of pavement. Similar to the pavement edge interceptor, the 6.6 and 13.1-foot interceptors were sloped slightly to promote directional flow for measurement. Figure 11 shows the downslope interceptors in cross section.

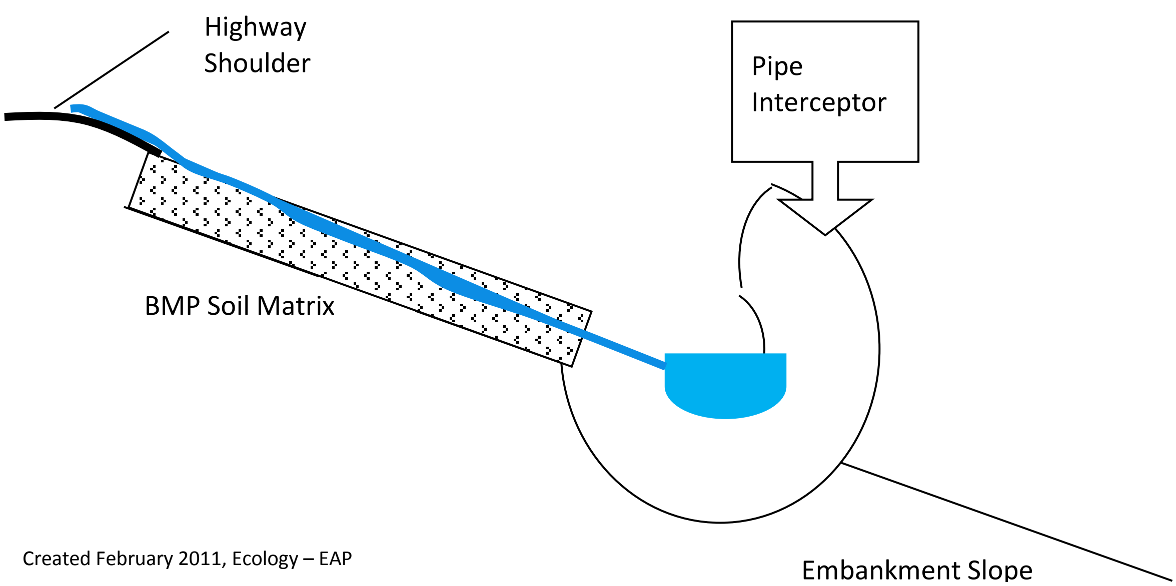

Figure 11 Cross section of the downslope interceptors.

Figure 12 shows a generalized drawing of a combined highway runoff and BMP effectiveness monitoring site. The diagram illustrates how interceptors were positioned to collect sheet flow runoff from the surface of the highway and downslope through the VFS. The data collection platform (DCP) with rain gage, solar panel, transmitting antennae, and enclosures were installed at the lower end of the roadside embankment.

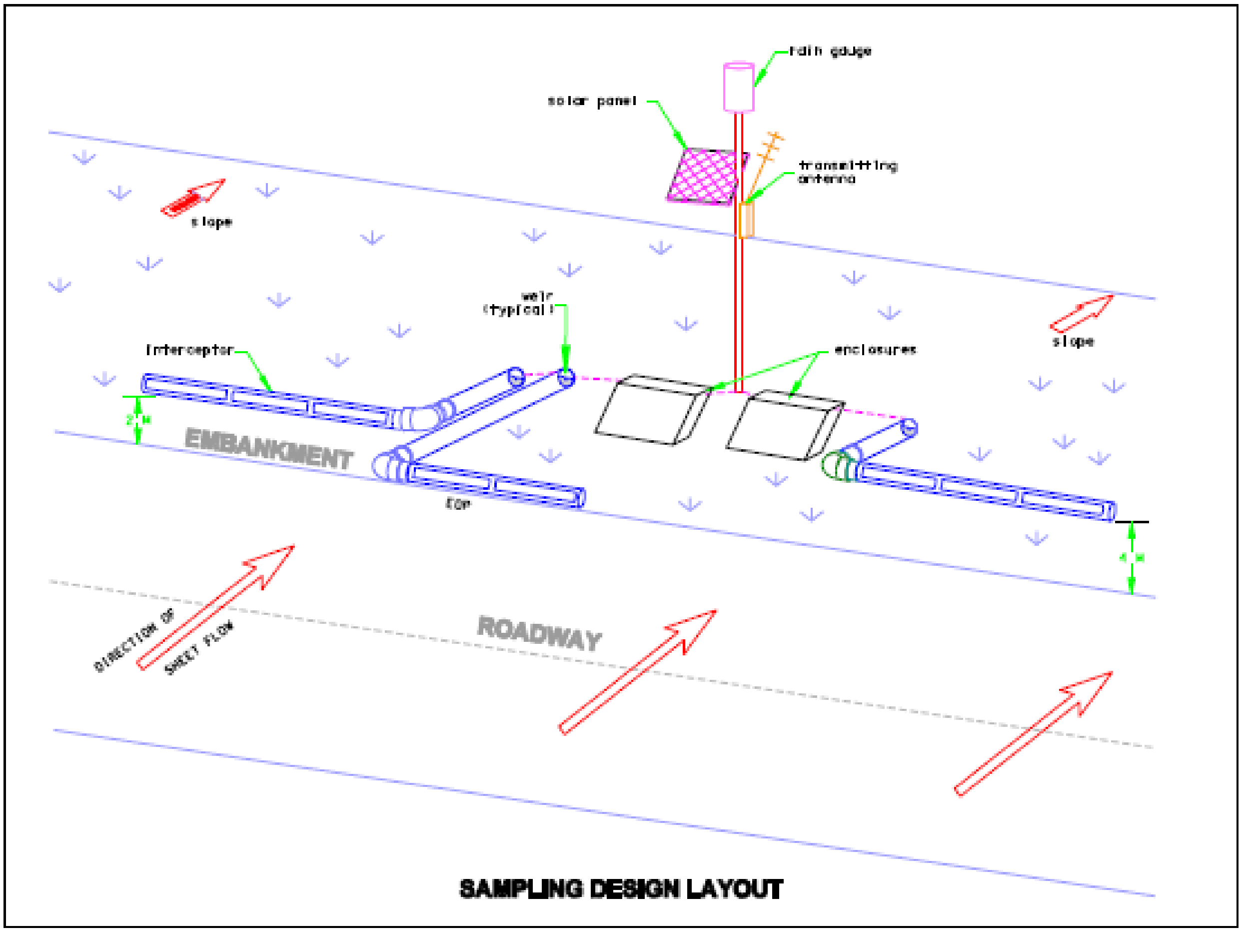

Figure 12 Generalized sampling design.

Figures 13, 14, and 15 depict the I-5 Everett, I-5 Pilchuck Creek, and SR 9 Marysville monitoring sites. Since the SR 9 Marysville monitoring site is not part of the BMP effectiveness evaluation, only one interceptor is installed along the slope of the VFS embankment.

The I-90 Pines highway runoff monitoring site uses an 80-foot concrete curb positioned behind a Jersey barrier to divert stormwater runoff toward monitoring equipment installed on the highway shoulder. The data collection platform (DCP) is similar to the monitoring station shown in Figure 12.

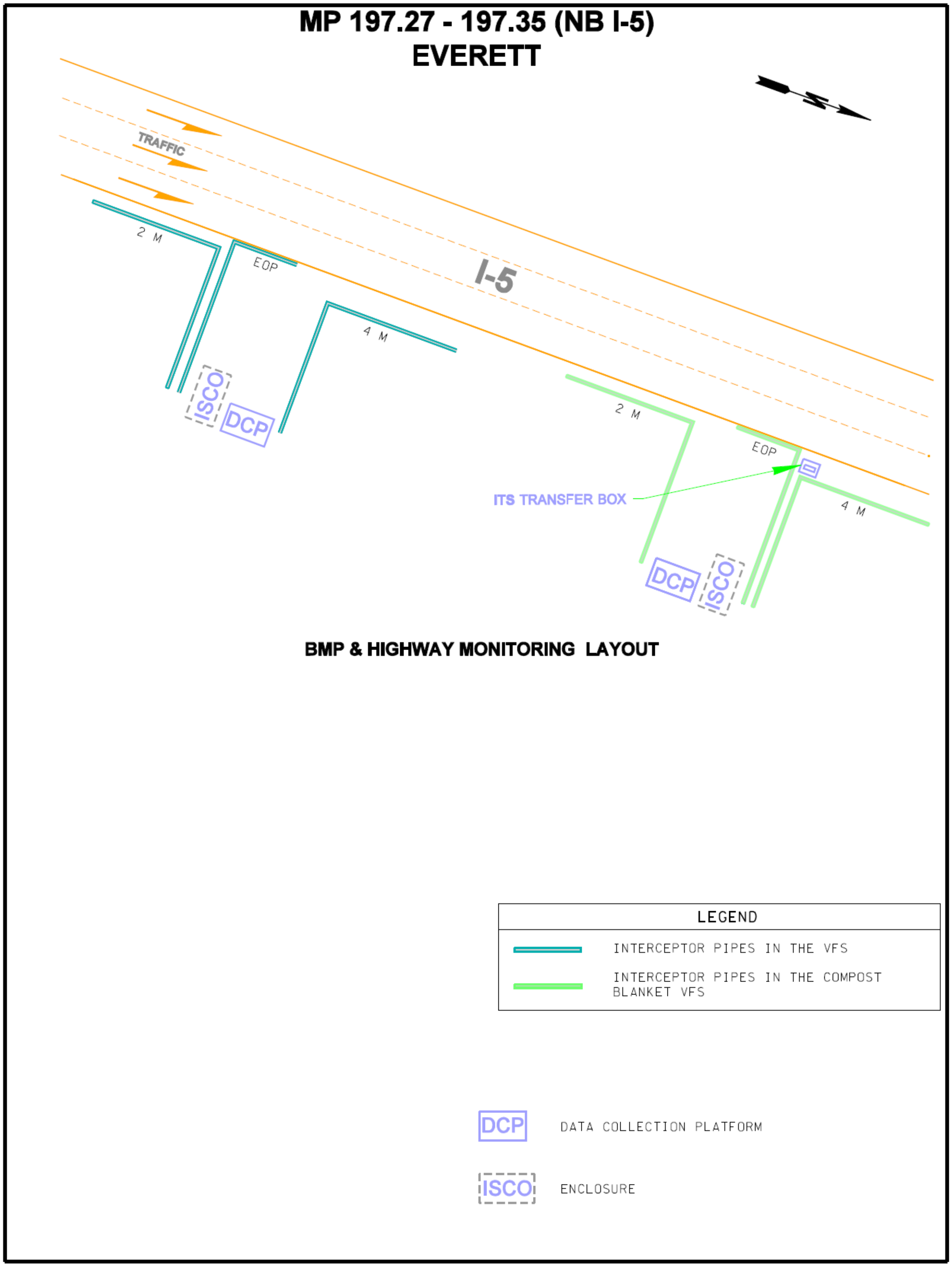

Figure 13 I-5 Everett Highway and BMP Effectiveness Monitoring Site.

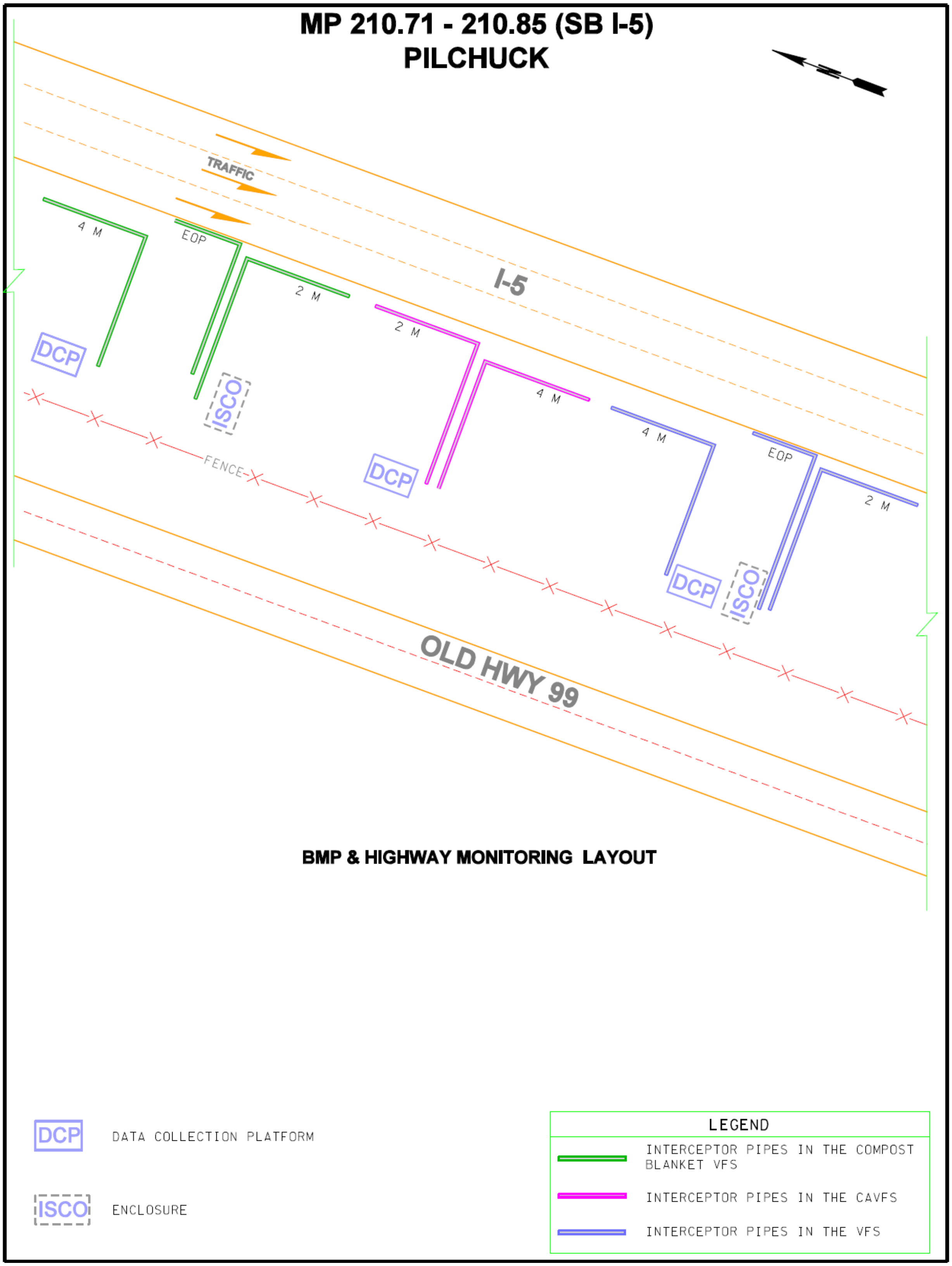

Figure 14 I-5 Pilchuck Creek Highway and BMP Effectiveness Monitoring Site.

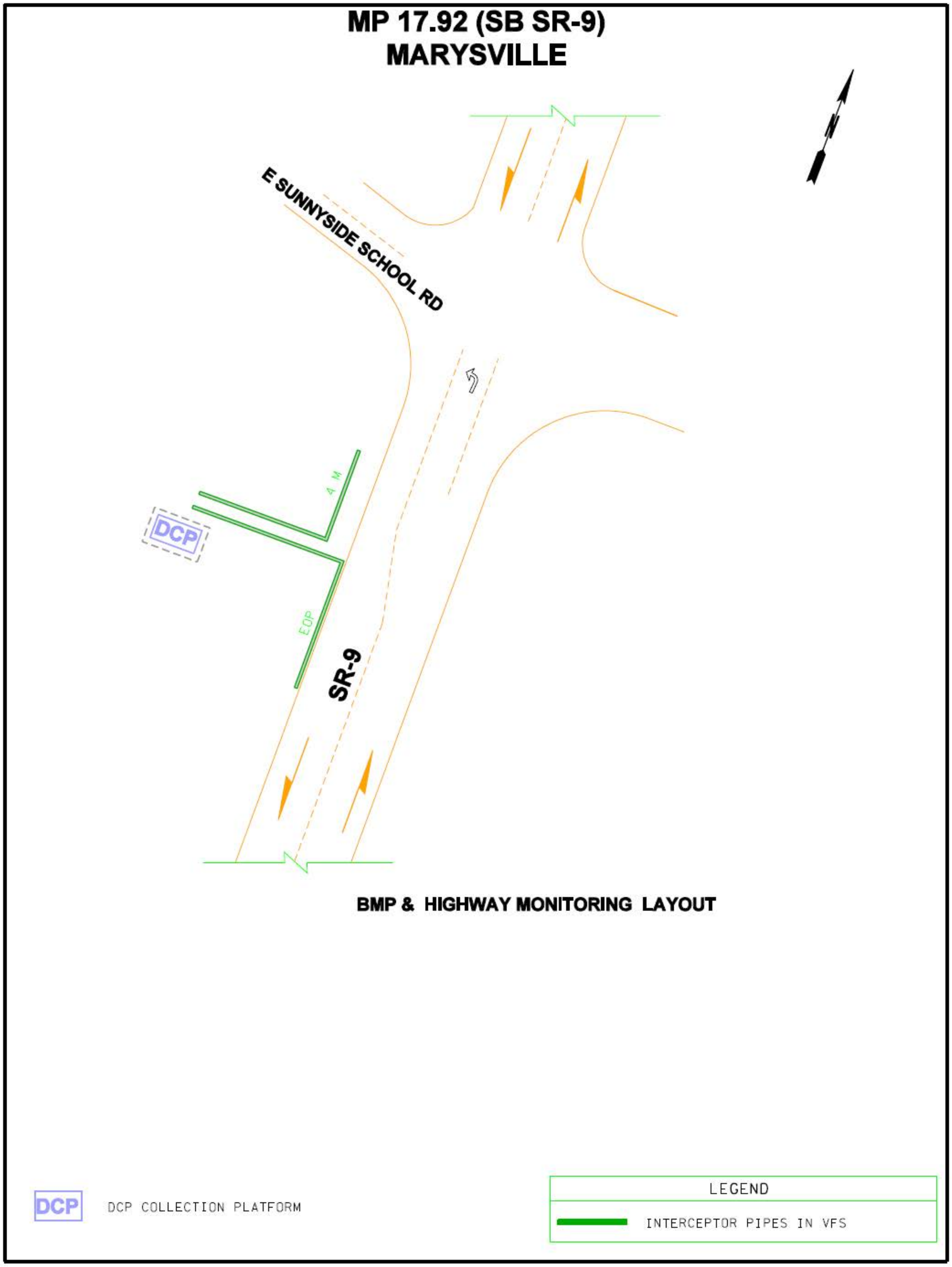

Figure 15 SR 9 Marysville Monitoring Site.

3 Sampling and Monitoring Procedures

3.1 Monitoring Stations

Monitoring stations at highway runoff characterization and best management practice (BMP) effectiveness monitoring sites typically include an equipment enclosure with lock, mounting pole, Global Positioning System (GPS), antenna, solar panel, and rain gage. The antenna, solar panel, and rain gage are attached to the mounting pole that is installed to the side of the equipment enclosure.

A data logger; refrigerated automatic sampler; sample tubing; an analog module to run a thermistor (temperature sensor); stage measuring devices, including a depth pressure transducer (PT) and compact bubble sensor (CBS); and a 12-volt battery are housed within the locked equipment enclosure. Sample tubing typically runs from the automatic sampler through protective conduit located outside the enclosure to the designated sampling point. The thermistor and PT wires as well as the CBS line runs through conduit to a stilling well where stage and temperature are recorded. The locked enclosure provides a secure location for equipment as well as protection from wind, rain, and snowfall.

3.2 Weather Tracking

WSDOT uses satellite imagery and model predictions augmented by weather information provided by the National Oceanic and Atmospheric Administration (NOAA), National Weather Service (NWS), and private forecasters. Monitoring field staff use this information to identify potential qualifying storm events on a daily basis. As candidate storms approach, staff use radar observations and hourly reports from land-based weather stations to track and evaluate storm potential as it approaches. Once a storm begins, data received from the individual monitoring stations via the Emergency Data Distribution Network (EDDN) message through Geostationary Operational Environmental Satellite Data Collection System (GOES DCS) are used to track the progress of a storm event and the beginning of runoff. Staff use this information to direct field team deployments for sample collection.

To qualify, a storm must meet minimum rainfall depth and antecedent dry period criteria as defined by the permit (S7.B.6 and S7.E.4) and TAPE (Ecology 2008). Table 4 lists storm event criteria for highway monitoring sites.

Table 4 Storm event criteria for highway monitoring.

Criteria	Wet Season	Dry Season
Monitoring Period	Western WA (Oct 1 – Apr 30); Eastern WA (Oct 1 – Jun 30)	Western WA (May 1 – Sep 30); Eastern WA (Jul 1 – Sep 30)
Rainfall Depth	0.20" minimum; no fixed maximum	0.20" minimum; no fixed maximum
Rainfall Duration	No fixed minimum or maximum	No fixed minimum or maximum
Antecedent Dry Period	< 0.02" rain or no surface runoff in the previous 24 hours	< 0.02" rain or no surface runoff in the previous 72 hours
Inter-Event Dry Period	6 hours	6 hours
Rainfall Intensity	Not specified	Not specified

At highway monitoring sites, WSDOT is required to sample 67 percent of forecast storms that result in actual qualifying storm events; up to a maximum of 14 storm events each water year. Eleven of the 14 storm events must meet qualifying storm event criteria. The department may collect and report data from three storm events that were forecast as qualifying storms but did not meet the qualifying storm event criterion for rainfall depth (i.e., 0.20-inch minimum).

Stormwater samples are to be distributed throughout the year. The goal for western Washington highway monitoring sites is to collect 60 to 80 percent of stormwater samples during the wet season, and 20 to 40 percent during the dry season. For the eastern Washington highway monitoring site, the goal is to collect 80 to 90 percent of the samples in the wet season, and 10 to 20 percent in the dry season.

A one-week antecedent dry period is required prior to seasonal first-flush toxicity sampling at the three highway runoff characterization and three BMP effluent monitoring locations in western Washington. The first-flush sampling event has to occur in August or September. If unsuccessful in August or September, a first-flush toxicity sample may be collected in October, irrespective of the antecedent dry period (S7.C.5).

Table 5 lists criteria for BMP effectiveness monitoring.

Table 5 Storm event criteria for BMP effectiveness monitoring.

Criteria	BMP Effectiveness Monitoring	BMP Effluent First-Flush Toxicity Monitoring
Monitoring Period	Year round	Annual (Aug 1 – Oct 31)
Rainfall Depth	0.15” minimum; no fixed maximum	Not specified
Rainfall Duration	1-hour minimum; no fixed maximum	Not specified
Antecedent Dry Period	< 0.04” rain in the previous 6 hours	< 0.04” rain in the previous week (168 hours)
Inter-Event Dry Period	Not specified	Not specified
Minimum Intensity	Lowest intensity that qualifies as a rainfall event[1]	Not specified

[1] Average intensities should exceed 0.03 inches per hour for at least half the sampled storms.

To make the best use of limited resources, WSDOT combined western Washington highway runoff characterization and BMP effectiveness monitoring sites. Where storm criteria for highways and BMP effectiveness monitoring differ, staff followed the most inclusive storm criteria. For example, the antecedent dry period criteria for highway monitoring require more time between storms. In this case, antecedent dry period criteria for highways are followed for both highway runoff and BMP effectiveness monitoring sites.

Precipitation Measurement

At each monitoring station, WSDOT installed a pole-mounted tipping bucket rain gage to accurately capture on-site rainfall measurements. Each rain gage was leveled and installed in a secure location where no trees, buildings, overpasses, or other objects obstruct or divert precipitation prior to entering the rain gage. WSDOT referenced National Weather Service criteria as guidance for rain gage installation (NWS 2010). Staff adhere to rain gage calibration and maintenance procedures according to manufacturers’ specifications. These procedures include leveling the gage and cleaning filter screens and drain holes during each maintenance visit. Field staff conduct maintenance every six to eight weeks.

WSDOT collected rain gage data every 15 minutes and stored it in the data logger’s memory. WSDOT used these data, transmitted via telemetry to a WSDOT database, to track and record site-specific precipitation measurements.

3.3 Sampling Parameters

WSDOT staff collect a different suite of sampling parameters for highway, toxicity, and BMP effectiveness monitoring sites. Table 6 lists these parameters in order of priority. If sufficient sample volume is collected, the department processes samples for the highest priority pollutants in accordance with volume requirements.

Table 6 Sampling water quality parameters listed in order of priority.

Highways	BMPs	Toxicity
TPH-Dx and TPH-Gx	TSS	Cu, Zn, Cd, Pb (total)
fecal coliform	PSD	Cu, Zn, Cd, Pb (dissolved)
temperature[1]	pH	triclopyr (not applied)[2]
visible sheen observation	total phosphorus	2, 4-D (not applied)
Cu, Zn, Cd, Pb (total)	orthophosphate	clopyralid (not applied)
Cu, Zn, Cd, Pb (dissolved)	hardness	diuron (not applied)
PAHs	Cu, Zn (total)	dichlobenil (not applied)
TSS	Cu, Zn (dissolved)	picloram (not applied)
chlorides		glyphosate
phthalates		TSS
triclopyr (not applied)[2]		chlorides
2, 4-D (not applied)		hardness
clopyralid (not applied)		MBAS
diuron (Pines only)		PAHs
dichlobenil (Pines only)		phthalates
picloram (not applied)		TPH-Dx and TPH-Gx
glyphosate		
total phosphorus		
orthophosphate		
hardness [3]		

[1] Temperature is measured by in situ probe and is also used as a threshold for triggering autosamplers.

[2] Herbicides are only required for monitoring if applied in the site drainage area (S7.B.4, S7.B.7, and S7.C.4).

[3] Hardness is not a permit-required parameter. It is included in this list by Ecology recommendation and because of the effect of hardness on the bioavailability of metals in solution.

WSDOT is required to sample and analyze herbicides at highway runoff and toxicity monitoring sites where listed herbicides are applied in the monitoring site vicinity. The stormwater monitoring team checks herbicide applications for all monitoring site drainage areas annually.

WSDOT staff used these annual reviews to update the list of herbicides monitored at each site. On the west side of the state, only glyphosate was applied in or near the monitoring study sites. At the highway monitoring site in Spokane (Pines), three herbicides were applied – glyphosate, diuron, and dichlobenil.

WSDOT also conducts annual baseline sediment quality testing at each highway sampling site. The department is required to sample, analyze, and report the following parameters *in order of priority* if insufficient volume exists:

1. particle size (grain size)
2. total organic carbon
3. total metals (copper, zinc, cadmium, and lead)
4. PAHs
5. TPH-Dx
6. phenolics
7. herbicides (if applied in the drainage area)
8. phthalates
9. total percent solids

Sediment sampling is also required for BMP effectiveness monitoring sites (S.7.E.6). However, the BMPs the department selected for monitoring (i.e., basic VFS, CAVFS, and modified compost-blanket VFS) are infiltration-type BMPs that use grass and soil, or compost, grass, and soil as filtration media. Sediment samples from these BMPs are not collected since there is no technique to ensure collected sediment represents only stormwater-carried sediments and not components of the soil or compost. Ecology approved this deviation from permit requirements during the QAPP approval process.

3.4 Sampling Methods

Highway runoff characterization and BMP effectiveness monitoring sites are established to measure stormwater quality and quantity. Table 7 lists parameter categories, sampling frequency, and methods.

Table 7 Sampling methods overview.

Parameter Category	Sampling Frequency	Sampling Method	Telemetered Data?
Rainfall	Continuous, year round	Rain gage	yes
Stage (flow)	Continuous, year round	Stage measuring device	yes
Temperature	Continuous, year round	In situ probe	yes
Chemical, except TPH	Discrete storm events	Autosampler	no
TPH and fecal coliform	Discrete storm events	Grab sample	no
Toxicity	Annually	Autosampler	no

Continuous Samples

WSDOT records continuous rainfall and runoff monitoring data at all highway runoff characterization and BMP effectiveness study site locations. Field staff installed data loggers and attached peripheral probes to collect water temperature and stage measurements every five minutes. Precipitation measurements are recorded every 15 minutes. These data are stored in the data loggers and transmitted at one-hour intervals to establish site-specific records. Hydrographs and hyetographs are created from collected rainfall and calculated discharge data to accurately compare and relate these two parameters.

Grab Samples

WSDOT staff collected grab samples by hand for total petroleum hydrocarbons (TPH) and fecal coliform bacteria as early in the runoff event as practical. If WSDOT staff are not able to collect grab samples during a qualifying storm event at highway monitoring sites, grab samples can be collected during nonqualifying storm events. The department follows procedures outlined in the *Standard Operating Procedure for Collecting Grab Samples from Stormwater Discharges* (Ecology 2009b) when collecting grab samples.

Although temperature may be collected as a grab sample, the department measures temperature continuously at each site using external probes connected to data loggers. Field staff also look for visible sheen during grab sample collection to enhance observations and stormwater characterization.

Composite Samples

WSDOT staff use refrigerated autosamplers to collect flow-weighted composite samples when enough runoff has accumulated to enable sample collection. Each station's telemetered data logger is programmed with a step-triggering system that collects environmental data (e.g., water temperature, rainfall, and stage) to determine whether a storm event qualifies and sampling should be initiated. When programmed thresholds are met, the data logger prompts the autosampler to initiate sample collection. Staff program composite samplers to collect at least 10 aliquots during storm events. Composite samples with 7 to 9 aliquots are acceptable if they meet other sampling criteria and help achieve a representative balance of storm events and sizes.

Monitoring stations can support different bottle configurations and types depending on sample volume requirements, planned replicates, or anticipated storm size. Table 8 lists minimum volumes, holding times, containers, and preservation requirements for highway characterization and BMP effectiveness monitoring water quality samples.

Table 8 Sample containers, amounts, preservation, and holding times (MEL 2008; 40 CFR 136.3; Ecology 2009a)

Analysis	Quantity Needed for Analysis	Container[1]	Holding Time	Preservative
Chloride	100 mL	125 mL w/m poly bottle	28 days	Cool to ≤6°C
Fecal coliform (grab)	250 mL	250 mL glass/poly bottle	6 hours + 2 at Lab	Fill bottle to Shoulder; cool to ≤10°C
Hardness as $CaCO_3$	100 mL	125 mL w/m poly bottle	6 months	H_2SO_4 to pH<2; cool to ≤6°C
Herbicides – Diuron	1 liter	1 liter amber glass bottle with Teflon® lid	7 days to extraction, 40 days after extraction	Cool to ≤6°C
Herbicides – Picloram, triclopyr (ester formula)	1 liter	1 liter amber glass bottle with Teflon® lid	7 days to extraction, 40 days after extraction	Cool to ≤6°C
Herbicides – Glyphosate* (nonaquatic formula)	60 mL	60 mL screw cap bottles with a Teflon® faced silicone septa	14 days	Cool to ≤4°C
Metals – dissolved (Cu, Cd, Zn, Pb)	100 mL	500 mL HDPE bottle with Teflon® lid	6 months	Filter within 15 minutes of collection, then add HNO_3 to pH <2; cool to ≤6°C
Metals – total recoverable (Cu, Cd, Zn, Pb)	100 mL	500 mL HDPE bottle with Teflon® lid	6 months	HNO_3 to pH <2
Orthophosphate (OP)	30 mL	125 mL amber w/m poly bottle	48 hours	Filter within 15 minutes of collection; cool to ≤6°C
pH	500 mL; no head space in bottle	500 mL w/m poly bottle	24 hours	Cool to ≤6°C
PAH compounds	1 liter	1 liter amber glass bottle with Teflon® lid	7 days to extraction, 40 days after extraction	Store in dark; cool to ≤6°C
Particle size distribution	2 liters	HDPE, glass, or Teflon® container	7 days	Cool to 4°C

Table 8 Sample containers, amounts, preservation, and holding times (continued).

Analysis	Quantity Needed for Analysis	Container[1]	Holding Time	Preservative
Phthalates	1 liter	1 liter amber glass bottle with Teflon® lid	7 days to extraction, 40 days after extraction	Store in dark; cool to ≤6°C
TSS	1 liter	1 liter w/m poly bottle	7 days	Cool to ≤6°C
Total phosphorus (TP)	50 mL	60 mL clear w/m poly bottle	28 days	HCl to pH<2; cool to 4°C ± 2°C
TPH-Diesel (NWTPH-Dx) (grab)	1 liter	1 liter n/m glass jar, organic free with Teflon® lined lids	7 days for unpreserved, 14 days for preserved	HCl to pH<2; cool to 4°C ±2°C
TPH-Gas (NWTPH-Gx) (grab)	120 mL (fill vial full)	(3) 40 mL glass VOA vials with Teflon® coated septum-lined screw tops	7 days for unpreserved, 14 days for preserved	HCl to pH<2; cool to 4°C ±2°C
H. *azteca* 24-hour acute toxicity test	6 liters	Glass bottle	36 hours	Cool to ≤6°C
Methylene blue active substances (MBAS)	400 mL	1 liter amber glass bottle	48 hours	Cool to 4°C

w/m = wide mouth
n/m = narrow mouth

[1] Due to large bottle orders required to meet sampling needs, alternative bottle sizes are sometimes provided by the analytical laboratories.

WSDOT uses the Environmental Protection Agency's "clean hands/dirty hands" protocol (USEPA 1996) for low-level detection of metals as a guideline during sample collection. Field staff use nitrile gloves and follow health and safety procedures. Preservation and filtration of samples (if applicable) occur as composited samples are collected.

After sampling is completed, field staff place sample bottles in coolers with bubble wrap and blue ice for shipping to analytical laboratories. Chain of custody (COC) forms are completed and shipped with coolers.

When sampling is completed and field staff retrieve the sample bottle from the autosampler, the data logger resets an internal clock until rain is measured during the next storm event. Staff manually reset autosamplers to prepare for collection of the next sampling event triggered by the data logger.

During the manual reset, field staff inspect and clean the autosampler, and check and replace sample collection tubing, if necessary. Standard operating procedures (SOPs) are followed as guides during the autosampler inspection and cleaning process (Ecology 2009c; WSDOT 2011e and WSDOT 2011f).

For highway monitoring sites, WSDOT staff collect sediment samples from the pavement edge interceptor after enough sediment has accumulated to process all analytes required by the permit and enough dry period has passed to allow satisfactory dewatering of the sediment. Staff use precleaned stainless steel spoons to collect a minimum of five subsamples from each interceptor. The subsamples are homogenized to uniform consistency and color, and placed in sampling jars for shipment to laboratories for analyses. Field staff collect sediment samples at or near the end of the wet season.

Table 9 lists the containers, amounts, preservation, and holding times required for sediment sample collection.

Table 9 Sediment sample containers, amounts, preservation, and holding times (MEL 2008; 40 CFR 136.3; Ecology, 2009a)

Analysis	Quantity Needed for Analysis	Container[1]	Holding Time	Preservative[2]
Herbicides[3]	100 wet g	8 oz glass jar	14 days	Cool to ≤6˚C
Particle size (grain size)	300 wet g	8 oz plastic jar	6 months	Cool to 4˚C, PSEP[5] standard: do not freeze
PAHs	100 wet g	8 oz glass jar	14 days/1 year if frozen	Cool to ≤6°C/; PSEP[5] standard: may freeze at ≤18°C at the lab
Phenols				
Phthalates				
Total solids (percent solids)	25 wet g	2 oz glass jar	7 days	Cool to ≤6˚C
Total metals (Cu, Cd, Zn, Pb)	10 wet g	4 oz glass jar[4]	6 months	Cool to ≤6˚C
Total organic carbon (TOC)	25 wet g	2 oz glass jar	14 days/1 year if frozen	Cool to ≤6°C/; PSEP[5] standard: may freeze at ≤18°C at the lab
TPH-Diesel (NWTPH-Dx) (grab)	100 wet g	4 oz glass jar	14 days	Cool to ≤6˚C

[1] If the sample containers are filled ¾ full (for freezing), no additional sample is needed for quality control.
[2] Preservation needs to occur in the field, unless otherwise noted. Ice will be used in cool samples to approximately 4°C.
[3] Limited to the herbicides listed in the permit and applied within the drainage area by WSDOT.
[4] Containers cleaned in accordance with Cleaning Protocol #9240.0-05 (MEL 2008).
[5] Puget Sound Estuary Protocols (1997).

3.5 Station Maintenance

WSDOT staff provide regular station maintenance every six to eight weeks or after sampled storm events. Monitoring staff perform a visual inspection of the monitoring site to identify possible damage to equipment and any new or unsafe conditions. Staff check equipment enclosures for signs of tampering or forced entry. Unusual odors and the presence of water or debris are noted for the record and addressed through further investigation and site retrofit or rehabilitation, if necessary.

Staff inspect and clean outlet pipes, sampling basins, and the conveyance system to ensure the monitoring station is in good condition prior to a sampled storm event. Field staff follow this inspection and cleaning procedure to ensure representative data from the system that is unbiased of accumulated debris and sensor drift.

Following the *Standard Operating Procedure for Equipment Maintenance and Cleaning* (WSDOT 2011f), field staff conduct station maintenance that includes equipment inventory, inspections, testing, and replacement of worn or missing parts. Monitoring staff inspect internal wires and cables to evaluate wear and ensure cable connections to the data logger are in good condition. Station antennae declinations and bearings are checked, and solar panels are cleaned to remove accumulated debris. If servicing or calibration of scientific equipment at monitoring stations is required, trained technicians follow manufacturers' specifications and conduct servicing and calibration of equipment on-site or in a controlled environment, as appropriate.

3.6 Equipment Decontamination

WSDOT staff or a contract lab decontaminate pump tubing, churners, and sample containers, as well as filters or other materials that come into contact with sampled stormwater, prior to each use or are certified as precleaned from the equipment source. Intake tubing is cleaned prior to installation and changed once a year. Equipment is cleaned and decontaminated using the following step-by-step procedure:

1. Wash in nonphosphate detergent and hot tap water.
2. Rinse with hot tap water.
3. Rinse with nitric acid solution (approximate pH of 2).
4. Rinse three times with deionized water.
5. Air dry in a clean area free of contaminants.
6. Rinse with pesticide-grade acetone or hexane.
7. Air dry in a contaminant-free area.

Air-dried equipment is wrapped in aluminum foil or stored in polyethylene bags for transport to field stations. If new equipment cannot be cleaned with solvents, it is washed with non-phosphate soap, rinsed three times with deionized water, and air dried.

3.7 Staff Roles and Responsibilities

WSDOT uses Stormwater and Watersheds Program staff in the headquarters' Environmental Services Office (ESO) and staff from the department's region offices to implement its monitoring program. In WY 12, seven staff from the Headquarters ESO played key roles in the stormwater monitoring strategy. Staff from field offices in Mount Vernon and Spokane supported ESO efforts on a part-time basis and participated in stormwater monitoring at different levels.

4 Quality Assurance and Quality Control

4.1 Field Quality Control Procedures

Throughout water year 2012 (WY 12), WSDOT staff implemented quality control (QC) procedures in all phases of fieldwork, including:

- Weather tracking
- Autosampler operation
- Stage measuring devices operation
- Conveyance system cleanout and leveling
- Documentation review and field audits

Weather Tracking QC Procedures

During WY 12, staff reviewed rainfall data from highway runoff and BMP effectiveness monitoring stations on a regular basis using telemetered data stored in the StreamTrac hydrologic database. Data were reviewed for inconsistencies such as excessive dry or wet periods that did not match observed conditions, measurements that were in conflict with other nearby rain gage readings, and any measurements that appeared unrealistic and out of the norm. Staff also manually downloaded rainfall data from the data logger during each site maintenance visit. Rain gages were examined at minimum every six weeks. During routine maintenance visits, gage levels were verified and debris was cleaned from gage catchment systems. The rain gage tipping buckets were checked and verified for volume precision.

When suspect rainfall data were observed, the stormwater monitoring field team deployed to inspect the station to verify the accuracy of the rainfall measurements and to repair, replace, or field-calibrate the rain gages, as needed. Such interventions included cleaning debris from rain gage catchment funnels, re-leveling the gages, and replacing the rain gages, if necessary.

Autosampler Operation QC Procedures

During regular site maintenance visits, WSDOT staff inspected and calibrated the autosamplers to ensure the quality and representativeness of the aliquots (individual discrete sample volumes) collected. Refrigeration temperature was checked regularly and autosamplers were replaced if they were not sufficiently cooling. Staff also visually inspected autosampler tubing for worn segments and replaced worn tubing to maintain integrity. The autosampler internal clock was checked during each maintenance visit for any positive or negative drift that could compromise the accuracy of aliquot collection times. If any autosampler clock discrepancies were noticed, they were corrected to match the data logger time. Staff also regularly checked and replaced desiccants and cables, if necessary. Volume calibrations were performed annually or as needed to ensure accurate aliquot programmed volumes were delivered to the sample bottle. If the autosampler pump tubing was replaced, staff performed a volume calibration.

Stage Measuring Devices Operation QC Procedures

Monitoring staff inspected and calibrated stormwater discharge measuring equipment during pre-storm visits or on WSDOT's routine maintenance trips to ensure accurate stage measurement and accurate discharge calculation. The primary gaging indices for these stations are Thel-Mar weirs located within the pipe conveyance systems. The weirs were leveled, checked for damage, and checked for debris build-up or leakage during each pre-storm visit. Once the weirs were verified for accuracy, staff used them to calibrate both of the recording gaging indices. These secondary gaging indices, consisting of a pressure transducer and a gas bubbler, were checked for drift and for proper reporting and functionality. These checks included routine removal of debris and checking of seals and bubble retention. Staff recalibrated or replaced the gaging indices when needed. The use of two gaging indices aided in ensuring high-quality data collection and assisted with verification and validation of the hydrological data collected.

Conveyance System Cleanouts and Leveling QC Procedures

WSDOT field staff inspected and cleared entire conveyance systems of debris and sediment before and during storm events. This was done to reduce bias before a discrete storm event by removing potential contaminants from the system. To keep the systems clean, field staff manually removed debris and sediment and used clean water to flush out the systems.

Documentation Review QC Procedures

WSDOT staff completed sampling field forms in the field during sampling events. Completing the forms during sample collection ensured accurate real time data were recorded. When staff returned to the office, the completed forms were submitted to the monitoring field lead or a member of the field team who did not participate in completing the form. This other team member then reviewed the document for errors and checked the field form for completeness. Reviewed field forms were initialed, dated by the reviewer, and submitted to a member of the data team for verification.

The data team then checked the information on the field forms with the telemetered data stored in the StreamTrac hydrologic database. The reviewer checked for any discrepancies in the telemetered sample start/end and duration times, the number of aliquots collected by the autosampler, and any potential disqualifiers to the validity of the collected data and the submitted field forms. Once all information was verified to be correct, the data team reviewer submitted the field forms to a central filing location.

Members of the field team similarly collected and completed site maintenance field forms. Completed site maintenance field forms were stored in the central filing location.

Field Audit QC Procedures

The monitoring field lead or delegated monitoring staff conducted field audits. Audits were performed on all WSDOT field staff involved in sample collection. Field audits included observing staff conducting sampling procedures during a sampling event or training. Sampling procedures reviewed during audits involved monitoring station setup, sample collection, completing sample field and chain of custody (COC) forms, and sample cooler shipment or delivery to the appropriate laboratories. During or immediately after an audit, the monitoring field lead or monitoring staff recorded competencies on an audit form. After completing the audit, staff were advised how to improve any noted deficiencies in the sampling process.

4.2 Hydrologic Data Quality Control Procedures

WSDOT staff conducted hydrologic quality control checks to ensure that the following procedures occurred to ensure high quality data. When 0.02 inch of rain is detected, the data logger initiates stormwater sampling procedures. The stage measuring devices in the outlet pipes are monitored in five-minute increments. The data logger then calculates and records cumulative and instantaneous discharge per measurement. The data logger also checks that the temperature of the stormwater runoff is above freezing. Sample collection will not occur if there is a chance of freezing.

If all three criteria are met (i.e., 0.02 inch rain threshold, temperature above freezing, and measureable discharge), the data logger waits for its established volumetric thresholds to be met. When the thresholds are met, a sample is collected into the refrigerated autosampler. This process continues until discharge ends or the bottle is full.

When verifying hydrologic data, staff need to confirm that there was a sufficient antecedent dry period prior to the start of precipitation. In the wet season, antecedent requirements dictate that less than 0.02 inch of rain (0.04 inch for BMPs) has fallen in the previous 24-hour period. For the dry season, the antecedent dry period is increased to 72 hours. Staff checked telemetered data from the rain gage during or immediately following a storm event to see that the antecedent dry period has been met. A second quality control verification of the antecedent dry period is performed later using data downloaded directly from the on-site data logger.

Following confirmation of a sufficiently long antecedent dry period, staff examine rainfall data to see the data fall within the required parameters for storm qualification. Telemetered rainfall data are used to verify that at least 0.15 inch of rain was received during the storm event. Post storm event, the rainfall data are rechecked using downloaded data.

WSDOT staff then compare the amount of rainfall received at the start of the event and the time of first aliquot collection by the autosampler. This comparison dictates whether the runoff lag time is within a reasonable range. Staff also check the timing and magnitude of rainfall against flow volume to make sure there is a reasonable relationship and there are no gaps in either of the data sets.

Lastly, staff compare the two-stage measuring devices against each other to ensure against sensor drift. If measurable drift occurred during the storm, a correction is applied to the questionable data and the hydrograph is reassessed to verify that at least 75-percent of the storm was sampled according to permit specifications. A final check of autosampler collection times and runoff water temperature completes the process.

4.3 Analytical Data Quality Assessment Report

A third-party analytical data quality assessment report (Appendix B) was prepared for WSDOT by Pyron Environmental, Inc. of Olympia, Washington and Cardno TEC, Inc. in Seattle. This report provides an overview of the analytical scheme, data verification and validation procedures, and quality of analytical data collected from September 17, 2011, through November 6, 2012. The quality of data is assessed and discussed in terms of Measurement Quality Objectives (MQOs) (i.e., precision, accuracy, representativeness, comparability, sensitivity, and completeness).

Data collected from WSDOT highway runoff characterization and BMP effectiveness monitoring sites are included in Appendices C and D of this report.

5 Status of the Monitoring Program

Due to the delay in monitoring station installation and an unusually dry spring and summer, only a few samples were collected from highway runoff characterization and BMP effectiveness monitoring sites in water year 2012 (WY 12). Calculation and analyses of pollutant loads and statistical data are not possible because of the small sample size.

The following discussion provides an update and status report for the department's highway runoff characterization and BMP effectiveness monitoring programs. We did not collect a full year of data so it was not possible to calculate a rainfall runoff curve for the monitoring sites.

5.1 Status of Highways and BMP Monitoring Sites

WSDOT successfully installed seven fully operational highway runoff and BMP effectiveness monitoring sites in WY 12. Highway runoff monitoring sites include a single sampling point at a pavement edge collector (interceptor or curb). Each of the BMP effectiveness monitoring sites includes three sampling points that characterize pollution removal and flow reduction through the stormwater treatment facility. In WSDOT's BMP vegetated filter strip studies, the sampling points are the interceptors at the pavement edge (PE), 6.6 feet (2 meters), and 13.1 feet (4 meters) downslope from the top of the roadside embankment.

5.2 Discussion of Monitoring Results

Sediment Sampling

WSDOT field staff successfully collected sediment samples for each of WSDOT's five highway characterization sites. Four of the five samples were collected with sufficient volume for analysis of all permit-required analytes. Appendix E provides WY 12 sediment sampling results.

The main analytes found in the sampled sediment were metals and lube oil. The samples were found to contain elevated levels of copper and zinc, with some samples showing elevated levels of lead. Lube oil levels were consistently between 2000-3000 mg/Kg dry weight.

Toxicity

Two successful attempts were made to collect toxicity samples from each of the required monitoring locations in September and October 2012. Results show no significant effect and a high survival rate for *Hyalella azteca*. Table 11 and Appendix F provide a summary.

Table 11 Toxicity Sampling Results

Date	Sample Description	Test Group (% rainwater or stormwater)	Control Water	Average Survival for All Replicates	EC_{50}
9/10/12	I-5 Pilchuck Creek Modified-VFS; pavement edge	0 0 6.25 12.5 25 50 100	dilution water hardness control[1]	100% 98% 100% 100% 100% 100% 98%	≥ 100%
10/13/12	SR-09 Marysville VFS effluent; 13.1-ft interceptor	0 0 6.25 12.5 25 50 100	dilution water hardness control	100% 100% 100% 98% 100% 98% 100%	≥ 100%
9/10/12	I-5 Pilchuck Creek rainwater reference; pH adjusted[2][3]	0 100	dilution water	100% 98%	≥ 100%
9/10/12	I-5 Pilchuck Creek rainwater reference	0 100	dilution water	100% 98%	≥ 100%
9/10/12	I-5 Everett rainwater reference; pH adjusted	0 100	dilution water	100% 100%	≥ 100%
9/10/12	I-5 Everett rainwater reference	0 100	2nd control	98% 100%	≥ 100%

[1] Hardness of the control was adjusted to match the stormwater samples' hardness.

[2] Rainwater reference samples were collected to determine if rainwater alone caused toxicity to *Hyalella azteca*. Rainwater was collected in precleaned stainless steel bowls elevated at least 30cm from the ground and away from sources that may contribute inputs other than rain, such as road spray.

[3] pH was adjusted to neutral, around 7.0.

Stormwater Sampling Attempts

SR 09 Marysville Rural Highway Runoff Monitoring Site

WSDOT attempted to collect six stormwater samples at the SR 09 Marysville highway runoff monitoring site in WY 12. Of these attempts, five were not successful because of equipment failure or weather variability. Due to insufficient sample volume, total suspended solids (TSS) and nutrient compounds were the only analytes evaluated. Analytical results from this sampling event were later rejected when hydrology validation discovered that 75 percent of the storm hydrograph had not been sampled. Appendices C and D include these sampling results.

I-5 Pilchuck Creek Highway Runoff and BMP Effectiveness Monitoring Sites

WSDOT attempted to collect seven highway and BMP stormwater runoff sample events at the three BMP sets at the I-5 Pilchuck Creek site in WY 12. Of these attempts, four were not successful due to equipment failure or weather variability. Storm reports, hydrographs, hyetographs, and analytical data are summarized in Appendices C and D.

I-5 Everett Highway Runoff and BMP Effectiveness Monitoring Sites

WSDOT attempted to collect four sample events at each of the I-5 Everett Highway runoff and BMP effectiveness monitoring sites in WY 12. Of these four attempts, only one was successful. Other attempts were not successful due to equipment failure or weather variability. Appendices C and D include the storm report, hydrograph, hyetograph, and analytical data for this sampling event.

I-90 Pines Highway Runoff Characterization Site

WSDOT attempted to collect three samples at the Pines highway characterization site in WY 12. Of these three attempts, only one grab sample was collected. The other attempts were not successful due to equipment failure or weather variability. Appendices C and D provide the storm report and analytical data for this event.

Projected Results from the Next Reporting Period

A larger number of highway runoff and BMP effectiveness samples were collected in WY 13. The data collected will appear in the October 31, 2014 monitoring report. In accordance with the permit guidelines, WSDOT will continue to collect stormwater monitoring data from its highway runoff and BMP effectiveness monitoring locations.

Glossary

analyte – An element, ion, compound, or chemical moiety (pH, alkalinity) that is to be determined. The definition can be expanded to include organisms, such as fecal coliform (Kammin 2010).

annual average daily traffic (AADT) – The average, over a year, of the number of vehicles passing a point on a highway in both directions each day (Mohamad et al., 1998). Counts are estimated using Trip Generation, published by the Institute of Transportation Engineers, or using a traffic study prepared by a professional engineer or transportation specialist with expertise in traffic volume estimation (WSDOT 2011c).

best management practices (BMPs) – The structural devices, maintenance procedures, managerial practices, prohibitions of practices, and schedules of activities that are used singly or in combination to prevent or reduce the detrimental impacts of stormwater, such as pollution of water, degradation of channels, damage to structures, and flooding (WSDOT 2011c).

Clean Water Act (CWA) – A federal act passed in 1972, formerly referred to as the Federal Water Pollution Control Act, which contains provisions to restore and maintain the quality of the nation's waters. Major amendments to the CWA in 1987 addressed stormwater pollution by extending the National Pollutant Discharge Elimination System (NPDES) permit program to include stormwater discharges. Section 402 of the CWA governs the NPDES permit program.

data collection platform (DCP) – A collection of instruments or sensors that operate and report to a central data logger. A DCP is collectively housed in a central location or "platform" at the monitoring site.

fecal coliform – That portion of the coliform group that is present in the intestinal tracts and feces of warm-blooded animals as detected by the product of acid or gas from lactose in a suitable culture medium within 24 hours at 44.5 plus or minus 0.2 degrees Celsius (WAC 173-201 A-020).

first flush – Typically, the first 30 to 60 minutes of runoff from a rainfall event (Caltrans 2003). A first-flush rain event for toxicity is defined in Special Condition S7.C.1 of the permit as the first qualifying rain event that occurs after July 31 with a one-week antecedent dry period (or October, irrespective of the antecedent dry period, if unsuccessful in August and September) (Ecology 2009a).

flow-weighted compositing – Samples of equal volume are taken at equal increments of flow volume and composited (Ecology 2009c)

Global Positioning System (GPS) – A satellite navigation system used to determine ground position and velocity (location, speed, and direction).

hydrograph – A graph of flow versus time for a given point (Caltrans 2003).

hyetograph – A graph of rainfall to a monitoring station versus time (Caltrans 2003).

Jersey barrier – A tapered concrete structure installed in the median or along the roadside shoulder to prevent vehicle crossovers.

low-impact development (LID) – An evolving approach to land development and stormwater management that uses a site's natural features and specifically-designed BMPs to manage stormwater. This approach involves assessing and understanding the site, protecting native vegetation and soils, and minimizing and managing stormwater at its source (WSDOT 2011c).

National Pollutant Discharge and Elimination System (NPDES) – The national program for issuing, modifying, revoking and reissuing, terminating, monitoring, and enforcing permits, and imposing and enforcing pretreatment requirements, under sections 307, 402, 318, and 405 of the Federal Clean Water Act, for the discharge of pollutants to surface waters of the state from point sources. These permits are referred to as NPDES permits and, in Washington State, are administered by the Washington State Department of Ecology (Ecology 2009a).

parameter – A specified characteristic of a population or sample. Also, an analyte or grouping of analytes. Benzene, nitrate+nitrite, and anions are all parameters (Kammin 2010; Ecology 2004).

pavement edge (PE) interceptor – A 6-inch HDPE pipe or similar device that is installed to collect runoff from an impervious roadway. PE interceptors also act as conveyance systems for stormwater from the road surface to pass through a flow measurement device and allow for composite sample collection.

pH – A measure of the acidity or alkalinity of water. A low pH value (0 to 7) indicates that an acidic condition is present, while a high pH (7 to 14) indicates a basic or alkaline condition. A pH of 7 is considered to be neutral. Since the pH scale is logarithmic, a water sample with a pH of 8 is ten times more basic than one with a pH of 7.

quality assurance project plan (QAPP) – A document that describes the objectives of a monitoring project and the procedures necessary to ensure the quality and integrity of the collected data (Ecology 2004).

representativeness – The state or quality of being accurately representative of something. Expresses the degree to which sample data accurately and precisely represent a characteristic of a population, parameter variations at the sampling point, or an environmental condition (USEPA 2006).

stormwater – That portion of precipitation that does not naturally percolate into the ground or evaporate, but flows via overland flow, interflow, pipes, and other features of a stormwater drainage system into a defined surface water body or a constructed infiltration facility (WSDOT 2011c).

thermistor – A temperature-sensing probe that displays large changes in resistance in proportion to small changes in temperature.

stilling well – A well or chamber that is connected to the main flow channel by a small inlet.

time of concentration – The time necessary for surface runoff to reach the edge of pavement interceptor from the hydraulically most remote point of the drainage area (WSDOT 2011c). Time of concentration provides a measure to ensure time pacing of the monitoring equipment is set to obtain a representative sample and to evaluate whether contributions from the entire basin are represented.

water year (WY) – The 12-month period beginning October 1 for any given year through September 30 of the following year. The water year is designated by the calendar year in which it ends. For example, the water year ending September 30, 2012, is called the "2012" water year (USGS 2013).

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Acronyms and Abbreviations

AADT	annual average daily traffic
AC	alternating current
BMP	best management practice
CAVFS	compost amended vegetated filter strip
Cd	cadmium
CBS	compact bubble sensor
COC	chain of custody
Cu	copper
DCP	data collection platform
Ecology	Washington State Department of Ecology
EDDN	Emergency Data Distribution Network
ESO	Environmental Services Office
GIS	geographical information system
GOES DCS	Geosynchronous Operational Environmental Satellite Data Collection System
GPS	Global Positioning System
HDPE	high density polyethylene
I-5	Interstate 5
I-90	Interstate 90
LID	low-impact development
MBAS	methylene blue active substances
MP	milepost
MQO	measurement quality objective
NB	northbound
NPDES	National Pollutant Discharge Elimination System
NOAA	National Oceanic and Atmospheric Association
NWS	National Weather Service

OP	ortho-phosphate
PAH	polycyclic aromatic hydrocarbons
Pb	lead
PE	pavement edge
pH	measure of alkalinity or acidity
PSD	particle size distribution
PT	pressure transducer
QAPP	Quality Assurance Project Plan
QA	quality assurance
QC	quality control
SB	southbound
SOP	standard operating procedure
SR	state route
SWPPP	Stormwater Pollution Prevention Plan
TAPE	Technology Assessment Protocol – Ecology (TAPE)
TOC	total organic carbon
TP	total phosphorus
TPH	total petroleum hydrocarbon
TSS	total suspended solids
VFS	vegetated filter strip
WSDOT	Washington State Department of Transportation
WY	water year
Zn	zinc

Appendix A:
Special Condition G20 Letters Submitted to the Washington State Department of Ecology

Washington State Department of Transportation
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Secretary of Transportation

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October 20, 2011

Mr. Foroozan Labib
WSDOT Municipal Stormwater Permit Manager
Washington State Department of Ecology
Water Quality Program
P. O. Box 47600
Olympia, WA 98504-7996

RE: NPDES and State Waste Discharge Permit for Municipal Stormwater, G20 Notification for Non-Compliance with Special Conditions S7.C.1 and S7.G.1.d.

Dear Mr. Labib:

In accordance with General Condition 20 (G20) of the 2009 WSDOT NPDES and State Waste Discharge Permit for Municipal Stormwater (permit), this letter provides notification to the Washington State Department of Ecology (Ecology) that WSDOT will be unable to fully comply with terms in Special Conditions S7.C.1 and S7.G.1.d. WSDOT became aware that it would be unable to fully comply with these requirements on October 13, 2011. WSDOT alerted Ecology by phone and email on October 17, 2011.

S7.G.1.d requires that, "WSDOT shall begin full implementation of the monitoring program no later than September 6, 2011." Due to recent state government hiring and equipment purchase freezes, there have been delays in hiring and training monitoring support staff, and in establishing fully functional monitoring sites.

To remedy this situation, WSDOT will use information from three Ecology-approved, WSDOT quality assurance project plans to deliver sampling instructions to region support staff in an online training session scheduled for October 26, 2011. This training will be followed by hands-on trainings at facility, highway, and BMP monitoring study sites in October, November, and December 2011.

In addition, WSDOT will complete final testing and installation of sampling equipment at one ferry terminal, two rest areas, and six maintenance facilities in November 2011. Monitoring will begin at these facilities no later than November 30, 2011.

Grass establishment at best management practices (BMP) effectiveness monitoring sites has been difficult this year due to the need to reapply compost, an extended dry period this past summer, and impacts from a high-fiber optic cable installation project. During the week of October 24, 2011, WSDOT will reseed unvegetated areas and apply clear, plastic covering to improve growing conditions.

WSDOT will complete installation and testing of equipment at baseline highway and BMP effectiveness monitoring sites along Interstate 5 (I-5), State Route 9 (SR 9), and I-90 in

December 2011. Monitoring will begin for highway sites no later than January 15, 2012. For BMP effectiveness monitoring sites, sampling will begin when vegetation is fully established.
Special Condition S7.C.1 requires that, "WSDOT shall collect six toxicity screening samples and associated chemical analysis at least once per monitoring year in August or September. Samples shall be collected with at least a one-week antecedent dry period (or in October, irrespective of antecedent dry period, if unsuccessful in August or September)."

WSDOT tracked storms since implementation of the monitoring program on September 6, 2011. This year, no forecasted storms qualified for toxicity sampling in September due to the lack of a one-week antecedent dry period. In regard to toxicity sampling thus far in October, our sites are not fully functional and, in our view, we have missed the first flush event due to rainfall. WSDOT would like to delay collecting toxicity screening samples until all monitoring sites are fully established and next season's first-flush sampling is possible in August 2012.

WSDOT will make every effort to keep Ecology informed of the status of the agency's stormwater monitoring program. If you have questions or require additional information regarding this matter, please contact Fred Bergdolt, Stormwater Monitoring and Research Coordinator, at bergdof@wsdot.wa.gov or 360-570-6648.

I certify under penalty of law, that this document was prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system or those persons directly responsible for gathering information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for willful violations.

Sincerely,

Megan White, P.E., Director
Environmental Services Office

MW:pf
FB

cc: Kenneth M. Stone, WSDOT, Resource Programs Branch Manager
Fred Bergdolt, WSDOT, Stormwater Monitoring and Research Coordinator
NPDES Municipal Permit File

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November 29, 2011

Foroozan Labib
WSDOT Municipal Stormwater Permit Manager
Washington State Department of Ecology
Water Quality Program
P. O. Box 47600
Olympia, WA 98504-7996

RE: NPDES and State Waste Discharge Permit for Municipal Stormwater, Revision to the October 20, 2011 G20 Notification of Non-Compliance with Special Condition S7.G.1.d.

Dear Mr. Labib:

WSDOT became aware on November 21, 2011 that it will be unable to fully comply with commitments made in the October 20, 2011 G20 notification letter. Extensions to these commitment timelines are needed to be able to fully implement the monitoring program per Special Condition S7.G.1.d and "to produce scientifically credible data that represents discharges from WSDOT's various land uses" per S7.A.1. Delayed implementation means WSDOT will also be unable to meet the conditions of S7.B.6, S7.D.4, and S7.E.4.b that specify the number of storms to be sampled per year.

The October 20, 2011 G20 notification letter stated that monitoring will begin at facilities study sites no later than November 30, 2011. On November 30, 2011, WSDOT plans to initiate monitoring at one rest area, one maintenance facility, and one ferry terminal study site. In order to produce representative and scientifically credible data from facilities monitoring sites, we have determined that it is necessary to implement a phased approach to facility monitoring start-up. This is necessary in order to establish the stormwater monitoring process from sample collection through generation of usable data. This approach provides the ability to troubleshoot unanticipated problems as we progress to full compliance. Facilities study sites will be added to the monitoring program as the process is established and problems are resolved. We anticipate full implementation of the monitoring program at all nine facilities study sites by March 1, 2012. It is WSDOT's goal to sample a minimum of two qualifying storm events during the remainder of the 2011-12 wet season for facilities monitoring.

It has also become apparent that WSDOT will be unable to begin baseline highway and BMP effectiveness monitoring by January 15, 2012, as stated in the October 20, 2011 G20 notification. This delay is due to recent equipment testing that identified major deficiencies. Prior to January 15, 2012, WSDOT will provide Ecology with a revised schedule for initiating highway and BMP monitoring. An explanation of the steps needed to fully implement this portion of the monitoring program will also be included.

Our expectation that toxicity/first flush monitoring will begin in August 2012 remains unchanged.

WSDOT will make every effort to keep Ecology informed of the status of the agency's stormwater monitoring program. If you have questions or require additional information regarding this matter, please contact Fred Bergdolt, Stormwater Monitoring and Research Coordinator, at bergdof@wsdot.wa.gov or 360-570-6648.

I certify under penalty of law, that this document was prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system or those persons directly responsible for gathering information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for willful violations.

Sincerely,

Megan White, P.E., Director
Environmental Services Office

MW:pf

cc: Kenneth M. Stone, Resource Programs Branch Manager, WSDOT
Richard A. Gersib, Stormwater and Watersheds Program Manager, WSDOT
NPDES Municipal Permit File

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January 13, 2012

Foroozan Labib
WSDOT Municipal Stormwater Permit Manager
Washington State Department of Ecology
Water Quality Program
P. O. Box 47600
Olympia, WA 98504-7996

RE: NPDES and State Waste Discharge Permit for Municipal Stormwater, Addendum to the November 29, 2011 G20 Notification of Non-Compliance with Special Condition S7.G.1.d.

Dear Mr. Labib:

Pursuant to the letter I sent you dated November 29, 2011, I am providing the Department of Ecology with a revised schedule for initiating highway and BMP monitoring. WSDOT intends to begin monitoring at all highway and BMP study sites on October 1, 2012. However, WSDOT intends to use a phased approach to this monitoring which will begin on May 1, 2012.

An explanation of the steps needed to fully implement this portion of the monitoring program are as follows:

- Construction and testing at the highway and BMP sites is expected to be complete by April 30, 2012;
- Field sampling at the Southbound I-5 Pilchuck study sites will start on May 1, 2012;
- Field sampling at the Northbound I-5 Everett, SR 9 Marysville, and Westbound I-90 Pines study sites will start on June 15, 2012; and
- Field sampling at the SR 518 research site will start on October 1, 2012.

WSDOT will make every effort to keep Ecology informed of the status of the agency's stormwater monitoring program. If you have questions or require additional information regarding this matter, please contact Fred Bergdolt, Stormwater Monitoring and Research Coordinator, at bergdof@wsdot.wa.gov or 360-570-6648.

I certify under penalty of law, that this document was prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system or those persons directly responsible for gathering information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for willful violations.

Sincerely,

Megan White, P.E., Director
Environmental Services Office

MW:pf

cc: Kenneth M. Stone, Resource Programs Branch Manager
Fred Bergdolt, Monitoring and Research Coordinator
NPDES Municipal Permit File
Day File

Appendix B: Analytical Data Quality Assessment Report

Analytical Data Quality Assessment Report

Washington State Department of Transportation

NPDES Stormwater Monitoring Program

for

Data Collected during September 17, 2011 through November 6, 2012

Prepared for:

Cardno TEC, Inc.

2825 Eastlake Avenue East, Suite 300

Seattle, WA 98102

Prepared by:

Pyron Environmental, Inc.

3530 32nd Way NW

Olympia, WA 98502

September 6, 2013

Executive Summary

This Data Quality Assessment Report (DQAR) presents an overview of the analytical scheme, data verification and validation procedures, and the quality of analytical data collected during the stormwater monitoring year 2012 (September 17, 2011 through November 6, 2012) under the Washington State Department of Transportation's (WSDOT) National Pollution Discharge Elimination System (NPDES) Stormwater Monitoring Program (Program). The quality of data was assessed and discussed in terms of Measurement Quality Objectives (MQOs), i.e., precision, accuracy, representativeness, comparability, sensitivity, and completeness.

A total of 82 stormwater and seven sediment samples were collected during this monitoring year. Sample analyses were primarily performed by the Washington State Department of Ecology (Ecology) Manchester Environmental Laboratory (MEL) with specialty analyses performed by AmTest Laboratories, Inc. (surfactants), TestAmerica Laboratories, Inc. (total Kjeldahl nitrogen [TKN] and glyphosate), and Analytical Resources, Inc. (particle size distribution in water).

A Stage 2a and 2b data validation was performed on 90 percent of the analytical data, and a Stage 3+4 validation on 10 percent of the data. Based on the on-going oversight of the laboratory performance and the outcome of the data validation, completeness of the data collection effort was calculated as 98.7 percent, thus achieving the monitoring goal of 95%. Significant observations and results of the analytical data quality assessment are summarized as follows:

1. Stormwater samples were not acid-digested for dissolved metals analyses (U.S. Environmental Protection Agency [EPA] Method 200.8). The re-analyses conducted on 11 samples showed no significant difference between the non-digested and digested results. The incident was then noted as a deviation from analytical method and the results footnoted in the Annual Report to indicate the deviation in sample preparation.

2. The sample filtration for dissolved metals and ortho-phosphate was to be conducted within 15 minutes of collection, according to 40CFR, Part 136. Due to technical difficulty, most of the samples were filtered outside the 15-minute window, yet within 24 hours of collection. The delay in filtration was not expected to result in significant effects on data quality. Dissolved metals and ortho-phosphate results were footnoted in the Annual Report for these cases.

3. The reporting limits (RLs) for semi-volatile organic compounds (SVOCs) in sediment samples were elevated three to eight times from the project goal for method RLs. This range of elevations resulted from the required dilution of sample extracts to overcome the oily nature of the samples. The reported sample-specific RLs were considered the best-possible RLs given the conditions of the samples. No further actions were feasible other than noting the incident in this document.

4. The initial calibration verification (ICV) analysis (using a second source standard) was not performed associated with herbicides (triclopyr, 2,4-D, clopyralid, and picloram) analyses. The laboratory instead reported the back-calculated recovery of each initial calibration

standard. The second-source verification was evaluated with the laboratory control sample (LCS) and LCS duplicate results. The lack of ICV analysis was noted as a deviation from analytical procedures

5. The recovery of all surrogate spikes for the polycyclic aromatic hydrocarbon (PAH) and phthalate analyses was less than 10% or the lower control limits in one stormwater sample, indicating a potential of unsuccessful extraction of this sample. The PAH and phthalate detections in this sample were qualified as estimate values and the non-detects were rejected.

Table of Contents

Acronyms and Abbreviations

%D	percent difference
%D_f	percent drift
%R	percent recovery
%RSD	percent relative standard deviation
ARI	Analytical Resources, Inc. – Tukwila, Washington
ASTM	American Society of Testing and Materials
CCB	continuing calibration blank
CCV	continuing calibration verification
CLP	U.S. EPA Contract Laboratory Program
COC	chain of custody
CS1	recovery of the first (lowest concentration) initial calibration standard
DQAR	data quality assessment report
DQO	data quality objective
DVR	data validation report
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
ICAL	initial calibration
ICB	initial calibration blank
ICP	Inductively coupled plasma
ICP/MS	Inductively coupled plasma/mass spectrometry
ICV	initial calibration verification
LCL	lower control limit
LCS	laboratory control sample
LCSD	laboratory control sample duplicate
µg/L	microgram per liter
mg/L	milligram per liter
MBAS	methylene blue active substances
MDL	method detection limit
MEL	Washington State Department of Ecology Manchester Environmental Laboratory
MQO	measurement quality objective

MS	matrix spike
MSD	matrix spike duplicate
NPDES	National Pollution Discharge Elimination System
OP	*ortho*-phosphate
PAH	polycyclic aromatic hydrocarbon
PQL	practical quantitation limit
Permit	WSDOT NPDES and State Waste Discharge Permit for Municipal Stormwater
Program	NPDES Stormwater Monitoring Program
PSD	particle size distribution
PSEP	Puget Sound Estuary Program
QAPP	quality assurance project plan
QC	quality control
RL	reporting limit
RPD	relative percent difference
SIM	selective ion monitoring
SMS	Washington State Sediment Management Standards
SVOCs	semi-volatile organic compounds
TAL	TestAmerica Laboratories, Inc.
TAPE	Guidance for Evaluating Emerging Stormwater Treatment Technologies, Technology Assessment Protocol – Ecology (Publication No. 02-10-037)
TKN	total Kjeldahl nitrogen
TOC	total organic carbon
TP	total phosphorus
TPH	total petroleum hydrocarbon
TSS	total suspended solids
WSDOT	Washington State Department of Transportation

SAMPLE COLLECTION AND ANALYTICAL PROGRAM

Field Sampling Program

Sample collection for the Washington State Department of Transportation (WSDOT) NPDES Stormwater Monitoring Program (Program) was conducted during September 17, 2011 through November 6, 2012 by WSDOT personnel, following the *Quality Assurance Project Plans* (QAPPs; WSDOT 2011a, 2011b, and 2011c). A total of 82 stormwater and seven sediment samples were collected during this period of monitoring.

Laboratory Analysis Program

Sample analyses were primarily performed by the Washington State Department of Ecology (Ecology) Manchester Environmental Laboratory (MEL) for semi-volatile organic compounds (SVOCs), polycyclic aromatic hydrocarbons (PAHs), phthalates, pesticides (triclopyr, 2,4-D, clopyralid, and picloram), herbicides (diuron and dichlobenil), gasoline range total petroleum hydrocarbon (TPH), diesel/motor oil range TPH, metals (total and dissolved cadmium copper, lead, and zinc), and inorganic parameters (total suspended solids, hardness, chloride, nitrate/nitrite, *ortho*-phosphate (OP), and total phosphorus (TP). Selected specialty analyses were performed by AmTest Laboratories, Inc. (surfactants), TestAmerica Laboratories, Inc. (total Kjeldahl nitrogen and glyphosate), and Analytical Resources, Inc. (particle size and distribution in water).

Sample analysis schedule is summarized in **Table 1-1**.

DATA VERIFICATION AND VALIDATION

Data Quality Objectives

Data quality objectives (DQOs) for the Program were defined to meet the WSDOT NPDES and State Waste Discharge Permit for Municipal Stormwater (Permit), which was issued by Ecology on February 4, 2009 (Permit No. WAR043000A). Specific data quality goals (*i.e.*, measurement quality objectives [MQOs] commonly presented as precision, accuracy, representativeness, comparability, sensitivity, and completeness) are defined in the QAPPs (WSDOT 2011a, 2011b, and 2011c).

Data Verification Procedures

Data verification was performed to ensure completeness of the hardcopy and electronic analytical data reported and archived. A complete crosschecking of laboratory identification numbers with field identification numbers was performed to ensure that analyses had been performed as specified by the chain of custody (COC) documentation.

Hardcopy laboratory reports were inventory checked for sample result forms, instrument run logs, instrument initial calibration and continuing calibration verifications, associated QC analyses, and supporting documents.

Data Validation Procedures

A Stage 2a and 2b data validation was performed on 90 percent of the data, and a Stage 3+4 validation on 10 percent of the data. The validation followed the procedures specified in U.S. Environmental Protection Agency (EPA) Contract Laboratory Program (CLP) National Functional Guidelines for Data Review (USEPA 2008–Organics; USEPA 2010–Inorganics), with modifications to accommodate program and analytical method requirements as specified in the WSDOT *Stormwater Monitoring Chemical Data Validation Guidance and Criteria, Version 1.2* (WSDOT 2013).

Data Assessment Results

As a result of the data validation, data qualifiers were appended to the affected data as:

- **J** - The result is an estimated quantity. The associated numerical value is approximate concentration of the analyte in the sample.
- **R** - The data are unusable due to deficiencies in the ability to analyze the sample and meet QC criteria.

- **U** - The analyte was analyzed for, but not detected. The associated numerical value is at or below the method reporting limit (RL).
- **UJ** - The analyte was analyzed for, but not detected. The method detection limit (MDL) and practical quantitation limit (PQL) are estimated values.

Detailed scope of the data validation, validation findings, and data qualification were presented in the data validation reports (DVRs).

DATA QUALITY AND USABILITY ASSESSMENT

Based on the outcomes of the validation, the following sections present a data quality overview for analytical data collected during the stormwater monitoring year 2012. The following sections address accuracy, precision, representativeness, comparability, sensitivity, and completeness. Quality control (QC) parameters applied to evaluating each of the MQOs are summarized in **Table 3-1**.

Accuracy

Accuracy is a statistical measurement of correctness and includes components of random and systematic errors. It is quantified as the degree of agreement between a measurement with a known reference. Analytical accuracy is evaluated via the percent recovery (%R), percent difference (%D), or percent drift (%D_f) values of initial and continuing calibration, internal standards, surrogate spikes, matrix spike (MS)/matrix spike duplicate (MSD), laboratory control sample (LCS)/ laboratory control sample duplicate (LCSD), in conjunction with results of method blanks, calibration blanks, and trip blanks. Results of blanks assist in identifying the type and magnitude of effects on system errors introduced via field and/or laboratory procedures.

Quality control anomalies affecting data accuracy were identified as follows:

Sample Preservation and Holding Times

The OP analyses were performed one to two days past the method recommended holding time for three samples. These results were qualified as estimated values, according to the data validation.

The surfactant analysis on sample GEIGER-01-WY11-04-01 was performed past the method recommended holding time; the result was qualified as estimated. Data qualified as a result of holding time and sample preservation violations are summarized in **Table 3-2**.

Calibration Verification

Initial and continuing calibration verification (ICV and CCV) analyses verify accuracy of the initial calibration (ICAL) and current instrument condition prior to sample analyses. The recovery of the first (lowest concentration) ICAL standard (CS1) was evaluated to verify the ICAL validity at the RL level. ICV, CCV, and CS1 results are presented as %D or %D_f values; excessive bias of a %D or %D_f value indicates a potential bias of the analytical results associated with these verification analyses.

The %D value for total Kjeldahl nitrogen (TKN) in one of the CCV analyses was less than the lower control limit (90-110%), indicating a potential low-bias associated the TKN analyses in this analytical batch. Seven samples were affected in this manner and the TKN results were qualified as estimated.

The %D value for benzo(a)anthracene in one of the ICV was less than the lower control limit. Three samples were affected and the benzo(a)anthracene results in these samples were qualified as estimated values.

The %D value for indeno(1,2,3-cd)pyrene in one of the ICV analyses was greater than the upper control limit, indicating a potential high-bias associated with the results of samples analyzed in this analytical sequence. Indeno(1,2,3-cd)pyrene was detected in sample BAINBRIDGE-01-WY11-02-01 and the result was qualified as estimated.

The recovery of CS1 biased low for dibenzo(a,h)anthracene and bis(2-ethylehxyl)phthalate in one of the initial calibrations. As a conservative measure, dibenzo(a,h)anthracene and *bis*(2-ethylehxyl)phthalate results for the five samples associated with this ICAL were qualified as estimated.

The recovery of CS1 biased high for benzo(a)pyrene in one of the initial calibrations. As a conservative measure, detections of this compound in the two samples associated with this ICAL were qualified as estimated.

The %D value for benzoic acid biased low in one of the CCV analyses. Two samples were affected and the results were qualified as estimated. Data usability affected by outlying CS1, ICV, and CCV results was summarized in **Table 3-3**.

Blanks

Presence of target analytes in blanks indicated potential effects on results for samples prepared/analyzed with these blanks, and the accuracy of the results might have been skewed.

Total Kjeldahl nitrogen was detected in one of the method blanks at a level less than the method RL. Ten samples were affected by the detection in this method blank. Associated sample results less than the RL were qualified as non-detected at the RL (0.5 mg/L). Results greater than the RL but less than 10x the detection in the method blank were qualified as estimated.

Naphthalene and *bis*(2-ethylehxyl)phthalate were each detected in a method blank; affected sample results were qualified likewise. Data qualified in this manner are summarized in **Table 3-4**.

Laboratory Control Sample (LCS) Recovery

The %R values for pentachloropenol, benzoic acid, and benzyl alcohol in one LCS analysis were less than 10%. Results for these compounds in the two sediment samples associated with this LCS were rejected.

The %R values for Diesel #2 and Lube Oil in two of the LCS analyses biased low. Results for the six associated samples were qualified as estimated.

The %R values for pesticides (2,4-D, clopyralid, diuron, and triclopyr) in selected LCS and/or LCSD analyses were less than the lower control limits (but greater than 10%). Pesticide results for the 18 samples associated with these LCS and LCSD analyses were qualified as estimated.

The %R values for selected PAHs and phthalates in a number of LCS and/or LCSD were less than the lower control limits. Affected sample results were qualified as estimated. Data affected by biased LCS and LCSD recovery are summarized in **Table 3-5**.

Matrix Spike (MS) and MS Duplicate (MSD) Recovery

The %R values for MS and MSD analyses indicate levels of potential effects on a given analytical system resulting from the nature of a sample.

The %R values for copper and lead in the MS and MSD analyses performed on sediment samples SED-SR09-01-WY11-01-01 and SED-PINES-02-WY11-01-01 were outside the control limits (75-125%). Copper and lead results for the six sediment samples in this preparation batch were qualified as estimated.

The %R value for zinc in the MS/MSD analyses performed on a water sample was outside the control limit (75-125%). Zinc results for the four samples were qualified as estimated.

Benzyl alcohol, benzoic acid, and pentachlorophenol were not recovered (%R = 0) from the MS/MSD analyses performed on sediment sample SED-PINES-02-WY11-01-01. Benzyl alcohol, benzoic acid, and pentachlorophenol results for sample SED-PINES-02-WY11-01-01 were rejected.

The %R values for benzo(g,h,i)perylene, indeno(1,2,3-cd)pyrene, bis(2-ethylhexyl)phthalate, and butyl benzyl phthalate were less than the lower control limits in the MS/MSD analyses performed on sediment sample SED-PINES-02-WY11-01-01. The benzo(g,h,i)perylene, indeno(1,2,3-cd)pyrene, *bis*(2-ethylhexyl)phthalate, and butyl benzyl phthalate results for sample SED-PINES-02-WY11-01-01 were qualified as estimated.

Sample results affected by outlying MS recovery are summarized in **Table 3-6**.

Surrogate Spike Recovery

Surrogate spike recovery indicates the efficiency of sample extraction in particular.

The %R values for all surrogate spikes for PAHs and phthalates in sample SMKYPT-01-WY11-04-03 were less than 10% or lower control limits, indicating a potential of unsuccessful extraction of this sample. The PAH and phthalate detections in sample SMKYPT-01-WY11-04-03 were qualified as estimated values and the non-detects were rejected.

The %R value for the NWTPH-Dx surrogate spike in sample BALLINGER-01-WY11-05-02 was less than the lower control limit. Diesel #2 and Lube Oil results in this sample were qualified as estimated.

The %R values for selected pesticide surrogate spikes in three stormwater samples were less than the lower control limit. Pesticide results for the three samples were qualified as estimated. **Table 3-7** summarizes the qualified data.

Precision

Precision is defined as the degree of mutual agreement among independent measurements as the result of repeated application of the same process under similar conditions. Analytical precision is evaluated via the relative percent difference (RPD) values of LCS/LCSD analyses, MS/MSD analyses, and concentrations obtained from the two analytical columns for dual column methodologies. In addition, the RPD values of field duplicate analyses represent the combined precision of sample collection and analysis procedures, as well as sample homogeneity.

Quality control anomalies affecting data accuracy are identified and summarized below.

MS/MSD and Laboratory Duplicate Relative Percent Difference (RPD)

The RPD value for an MS/MSD pair or a laboratory duplicate analyses indicate the variability (imprecision) resulting from the sample matrix and/or analytical system.

The RPD values for copper in the laboratory duplicate analyses performed on sample SED-PINES-02-WY11-01-01 exceeded the control limit (<20%). Copper results for the two associated samples were qualified as estimated.

Relative percent difference values for *bis*(2-ethylhexyl)phthalate and butyl benzyl phthalate in the MS/MSD analyses performed on sample SED-PINES-02-WY11-02-01 were less than the lower control limits. *bis*(2-Ethylhexyl)phthalate and butyl benzyl phthalate results for sample SED-PINES-02-WY11-02-01 were qualified as estimated.

The RPD value for TKN in the laboratory duplicate analyses performed on sample GEIGER-01-WY11-06-03 exceeded the control limit (<20%). The TKN result for sample GEIGER-01-WY11-06-03 was qualified as estimated. Data qualified as a result of outlying MS/MSD and laboratory duplicate RPD values are presented in **Table 3-8**.

LCS/LCSD RPD

The RPD value for a LCS/LCSD pair indicates the variability resulted from the sample preparation and/or sample analysis processes. The RPD value for 2,4-D and selected PAHs in a number of LCS/LCSD pairs were outside the control criteria. Selected PAHs and 2,4-D results for the associated samples were qualified as estimated. Qualified data are presented in **Table 3-8**.

Representativeness

Representativeness is the level of confidence that the analytical data reflect the actual field condition. Representativeness is ensured by maintaining sample integrity during collection, preparation, and analysis. The evaluation of associated method and field blanks also assists in identifying artifacts that may skew the representativeness of the samples.

No anomalies were identified in sample preservation, handling, preparation, and analysis that affected data representativeness, except for the QC anomalies affecting accuracy (Section 3.1) and precision (Section 3.2) as discussed above. The data quality potentially resulting from these anomalies were evaluated and determined to have no significant effects on the data representativeness.

Comparability

Comparability is the confidence with which one data set can be compared to another data set. Using standard methods throughout the data generation processes ensures the comparability of data generated in separate sampling days or events.

All samples collected during monitoring year 2012 were analyzed using standardized analytical methodologies. Data generated from upcoming stormwater monitoring events are expected to be comparable to data generated in 2012, as long as the same or equivalent sampling protocols and analytical methodologies are applied to future sample collection activities and laboratory analysis.

Sensitivity

Sensitivity depicts the level of ability for an analytical system (*i.e.,* sample preparation and instrumental analysis) to detect a target component in a given sample matrix with a defined level of confidence. Factors affecting the sensitivity of an analytical system include: analytical system background (*e.g.,* laboratory artifact or method blank contamination), sample matrix (*e.g.,* mass spectrometry ion ratio change, co-elution of peaks, or baseline elevation) and instrument instability.

To evaluate if the analytical sensitivity achieved the project expectation, sample-specific PQLs were compared against the RL goals set forth in the *QAPPs.* In addition, sample results were compared to detections of target analytes in method blanks to identify potential effects of laboratory background on sensitivity.

The blank-related effects are discussed above in Section 3.1. Sample results affected by the detections in the blanks were qualified as non-detects at the standard PQLs, which sufficed the project PQL goals.

Sample Matrix Interference

The presence of target or non-target chemicals or subjects in samples may affect the ability of an analytical system to accurately quantitate the target analyte at the expected sensitivity

Non-target chemicals were present in sample BAINBRIDGE-01-WY11-02-02 interfering with the Lube Oil quantitation. The Lube Oil result for sample BAINBRIDGE-01-WY11-02-02 was qualified as estimated. Qualified data are presented in **Table 3-9**.

Sample-Specific Quantitation Limits

The RLs for SVOCs in sediment samples were elevated three to eight times from the project goal for method RLs. This range of elevations resulted from the required dilution of sample extracts to overcome the oily nature of the samples. The reported sample-specific RLs were considered the best-possible RLs given the conditions of the samples. No further actions were feasible other than noting the incident in this document.

Completeness and Data Usability

Completeness is defined as the percentage of usable data over the total amount of data collected. Data qualified (R)[2] and target analytes that were not analyzed or reported by the laboratory were counted as unusable data and factored in the completeness determination.

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[2] R - The data are unusable due to deficiencies in the ability to analyze the sample and meet QC criteria.

Overall Data Completeness

A total of 2,044 data points were collected, with 27 of the data points rejected. Overall analytical data completeness for WSDOT's NPDES Stormwater Monitoring Program during monitoring year 2012 was calculated at 98.7 percent, achieving the project goal of 95 percent.

REFERENCES

USEPA Methods for the Determination of Organic Compounds in Drinking Water, U.S. Environmental Protection Agency, December 1988 and Supplements I, II, and III, EPA 600/4-88/039.

USEPA Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846, Third Edition, December 1996.

USEPA Contract Laboratory Program National Functional Guidelines for Superfund Organic Methods Data Review, Office of Superfund Remediation and Technology Innovation, U.S. Environmental Protection Agency, June 2008, EPA-540-R-08-01.

USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Superfund Data Review, Office of Superfund Remediation and Technical Innovation, U.S. Environmental Protection Agency, January 2010, USEPA 540/R-10/011.

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WSDOT 2011a. *QAPP for Baseline Monitoring of WSDOT Highway Run-off.* Working draft, February 2011.

WSDOT 2011b. *QAPP for Baseline Monitoring of WSDOT Maintenance Facilities, Rest Area, and Ferry Terminals.* Working draft, February 2011.

WSDOT 2011c. *QAPP for WSDOT Roadway Stormwater Treatment Evaluation: Best Management Practices.* Working draft, March 2011.

TABLES

Table 1-1 Sample Analysis Schedule

Stormwater			
Parameter	**Analytical Method**	**Number of Samples**	**Analytical Laboratory**
Total Chloride	USEPA 300.0	42	Washington State Department of Ecology, Manchester Environmental Laboratory (MEL), Manchester, WA
Total Suspended Solids (TSS)	SM 2540D	53	
Fecal Coliform	SM 9222D	1	
Nitrate/Nitrite	SM 4500 NO_3-I	37	
Ortho-phosphate (OP)	SM 4500 P-G	30	
Total Phosphorus (TP)	SM 4500 P-F	38	
Total Metals (Cd, Cu, Pb, Zn)	EPA 200.8	45	
Dissolved Metals (Cd, Cu, Pb, Zn)	EPA 200.8	36	
Hardness	SM 2340B	38	
TPH-Diesel & Motor Oil	NWTPH-Dx	25	
TPH-Gasoline	NWTPH-Gx	20	
Polycyclic Aromatic Hydrocarbons (PAHs)	SW8270-SIM	49	
Phthalates	SW8270-SIM	13	
Triclopyr (total formula), 2,4-D, Clopyralid, Picloram	SW8270	37	
Diuron & Dichlobenil	SW8270	38	
Particle Size Distribution (PSD)	ASTM D3977-97/TAPE	1	Analytical Resources, Inc. (ARI) – Tukwila, WA
Glyphosate (non-aquatic formula)	USEPA 547	35	TestAmerica Laboratories, Inc. (TAL) – Savannah, GA
Total Kjeldahl Nitrogen (TKN)	USEPA 351.2	39	TAL – Portland, OR, Denver, CO, & Savannah, GA
Methylene Blue Active Substances (MBAS)	SM 5540C	16	AmTest Laboratories, Inc. Kirkland, Washington
Fecal Coliform	SM 9222D	1	
Sediment			
Parameter	**Analytical Method**	**Number of Samples**	**Analytical Laboratory**
Total Solids	SM 2540G	5	TAL – Seattle, WA
Grain Size	ASTM D422	6	
Total Organic Carbon (TOC)	PSEP Protocols	6	MEL – Manchester, WA
Metals (Cd, Cu, Pb, Zn)	EPA 200.8	6	
TPH-Diesel & Motor Oil	NWTPH-Dx	5	
Triclopyr (total formula) & Picloram	SW8270-SIM	5	
SVOCs (SMS compounds)	SW8270-SIM	5	

Notes:

1. SM – *Standard Methods for the Examination of Water and Wastewater*, American Public Health Association, 20th Edition, 1995

2. EPA Methods - *USEPA Methods for Chemical Analysis of Water and Wastes,* EPA–600/4-79-020, March 1983 Revision

3. SW Methods - *USEPA Test Methods for Evaluating Solid Waste, Physical/Chemical Methods,* SW-846, Third Edition, December 1996

4. NWTPH - *Analytical Methods for Petroleum Hydrocarbons,* ECY 97-602, Washington State Department of Ecology, June 1997

5. ASTM – American Society of Testing and Materials

6. PSEP – Puget Sound Estuary Program

7. SIM – Selective ion monitoring

8. SMS – Washington State Sediment Management Standards

9. TAPE - Guidance for Evaluating Emerging Stormwater Treatment Technologies, Technology Assessment Protocol – Ecology, 2008

Table 3-1 Quality Control Parameters Corresponding to Measurement Quality Objectives

MQOs	QC Parameters
Precision	**RPD or Concentration Difference Values of:** LCS/LCSD MS/MSD (or Laboratory Duplicate) Dual Column Confirmation
Accuracy	Holding Time **%RPD, %R, %D, or %D_f Values of:** Calibration Verification (CS1, ICV, CCV) Surrogate Spikes Internal Standards LCS and LCSD MS and MSD Interference Check Sample for Metals Analyzed with ICP Methodologies Serial Dilution for Metals Analyzed with ICP Methodologies **Results of:** Instrument and Calibration Blanks (ICB/CCB) Method (Preparation) Blanks Trip Blanks
Representativeness	Results of All Blanks Sample Integrity Holding Times
Comparability	Sample-specific PQLs Sample Collection Methodologies Sample Preparation and Analytical Methodologies
Completeness	Data Qualifiers Laboratory Deliverables and Analyte Lists Requested/Reported Valid Results Number of Rejected Results
Sensitivity	Sample-specific MDLs and PQLs

Notes:

%RSD – Percent relative standard deviation
%R – Percent recovery
%D – Percent difference
%D_f – Percent drift
%RPD – Percent relative percent difference
CCB – Continuing calibration blank
CCV – Continuing calibration verification
CS1 – First (lowest) initial calibration standard
ICB – Initial calibration blank
ICV – Initial calibration verification
LCS – Laboratory control sample
LCSD – Laboratory control sample duplicate
MS – Matrix Spike
MSD – Matrix spike duplicate
PQL – Practical quantitation limit
RPD – Relative percent difference

Table 3-2 Data Affected by Sample Preservation and Holding Time Violations

Field Sample ID	Lab Sample ID	Analyte	Qualifier	Reason Code
CLARKSTON-01-WY11-02-01	1203075-01	Ortho-Phosphate	**J**	Holding Time
GEIGER-01-WY11-04-01	1203082-01	Ortho-Phosphate	**J**	Holding Time
SMKYPT-01-WY11-04-01	1205076-01	Ortho-Phosphate	**J**	Holding Time
GEIGER-01-WY11-04-01	12-A004383	Surfactants	**J**	Holding Time

Notes:

Holding Time – Analysis of the sample was performed past the method required holding time.

Table 3-3 Data Affected by Calibration Verification Outliers

Field Sample ID	Laboratory Sample ID	Analyte	Qualifier	Comment
SED-PINES-01-WY11-01-01	1211039-01	Benzoic Acid	**UJ**	CCV biased low
SED PINES-02-WY11-01-01	1211039-02	Benzoic Acid	**UJ**	CCV biased low
LAKEVIEW-01-WY11-01-01	580-32196-2	Total Kjeldahl Nitrogen	**J**	CCV biased low
BALLINGER-01-WY11-06-03	580-32628-1	Total Kjeldahl Nitrogen	**U**	CCV biased low
LAKEVIEW-01-WY11-05-01	580-32629-1	Total Kjeldahl Nitrogen	**J**	CCV biased low
LAKEVIEW-01-WY11-05-03	580-32630-1	Total Kjeldahl Nitrogen	**U**	CCV biased low
SMKYPT-02-WY11-03-01	580-32674-1	Total Kjeldahl Nitrogen	**J**	CCV biased low
GEIGER-01-WY11-06-03	580-33602-1	Total Kjeldahl Nitrogen	**UJ**	CCV biased low
VANCOUVER-01-WY11-05-03	580-33699-1	Total Kjeldahl Nitrogen	**J**	CCV biased low
BAINBRIDGE-01-WY11-02-01	1201046-01	Benzo(a)pyrene	**J**	CS1 biased high
BAINBRIDGE-01-WY11-05-01	1203074-03	Benzo(a)pyrene	**J**	CS1 biased high
BAINBRIDGE-01-WY11-02-01	1201046-01	Dibenzo(a,h)anthracene	**J**	CS1 biased low
BAINBRIDGE-01-WY11-06-01	1203074-01	Dibenzo(a,h)anthracene	**UJ**	CS1 biased low
BAINBRIDGE-01-WY11-05-01	1203074-03	Dibenzo(a,h)anthracene	**UJ**	CS1 biased low
SED-PINES-01-WY11-01-01	1211039-01	*bis*(2-Ethylhexyl) Phthalate	**J**	CS1 biased low
SED-PINES-01-WY11-01-01	1211039-01	Dibenzo(a,h)anthracene	**UJ**	CS1 biased low
SED PINES-02-WY11-01-01	1211039-02	*bis*(2-Ethylhexyl) Phthalate	**J**	CS1 biased low
SED PINES-02-WY11-01-01	1211039-02	Dibenzo(a,h)anthracene	**UJ**	CS1 biased low
BAINBRIDGE-01-WY11-02-01	1201046-01	Indeno(1,2,3-cd)pyrene	**J**	ICV biased high
BAINBRIDGE-01-WY11-02-01	1201046-01	Benz[a]anthracene	**J**	ICV biased low
BAINBRIDGE-01-WY11-06-01	1203074-01	Benz[a]anthracene	**UJ**	ICV biased low
BAINBRIDGE-01-WY11-05-01	1203074-03	Benz[a]anthracene	**J**	ICV biased low

Notes:

CCV – Continuing calibration verification

CS1 – First (lowest) initial calibration standard

ICV – Initial calibration verification

Table 3-4 Data Affected by Detections in Blanks

Field Sample ID	Laboratory Sample ID	Analyte	Adjusted Value	Qualifier	Unit	Comment
BALLINGER-01-WY11-05-01	580-32275-2	Total Kjeldahl Nitrogen	1.4	**J**	mg/L	MB
CLARKSTON-01-WY11-03-01	580-32275-1	Total Kjeldahl Nitrogen	0.99	**J**	mg/L	MB
SMKYPT-02-WY11-01-01	580-32275-3	Total Kjeldahl Nitrogen	1.2	**J**	mg/L	MB
VANCOUVER-01-WY11-02-01	580-32196-3	Total Kjeldahl Nitrogen	1.1	**J**	mg/L	MB
LAKEVIEW-01-WY11-05-01	580-32629-1	Total Kjeldahl Nitrogen	0.75	**J**	mg/L	MB
LAKEVIEW-01-WY11-05-03	580-32630-1	Total Kjeldahl Nitrogen	0.5	**U**	mg/L	MB
BALLINGER-01-WY11-06-03	580-32628-1	Total Kjeldahl Nitrogen	0.5	**U**	mg/L	MB
LAKEVIEW-01-WY11-01-01	580-32196-2	Total Kjeldahl Nitrogen	0.62	**J**	mg/L	MB
VANCOUVER-01-WY11-05-03	580-33699-1	Total Kjeldahl Nitrogen	0.55	**J**	mg/L	MB
SMKYPT-02-WY11-03-01	580-32674-1	Total Kjeldahl Nitrogen	1.4	**J**	mg/L	MB
BAINBRIDGE-01-WY11-09-01	1202066-01	Naphthalene	0.025	**J**	µg/L	MB
PILCHUCK-01-WY11-02-01	1207089-01	Naphthalene	0.022	**J**	µg/L	MB
EVERETT-04-WY11-01-01	1207104-01	Naphthalene	0.028	**J**	µg/L	MB
SMKYPT-02-WY11-03-01	1205044-01	*bis*(2-Ethylhexyl) Phthalate	0.76	**J**	µg/L	MB

Notes:
MB – Analyte was detected in method blank and sample result was affected.
µg/L – microgram per liter
mg/L – milligram per
U – Analyte was not detected at or above the adjusted value.

Table 3-5 Data Affected by Laboratory Control Sample Outliers

Field Sample ID	Laboratory Sample ID	Analyte	Qualifier	Comment
SED-PINES-01-WY11-01-01	1211039-01	Benzoic Acid	**R**	LCS %R <10%
SED PINES-02-WY11-01-01	1211039-02	Benzoic Acid	**R**	LCS %R <10%
SED-PINES-01-WY11-01-01	1211039-01	Benzyl Alcohol	**R**	LCS %R <10%
SED PINES-02-WY11-01-01	1211039-02	Benzyl Alcohol	**R**	LCS %R <10%
SED-PINES-01-WY11-01-01	1211039-01	Pentachlorophenol	**R**	LCS %R <10%
SED PINES-02-WY11-01-01	1211039-02	Pentachlorophenol	**R**	LCS %R <10%
BAINBRIDGE-01-WY11-04-02	1203052-02	#2 Diesel	**UJ**	LCS %R <LCL
GEIGER-01-WY11-04-02	1203082-02	#2 Diesel	**UJ**	LCS %R <LCL
EUCLID-01-WY11-01-02	1203083-01	#2 Diesel	**UJ**	LCS %R <LCL
LAKEVIEW-01-WY11-01-02	1204038-02	#2 Diesel	**UJ**	LCS %R <LCL
VANCOUVER-01-WY11-02-02	1204039-02	#2 Diesel	**UJ**	LCS %R <LCL
BALLINGER-01-WY11-05-02	1204040-02	#2 Diesel	**UJ**	LCS %R <LCL
BALLINGER-01-WY11-01-01	1201048-01	2,4-D	**UJ**	LCS %R <LCL
BALLINGER-01-WY11-02-01	1202064-01	2,4-D	**UJ**	LCS %R <LCL
BALLINGER-01-WY11-03-01	1203038-01	2,4-D	**UJ**	LCS %R <LCL
VANCOUVER-01-WY11-01-01	1203039-01	2,4-D	**UJ**	LCS %R <LCL
LAKEVIEW-01-WY11-02-01	1204055-01	2,4-D	**J**	LCS %R <LCL
LAKEVIEW-01-WY11-03-01	1204067-01	2,4-D	**J**	LCS %R <LCL
VANCOUVER-01-WY11-03-01	1204068-01	2,4-D	**J**	LCS %R <LCL
SMKYPT-01-WY11-04-01	1205076-01	2,4-D	**UJ**	LCS %R <LCL
SMKYPT-02-WY11-04-01	1205077-01	2,4-D	**UJ**	LCS %R <LCL
SMKYPT-01-WY11-04-03	1205078-01	2,4-D	**UJ**	LCS %R <LCL
EUCLID-01-WY11-03-01	1206050-01	2,4-D	**J**	LCS %R <LCL
GEIGER-01-WY11-07-01	1210077-01	2,4-D	**UJ**	LCS %R <LCL
BAINBRIDGE-01-WY11-03-01	1202056-01	Acenaphthylene	**J**	LCS %R <LCL
BALLINGER-01-WY11-02-01	1202064-01	Acenaphthylene	**J**	LCS %R <LCL
BAINBRIDGE-01-WY11-09-01	1202066-01	Acenaphthylene	**J**	LCS %R <LCL
BALLINGER-01-WY11-03-01	1203038-01	Acenaphthylene	**J**	LCS %R <LCL
BAINBRIDGE-01-WY11-04-01	1203052-01	Acenaphthylene	**J**	LCS %R <LCL
SMKYPT-02-WY11-02-01	1203062-01	Acenaphthylene	**J**	LCS %R <LCL
BALLINGER-01-WY11-04-01	1203063-01	Acenaphthylene	**J**	LCS %R <LCL
SMKYPT-01-WY11-02-01	1203064-01	Acenaphthylene	**J**	LCS %R <LCL
GEIGER-01-WY11-03-01	1205048-01	Acenaphthylene	**J**	LCS %R <LCL
BAINBRIDGE-01-WY11-07-01	1205075-01	Acenaphthylene	**UJ**	LCS %R <LCL
SMKYPT-02-WY11-04-01	1205077-01	Acenaphthylene	**J**	LCS %R <LCL
EUCLID-01-WY11-03-01	1206050-01	Acenaphthylene	**UJ**	LCS %R <LCL

Field Sample ID	Laboratory Sample ID	Analyte	Qualifier	Comment
BAINBRIDGE-01-WY11-07-01	1205075-01	Anthracene	**UJ**	LCS %R <LCL
SMKYPT-01-WY11-04-01	1205076-01	Anthracene	**UJ**	LCS %R <LCL
SMKYPT-02-WY11-04-01	1205077-01	Anthracene	**UJ**	LCS %R <LCL
GEIGER-01-WY11-03-01	1205048-01	Benz[a]anthracene	**J**	LCS %R <LCL
BALLINGER-01-WY11-02-01	1202064-01	Benzo(a)pyrene	**J**	LCS %R <LCL
BAINBRIDGE-01-WY11-09-01	1202066-01	Benzo(a)pyrene	**J**	LCS %R <LCL
BALLINGER-01-WY11-03-01	1203038-01	Benzo(a)pyrene	**J**	LCS %R <LCL
VANCOUVER-01-WY11-01-01	1203039-01	Benzo(a)pyrene	**UJ**	LCS %R <LCL
GEIGER-01-WY11-03-01	1205048-01	Benzo(a)pyrene	**J**	LCS %R <LCL
BAINBRIDGE-01-WY11-07-01	1205075-01	Benzo(a)pyrene	**J**	LCS %R <LCL
SMKYPT-01-WY11-04-01	1205076-01	Benzo(a)pyrene	**UJ**	LCS %R <LCL
SMKYPT-02-WY11-04-01	1205077-01	Benzo(a)pyrene	**UJ**	LCS %R <LCL
BALLINGER-01-WY11-03-01	1203038-01	*bis*(2-Ethylhexyl) Phthalate	**J**	LCS %R <LCL
SMKYPT-01-WY11-03-01	1205043-01	*bis*(2-Ethylhexyl) Phthalate	**J**	LCS %R <LCL
SMKYPT-02-WY11-03-01	1205044-01	*bis*(2-Ethylhexyl) Phthalate	**J**	LCS %R <LCL
SMKYPT-01-WY11-04-01	1205076-01	*bis*(2-Ethylhexyl) Phthalate	**J**	LCS %R <LCL
PILCHUCK-WY11-01-01	1206077-01	*bis*(2-Ethylhexyl) Phthalate	**J**	LCS %R <LCL
BALLINGER-01-WY11-01-01	1201048-01	Clopyralid	**UJ**	LCS %R <LCL
BALLINGER-01-WY11-02-01	1202064-01	Clopyralid	**UJ**	LCS %R <LCL
BALLINGER-01-WY11-03-01	1203038-01	Clopyralid	**UJ**	LCS %R <LCL
VANCOUVER-01-WY11-01-01	1203039-01	Clopyralid	**UJ**	LCS %R <LCL
GEIGER-01-WY11-04-01	1203082-01	Clopyralid	**UJ**	LCS %R <LCL
BALLINGER-01-WY11-03-01	1203038-01	Di-N-Octyl Phthalate	**J**	LCS %R <LCL
SMKYPT-01-WY11-02-01	1203064-01	Di-N-Octyl Phthalate	**J**	LCS %R <LCL
SMKYPT-02-WY11-01-01	1204041-01	Di-N-Octyl Phthalate	**J**	LCS %R <LCL
SMKYPT-01-WY11-01-02	1204041-02	Di-N-Octyl Phthalate	**UJ**	LCS %R <LCL
SMKYPT-01-WY11-03-01	1205043-01	Di-N-Octyl Phthalate	**J**	LCS %R <LCL
SMKYPT-02-WY11-03-01	1205044-01	Di-N-Octyl Phthalate	**UJ**	LCS %R <LCL
SMKYPT-01-WY11-04-01	1205076-01	Di-N-Octyl Phthalate	**UJ**	LCS %R <LCL
SMKYPT-02-WY11-04-01	1205077-01	Di-N-Octyl Phthalate	**UJ**	LCS %R <LCL
PILCHUCK-WY11-01-01	1206077-01	Di-N-Octyl Phthalate	**J**	LCS %R <LCL
BALLINGER-01-WY11-01-01	1201048-01	Diuron	**UJ**	LCS %R <LCL
LAKEVIEW-01-WY11-01-01	1204038-01	Diuron	**UJ**	LCS %R <LCL
BALLINGER-01-WY11-05-01	1204040-01	Diuron	**UJ**	LCS %R <LCL
SMKYPT-02-WY11-01-01	1204041-01	Diuron	**UJ**	LCS %R <LCL
SMKYPT-01-WY11-01-02	1204041-02	Diuron	**UJ**	LCS %R <LCL
CLARKSTON-01-WY11-03-01	1204043-01	Diuron	**UJ**	LCS %R <LCL

Field Sample ID	Laboratory Sample ID	Analyte	Qualifier	Comment
LAKEVIEW-01-WY11-04-01	1204076-01	Diuron	**UJ**	LCS %R <LCL
CLARKSTON-01-WY11-04-01	1204078-01	Diuron	**UJ**	LCS %R <LCL
EUCLID-01-WY11-02-01	1204079-03	Diuron	**UJ**	LCS %R <LCL
LAKEVIEW-01-WY11-05-03	1204086-01	Diuron	**UJ**	LCS %R <LCL
LAKEVIEW-01-WY11-05-01	1204088-01	Diuron	**UJ**	LCS %R <LCL
SMKYPT-01-WY11-03-01	1205043-01	Diuron	**UJ**	LCS %R <LCL
SMKYPT-02-WY11-03-01	1205044-01	Diuron	**UJ**	LCS %R <LCL
GEIGER-01-WY11-03-01	1205048-01	Diuron	**J**	LCS %R <LCL
GEIGER-01-WY11-06-03	1206075-01	Diuron	**J**	LCS %R <LCL
GEIGER-01-WY11-05-01	1206081-01	Diuron	**J**	LCS %R <LCL
BAINBRIDGE-01-WY11-04-02	1203052-02	Lube Oil	**J**	LCS %R <LCL
GEIGER-01-WY11-04-02	1203082-02	Lube Oil	**J**	LCS %R <LCL
EUCLID-01-WY11-01-02	1203083-01	Lube Oil	**J**	LCS %R <LCL
LAKEVIEW-01-WY11-01-02	1204038-02	Lube Oil	**J**	LCS %R <LCL
VANCOUVER-01-WY11-02-02	1204039-02	Lube Oil	**J**	LCS %R <LCL
BALLINGER-01-WY11-05-02	1204040-02	Lube Oil	**J**	LCS %R <LCL
SED-PILCHUCK-01-WY11-01-01	1207080-02	Pentachlorophenol	**UJ**	LCS %R <LCL
SED-EVERETT-04-WY11-01-01	1207080-03	Pentachlorophenol	**UJ**	LCS %R <LCL
SED-EVERETT-01-WY11-01-01	1207080-04	Pentachlorophenol	**UJ**	LCS %R <LCL
BALLINGER-01-WY11-02-01	1202064-01	Picloram	**UJ**	LCS %R <LCL
BALLINGER-01-WY11-03-01	1203038-01	Picloram	**UJ**	LCS %R <LCL
VANCOUVER-01-WY11-01-01	1203039-01	Picloram	**UJ**	LCS %R <LCL
BALLINGER-01-WY11-02-01	1202064-01	Triclopyr	**UJ**	LCS %R <LCL
BALLINGER-01-WY11-03-01	1203038-01	Triclopyr	**UJ**	LCS %R <LCL
VANCOUVER-01-WY11-01-01	1203039-01	Triclopyr	**J**	LCS %R <LCL

Notes:
LCS – Laboratory control sample
%R – Percent recovery
LCL = Lower control limit

Table 3-6 Data Affected by Matrix Spike Recovery Outliers

Field Sample ID	Laboratory Sample ID	Analyte	Qualifier	Comment
GEIGER-01-WY11-04-01	580-32196-1	Total Kjeldahl Nitrogen	**J**	
BALLINGER-01-WY11-07-01	580-33672-1	Total Kjeldahl Nitrogen	**J**	
LAKEVIEW-01-WY11-06-01	580-33672-3	Total Kjeldahl Nitrogen	**J**	
PILCHUCK-01-WY11-01-01	580-33672-2	Total Kjeldahl Nitrogen	**J**	
SED-SR09-01-WY11-01-01	1207080-01	Copper	**J**	
SED-PILCHUCK-01-WY11-01-01	1207080-02	Copper	**J**	
SED-EVERETT-04-WY11-01-01	1207080-03	Copper	**J**	
SED-EVERETT-01-WY11-01-01	1207080-04	Copper	**J**	
SED-SR09-01-WY11-01-01	1207080-01	Lead	**J**	
SED-PILCHUCK-01-WY11-01-01	1207080-02	Lead	**J**	
SED-EVERETT-04-WY11-01-01	1207080-03	Lead	**J**	
SED-EVERETT-01-WY11-01-01	1207080-04	Lead	**J**	
SED-PINES-01-WY11-01-01	1211039-01	Lead	**J**	
SED PINES-02-WY11-01-01	1211039-02	Lead	**J**	
SED-PINES-01-WY11-01-01	1211039-01	Copper	**J**	
SED PINES-02-WY11-01-01	1211039-02	Copper	**J**	
TOX-PILCHUCK-06-WY11-01-01	1209085-01	Zinc	**J**	
TOX-EVERETT-REF-WY11-01-01	1209085-02	Zinc	**J**	
TOX-PILCHUCK-REF-WY11-01-01	1209085-03	Zinc	**J**	
TOX-PILCHUCK-06-WY11-01-03	1209087-01	Zinc	**J**	
SED PINES-02-WY11-01-01	1211039-02	Benzyl Alcohol	**R**	MS/MSD %R <10%
SED PINES-02-WY11-01-01	1211039-02	Pentachlorophenol	**R**	MS/MSD %R <10%
SED PINES-02-WY11-01-01	1211039-02	Benzoic Acid	**R**	MS/MSD %R <10%
SED-PILCHUCK-01-WY11-01-01	1207080-02	Benzo(ghi)perylene	**J**	
SED-PILCHUCK-01-WY11-01-01	1207080-02	Indeno(1,2,3-cd)pyrene	**J**	
SED-PILCHUCK-01-WY11-01-01	1207080-02	*bis*(2-Ethylhexyl) Phthalate	**J**	
SED PINES-02-WY11-01-01	1211039-02	Butyl benzyl phthalate	**J**	

Notes:

MS – Matrix spike

MSD – Matrix spike duplicate

%R – Percent recovery

Table 3-7 Data Affected by Surrogate Spike Recovery Outliers

Field Sample ID	Laboratory Sample ID	Analyte	Qualifier	Comment
BALLINGER-01-WY11-05-02	1204040-02	#2 Diesel	**UJ**	
BALLINGER-01-WY11-05-02	1204040-02	Lube Oil	**J**	
BALLINGER-01-WY11-04-01	1203063-01	Triclopyr	**J**	
GEIGER-01-WY11-02-01	1203069-01	Dichlobenil	**J**	
GEIGER-01-WY11-02-01	1203069-01	Diuron	**J**	
GEIGER-01-WY11-03-01	1205048-01	Dichlobenil	**J**	
GEIGER-01-WY11-03-01	1205048-01	Diuron	**J**	
SMKYPT-01-WY11-04-03	1205078-01	Dichlobenil	**J**	
SMKYPT-01-WY11-04-03	1205078-01	Acenaphthene	**R**	Unsuccessful extraction
SMKYPT-01-WY11-04-03	1205078-01	Acenaphthylene	**R**	Unsuccessful extraction
SMKYPT-01-WY11-04-03	1205078-01	Anthracene	**R**	Unsuccessful extraction
SMKYPT-01-WY11-04-03	1205078-01	Benz[a]anthracene	**R**	Unsuccessful extraction
SMKYPT-01-WY11-04-03	1205078-01	Benzo(a)pyrene	**R**	Unsuccessful extraction
SMKYPT-01-WY11-04-03	1205078-01	Benzo(b)fluoranthene	**R**	Unsuccessful extraction
SMKYPT-01-WY11-04-03	1205078-01	Benzo(g,h,i)perylene	**R**	Unsuccessful extraction
SMKYPT-01-WY11-04-03	1205078-01	Benzo(k)fluoranthene	**R**	Unsuccessful extraction
SMKYPT-01-WY11-04-03	1205078-01	*bis*(2-Ethylhexyl) Phthalate	**J**	Unsuccessful extraction
SMKYPT-01-WY11-04-03	1205078-01	Butyl benzyl phthalate	**R**	Unsuccessful extraction
SMKYPT-01-WY11-04-03	1205078-01	Chrysene	**R**	Unsuccessful extraction
SMKYPT-01-WY11-04-03	1205078-01	Dibenzo(a,h)anthracene	**R**	Unsuccessful extraction
SMKYPT-01-WY11-04-03	1205078-01	Diethyl phthalate	**R**	Unsuccessful extraction
SMKYPT-01-WY11-04-03	1205078-01	Dimethyl phthalate	**R**	Unsuccessful extraction
SMKYPT-01-WY11-04-03	1205078-01	Di-N-Butylphthalate	**R**	Unsuccessful extraction
SMKYPT-01-WY11-04-03	1205078-01	Di-N-Octyl Phthalate	**R**	Unsuccessful extraction
SMKYPT-01-WY11-04-03	1205078-01	Fluoranthene	**R**	Unsuccessful extraction
SMKYPT-01-WY11-04-03	1205078-01	Fluorene	**R**	Unsuccessful extraction
SMKYPT-01-WY11-04-03	1205078-01	Indeno(1,2,3-cd)pyrene	**R**	Unsuccessful extraction
SMKYPT-01-WY11-04-03	1205078-01	Naphthalene	**R**	Unsuccessful extraction
SMKYPT-01-WY11-04-03	1205078-01	Phenanthrene	**R**	Unsuccessful extraction
SMKYPT-01-WY11-04-03	1205078-01	Pyrene	**R**	Unsuccessful extraction

Notes:

Unsuccessful extraction – Recovery of all surrogate spikes was less than the lower control limits or, in some cases, <10%, indicating a great potential of unsuccessful extraction of the sample. Detections in the samples were qualified (J) and non-detects qualified (R) and the results rejected.

Table 3-8 Data Affected by Precision Outliers

Field Sample ID	Laboratory Sample ID	Analyte	Qualifier	Comment
SED-PINES-01-WY11-01-01	1211039-01	Copper	**J**	Laboratory Duplicate
SED PINES-02-WY11-01-01	1211039-02	Copper	**J**	Laboratory Duplicate
SED-PILCHUCK-01-WY11-01-01	1207080-02	*bis*(2-Ethylhexyl) Phthalate	**J**	MS/MSD
SED PINES-02-WY11-01-01	1211039-02	Butyl Benzyl Phthalate	**J**	MS/MSD
GEIGER-01-WY11-06-03	580-33602-1	Total Kjeldahl Nitrogen	**UJ**	Laboratory Duplicate
BALLINGER-01-WY11-05-01	1204040-01	2,4-D	**UJ**	LCS/LCSD
LAKEVIEW-01-WY11-01-01	1204038-01	2,4-D	**J**	LCS/LCSD
CLARKSTON-01-WY11-03-01	1204043-01	2,4-D	**J**	LCS/LCSD
GEIGER-01-WY11-04-01	1203082-01	2,4-D	**J**	LCS/LCSD
VANCOUVER-01-WY11-02-01	1204039-01	2,4-D	**UJ**	LCS/LCSD
SMKYPT-02-WY11-01-01	1204041-01	2,4-D	**UJ**	LCS/LCSD
SMKYPT-01-WY11-01-02	1204041-02	2,4-D	**UJ**	LCS/LCSD
GEIGER-01-WY11-04-01	1203082-01	Picloram	**J**	LCS/LCSD
GEIGER-01-WY11-04-01	1203082-01	Triclopyr	**J**	LCS/LCSD
VANCOUVER-01-WY11-03-01	1204068-01	2,4-D	**J**	LCS/LCSD
LAKEVIEW-01-WY11-02-01	1204055-01	2,4-D	**J**	LCS/LCSD
LAKEVIEW-01-WY11-03-01	1204067-01	2,4-D	**J**	LCS/LCSD
SMKYPT-01-WY11-04-01	1205076-01	2,4-D	**UJ**	LCS/LCSD
VANCOUVER-01-WY11-01-01	1203039-01	2,4-D	**UJ**	LCS/LCSD
SMKYPT-02-WY11-04-01	1205077-01	2,4-D	**UJ**	LCS/LCSD
SMKYPT-01-WY11-04-03	1205078-01	2,4-D	**UJ**	LCS/LCSD
GEIGER-01-WY11-04-01	1203082-01	Clopyralid	**UJ**	LCS/LCSD
LAKEVIEW-01-WY11-04-01	1204076-01	Acenaphthylene	**J**	LCS/LCSD
LAKEVIEW-01-WY11-05-03	1204086-01	Acenaphthylene	**UJ**	LCS/LCSD
LAKEVIEW-01-WY11-05-01	1204088-01	Acenaphthylene	**UJ**	LCS/LCSD
VANCOUVER-01-WY11-04-01	1204077-01	Acenaphthylene	**UJ**	LCS/LCSD
BALLINGER-01-WY11-06-03	1204087-01	Acenaphthylene	**UJ**	LCS/LCSD
SMKYPT-01-WY11-04-01	1205076-01	Acenaphthylene	**J**	LCS/LCSD
SMKYPT-01-WY11-03-01	1205043-01	Acenaphthylene	**UJ**	LCS/LCSD
SMKYPT-02-WY11-03-01	1205044-01	Acenaphthylene	**UJ**	LCS/LCSD
EUCLID-01-WY11-02-01	1204079-03	Acenaphthylene	**J**	LCS/LCSD
CLARKSTON-01-WY11-04-01	1204078-01	Acenaphthylene	**UJ**	LCS/LCSD
BALLINGER-01-WY11-02-01	1202064-01	Anthracene	**J**	LCS/LCSD
BALLINGER-01-WY11-03-01	1203038-01	Anthracene	**J**	LCS/LCSD
VANCOUVER-01-WY11-01-01	1203039-01	Anthracene	**UJ**	LCS/LCSD
BAINBRIDGE-01-WY11-07-01	1205075-01	Benz[a]anthracene	**J**	LCS/LCSD
SMKYPT-01-WY11-04-01	1205076-01	Benz[a]anthracene	**UJ**	LCS/LCSD
SMKYPT-02-WY11-04-01	1205077-01	Benz[a]anthracene	**UJ**	LCS/LCSD
BAINBRIDGE-01-WY11-07-01	1205075-01	Dibenzo(a,h)anthracene	**UJ**	LCS/LCSD
SMKYPT-01-WY11-04-01	1205076-01	Dibenzo(a,h)anthracene	**UJ**	LCS/LCSD

Field Sample ID	Laboratory Sample ID	Analyte	Qualifier	Comment
SMKYPT-02-WY11-04-01	1205077-01	Dibenzo(a,h)anthracene	**UJ**	LCS/LCSD
BAINBRIDGE-01-WY11-04-01	1203052-01	Acenaphthylene	**J**	LCS/LCSD
BALLINGER-01-WY11-02-01	1202064-01	Acenaphthylene	**J**	LCS/LCSD
BALLINGER-01-WY11-03-01	1203038-01	Acenaphthylene	**J**	LCS/LCSD
BALLINGER-01-WY11-04-01	1203063-01	Acenaphthylene	**J**	LCS/LCSD
BAINBRIDGE-01-WY11-09-01	1202066-01	Acenaphthylene	**J**	LCS/LCSD
SMKYPT-01-WY11-02-01	1203064-01	Acenaphthylene	**J**	LCS/LCSD
SMKYPT-02-WY11-02-01	1203062-01	Acenaphthylene	**J**	LCS/LCSD
SMKYPT-02-WY11-04-01	1205077-01	Acenaphthylene	**J**	LCS/LCSD
SMKYPT-02-WY11-04-01	1205077-01	Anthracene	**UJ**	LCS/LCSD
BAINBRIDGE-01-WY11-07-01	1205075-01	Benzo(a)pyrene	**J**	LCS/LCSD
BALLINGER-01-WY11-02-01	1202064-01	Benzo(a)pyrene	**J**	LCS/LCSD
BALLINGER-01-WY11-03-01	1203038-01	Benzo(a)pyrene	**J**	LCS/LCSD
SMKYPT-01-WY11-04-01	1205076-01	Benzo(a)pyrene	**UJ**	LCS/LCSD
BAINBRIDGE-01-WY11-09-01	1202066-01	Benzo(a)pyrene	**J**	LCS/LCSD
VANCOUVER-01-WY11-01-01	1203039-01	Benzo(a)pyrene	**UJ**	LCS/LCSD
SMKYPT-02-WY11-04-01	1205077-01	Benzo(a)pyrene	**UJ**	LCS/LCSD

Notes:
MS/MSD – The relative percent difference (RPD) value for matrix spike and matrix spike duplicate was outside the control criteria.
LCS/LCSD – The RPD value for laboratory control sample and laboratory control sample duplicate was outside the control criteria.
Laboratory Duplicate - The RPD value for the laboratory duplicate analysis was outside the control criteria.

Table 3-9 Data Affected by Sample Matrix Interference

Field Sample ID	Laboratory Sample ID	Analyte	Qualifier	Comment
BAINBRIDGE-01-WY11-02-02	1201046-02	Lube Oil	**J**	Matrix Interference

Notes:
Matrix interference – Non-target chemical/subject that affected the accurate quantitation of the analyte was observed during analysis as noted by laboratory analyst.
Ion Ration – Ion abundance ratio for the reported detection did not meet method criteria for compound identification.

Appendix C:
Storm Report Data

SR9 (VFS PE)														
Precipitation						**Water Temp**		**Aliquot**						
Start Time	End Time	Total (in)	Duration (hrs)	Antecedent Met?	Interevent Met?	Min (C°)	Max (C°)	Sample Point (m)	Samples Collected	First Sample	Last Sample	Sample Duration (hrs)	Aliquot Volume (mL)	Total Sample Volume (mL)
5/20/2012 11:00	5/20/2012 23:05	0.39	12.1	Y	Y	13.7	15.4	0	10	5/20/2012 19:30	5/20/2012 22:25	2.9	700	7000
Runoff					**Volume**			**Sampled**		**Flow**		**Validation Code**		
Sample Point (m)	Start Time	End Time	Duration (hrs)		Total(L)	Intensity (L/hr)	First 24 hrs (L)	Total Discharge Volume Sampled (L)	% Hydrograph Sampled	Peak (Lpm)	Mean (Lpm)			
0	5/20/2012 19:15	5/20/2012 22:45	3.5		783.3	223.8	783.3	N/A	N/A	N/A	N/A	R		

Comment: Samples were rejected due to equipment failure.

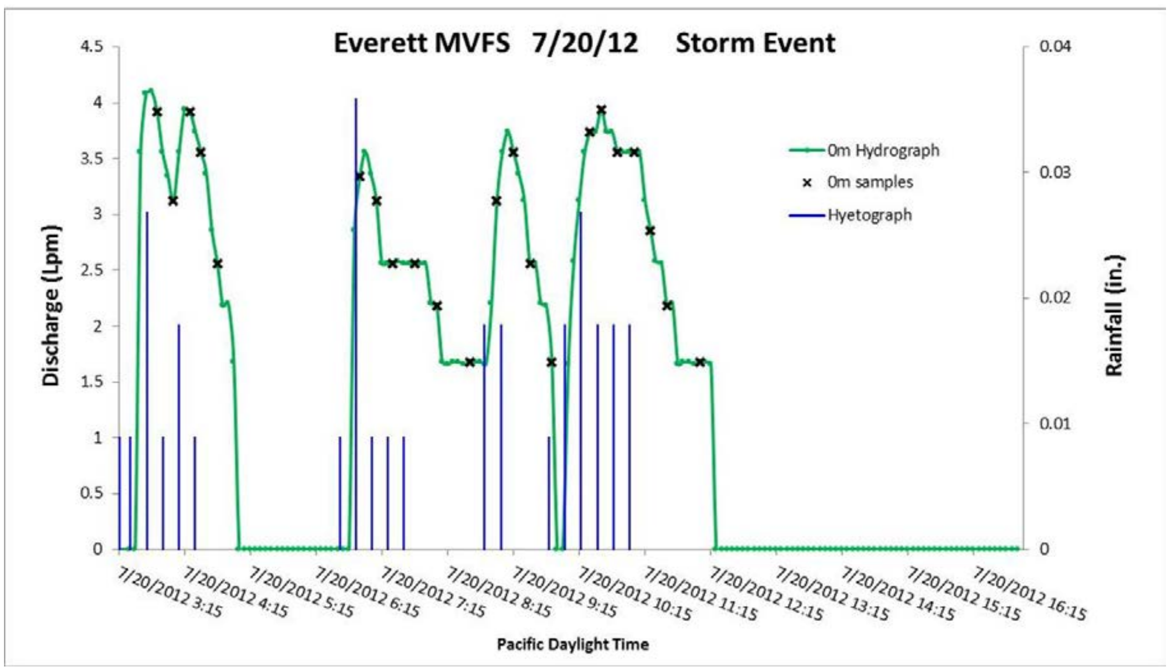
Pines (PE)														
Precipitation						**Water Temp**		**Aliquot**						
Start Time	End Time	Total (in)	Duration (hrs)	Antecedent Met?	Interevent Met?	Min (C°)	Max (C°)	Sample Point (m)	Samples Collected	First Sample	Last Sample	Sample Duration (hrs)	Aliquot Volume (mL)	Total Sample Volume (mL)
6/26/2012 08:15	6/26/2012 14:10	0.55	5.9	Y	Y	13.2	14.6	0	N/A	N/A	N/A	N/A	N/A	N/A
Runoff				**Volume**				**Sampled**		**Flow**		**Validation Code**		
Sample Point (m)	Start Time	End Time	Duration (hrs)	Total(L)		Intensity (L/hr)	First 24 hrs (L)	Total Discharge Volume Sampled (L)	% Hydrograph Sampled	Peak (Lpm)	Mean (Lpm)			
0	N/A	N/A	N/A	N/A		N/A	N/A	N/A	N/A	N/A	N/A	N/A		

Comment: Grab samples only. No hydrology or composite samples collected.

Everett 04 (MVFS PE)														
Precipitation						**Water Temp**		**Aliquot**						
Start Time	End Time	Total (in)	Duration (hrs)	Antecedent Met?	Interevent Met?	Min (C°)	Max (C°)	Sample Point (m)	Samples Collected	First Sample	Last Sample	Sample Duration (hrs)	Aliquot Volume (mL)	Total Sample Volume (mL)
7/20/2012 02:45	7/20/2012 11:10	0.33	8.4	Y	Y	15.8	17.2	0	22	7/20/2012 03:50	7/20/2012 12:05	8.3	700	15400

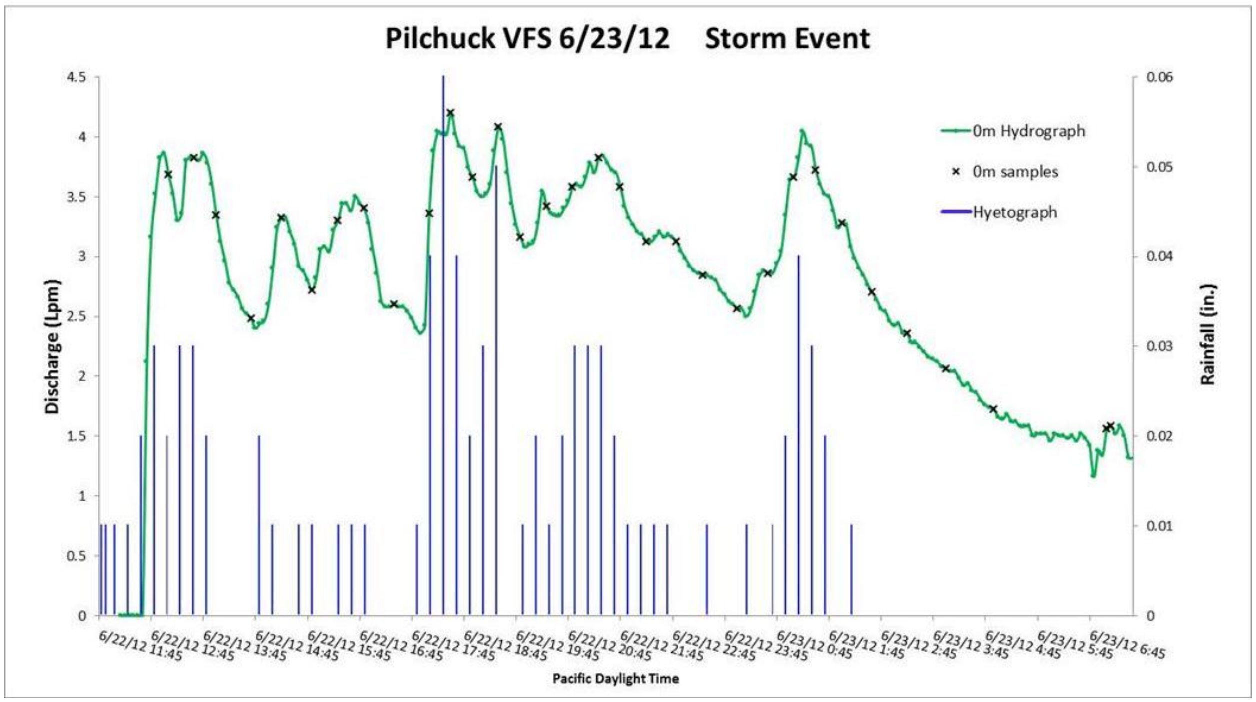
Runoff				**Volume**			**Sampled**		**Flow**		**Validation Code**		
Sample Point (m)	Start Time	End Time	Duration (hrs)	Total(L)	Intensity (L/hr)	First 24 hrs (L)	Total Discharge Volume Sampled (L)	% Hydrograph Sampled	Peak (Lpm)	Mean (Lpm)			
0	7/20/2012 03:40	7/20/2012 12:20	8.7	1133.2	130.3	1133.2	1133.2	95	4.1	1.4			

Comment: Successfully sampled storm.



Pilchuck 01 (VFS PE)														
Precipitation						**Water Temp**		**Aliquot**						
Start Time	End Time	Total (in)	Duration (hrs)	Antecedent Met?	Interevent Met?	Min (C°)	Max (C°)	Sample Point (m)	Samples Collected	First Sample	Last Sample	Sample Duration (hrs)	Aliquot Volume (mL)	Total Sample Volume (mL)
6/22/2012 11:45	6/23/2012 02:10	0.88	14.4	Y	Y	12.5	15.3	0	32	6/22/2012 13:05	6/23/2012 07:10	18.1	700	22400
Runoff				**Volume**				**Sampled**		**Flow**		**Validation Code**		
Sample Point (m)	Start Time	End Time	Duration (hrs)	Total(L)		Intensity (L/hr)	First 24 hrs (L)	Total Discharge Volume Sampled (L)	% Hydrograph Sampled	Peak (Lpm)	Mean (Lpm)			
0	6/22/2012 12:40	6/23/2012 07:45	19.1	3253.3		170.5	3253.3	3253	95	4.04	2.8			

Comment: Successfully sampled storm event

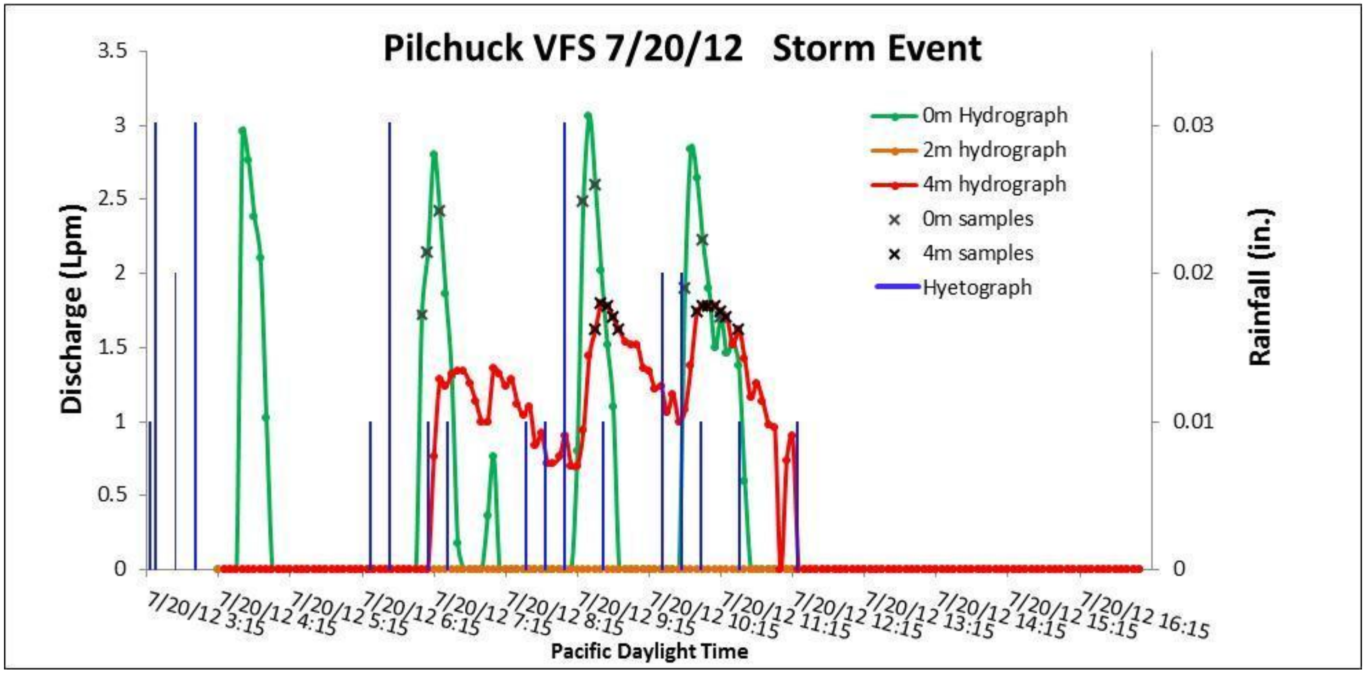


Pilchuck 01 (VFS PE)														
Precipitation						**Water Temp**		**Aliquot**						
Start Time	End Time	Total (in)	Duration (hrs)	Antecedent Met?	Interevent Met?	Min (C°)	Max (C°)	Sample Point (m)	Samples Collected	First Sample	Last Sample	Sample Duration (hrs)	Aliquot Volume (mL)	Total Sample Volume (mL)
7/20/2012 03:00	7/20/2012 12:20	0.27	9.3	Y	Y	15.7	17.6	0	8	7/20/2012 04:45	7/20/2012 11:15	6.5	700	5600
Runoff				**Volume**				**Sampled**		**Flow**		**Validation Code**		
Sample Point (m)	Start Time	End Time	Duration (hrs)	Total(L)		Intensity (L/hr)	First 24 hrs (L)	Total Discharge Volume Sampled (L)	% Hydrograph Sampled	Peak (Lpm)	Mean (Lpm)			
0	7/20/2012 04:35	7/20/2012 11:35	7	290.1		41.4	290.1	256	88	3.06	0.7			

Comment: Successfully sampled storm event.

Pilchuck 03 (VFS 4M)														
Precipitation						**Water Temp**		**Aliquot**						
Start Time	End Time	Total (in)	Duration (hrs)	Antecedent Met?	Interevent Met?	Min (C°)	Max (C°)	Sample Point (m)	Samples Collected	First Sample	Last Sample	Sample Duration (hrs)	Aliquot Volume (mL)	Total Sample Volume (mL)
7/20/2012 03:15	7/20/2012 12:20	0.27	9.1	Y	Y	15.7	17.6	4	12	7/20/2012 09:30	7/20/2012 11:30	2	700	8400
Runoff					**Volume**			**Sampled**		**Flow**		**Validation Code**		
Sample Point (m)	Start Time	End Time	Duration (hrs)		Total(L)	Intensity (L/hr)	First 24 hrs (L)	Total Discharge Volume Sampled (L)	% Hydrograph Sampled	Peak (Lpm)	Mean (Lpm)			
4	7/20/2012 07:15	7/20/2012 12:15	5		374.8	74.9	374.8	374.8	40	1.8	0.7	R		

Comment: Hydrology validation found that this attempt did not sample >75% of the storm hydrograph. This was due to a data logger programming error.

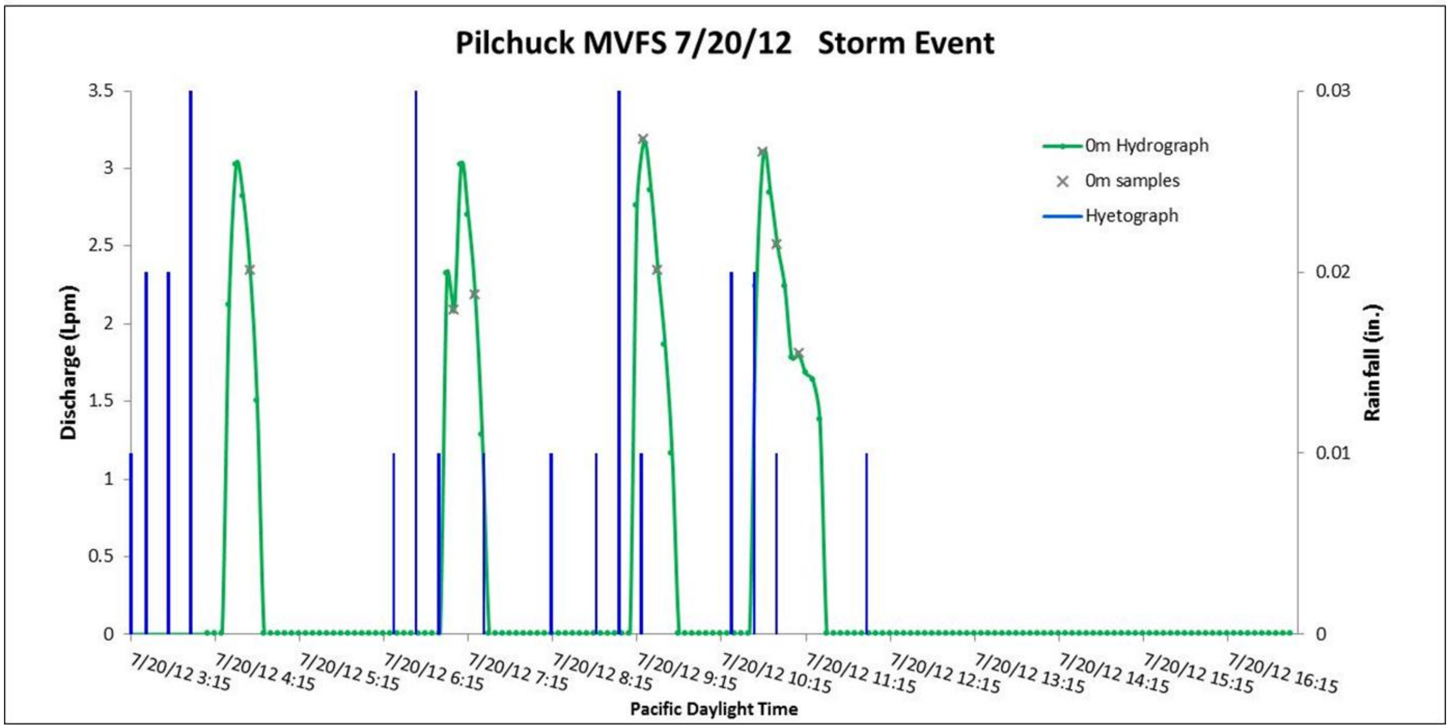

Pilchuck VFS 7/20/12 Storm Event
Discharge (Lpm)
Rainfall (in.)
0m Hydrograph
2m hydrograph
4m hydrograph
0m samples
4m samples
Hyetograph
3.5
3
2.5
2
1.5
1
0.5
0
0.03
0.02
0.01
0
7/20/12 3:15
7/20/12 4:15
7/20/12 5:15
7/20/12 6:15
7/20/12 7:15
7/20/12 8:15
7/20/12 9:15
7/20/12 10:15
7/20/12 11:15
7/20/12 12:15
7/20/12 13:15
7/20/12 14:15
7/20/12 15:15
7/20/12 16:15
Pacific Daylight Time

Pilchuck 06 (MVFS PE)

Precipitation						Water Temp		Aliquot						
Start Time	End Time	Total (in)	Duration (hrs)	Antecedent Met?	Interevent Met?	Min (C°)	Max (C°)	Sample Point (m)	Samples Collected	First Sample	Last Sample	Sample Duration (hrs)	Aliquot Volume (mL)	Total Sample Volume (mL)
7/20/2012 03:15	7/20/2012 12:05	0.26	8.8	Y	Y	16.7	17.5	0	8	7/20/2012 4:40	7/20/2012 11:10	6.5	700	5600

Runoff				Volume			Sampled		Flow		Validation		
Sample Point (m)	Start Time	End Time	Duration (hrs)	Total(L)	Intensity (L/hr)	First 24 hrs (L)	Total Discharge Volume Sampled (L)	% Hydrograph Sampled	Peak (Lpm)	Mean (Lpm)			
0	7/20/2012 04:30	7/20/2012 11:30	7	303.7	43.4	303.7	303.7	93	3.18	0.4			

Comment: Successful sampled storm event.



Appendix D:
Stormwater Water Quality Data

Everett-04 (MVFS PE)	Storm Event			
PARAMETER	**UNITS**	**7/20/2012**		
Conventionals				
TSS	mg/L	109		
Chloride	mg/L	2.82		
Hardness as $CaCO_3$	mg/L	21.5		
pH	N/A	--		
Temperature	degrees C	--		
Bacteria				
Fecal coliform	cfu/100ml	--		
Nutrients				
Total Phosphorous	mg/L	0.268		
Orthophosphate	mg/L	--		
Total Kjeldahl Nitrogen	mg/L	2		
Nitrate-Nitrite	mg/L	0.983		
Metals				
Total Recoverable Copper	ug/L	--		
Dissolved Copper	ug/L	--		
Total Recoverable Lead	ug/L	--		
Dissolved Lead	ug/L	--		
Total Recoverable Cadmium	ug/L	--		
Dissolved Cadmium	ug/L	--		
Total Recoverable Zinc	ug/L	--		
Dissolved Zinc	ug/L	--		
PAH Compounds				
Acenaphthene	ug/L	0.0099	U	
Acenaphthylene	ug/L	0.0099	U	
Anthracene	ug/L	0.0099	U	
Benzo(a)anthracene	ug/L	0.041		
Benzo(b)fluoranthene	ug/L	0.099		
Benzo(k)fluoranthene	ug/L	0.026		
Benzo(ghi)perylene	ug/L	0.12		
Benzo(a)pyrene	ug/L	0.047		
Chrysene	ug/L	0.081		
Dibenzo(a,h)anthracene	ug/L	0.013		
Fluoranthene	ug/L	0.16		
Fluorene	ug/L	0.0099	U	
Indeno(1,2,3-cd)pyrene	ug/L	0.047		
Naphthalene	ug/L	0.028	J	
Phenanthrene	ug/L	0.083		
Pyrene	ug/L	0.26		
Phthalates				
bis(2-Ethylhexyl)phthalate	ug/L	13		
Butyl benzyl phthalate	ug/L	0.31		
Di-n-butyl phthalate	ug/L	0.47	UJ	
Diethyl phthalate	ug/L	0.27		
Dimethyl phthalate	ug/L	0.2	U	
Di-n-octyl phthalate	ug/L	1.5		

Everett-04 (MVFS PE) (continued)

Herbicides				
Dichlobenil	ug/L	--		
Diuron	ug/L	--		
2,4-D	ug/L	--		
Clopyralid	ug/L	--		
Picloram	ug/L	--		
Triclopyr	ug/L	--		
Glyphosate	ug/L	25	U	
TPH				
TPH-Diesel (NWTPH-Dx)	mg/L	--		
Diesel	mg/L	--		
Lube Oil	mg/L	--		
TPH-Gas (NWTPH-Gx)	mg/L	--		
Surfactants				
Methylene blue active substances (MBAS)	mg/L	--		
Particle Size Distribution				
Particle/Grain Size, Phi Scale <1 (>500 um)	mg/L	64.27		
Particle/Grain Size, Phi Scale >10 (<1.0 um)	mg/L	5.64		
Particle/Grain Size, Phi Scale 1-2 (250-500 um)	mg/L	8.07		
Particle/Grain Size, Phi Scale 2-3 (125-250 um)	mg/L	0.01	U	
Particle/Grain Size, Phi Scale 3-4 (62.5-125 um)	mg/L	47.95		
Particle/Grain Size, Phi Scale 4-8 (3.9-62.5 um)	mg/L	58.02		
Particle/Grain Size, Phi Scale 8-10 (1.0-3.9 um)	mg/L	4.22		

Notes:

-- Parameter not analyzed

U – Analyte not detected above reported result

J – Estimated value

UJ – Analyte not detected above reported result; reported reporting limit may be inaccurate

TPH-Diesel (NWTPH-Dx) values are calculated as the sum of the Diesel and Lube Oil concentrations

Pilchuck-01 (VFS PE)		Storm Event			
PARAMETER	**UNITS**	**6/23/2012**		**7/20/2012**	
Conventionals					
TSS	mg/L	29		117	
Chloride	mg/L	1.53		2.78	
Hardness as $CaCO_3$	mg/L	25.6		38	
pH	N/A	--		--	
Temperature	degrees C	--		--	
Bacteria					
Fecal coliform	cfu/100ml	--		--	
Nutrients					
Total Phosphorous	mg/L	0.0806		0.266	
Orthophosphate	mg/L	--		--	
Total Kjeldahl Nitrogen	mg/L	1	J	1.4	
Nitrate-Nitrite	mg/L	0.112		0.411	
Metals					
Total Recoverable Copper	ug/L	--		--	
Dissolved Copper	ug/L	--		--	
Total Recoverable Lead	ug/L	--		--	
Dissolved Lead	ug/L	--		--	
Total Recoverable Cadmium	ug/L	--		--	
Dissolved Cadmium	ug/L	--		--	
Total Recoverable Zinc	ug/L	--		--	
Dissolved Zinc	ug/L	--		--	
PAH Compounds					
Acenaphthene	ug/L	0.0098	U	0.0098	U
Acenaphthylene	ug/L	0.0098	U	0.023	
Anthracene	ug/L	0.0098	U	0.0098	U
Benzo(a)anthracene	ug/L	0.0098	U	0.021	
Benzo(b)fluoranthene	ug/L	0.020		0.063	
Benzo(k)fluoranthene	ug/L	0.0098	U	0.017	
Benzo(ghi)perylene	ug/L	0.041		0.12	
Benzo(a)pyrene	ug/L	0.011		0.04	
Chrysene	ug/L	0.016		0.042	
Dibenzo(a,h)anthracene	ug/L	0.0098	U	0.0098	U
Fluoranthene	ug/L	0.033		0.089	
Fluorene	ug/L	0.0098	U	0.0098	U
Indeno(1,2,3-cd)pyrene	ug/L	0.12		0.041	
Naphthalene	ug/L	0.013	UJ	0.022	J
Phenanthrene	ug/L	0.019		0.04	
Pyrene	ug/L	0.052		0.13	
Phthalates					
bis(2-Ethylhexyl)phthalate	ug/L	4.3	J	7.1	
Butyl benzyl phthalate	ug/L	0.20	U	0.2	U
Di-n-butyl phthalate	ug/L	0.26	UJ	0.3	UJ
Diethyl phthalate	ug/L	0.20	U	0.16	J
Dimethyl phthalate	ug/L	0.20	U	0.84	
Di-n-octyl phthalate	ug/L	0.77	J	0.2	U

Pilchuck-01 (VFS PE) (continued)

Herbicides					
Dichlobenil	ug/L	--		--	
Diuron	ug/L	--		--	
2,4-D	ug/L	--		--	
Clopyralid	ug/L	--		--	
Picloram	ug/L	--		--	
Triclopyr	ug/L	--		--	
Glyphosate	ug/L	25	U	25	U
TPH					
TPH-Diesel (NWTPH-Dx)	mg/L	--		--	
Diesel	mg/L	--		--	
Lube Oil	mg/L	--		--	
TPH-Gas (NWTPH-Gx)	mg/L	--		--	
Surfactants					
Methylene blue active substances (MBAS)	mg/L	--		--	
Particle Size Distribution					
Particle/Grain Size, Phi Scale <1 (>500 um)	mg/L	0.01	U	0.2	
Particle/Grain Size, Phi Scale >10 (<1.0 um)	mg/L	3.81		11.54	
Particle/Grain Size, Phi Scale 1-2 (250-500 um)	mg/L	4.55		1.43	
Particle/Grain Size, Phi Scale 2-3 (125-250 um)	mg/L	0.01	U	0.02	
Particle/Grain Size, Phi Scale 3-4 (62.5-125 um)	mg/L	0.01	U	42.14	
Particle/Grain Size, Phi Scale 4-8 (3.9-62.5 um)	mg/L	26.42		65.4	
Particle/Grain Size, Phi Scale 8-10 (1.0-3.9 um)	mg/L	5.42		13.82	

Notes:

-- Parameter not analyzed

U – Analyte not detected above reported result

J – Estimated value

UJ – Analyte not detected above reported result; reported reporting limit may be inaccurate

TPH-Diesel (NWTPH-Dx) values are calculated as the sum of the Diesel and Lube Oil concentrations

Pilchuck-03 (VFS 4M)		Storm Event	
PARAMETER	**UNITS**	**7/20/2012**	
Conventionals			
TSS	mg/L	28	
Hardness as $CaCO_3$	mg/L	83.9	
pH	N/A	--	
Temperature	degrees C	--	
Bacteria			
Fecal coliform	cfu/100ml	--	
Nutrients			
Total Phosphorous	mg/L	0.657	
Orthophosphate	mg/L	--	
Total Kjeldahl Nitrogen	mg/L	2.5	
Nitrate-Nitrite	mg/L	2.51	
Metals			
Total Recoverable Copper	ug/L	--	
Dissolved Copper	ug/L	--	
Total Recoverable Zinc	ug/L	--	
Dissolved Zinc	ug/L	--	
TPH			
TPH-Diesel (NWTPH-Dx)	mg/L	--	
Diesel	mg/L	--	
Lube Oil	mg/L	--	
TPH-Gas (NWTPH-Gx)	mg/L	--	
Surfactants			
Methylene blue active substances (MBAS)	mg/L	--	
Particle Size Distribution			
Particle/Grain Size, Phi Scale <1 (>500 um)	mg/L	1.71	
Particle/Grain Size, Phi Scale >10 (<1.0 um)	mg/L	0.79	
Particle/Grain Size, Phi Scale 1-2 (250-500 um)	mg/L	1.01	
Particle/Grain Size, Phi Scale 2-3 (125-250 um)	mg/L	0.01	U
Particle/Grain Size, Phi Scale 3-4 (62.5-125 um)	mg/L	2.6	
Particle/Grain Size, Phi Scale 4-8 (3.9-62.5 um)	mg/L	20.59	
Particle/Grain Size, Phi Scale 8-10 (1.0-3.9 um)	mg/L	0.54	

Notes:

-- Parameter not analyzed

U – Analyte not detected above reported result

J – Estimated value

UJ – Analyte not detected above reported result; reported reporting limit may be inaccurate

TPH-Diesel (NWTPH-Dx) values are calculated as the sum of the Diesel and Lube Oil concentrations

Pilchuck-06 (MVFS PE)		Storm Event	
PARAMETER	**UNITS**	**7/20/2012**	
Conventionals			
TSS	mg/L	106	
Chloride	mg/L	--	
Hardness as $CaCO_3$	mg/L	35.2	
pH	N/A	--	
Temperature	degrees C	--	
Bacteria			
Fecal coliform	cfu/100ml	--	
Nutrients			
Total Phosphorous	mg/L	--	
Orthophosphate	mg/L	--	
Total Kjeldahl Nitrogen	mg/L	1.4	
Nitrate-Nitrite	mg/L	--	
Metals			
Total Recoverable Copper	ug/L	--	
Dissolved Copper	ug/L	--	
Total Recoverable Cadmium	ug/L	--	
Dissolved Cadmium	ug/L	--	
TPH			
TPH-Diesel (NWTPH-Dx)	mg/L	--	
Diesel	mg/L	--	
Lube Oil	mg/L	--	
TPH-Gas (NWTPH-Gx)	mg/L	--	
Surfactants			
Methylene blue active substances (MBAS)	mg/L	--	
Particle Size Distribution			
Particle/Grain Size, Phi Scale <1 (>500 um)	mg/L	3.49	
Particle/Grain Size, Phi Scale >10 (<1.0 um)	mg/L	6.14	
Particle/Grain Size, Phi Scale 1-2 (250-500 um)	mg/L	7.57	
Particle/Grain Size, Phi Scale 2-3 (125-250 um)	mg/L	0.02	
Particle/Grain Size, Phi Scale 3-4 (62.5-125 um)	mg/L	34.95	
Particle/Grain Size, Phi Scale 4-8 (3.9-62.5 um)	mg/L	61.66	
Particle/Grain Size, Phi Scale 8-10 (1.0-3.9 um)	mg/L	8.49	

Notes:

-- Parameter not analyzed

U – Analyte not detected above reported result

J – Estimated value

UJ – Analyte not detected above reported result; reported reporting limit may be inaccurate

TPH-Diesel (NWTPH-Dx) values are calculated as the sum of the Diesel and Lube Oil concentrations

Pines Highway (Pavement Edge)		Storm Event	
PARAMETER	**UNITS**	**6/26/2012**	
Conventionals			
TSS	mg/L	--	
Chloride	mg/L	--	
Hardness as $CaCO_3$	mg/L	--	
Temperature	degrees C	--	
Bacteria			
Fecal coliform	cfu/100ml	--	
Nutrients			
Total Phosphorous	mg/L	--	
Orthophosphate	mg/L	--	
Total Kjeldahl Nitrogen	mg/L	--	
Nitrate-Nitrite	mg/L	--	
Metals			
Total Recoverable Copper	ug/L	--	
Dissolved Copper	ug/L	--	
Total Recoverable Lead	ug/L	--	
Dissolved Lead	ug/L	--	
Total Recoverable Cadmium	ug/L	--	
Dissolved Cadmium	ug/L	--	
Total Recoverable Zinc	ug/L	--	
Dissolved Zinc	ug/L	--	
PAH Compounds			
Acenaphthene	ug/L	--	
Acenaphthylene	ug/L	--	
Anthracene	ug/L	--	
Benzo(a)anthracene	ug/L	--	
Benzo(b)fluoranthene	ug/L	--	
Benzo(k)fluoranthene	ug/L	--	
Benzo(ghi)perylene	ug/L	--	
Benzo(a)pyrene	ug/L	--	
Chrysene	ug/L	--	
Dibenzo(a,h)anthracene	ug/L	--	
Fluoranthene	ug/L	--	
Fluorene	ug/L	--	
Indeno(1,2,3-cd)pyrene	ug/L	--	
Naphthalene	ug/L	--	
Phenanthrene	ug/L	--	
Pyrene	ug/L	--	
Phthalates			
bis(2-Ethylhexyl)phthalate	ug/L	--	
Butyl benzyl phthalate	ug/L	--	
Di-n-butyl phthalate	ug/L	--	
Diethyl phthalate	ug/L	--	
Dimethyl phthalate	ug/L	--	
Di-n-octyl phthalate	ug/L	--	

Pines Highway (Pavement Edge) (continued)

Herbicides			
Dichlobenil	ug/L	--	
Diuron	ug/L	--	
2,4-D	ug/L	--	
Clopyralid	ug/L	--	
Picloram	ug/L	--	
Triclopyr	ug/L	--	
Glyphosate	ug/L	--	
TPH			
TPH-Diesel (NWTPH-Dx)	mg/L	1.35	
Diesel	mg/L	0.05	U
Lube Oil	mg/L	1.3	
TPH-Gas (NWTPH-Gx)	mg/L	0.07	U

Notes:

-- Parameter not analyzed

U – Analyte not detected above reported result

J – Estimated value

UJ – Analyte not detected above reported result; reported reporting limit may be inaccurate

TPH-Diesel (NWTPH-Dx) values are calculated as the sum of the Diesel and Lube Oil concentrations

State Route-09		Storm Event	
PARAMETER	**UNITS**	**5/21/2012**	
Conventionals			
TSS	mg/L	288	J
Chloride	mg/L	--	
Hardness as $CaCO_3$	mg/L	--	
pH		--	
Temperature	degrees C	--	
Bacteria			
Fecal coliform	cfu/100ml	--	
Nutrients			
Total Phosphorous	mg/L	11.1	
Orthophosphate	mg/L	--	
Total Kjeldahl Nitrogen	mg/L	33	
Nitrate-Nitrite	mg/L	0.241	
Metals			
Total Recoverable Copper	ug/L	--	
Dissolved Copper	ug/L	--	
Total Recoverable Lead	ug/L	--	
Dissolved Lead	ug/L	--	
Total Recoverable Cadmium	ug/L	--	
Dissolved Cadmium	ug/L	--	
Total Recoverable Zinc	ug/L	--	
Dissolved Zinc	ug/L	--	
PAH Compounds			
Acenaphthene	ug/L	--	
Acenaphthylene	ug/L	--	
Anthracene	ug/L	--	
Benzo(a)anthracene	ug/L	--	
Benzo(b)fluoranthene	ug/L	--	
Benzo(k)fluoranthene	ug/L	--	
Benzo(ghi)perylene	ug/L	--	
Benzo(a)pyrene	ug/L	--	
Chrysene	ug/L	--	
Dibenzo(a,h)anthracene	ug/L	--	
Fluoranthene	ug/L	--	
Fluorene	ug/L	--	
Indeno(1,2,3-cd)pyrene	ug/L	--	
Naphthalene	ug/L	--	
Phenanthrene	ug/L	--	
Pyrene	ug/L	--	
Phthalates			
bis(2-Ethylhexyl)phthalate	ug/L	--	
Butyl benzyl phthalate	ug/L	--	
Di-n-butyl phthalate	ug/L	--	
Diethyl phthalate	ug/L	--	
Dimethyl phthalate	ug/L	--	
Di-n-octyl phthalate	ug/L	--	

State Route-09 (continued)

Herbicides			
Dichlobenil	ug/L	--	
Diuron	ug/L	--	
2,4-D	ug/L	--	
Clopyralid	ug/L	--	
Picloram	ug/L	--	
Triclopyr	ug/L	--	
Glyphosate	ug/L	--	
TPH			
TPH-Diesel (NWTPH-Dx)	mg/L	--	
Diesel	mg/L	--	
Lube Oil	mg/L	--	
TPH-Gas (NWTPH-Gx)	mg/L	--	

Notes:

-- Parameter not analyzed

U – Analyte not detected above reported result

J – Estimated value

UJ – Analyte not detected above reported result; reported reporting limit may be inaccurate

TPH-Diesel (NWTPH-Dx) values are calculated as the sum of the Diesel and Lube Oil concentrations

Appendix E:
Stormwater Sediment Data

Everett-01 Sediment (VFS Pavement Edge)	UNITS	Collection Date 7/12/2012	
PARAMETER			
Conventionals			
Total Organic Carbon	%	3.08	--
Percent Solids	%	99.2	--
Metals			
Total Recoverable Copper	mg/Kg dw	76.1	J
Total Recoverable Lead	mg/Kg dw	57	J
Total Recoverable Cadmium	mg/Kg dw	0.626	--
Total Recoverable Zinc	mg/Kg dw	303	--
PAH Compounds			
Acenaphthene	ug/Kg dw	250	U
Acenaphthylene	ug/Kg dw	250	U
Anthracene	ug/Kg dw	500	U
Benzyl Alcohol	ug/Kg dw	2500	U
Benzoic Acid	ug/Kg dw		R
Benzo(a)anthracene	ug/Kg dw	500	U
Benzo(b)fluoranthene	ug/Kg dw	140	J
Benzo(k)fluoranthene	ug/Kg dw	250	U
Benzo(ghi)perylene	ug/Kg dw	120	J
Benzo(a)pyrene	ug/Kg dw	250	U
Chrysene	ug/Kg dw	130	J
Dibenzo(a,h)anthracene	ug/Kg dw	500	UJ
Fluoranthene	ug/Kg dw	200	J
Fluorene	ug/Kg dw	250	U
Indeno(1,2,3-cd)pyrene	ug/Kg dw	190	J
Naphthalene	ug/Kg dw	500	U
Phenanthrene	ug/Kg dw	100	J
Pyrene	ug/Kg dw	320	J
Phthalates			
bis(2-Ethylhexyl)phthalate	ug/Kg dw	4700	--
Butyl benzyl phthalate	ug/Kg dw	1000	U
Di-n-butyl phthalate	ug/Kg dw	250	U
Diethyl phthalate	ug/Kg dw	500	U
Dimethyl phthalate	ug/Kg dw	500	U
Di-n-octyl phthalate	ug/Kg dw	5000	UJ
Phenols			
2,4-Dimethylphenol	ug/Kg dw	2500	U
Phenol	ug/Kg dw	1000	U
Pentachlorophenol	ug/Kg dw	2500	UJ
2-Methylphenol	ug/Kg dw	2500	U
TPH			
TPH-Diesel (NWTPH-Dx)	mg/Kg dw	2299	
Diesel	mg/Kg dw	99	U
Lube Oil	mg/Kg dw	2200	--

Everett-01 Sediment (continued)

Everett-01 Sediment (VFS Pavement Edge)	UNITS	Collection Date 7/12/2012	
PARAMETER			
Particle Size Distribution			
Particle/Grain Size, >2.0 mm	%	0	--
Particle/Grain Size, 850um-2 mm	%	7.1	--
Particle/Grain Size, 250-850 um	%	30.7	--
Particle/Grain Size, 75-250 um	%	43.8	--
Particle/Grain Size, 29.5-63 um	%	7.7	--
Particle/Grain Size, <29.53 um	%	10.7	--

Notes:

-- Parameter not analyzed

U – Analyte not detected above reported result

J – Estimated value

UJ – Analyte not detected above reported result; reported reporting limit may be inaccurate

TPH-Diesel (NWTPH-Dx) values are calculated as the sum of the Diesel and Lube Oil concentrations

Everett-04 Sediment (Modified-VFS Pavement Edge)	UNITS	Collection Date 7/12/2012	
PARAMETER			
Conventionals			
Total Organic Carbon	%	2.1	--
Percent Solids	%	99.5	--
Metals			
Total Recoverable Copper	mg/Kg dw	71.7	J
Total Recoverable Lead	mg/Kg dw	31.6	J
Total Recoverable Cadmium	mg/Kg dw	0.526	--
Total Recoverable Zinc	mg/Kg dw	330	--
PAH Compounds			
Acenaphthene	ug/Kg dw	250	U
Acenaphthylene	ug/Kg dw	250	U
Anthracene	ug/Kg dw	500	U
Benzyl Alcohol	ug/Kg dw		R
Benzoic Acid	ug/Kg dw		R
Benzo(a)anthracene	ug/Kg dw	500	U
Benzo(b)fluoranthene	ug/Kg dw	130	J
Benzo(k)fluoranthene	ug/Kg dw	250	U
Benzo(ghi)perylene	ug/Kg dw	120	J
Benzo(a)pyrene	ug/Kg dw	250	U
Chrysene	ug/Kg dw	110	J
Dibenzo(a,h)anthracene	ug/Kg dw	500	UJ
Fluoranthene	ug/Kg dw	200	J
Fluorene	ug/Kg dw	250	U
Indeno(1,2,3-cd)pyrene	ug/Kg dw	200	J
Naphthalene	ug/Kg dw	500	U
Phenanthrene	ug/Kg dw	86	J
Pyrene	ug/Kg dw	320	J
Phthalates			
bis(2-Ethylhexyl)phthalate	ug/Kg dw	5100	J
Butyl benzyl phthalate	ug/Kg dw	1000	U
Di-n-butyl phthalate	ug/Kg dw	250	U
Diethyl phthalate	ug/Kg dw	500	U
Dimethyl phthalate	ug/Kg dw	500	U
Di-n-octyl phthalate	ug/Kg dw	5000	UJ
Phenols			
2,4-Dimethylphenol	ug/Kg dw	2500	U
Phenol	ug/Kg dw	1000	U
Pentachlorophenol	ug/Kg dw	2500	UJ
2-Methylphenol	ug/Kg dw	2500	U
TPH			
TPH-Diesel (NWTPH-Dx)	mg/Kg dw	2097	
Diesel	mg/Kg dw	97	U
Lube Oil	mg/Kg dw	2000	--

Everett-04 Sediment (continued)

Everett-04 Sediment (Modified-VFS Pavement Edge)	UNITS	Collection Date 7/12/2012	
PARAMETER			
Particle Size Distribution			
Particle/Grain Size, >2.0 mm	%	0.6	--
Particle/Grain Size, 850um-2 mm	%	11	--
Particle/Grain Size, 250-850 um	%	30.3	--
Particle/Grain Size, 75-250 um	%	41.6	--
Particle/Grain Size, 29.5-63 um	%	5.9	--
Particle/Grain Size, <29.53 um	%	10.6	--

Notes:

-- Parameter not analyzed

U – Analyte not detected above reported result

J – Estimated value

UJ – Analyte not detected above reported result; reported reporting limit may be inaccurate

TPH-Diesel (NWTPH-Dx) values are calculated as the sum of the Diesel and Lube Oil concentrations

Pilchuck-01 Sediment (VFS Pavement Edge)	UNITS	Collection Date 7/12/2012	
PARAMETER			
Conventionals			
Total Organic Carbon	%	2.87	--
Percent Solids	%	99.2	--
Metals			
Total Recoverable Copper	mg/Kg dw	99.8	J
Total Recoverable Lead	mg/Kg dw	35.3	J
Total Recoverable Cadmium	mg/Kg dw	0.831	--
Total Recoverable Zinc	mg/Kg dw	292	--
PAH Compounds			
Acenaphthene	ug/Kg dw	250	U
Acenaphthylene	ug/Kg dw	250	U
Anthracene	ug/Kg dw	500	U
Benzyl Alcohol	ug/Kg dw	2500	U
Benzoic Acid	ug/Kg dw		R
Benzo(a)anthracene	ug/Kg dw	140	J
Benzo(b)fluoranthene	ug/Kg dw	200	J
Benzo(k)fluoranthene	ug/Kg dw	83	J
Benzo(ghi)perylene	ug/Kg dw	240	J
Benzo(a)pyrene	ug/Kg dw	150	J
Chrysene	ug/Kg dw	190	J
Dibenzo(a,h)anthracene	ug/Kg dw	500	UJ
Fluoranthene	ug/Kg dw	320	J
Fluorene	ug/Kg dw	250	U
Indeno(1,2,3-cd)pyrene	ug/Kg dw	250	J
Naphthalene	ug/Kg dw	500	U
Phenanthrene	ug/Kg dw	210	J
Pyrene	ug/Kg dw	460	J
Phthalates			
bis(2-Ethylhexyl)phthalate	ug/Kg dw	5000	J
Butyl benzyl phthalate	ug/Kg dw	120	J
Di-n-butyl phthalate	ug/Kg dw	250	U
Diethyl phthalate	ug/Kg dw	500	U
Dimethyl phthalate	ug/Kg dw	500	U
Di-n-octyl phthalate	ug/Kg dw	5000	UJ
Phenols			
2,4-Dimethylphenol	ug/Kg dw	2500	U
Phenol	ug/Kg dw	1000	U
Pentachlorophenol	ug/Kg dw	2500	UJ
2-Methylphenol	ug/Kg dw	2500	U
TPH			
TPH-Diesel (NWTPH-Dx)	mg/Kg dw	2097	
Diesel	mg/Kg dw	97	U
Lube Oil	mg/Kg dw	2000	--

Pilchuck-01 Sediment (continued)

Pilchuck-01 Sediment (VFS Pavement Edge)	UNITS	Collection Date 7/12/2012	
PARAMETER			
Particle Size Distribution			
Particle/Grain Size, >2.0 mm	%	2.5	--
Particle/Grain Size, 850um-2 mm	%	10.7	--
Particle/Grain Size, 250-850 um	%	28.5	--
Particle/Grain Size, 75-250 um	%	35.4	--
Particle/Grain Size, 29.5-63 um	%	9.2	--
Particle/Grain Size, <29.53 um	%	13.7	--

Notes:

-- Parameter not analyzed

U – Analyte not detected above reported result

J – Estimated value

UJ – Analyte not detected above reported result; reported reporting limit may be inaccurate

TPH-Diesel (NWTPH-Dx) values are calculated as the sum of the Diesel and Lube Oil concentrations

Pines-01 Sediment (Pavement Edge)	UNITS	Collection Date 11/6/2012	
PARAMETER			
Conventionals			
Total Organic Carbon	%	3.08	--
Percent Solids	%	88	--
Metals			
Total Recoverable Copper	mg/Kg dw	128	J
Total Recoverable Lead	mg/Kg dw	101	J
Total Recoverable Cadmium	mg/Kg dw	1.16	--
Total Recoverable Zinc	mg/Kg dw	655	--
PAH Compounds			
Acenaphthene	ug/Kg dw	280	U
Acenaphthylene	ug/Kg dw	280	U
Anthracene	ug/Kg dw	560	U
Benzyl Alcohol	ug/Kg dw		R
Benzoic Acid	ug/Kg dw		R
Benzo(a)anthracene	ug/Kg dw	560	U
Benzo(b)fluoranthene	ug/Kg dw	170	J
Benzo(k)fluoranthene	ug/Kg dw	280	U
Benzo(ghi)perylene	ug/Kg dw	560	U
Benzo(a)pyrene	ug/Kg dw	280	U
Chrysene	ug/Kg dw	260	J
Dibenzo(a,h)anthracene	ug/Kg dw	560	UJ
Fluoranthene	ug/Kg dw	300	J
Fluorene	ug/Kg dw	280	U
Indeno(1,2,3-cd)pyrene	ug/Kg dw	190	J
Naphthalene	ug/Kg dw	560	U
Phenanthrene	ug/Kg dw	240	J
Pyrene	ug/Kg dw	320	J
Phthalates			
bis(2-Ethylhexyl)phthalate	ug/Kg dw	4900	J
Butyl benzyl phthalate	ug/Kg dw	280	J
Di-n-butyl phthalate	ug/Kg dw	280	U
Diethyl phthalate	ug/Kg dw	560	U
Dimethyl phthalate	ug/Kg dw	560	U
Di-n-octyl phthalate	ug/Kg dw	5600	UJ
Herbicides			
Picloram	ug/Kg dw	72	U
Triclopyr	ug/Kg dw	72	U
Phenols			
2,4-Dimethylphenol	ug/Kg dw	2800	U
Phenol	ug/Kg dw	1100	U
Pentachlorophenol	ug/Kg dw	--	R
2-Methylphenol	ug/Kg dw	2800	U

Pines-01 Sediment (continued)

Pines-01 Sediment (Pavement Edge)	UNITS	Collection Date 11/6/2012	
PARAMETER			
TPH			
TPH-Diesel (NWTPH-Dx)	mg/Kg dw	2128	
Diesel	mg/Kg dw	28	U
Lube Oil	mg/Kg dw	2100	--
Particle Size Distribution			
Particle/Grain Size, >2.0 mm	%	0	--
Particle/Grain Size, 850um-2 mm	%	0	--
Particle/Grain Size, 250-850 um	%	26.6	--
Particle/Grain Size, 75-250 um	%	60.5	--
Particle/Grain Size, 29.5-63 um	%	8.5	--
Particle/Grain Size, <29.53 um	%	4.4	--

Notes:

-- Parameter not analyzed

U – Analyte not detected above reported result

J – Estimated value

UJ – Analyte not detected above reported result; reported reporting limit may be inaccurate

TPH-Diesel (NWTPH-Dx) values are calculated as the sum of the Diesel and Lube Oil concentrations

SR9-01 Sediment	UNITS	Collection Date 7/12/2012	
PARAMETER			
Conventionals			
Total Organic Carbon	%	1.78	--
Percent Solids	%	99	--
Metals			
Total Recoverable Copper	mg/Kg dw	807	J
Total Recoverable Lead	mg/Kg dw	26.6	J
Total Recoverable Cadmium	mg/Kg dw	5.26	--
Total Recoverable Zinc	mg/Kg dw	164	--
PAH Compounds			
Acenaphthene	ug/Kg dw	--	
Acenaphthylene	ug/Kg dw	--	
Anthracene	ug/Kg dw	--	
Benzyl Alcohol	ug/Kg dw	--	
Benzoic Acid	ug/Kg dw	--	
Benzo(a)anthracene	ug/Kg dw	--	
Benzo(b)fluoranthene	ug/Kg dw	--	
Benzo(k)fluoranthene	ug/Kg dw	--	
Benzo(ghi)perylene	ug/Kg dw	--	
Benzo(a)pyrene	ug/Kg dw	--	
Chrysene	ug/Kg dw	--	
Dibenzo(a,h)anthracene	ug/Kg dw	--	
Fluoranthene	ug/Kg dw	--	
Fluorene	ug/Kg dw	--	
Indeno(1,2,3-cd)pyrene	ug/Kg dw	--	
Naphthalene	ug/Kg dw	--	
Phenanthrene	ug/Kg dw	--	
Pyrene	ug/Kg dw	--	
Phthalates			
bis(2-Ethylhexyl)phthalate	ug/Kg dw	--	
Butyl benzyl phthalate	ug/Kg dw	--	
Di-n-butyl phthalate	ug/Kg dw	--	
Diethyl phthalate	ug/Kg dw	--	
Dimethyl phthalate	ug/Kg dw	--	
Di-n-octyl phthalate	ug/Kg dw	--	
Phenols			
2,4-Dimethylphenol	ug/Kg dw	--	
Phenol	ug/Kg dw	--	
Pentachlorophenol	ug/Kg dw	--	
2-Methylphenol	ug/Kg dw	--	
TPH			
TPH-Diesel (NWTPH-Dx)	mg/Kg dw	--	
Diesel	mg/Kg dw	--	
Lube Oil	mg/Kg dw	--	

SR9-01 Sediment (continued)

SR9-01 Sediment	UNITS	Collection Date 7/12/2012	
PARAMETER			
Particle Size Distribution			
Particle/Grain Size, >2.0 mm	%	0	--
Particle/Grain Size, 850um-2 mm	%	0.1	--
Particle/Grain Size, 250-850 um	%	42	--
Particle/Grain Size, 75-250 um	%	48.4	--
Particle/Grain Size, 29.5-63 um	%	3.2	--
Particle/Grain Size, <29.53 um	%	6.3	--

Notes:

-- Parameter not analyzed

U – Analyte not detected above reported result

J – Estimated value

UJ – Analyte not detected above reported result; reported reporting limit may be inaccurate

TPH-Diesel (NWTPH-Dx) values are calculated as the sum of the Diesel and Lube Oil concentrations

Appendix F: Highway Toxicity Data

Water Year 2012 Toxicity sampling results.

Sample Date	Sample Description	Test Group (% Rainwater or Stormwater)	Control Water	Average Survival for All Replicates	EC_{50}
9/10/12 3:04	Pilchuck-Compost Blanket VFS – Edge of Pavement Stormwater	0	Dilution Water	100%	**≥100%**
		0	Hardness Control [1]	98%	
		6.25		100%	
		12.5		100%	
		25		100%	
		50		100%	
		100		98%	
10/13/12 11:54	SR-09-VFS – 4 meters from Edge of Pavement Stormwater	0	Dilution Water	100%	**≥100%**
		0	Hardness Control [1]	100%	
		6.25		100%	
		12.5		98%	
		25		100%	
		50		98%	
		100		100%	
9/10/12 3:40	Pilchuck Rainwater Reference [2] pH adjusted [3]	0	Dilution Water	100%	**≥100%**
		100		98%	
9/10/12 3:40	Pilchuck Rainwater Reference [2]	0	Dilution Water	100%	**≥100%**
		100		98%	
9/10/12 1:30	Everett Rainwater Reference [2] pH adjusted [3]	0	Dilution Water	100%	**≥100%**
		100		100%	
9/10/12 1:30	Everett Rainwater Reference [2]	0	2nd Control	98%	**≥100%**
		100		100%	

[1] Hardness of the control was adjusted to match the stormwater samples hardness.

[2] Rainwater reference samples were collected to determine if rainwater alone caused toxicity to *Hyalella azteca*. Rainwater was collected in precleaned stainless steel bowls elevated at least 30cm from the ground and away from sources that may contribute inputs other than rain such as road spray.

[3] pH was adjusted to neutral around 7.0.

SR9-01		**Storm Event**	
PARAMETER	**UNITS**	**10/12/2012**	
TPH			
TPH-Diesel (NWTPH-Dx)	mg/L	12.05	
Diesel	mg/L	0.05	U
Lube Oil	mg/L	12	--
TPH-Gas (NWTPH-Gx)	mg/L	0.07	U

SR9-02		Storm Event	
PARAMETER	**UNITS**	**10/12/2012**	
Conventionals			
Chloride	mg/L	14.6	--
Hardness as $CaCO_3$	ug/L	36.5	--
Bacteria			
Fecal coliform	cfu/100ml	900	--
Metals			
Total Recoverable Copper	ug/L	22.1	--
Total Recoverable Lead	ug/L	2.82	--
Total Recoverable Cadmium	ug/L	0.1	--
Total Recoverable Zinc	ug/L	112	--
Herbicides			
Dichlobenil	ug/L	0.093	--
Diuron	ug/L	0.049	U
2,4-D	ug/L	0.062	U
Clopyralid	ug/L	0.062	U
Picloram	ug/L	0.062	U
Triclopyr	ug/L	1.1	--
Glyphosate	ug/L	50	U
TPH			
TPH-Diesel (NWTPH-Dx)	ug/L	0.9	
Diesel	ug/L	0.05	U
Lube Oil	ug/L	0.85	--

Pilchuck-01		Storm Event	
PARAMETER	**UNITS**	**10/12/2012**	
Bacteria			
Fecal Coliform	Cfu/100ml	80	--
TPH			
TPH-Diesel (NWTPH-Dx)	mg/L	1.45	
Diesel	mg/L	0.05	U
Lube Oil	mg/L	1.4	--
TPH-Gas (NWTPH-Gx)	mg/L	0.07	U

Pilchuck-03		Storm Event	
PARAMETER	**UNITS**	**10/12/2012**	
TPH			
TPH-Diesel (NWTPH-Dx)	mg/L	0.6	
Diesel	mg/L	0.05	U
Lube Oil	mg/L	0.55	--
TPH-Gas (NWTPH-Gx)	mg/L	0.07	U

Pilchuck-06		Storm Event			
PARAMETER	**UNITS**	**9/10/2012**		**10/12/2012**	
Bacteria					
Fecal coliform	cfu/100ml	--		2700	
Conventionals					
Chloride	mg/L	8.52	--	--	
Metals					
Total Recoverable Copper	ug/L	35.7	--	--	
Dissolved Copper	ug/L	18	--	--	
Total Recoverable Lead	ug/L	10.6	--	--	
Dissolved Lead	ug/L	0.429	--	--	
Total Recoverable Cadmium	ug/L	0.36	--	--	
Dissolved Cadmium	ug/L	0.09	--	--	
Total Recoverable Zinc	ug/L	129	--	--	
Dissolved Zinc	ug/L	23.3	J	--	
TPH					
TPH-Diesel (NWTPH-Dx)	mg/L	--	--	3.85	
Diesel	mg/L	--	--	0.05	U
Lube Oil	mg/L	--	--	3.8	--
TPH-Gas (NWTPH-Gx)	mg/L	--	--	0.07	U

Pilchuck-08		Storm Event	
PARAMETER	**UNITS**	**10/12/2012**	
TPH			
TPH-Diesel (NWTPH-Dx)	mg/L	0.68	
Diesel	mg/L	0.05	U
Lube Oil	mg/L	0.63	--
TPH-Gas (NWTPH-Gx)	mg/L	0.07	U

Everett-01		Storm Event	
PARAMETER	**UNITS**	**10/12/2012**	
Bacteria			
Fecal coliform	cfu/100ml	9300	--
TPH			
TPH-Diesel (NWTPH-Dx)	mg/L	2.1	
Diesel	mg/L	0.1	U
Lube Oil	mg/L	2	--
TPH-Gas (NWTPH-Gx)	mg/L	0.07	U

Everett-03		Storm Event	
PARAMETER	**UNITS**	**10/12/2012**	
TPH			
TPH-Diesel (NWTPH-Dx)	mg/L	0.43	
Diesel	mg/L	0.05	U
Lube Oil	mg/L	0.38	--
TPH-Gas (NWTPH-Gx)	mg/L	0.07	U

Everett-04		Storm Event	
PARAMETER	**UNITS**	**10/12/2012**	
Bacteria			
Fecal coliform	cfu/100ml	40000	--
TPH			
TPH-Diesel (NWTPH-Dx)	mg/L	2.15	
Diesel	mg/L	0.05	U
Lube Oil	mg/L	2.1	--
TPH-Gas (NWTPH-Gx)	mg/L	0.07	U

Everett-06		Storm Event	
PARAMETER	**UNITS**	**10/12/2012**	
TPH			
TPH-Diesel (NWTPH-Dx)	mg/L	1	
Diesel	mg/L	0.05	U
Lube Oil	mg/L	0.95	--
TPH-Gas (NWTPH-Gx)	mg/L	0.07	U

Notes:

-- Parameter not analyzed

U – Analyte not detected above reported result

J – Estimated value

UJ – Analyte not detected above reported result; reported reporting limit may be inaccurate

TPH-Diesel (NWTPH-Dx) values are calculated as the sum of the Diesel and Lube Oil concentrations