Quality Assurance Project Plan for Baseline Monitoring of WSDOT Highway Runoff

September 2011

Prepared by

Environmental Assessment Program,

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for

Environmental Services Office,

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WSDOT = Washington State Department of Transportation

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1 Abstract

The Washington State Department of Ecology's (Ecology) Environmental Assessment Program (EAP) was contracted by the Washington State Department of Transportation's (WSDOT) Stormwater and Watersheds Program to prepare a Quality Assurance Project Plan (QAPP) for stormwater monitoring under the 2009 WSDOT National Pollutant Discharge and Elimination System (NPDES) and State Waste Discharge Permit for Municipal Stormwater (hereinafter "permit") (Ecology, 2009a).

A QAPP describes the objectives of the study and the procedures to be followed to ensure the quality and integrity of collected data and ensure the results are representative, accurate, and complete.

This QAPP is specifically written for monitoring activities required under S7.B and S7.C of the permit, which require WSDOT to conduct seasonal first flush toxicity testing and monitoring of stormwater runoff from WSDOT-managed highways. The QAPP has been created to guide WSDOT in development and implementation of a monitoring program that will meet the requirements of this permit.

2 Background

WSDOT is responsible for more than 7,000 miles of highway across the state. The stormwater generated by these impervious surfaces is regulated by the U.S. Environmental Protection Agency's (EPA) National Pollutant Discharge and Elimination System (NPDES) program. EPA has delegated the NPDES permit development and issuance authority to Ecology, which oversees implementation at the state level.

Three QAPPs were prepared by Ecology's Environmental Assessment Program (EAP) for WSDOT to meet the permit's monitoring requirements. This QAPP describes a plan to conduct stormwater monitoring of Washington State highways maintained by WSDOT to meet the 2009 NPDES State Waste Discharge Permit for Municipal Stormwater requirements (Ecology, 2009a). Other QAPPs describe stormwater monitoring from WSDOT facilities and effectiveness monitoring for WSDOT stormwater best management practices (BMPs).

Stormwater monitoring conducted under the NPDES permit will provide information for WSDOT to include in its *Highway Runoff Manual* (HRM) (WSDOT, 2010). This QAPP is designed to ensure the quality and integrity of the collected samples and to describe monitoring stations, field sampling procedures, and the quality assurance and quality control (QA/QC) procedures used to ensure the results are representative, accurate, and complete. Additional information is provided in the appendices:

- Appendix A provides a glossary of terms and acronyms used in this QAPP.
- Appendix B provides a copy of the NPDES stormwater permit S7. A–E.
- Appendix C provides a copy of the toxicity guidance from Appendix 6 of the permit.

2-1 WSDOT NPDES Permit History

Stormwater discharges are regulated through the NPDES program, which was established by the federal government in Section 402 of the Clean Water Act (CWA). In the state of Washington, EPA has delegated authority to Ecology to implement all provisions of the CWA, including the NPDES program. Municipal stormwater permits are one component of the NPDES program. Phase I of the NPDES stormwater permitting program was promulgated in 1990 and applies to all municipalities with populations greater than 100,000. Phase I permittees in Washington are required to conduct monitoring under their NPDES permits. In 1999, federal Phase II stormwater requirements were published, which expanded coverage of NPDES permits to smaller urbanized areas.

In 1995 Ecology issued an NPDES municipal separate stormwater permit, which requires WSDOT to prepare and implement a stormwater program to treat highway runoff before it is released into receiving water bodies. The following water quality management areas in Washington State were designated as Phase I areas and covered by the 1995 permit: Cedar/Green, Island/Snohomish, and South Puget Sound. In those permits, WSDOT was identified as a co-permittee with other Phase I jurisdictions (King, Pierce, and Snohomish Counties and the cities of Seattle and Tacoma). In 1999 Ecology issued a Phase I stormwater permit covering Clark County. Those permits were originally scheduled to expire on July 5, 2000. However, Ecology granted the permittees, including WSDOT, an administrative extension until the permits were updated and reissued.

In January 2007 Ecology reissued the Phase I municipal stormwater permit, with the Port of Seattle and Port of Tacoma identified as Phase I secondary permittees. Concurrently, Ecology issued the Phase II municipal stormwater permits, which apply to more than 100 cities statewide and parts of 13 counties, covering areas that generally have a population density of more than 1,000 people per square mile.

WSDOT's permit coverage continued under the original 1995 permit, until it was issued its own municipal stormwater permit (number WAR043000A) on February 4, 2009. WSDOT's current permit covers discharges from municipal separate storm sewer systems (MS4s) owned or operated by the department. MS4s are conveyances or a system of conveyances, including roads with drainage systems, municipal streets, curbs, gutters catch basins, ditches, constructed channels, and storm drains. Discharges covered in the WSDOT permit include stormwater runoff from state highways, rest areas, park and ride lots, ferry terminals, and maintenance facilities. The geographic area of coverage includes Phase I and Phase II permitted areas, as shown in Figure 1.

The WSDOT permit was most recently modified on May 5, 2010, in response to a settlement agreement with Puget Soundkeeper Alliance, an environmental advocacy organization. WSDOT's permit is effective through March 6, 2014.

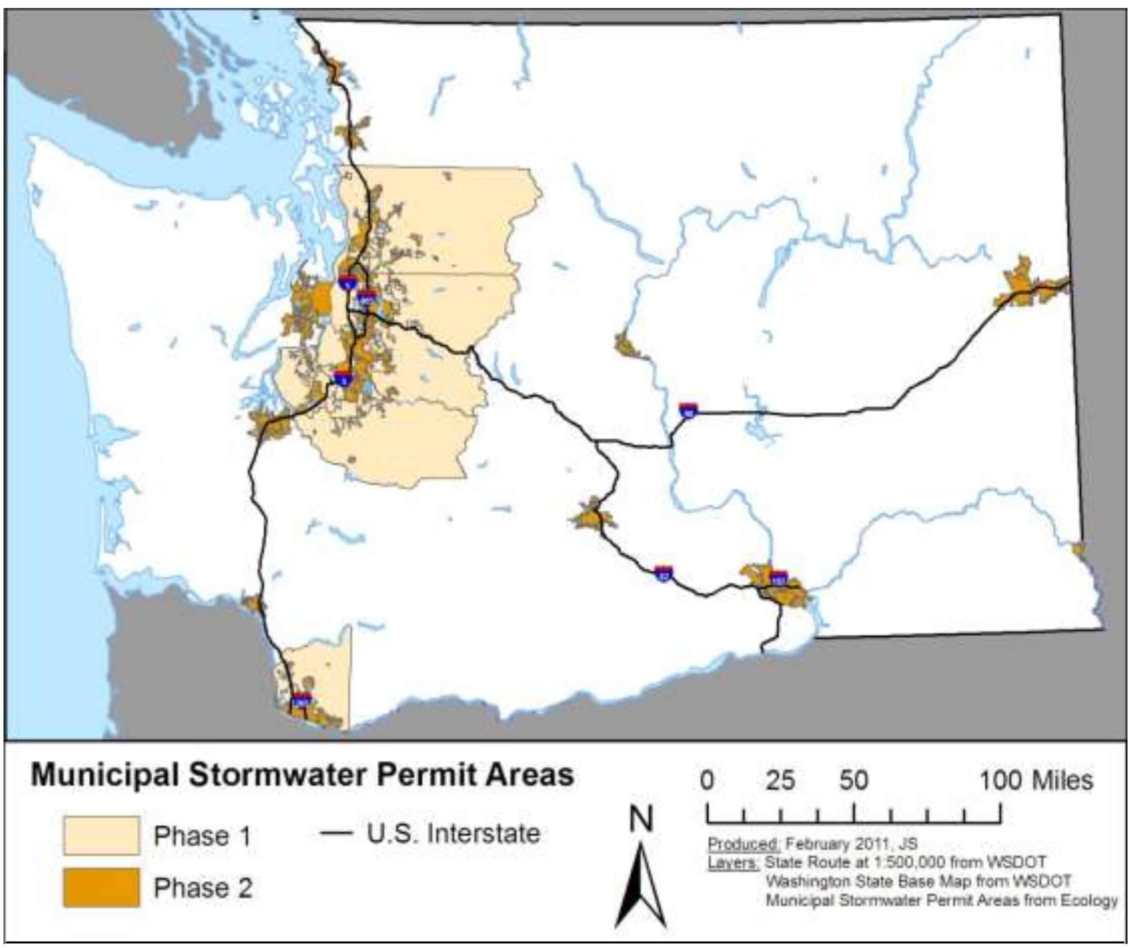


Figure 1 WSDOT municipal stormwater permit area.

2-1.1 Permit Monitoring Requirements

S7 of the permit (see Appendix B) requires WSDOT to develop and implement a stormwater monitoring program. The permit identifies three WSDOT land uses, each with specific monitoring requirements:

- Highways: Baseline stormwater and sediment characterization monitoring (S7.B) and seasonal first flush toxicity testing (S7.C).
- Rest areas, maintenance facilities, and ferry terminals: Baseline stormwater characterization (S7.D).
- Best management practices (BMPs): Stormwater treatment and hydrologic management evaluation monitoring (S7.E) and seasonal first flush toxicity testing (S7.C).

A separate QAPP was submitted to Ecology's Water Quality Program for each land use to meet the S7 monitoring requirements in the permit. Each QAPP addresses the specific monitoring requirements for the land use designated in the permit. This QAPP addresses the requirements in S7.B and S7.C of the permit related to highways. It also describes how monitoring will be conducted to gather water quality and quantity stormwater data from highways. Highway sampling will include collecting year-round stormwater samples with hand grabs and composite autosamplers and annual sampling for seasonal first flush toxicity and accumulated highway sediment.

This QAPP describes the process to:

- Target storm events
- Monitor rainfall and runoff
- Collect samples
- Analyze results to ensure quality data
- Locate sampling points
- Set up monitoring stations
- Verify and summarize data

This sampling program is designed to monitor real time continuous rainfall, temperature, and stormwater hydrology at each of the sites year round.

2-2 Previous Highway Monitoring Studies

Washington Studies

Highway runoff in western Washington has been studied for decades, with the majority of data collected since 1995. WSDOT (2007) compiled data from 11 studies and 35 different monitoring locations. Their study separates sources of pollutants into three general categories, which are shown in Table 1.

Table 1 General source categories of highway pollutants (WSDOT, 2007).

Source Category	Potential Sources	Pollutants
Atmospheric deposition	Industrial sources, incomplete combustion of fossil fuel, and historic use of PCBs in deposition materials	Particulates, nitrogen, phosphorus, metals, PAHs, and PCBs
Vehicles	Engine wear, exhaust, brake pad wear, rust, tire wear, and lubricants	Particulates, rubber, asbestos, metals, sulfates, bromide, petroleum, and PAHs
Direct and indirect deposition and application	Maintenance (such as mowing and application of fertilizers, herbicides, and pesticides), roadway maintenance (such as deicing and road repair), animal waste, and atmospheric deposition from local uses (such as agriculture and industry/urban applications)	Particulates, nitrogen, phosphorus, metals, sodium, chloride, sulfates, petroleum, pesticides, and pathogens

PAHs = polycyclic aromatic hydrocarbons

PCBs = polychlorinated biphenyls

California Studies

The California Department of Transportation (Caltrans) has monitored highway runoff since 1997 for NPDES compliance. The Discharge Characterization Study Report (Caltrans, 2003) identified several important factors that influence pollutant levels. Annual average daily traffic (AADT) was determined to be the most important factor affecting the level of pollutants in highway runoff in California (Caltrans, 2003). Additional contributing factors included facility type, characteristics of geographic region, antecedent dry periods, storm event duration, total event rainfall, and seasonal cumulative precipitation (Barber et al., 2006; Caltrans, 2003). Pollutant build-up and wash-off were determined to be important in seasonal and event first flush effects (Caltrans, 2003). A summary of the Caltrans highway runoff data collected from 1998-2002 is shown in Table 2.

Table 2 Summary of Caltrans monitoring data for highway runoff 1998–2002 (Caltrans, 2003).

Parameter	Units	Total			Dissolved		
		n	Mean	SD	n	Mean	SD
pH		1372	7.13	0.69			
TSS	(mg/L)	1483	142.3	288.2			
Hardness	(mg/L)	1479	45.0	64.8			
Nitrate as N	(mg/L)	1469	1.02	1.75			
TKN	(mg/L)	1466	2.23	2.31			
Phosphorus, total	(mg/L)	1415	0.45	1.34			
As	(ug/L)	1201	2.64	6.77	1179	1.1	1.58
Cd	(ug/L)	1425	0.8	1.26	1432	0.24	0.45
Cu	(ug/L)	1482	43.74	335.88	1489	15.02	15.72
Pb	(ug/L)	1482	58.5	160.2	1489	5.81	26.12
Zn	(ug/L)	1482	198.8	209.8	1489	71.3	108.5

n = number of samples

SD = standard deviation

In a report to the California Transportation Research Board, Kayhanian (2002) compared the statewide stormwater study results to older data collected from 1997–2000 from southern California. Mean concentrations of pollutants in stormwater tended to be lower for the statewide study. The differences are believed to be primarily due to the effect from surrounding land uses. Southern California is highly developed, with more industrial activities, higher traffic, more impervious surfaces, and less open area adjacent to roadways. Comparisons from the two studies are shown in Table 3 (Kayhanian et al., 2002). In a later report, Kayhanian concluded that antecedent dry periods, drainage area, maximum rain intensity, and land use other than transportation-related activities were found to contribute to higher pollution rates in nonurban highway runoff (Kayhanian et al., 2003).

Table 3 Summary of Caltrans statewide highway stormwater runoff characteristics compared to historical data (Kayhanian et al., 2002).

Parameter	Reporting Limit±	California Statewide Monitoring (2000–2001)				Southern California Monitoring (1997–2000)			
		Min	Max	Mean	Median	Min	Max	Mean	Median
pH	0.1	5.1	10.1	7.2	7.2	6.2	9.6	7.5	7.4
TSS (mg/L)	1.0	2.0	1373	94.4	55	3	29000	276.4	77
Hardness (mg/L)	1.0	3.0	400	36.8	26	5	1000	62.8	45.3
Nitrate as N (mg/L)	0.1	0.1	48	1.2	NA	0.03	9.5	1.2	0.8
TKN (mg/L)	0.01	0.1	14.5	1.8	1.4	0.08	57	3.0	1.7
Phos., total (mg/L)	0.03	0.03	4.7	0.3	NA	0.01	37.5	0.8	0.2
As, total (ug/L)	1.0	0.5	8.6	1.4	NA	0.2	2300	26.6	0.6
As, dissolved (ug/L)	1.0	0.6	4.8	0.9	0.8	0.4	10	1.8	1.2
Cd, total (ug/L)	0.2	0.2	5.0	0.7	NA	0.1	24	1.3	0.8
Cd, dissolved (ug/L)	0.2	0.2	4.7	0.4	0.4	0.02	6.1	0.2	0.2
Cu, total (ug/L)	1.0	1.2	230	22.3	16.8	0.2	9500	63.8	26.6
Cu, dissolved (ug/L)	1.0	1.1	121	11.4	8.5	1.1	88	13.2	9.9
Pb, total (ug/L)	1.0	1.0	327	21.9	6.1	0.1	2300	107.6	33.7
Pb, dissolved (ug/L)	1.00	1.1	121	11.4	8.5	1.1	88	13.2	9.9
Zn, total (ug/L)	5.0	7.5	1245	129.8	81	2.5	4800	258.9	142.6
Zn, dissolved (ug/L)	5.0	3.0	1017	59.4	28.0	5.1	870	63.8	42

While monitoring of highway contributions to stormwater pollution has been studied for decades, there is more that can be learned. It is very difficult to summarize and make conclusions based on stormwater monitoring data because each storm event is unique and produces a distinctive mixture of pollutants in runoff. This complexity is reflected in the large standard deviations in Table 2 and the large ranges in Table 3. Data produced as a result of permit compliance will help to further our understanding of the complexities of highway runoff in the state of Washington.

3 Project Description

3-1 Project Goals

The goal of this QAPP is to describe a monitoring program intended to collect high-quality data that characterizes baseline stormwater runoff quality and quantity from WSDOT highways in accordance with the requirements in S7.B and the toxicity guidance in S7.C and Appendix 6 of the permit (Appendix 6 is attached as Appendix C). Four of the five highway characterization sites will also be used to meet the best management practice (BMP) requirements in the permit. Therefore, additional requirements are specified for those four sites.

Specifically, this QAPP addresses hydrological monitoring at the edge of pavement (EOP), sediment monitoring, and the seasonal first flush toxicity testing from untreated highway runoff. This information, along with other data, will be used to address the following permit goals:

1. Produce scientifically credible data that represent discharges from WSDOT's various land uses.
2. Provide information that can be used by WSDOT for designing and implementing effective stormwater management strategies for Washington's highways.
3. Provide data that can be used to inform WSDOT's *Highway Runoff Manual* (HRM) (WSDOT, 2010).

EOP highway monitoring will improve the understanding of how untreated highway runoff influences the surrounding environment and help identify highway pollutant contributions to stormwater. This information will be incorporated into future versions of WSDOT's HRM for retrofit and new construction projects, as well as WSDOT's stormwater management program to improve stormwater, water quality.

3-2 S7.B and S7.C Monitoring Requirements

The permit guides WSDOT to select monitoring locations according to AADT requirements and urbanization levels. A requirement of S7.B of the permit is a baseline monitoring program to collect discharge quality and quantity data from EOP at highway monitoring locations, analyze samples for pollutants, and prioritize parameters of concern. In addition, S7.C directs WSDOT to monitor three sites annually for the seasonal first flush toxicity, to test (for screening purposes only) the chemistry and toxicity of the stormwater runoff on the biological endpoint *Hyalella azteca,* a small aquatic crustacean. Permit-required monitoring is summarized in Table 4.

Table 4 Permit requirements for stormwater sampling data (Ecology, 2009a).

Type	Description
Number of Sites	S7.B.3 of the permit requires WSDOT to monitor at least five highway EOP characterization sites: four in western Washington and one in eastern Washington. This requirement will be met with monitoring at sites on Interstate 5 (I-5), Interstate 90 (I-90), and State Route 9 (SR 9), as described in this QAPP.
Location	S7.B.3. requires sites to be located at the following AADTs: a. Two highly urbanized western Washington sites (≥100,000 AADT) b. One urbanized western Washington site (≤100,000 and ≥30,000 AADT) c. One urbanized eastern Washington site (≤100,000 and ≥30,000 AADT) d. One rural western Washington site (≤30,000 AADT) These requirements will be met with monitoring at sites on I-5, I-90, and SR 9. Seasonal first flush toxicity testing is required from the western Washington highly urbanized, urbanized, and rural locations used for highway monitoring (three sites total).
Sampling Method	S7.B.5 and S7.B.6 require automatic composite samplers to collect a flow-weighted composite sample. Flow weighting will be based on equal subsample volumes collected at various time increments, proportional to flow rates. Samples will be collected from at least 75% of the storm event hydrograph and will consist of a minimum of ten aliquots. For non-BMP highway characterization sites, only 75% of the first 24 hours of the storm will be sampled. Annual seasonal first flush toxicity samples will be collected either by flow-weighted or time-weighted programmed automatic composite samplers, per S7.C.5. S7.B.7 requires an annual sediment sample from each highway site. Sediment should be collected from an in-line trap.
Sample Timing and Frequency	S7.B.2 states that continuous flow recordings of all storm events are necessary for at least one year to establish a baseline rainfall/runoff relationship. Rain gages and continuously monitored weirs or flumes will be used to gather this data. S7.B.6 states that WSDOT will conduct sampling as early in the runoff event as practical. At least 11 samples per year will be collected from qualified storms, representing 67% of the total storms and up to a maximum of 14 events for each water year. Three nonqualifying events may be substituted if needed as part of the 14 events, as long as no fewer than 11 collected storm events meet criteria. WSDOT will ensure the storm samples are distributed throughout the year and reflect the approximate distribution of rainfall between the wet and dry seasons. Additionally, S7.C.1 specifies that WSDOT will collect a sample that represents the seasonal first flush event no earlier than August 1. The seasonal first flush sample must have a one-week antecedent dry period. S7.C.3 states toxicity from the seasonal first flush will be tested once annually at 3 untreated highway runoff monitoring locations.
Storm Event Criteria (Wet Season)	S7.B.6.b.i states that the storm event criteria for the *wet season* in western Washington (October 1 through April 30) and in eastern Washington (October 1 through June 30) will meet the following conditions: 1) Rainfall depth: 0.20-inch minimum, no fixed maximum 2) Rainfall duration: no fixed minimum or maximum 3) Antecedent dry period: less than 0.02-inch rain or no surface runoff in the previous 24 hours 4) Inter-event dry period: 6 hours
Storm Event Criteria (Dry Season)	S7.B.6.b.ii states that the storm event criteria for the *dry season* in western Washington (May 1 through September 30) and in eastern Washington (July 1 through September 30) will meet the following conditions: 1) Rainfall depth: 0.20-inch minimum, no fixed maximum 2) Rainfall duration: no fixed minimum or maximum 3) Antecedent dry period: less than 0.02-inch rain in previous 72 hours 4) Inter-event dry period: 6 hours
Parameters	Parameters required for sampling by the permit for baseline monitoring of highways, annual first flush toxicity, and baseline sediment testing are listed in Table 15.

3-3 Data Collection

The permit monitoring implementation will begin on Sept 6, 2011; however, the 2013 Annual Monitoring Report is only required to cover monitored events that occur after October 1, 2011. During the three-week interim period, the following will apply:

1. Sampling for dry season storms from September 6 to September 30 will not be conducted because the entire dry season will not be captured.
2. Because only one seasonal first flush toxicity storm event is required after August 1, this sample will still be attempted and reported regardless of whether the sampling occurs before or after October 1, 2011.
3. Missed storms will be documented.

To characterize site hydrology, data collection at some locations will begin before September. Monitoring will continue through the three-year permit cycle. Information to meet the permit objectives includes:

- Identification of highway pollutant-generating activity areas and drainage area maps of the selected characterization locations.
- Continuous annual records of rainfall data and site runoff flow data, not just sampled events, for at least one year.
- Concentrations of constituents of concern in samples collected.

To accomplish monitoring at all field sites as early in the runoff event as feasible, a data collection platform (DCP) consisting of composite autosamplers, a data logger, and associated equipment will be installed at each highway runoff site.

Rainfall data will be collected continuously to characterize the antecedent dry period, total rainfall distribution during the sampled events, inter-event dry period, and rainfall intensity during the sampled storm events.

Data loggers at each site will record measurement data from the autosampler and all other associated monitoring equipment, such as the rain gage, stage measuring device, and temperature meter. Data from the logger will be manually downloaded as well as telemetered to WSDOT. Telemetered data will be restricted to the information most valuable to help with timing deployment of the sampling teams. More sampling and data collection information is presented in Section 7, Sampling Process Design.

3-3.1 Target Population and Sampling Frequency

For the stormwater monitoring effort under this permit, target stormwater populations are characterized by the following:

- Wet and dry season storm criteria
- Continuous rainfall and flow monitoring throughout all sampled storm events
- Composite sampling for chemical and biological analyses
- Grab sampling for chemical and biological analyses
- Seasonal first flush toxicity monitoring (at three sites)

Automatic flow-weighted composite and manual grab sampling methods will be used to collect stormwater samples from no less than 67 percent of the forecasted qualifying storms: 11 up to a maximum of 14 qualifying storm events each year, in accordance with S7.B.6 of the permit.

Automatic samplers will be programmed to begin composite sampling as early in the runoff as feasible, and to composite flow-weighted samples representative of 75 percent of the storm event. Each sample must have at least 10 collected aliquots. If it is not possible to collect a manual grab sample (for TPH/fecal coliform) during the same storm event as a composite sample, a grab sample will be collected from a separate qualifying event.

Highway sediment will be collected at or in the vicinity of the highway stormwater characterization monitoring site. The target population for sediment is the accumulated sediment from an "in-line sediment trap," in accordance with S7.B.7 of the permit. Sediment will be collected annually from EOP interceptors.

3-3.2 Qualifying Sample Criteria

The permit defines "representative" storms that must be monitored for stormwater characterization. Storm event criteria were determined using the criteria listed in the permit and the "Guidance for Evaluating Emerging Stormwater Treatment Technologies, Technology Assessment Protocol – Ecology" (TAPE) (Ecology, 2008a) for highway sites co-located with BMP sites. The permit specifies a rainfall depth of 0.20-inch minimum; however, TAPE specifies a rainfall depth of 0.15-inch minimum. Where the permit and TAPE conflict, the more conservative value will be used. In this case, WSDOT will initiate sampling when a rainfall depth of 0.15-inch is attained as long as other criteria are met. Table 5 lists the qualifying criteria to ensure the storm event sampled is representative.

Storm event criteria are established to: ensure adequate flow will be discharged for monitoring, allow some build-up of pollutants during the dry weather intervals, and ensure the storm will be "representative" (that is, typical for the area in terms of intensity, depth, and duration). Ensuring a representative sample requires two considerations: the storm event must be representative, and the sample collected must represent the storm event.

Table 5 Qualifying sampler collection criteria (Ecology, 2008a and 2009a).

Storm Event Duration	<24 hours	>24 hours	Source of Requirement
Minimum storm volume to sample	75% of the storm event hydrograph	75% of the hydrograph of the first 24 hours of the storm	Permit
No. of aliquots	At least 10 flow-weighted subsamples (or aliquots) must be collected during 75% of the storm runoff volume, during the event. If fewer than 10 but 7 or more aliquots are collected, then the sample will be considered valid only if all other sampling criteria have been met		TAPE and the permit
Maximum time period for sample collection (hours)	Whole storm	24 hours or whole storm[1]	Permit states sampling will occur past the longest time of concentration for the site (see Table 12 for times of concentration for the highway runoff sites)

[1] If the storm is monitored for BMP effectiveness, then the whole storm event, as defined by criteria above, will be sampled. Only highway runoff monitoring may end at 24 hours if the minimum storm volume is met.

3-4 Practical Constraints for Highway Monitoring

Practical constraints for a successful permit monitoring program include:

- Study boundaries.
- Geographic limitations and climatic challenges.
- Study design requirements.
- Physical challenges of the study design.
- Logistical challenges regarding weather forecasting, verification of storm quality, and synchronization of sampling.

WSDOT will put forth good faith efforts to collect and meet this permit requirement. The phrase “good faith efforts” was used in the permits for the other Phase I permittees and is believed to apply to WSDOT as well, although it may have been inadvertently deleted. The following text is from the Phase I Municipal Stormwater NPDES and State Waste Discharge General Permit S8.D.2.a, page 45 (Ecology, 2010a):

> *Each stormwater monitoring site shall be sampled according to the following frequency unless good faith efforts with good professional practice by the Permittee do not result in collecting a successful sample for the full number of storms.*

3-4.1 Study Boundaries

The study area for each monitoring site includes the physical location of the section of highway to be monitored and the area that drains to the EOP interceptor. An EOP interceptor is a type of collector that intercepts stormwater and consolidates it to enable sample collection. Monitoring sites were selected for safety of sampling, representative drainage areas, and required AADT levels.

3-4.2 Geographic Limitations and Climatic Challenges

During the winter, western Washington storms are typically long in duration (multiple days) and frequent. In eastern Washington, storms are shorter in duration, less frequent, and conditions are drier. Therefore, a reduced number of qualifying storm events is expected in eastern Washington.

Additionally, precipitation east of the Cascades is more likely to be snow. The combination of fewer storms and more snow at eastern Washington monitoring sites may influence the number of successful sampling events. In other words, the requirement to sample 67 percent of forecasted qualifying storms may not equal the 11–14 storms required at all WSDOT sites; it may result in a lower number of storms. Another challenge is the ambiguity of forecasting rain, particularly in western Washington.

The third study design limitation is the large stormwater volumes required to analyze for seasonal first flush toxicity samples. Adequate stormwater volumes may or may not be available for the first two qualifying storms of the fall season.

3-4.3 Study Design Requirements

Site-selection requirements for AADT were a major factor that influenced finding suitable sites. In particular, there were very few highway sections that satisfied the "rural" AADT requirement in S7.B.3 and S7.C.3 of the permit and were also suitable for monitoring.

In all, more than 12 highway locations were considered for monitoring. Many sections of highway were ruled out because they were located in areas that would pose complications for monitoring (such as lack of a safe area for sample collection, poor access to the sampling area, or they did not meet permit criteria for AADT).

Monitoring the seasonal first flush for toxicity once each year is a requirement at three of the WSDOT highway characterization sites. This requirement presents some logistical challenges—specifically, when sampling for grab samples of total petroleum hydrocarbons (TPH) and fecal coliform bacteria.

3-4.4 Physical Challenges of the Study Designs

Baseline monitoring of stormwater from a section of highway presents some physical design limitations. The areas contributing to the EOP interceptors are relatively small (roughly two or three lanes of highway); therefore, sampling enough stormwater from the collectors may prove to be difficult. In addition to the "flashy" nature of stormwater runoff from small catchment areas, low runoff volumes will be an ongoing concern and may pose potential problems for sample collection.

To overcome the physical and climatic challenges discussed, technology will be relied on to minimize unsuccessful sampling trips. Automatic samplers, rain gages, temperature probes, and telemetry equipment will be installed at each site. Rainfall data will be collected continuously to characterize the antecedent dry period, total rainfall distribution during the sampled events, inter-event dry period, and rainfall intensity during the sampled storm events. Since the runoff from a small paved area can be expected to be flashy in nature, the autosamplers will be set to sample as early as the first runoff.

3-4.5 Logistical Challenges

Some of the logistical challenges associated with this project include: monitoring small, flashy drainage areas; the complexity and variability of stormwater discharge; requirements to sample within the first hour of runoff; the large geographic scale of the monitoring site locations; and holding times.

Logistical complications are anticipated to reduce sampling success. An example is the large amount of driving necessary to reach the monitoring site, even if the field sampling teams stay in hotels near the sites. These travel times may limit successful grab sample collection.

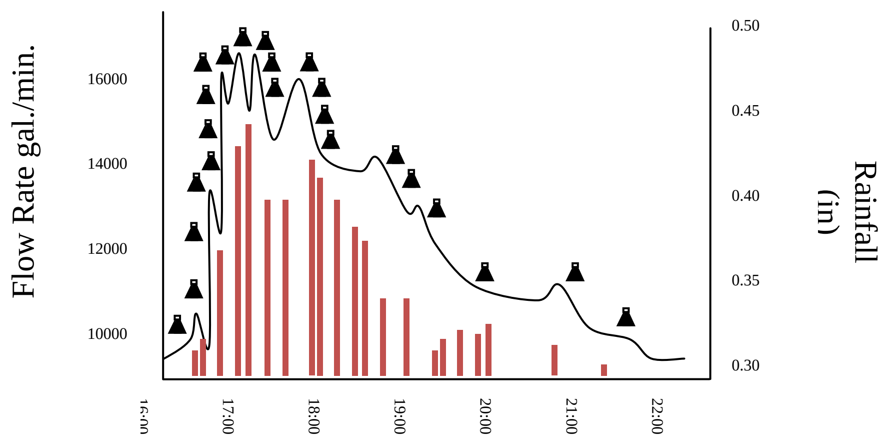
Geographic and Climatic Logistical Challenges

The four western Washington highway monitoring sites are located more than 90 miles from where the WSDOT sampling team will be based in Tumwater. The fifth highway monitoring site is located in Spokane. Samples could be missed due to the amount of driving necessary to reach the sites, even if the field sampling teams stay in hotels near the sites. In particular, travel times may limit successful grab sample collection. The geographic scope of the monitoring locations requires advanced warning of qualifying storm events to allow travel time. However, the variability of Washington's precipitation patterns increases the difficulty of predicting storms.

Successful sampling and monitoring will require a well-developed automated field data collection system and supporting monitoring team. WSDOT will train staff and maintain a field crew that will likely deploy to the field location or a local hotel when a promising forecast occurs during the work week. Telemetered data reporting and automated sample collection will be utilized to accomplish the monitoring goals by improving the successful rate of storm event sampling. Nonetheless, travel times and storm dynamics will likely be major factors contributing to missing some of the holding times for filtration of dissolved metals and orthophosphate.

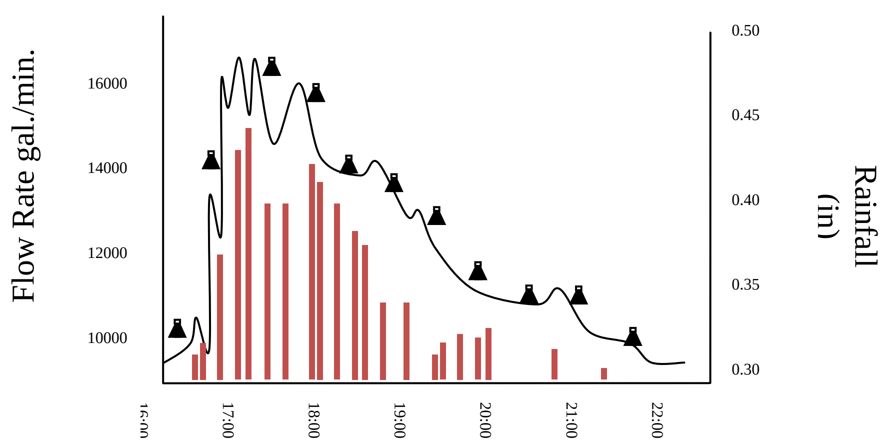
Automatic samplers will be programmed to collect flow-weighted composite samples for water quality monitoring and flow- or time-weighted compositing for toxicity parameters. Figure 2 shows how samples of equal volume are collected at equal increments of flow volume in a flow-weighted compositing scheme. Figure 3 shows how samples of equal volume are collected at equal increments of time in a time-weighted compositing scheme (Ecology, 2009b).

Grab samples may be missed due to the flashy nature of storms and the potential for limited availability of representative runoff. Timing of the sampling will be difficult because the samples must be collected by hand and require staff to be on-site within the first hour of runoff. WSDOT staff nearby or located at the facilities will be encouraged to participate in grab sampling efforts.



Constant Volume/Constant Flow Volume Increment: Samples of equal volume are taken at equal increments of flow volume and composited (Ecology, 2009b).

Figure 2 Flow-weighted compositing schemes.



Constant Time/Constant Volume: Samples of equal volume are taken at equal increments of time and composited to make an average sample (Ecology, 2009b).

Figure 3 Time-weighted compositing schemes.

In several cases, grab samples will be collected from the outlet of the EOP interceptor. A pole sampler or hand sampling is believed to be sufficient for grab sample collection.

Collecting annual accumulated sediment samples from the edge of the highway may also present logistical challenges. In order to reduce sediment interactions with shoulder sediments, samples will only be taken from within the confines of the EOP interceptor. It is unknown whether the sediments will build up and be retained in the EOP interceptor in sufficient quantities for sampling. Sampling sediment from the EOP will likely occur during the winter or spring seasons when sediment loads are expected to be highest.

Laboratory Logistical Challenges

Several of the sample parameters have short holding times that will require laboratories to process samples possibly within 8 hours of receiving them. Many laboratories, including Manchester Environmental Laboratory in Port Orchard, do not maintain 24-hour and 7-day-a-week staffing levels. Some labs have limited working hours on weekends. As a result, the days and times of the sampling program may be limited to the following proposed schedule:

- Sample during weekdays until noon on Fridays.
- Do not sample on Saturdays or on Sunday mornings.
- Sampling late (after 3:00 pm) Sundays is a possibility.

Programmed Equipment Errors Logistical Challenges

The potential for human programming errors is a possibility when operating any monitoring equipment. While some testing will be conducted prior to sampling, there will likely be a continuous need to monitor and adjust programming to meet permit requirements given site conditions. Care will be taken to follow standard operating procedures (SOPs) in an effort to minimize human programming errors. Field staff will be prompted to notify the Field Lead or check the NOAA Emergency Data Distribution Network website to verify station transmissions after any alterations to programming.

A loss of power to any of these stations may inhibit monitoring by turning the data logger and automatic sampler off. To avoid power loss, field staff will visit each station on a six-week rotational maintenance schedule or earlier for storm event sampling. During scheduled maintenance trips, batteries and solar panels will be maintained according to standard operating procedures.

Environmental/Remote Location Logistical Challenges

Damage from storm events (e.g., washouts or flooding) or the immediate environment (e.g., trees falling or traffic accidents) may present limitations for stormwater monitoring. Site equipment design and implementation will identify, remove, or prevent equipment damage or safety hazards. By utilizing telemetry, WSDOT will be able to identify malfunctions, errors, and damaged equipment via the hourly transmission from each station. Field staff will be dispatched as soon as feasible to repair or replace damaged equipment.

4 Organization and Schedule

The following section describes the roles and responsibilities of the key participants, including participants of WSDOT's Stormwater and Watersheds Program and staff from Ecology. The organizational structure was designed to provide project control and proper quality assurance and quality control (QA/QC) for the field investigations.

4-1 Organization

The roles of key individuals involved in the study are provided in Table 6. A detailed description of the lines of authority and reporting between these individuals and organizations is provided. WSDOT staff may delegate their responsibilities to other staff when they are not present or are busy with other tasks. This allows for adaptive management of the monitoring program responsibilities and may be necessary to meet permit requirements. If responsibilities are delegated, staff will still be responsible for ensuring their responsibilities were carried out properly in their absence.

4-1.1 Training

Field personnel will receive training in proper sampling and field analysis for each standard operating procedure they will be using. They will demonstrate to the Field Lead their ability to properly operate the automatic samplers and retrieve the samples. The Field Lead will sign off on each field staff member.

A field audit will be performed at least annually to verify proper methods and techniques. In addition, a follow-up meeting at the end of the water year will be organized to discuss methods and procedures. Stormwater monitoring crews will receive training for working in wet, cold, and poor-visibility conditions. Monitoring personnel and workers who install or maintain equipment may be exposed to traffic hazards, confined spaces, and slippery conditions. Workers and staff who install or maintain the equipment may need confined space entry training.

Monitoring crews will be trained on the traffic control plan for sites that expose them to traffic hazards. A traffic safety plan and safety guidelines for use while conducting monitoring or maintenance activities at field sites are presented in Appendix D. These traffic controls were adapted from WSDOT's *Work Zone Traffic Control Guidelines* (WSDOT, 2009b). The safety plans specify personal protective gear and include a Pre-Activity Safety Plan for Stormwater Field Work form, which is to be filled-out on each site visit.

Table 6 Organization of project staff and responsibilities.

Name	Roles	Responsibilities
WSDOT Stormwater and Watersheds Program Staff		
Fred Bergdolt	NPDES Stormwater Monitoring Project Manager	Manages overall WSDOT compliance activities; verifies whether or not the QAPP is followed and the project is producing data of known and acceptable quality; ensures adequate field training and supervision of all monitoring staff; complies with corrective action requirements.
Sarah Burdick	Quality Assurance Officer	Develops a quality management system for stormwater monitoring; oversees all operations, identifying whether QA/QC goals are met; validates and aids in verifying data collected; assists with the monitoring reports to Ecology.
Janice Sloan	Data Steward	Acquires data from telemetered systems and contract laboratories; verifies and transfers data collected into databases; manages laboratory contracts; analyzes and interprets data; assists with reports to Ecology.
Zackary Holt	Field Lead	Manages and oversees stormwater monitoring activities, sampling decisions, and equipment maintenance; manages internal and external field teams. Served as co-author during QAPP development and site design.
Brad Archbold	Logistics Lead	Coordinates with laboratories and field staff to ensure sampling equipment and bottles are tracked and distributed; cleans, calibrates, and organizes monitoring equipment.
Field Crew x 2	Field Sampling	Assist in collecting and processing of field composite and grab samples.
WSDOT staff	Field Sampling / Project Reporting	WSDOT region staff assist in collecting and processing field composite and grab samples. WSDOT HQ staff assist with storm forecasting activities and in writing the draft and final reports.
ECOLOGY Staff		
Foroozan Labib, Water Quality Program	Permit Coordinator	Reviews and approves QAPPs and project deliverables from WSDOT to Ecology for NPDES Municipal Stormwater Permit implementation.
Julie Lowe, Water Quality Program	Permit Monitoring Coordinator	Reviewed monitoring elements and provided advice/comments for QAPP development during the period of Feb. 2009 to June 2011.
Brandi Lubliner, Toxic Studies Unit, EAP	Project Manager (WSDOT Contractor)	Lead author for QAPP development and site design; assisted in site set up; coordinated technical lead duties and analytical contracts during the period of Aug. 2009 to April 2011.

EAP = Environmental Assessment Program, within Ecology

QAPP = Quality Assurance Project Plan

4-2 Schedule

Table 7 lists key deadlines for WSDOT under the permit. This schedule reflects the extension in time due to the exceedance of the 90-day review time frame by Ecology's Water Quality Program's (WQP).

Table 7 Key deadlines for QAPPs and reports.

Due	Description
September 6, 2010	Draft QAPPs due from WSDOT to Ecology's WQP (submitted September 2, 2010).
October 31, 2010	SWMP Progress Report and First Stormwater Monitoring Report on status of preparations to meet permit conditions S7.A through S7.E.
December 1, 2010	Ecology WQP reviews the QAPP within 90 days and responds with comments to WSDOT. Since Ecology's WQP did not meet the 90-day review period, the QAPP approval deadline is extended by the equivalent number of days (7 days) per permit condition S7.G.
March 13, 2011	The deadline for Ecology approval of the revised QAPP. Deadline was extended from March 6 to March 13, 2011.
September 6, 2011	Final QAPPs due to Ecology WQP program, with all revisions complete.
September 6, 2011	Full implementation of the monitoring program begins. Collection of toxicity monitoring data for reporting begins.
October 1, 2011	Collection of highway characterization monitoring data for reporting begins.
October 31, 2011	Second Stormwater Monitoring Report on status of preparations to meet S7.A through S7.E.
October 31, 2012	Third Stormwater Monitoring Report on status of preparations to meet S7.A through S7.E.
October 31, 2013	Fourth Stormwater Monitoring Report will be prepared and submitted with the Annual SWMP Progress Report, covering data collected from October 1, 2011–September 30, 2012, described in S8.F of the permit. This will be the first time a monitoring report will be submitted with the annual report.
February 6, 2014	A Final Water Quality Monitoring Report for each program outlined in S7 is due to Ecology's WQP.

5 Quality Objectives

A primary purpose of this QAPP is to ensure data collected for the WSDOT stormwater permit are scientifically and legally defensible and meet the requirements of WSDOT's permit. This section primarily discusses the chemical quality assurance (QA) topics for stormwater. Biological and chemical toxicity guidance (see Appendix C) and quality assurance criteria are also discussed.

The permit requires that some data quality objectives from Ecology's Technology Assessment Protocol (TAPE) process (Ecology, 2008a) or 40 CFR 136 are followed. All data quality objectives are discussed.

5-1 Data Quality Objectives (DQOs)

DQOs are qualitative and quantitative statements developed using the data quality objectives process. This process clarifies study objectives and defines the appropriate type of data and tolerable levels of potential errors. The DQOs for WSDOT's stormwater monitoring projects are as follows:

1. The data will be generated according to set criteria and procedures for field sampling, sample handling and processing, laboratory analysis, and recordkeeping.
2. The data will be representative of the monitoring site and be of known precision, bias, and accuracy.
3. Data reporting and analytical sensitivity will be clearly established and adequate for stormwater management program decisions and endpoints.

Once established, DQOs become the basis for measurement quality objectives (MQOs), which are discussed for both hydrological and chemistry data under each heading in this section.

5-2 Measurement Quality Objectives (MQOs)

MQOs are the acceptance thresholds for data, based on the data quality indicators, and are specifically used to address instrument and analytical performance.

Quality control (QC) is often confused with quality assurance (QA). Quality control (discussed further in Section 10) refers to a set of standard operating procedures for the field and laboratory that are used to evaluate and control the accuracy of measurement data. Quality assurance is a decision-making process, based on all available information, that determines whether the data are usable for all intended purposes (Ecology, 2004).

The QA decision-making process relies on measurable values, such as MQOs that specify how good the data must be in order to meet the objectives of the study. MQOs established for WSDOT stormwater permit monitoring are based on guidance from multiple sources, which include EPA, Ecology, laboratory experience, and best professional judgment. The hierarchy of guidelines to be followed in descending order is:

1. Permit (Ecology, 2009a) (and TAPE [Ecology, 2008a] for BMP stations)
2. 40 CFR 136
3. Guidance documents referred to in the permit
4. Other guidance documents from:
    - Ecology, such as standard operating procedures (SOPs), and
    - EPA, such as *Methods and Functional Guidelines* (USEPA, 2008 and 2010), and 2002 EPA guidance on Environmental Data Verification and Data Validation (USEPA, 2002a)
5. Best professional judgment

MQOs are the performance or acceptance thresholds or goals for the study's data, based primarily on the data quality indicators (DQIs). DQI performance measures are expressed in terms of:

- Sensitivity
- Bias
- Representativeness
- Precision
- Accuracy
- Completeness
- Comparability

Measurements to address these DQIs are in Tables 8–10, and further descriptions are in the following sections. Tables 8–10 represent how the data will be verified by WSDOT to assess sensitivity, accuracy, precision, and comparability. Failure to meet the MQOs may result in data being qualified or rejected.

Refer to Section 9, Measurement Procedures, for a thorough discussion of laboratory-specific MQOs.

Table 8 Measurement quality objectives for chemical analysis of stormwater (Ecology, 2009a and 2011; USEPA, 2010 and 2008).

Parameter	Lowest Concentration of Interest (Reporting Limit)	Lab Duplicate[1] (RPD)	Matrix Spike[2] (% Rec*)	Matrix Spike Duplicate[1] (RPD)	Control Standard (LCS)/ Surrogate Standard[6] (% Rec*)
MQO	**Sensitivity**	**Bias and Precision**	**Bias and Accuracy**	**Bias and Precision**	**Bias and Accuracy**
Conventionals					
TSS	1 mg/L	≤20%	n/a	n/a	80–120
Chloride	0.2 mg/L	≤20%	75–125	≤20%	90–110
Hardness as $CaCO_3$[5]	1 mg/L	≤20%	75–125	≤20%	70–130
Particle size distribution[4]	n/a	≤20%	n/a	n/a	n/a
pH[4]	0.2 units	≤5%	n/a	n/a	n/a
Temperature	0.1°C	n/a	n/a	n/a	n/a
Bacteria					
Fecal coliform	2 min, 2 x 10^6 max/100 mL	≤20%	n/a	n/a	n/a
Nutrients					
Total phosphorus (TP)	0.01 mg/L	≤20%	75–125	≤20%	80–120
Orthophosphate (OP)	0.01 mg/L	≤20%	75–125	≤20%	80–120
Metals					
Total recoverable (Cu, Pb, Cd, Zn)[5]	(0.1, 0.1, 0.2, 5) µg/L	≤20%	75–125	≤20%	70–130
Dissolved (Cu, Pb, Cd, Zn)[5]	(0.1, 0.1, 0.1, 1) µg/L	≤20%	75–125	≤20%	70–130
Organics					
PAH Compounds:					
acenaphthene	0.1 µg/L	≤40%	55–97	≤40%	40–112
acenaphthylene	0.1 µg/L	≤40%	48–103	≤40%	10–126
anthracene	0.1 µg/L	≤40%	51–113	≤40%	24–127
benzo[a]anthracene	0.1 µg/L	≤40%	59–137	≤40%	38–147
benzo[b]fluoranthene	0.1 µg/L	≤40%	53–99	≤40%	42–116
benzo[k]fluoranthene	0.1 µg/L	≤40%	33–122	≤40%	38–131
benzo[ghi]perylene	0.1 µg/L	≤40%	38–110	≤40%	12–122
benzo[a]pyrene	0.1 µg/L	≤40%	42–110	≤40%	14–129
chrysene	0.1 µg/L	≤40%	51–116	≤40%	37–128
dibenzo[a,h]anthracene	0.1 µg/L	≤40%	27–129	≤40%	10–134
fluoranthene	0.1 µg/L	≤40%	60–107	≤40%	42–123
fluorene	0.1 µg/L	≤40%	50–134	≤40%	50–134
indeno[1,2,3-cd]pyrene	0.1 µg/L	≤40%	37–135	≤40%	29–129
naphthalene	0.1 µg/L	≤40%	41–97	≤40%	41–105
phenanthrene	0.1 µg/L	≤40%	18–105	≤40%	18–105
pyrene	0.1 µg/L	≤40%	61–118	≤40%	43–131
PAH Surrogates:					
Terphenyl-D_{14}	n/a	n/a	n/a	n/a	34–148
2-Fluorobiphenyl	n/a	n/a	n/a	n/a	28–136
Acenaphthylene-D_8	n/a	n/a	n/a	n/a	50–150
Fluorene-D_{10}	n/a	n/a	n/a	n/a	50–150
Anthracene-D_{10}	n/a	n/a	n/a	n/a	50–150
Pyrene-D_{10}	n/a	n/a	n/a	n/a	48–143
Benzo(a)pyrene-D_{12}	n/a	n/a	n/a	n/a	50–150

Table 8 (continued) Measurement quality objectives for chemical analysis of stormwater (Ecology, 2009a and 2011; USEPA, 2010 and 2008).

Parameter	Lowest Concentration of Interest (Reporting Limit)	Lab Duplicate[1] (RPD)	Matrix Spike[2] (% Rec*)	Matrix Spike Duplicate[1] (RPD)	Control Standard (LCS)/ Surrogate Standard[6] (% Rec*)
MQO	**Sensitivity**	**Bias and Precision**	**Bias and Accuracy**	**Bias and Precision**	**Bias and Accuracy**
Phthalates:					
bis(2-Ethylhexyl)phthalate	1.0 µg/L	≤40%	61–131	≤40%	80–128
Butyl benzyl phthalate	1.0 µg/L	≤40%	80–150	≤40%	23–183
Di-n-butyl phthalate	1.0 µg/L	≤40%	73–148	≤40%	70–156
Diethyl phthalate	1.0 µg/L	≤40%	79–117	≤40%	77–123
Dimethyl phthalate	1.0 µg/L	≤40%	73–126	≤40%	74–122
Di-n-octyl phthalate	1.0 µg/L	≤40%	61–148	≤40%	75–135
Phthalate Surrogates:					
Dimethylphthalate-D_6	n/a	n/a	n/a	n/a	50–150
Herbicides[3]:					
Diuron	0.05 µg/L	≤40%	50–150	≤40%	50–140
Picloram	0.0625 µg/L	≤40%	10–100	≤40%	10–100
Triclopyr (ester formula)	0.0625 µg/L	≤40%	50–150	≤40%	50–140
Glyphosate	25 µg/L[8]	≤40%	50–150	≤40%	50–140
Herbicide Surrogates:					
2,4,6-Tribromophenol	n/a	n/a	n/a	n/a	33–99
2,4-Dichlorophenylacetic acid	n/a	n/a	n/a	n/a	37–91
1,3-Dimethyl-2-nitrobenzene	n/a	n/a	n/a	n/a	41–135
Surfactants:					
Methylene blue active substances (MBAS)	0.025 mg/L	Meet all performance criteria in lab method relative to sample replication and reference toxicant.			
TPH:					
TPH-Diesel (NWTPH-Dx)	0.25-0.5 mg/L[7]	≤40%	70–130	≤40%	70–130
TPH-Gas (NWTPH-Gx)	0.25 mg/L	≤40%	70–130	≤40%	70–130
TPH Surrogates:					
Pentacosane	n/a	n/a	n/a	n/a	50–150
1,4-Difluorobenzne	n/a	n/a	n/a	n/a	70–130
Benzene, 1,4-dibromo-2-methyl-	n/a	n/a	n/a	n/a	70–130

[1] The relative percent difference must be less than or equal to the indicated percentage for values that are greater than 5 times the reporting limit. Relative percent difference (RPD) must be ± 2 times the reporting limit for values that are less than or equal to 5 times the reporting limit.

[2] For inorganics, the *Contract Laboratory Program Functional Guidelines* state that the spike recovery limits do not apply when the sample concentration exceeds the spike concentration by a factor of four or more (USEPA, 2010).

[3] Limited to the herbicides as listed in the permit and used within the drainage area by WSDOT. This list may decrease based on usage records from WSDOT. This list will be updated annually.

[4] Required for shared highway and BMP monitoring sites for TAPE compliance and/or toxicity sampling.

[5] Method quality objectives (matrix spike & LCS values) are based on *Contract Laboratory Program Functional Guidelines* for inorganic data review (USEPA, 2010) and organic data review (USEPA, 2008). All other values were obtained from Manchester Environmental Laboratory performance criteria (Ecology, 2011).

[6] For PAHs and phthalates, both deuterated and nondeuterated monitoring compounds are the surrogate standards.

[7] The reporting limit depends on the hydrocarbons detected. The lighter the hydrocarbons, the lower the limit; therefore, a range is used for the acceptable reporting limit.

[8] Results for glyphosate analysis between the RL of 25 ug/L and MDL of 2.5 ug/L will be reported. These results will be qualified as estimates.

* Recovery

Table 9 Measurement quality objectives for biological analysis of stormwater (Ecology, 2009a; USEPA, 2010 and 2008).

Test	Temp	Animal age	Acclimation Period	Aeration	Water[1] and Substrate	Control of Performance
	(°C)	(Days)	(Days)	(mg/l)	n/a	(Survival)
Hyalella azteca (controlled and tested organisms) 24-hr acute toxicity test	23±1	7–14, 1–2 day range in age	Feed ground cereal leaf prior to testing; no feeding during testing	If D.O. is below 4.0	Moderately hard synthetic water on square of nitex screen	≥90% survival in negative control and reference (if provided)

[1] Stormwater sample hardness may be adjusted to match receiving waters.

Table 10 Measurement quality objectives for chemical analysis of sediments (Ecology, 2009a and 2011; USEPA, 2010 and 2008).

Parameter	Lowest Concentration of Interest (Reporting Limit)	Lab Duplicate[1] (RPD)	Matrix Spike[2] (% Rec)	Matrix Spike Duplicate[8] (RPD)	Control Standard (LCS)/ Surrogate Standard (% Rec) [6]
MQO	**Sensitivity**	**Bias and Precision**	**Bias and Accuracy**	**Bias and Precision**	**Bias and Accuracy**
Conventionals					
Particle size (grain size)[4]	n/a	≤20% RSD[9]	n/a	n/a	n/a
Total org. carbon (TOC)	0.1%	≤20%	75–125	n/a	80–120
Total solids[4]	n/a	≤20%	n/a	n/a	n/a
Metals					
Total recoverable (Cu, Pb, Cd, Zn)[5]	(0.1, 0.1, 0.1, 5.0) mg/Kg dry	≤20%	75–125	≤20%	80–120
Organics					
PAH Compounds:					
acenaphthene	70 µg/Kg dry	n/a	50–150	≤ 35%	50–150
acenaphthylene	70 µg/Kg dry	n/a	50–150	≤ 35%	50–150
anthracene	70 µg/Kg dry	n/a	50–150	≤ 35%	50–150
benzo[a]anthracene	70 µg/Kg dry	n/a	50–150	≤ 35%	50–150
benzo[b]fluoranthene	70 µg/Kg dry	n/a	50–150	≤ 35%	50–150
benzo[k]fluoranthene	70 µg/Kg dry	n/a	50–150	≤ 35%	50–150
benzo[ghi]perylene	70 µg/Kg dry	n/a	50–150	≤ 35%	50–150
benzo[a]pyrene	70 µg/Kg dry	n/a	50–150	≤ 35%	50–150
chrysene	70 µg/Kg dry	n/a	50–150	≤ 35%	50–150
dibenzo[a,h]anthracene	70 µg/Kg dry	n/a	50–150	≤ 35%	50–150
fluoranthene	70 µg/Kg dry	n/a	50–150	≤ 35%	50–150
fluorene	70 µg/Kg dry	n/a	50–150	≤ 35%	50–150
indeno[1,2,3-cd]pyrene	70 µg/Kg dry	n/a	50–150	≤ 35%	50–150
naphthalene	70 µg/Kg dry	n/a	50–150	≤ 35%	50–150
phenanthrene	70 µg/Kg dry	n/a	50–150	≤ 35%	50–150
pyrene	70 µg/Kg dry	n/a	50–150	≤ 35%	50–150
PAH Surrogates:					
Terphenyl-D_{14}	n/a	n/a	n/a	n/a	18–137
2-Fluorobiphenyl	n/a	n/a	n/a	n/a	30–115
Acenaphthylene-D_8	n/a	n/a	n/a	n/a	50–150
Fluorene-D_{10}	n/a	n/a	n/a	n/a	50–150
Anthracene-D_{10}	n/a	n/a	n/a	n/a	50–150
Pyrene-D_{10}	n/a	n/a	n/a	n/a	50–150
Benzo(a)pyrene-D_{12}	n/a	n/a	n/a	n/a	50–150

Table 10 (continued) Measurement quality objectives for chemical analysis of sediments (Ecology, 2009a and 2011; USEPA, 2010 and 2008).

Parameter	Lowest Concentration of Interest (Reporting Limit)	Lab Duplicate[1] (RPD)	Matrix Spike[2] (% Rec)	Matrix Spike Duplicate[8] (RPD)	Control Standard (LCS)/ Surrogate Standard (% Rec) [6]
Phthalates:					
bis(2-Ethylhexyl)phthalate	70 µg/Kg dry	n/a	50–150	≤ 35%	50–140
Butyl benzyl phthalate	70 µg/Kg dry	n/a	50–150	≤ 35%	50–140
Di-n-butyl phthalate	70 µg/Kg dry	n/a	50–150	≤ 35%	50–140
Diethyl phthalate	70 µg/Kg dry	n/a	50–150	≤ 35%	50–140
Dimethyl phthalate	70 µg/Kg dry	n/a	50–150	≤ 35%	50–140
Di-n-octyl phthalate	70 µg/Kg dry	n/a	50–150	≤ 35%	50–140
Phthalate Surrogates:					
Dimethylphthalate-D_6	n/a	n/a	n/a	n/a	50–150
Phenols:					
Phenol	70 µg/Kg dry	n/a	50–150	≤ 35%	50–150
Benzyl Alcohol	70 µg/Kg dry	n/a	50–150	≤ 35%	50–150
2-methylphenol	70 µg/Kg dry	n/a	50–150	≤ 35%	50–150
2,4-dimethyphenol	70 µg/Kg dry	n/a	50–150	≤ 35%	50–150
Pentachlorophenol	70 µg/Kg dry	n/a	50–150	≤ 35%	50–150
Benzoic acid	70 µg/Kg dry	n/a	50–150	≤ 35%	50–150
Phenol surrogates:					
2-Chlorophenol-D_4	n/a	n/a	n/a	n/a	20-130
4-Methylphenol-D_8	n/a	n/a	n/a	n/a	50-150
Phenol-D_5	n/a	n/a	n/a	n/a	24-113
2,4-Dichlorophenol-D_3	n/a	n/a	n/a	n/a	50-150
Herbicides[3]:					
Picloram	70 µg/Kg dry	n/a	30–140	≤ 35%	30–140
Triclopyr (ester formula)	70 µg/Kg dry	n/a	30–140	≤ 35%	30–140
Herbicide Surrogates:					
2,4,6-Tribromophenol	n/a	n/a	n/a	n/a	30–140
2,4-dichlorophenylacetic acid	n/a	n/a	n/a	n/a	30–140
1,3-dimethyl-2-nitrobenzene	n/a	n/a	n/a	n/a	30–140
TPH:					
TPH-Diesel (NWTPH-Dx)	25.0-100.0[7] mg/Kg dry	n/a	n/a	n/a	70–130
TPH Surrogate:					
Pentacosane	n/a	n/a	n/a	n/a	50-150

[1] The relative percent difference must be less than or equal to the indicated percentage for values that are greater than 5 times the reporting limit. Relative percent difference (RPD) must be ± 2 times the reporting limit for values that are less than or equal to 5 times the reporting limit.

[2] For inorganics, the *Contract Laboratory Program Functional Guidelines* state that the spike recovery limits do not apply when the sample concentration exceeds the spike concentration by a factor of four or more (USEPA, 2010).

[3] Limited to the herbicides as listed in the permit and used within the drainage area by WSDOT. This list may increase or decrease based on usage records from WSDOT. This list will be updated annually.

[4] MQOs are taken from the Sediment Sampling and Analysis Plan Appendix: http://www.ecy.wa.gov/biblio/0309043.html

[5] Method quality objectives (matrix spike & LCS values) are based on *Contract Laboratory Program Functional Guidelines* for inorganic data review (USEPA, 2010) and organic data review (USEPA, 2008). All other values were obtained from Manchester Environmental Laboratory performance criteria (Ecology, 2011).

[6] For PAHs and phthalates, both deuterated and nondeuterated monitoring compounds are the surrogate standards.

[7] The reporting limit depends on the hydrocarbons detected. The lighter the hydrocarbons, the lower the limit; therefore, a range is used for the acceptable reporting limit.

[8] The matrix spike duplicate RPD is applied when the analyte concentration is greater than the practical quantitation limit (PQL).

[9] Grain size requires a triplicate analysis; therefore, a relative standard deviation (RSD) is calculated.

5-2.1 Sensitivity

Sensitivity is the measure of the concentration at which an analytical method can positively identify and report analytical results. The sensitivity of a method is commonly called the "detection limit." In fact, there are multiple and different limits in analytical analysis and reporting.

- Instrument detection limit (IDL)
- Method detection limit (MDL)
- Practical quantitation limit = reporting limit (RL)

The "reporting limit" expressed in the permit refers to the practical quantification limit established by the laboratory, not the method detection limit.

Ecology specified the reporting limits and analytical methods in the permit's Appendix 5, and they are restated in Tables 8–10. MQOs that were not stated in the permit's Appendix 5 were based on other sources, such as the Manchester Environmental Laboratory's (MEL) *Laboratory Users Manual*, 9th Edition (MEL, 2008), and the EPA's published guidelines for the Contract Laboratory Protocols (CLP) for inorganic and organic data (USEPA, 2010 and 2008).

5-2.2 Bias and Blanks

Bias represents systematic error and can be used to describe a tendency or preference in one direction. Bias in water quality samples will be assessed based on the analyses of method blanks, field blanks, transport blanks, matrix spikes, and laboratory control samples (LCS).

A hydrologic example of bias can be described as: the difference between instrument readings and an independently measured "true" value.

- Bias in rain gage measurements will be assessed by comparing known volumes of water to the rain gage's measurements.
- Bias in stage measurements will be assessed by comparing field observations of stage (at the weir or flume) with collected stage data in the data logger during a rain event.
- Hydrological biases from temperature can be checked by observing temperature readings to check for frozen water.
- Bias from sediment accumulation behind weirs will be managed with regular cleaning and removal of debris that has settled behind the weirs.

Field Sample Bias and Blanks

Field blank results greater than the reporting limit (RL) will be flagged as blank contamination (*B*). The associated project samples collected with that blank sample will be scrutinized by the Quality Assurance Officer upon receipt of the laboratory report. Depending on the type of blank collected (trip, transfer, or equipment), the Field Lead should be notified as soon as possible to re-run the blank and reclean the equipment that may have contaminated the field blank. Typically, associated project samples within five times the blank concentration will be qualified as an estimate (*J*). Data flagged with a *B* and qualified as *J* due to blank contamination will not be considered valid for TAPE compliance.

Laboratory Bias and Blanks

The following sections describe the differences between method blanks and matrix spikes, both of which are used to identify potential biases affecting results.

Blanks

Laboratory method blanks should not exceed the reporting limit. If this occurs, the associated blank concentration is defined as the new reporting limit. For all samples with identified contaminants, the sample concentration must be at least five times the method blank concentration for the result to be considered valid, per TAPE guidelines (Ecology, 2008a). Sample concentrations within this five times de facto reporting limit will be flagged by the laboratory as *B*, associated project data reviewed and qualified as *U* or *J*, and the WSDOT Data Steward will be alerted to the contamination. Common laboratory contaminants within ten times the de facto reporting limit will be flagged as *B*, per Contract Laboratory Protocols (CLP) guidance. WSDOT will determine how many samples are affected and whether corrective actions are necessary.

Matrix spikes

The targeted range for percent recovery of matrix spikes and matrix spike duplicates (ms/msd) varies according to the parameter, as shown in Tables 8 and 10. Percent recovery for matrix spikes will be calculated using Equation 1 (Ecology, 2004).

Equation 1: Percent Recovery for MS/MSD

$$\%R = \frac{(X_S - X_O)}{C_S} \times 100\%$$

Where:

$\%R$ = percent recovery
X_s = spike sample result
X_o = original sample amount
C_s = concentration of spike

Laboratory Control Sample

The Laboratory Control Sample (LCS) serves as a monitor of the overall performance of each step during the analysis, including the sample preparation (USEPA 2010). The goals for percent recovery of LCS vary for each parameter. Percent recovery for LCS will be calculated using Equation 2 (USEPA, 2010).

Equation 2: Percent Recovery for LCS

$$\%\mathrm{R} = \frac{M}{T} \times 100\%$$

Where:

%R = percent recovery
M = measured value
T = true value

5-2.3 Representativeness

Representativeness is a qualitative measure of the degree to which sample data represent characteristic environmental conditions or, more specifically, site conditions. Representativeness of the hydrologic data will be ensured by proper site selection and proper selection and installation of all associated monitoring equipment. Rainfall patterns, stormwater conveyance features, and surrounding land uses were elements considered in the identification of monitoring locations and sampling frequencies. Hydrologic monitoring will be conducted over a sufficient length of time (three years) to ensure data are collected during representative climatic conditions for the region.

Representativeness of the water quality data from WSDOT highway monitoring sites will be ensured by targeting criteria set forth in S7.C and S7.B.6 (and S7.E for BMP stations) of the permit and listed in Table 4. It is understood that these data will systematically not include very low-volume storms or the long, intermittent storms typical of the Northwest.

Representativeness of the samples can also be evaluated by analysis of field replicates. Field variability found using composite techniques may be different from the field variability found between replicate grab samples. Any sample data may be deemed "nonrepresentative" and rejected by the Quality Assurance Officer or Data Steward if any of these criteria are not met.

The representativeness of the seasonal first flush toxicity data will be ensured by employing consistent and standard sampling procedures. If sampling requirements cannot be met in the first two qualified seasonal first flush storm events, the representativeness of seasonal first flush characteristics will be considered unmet and this type of sampling will be discontinued.

5-2.4 Precision

Precision is the measure of nearness of repeated measurements to the same value over time. Precision of samples and data collected will be evaluated using field replicate and laboratory duplicate sample analyses. Poor precision of field replicates may be due to heterogeneity of the stormwater and entrained sediments, which has been a fairly common problem in stormwater characterization studies. Field replicates may be evaluated at the targeted relative percent difference (RPD) or relative standard deviation (or RSD) as listed in Tables 8 and 10. Other reasons for poor precision may include contamination, problems with sampling, or poor sensitivity of the analytical methods. Bias and blanks will assist with determining a reason for poor precision.

Analytical precision is measured using laboratory duplicate (split) samples for inorganic analyses and matrix spike/matrix spike duplicate (ms/msd) samples for organic analyses. Poor laboratory precision may indicate:

- Poor sample homogenization
- High sample heterogeneity
- Matrix interferences
- Poor sample handling in the laboratory
- Contamination of laboratory chemicals or equipment
- Poor sensitivity of the analytical methods

Laboratory duplicates are generally performed by splitting one sample into two and performing the analysis separately on each split. Matrix spikes and matrix spike duplicates (ms/msd) are prepared by adding a known concentration of a compound to the sample and determining the concentration of that spike in the sample matrix. The matrix spike and matrix spike duplicate are compared to provide an estimate of the precision of the laboratory method.

Often in stormwater samples, the poor recovery of the ms/msd data will help quantify the interferences that may be part of the original (native) sample.

Precision of a duplicate pair is calculated as the relative percent difference (RPD), which is usually expressed as a percentage (shown in Equation 3) (Ecology, 2004).

Equation 3: Relative Percent Difference

$$\text{RPD} = \frac{|C_1 - C_2|}{\bar{x}} \times 100\%$$

Where:

RPD = relative percent difference
C_1 = concentration of original sample
C_2 = concentration of duplicate
$\bar{x}$ = mean of samples

Precision of more than three sample duplicates is calculated as the relative standard deviation (RSD), which is expressed as a percentage (shown in Equation 4) (Ecology, 2004).

Equation 4: Relative Standard Deviation

$$\text{RSD} = \frac{S}{\bar{x}} \times 100\%$$

Where:

RSD = percent relative standard deviation
S = standard deviation
$\bar{x}$ = mean of samples

5-2.5 Accuracy

Accuracy is the measure of agreement between a measurement's result and the true or known value. Analytical accuracy can be found by analyzing known reference materials or known standards (LCS, ms/msd, and/or surrogates). A common metric is the percent recovery of a spike. Factors that influence analytical accuracy include laboratory calibration procedures, sample (field and laboratory) preparation procedures, and laboratory equipment or deionized water contamination.

Accuracy is calculated as the percent recovery, which is usually expressed as a percentage (see Equation 1).

5-2.6 Completeness

Completeness is the percentage of measurements judged to be valid over the total number of measurements compared to the amount of data deemed necessary to meet monitoring objectives. Completeness goals in terms of number of storm events sampled is set to the number of storm events required by the permit. Completeness of data gathered will be maximized in the field by telemetry, composite autosamplers, refrigerated samples, packaging samples for transport to avoid breakage, and timely sample processing.

Laboratories can improve completeness by processing samples within their holding times. Completeness for telemetered data is anticipated to be high; however, the grab sample data completeness is expected to be much lower. For data analysis, valid sample data may include all unflagged data and (*J*) flagged data reviewed by the Data Steward.

5-2.7 Comparability

Comparability is a qualitative measure designed to express the confidence with which one data set may be compared to another. Standard sampling procedures, analytical methods, units of measurement, reporting rules, and reporting limits will be applied to meet the goal of data comparability. Comparability is limited by other MQOs because data sets can be compared with confidence only when precision and accuracy are known.

6 Site Descriptions

This section addresses the experimental design, monitoring methods, site descriptions, and site development for data collection. Detailed drawings and tables containing technical and hydrological information for highway monitoring sites are available in Appendix E.

6-1 Selected Highway Monitoring Sites

WSDOT has combined permit-required monitoring for highways with permit-required monitoring for BMP effectiveness to reduce travel time and the number of sampling sites. Table 11 and Figure 4 describe the selected highway monitoring locations. The three I-5 locations and the SR 9 location are all in western Washington, and they serve a dual purpose as highway characterization and BMP effectiveness monitoring sites. Combining the highway and BMP monitoring sites conserves monitoring efforts and costs. In addition, staff becomes familiar with the hazards of fewer sites, making field work safer.

Table 91 Highway runoff monitoring sites.

Permit Traffic Designation	AADT	Location	Description
Urban[1]	78,500	I-5, Pilchuck Creek, MP 210.71	EOP; interceptor on embankment
Highly Urban[1]	120,500	I-5, Everett, MP 197.27	1 of 2 EOP; interceptor on embankment
Highly Urban	120,500	I-5, Everett, MP 197.35	2 of 2 EOP; interceptor on embankment
Rural[1]	6,700	SR 9, Marysville, MP 17.92	VFS; EOP interceptor on embankment
Urban (Eastern WA)	87,168	I-90, Spokane, MP 289.54	EOP curb/collector along highway shoulder

[1] Toxicity samples will be taken at these highway sites.

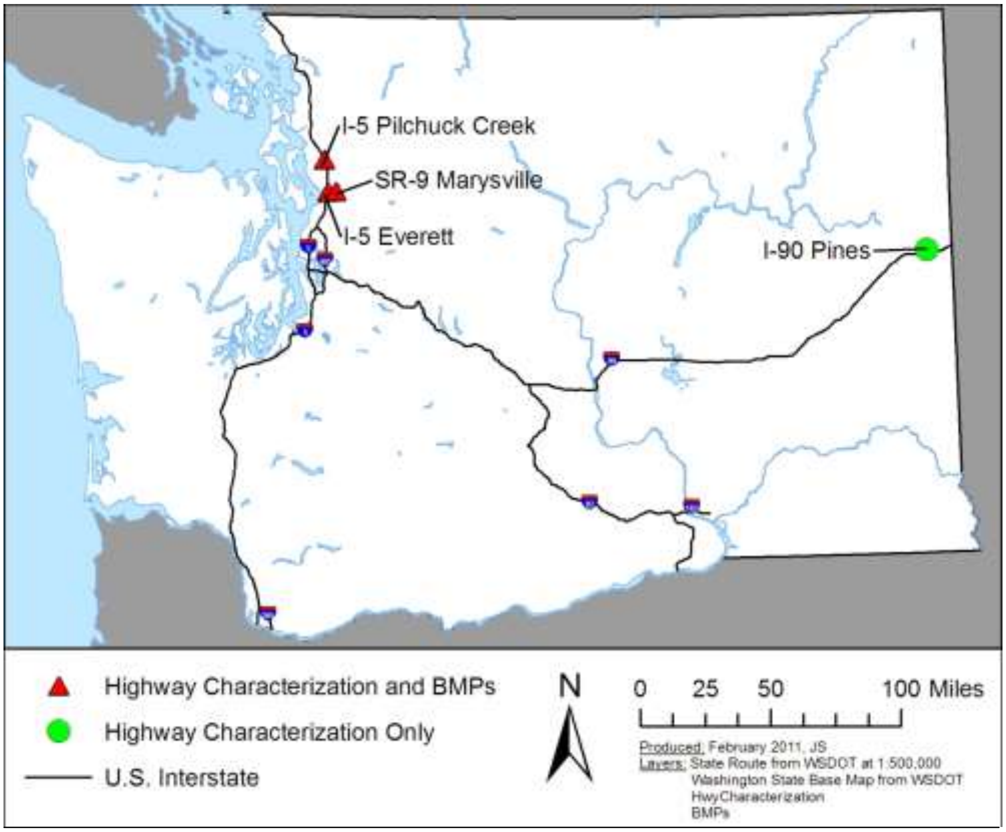


Figure 4 Highway characterization monitoring locations.

The following sections provide contextual and technical information on the highway characterization monitoring sites. Photographs of the highway runoff monitoring sites are in Appendix E.

6-2 I-5 Sites: Pilchuck Creek and Everett

For baseline highway characterization, EOP interceptors will be located at the Everett and Pilchuck Creek locations (see Figures 5 and 6). The EOP highway characterization interceptors will serve as the "influent" samples for BMP effectiveness monitoring under the permit.

Attributes of these sites include:

1. They qualify for use as highway characterization and BMP monitoring sites. Co-locating sites reduces monitoring costs and the hazards of putting crews on the side of the highway at multiple sites.
2. Both EOP monitoring stations on I-5 at Everett qualify as "highly urban" locations.
3. One EOP at I-5 near Pilchuck Creek qualifies as an "urban" location.
4. Support of WSDOT stormwater research priorities.
5. WSDOT research funds will help pay for the project, and the timeline fits well within the permit monitoring schedule.

I-5 Everett Descriptions (Highly Urban)

The two I-5 northbound study sites are north of Everett on the eastern shoulder of I-5 in Snohomish County, just north of the Snohomish River. The AADT of I-5 (northbound only) at these monitoring sites is listed as 120,500.

The first "highly urban" EOP interceptor will be the southernmost of two EOPs on this section of I-5. The center of the EOP interceptor is located at milepost (MP) 197.27. The center of the second "highly urban" EOP interceptor is located at MP 197.35.

Both EOP interceptor pipes are 12 meters in length and receive sheet flow from three traffic lanes and the paved shoulder. They can only be accessed from the shoulder of the highway. The size of the drainage area, slope, and time of concentration are listed in Table 12.

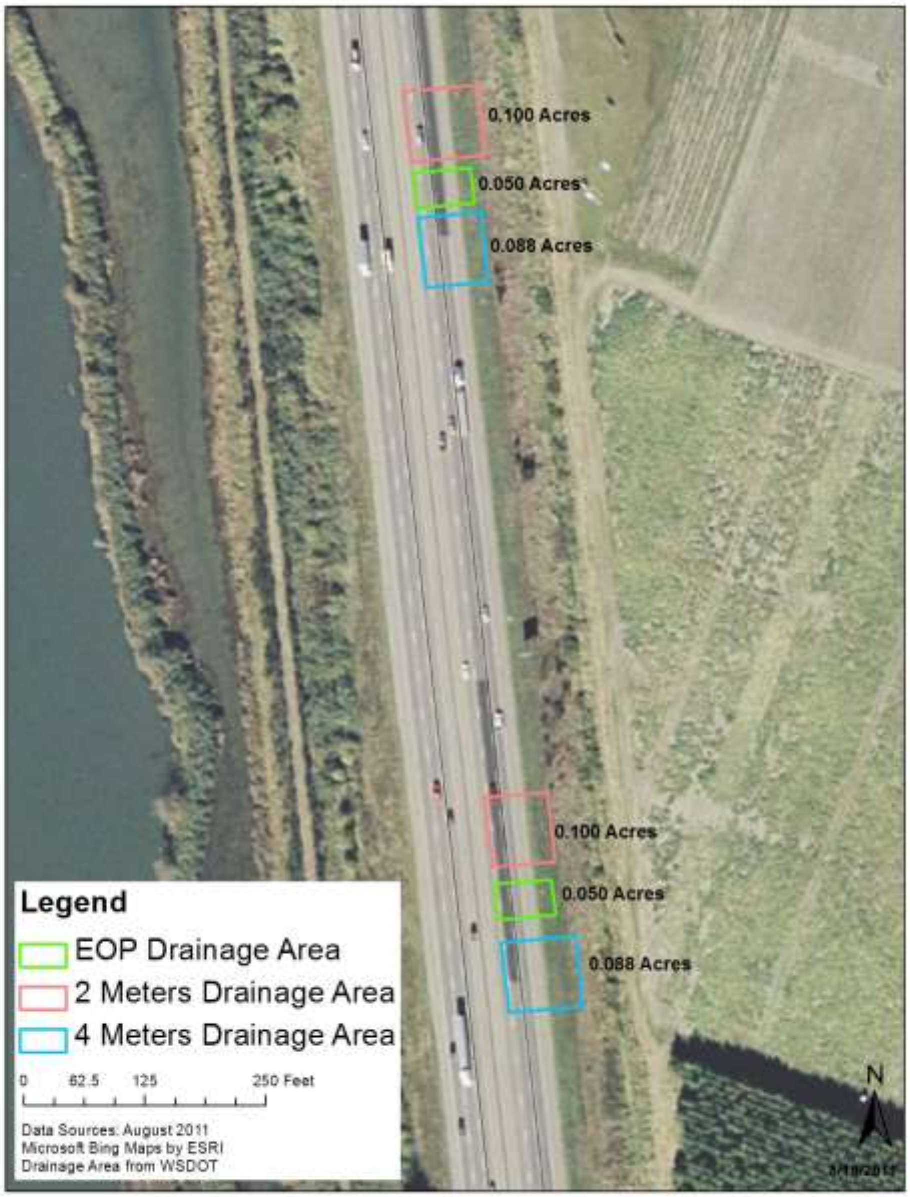


Figure 5 I-5 Everett "Highly Urban" highway characterization sites.

I-5 Pilchuck Creek Description (Urban)

The I-5 Pilchuck Creek site (southbound) is located just north of the Stillaguamish River and Pilchuck Creek. Only one of the EOP interceptors (the southernmost one) at the Pilchuck Creek BMP monitoring sites will be used as the highway monitoring location.

The center of the EOP interceptor is located at MP 210.71. The monitoring site can be accessed from the shoulder of I-5 or from Old Highway 99, which runs parallel to I-5. The AADT (southbound only) at this site is 78,500. The EOP monitoring station receives sheet flow from two of the three southbound lanes and the paved westernmost shoulder. The size of the drainage area, slope, and time of concentration are listed in Table 12.

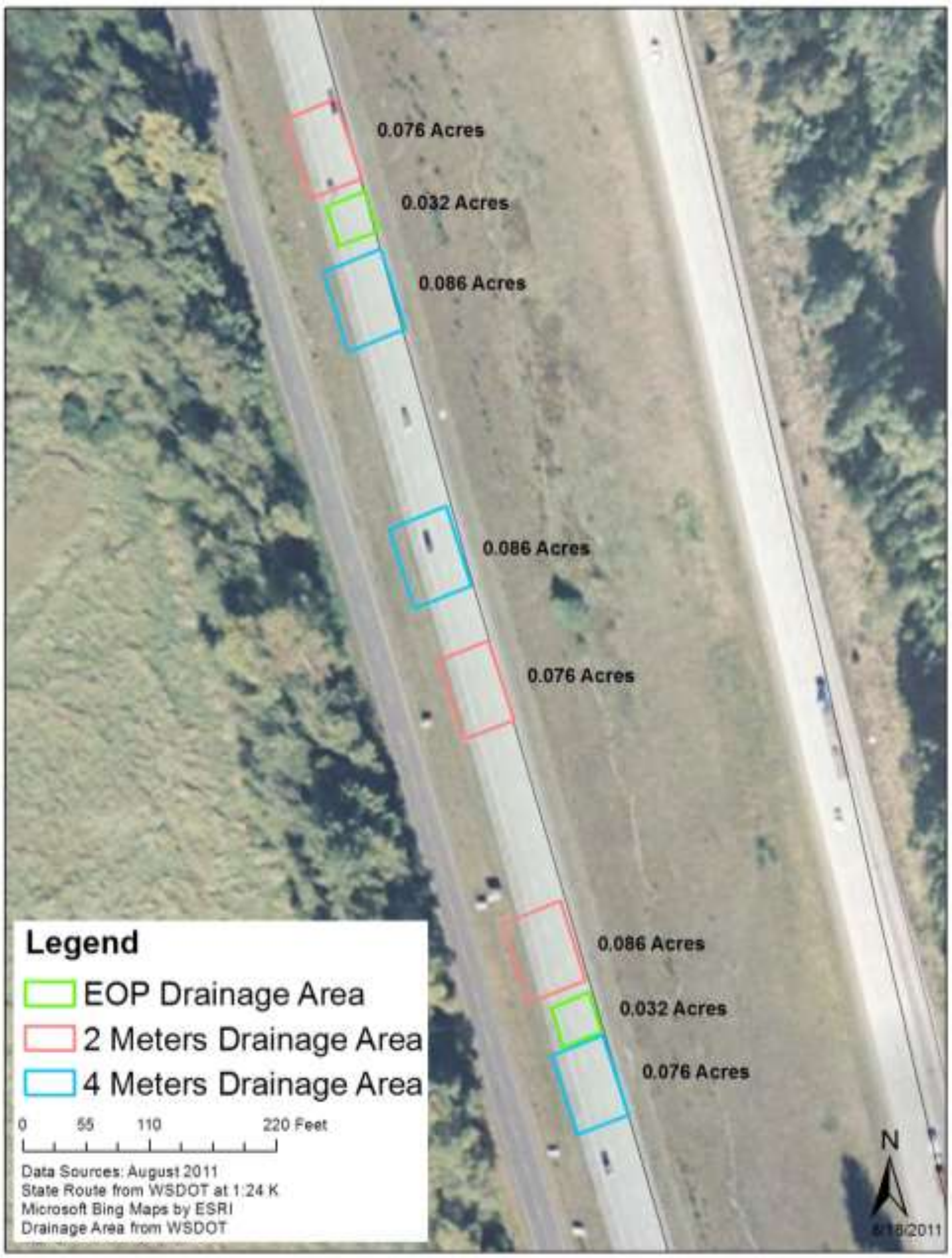


Figure 6 I-5 Pilchuck "Highly Urban" highway characterization sites.

6-3 SR 9, Marysville (Rural AADT Monitoring Site)

The fourth western Washington highway runoff monitoring site is located along a highway with a "rural" AADT designation. A suitable monitoring site was found on SR 9 north of Lake Stevens on the eastern edge of the city of Marysville. There is a photo of the SR 9 Marysville site in Appendix E.

6-3.1 SR9, Marysville (Rural) Description

Recent work to improve the intersection of SR 9 with E. Sunnyside Rd. included installation of several stormwater treatment BMPs. A vegetated filter strip (VFS) receives runoff from SR 9 just south of the intersection with E. Sunnyside Rd., along the west side of the highway. The location's traffic level designation satisfies permit requirements with an AADT of 16,500. The AADT level is under 30,000, which is the maximum allowable AADT for a rural designation required by S7.B of the permit. This monitoring site serves a dual purpose by providing opportunities for highway characterization and BMP effectiveness monitoring at the same location. Attributes of this site include:

1. Fulfills the "rural" AADT highway characterization monitoring requirements.
2. Fulfills the "rural" AADT BMP permit requirements for toxicity monitoring.

Sheet flow runoff from one and one half lanes of SR 9 enters the VFS. At the edge of the shoulder pavement, an EOP interceptor will be installed to capture the highway characterization sample as well as the VFS BMP influent sample.

Figure 7 shows the drainage area and location of the proposed EOP (which still has to be built) at the SR 9 monitoring site.

Figure 7 SR 9 highway characterization site (near Marysville).

6-4 Interstate-90 (Urban Eastern Washington AADT)

One highway characterization location is required for stormwater monitoring in eastern Washington, with an AADT designation of urban (≤100,000 and ≥30,000 AADT). The most suitable location is along westbound I-90 at the Exit 289 on-ramp. This station is located at MP 289.55, behind a Jersey barrier along the WSDOT right of way. Monitoring equipment will be stationed within the WSDOT Pines Maintenance Facility property that borders the site to the north (see Figures 8 and 9).

Figure 8 I-90 highway characterization site (urban AADT, beside Pines Maintenance Facility in Spokane).

Runoff will be collected from the edge of the pavement, using typical concrete curb to intercept runoff behind the Jersey barriers to a safe distance from the highway (see Figure 9).

Figure 9 **Proposed curb location behind Jersey barrier (I-90 in Spokane).**

6.5 Summary of Highway Setting and Details

6.5-1 Drainage Area Confirmation Methods

Drainage areas conveying water to the EOP monitoring stations were defined using WSDOT's Geographic Information System (GIS) Workbench (WSDOT, 2011) or the Design Office's Computer Aided Design (CAD) files. Mapping and documenting conveyance systems is an ongoing effort at WSDOT. Using as-built and design drawings in combination with field survey verification with global position systems (GPS) allows staff to verify the exact collection system information.

6.5-2 Time of Concentration Methods

Permit sections S7.B.3 and S7.B.6 require automatic flow-weighted composite samplers to be programmed to begin sampling as early in the runoff event as feasible and to continue sampling past the longest estimated time of concentration. Time of concentration provides a measure to ensure the time pacing is set to obtain a representative sample and to ascertain whether contributions from the entire basin are represented. All estimated times of concentration will most likely be less than one hour, which is the minimum time the automatic sampler will be programmed for sample collection in order to meet this permit requirement. Time of concentration is defined as the largest combination of overland flow time (sheet flow, swale or ditch flow, and storm drain, culvert, or channel time). The Natural Resources Conservation Service (NRCS) specifies using the Manning kinematic equation (Overton and Meadows, 1976) for calculating sheet flow time travel over distances of less than 300 feet. Time of concentration (T_c) sheet flow is shown in Equation 5, using methodology from the Soil Conservation Service (SCS) Technical Release 55 (SCS, 1986).

Equation 5: Time of Concentration

$$T_{c\text{ sheet flow}} = \frac{0.007(n\mathrm{L_o})^{0.8}}{\sqrt{\mathrm{R}} \times (\mathrm{s})^{0.4}}$$

Where:

T_c = time of concentration (minutes)
n = *manning's roughness coefficient*
L_o = flow length of longest distance (ft)
R = *rainfall (in)*
s = slope of flow path (ft/ft)

Flow lengths across the lanes of the freeways will be estimated from previous reports, field estimates, as-builts, aerial photography, or WSDOT's GIS Workbench files.

Slopes used for each site come from field laser level measurements or WSDOT documentation. The slopes of the shoulders and highways may differ slightly, but the overall slope was calculated as if they existed on the same plane.

Table 12 lists the highway runoff site characteristics and the calculated time of concentration based on a range of rainfall depths that are typical to Washington State. The time of concentration is shown based on Equation 5, using a Manning's roughness coefficient of 0.011 for concrete or asphalt. The range in rainfall depths (0.15 to 2.00 inches) used to calculate the time of concentration is based on rainfall values that the sites may experience. A precipitation analysis prepared for WSDOT by MGS Engineering Consultants, Inc. was accessed in January 2011 (🖰 http://www.mgsengr.com/Precipitation.html) to verify rainfall intensity rates.

Based on these calculations, the maximal total time of concentration for highway runoff at any site is approximately 6 minutes for the lowest rainfall depth of 0.15 inch. Six minutes is a relatively low number; therefore, the autosamplers will be programmed to stop compositing samples after the 6-hour inter-event period has occurred.

Table 102 Highway site characteristics and times of concentration for typical seasonal storms.

Site Location	Flow Length of Longest Path	Drainage Area (ac)[2]	Rainfall at 0.15"		Rainfall at 2"	
			Tc (min)[4]	Qp (L/min)[5]	Tc (min)[4]	Qp (L/min)[5]
I-5 Everett, MP 197.27	136[1]	0.05	5.78	0.46	2.42	6.17
I-5 Everett, MP 197.35	136[1]	0.05	5.78	0.46	2.42	6.17
I-5 Pilchuck, MP 210.71	93[1]	0.03	1.97	0.26	1.32	3.50
SR-9 Marysville, MP 18	121	0.04	3.93	0.32	2.59	4.32
I-90 Spokane, MP 289.54[3]	172	0.13	5.48	1.11	1.87	14.81

[1] Lane width is 12 feet and shoulder width varies between 5–12 feet (FHWA, 2007).

[2] Drainage area is the flow length multiplied by the width of the EOP.

[3] Values are from field measurements instead of WSDOT documentation.

[4] Tc: Time of concentration (minutes)

[5] Qp (L/min): Peak flow (liters/minute)

Note: Table 12 represents the best available information to date for highway monitoring sites.

7 Sampling Process Design

The sampling process design was developed based on monitoring requirements identified in the permit and in TAPE. This section addresses sampling experimental design to ensure the data collection and monitoring methodologies satisfy the requirements of the permit and data of known quality are generated from this monitoring effort.

7-1 Monitoring Set-Up for EOP Highway

A high-density polyethylene (HDPE) pipe with a one-quarter section removed will be buried and mortared to the edge of pavement to the level that water can freely enter. Figure 10 shows the interceptor pipe. The interceptor itself will be sloped downhill slightly toward the pipe weirs and sampling equipment.

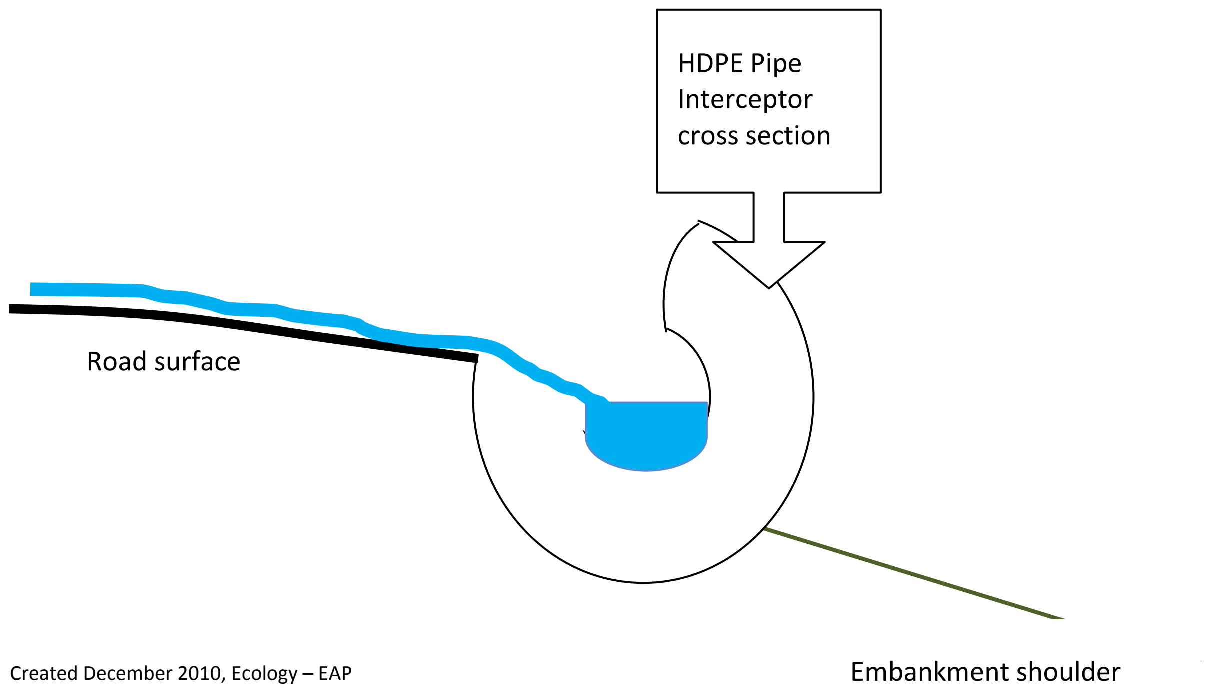


Figure 10 Cross section of EOP interceptor.

The EOP station will be used to represent the highway runoff as well as the "influent" to the BMP for BMP effectiveness monitoring. The EOP interceptor pipe design is 12 meters in length (parallel to the pavement). This design is believed to be long enough to capture adequate volume of stormwater to monitor the required list of parameters in Table 15. Peak flows calculated and shown in Table 12 range from 3.5 to 14.8 liters per minute for the minimum qualifying rainfall depth of 0.2 inches. Collecting adequate runoff volumes is not anticipated to be an issue based on these numbers. If these western Washington highway runoff EOPs fail to capture enough runoff, WSDOT will take corrective actions to extend the EOPs in the summer of 2012.

WSDOT intends to build the eastern Washington interceptor with a longer (80m) EOP length (see Figure 8), anticipating the dryer climate.

Figure 11 shows an example sampling layout of the interceptors at the combined highway runoff and BMP effectiveness sites. This diagram illustrates that the EOP interceptor collects sheet flow runoff from the highway and transports the stormwater downslope through an HDPE pipe to the weir for flow measurement.

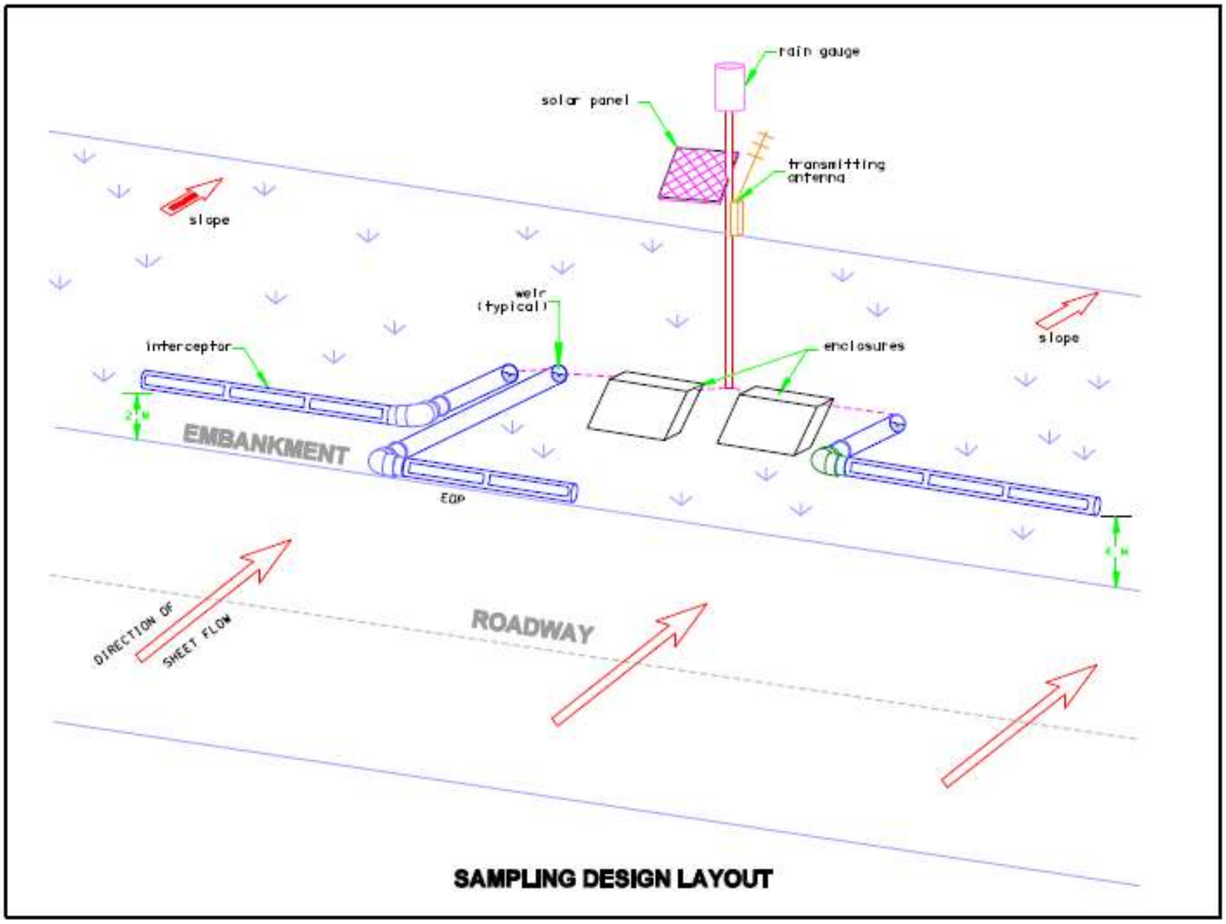


Figure 11 Example sampling design layout with EOP interceptor and sampling equipment.

A more detailed example of a data collection platform, including the pipes, weirs, and concrete pads, is shown in Figure 12.

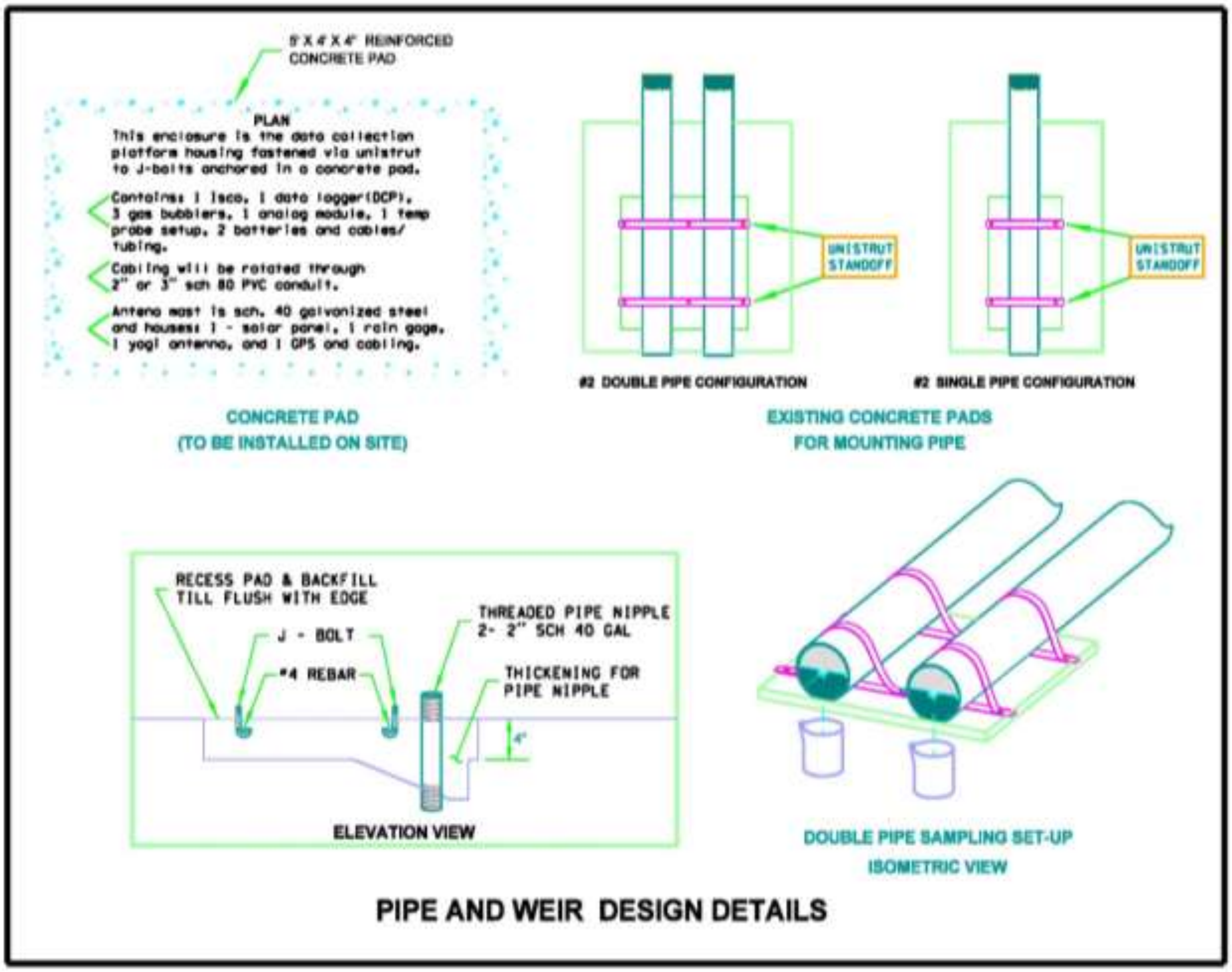


Figure 12 Example pipe and weir details.

Figures 13, 14, and 15 are line drawings of the Everett, Pilchuck, and SR 9 monitoring sites, respectively. The I-5 Everett site has two highway runoff monitoring stations and the I-5 Pilchuck and SR 9 Marysville site each has one highway monitoring station. A monitoring site refers to the physical locality and the monitoring station refers to the sample collection location.

All three of these sites serve a dual purpose as highway runoff and BMP effectiveness monitoring sites.

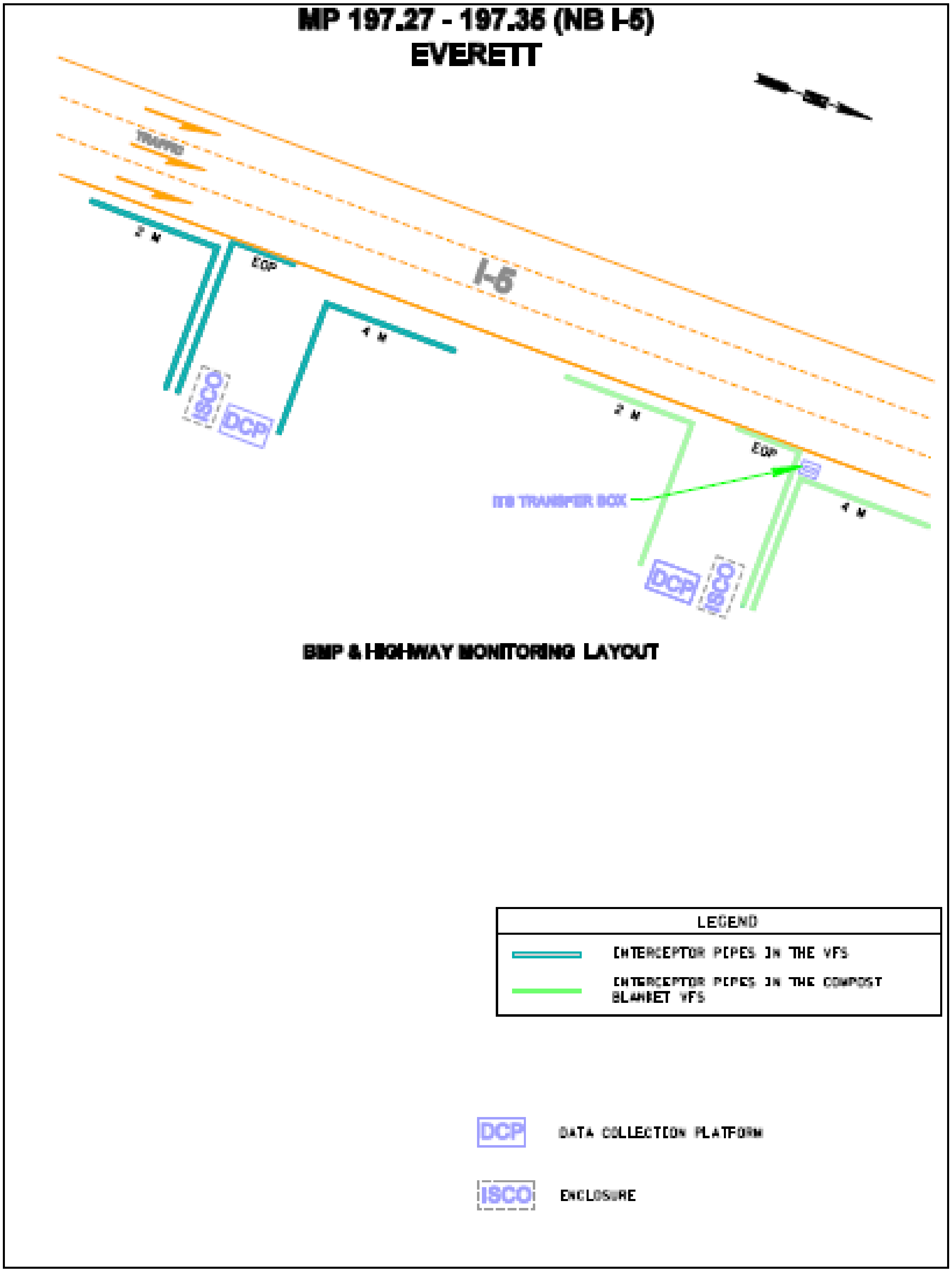


Figure 13 Line drawings of Everett.

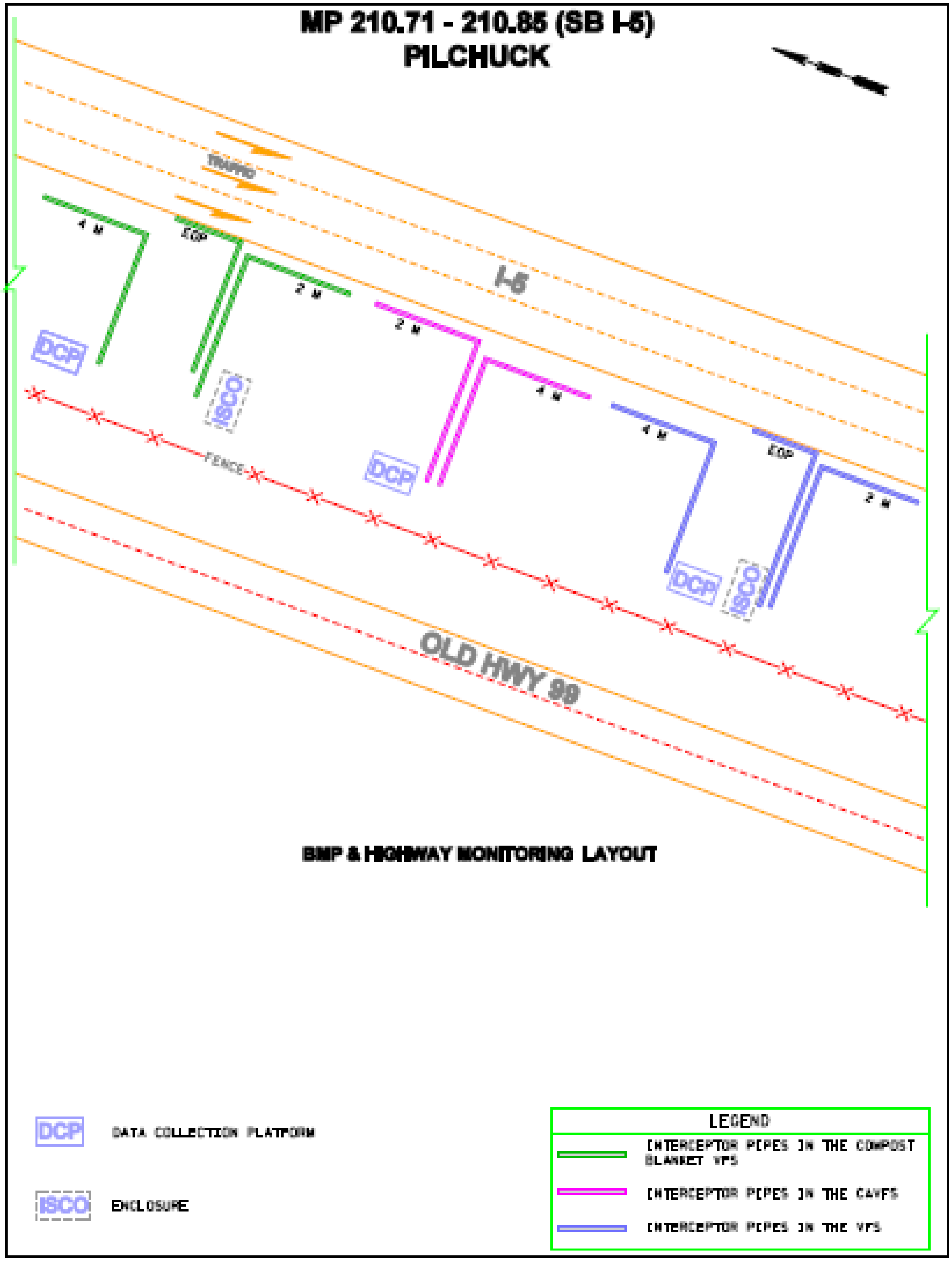


Figure 14 Line drawings of Pilchuck.

More photos are shown in Appendix E. Also shown in Figures 13, 14, and 15 are the BMPs, which are discussed in the BMP QAPP written as part of this monitoring effort.

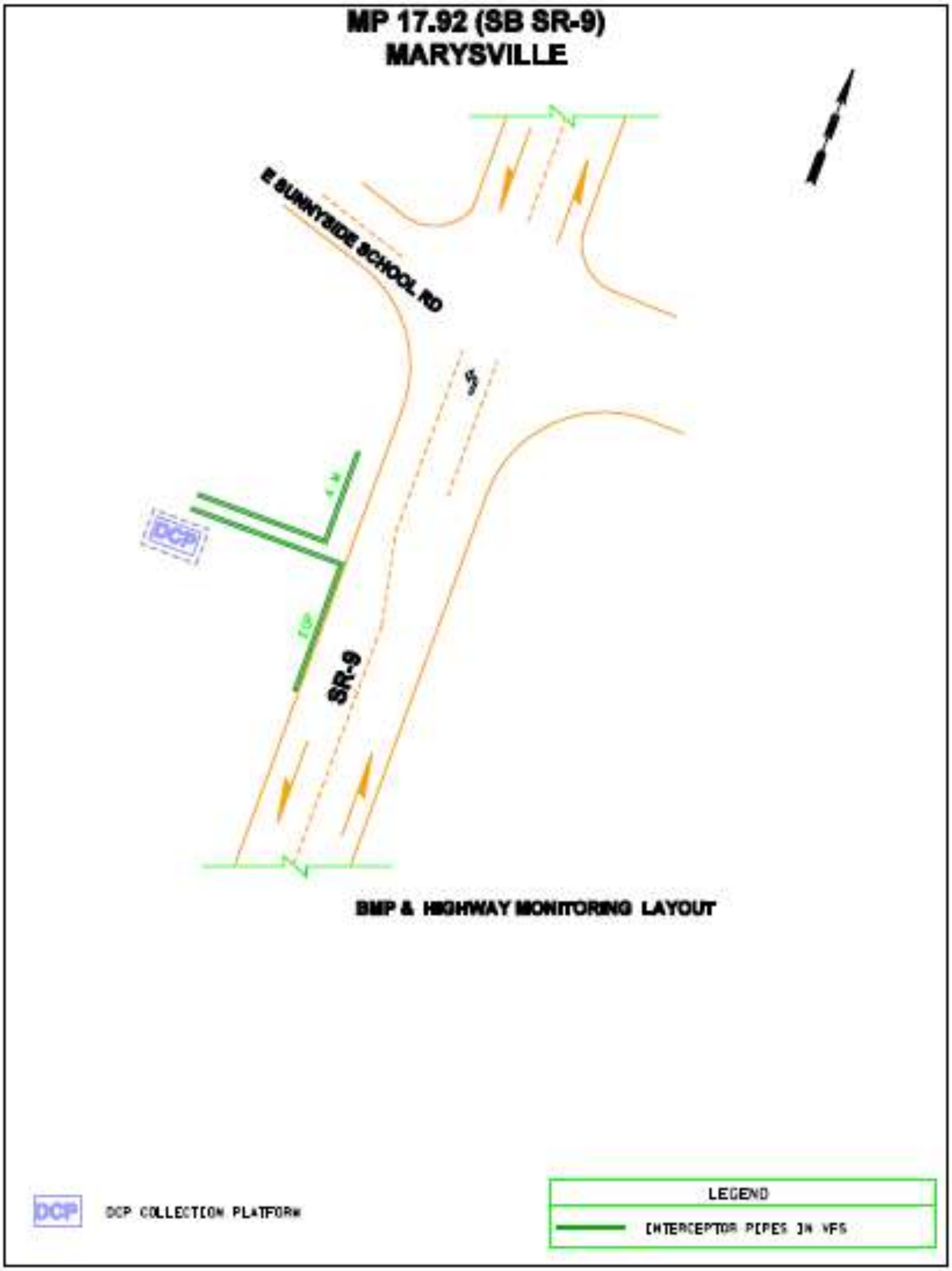


Figure 15 Line drawings of SR 9 near Marysville.

7-2 Monitoring Strategy Overview

Monitoring to characterize stormwater will require installation of monitoring stations at the selected highway characterization sites to measure stormwater quantity and quality as well as sediment quality. Table 13 lists the parameter categories, sampling frequency, and methods.

Table 113 Overview of monitoring at WSDOT highway sites.

Parameters	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 grab samples	Discrete storm events	Autosampler	No
TPH, fecal coliform, and visible sheen observation	Discrete storm events	Grab sample	No
Baseline sediment	Once annually	In-line sediment trap	No

7-2.1 Methods of Sampling

Continuous Samples

Rainfall, temperature, and stormwater flow rates will be continuously monitored at all highway station locations. A data collection platform (DCP) will be located at each monitoring location. The DCP will consist of the data logger, autosampler, and attached peripheral probes for water temperature, rain gage, and stage at the weir or flume. Data loggers will be programmed to record measurements every 15 minutes, in accordance with TAPE guidance (Ecology, 2008a). Each data logger will be equipped with a satellite antenna to telemeter flow data. These 15-minute data blocks will be saved to the internal logger memory and will also be transmitted at one-hour intervals year round to establish a site-specific characterization. Field crews will also manually download data from the data loggers. Hydrographs and hyetographs will be created from the collected rain gage and discharge data to accurately compare and relate the two parameters.

Stormwater flow rates and water quality will be continuously monitored at the following highway EOP locations:

- (2) EOP stations on I-5 NB near Everett
- (1) EOP station on I-5 SB near Pilchuck Creek
- (1) EOP station on SR 9 SB near Marysville
- (1) EOP station on I-90 WB at Spokane

Grab Samples

Section S7.B.4.b of the permit states that grab samples should be collected as early in the runoff event as practical, but gives permission to collect grabs from nonqualifying events as well.

Grab samples are typically those collected manually in jars or measured in situ with a probe. Stormwater characterization of WSDOT highways requires grab samples for fecal coliform, TPH, temperature, and visible sheen. Fecal coliform and TPH will be collected by hand. Temperature will be measured using a probe. The entire length of the EOP interceptor will be visually inspected for oil sheen and noted on field forms as presence/absence. Ecology's SOP for Collecting Grab Samples from Stormwater Discharges will be followed (Ecology, 2009c).

Annual seasonal first flush toxicity sampling has only one grab sample requirement for total petroleum hydrocarbon (TPH), both gas and diesel fractions, which are discussed further in the Appendix C, Toxicity Guidance.

Composited Samples

The permit specifies that stormwater runoff must be collected by flow-weighted compositing. Refrigerated autosamplers such as ISCO's Avalanche or a similar product will be used at each of the monitoring stations to collect stormwater samples during a qualifying storm event. Autosamplers will be programmed to begin sampling at the predetermined rates required for analysis. Sample collection into autosampler bottles will be triggered by a three-step threshold system. The three thresholds are:

- Rainfall, to ensure a storm event is occurring.
- Presence of runoff, to ensure water is flowing through the conveyance system.
- Water temperature, to prevent sampling during freezing conditions.

Water temperature, rainfall, and stage will be measured using external probes connected to the data logger. If these three thresholds do not meet the programming criteria, samples will not be collected. Each monitoring station will be equipped with a refrigerated compositor and a pre-cleaned glass bottle for sample containment. Ecology's SOP for Automatic Sampling for Stormwater Monitoring will be followed (Ecology, 2009b; WSDOT, in draft 2011).

Annual Sediment Samples

As required in S7.B.7 of the permit, sediment samples will be collected annually from the EOP at least once each year at each of the five highway EOP monitoring locations. At each site the sediment grab sample will be collected by stainless steel spoons or HDPE scoops from a minimum of five subsamples within the interceptor. They will then be homogenized in stainless steel bowls and transferred to appropriate jars for chemical analysis.

Because the four western Washington highway runoff monitoring locations serve a dual purpose as the BMP influent, the sediment volume will also be monitored. Sediment volume is a requirement under TAPE guidance for BMP sites. The amount of sediment that accumulates in the EOP will be measured prior to the collection or cleaning and the date noted on field forms. A tape measure will be used to measure the width of the sediment accumulation and a ruler will be used to estimate the depth in five locations. Values will be averaged to determine the average depth in the structure. Sediment volume will be estimated using the average depth, the geometric shape of the EOP, and the width of sediment accumulation. Gross solids such as debris, litter, and other particles exceeding 500 microns in diameter will be removed from the samples.

7-2.2 Monitoring Timeline

A general timeline for highway characterization monitoring is presented in Table 14.

Table 124 Timeline of highway monitoring events.

Timeline	Event	Purpose
November 2010	Hydrological equipment is installed at two I-5 monitoring sites (Pilchuck and Everett)	Monitoring the rainfall and runoff hydrology for a period of time before the permit monitoring is required will improve understanding of the site's characteristics
March 2011	Geotechnical assessments of soils are conducted	Site soils, porosity, and infiltration characterization
Spring 2011	A single storm grab sample is collected for TSS and PSD sample from the four western Washington highway runoff/BMP monitoring sites	Required in TAPE to assess the site suitability for BMP installation
August 2011	Receiving water monitoring may be conducted at three western Washington highway runoff/BMP monitoring sites	Suggested for toxicity
September 6, 2011	Full implementation of the permit is required	WSDOT will begin monitoring for seasonal first flush toxicity
October 1, 2011	Permit monitoring begins	Full permit monitoring effort begins
May 2012	Field audit	Permit compliance
May 2013	Field audit	Permit compliance
May 2014	Field audit	Permit compliance

7-2.3 Parameters

S7.B.4, S7.B7, and S7.C.4 of the permit specify the required parameters for baseline highway runoff characterization, annual sediment testing, and seasonal first flush toxicity testing, respectively. These parameters are listed in Table 15, in the priority order of analysis.

Stormwater samples will be collected by either grab or composited techniques, as required by the permit. If an insufficient sample quantity is collected, WSDOT is advised to process the sample for the next-highest priority pollutants in accordance with the volume requirement. Sampling for toxicity is the exception to this advice and is further discussed in Section 7-3, Annual Seasonal First Flush Toxicity Monitoring.

Table 135 Water quality and sediment parameters to be monitored, in order of priority (Ecology, 2009a).

Baseline Highway Stormwater Monitoring	Annual Sediment Monitoring	Seasonal First Flush Toxicity Testing (Stormwater)[3]
Total recoverable and dissolved metals (Cd, Cu, Zn, Pb)	Particle size (grain size)	*Hyalella azteca* 24-hr acute toxicity test
PAHs	Total org. carbon (TOC)	Total recoverable and dissolved metals (Cd, Cu, Zn, Pb)
TSS	Total recoverable metals (Cu, Cd, Zn, Pb)	Herbicides (if used in drainage area)[4]
Chlorides	PAHs	TSS
Phthalates	TPH-Diesel (NWTPH-Dx) + (visible sheen)[2]	Chlorides
Herbicides (if applied near the monitoring site vicinity)[4]	Phenolics	Hardness
Nutrients: total phosphorus and orthophosphate	Herbicides (if used in drainage area) [4]	Methylene blue active substances (MBAS)
Hardness[1]	Phthalates	Polycyclic aromatic hydrocarbons (PAHs)
TPH-Diesel and Gas (NWTPH-Dx and NWTPH-Gx)[2]	Total solids (percent solids)	Phthalates
Fecal coliform[2]		TPH-Diesel and Gas (NWTPH-Dx and NWTPH-Gx)[2]
Temperature[2]		pH[5]
Visible sheen observation[2]		
pH[5]		

[1] Not permit-required for highway characterization monitoring, but is recommended, and is required for toxicity monitoring. The Project Manager will decide whether the data will be reported in official documents.

[2] Grab sample.

[3] Hardness, conductivity, dissolved oxygen, and pH will be measured on seasonal first flush toxicity samples by the toxicity laboratory at a minimum.

[4] Limited to the herbicides listed in the permit and applied within the drainage area.

[5] Required for shared highway and BMP monitoring sites for TAPE compliance and/or toxicity sampling.

Herbicides

The permit requires herbicide monitoring at highway sites only "if applied near the monitoring site vicinity." For annual sediment monitoring and first flush toxicity, the permit requires herbicide monitoring "only if applied in the monitoring site drainage area." The drainage area for the highway is assumed to mean only the area contributing runoff collected at the monitoring site at the edge of the highway.

Based on WSDOT's current and historical records of usage from 2008 to the present, the herbicides listed in the permit that were used at the selected highway sites are:

- Everett I-5 MP 197.27: Glyphosate (nonaquatic formula)
- Everett I-5 MP 197.35: Glyphosate (nonaquatic formula)
- Pilchuck I-5 MP 210.71: Glyphosate (nonaquatic formula)
- Marysville SR-9 MP 17.92: Glyphosate (nonaquatic formula)
- Spokane I-90 MP 289.54: Diuron, picloram, triclopyr (ester formula), and glyphosate (nonaquatic formula)

WSDOT will communicate with staff at least annually to stay up to date on the application of herbicides near the monitoring locations and adaptively manage sampling to meet permit requirements. These yearly reviews will be used to update the list of herbicides to be monitored at each site. Modifications to the list of herbicides and fertilizers to be monitored will be made using an addendum to this QAPP.

S7.B.4 of the permit provides the list of herbicides that WSDOT would need to monitor:

- Triclopyr (ester formula only)
- 2,4-D
- Clopyralid
- Diuron
- Dichlobenil
- Picloram
- Glyphosate (nonaquatic formula only)

From this list, anytime the herbicide triclopyr is mentioned later in the permit, it is assumed that triclopyr (ester formula only) is implied.

7-3 Annual Seasonal First Flush Toxicity Monitoring

This section describes the toxicity study design for required seasonal first flush toxicity sampling from the three highway EOP monitoring stations. The sampling process design was developed based on the monitoring requirements identified in the permit and recommended procedures from Ecology (ASTM E1192-97).

7-3.1 Toxicity Target Population

S7.C.1 of the permit requires that WSDOT "collect six toxicity screening samples and associated chemical analyses at least once per monitoring year in August or September." Samples will be collected with at least a one-week antecedent dry period (or October, irrespective of antecedent dry period, if unsuccessful in August or September). The permit's toxicity guidance (see Appendix C) states that "WSDOT shall not be required to make more than two sample attempts for toxicity testing described in S8.C." Presumably, this reference to S8.C actually meant to refer to S7.C, because S8.C refers to records retention. WSDOT will only make two attempts annually to collect seasonal first flush toxicity testing samples from the highway EOP.

The seasonal first flush toxicity will be tested for screening purposes only. If a qualifying event is missed despite documented good faith efforts, or if the sample is invalid or has an anomalous test result, a second sample collection will be attempted if sufficient time remains to meet the toxicity storm event criteria. If the second attempt is unsuccessful, then no additional attempts will be made that calendar year.

7-3.2 Toxicity Monitoring Requirements

Annually, one seasonal first flush toxicity sample will be collected from each of the following highway characterization monitoring locations:

- EOP Station on I-5 NB at Everett
- EOP Station on I-5 SB at Pilchuck
- EOP on SR 9 at Marysville

It may prove difficult to collect sufficient volume for toxicity sampling from the relatively small areas contributing to the runoff at these highway monitoring sites. The total volume required for toxicity testing and associated chemical analyses is in the range of 9.9 liters, without any extra volume for chemical duplicates. If a minimum volume of 2.0 liters (1.2 liters for toxicity at 4 replicates at 4 concentrations and 100 mL per replicate and 0.8 liters for metals and chloride) is not collected, then the sample will not be analyzed. Table 16 lists the parameters to be tested when the volume collected is between 2.0 and 9.9 liters, as well as the parameter priority, in descending order, when the volume collected is less than 9.9 liters. The irregular intervals of sample volume for toxicity and chemistry combined are due to variations in sample quantity needs for different parameters. Any excess sample volume that is not used for toxicity testing or chemistry will be reserved for use during follow-up actions outlined in Appendix F.

The toxicity lab will measure conductivity, dissolved oxygen, and pH for each site once the samples reach the laboratory.

To improve the chances of collecting enough volume, an additional autosampler will be placed at each toxicity EOP sampling location. Toxicity autosamplers will be preset and deployed by field staff just before the first qualifying seasonal storm in order to collect a composited toxicity sample.

A decision will be made by the Field Lead and Project Manager on whether to program the autosampler for time-weighted (equally time-spaced subsamples) or flow-weighted compositing programs. S7.C.5 of the permit allows flexibility in the sampling method between time- or flow-weighted compositing programs when collecting seasonal first flush toxicity samples only. Time-weighted sampling would likely provide larger volumes for the average storm; however, the chemistry data will not qualify for the baseline highway characterization monitoring if not collected by the flow-weighted sampling program. Seasonal first flush toxicity samples will be collected in a sterilized glass carboy and capped with Parafilm® to prevent contamination. Use of a modified clean hands/dirty hands technique to prevent field contamination of samples is not required but will serve as a guideline for clean field practices.

Grab samples for TPH for toxicity testing will be collected into an appropriate jar and sent to a laboratory for measurement. The method of grab collection may vary due to access to the discharged stormwater: a jar may be held by hand or fixed to a pole sampler. Refer to the SOP for Collecting Grab Samples from Stormwater (Ecology, 2009c) for further details on this method.

WSDOT must notify the toxicity laboratory two days prior to the date of the forecasted storm event, and they must be notified upon sample collection that the field trip was successful.

Table 146 Toxicity order of priority for sampling (Ecology, 2009a).

Volume (L) Obtained [1]	Sample Volume (L) Toxicity and Chemistry	Sample Volume (L) for Toxicity	Toxicity Test Details[1]	Sample Volume (L) for Chemistry	Chemistry Analyses Performed
2.0-2.4	2.0	1.12	4 reps, 4 concentrations, 100 mL per replicate	0.8	Metals, Chloride
	2.1			0.9	Metals, Chloride, Hardness
2.4-3.0	2.5	1.15	4 reps, 5 concentrations, 100 mL per replicate	1.3	Metals, Chloride, Hardness, MBAS
	2.9			1.7	Metals, TSS
	3.0			1.8	Metals, TSS, Chlorides
3.0-6.0	3.1	1.4	4 reps, 5 concentrations, 125 mL per replicate	1.7	Metals, TSS
	3.2			1.8	Metals, TSS, Chlorides
	3.3			1.9	Metals, TSS, Chlorides, Hardness
	3.7			2.3	Metals, TSS, Chlorides, Hardness, MBAS
	4.7			3.3	Metals, TSS, Chlorides, Hardness, MBAS, PAH
	5.2			3.8	Metals, Herbicides[2]
	5.3			3.9	Metals, Herbicides,[2] Chloride
	5.4			4.0	Metals, Herbicides,[2] Chloride, Hardness
	5.8			4.4	Metals, Herbicides,[2] Chloride, Hardness, MBAS
>6.0	7.3	2.5	4 reps, 5 concentrations, 250 mL per replicate	4.8	Metals, Herbicides,[2] TSS
	7.4			4.9	Metals, Herbicides,[2] TSS, Chlorides
	7.5			5.0	Metals, Herbicides,[2] TSS, Chlorides, Hardness
	7.9			5.4	Metals, Herbicides,[2] TSS, Chlorides, Hardness, MBAS
	6.4			8.9	Metals, Herbicides,[2] TSS, Chlorides, Hardness, MBAS, PAH
	7.4			9.9	Metals, Herbicides,[2] TSS, Chlorides, Hardness, MBAS, PAH, Phthalates

[1] Laboratory guidance for *H. azteca* is discussed in detail in Appendix C. Replicate totals and volumes needed are listed.

[2] Limited to the herbicides listed in the permit and used within the drainage area by WSDOT.

The toxicity sample must be cooled and sent to the laboratory immediately. If the sample temperature exceeds 6°C by its receipt at the laboratory, the Ecology WET coordinator must be contacted for conditional acceptance for a sample temperature deviation. Acceptance of a temperature deviation will be based upon Ecology's "Laboratory Guidance and Whole Effluent Toxicity Test Review Criteria" (Ecology, 2008b). Temperature deviations will not be granted for samples warmer than 14°C unless the sample is received within one hour of collection.

The toxicity guidance (see Appendix C) suggests that WSDOT collect additional samples of the stormwater and receiving waters. The purpose of these additional samples would be to improve the understanding of the toxicant in the stormwater and to gather enough information for use in the Biotic Ligand Model. WSDOT may collect a grab sample for hardness from the receiving water, which will be collected and sent to the laboratory for hardness correction of the stormwater samples. Other parameters suggested for receiving water monitoring, permit-suggested toxicant identification testing, and required follow-up actions are discussed in Appendix F.

7-3.3 Toxicity Data Management and Follow-Up Requirements

The permit allows for adaptive management in analyzing for toxicity parameters. S7.C.4 of the permit states “Chemicals below reporting limits after two years of data analysis may be dropped from the list of parameters.” This pertains only to the toxicity parameters in Table 16.

The permit’s toxicity guidance (see Appendix C) encourages preparation of a toxicity identification plan for identifying a toxicant if the list of chemical analytical results did not point to a likely toxicant. A plan for interpretation of toxicity test results and permit-required follow-up actions is discussed in detail in Appendix F. These follow-up actions include suggested monitoring for indentifying the toxicant if still unknown. An additional parameter, cobalt thiocyanate activating substances (CTAS), may be analyzed if the toxicant identity is unknown and nonionic surfactants may be present.

8 Sampling Procedures

The following sections describe the methods and procedures for identifying, organizing, collecting, maintaining, and processing samples, equipment, and data in the field. Any field sampling for this project will follow these specific guidelines.

8-1 Storm Event Targeting Procedures

Satellite imagery and model predictions will be used as a basis for weather information provided by the National Oceanic and Atmospheric Administration, the National Weather Service, and/or private forecasters. These predictions will be evaluated by the Field Lead to determine potential qualifying storm events. As candidate storms approach, radar observations and hourly reports from land-based weather stations will be used to track and evaluate storm progress. Land-based weather stations include universities, news programs, or state and national agencies, and they will be observed via the Internet.

The minimum rainfall criterion set forth in the permit is a rainfall depth of 0.20 inch; however, TAPE guidelines for BMP sites set the rainfall depth at 0.15 inch. This means that for a storm event to qualify for permit compliance, these minimum rainfall criteria must be met. Autosamplers and WSDOT field crews may initiate sampling before the minimum rainfall has accumulated so that the entire hydrograph is sampled for highway and BMP monitoring sites.

Establishment of the rainfall-runoff relationship will help guide sampling, to minimize the sampling of storms that do not qualify. Establishment of this relationship has begun at two I-5 EOP stations. For example, runoff has been determined to begin at less than 0.10 inch of rainfall based on preliminary data. This information can be used to program equipment to better capture the beginning of the storm hydrograph.

Snowmelt alone will not be considered a qualifying event. Snowmelt accompanied by rainfall (typically called sleet) and a rain-on-snow event are considered qualifying events that will be monitored. Once a storm is determined to be a candidate for measurement, the Field Lead will notify the appropriate personnel (and appropriate laboratories) and initiate mobilization for stormwater sampling as soon as feasible.

These decisions and further explanations regarding staff training are documented in the SOP for Decision Matrix for Targeting Storm Events (WSDOT, in draft 2011). This SOP will also inform staff on the decision-making process to mobilize for criteria versus a noncriteria storm event. The estimated duration and estimated rainfall used in the decision (the "*Go*" decision) to initiate sampling procedures will be logged on storm-tracking forms (see example form in Appendix G) and stored in WSDOT central files, along with a printed copy of the forecast. A diagram of the series of decisions and events for sampling is shown in Figure 16.

The Field Lead will notify the sampling field crew to begin pre-event preparation for stormwater sampling. Given the logistical difficulties in getting to the sampling sites, the Field Lead may make the decision based on storm size (for example, if the storm is predicted to be small) not to deploy the sampling team for a grab sample.

8-2 Pre-Event Preparation Procedures

Figure 16 is a simplified flow diagram of the decisions and actions needed for successful sampling.

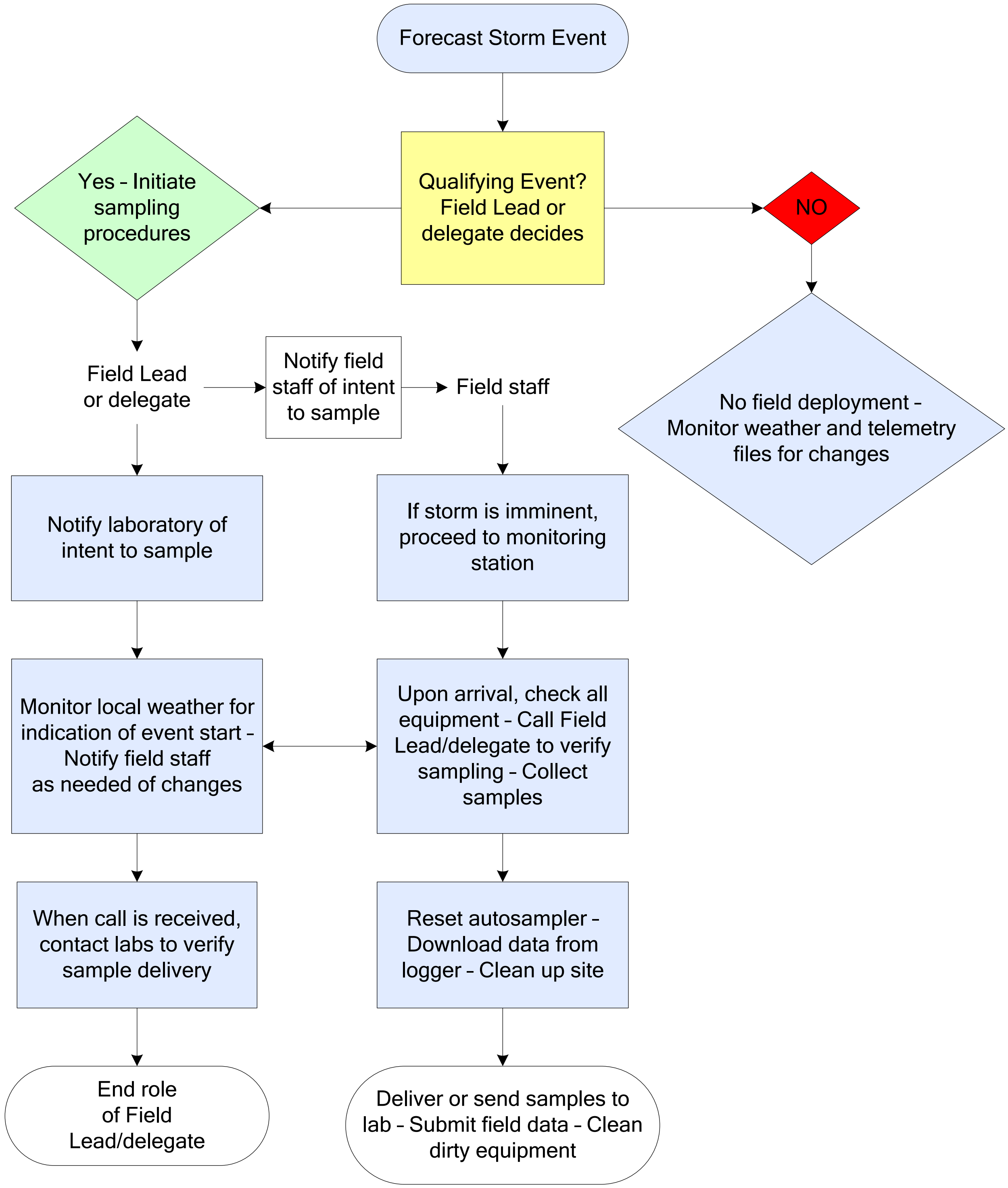


Figure 16 WSDOT sampling procedures flow diagram.

8-2.1 Trip Preparation

When a storm has been categorized as "qualified" by the Field Lead, it may be necessary to be on-site before the rainfall begins in order to be ready for early event grab sampling. In certain areas, this may require time allocations for commutes or for hotel arrangements prior to the storm events. Draft packing lists and trip checklists, with detailed instructions, will be used; example lists are included in Appendix H. Prior to deployment, field technicians are responsible for packing all necessary equipment for site maintenance, sampling, and sending the samples to the lab. Due to the potential for short notices for storm events, the travel vehicles should be staged and ready.

Monitoring the telemetered data from a mobile Internet-capable device will assist in the timing of field deployment. Deployment timing will depend on when the level of rainfall predicted to generate runoff begins. After each sampling event, autosamplers will be reset for the next sampling event; therefore, crews will be prepared to clean the sampler and exchange bottles and equipment as necessary.

8-2.2 Lab Notification

Once samples are collected, the field technicians must notify the laboratories whether sampling was successful and whether they need to prepare for the reception of samples. If the sampling trip is to collect the seasonal first flush toxicity samples, the field technician is responsible for notifying the appropriate laboratories 48 hours in advance of the storm event for toxicity testing.

8-2.3 Site Preparation

Upon arrival at the monitoring site, field technicians will visually inspect sampling equipment activity in progress. Any necessary alterations will be catalogued and reset to ensure sampling precision. If field crews arrive before sampling begins, they will:

- Check the data logger program to verify sampling will take place when the step triggers have been satisfied.
- Inspect autosamplers to verify bottles are appropriately set and tubing is attached properly at the sampling point.
- Check the leveling of flow-measuring devices (weirs, flumes, etc.) and remove any obstructions and sediment that could impede the flow of stormwater.
- Prepare for grab sampling.

8-3 Monitoring and Maintenance Procedures

8-3.1 Precipitation Measurement

At each monitoring site, pole-mounted tipping bucket rain gages will be deployed to accurately represent on-site rainfall characteristics. Rain gages must be installed in a secure, level fashion in a location where no buildings, trees, overpasses, or other objects obstruct or divert rainfall prior to entering the rain gage. Rain gage placement will, to the best of WSDOT's ability, follow the

National Weather Service specifications (http://www.weather.gov/om/coop/standard.htm). Rain gages will be calibrated prior to the onset of permit monitoring and maintained in accordance with the manufacturers' specifications.

Rain gage data are collected every 15 minutes and stored in the data logger's memory. In addition, the rain gage data are broadcast hourly via telemetry to a WSDOT database in order to remotely identify on-site weather characteristics. During each station visit, the rain gages will be inspected, cleared of debris, and maintained in accordance with the manufacturers' specifications. Rain gage data will be downloaded from the logger for each storm event or during the maintenance checks.

8-3.2 Discharge Measurement

Discharge will be calculated by the data logger using stage values combined with equations specific to the gaging device (weir or flume). Discharge data will be plotted with the rainfall data in a site-specific rating curve. Pipe weirs (Thel-Mar type) tend to be preferred over Parshall flumes in lower-flow "flashy" systems in order to more accurately characterize small-scale hydrological features (Rantz et al., 1982, and USEPA, 2002b).

Equations for v-notch pipe weirs are derived specifically for each weir and will be provided by the manufacturer. Refer to the USGS *Water Supply Paper 2175* and the USEPA *Urban Stormwater BMP Performance Monitoring* guidance manual (EPA-821-B-02-001) for additional flume and weir equations and applications (Rantz et al., 1982, and USEPA, 2002b).

Flow-Monitoring Equipment

Pipes will be fitted with Thel-Mar-type removable weirs or Parshall flumes (as shown in Figure 17). Thel-Mar-type v-notch weirs may be installed to improve the accuracy of stage height readings for lower flows.

Water quality samples collected by the autosampler or manually will be gathered from a collection device that is mounted at the outlet beyond the weir and flume. Peripheral sensors will be fitted to a pipe extension.

A stage measuring device (such as a gas bubbler or pressure transducer) will be installed behind the weirs or in the flume stilling wells. These instruments will be connected to data loggers to record water level measurements. DC power from solar panels and batteries will be used if access to AC power is not possible. Monitoring equipment will be housed in protective enclosures. Enclosures will be installed on concrete pads or anchored securely to the ground via driven anchors near the sampling location. Tubing and sensor cables will be routed to the enclosures in protective conduit. Routine maintenance and calibration training will be captured by the SOP for Equipment Calibration and Cleaning (WSDOT, in draft 2011).

Figure 17 Photos of Thel-Mar-type v-notch weir and 1-inch throated Parshall flume.

8-3.3 Grab Sampling

Two types of grab samples will be collected for monitoring. Water grab samples will be collected throughout the year when storm events occur. Sediment grab samples will be collected once a year and do not require a storm event to be occurring during collection.

Stormwater Grab Samples

Manual collection of grab samples for TPH and Fecal coliform will begin as early in the runoff event as feasible. Visible sheen will be observed (if present) by staff. If the drainage area is very small, field staff may need to be on-site before the storm begins in order to prepare for grab sampling. Grab samples will be collected either by using an appropriate pole sampler with a bucket or claw for holding the sample jar or by hand into the sample jars, following the guidance in the SOP for Collecting Grab Samples from Stormwater Discharges (Ecology, 2009c).

Hand-held portable meters may sometimes be used to enhance stormwater characterization by measuring water quality parameters, although this is not required for permit compliance. Field grab sampling efforts and other activities will be documented on a field sampling form (see example in Appendix H).

Annual Sediment Grab Samples

A sediment sample will be collected from the EOP interceptor on an annual basis. This interceptor device will be used as an in-line sediment trap. Sediment accumulation is believed to occur rapidly. A sample will be collected once enough sample has accumulated to process all analytes required by the permit. Sediment will be allowed to accumulate within the EOP interceptor until it poses an interference with stormwater conveyance, at which point it will be removed and processed.

At each site the sediment grab sample will be collected by precleaned stainless steel spoons or HDPE scoops from a minimum of five subsamples within the interceptor. Cleaning of spoons and bowls will be done to EPA QA/QC specifications (USEPA, 1992). Sediment will be homogenized to uniform color and consistency by stirring in precleaned stainless steel bowls with precleaned stainless steel spoons. Subsamples of the homogenate will be placed in appropriate glass jars for laboratory analysis and sealed in two polyethylene bags prior to shipment to the laboratory.

8-3.4 Composited Sample Retrieval

Upon completion of sampling, the data logger and autosampler will return to normal operating modes. The autosampler will be ready for the field technicians to recover the sample bottles. Field personnel will wear nitrile gloves at all times during sample collection and follow standard health and safety procedures. Preservation and filtration of samples (if needed) will occur immediately after composited samples have been collected.

Upon completion of sampling, prefabricated labels will be verified and samples will be placed in coolers with bubble wrap and blue ice packs for transport. Chain of custody (COC) forms will be filled out completely and sent with the coolers (see Appendix I for an example COC form from Ecology's Manchester Environmental Laboratory).

Collection of blanks will occur as scheduled and be included in the transport coolers.

The autosampler will then be inspected, cleaned, and restocked according to a Field Sampling with Autosamplers SOP specific to WSDOT's program for field crew training (WSDOT, in draft 2011). Ecology's SOP for Automatic Sampling for Stormwater Monitoring (Ecology, 2009b) will serve as a guide. An important aspect of cleaning and restocking the autosampler will be switching the bottles on an as-needed basis.

8-3.5 Field Filtration

Prefiltration Holding Time

Orthophosphate and dissolved metals will be filtered in the field within 15 minutes of final aliquot collection. If filtering occurs between 15 minutes and 24 hours, the sample will be *J* qualified. If field filtering occurs after 24 hours for both orthophosphate and the dissolved metals, then the sample will be rejected and labeled with an *R* on the field forms. Field sampling efforts, including filtration and other activities, will be documented on a field sampling form (see example in Appendix H).

Metals Sample Collection/Handling

A modified version of the EPA's "clean hands/dirty hands" protocol for low-level detection of metals (USEPA, 1996) will be used as a guideline during sample collection. A modified version of the protocol will allow sampling to be performed by one field technician as opposed to two.

Accordingly, the laboratory will preclean laboratory bottles for metals, as required for the analytical method. The laboratory will then place the metals bottles into two separate Ziploc® (or comparable) sealed plastic bags for transport to the site. Prior to sample collection, the field technician will wear a new set of gloves (i.e., clean and powder free) for each sequence of clean or dirty hands sampling that is required for proper implementation of the protocol. The sequence of clean and dirty hands operations to be used during sampling is described in detail as follows:

Dirty Hands (two sets of new gloves):

- Open the cooler with sample bottles
- Remove double-bagged sample bottle from cooler
- Unseal outer bag

Clean Hands (remove outer set of gloves):

- Unseal inner bag containing sample bottle
- Remove bottle and unscrew cap
- Rinse bottle three times in water to be sampled (if sample contains no preservative)
- Fill sample bottle
- Return sample bottle to inner bag
- Reseal inner bag
- Reseal outer bag
- Return double-bagged sample to cooler

8-3.6 Field Sample Verification

Before sending the coolers to the laboratory, field staff must fill out field sampling forms. Draft versions of a sampling form are presented in Appendices H and I. Additionally, field staff may need to verify that the storm event met the permit requirements for storm sampling (antecedent dry period and rainfall quantity) before sending the coolers to the laboratory (see Section 9-2.2, Post-Event Processing, Preservation, and Holding Times). However, if in doubt, technicians should always send the cooler as soon as possible. They should follow up with a call to the laboratory to cancel the analysis if the Field Lead or Project Manager determines that the storm event did not meet permit criteria or whether the samples should be used as one of the three nonqualifying events. Communication between the field crew and Field Lead or Project Manager is critical and will require cellular phones.

The field technician will be able to determine the final volume of the captured sample and aliquot samples to their respective sample jars. If insufficient sample volume was collected for analysis of all parameters, parameters will be analyzed in order of priority according to the list (see Table 15). After shipping the samples to the laboratory, field technicians will return to headquarters (or the field station) and submit their field notes and copies of COC forms to the Field Lead for review.

The Field Lead will review the collected storm reports, hydrographs, field notes, COC forms, and maintenance forms to determine whether any data quality errors were made. If errors are found, notice will be given to the laboratory regarding the type of error, which sample was collected erroneously, and whether the sample should be disqualified for analysis based on the error.

If hydrograph errors are found, a ratings shift may be applied to the hydrograph. These errors must be validated by field observation of stage during storm events. A shift may be applied at any time to a rating to better fit the hydrograph to actual measurements and account for drift.

8-3.7 Telemetered Data Collection

Each station's telemetered data logger will be preprogrammed to continuously collect temperature, stage, and rainfall data, as well as composite samples when conditional requirements are met. The data loggers are programmed with a step-triggering system designed to minimize falsely triggered sampling. The step-triggering system utilizes environmental data (such as rainfall, water temperature, and stage) collected by the data logger to determine whether a storm event is qualified and whether or not to initiate sample collection. Upon qualification, the logger will wake up the autosampler and initiate its sample collection program. The autosampler will collect preprogrammed amounts in accordance with the permit requirements and analytical needs.

Temperature, rainfall, and stage data will be collected and logged every 15 minutes and transmitted every hour to the WSDOT database throughout the duration of the storm event.

Upon receipt of transmission in the central database, data will be qualified, tabulated, and stored until the data are able to be reviewed and finalized by the Data Steward.

Field technicians must download the internal memory of the data logger to a specified storage drive (thumb drive) after final stormwater samples have been collected. These data will supplement the telemetered data and be used to fill the transmission or data gaps that may have occurred.

8-3.8 Equipment Maintenance and Cleaning

Servicing of scientific instrumentation will follow manufacturers' methods or will be conducted as needed by trained technicians in a controlled environment. Routine site visits will occur every six weeks or after a sampled storm event. Refer to the Equipment Maintenance and Cleaning SOP for the specifics on instrument cleaning, station visit, and maintenance (WSDOT, in draft 2011). For specific equipment maintenance, refer to operators' manuals.

Generally, maintenance will consist of equipment inventories, inspections, testing, and replacement of worn or missing components.

Equipment Decontamination

All sampling equipment and containers will be prepared prior to the sampling event. Any portion of the autosampler (including intake screen, intake tubing, pump tubing, and sampler containers), filters, or other materials coming into contact with the sampled stormwater will be decontaminated prior to use or will be certified as precleaned from the equipment source.

Plastic or tubing will be washed or rinsed with nonphosphate soap, rinsed three times with deionized water, and air dried. Clean implements will be stored in aluminum foil or polyethylene bags for transport to the field station. Stainless steel sampling implements, including the spoons, bowls, and stirrers, will be cleaned by sequentially:

1. Washing in nonphosphate detergent and hot tap water
2. Rinsing with hot tap water
3. Rinsing with 10% nitric acid (if sampling for metals)
4. Rinsing with deionized water three times
5. Air drying in clean area free of contaminants
6. Rinsing with pesticide-grade acetone (if sampling for organics)
7. Air drying in clean area free of contaminants
8. Rinsing with pesticide-grade hexane (if sampling for organics)
9. Air drying in clean area free of contaminants

After drying, equipment will be wrapped in aluminum foil and stored in polyethylene bags until used in the field. Sampling equipment will be dedicated to the station and will only be used at subsequent stations after cleaning in accordance with the above procedures, which are based on EPA guidelines (USEPA, 1992).

8-3.9 Adaptive Management

Once experience is gained with monitoring, a process called “adaptive management” will be employed for minor or major changes. Relatively small changes to the monitoring program will not incur authoritative signature approval.

Examples of small changes include, but are not limited to:

- Sizes of bottles used in the automatic sampler
- The equipment used for field filtration
- Using a different brand of equipment but retaining functional equivalency
- Adjustments to the programming of the automatic samplers

Major changes to the sampling program are required by the permit to get signatory approval from WSDOT and Ecology prior to the changes. Major changes may include:

- Changing the sampling location at a site
- Changes in analytical methods

9 Measurement Procedures

This section describes the laboratory selection process, sample processing procedures, sample labeling and chain of custody, laboratory methods, and reporting limits.

9-1 Laboratory Selection

Laboratories have been be selected based on their current accreditation status with Ecology (http://www.ecy.wa.gov/programs/eap/labs/search.html) and their ability to achieve acceptable limits of detection for the parameters measured as part of this project. Due to the scale of sampling under this permit, multiple laboratories have been selected to ensure sample completeness. For example, fecal coliform samples that are collected in eastern Washington will be sent to a nearby laboratory instead of sending samples to another laboratory. This is necessary to meet the 8 hour holding time (6 hours transit + 2 hours at the laboratory).

The laboratory will report the analytical results to WSDOT in a timely manner. The laboratory will provide all sample and quality control data in standardized laboratory reports suitable for evaluating the project data. Laboratory reporting of reviewed and qualified data will include, but not be limited to:

- Case narratives and data summaries discussing laboratory QA/QC.
- Reported result values including those between the method detection limit and the laboratory reporting limit.
- The method detection limits and laboratory reporting limits for all analytes for each batch.
- QA/QC results such as field replicates, laboratory duplicates, surrogates, method blanks, and matrix spikes.
- A PDF or equivalent copy of the case narrative and data.
- An electronic deliverable datum developed by WSDOT specifying the format in which laboratories are to report data.

The laboratory reports will also include any problems encountered in the analyses. Raw data will be kept at the laboratory for a minimum of five years.

9-1.1 List of Laboratories

Laboratories selected by WSDOT are accredited and capable of meeting reporting limits and holding times set forth by the method or permit, unless noted otherwise in this QAPP. Table 17 lists the selected laboratories for sample processing. A complete list of accredited laboratories and parameters analyzed can be found at:
http://www.ecy.wa.gov/programs/eap/labs/search.html

Table 157   Selected laboratories for sample processing

Laboratory Name	Analytical Purpose	Address	Phone
Manchester Environmental Laboratory	All parameters in Table 20 except: glyphosate, MBAS, toxicity, and grain and particle size distribution	Washington State Dept of Ecology Manchester Environmental Laboratory 7411 Beach Drive East Port Orchard, WA 98366 Work Hours 8:00 to 4:30 Weekdays	Stuart Magoon 360-871-8800
TestAmerica Laboratories, Inc.	Glyphosate, grain size distribution, orthophosphate,[1] total Kjeldahl nitrogen	Labs nationally – GA contract: TestAmerica: Seattle, Tacoma, Spokane, Portland	Katie Downie 253-922-2310
Analytical Resources, Inc.	Particle size distribution	4611 South 134th Pl., Suite 100 Tukwila, WA 98168	Mark Harris 206-695-6210
Anatek Labs, Inc.	Fecal coliforms[1]	504 E. Sprague Suite D Spokane, WA 99202	Kathy Sattler 509-838-3999
AmTest Laboratory	Fecal coliforms,[1] MBAS	13600 NE 126th Pl., Suite C Kirkland, WA 98034	Aaron Young 425-885-1664
NewFields Northwest, LLC	Toxicity	PO Box 216 Port Gamble, WA 98364	Brian Hester 360-297-6070
WSDOT	pH	pH analysis will be conducted using a meter in the field	Fred Bergdolt 360-570-6648

[1] Additional laboratories beyond Manchester Environmental Laboratory are needed to meet holding times for this analysis.

9-2 Sample Processing Procedure

This section presents the post-storm event sample processing procedures for stormwater and sediment samples. At the end of a successful sampling event, a final composite sample may be required at sites where more than one bottle was filled. Post-storm event sample processing for routine samples will take place after the storm event is completed and all runoff samples are taken.

9-2.1 Sample Amounts and Containers

Tables 18 and 19 list sample volumes, holding times, containers, and preservation requirements for highway characterization monitoring. Tables 18 and 19 also list the toxicity testing parameters for stormwater and sediment. These tables were created from MEL's *Laboratory Users Manual* (MEL, 2008), Table II of 40 CFR 136.3, and specified methods within the permit. Seasonal first flush toxicity sample parameters are listed in Appendix C. If toxicity is found in stormwater samples, testing for additional parameters will be conducted. Appendix C provides details for this testing.

Table 18 Sample containers, amounts, preservation, and holding times for stormwater samples. (MEL, 2008; 40 CFR 136.3; Ecology, 2009a).

Analysis	Quantity Needed for Analysis	Quantity Needed for QC Samples	Container	Holding Time	Preservative[1]
Chloride	100 mL	MS, MSD, and Dup = 100 mL each	125 mL w/m poly bottle	28 days	Cool to ≤6°C
Fecal coliform (grab)	250 mL	Dup = 250 mL	250 mL glass/polypropylene bottle	6 hours + 2 at Lab	Fill the bottle to the shoulder, cool to ≤ 10°C[2]
Hardness as $CaCO_3$	100 mL	Dup = 100 mL	125 mL w/m poly bottle	6 months	H_2SO_4 to pH<2; cool to ≤6°C
Herbicides – Diuron	1 liter	MS & MSD = 1 liter each	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	MS & MSD = 1 liter each	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	60 mL screw cap bottles with a Teflon® faced silicone septa	14 days	Cool to ≤4°C[2]
Metals – dissolved (Cu, Cd, Zn, Pb)	100 mL	MS, MSD, and Dup = 100 mL each	500 mL HDPE bottle[4] with Teflon® lid	6 months	Filter within 15 minutes of collection,[4] then add HNO_3 to pH <2;[5] cool to ≤6°C
Metals – total recoverable (Cu, Cd, Zn, Pb)	100 mL	MS, MSD, and Dup = 100 mL each	500 mL HDPE bottle[4] with Teflon® lid	6 months	HNO_3 to pH <2
Orthophosphate (OP)	30 mL	MS, MSD, and Dup = 125 mL each	125 mL amber w/m poly bottle	48 hours	Filter within 15 minutes of collection[4]; cool to ≤6°C

Table 18 (continued) Sample containers, amounts, preservation, and holding times for stormwater samples (MEL, 2008; 40 CFR 136.3; Ecology, 2009a).

Analysis	Quantity Needed for Analysis	Quantity Needed for QC Samples	Container	Holding Time	Preservative[1]
PAH compounds	1 liter	MS and MSD = 1 liter each	1 liter amber glass bottle with Teflon® lid	7 days to extraction, 40 days after extraction	Store in dark; cool to ≤6°C[2]
Particle size distribution	2 liters	2 liters	HDPE, glass, or Teflon® container	7 days	Cool to 4°C
Phthalates	1 liter	MS and MSD = 1 liter each	1 liter amber glass bottle with Teflon® lid	7 days to extraction, 40 days after extraction	Store in dark; cool to ≤6°C[2]
TSS	1 liter	Dup = 1 liter for clear water, less to none if dirty	1 liter w/m poly bottle	7 days	Cool to ≤6°C
Total phosphorus (TP)	50 mL	MS, MSD, and Dup = 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	Dup = 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)	Dup = 120 mL	(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
Toxicity Only (collected once per year)					
H. azteca 24-hour acute toxicity test	6 liters	none	Glass bottle	36 hours	Cool to ≤6°C
Methylene blue active substances (MBAS)	400 mL	400 mL	1 liter amber glass bottle	48 hours	Cool to 4˚C

w/m = wide mouth
n/m = narrow mouth
MS = Matrix spike
MSD = Matrix spike duplicate
Dup = Laboratory duplicate

[1] Preservation needs to be done in the field, unless otherwise noted. Ice will be used in cool samples to approximately 4°C.
[2] At the lab a reducing agent may be added as a preservative if an oxidant such as chlorine is present.
[3] Containers cleaned in accordance with OSWER Cleaning Protocol #9240.0-05 (MEL, 2008).
[4] 0.45 micron pore size filters.
[5] Preserved in lab within 24 hours of arrival.
* EPA Method 547
** ECY 97-602

Table 19 Sample containers, amounts, preservation and holding times for sediment samples (MEL, 2008; 40 CFR 136.3; Ecology, 2009a).

Analysis	Quantity Needed for Analysis	Quantity Needed for QC Samples	Container[1]	Holding Time	Preservative[2]
Herbicides[3]	100 wet g	None if jar filled	8 oz glass jar	14 days	Cool to ≤6˚C
Particle size (grain size)	300 wet g	None if jar filled	8 oz plastic jar	6 months	Cool to 4˚C, PSEP[6] standard: do not freeze
PAHs	100 wet g	None if jar filled	8 oz glass jar	14 days/ 1 year if frozen	Cool to ≤6°C/; PSEP[6] standard: may freeze at ≤18°C at lab
Phenols					
Phthalates					
Total solids (percent solids)[4]	25 wet g	None if jar filled	2 oz glass jar	7 days	Cool to ≤6˚C
Total metals (Cu, Cd, Zn, Pb)	10 wet g	None if jar filled	4 oz glass jar[5]	6 months	Cool to ≤6˚C
Total organic carbon (TOC)	25 wet g	None if jar filled	2 oz glass jar	14 days/ 1 year if frozen	Cool to ≤6°C/; PSEP[6] standard: may freeze at ≤18°C at lab
TPH-Diesel (NWTPH-Dx) (grab)	100 wet g	None if jar filled	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 QC.
[2] Preservation needs to be done 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] Permit called for "Total Solids," which is an incorrect term for sediment solids analysis. WSDOT believes the permit intended to ask for "percent solids" analysis.
[5] Containers cleaned in accordance with OSWER Cleaning Protocol #9240.0-05 (MEL, 2008).
[6] Puget Sound Estuary Protocols (1997).

Sample Volumes

For the purpose of ensuring the highest possible quality of data and to ensure fulfillment of permit-required parameter sampling, an excess amount of sample will be collected (if available) for each composited sample. Each autosampler will hold glass carboys to collect composited stormwater for highway runoff samples, unless otherwise specified. Sample amounts listed in Tables 18 and 19 are based on the needed quantity for a single laboratory analysis for each analyte and the excess volume for lab QC samples. This volume has been determined by the laboratory to be satisfactory for its minimum requirements. Field replicates will be collected according to the established schedule. For toxicity samples, a glass carboy will be set up for autosampler collection. Refer to Appendix C for specific permit requirements related to toxicity sampling.

Sediment volumes may vary due to the relatively small contributing road surface area. Approximately 950 g of accumulated stormwater sediment is necessary to process all the parameters, not including any field replicates.

Sample Containers

For all samples, commercially available precleaned sample containers will be used, and the laboratory will maintain a record of certification from the suppliers. The sample container shipment documentation will record batch numbers for the containers. With this documentation, containers can be traced to the supplier, and container wash analysis results can be reviewed.

Laboratories are able to clean and reuse many containers. Containers will be cleaned to EPA QA/QC specifications (USEPA, 1992). Precleaned sample containers (bottles and carboys) will be used for sampling.

A glass carboy (volume dependent upon parameters required per site) will be used primarily to collect composited samples directly from the autosampler in the field. Tubing lined with fluorinated ethylene propylene (FEP) or a similar product will be inserted into the opening of the carboy and sealed with an appropriate stopper, or it will be wrapped in Parafilm® to form a seal. Several parameters can be analyzed from the same composite sample; therefore, sample splitting is required. Sample splitting will take place in the field unless contamination is a concern; then it will be done at the laboratory. Unpredicted conditions or circumstances may require the use of rosettes containing individual bottles, instead of one large bottle.

For sediment samples, the homogenized sample will be placed in the appropriate glass jars, which are supplied precleaned by the laboratory to EPA QA/QC specifications (USEPA, 1992).

Sample Splitting

Parameters that require preservatives or field filtration from the master composite and/or grab samples will be processed in the field. Processing in the field for automatically composited samples will consist of homogenizing the bottle's contents and placing aliquots of the composite into appropriate precleaned laboratory containers for subsequent analysis. Sample splitting will be performed using the automatic sampler head and tubing used to collect the sample. This process will involve replacing the inlet tubing with a precleaned shorter section of tubing and reversing the autosampler pump to fill lab bottles. The tubing and top of the carboy will be wrapped with Parafilm® to prevent sample contamination. The carboy will be agitated during the reverse pumping timeframe. Agitation will be done by placing the carboy on a prefabricated stool with only one central leg that can be held by a field crew member and swirled back and forth and side to side. Vortex swirling will be avoided to prevent entrapment of heavier particles in the middle of the carboy. If this method of sample splitting is inadequate in practice, the widely available churn splitter will be employed.

Post-storm event sample handling is described below and will be developed into training for field crew. Contents of this training will be based on the following section.

9-2.2 Post-Event Processing, Preservation, and Holding Times

After the storm event, data collected during the storm will be assessed to determine whether the storm qualified according to the permit specifications. If the storm event did not qualify, the samples may be discarded and the associated bottles sent to the laboratory for cleaning in preparation for the next storm event. If the criteria have been met, field crews will remove the chilled carboys and bottles for sample splitting, filtration (if necessary), and preservation. The Field Lead and Data Steward will decide whether a nonqualifying storm event will be sampled to meet permit requirements.

Sample Preservation

Some of the parameters to be analyzed (TP, TPH, metals, and hardness) will require chemical preservation to maintain the integrity of the samples and prevent them from degrading prior to laboratory analysis. Filtration is required as well for orthophosphate and dissolved metals and will be conducted immediately after composited sample collection is completed.

Samples for orthophosphate and dissolved metals will be filtered using a filtering set-up that pulls the sample through a filter using vacuum pressure created by a peristaltic (or hand) pump. Prior to filtering the sample, an aliquot of deionized water will be passed through the filter to rinse the filter and container. After rinsing, the filtered sample will be collected and distributed into the laboratory sample bottles. Disposable filter set-ups will be used for each sample.

Sample cooling to 4º – 6ºC or less, but not freezing, is necessary for preservation of most of the parameters to be analyzed. Collected samples must be transferred from the field station to the lab in an ice-filled or blue ice-filled cooler to maintain temperature requirements.

Sample Holding Times

Holding times can be described as the maximum allowable length of time between sample collection and laboratory manipulation. The holding time for parameters collected by the autosampler will be calculated from the time the autosampler's final aliquot is collected. Holding times are different for each analyte and are in place to maximize analytical accuracy and representativeness. Each sample collected will be packaged in a container and labeled accordingly. Refer to Appendix C for toxicity sample holding times. If holding times cannot be met, the Field Lead will process and label the sample for the next appropriate parameter.

The holding time for fecal coliform samples is 6 hours plus 2 hours at the laboratory. Given the inherent logistical difficulties of meeting this holding time, samples analyzed between 8 and 24 hours will be acceptable but flagged as estimates with a *J* qualifier; samples held longer than 24 hours will be rejected, indicated by an *R* qualifier.

If necessary, the Field Lead will coordinate with the analytical laboratory to ensure samples can be transported, received, and processed during nonbusiness hours. Sample containers will be transported or sent by the field team to the analytical laboratory, following established sample handling and chain of custody procedures. At the laboratory, samples may be further divided for analysis or storage.

9-3 Sample Labeling and Chain of Custody

9-3.1 Labeling

Labeling is used to identify where and when a sample was collected and the analyte(s) in that sample to be analyzed. Laboratory-prepared bottles will be labeled to identify the cleanliness and/or preservative contents for each bottle. Labels will be premade. Bottles will be either numbered or prelabeled to ensure proper handling. Labels will be filled out in pencil or permanent pen, placed on sample containers, and taped with packing tape to reduce water damage to the label. Sample labels will contain the following information:

1. Station name/identification
2. Analysis to be performed
3. Date and time of sampling
4. Sample ID or coding information
5. Sample numbers (1 of 3, 2 of 3, and so on)
6. Name/initials of field tech performing the sampling

This labeling information will be written in the chain of custody forms (discussed below).

9-3.2 Chain of Custody

Chain of custody (COC) can be defined as a systematic procedure for tracking a sample or datum from its origin to its final use. COC procedures are necessary to ensure thorough documentation of handling for each sample, from field collection to laboratory analysis. The purpose of this procedure is to minimize errors, maintain sample integrity, and protect the quality of data collected. A COC form will accompany each cooler of samples. After completing the form and packaging the samples for shipping, the sampler should retain a copy of the form for the records. Individuals who manipulate or handle these samples are required to log their activities on the form. Definitions of custody from MEL's *Laboratory Users Manual* (MEL, 2008) are described below:

> *A sample is considered to be under a person's custody if it is:*
> *In the individual's physical possession*
> *In the individual's sight*
> *Secured in a tamper-proof way by that person, or*
> *Secured by the person in an area that is restricted to authorized personnel*
>
> *Elements of chain-of-custody include:*
> *Sample identification*
> *Security seals and locks*
> *Security procedures*
> *Chain-of-custody record*
> *Field log book*
>
> When the laboratory receives a cooler of samples, it will assume responsibility for samples and maintenance of the COC forms. The laboratory will then conduct its procedures for sample log-ins, storage, holding times, tracking, and submittal of final data to the responsible parties.

9-4 Laboratory Methods, Instruments, and Reporting Limits

9-4.1 Laboratory Methods and Analytical Reporting Limits

Tables 20 and 21 show the selected parameters, analytical methods, and reporting limits for stormwater and sediments.

Table 20 Methods and reporting limits for water samples.

Parameter	Method in Water (SM=Standard Method,* EPA=EPA Method,** ASTM= American Society of Testing and Materials Method***)	Reporting Limit
Chloride	EPA 300.0	0.2 mg/L
Dissolved (Cd, Cu, Pb)	EPA 200.8 (ICP/MS)	0.1 ug/L
Dissolved (Zn)	EPA 200.8 (ICP/MS)	1.0 ug/L
Fecal coliform[4]	SM 9221E or SM 9222D	2 min., 2E6 max
Hardness as $CaCO_3$	SM 2340B (ICP)	1.0 mg/L
Herbicides: – Picloram, triclopyr (ester formula only)	EPA 8270D GC/MS	0.01 – 1.0 ug/L
Herbicides – Diuron	EPA 8270/8321 LC/MS	
Herbicides – Glyphosate[5] (nonaquatic formula)	EPA 547 drinking water method, HPLC or LC/MS, readily breaks down	25 ug/L
Orthophosphate (OP)	SM 4500-P G	0.01 mg P/L
PAH compounds[1]	EPA 8270D	0.1 ug/L
Particle size distribution (PSD)	Laser diffraction	NA
pH[3]	SM 4500H^+	0.2 units
Phthalates[2]	EPA 8270D	1.0 ug/L
Total phosphorus (TP)	SM 4500-P F	0.01 mg P/L
Total recoverable (Cd)	EPA 200.8 (ICP/MS)	0.2 ug/L
Total recoverable (Cu)	EPA 200.8 (ICP/MS)	0.1 ug/L
Total recoverable (Pb)	EPA 200.8 (ICP/MS)	0.1 ug/L
Total recoverable (Zn)	EPA 200.8 (ICP/MS)	5.0 ug/L
TSS	SM 2540D (TAPE requires TSS samples not to exceed 500 microns – A US Standard sieve [#35] or equivalent device may be used for sieving at the lab)	1.0 mg/L
TPH-Diesel	NWTPH-Dx – Ecology, 1997 (Publication No. 97-602)	0.25 – 0.50 mg/L
TPH-Gas	NWTPH-Gx – Ecology, 1997 (Publication No. 97-602)	0.25 mg/L
Toxicity Only (collected annually)		
H. azteca 24-hr acute toxicity test	ASTM E1192-97	50% mortality
Methylene blue active substances (MBAS)	SM 5540C	0.025 mg/L

[1] PAHs of interest: acenaphthene, acenaphthylene, anthracene, benzo[a]anthracene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[ghi]perylene, benzo[a]pyrene, chrysene, dibenzo[a,h]anthracene, fluoranthene fluorine, indeno[1,2,3-cd]pyrene, naphthalene, phenanthrene, and pyrene.

[2] Phthalates of interest: bis(2-Ethylhexyl)phthalate, Butyl benzyl phthalate, Di-n-butyl phthalate, Diethyl phthalate, Dimethyl phthalate, and Di-n-octyl phthalate.

[3] Required at BMP sites for TAPE compliance.

[4] Each laboratory analyzing for fecal coliforms is accredited for both methods. Laboratories were allowed to select their preferred method. MEL and AmTest selected SM 9222D, and Anatek selected SM9221E. However, laboratories may use the nonpreferred method if sample or condition specific issues arise.

[5] Results for glyphosate analysis between the RL of 25 ug/L and MDL of 2.5 ug/L will be reported. These results will be qualified as estimates.

* http://www.standardmethods.org/

** http://water.epa.gov/scitech/methods/cwa/methods_index.cfm, http://www.epa.gov/osw/hazard/testmethods/sw846/online/index.htm

*** http://www.astm.org/SITEMAP/index.html

Table 21 Methods and reporting limits for sediment.

Parameter	Method in Sediment*	Reporting Limit Target
Particle size (grain size)	ASTM D422	NA
Herbicides[4]	EPA 8270D (GC/MS)	70µg/Kg dry
TPH-Diesel (NWTPH-Dx)	Ecology, 1997 (Publication No. 97-602)	25.0-100.0 mg/Kg
PAH compounds[1]	EPA 8270D (GC/MS)	70 ug/kg dry
Phenolics [2]	EPA 8270D (GC/MS)	70 ug/kg dry
Phthalates [3]	EPA 8270D (GC/MS)	70 ug/kg dry
Total org. carbon (TOC)	SM 5310 B	0.1%
Total solids (%)	SM 2540B	NA
Total volatile solids	EPA 160.4	0.1%
Total recoverable (Zn)	EPA 200.8 (ICP/MS)	5.0 mg/kg
Total recoverable (Pb, Cu, Cd)	EPA 200.8 (ICP/MS)	0.1 mg/kg

[1] PAH compounds, including, at a minimum, but not limited to: acenaphthene, acenaphthylene, anthracene, benzo[a]anthracene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[ghi]perylene, benzo[a]pyrene, chrysene, dibenzo[a,h]anthracene, fluoranthene, fluorine, indeno[1,2,3-cd]pyrene, naphthalene, phenanthrene, and pyrene.

[2] Phenolics, including, at a minimum, but not limited to: phenol, 2-methylphenol, 4-methylphenol, 2,4- dimethyphenol, pentachlorophenol, benzyl alcohol, and benzoic acid.

[3] Phthalates, including, at a minimum, but not limited to: *bis*(2-Ethylhexyl)phthalate, Butyl benzyl phthalate, Di-n-butyl phthalate, Diethyl phthalate, Dimethyl phthalate, and Di-n-octyl phthalate.

[4] Limited to the herbicides listed in the permit and used within the drainage area by WSDOT.

* http://www.standardmethods.org/, http://water.epa.gov/scitech/methods/cwa/methods_index.cfm,
http://www.epa.gov/osw/hazard/testmethods/sw846/online/index.htm, http://www.astm.org/SITEMAP/index.html
http://www.ecy.wa.gov/biblio/97602.html, PSEP 1997

9-4.2 Laboratory Instrumentation

Maintenance of laboratory equipment will be conducted in a manner specified by the manufacturer or by the quality assurance guidelines established by the chosen laboratory. The instrumentation in service records will either meet or exceed manufacturers' specifications for use.

10 Quality Control Procedures

This section discusses the quality control (QC) procedures that will be implemented in order to provide high-quality data that meet the requirements of the WSDOT permit. Quality control procedures will encompass field collection and laboratory processing of all samples, and will be monitored throughout the duration of the study. The quality of raw, unprocessed, and processed data is subject to review according to the established protocols in Section 5-2, Measurement Quality Objectives.

10-1 Field Quality Control Procedures

10-1.1 Standard Operating Procedures (SOPs)

Quality control in the field will refer to SOPs (listed in Table 22) for field sampling; maintaining field equipment; field documentation; sample collection; blank or replicate sample collection; and appropriate action for correcting and documenting potential field errors. The field quality control schedule for monitoring efforts is shown in Table 23. To ensure the quality and consistency of sample collections, equipment maintenance and sample collection SOPs will be followed.

Table 22 Standard Operating Procedures.

SOPs Published by Ecology[1]
ECY001 – Collecting Grab Samples from Stormwater Discharges
ECY002 – Automatic Sampling for Stormwater Monitoring
ECY004 – Calculating Pollutant Loads for Stormwater Discharges
EAP029 – Metals Sampling
EAP030 – Fecal Coliform Sampling
EAP015 – Manually Obtaining Surface Water Samples
SOPs Developed by WSDOT (in draft)[2]
Equipment Maintenance and Cleaning
Decision Matrix for Targeting Storm Events
Field Sampling with Autosamplers
Using Portable Meters

[1] Ecology 2006, 2007, 2009b, 2009c, 2009d, 2010b.
[2] WSDOT, in draft 2011.

These SOPs will describe the following elements in detail:

- Regular maintenance of monitoring stations to ensure data relevance.
- Collection of continuous temperature, rainfall, and stage data for reference.
- Collection of automated, refrigerated, composited samples to characterize storm events.
- Use of certified, contaminant-free, or decontaminated sample containers.
- Storage of unused sampling bottles in clean sealed containers prior to use.

- Implementation of modified "clean hands/dirty hands" techniques (for example, one person collects samples, while the other person opens the manhole covers and changes batteries) for sample collection and site maintenance.
- Replacement of sampler tubing with its surrogate tube (two tubes for each sampler, one always clean and stored away while the other is in use; switch when dirty, clean, and repeat as needed).
- Storage of collected samples on ice in a designated, labeled cooler for transport.
- Delivery of samples to the laboratory, with completed COC forms and within proper holding times.

10-1.2 Field Instrument Quality Control

In order to maintain the highest degree of data quality, field equipment will undergo routine cleaning, calibrations, and maintenance at the recommended frequency specified by each manufacturer. Battery maintenance and data downloads from the data loggers will occur for each storm event or every six weeks, whichever comes first.

10-1.3 Documentation

Field data sheets will be printed on Rite-in-the-Rain® water-resistant forms or waterproofed tablet PCs to allow ease of use during storm events. When completed, these field sheets will be submitted to the Data Steward and stored in an organized central filing location. Forms and documentation will include the station visit/maintenance sheet, weather qualification report, and chain of custody forms. (See Appendices G and H for examples of field forms.) All entries on field documents will be made in pencil or permanent pen, and will list the field technician's name(s). Any errors or typos will be crossed out and rewritten by the technician who recorded the data. All corrections will be initialed and dated when made.

If field sampling or procedural errors are discovered, action will be taken to manage and correct those errors. Corrections may occur with corrective editing, relabeling, or, if warranted, flagging, discarding, and resampling. If a consistent error persists, an amendment to the sampling procedures may be required. Refer to Appendices C and F for guidance on corrective and follow-up actions for seasonal first flush toxicity sampling.

10-1.4 Composite/Grab Field Replicate Samples

Composited field replicate samples will be collected at a rate of 10 percent of the total samples collected for monitoring under the permit. Field replicates will be collected by splitting composited samples or by setting up an additional autosampler to collect additional sample volume as equipment is available. Excess volume will be programmed into loggers to provide enough sample volume for field replicates collected by splitting composite samples (if the storm event is large enough). A schedule will be maintained by site to facilitate field crews knowing when to collect field replicate samples at each site. Parameters measured in the field sample will also be measured in the replicate sample for a particular storm event.

Grab field replicates will be collected following a similar schedule to the composited field replicates, but they may not be collected during the same storm event at the same site. Staggering the grab samples and composite samples may be necessary to increase the volume of sample available for collection. Grab field replicates will also be collected at a rate of 10 percent of the total samples.

All field replicates will be labeled the same as other samples, so that the sample has its own unique number. These replicate samples will be submitted blind to the laboratory, with all other field samples.

The sampling schedule may be adjusted to meet the field replicate frequencies early in the fall/winter sampling season to prepare for a dry spring/summer season. The Field Lead and Data Steward should continuously manage the field replicate collections to achieve the 10 percent goal and communicate with the field crews so they know what samples, which storms, and to which monitoring sites field replicates should be taken for the monitoring program.

10-1.5 Field Blanks

The term field blanks includes equipment rinsate blank, transport blanks, transfer blanks, or specific equipment blanks such as tubing. For BMP sites, an initial effort to collect equipment rinsate blanks at each site will be conducted two times early in the monitoring program but after the first sampling event. After this initial effort, equipment rinsate blanks will be collected at the remaining monitoring sites within the first year of monitoring. Equipment rinsate blanks will be collected at least once a year at each site.

The equipment rinsate blanks will consist of laboratory-supplied contaminant-free water that is run through the decontaminated autosampler system into a clean sample bottle. The goal is mimic the sampling process to determine whether contamination is present from any part of sampling such as equipment, sample filtration, sample handling, or transport.

Additional field blanks will be collected if sample procedures or site conditions change. They may also be used as part of field audits to ensure procedures to reduce contamination are being followed. All field blank samples will be labeled with unique numbers and will accompany field samples sent to the laboratory.

If field blank contamination is discovered, additional field blank samples will be used to determine the source of the contamination. These field blank samples may include:

- A tubing equipment blank collected after an autosampler's Teflon® tubing is replaced, to determine whether contamination is from the tubing.
- A field equipment blank collected from the filtration apparatus used to filter metals and orthophosphate.
- A field transfer blank collected by pouring lab-provided deionized water into a clean sample bottle to determine whether field contamination is present, unrelated to the equipment.
- A field transport blank collected by transporting unopened bottles containing organic and metal-free certified clean water from the laboratory into the field, and then returning it to the laboratory (bottles are not opened in the field). Transport blanks are used to determine whether any contamination occurs while traveling from field to laboratory.

Any field blank contamination will be reviewed by the QA Officer or Data Steward to determine if samples associated with the field blanks should be qualified based on the contamination. Sample results will be flagged with a *J* if they are less than or equal to 5 times the field blank concentration.

A schedule of storm events with planned field replicate, blank, or other QC samples will be maintained and followed as part of the stormwater sampling program.

Table 23 Field quality control schedule.*

Field Sample Collected	Frequency [2]	Control Limit	Corrective Action
Composited field replicate	10% of total samples or 1 per batch[1]	Qualitative control – Assess representativeness, comparability, and field variability	Review procedures; alter if needed
Grab field replicate	10% of total samples or 1 per batch[1]		Review procedures; alter if needed
Equipment rinsate blank	At least once a year at each site (the first year BMP sites will be sampled twice early in the program, per TAPE guidance)	Blank analyte concentration should be below the reporting limit	Compare blanks for analyte to determine whether the sampling process is the source of contamination; re-evaluate decontamination procedures; evaluate results greater than 5x blank concentrations
Blank samples for determining a contamination source	As needed	Blank analyte concentration should be below the reporting limit	Compare results from separated blanks to isolate the source of contamination; evaluate results greater than 5x blank concentrations

[1] Total samples are for the entire monitoring program under S7 in the permit.

[2] Frequencies will be maintained for the monitoring program in its entirety.

* Table is based in part on an EPA QA and SOP website (Appendix B-3: Field QC and Laboratory QC Sample Collection and Documentation Requirements) accessed January 2011: http://www.epa.gov/earth1r6/6pd/qa/qadevtools/mod5_sops/sample_handling_preservation/appendix_b3.pdf

10-2 Laboratory Quality Control Procedures

This section discusses the quality control (QC) procedures that will be implemented by the contracted analytical laboratory in order to provide high-quality chemical and physical analyses that meet the requirements of the WSDOT permit. Contract laboratories will make every effort to meet sample holding times and target reporting limits for all parameters.

Laboratory QC procedures and results will be closely monitored throughout the duration of the permit-mandated sampling. For guidance on seasonal first flush toxicity quality control procedures, refer to Appendix C. The quality of laboratory data is subject to review via the established protocols in Section 5-2, Measurement Quality Objectives. A typical schedule for laboratory QC samples is shown in Table 24 and, at a minimum, includes:

- Laboratory duplicates
- Matrix spikes
- Matrix spike duplicates
- Method/instrument blanks
- References (lab standards/surrogate standards/internal standards)

10-2.1 Laboratory Instrument Calibration

The instrumentation utilized by the chosen laboratories will meet or exceed manufacturers' specifications for use and maintenance. Maintenance of this equipment will be conducted in a manner specified by the manufacturer or by the quality assurance guidelines established by the chosen laboratory. Use of this equipment will follow the chosen laboratory's standard operating procedures or the methods established by the manufacturer.

10-2.2 Laboratory Duplicate/Splits

Laboratory duplicate samples will be analyzed regularly to verify that the laboratory's analytical methods are maintaining their precision. The contracted laboratory should perform "random" duplicate selection on submitted samples that meet volume requirements. After a sample is randomly selected, the laboratory should homogenize the sample and divide it into two identical "split" samples. To verify method precision, identical analyses of these lab splits should be performed and reported. Some parameters may require a double volume for the parameter to be analyzed as the laboratory duplicate. Matrix spike duplicates may be used to satisfy frequencies for laboratory duplicates.

10-2.3 Laboratory Matrix Spikes and Matrix Spike Duplicates

Matrix spike samples are triple-volume field samples (per parameter tested) to which method-specific target analytes are added or spiked into two of the field samples, and then analyzed under the same conditions as the field sample. A matrix spike provides a measure of the recovery efficiency and accuracy for the analytical methods being used. Matrix spikes are typically analyzed in duplicate (matrix spike/matrix spike duplicate [ms/msd]) to determine method accuracy and precision. Matrix spikes will be prepared and analyzed at a rate of 1 pair/20 (five percent) samples collected or one pair for each analytical batch, whichever is most frequent. In addition, metals must have at least two ms/msd samples per year per TAPE guidance. (Batch matrix spikes may be performed on other samples not related to this monitoring effort.) The ms/msd samples should be collected in the first shipment of organics samples.

Use of ms/msd at the frequency of five percent of the total number of samples is common practice. For the purposes of permit monitoring, these frequencies meet the expectations. However, WSDOT may consider a more frequent use of ms/msd samples early in the monitoring program, then taper off to five percent or one pair for each analytical batch later in the program. Laboratory duplicates may be used to satisfy frequencies for matrix spike duplicates.

10-2.4 Laboratory Blanks and Standards

Laboratory blanks are useful for instrument calibrations and method verifications, as well as to determine whether any contamination is present in laboratory handling and processing of samples.

Laboratory Standards

Laboratory standards (reference standards) are objects or substances that can be used as a measurement base for similar objects or substances. In many instances, laboratories using digital or optical equipment will purchase from an outside accredited source a solid, powdered, or liquid standard to determine high- or low-level quantities of a specific analyte. These standards are accompanied with acceptance criteria and are used to test the accuracy of the laboratory's methods. Laboratory standards are typically used after calibration of an instrument and prior to sample analysis.

Surrogate and Internal Standards

Surrogate standards are used for processing and analysis of extractable organic compounds (TPH, PAHs, phthalates, and herbicides). A surrogate standard is added before extraction, and it monitors the efficiency of the extraction methods. Internal standards are added to organic compounds and metal digestates to verify instrument operation when using inductively coupled plasma mass spectrometry (ICP-MS) analysis.

Method Blanks

Method blanks are designed to determine whether contamination sources may be associated with laboratory processing and analysis. Method blanks are prepared in the laboratory using the same reagents, solvents, glassware, and equipment as the field samples, and they will accompany the field samples through analysis.

Instrument Blank

An instrument blank is used to "zero" analytical equipment used in the laboratory's procedures. Instrument blanks usually consist of laboratory-pure water and any other method-appropriate reagents, and they are used to zero instrumentation.

Table 24 Example of laboratory quality control schedule for monitoring effort.

Quality Control Sample[1]	Analysis Type	Frequency[2]	Control Limit	Corrective Action
Laboratory Duplicates[3]	inorganic	5% of total samples or 1 per batch (method-specific)	RPD[4] >20%	Evaluate procedure; ID contaminant source; reanalyze or qualify affected data
	conventional		Analyte/matrix-specific: usually RPD >20%	
	organics		RPD >40%	
Matrix Spikes	inorganic	For metals at least 2 samples per year, otherwise 5% of total samples or 1 per batch[1]	Analyte/matrix-specific: usually Recovery <75% or >125%	Evaluate procedure and assess potential matrix effects; reanalyze or qualify data
	conventional	5% of total samples or 1 per batch[1]	Analyte/matrix-specific: usually Recovery <75% or >125%	
	organics	5% of total samples or 1 per batch[1]	Analyte/matrix-specific: ranges from Recovery <10% or >150%	Evaluate lab duplicates/standards recoveries and assess matrix effects; evaluate or qualify affected data
Matrix Spike Duplicates[3]	inorganic	For metals at least 2 samples per year, otherwise 5% of total samples or 1 per batch	RPD >20%	Evaluate procedure and assess potential matrix effects; reanalyze or qualify data
	conventional	5% of total samples or 1 per batch	Analyte/matrix -specific: usually RPD >20%	
	organics	5% of total samples or 1 per batch	Analyte/matrix-specific: usually RPD >40% (water); RPD >20% (soil)	
Method / Instrument Blanks	inorganic	5% of total samples or 1 per batch (method-specific)	Blank analyte/matrix concentration ≤ reporting limit	Blank concentration is defined as the new reporting limit. Evaluate procedure; ID contaminant source; reanalyze blanks or qualify sample data (<5-10x blank concentration). Sample concentrations must be ≥ 5x blank results to be considered valid by TAPE.
	conventional			
	organics			
References (lab control standard, surrogate, and internal standards)	inorganic	5% of total samples or 1 per batch (method-specific)	Analyte/matrix-specific: ranges from Recovery <70% or >130%	Evaluate lab duplicates, matrix spike recoveries, and assess efficiency of extraction method; evaluate or qualify affected data
	conventional		Analyte/matrix-specific: ranges from Recovery <70% or >130%	
	organics		Analyte/matrix-specific: ranges from Recovery <10% or >183%	

[1] Quality control samples may be from different projects for frequencies on a per batch basis.

[2] Frequencies may be maintained for the monitoring program in its entirety. BMP sites will hold to the frequencies in this table per TAPE guidance.

[3] Laboratory and matrix spike duplicates both measure precision and accuracy; a combination of these two quality control samples may be used to satisfy frequencies.

[4] RPD: relative percent difference.

11 Data Management Procedures

WSDOT's stormwater monitoring program will be collecting and managing data from three sources: telemetered field stations, field observations/measurements, and laboratory analysis of field samples. All data will be managed and stored by WSDOT. Post-processed data will be finalized and incorporated into annual reports and electronic reports. Reports and data will be submitted in the format required by the permit to Ecology.

11-1 Telemetered Data Management

Telemetered data will be transmitted from each station hourly throughout the year and will be managed by WSDOT and stored in a WSDOT database. Telemetered data will be augmented with data downloaded from the data logger to fill any potential data gaps. Hydrographs and hyetographs will be developed for report comparisons and to determine baseline rainfall/runoff relationships.

11-2 Field Data Management

Field checklists and forms will be completed in the field during sampling and maintenance visits. All field documentation will be reviewed by the field technicians for completeness and identification of potential errors while in the field. Documents will be organized and stored in the appropriate central storage, which will be determined by the WSDOT Data Steward.

Data downloaded from the field data loggers will be uploaded to a centralized dedicated location at WSDOT. After uploading data, field staff will send the responsible senior staff an e-mail notifying them that the data have been moved to the storage folder for processing. Senior staff will then import, verify, and process these data via WSDOT's database.

11-3 Laboratory Data

Finalized laboratory data will be sent to WSDOT from each laboratory following analysis. The laboratories will be allowed to batch samples based on holding times to provide cost savings. Therefore, reporting will vary depending on holding time but should not exceed 6 months of the documented sampling date. Data will be submitted as an electronic data deliverable and a hard copy or PDF report. Hard copies or PDFs will be mailed or e-mailed to the Data Steward at WSDOT. Laboratory reports will be reviewed by the Data Steward/Quality Assurance Officer. Any errors or missing data will be reported to the responsible laboratory for amendment or correction. Finalized electronic laboratory data will be incorporated into WSDOT's database, while hard copy data sheets will be filed in WSDOT's central data storage.

The toxicity data submitted to WSDOT by the labs will be formatted for Ecology's CETIS database.

11-4 Audits

Routine audits will be conducted by senior staff to ensure this QAPP is being implemented correctly and the quality of the data is acceptable. A review of field procedures will be conducted once annually for each crew. If QA issues are identified during an audit, assessment and response actions will be implemented as necessary. The sections below describe in detail the steps to be carried out in connection with each of these activities.

During an audit review, the auditor may check that:

- Sampling locations were correctly sampled.
- SOPs were followed.
- There is documentation of the visit, with chain of custody or maintenance forms.
- There is proper identification and resolution of nonconformances.
- Correction of identified deficiencies has been made.
- Assessment has been made and corrective action taken.

The need for an audit can be determined by any participating member in the stormwater monitoring program. An audit may include procedural reviews, field visits, technical oversight, inspection, data quality assessment, or management system review. Audits of the analytical laboratories are limited to the subcontract agreements made with those laboratories.

11-5 Deficiencies, Nonconformances, and Corrective Action

Deficiencies are defined as unauthorized deviations from those procedures documented in the QAPP or SOPs. Nonconformances are deficiencies that severely affect the data quality and render them unacceptable or indeterminate. Deficiencies related to field and laboratory measurement systems include, but are not limited to, missed field visit forms, instrument malfunctions, blanks contamination, and quality control sample failures.

Routine audits will be performed to detect potential deficiencies in the hydrologic and water quality data collected for this project. Audits for hydrologic data will occur on a weekly to biweekly basis, when data are remotely downloaded from the monitoring stations. The newly downloaded data will be compared with previously downloaded and audited data to identify potential QA issues. This audit will specifically include an examination of the data record for gaps, anomalies, or inconsistencies among the discharge, water level, and/or precipitation data from the various monitoring stations.

Any data generated from calibration checks that were performed at a particular monitoring station will also be entered into control charts and reviewed to detect potential instrument drift or other operational problems. If QA issues are identified on the basis of these audits, a site visit will be performed immediately to troubleshoot the problem and to implement corrective actions. For specific deficiencies, anomalous data, or corrective action relating to seasonal first flush toxicity sampling, refer to Appendix C for more details. Any quality assurance issues that are detected through these audits will be documented in the electronic data record.

Audits performed for water quality data will occur according to WSDOT's Stormwater Monitoring Quality Management Plan. This review will be performed to ensure all data are consistent, correct, and complete, and all required quality control information has been provided.

Results from these audits will be documented in quality assurance worksheets that will be prepared for each batch of samples. If a potential QA issue is identified through these audits, the Quality Assurance Officer will review the data to determine whether any response actions are required. Response actions in this case might include the collection of additional samples or the reanalysis of existing samples. If reanalysis is not an option, corrective actions may include the qualification of the data as estimated (*J*) or rejected (*R*) values. All deficiencies, nonconformances, and corrective actions will be documented in annual data reports for the project.

Deficiencies detected through routine audits will be documented in accordance with the procedures identified above. The Quality Assurance Officer, in consultation with the Project Manager, will determine whether the deficiency constitutes a nonconformance. If it is determined that a nonconformance exists, the Quality Assurance Officer will decide the disposition of the nonconforming data and any necessary corrective action(s). Corrective actions may include the qualification of the data as estimated (*J*) or rejected (*R*) values. All deficiencies, nonconformances, and corrective actions will be documented in annual status reports for the project. Status reports may include:

- Graphical and tabular summaries of the collected data.
- Results from comparisons in hydrology and water quality between the monitoring sites.
- Conclusions.
- Appendices: quality assurance memoranda, raw data tables, field datasheets, and chain of custody documentation.

12 Data Verification, Validation, and Usability

12-1 Data Verification

Data verification refers to the process of data review that occurs at the end of a data collection effort, such as at the end of the wet season or year. Data verification is defined as:

> *Examination of a dataset for errors or omissions, and assessment of the Data Quality Indicators related to that dataset for compliance with acceptance criteria (MQOs). Verification is a detailed quality review of a dataset.* (Kammin, 2010)

The Quality Assurance Officer or the Data Steward will implement the data verification process. Field data inputs, the completed chain of custody (COC), and laboratory reports, bench sheets, laboratory certifications, and laboratory process documentation will be reviewed to see whether they met requirements. If poor data quality trends or significant problems are identified, corrective action(s) will be implemented to improve the data quality.

The data verification procedures are being developed by a consultant for WSDOT to complement the QAPPs. As a result, verification procedure documentation will provide WSDOT a data assessment toolbox and programmatic approach to ensure quality goals. The verification procedures will be a stand-alone document and will not be submitted along with the QAPPs. Initial data verification will focus on reviewing the data records, laboratory reports, field reports, and COCs. This review will look at previously qualified or flagged data and evaluate their impact on the overall data quality objectives. If the data do not meet the statistical data review criteria, then the data point will be removed from the overall data set. The preliminary review may incorporate the statistical review methods described in Section 12-1.1. Issues that could affect the usability of the data may include: apparent anomalies in recorded data, missing values, deviations from standard operating procedures, and the use of nonstandard data collection methods (USEPA, 2002a).

Any changes to the results as originally reported by the laboratory should either be accompanied by a note of explanation from the data verifier/laboratory or reflected in a revised laboratory data report.

Data verification records include certification statements, which certify the data have been verified and signed by appropriate personnel. Data verification records can also include a narrative that identifies technical noncompliance issues or shortcomings of the data produced during the field or laboratory activities.

12-1.1 Statistical Data Review

A statistical data review will be conducted to identify outliers and other abnormalities in the data. Statistical analyses will calculate the mean, median, mode, sample range, sample variance, standard deviation, standardized mean difference, and coefficient of variation. Outliers or data that are anomalous with the entire data set will be reviewed for the origin of the error in data collection, laboratory analysis, data input and recording, QA/QC, and data verification.

The data will be plotted (using scatter plots) to identify additional outliers or confirm outliers and abnormal data. Outlying data will be compared against the statistical and preliminary data review to confirm that the point is an outlier or anomaly.

If the data are unable to conform or do not meet the data quality objectives, or it is uncertain whether the data are able to conform to the project data set and goals, then the data will be removed.

12-1.2 Nondetects

Nondetected data will be addressed through the use of statistical methods, commonly agreed upon by the group of Phase I permittees. An SOP for evaluating nondetects (currently in draft form) provides a summary and comparison of the following methods: Substitution Half-U, Maximum Likelihood Estimation, Regression on Order Statistics, Robust Regression on Order Statistics (RROS), or Kaplan Meier (Non-parametric).

12-2 Data Validation

Data validation goes beyond data verification to examine the data for usability. WSDOT may seek data validation on all or parts of the stormwater monitoring program for its own purposes; however, data validation is not required by the permit. Validation is defined as:

> *An analyte-specific and sample-specific process that extends the evaluation of data beyond data verification to determine the usability of a specific data set. It involves a detailed examination of the data package, using both professional judgment, and objective criteria, to determine whether the MQOs for precision, bias, and sensitivity have been met. It may also include an assessment of completeness, representativeness, comparability and integrity, as these criteria relate to the usability of the dataset.* (Kammin, 2010)

Ecology considers the following three key criteria to determine whether data validation has actually occurred:

- Use of raw or instrument data for evaluation
- Use of third-party assessors
- Use of EPA *National Functional Guidelines* (USEPA, 2008 and 2010*)* or the equivalent for review

12-3 Usability Statement

If the data verification process finds that the data quality objectives (DQOs) stated in this QAPP are met, then the data will be useable for project objectives. This statement of usability pertains to the data being acceptable for the purposes under which it was collected, but does not cover uses outside of the original intent. If the DQOs are not met, a determination will be made to either quantify and qualify the offending data and proceed with project goals or to consider elimination of the offending data completely. Anomalies in the data will be identified and their impacts on the data assessed in each annual Stormwater Monitoring Report.

Three main aspects of the Usability Statement are:

1. Determining whether the stormwater runoff and sediment samples are representative.
2. Ensuring sample results met the storm and sample criteria.
3. Ensuring the statistical goals are met to calculate wet and dry season loads.

13 Reports

In accordance with the schedule presented in Section 4, Organization and Schedule, the following four types of reports will be generated in relation to the Stormwater Monitoring Program activities covered in this QAPP:

1. Sample Field Notes
2. Sample Event Records
3. Stormwater Monitoring Report
4. Final Water Quality Monitoring Report

13-1 Field Notes and Event Records

13-1.1 Field Notes

Notes recorded in the field will be kept in an organized filing system and may include the following (paper or electronic) information:

- Field sampler name, date, and time of sampling
- Filtration and preservation of samples
- Volume of water collected
- Measurements made by multi-meter probes
- Visual observations
- Rainfall and runoff observations
- Records of number of grab samples taken
- Maintenance activity logs
- Maintenance inspection field sheets

13-1.2 Event Records

Records of the storm event will be kept in an organized filing system and may include the following (paper or electronic) information or components:

- Website print-outs of predicted rainfall
- Storm event hydrograph
- Sampling time frame for the storm event
- Data quality analysis indicating how the sampled event met criteria
- Chain of custody forms
- Support documents such as calculations or problems encountered

13-1.4 Annual Stormwater Monitoring Report

The annual Stormwater Monitoring Report is required by S8.F of the permit to provide a summary of the previous water year's monitoring results. Detailed stormwater monitoring data reports are due to Ecology by October 31, beginning in 2013 and annually thereafter. The complete Annual Stormwater Monitoring Report will include, at a minimum, the information specified by the permit in S7 and S8.

For the reports submitted in 2010, 2011, and 2012, reporting requirements include the status of preparations to meet requirements in S7.A through S7.E of the permit and will be included in the annual Stormwater Management Plan (SWMP) Progress Report. In October 2013, a complete and separate Stormwater Monitoring Report is due, to accompany the annual SWMP Progress Report (Table 25).

Table 25 outlines the monitoring report requirements as stated in the permit for each report. Data sets required to be submitted to Ecology will be in Excel format and included in the reports as tables or data summaries. All required reports will be submitted to Ecology in both paper and electronic formats.

Table 25 Reporting requirements for the 3rd, 4th, and 5th Annual Stormwater Monitoring Reports beginning in 2013 (Ecology, 2008b; Ecology, 2009a).

Category	Reporting Requirement
Sampled Storm Event	Sample event identification (date, time, location).
	Tabular water quality data and summary results for each monitored parameter, including sediments.
	Antecedent dry period, inter-event period, and total precipitation depth.
	A graphical representation of storm hyetograph and hydrograph for both the influent and effluent, with each aliquot collection point spatially located throughout the hydrograph; the sampled time period (% of hydrograph sampled), total runoff time period and total runoff volume.
Site	Rainfall/runoff relationship established using continuous flow records and precipitation data.
	WSDOT shall express the loadings as total pounds and as pounds per acre.
Site for Each Parameter	Mean and median Event Mean Concentrations (EMCs) only from sampled storm events.
	Total annual pollutant load and the seasonal pollutant load for the wet and dry seasons only from sampled storm events.
	Mean and median EMCs only from sampled storm events.
	Total annual pollutant load and the seasonal pollutant load for the wet and dry seasons for both sampled and estimated unsampled storm events.[1]
	The method used to estimate loads for unsampled events shall be applied to previously submitted data and continue for the remaining years of the permit cycle.[1]
	Any proposed changes to the monitoring program that could affect future data results.
First Flush Toxicity Sampling Event	WSDOT shall report an EC_{50} for each test. WSDOT shall submit all reports for toxicity testing in accordance with the most recent version of Department of Ecology Publication # WQ-R-95-80,[2] Laboratory Guidance and Whole Effluent Toxicity Test Review Criteria.
	Reports shall contain bench sheets, and reference toxicant results if required for the protocol, for test methods.
	WSDOT shall submit toxicity test reports, bench sheets, and reference toxicity results in electronic format for entry into Ecology's database and shall submit a hard copy.
	WSDOT shall calculate the EC_{50} by the trimmed Spearman-Karber procedure. WSDOT may apply Abbott's correction to the data before deriving this point estimate.

[1] These requirements do not apply to the 2013 report; instead S7.B.8.iii states these requirements apply to all other Annual Stormwater Monitoring Reports.

[2] Ecology, 2008b.

13-1.5 Final Water Quality Monitoring Report

A Final Water Quality Monitoring Report is due February 6, 2014. It will include a complete discussion of each monitoring program outlined in S7 and S8.F of the permit. The report must include these items:

- An estimated cost for each monitoring program component.
- Stormwater management actions taken/planned to reduce pollutants from WSDOT land uses.
- A description of the monitoring programs still in progress.
- A cumulative water quality and sediment quality results summary for each site.
- An estimated water quality loading from highway runoff sites for each pollutant based on precipitation and runoff volume.
- Evaluation of monitoring sites.
- A cumulative analysis of parameters of concern from each of WSDOT's land use monitoring sites.

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15 Appendices

Appendix A Glossary, Acronyms, Abbreviations, and Units of Measurement

Glossary

accreditation – A certification process for laboratories, designed to evaluate and document a lab's ability to perform analytical methods and produce acceptable data. For Ecology, it is "Formal recognition by (Ecology)…that an environmental laboratory is capable of producing accurate analytical data" (WAC 173-50-040) (Kammin, 2010).

accuracy – The degree to which a measured value agrees with the true value of the measured property. EPA recommends that this term not be used, and that the terms *precision* and *bias* be used to convey the information associated with the term *accuracy* (USGS, 1998).

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 or Klebsiella (Kammin, 2010).

best management practices (BMPs) – The schedules of activities, prohibitions of practices, maintenance procedures, and structural and/or managerial practices approved by Ecology that, when used singly or in combination, prevent or reduce the release of pollutants and other adverse impacts to waters of Washington State (Ecology, 2009a).

bias – The difference between the population mean and the true value. Bias usually describes a systematic difference reproducible over time, and is characteristic of both the measurement system and the analyte(s) being measured. Bias is a commonly used data quality indicator (DQI) (Kammin, 2010; Ecology, 2004).

blank – A sample prepared to contain none (or as little as possible) of the analyte of interest. For example, in water analysis, pure water is used for the blank. In chemical analysis, a blank is used to estimate the analytical response to all factors other than the analyte in the sample. In general, blanks are used to assess possible contamination or inadvertent introduction of analyte during various stages of the sampling and analytical process (USGS, 1998).

calibration – The process of establishing the relationship between the response of a measurement system and the concentration of the parameter being measured. The most important aspect of any calibration method is its ability to obtain accurate results with a high degree of certainty and repeatability (Kammin, 2010; Ecology, 2004).

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. Section 303(d) of the CWA establishes the Total Maximum Daily Load (TMDL) program. Pub.L.92-500, as amended Pub. L.95-217, Pub. L.95-576, Pub. L. (6-483 and Pub.L.97-117, 33 USC 1251et.seq).

comparability – The degree to which different methods, data sets, and/or decisions agree or can be represented as similar; a data quality indicator (USEPA, 1997).

completeness – The amount of valid data obtained from a data collection project compared to the planned amount. Completeness is usually expressed as a percentage; a data quality indicator (USEPA, 1997).

control chart – A graphical representation of quality control results demonstrating the performance of an aspect of a measurement system (Kammin, 2010; Ecology, 2004).

control limit – Statistical warning and action limits calculated based on control charts. Warning limits are generally set at +/- 2 standard deviations from the mean—action limits at +/- 3 standard deviations from the mean (Kammin, 2010).

data integrity – A qualitative DQI that evaluates the extent to which a data set contains data that are misrepresented, falsified, or deliberately misleading (Kammin, 2010).

data quality indicators (DQI) – Data quality indicators are commonly used measures of acceptability for environmental data. The principal DQIs are precision, bias, representativeness, comparability, completeness, sensitivity, and integrity (USEPA, 2006).

data quality objectives (DQO) – Data quality objectives are qualitative and quantitative statements derived from systematic planning processes that clarify study objectives, define the appropriate type of data, and specify tolerable levels of potential decision errors that will be used as the basis for establishing the quality and quantity of data needed to support decisions (USEPA, 2006).

data set – A grouping of samples, usually organized by date, time, and/or analyte (Kammin, 2010).

data validation – An analyte- and sample-specific process that extends the evaluation of data beyond method, procedural, or contractual compliance (i.e., data verification) to determine the analytical quality of a specific data set (Ecology, 2004). Data validation criteria are based upon the measurement quality objectives developed in the QA Project Plan or similar planning document, or presented in the sampling or analytical method. Data validation includes a determination, where possible, of the reasons for any failure to meet method, procedural, or contractual requirements, and an evaluation of the impact of such failure on the overall data set. Data validation applies to activities in the field as well as in the analytical laboratory (USEPA, 2002a). Data validation follows data verification (USEPA, 2006). Ecology considers four key criteria to determine whether data validation has actually occurred. These are:

- Use of raw or instrument data for evaluation
- Use of third-party assessors
- Data set is complex
- Use of EPA *Functional Guidelines* or equivalent for review

Examples of data types commonly validated would be:

- Gas Chromatography (GC)
- Gas Chromatography-Mass Spectrometry (GC-MS)
- Inductively Coupled Plasma (ICP)

The end result of a formal validation process is a determination of usability that assigns qualifiers to indicate usability status for every measurement result. These qualifiers include:

- No qualifier, data is usable for intended purposes
- *J*, data is estimated, may be usable, may be biased high or low
- *R*, data is rejected, cannot be used for intended purposes (Kammin, 2010; Ecology, 2004)

data verification – The process of evaluating the completeness, correctness, and conformance/compliance of a specific data set against the method, procedural, or contractual requirements. Again, the goal of data verification is to ensure and document that the data are what they purport to be, that is, that the reported results reflect what was actually done. When deficiencies in the data are identified, then those deficiencies should be documented for the data user's review and, where possible, resolved by corrective action. Data verification applies to activities in the field as well as in the laboratory (USEPA, 2002a). Data verification precedes data validation (USEPA, 2006).

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.

detection limit (limit of detection) – The concentration or amount of an analyte that can be determined to a specified level of certainty to be greater than zero (Ecology, 2004).

duplicate samples – Two samples taken from and representative of the same population, and carried through the steps of the sampling and analytical procedures in an identical manner. Duplicate samples are used to assess the variability of all method activities, including sampling and analysis (USEPA, 1997).

EC_{50} (effective concentration, fifty percent) means the effluent concentration estimated to cause an adverse effect in fifty percent of the test organisms in a toxicity test involving a series of dilutions of effluent (WAC 173-205-020).

edge of pavement (EOP) interceptor – A 6-inch HDPE pipe or similar device that is set up to collect runoff from an impervious roadway. EOP 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.

fecal coliform – That portion of the coliform group which 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 twenty-four hours at 44.5 plus or minus 0.2 degrees Celsius (WAC 173-201A-020).

field blank – Blanks that are analyzed to determine whether there is contamination during sampling. For water sampling, these consist of pure (e.g., deionized, micro-filtered) water that is subjected to all aspects of sample collection, field processing, preservation, transportation, and laboratory handling as an environmental sample. The pure water must be obtained from the laboratory or other reliable supplier (Ecology, 2004). Field blanks include the following types:

equipment rinsate blank – Pure (deionized, micro-filtered) water that is run through the sample pickup, tubing, and collection apparatus of the automated sampler, and is otherwise subjected to all subsequent aspects of sample collection, field processing, preservation, transportation, and laboratory handling as an environmental sample. If the equipment is not cleaned or rinsed with pure water before each environmental sample is drawn, then the equipment should not be cleaned or rinsed with pure water before collecting the rinsate blank.

filter blank – A special case of a rinsate blank prepared by filtering pure water through the filtration apparatus after routine cleaning. The filter blank may detect contamination from the filter or other part of the filtration apparatus (Ecology, 2004). This is only applicable if filtration is done in the field.

transport blank – A container of pure water that is prepared at the lab and carried unopened to the field and back with the other sample containers to check for possible contamination in the containers or for cross-contamination during transportation, storage of the samples (Ecology, 2004).

transfer blank – Prepared by filling a sample container with pure water during routine sample collection to check for possible contamination from the surroundings. The transfer blank will also detect contamination from the containers or from cross-contamination during transportation and storage of the samples (Ecology, 2004).

laboratory control sample (LCS) – A sample of known composition prepared using contaminant-free water or an inert solid that is spiked with analytes of interest at the midpoint of the calibration curve or at the level of concern. It is prepared and analyzed in the same batch of regular samples using the same sample preparation method, reagents, and analytical methods employed for regular samples (USEPA, 1997).

matrix spike – A QC sample prepared by adding a known amount of the target analyte(s) to an aliquot of a sample to check for bias due to interference or matrix effects (Ecology, 2004).

measurement quality objectives (MQOs) **–** A subset of data quality objectives (DQOs) that specify how good the data must be in order to meet the objectives of a project (Ecology, 2004). The acceptance thresholds or goals for a project's data, usually based on the individual data quality indicators (DQIs) for each matrix and analyte group or analyte. These include bias, precision, accuracy, representativeness, comparability, completeness, and sensitivity (USEPA, 2006).

measurement result – A value obtained by performing the procedure described in a method. (Ecology 2004).

method – A formalized group of procedures and techniques for performing an activity e.g., sampling, chemical analysis, or data analysis), systematically presented in the order in which they are to be executed (USEPA, 1997).

method blank – A blank prepared to represent the sample matrix, prepared and analyzed with a batch of samples. A method blank will contain all reagents used in the preparation of a sample, and the same preparation process is used for the method blank and samples (Kammin, 2010; Ecology, 2004).

method detection limit (MDL) – The minimum concentration of an analyte that, in a given matrix and with a specific method, has a 99 percent probability of being identified and reported to be greater than zero (40 CFR 136).

National Pollutant Discharge 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).

nonpoint source – The term nonpoint source is used to identify sources of pollution that are diffuse and do not have a point of origin or that are not introduced into a receiving stream from a specific outlet. Common non-point sources are rainwater and runoff from agricultural lands, industrial sites, parking lots, and timber operations, as well as escaping gases from pipes and fittings (EPA Waste and Cleanup Risk Assessment Glossary).

nutrient – A substance such as carbon, nitrogen, or phosphorus used by organisms to live and grow. Too many nutrients in the water can promote algal blooms and rob the water of oxygen vital to aquatic organisms.

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).

pathogen – Disease-causing microorganisms such as bacteria, protozoa, and viruses.

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.

point source – Any discernible, confined, and discrete conveyance, including, but not limited to, any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock concentrated animal feeding operation (CAFO), landfill leachate collection system, vessel or other floating craft from which pollutants are or may be discharged. This term does not include return flows from irrigated agriculture or agricultural stormwater runoff (NPDES Glossary).

pollution – Contamination, or other alteration of the physical, chemical, or biological properties, of any waters of the state, including change in temperature, taste, color, turbidity, or odor of the waters, or such discharge of any liquid, gaseous, solid, radioactive, or other substance into any waters of the state as will or is likely to create a nuisance or render such waters harmful, detrimental, or injurious to the public health, safety, or welfare, or to domestic, commercial, industrial, agricultural, recreational, or other legitimate beneficial uses, or to livestock, wild animals, birds, fish, or other aquatic life (WAC 173-200-020).

precision – The extent of random variability among replicate measurements of the same property; a data quality indicator (USGS, 1998). Usually expressed as relative percent difference (RPD) or relative standard deviation (RSD) (Ecology, 2004).

quality assurance (QA) – A set of activities designed to establish and document the reliability and usability of measurement data (Kammin, 2010).

Quality Assurance Project Plan (QAPP) – A document that describes the objectives of a project and the processes and activities necessary to develop data that will support those objectives (Kammin, 2010; Ecology, 2004).

quality control (QC) – The routine application of measurement and statistical procedures to assess the accuracy of measurement data (Ecology, 2004).

replicate samples – Two or more samples taken from the environment at the same time and place, using the same protocols. Replicates are used to estimate the random variability of the material sampled (USGS, 1998).

reporting limit – (1) The minimum value below which data are documented as nondetects. (2) The minimum value of the calibration range. Analyte detections between the detection limit and the reporting limit are reported as having estimated concentrations (EPA Environmental Measurement Glossary 2010).

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).

sample (field) – A portion of a population (environmental entity) that is measured and assumed to represent the entire population (USGS, 1998).

sample (statistical) – A finite part or subset of a statistical population (USEPA, 1997).

sensitivity – In general, denotes the rate at which the analytical response (e.g., absorbance, volume, or meter reading) varies with the concentration of the parameter being determined. In a specialized sense, it has the same meaning as the detection limit (Ecology, 2004).

spiked blank – A specified amount of reagent blank fortified with a known mass of the target analyte(s); usually used to assess the recovery efficiency of the method (USEPA, 1997).

spiked sample – A sample prepared by adding a known mass of target analyte(s) to a specified amount of matrix sample for which an independent estimate of target analyte(s) concentration is available. Spiked samples can be used to determine the effect of the matrix on a method's recovery efficiency (USEPA, 1997).

split sample – This term denotes when a discrete sample is further subdivided into portions, usually duplicates (Kammin, 2010).

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, 2010).

surrogate – For environmental chemistry, a surrogate is a substance with properties similar to those of the target analyte(s). Surrogates are unlikely to be native to environmental samples. They are added to environmental samples for quality control purposes, to track extraction efficiency and/or measure analyte recovery. Deuterated organic compounds are examples of surrogates commonly used in organic compound analysis (Kammin, 2010).

systematic planning – A step-wise process that develops a clear description of the goals and objectives of a project and produces decisions on the type, quantity, and quality of data that will be needed to meet those goals and objectives. The data quality objectives (DQO) process is a specialized type of systematic planning (USEPA, 2006).

Technology Assessment Protocol – Ecology (TAPE) – A Washington State Department of Ecology process for reviewing and approving new stormwater treatment technologies (Ecology, 2008a).

Total Maximum Daily Load (TMDL) – TMDL means a water cleanup plan. A TMDL is a calculation of the maximum amount of a pollutant that a water body can receive and still meet water quality standards, and an allocation of that amount to the pollutant's sources. A TMDL is the sum of the allowable loads of a single pollutant from all contributing point and nonpoint sources. The calculation must include a margin of safety to ensure the water body can be used for the purposes the state has designated. The calculation must also account for seasonable variation in water quality. Water quality standards are set by states, territories, and tribes. They identify the uses for each water body, for example, drinking water supply, contact recreation (swimming), and aquatic life support (fishing), and the scientific criteria to support that use. The Clean Water Act, section 303, establishes the water quality standards and TMDL programs (Ecology, 2009a).

Acronyms and Abbreviations

40 CFR	Title 40 of the Code of Federal Regulations
AADT	annual average daily traffic
BMP	best management practice
CAD	Computer Aided Design
CFR	Code of Federal Regulations
CLP	Contract Laboratory Protocols
COC	chain of custody
CTAS	cobalt thiocyanate activating substances
CWA	Clean Water Act
DCP	data collection platform
DQI	data quality indicator
DQO	data quality objective
EAP	Environmental Assessment Program
EOP	edge of pavement
Ecology	Washington State Department of Ecology
EMC	event mean concentration
EPA	U.S. Environmental Protection Agency
et al.	and others
FEP	fluorinated ethylene propylene
GIS	Geographic Information System
GPS	Global Positioning System
HDPE	high-density polyethylene
HRM	*Highway Runoff Manual*
ICP-MS	inductively coupled plasma- mass spectrometry
IDL	instrument detection limit
LCS	laboratory control samples
MBAS	methylene blue active substances
MDL	method detection limit
MEL	Manchester Environmental Laboratory
MQO	measurement quality objective
MS4	municipal separate storm sewer system
MS/MSD	matrix spike/matrix spike duplicate
NB	northbound
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
OP	orthophosphate
PAH	polycyclic aromatic hydrocarbons
PASP	pre-activity safety plan
PCB	polychlorinated biphenyls
PPE	personal protective equipment
PSD	particle size distribution
QA	quality assurance
QA/QC	quality assurance/quality control
QAPP	Quality Assurance Project Plan

QC	quality control
RL	reporting limit
RPD	relative percent difference
RSD	relative standard deviation
SB	southbound
SCS	Soil Conservation Service
SOP	standard operating procedure
SR	state route
SWMP	Stormwater Management Program
TAPE	Guidance for Evaluating Emerging Stormwater Treatment Technologies, Technology Assessment Protocol – Ecology (TAPE)
TEF	Technology Equipment Fund
TIE	toxicity identification evaluation
TI/RE	toxicity identification/reduction evaluation
TKN	total Kjeldahl nitrogen
TMDL	Total Maximum Daily Load
TP	total phosphorus
TPH	total petroleum hydrocarbons
TRE	toxicity reduction evaluation
TSS	total suspended solids
USGS	United States Geological Survey
VFS	vegetated filter strip
WAC	Washington Administrative Code
WB	westbound
WQP	Water Quality Program
WSDOT	Washington State Department of Transportation

Units of Measurement

°C	degrees centigrade
cfs	cubic feet per second
ft	feet
g	gram, a unit of mass
in	inch
L/min	liters per minute
mg	milligram
mg/Kg	milligrams per kilogram (parts per million)
mg/L	milligrams per liter (parts per million)
mL	milliliters
ug/Kg	micrograms per kilogram (parts per billion)
µg/L	micrograms per liter (parts per billion)
µm	micrometer
oz	ounce

Appendix B Section 7 A-E of 2009 WSDOT NPDES Municipal Stormwater Permit

S7. MONITORING

A. Monitoring Objectives

WSDOT shall develop and implement a monitoring program to establish baseline stormwater discharge information from its highway conveyances, rest areas, maintenance facilities, and ferry terminals and develop and implement a monitoring program to evaluate Best Management Practice (BMP) effectiveness. Annual monitoring report data requirements shall be submitted as described in S8.F Stormwater Monitoring Report. WSDOT shall design the monitoring strategy to:

1. Produce scientifically credible data that represents discharges from WSDOT's various land uses;
2. Provide information that can be used by WSDOT for designing and implementing effective stormwater management strategies for WSDOT facilities; and
3. Determine the long-term effectiveness of individual facility Stormwater Pollution Prevention Plans.

B. Baseline Monitoring of WSDOT Highways

1. WSDOT shall obtain stormwater discharge quality and quantity data from the edge of pavement at highway sites. WSDOT shall collect data to allow analysis of pollutant loads and prioritize parameters of concern. WSDOT shall collect samples at each site, at the frequencies and durations, and for the parameters specified in this section.

2. Continuous flow recording of all storm events (not just sampled storm events) is necessary for at least one year to establish a baseline rainfall/runoff relationship.

3. Baseline Monitoring Site Selection

   Baseline monitoring sites shall have the conveyance system and drainage area mapped, and be suitable for permanent installation and operation of flow-weighted composite sampling equipment. WSDOT shall document the time of concentration for each selected drainage area using rainfall durations for typical seasonal storms.

   WSDOT shall establish monitoring sites at locations with the following annual average daily traffic (AADT):

   a. Two highly urbanized Western Washington sites (≥100,000 AADT)
   b. One urbanized Western Washington site (≤100,000 and ≥30,000 AADT)
   c. One rural Western Washington site (≤30,000 AADT)
   d. One urbanized Eastern Washington site (≤100,000 and ≥30,000 AADT)

4. Parameters To Be Sampled and Analyzed

   a. WSDOT shall sample, analyze, and report the following parameters as indicated in order of priority if insufficient volume exists. Chemicals below method detection limits after two years of data analysis may be dropped from the list of parameters. Parameter details, analytical methods and reporting limits are included in Appendix 5.
      i. Total and dissolved metals: copper, zinc, cadmium and lead
      ii. Polycyclic Aromatic Hydrocarbons (PAHs)

iii. Total suspended solids (TSS)
iv. Chlorides
v. Phthalates
vi. Herbicides: Triclopyr (Ester formula only), 2,4-D, Clopyralid, Diuron, Dichlobenil, Picloram , and Glyphosate (only if NON aquatic formula is used). Herbicides shall be sampled and analyzed only if applied near the monitoring site vicinity.
vii. Nutrients: Total phosphorus, orthophosphate

b. Grab samples shall be collected as early in the runoff event as practical. If grab samples are not collected during *qualifying* storm events, non-qualifying sized storm events may be sampled. Grab samples shall be collected, analyzed and reported for the parameters listed below. The total number of grab samples collected shall be equal to the total number of storm events collected to meet the conditions in S7.B.6.a. Parameter details, analytical methods and reporting limits are included in Appendix 5.
  i. Total Petroleum Hydrocarbons (TPH): NWTPH-Dx and NWTPH-Gx
  ii. Fecal coliform
  iii. Temperature (collected from runoff in-situ or as a grab sample)
  iv. Visible sheen observation

5. Sampling method

WSDOT shall use flow-weighted composite samplers to sample qualifying storm events, except where this permit specifies grab samples or other sampling methods. The automated sampler shall be programmed to begin sampling as early in the runoff event as practical. Each composite sample must consist of at least 10 aliquots. Composite samples with 7 to 9 aliquots are acceptable if they meet the other sampling criteria and help achieve a representative balance of storm events and storm sizes. WSDOT shall obtain samples from the edge of the pavement or from a location within a pipe conveyance system as long as in the latter case, the stormwater has not passed through a treatment BMP, a vegetated area, or the soil column.

6. Sample timing and frequency

WSDOT shall sample storm events as early in the storm event as practical and continue sampling past the longest estimated time of concentration for the contributing drainage area. For storm events lasting less than 24 hours, samples shall be collected for at least seventy-five percent of the storm event hydrograph. For storm events lasting longer than 24 hours, samples shall be collected for at least seventy-five percent of the hydrograph of the first 24 hours of the storm.

a. WSDOT shall sample each stormwater monitoring site at the following frequency:
  i. Sixty-seven percent of the forecasted qualifying storms, which result in actual *qualifying* storm events up to a maximum of 14 storm events per water year. 11 of the 14 storm events must meet the qualifying storm event criteria defined in Section S7.B.6.b.
  ii. WSDOT may collect and report data from up to 3 storm events that were forecasted qualifying storms but which did not meet the qualifying storm

event criteria for rainfall depth (0.2-inch minimum). These 3 non qualifying storms events may be collected and counted as part of the 14 required storm events.

iii. WSDOT shall ensure that storm samples are distributed throughout the year and approximately reflecting the distribution of rainfall between the wet and dry seasons. The goal for western Washington sites is to collect 60-80% of the samples during the wet season and 20-40% during the dry season. For eastern Washington, the goal is to collect 80-90% of the samples in the wet season and 10-20% of the samples in the dry season.

b. Storm Event Criteria

i. A qualifying storm event during the wet season in Western Washington (October 1 through April 30) and in Eastern Washington (October 1 through June 30) shall meet the following conditions:
   1) Rainfall depth: 0.20-inch minimum, no fixed maximum
   2) Rainfall duration: No fixed minimum or maximum
   3) Antecedent dry period: less than 0.02-inch rain or no surface runoff in the previous 24 hours
   4) Inter-event dry period: 6 hours

ii. A qualifying storm event during the dry season in Western Washington (May 1 through September 30) and in Eastern Washington July 1 through September 30) shall meet the following conditions:
   1) Rainfall depth: 0.20-inch minimum, no fixed maximum
   2) Rainfall duration: No fixed minimum or maximum
   3) Antecedent dry period: less than 0.02-inch rain in previous 72 hours
   4) Inter-event dry period: 6 hours

7. Baseline Sediment Testing

WSDOT shall trap and analyze sediments at each highway sampling site or at the vicinity of each stormwater monitoring site at least annually. WSDOT shall collect sediment samples using in-line sediment traps. Similar methods or sampling of receiving water sediment deposits shall be approved by Ecology at the time of QAPP submittal.

a. WSDOT shall sample, analyze, and report the following parameters in sediments, as indicated in order of priority if insufficient volume exists. Chemicals below method detection limits after two years of data analysis may be dropped from the list of parameters. Parameter details, analytical methods and reporting limits are listed in Appendix 5.

i. Particle size (grain size)
ii. Total organic carbon
iii. Total metals: copper, zinc, cadmium and lead
iv. PAHs
v. TPH – NWTPH-Dx Phenolics
vi. Herbicides: Dichlobenil, Triclopyr, Pircloram, and Clopyralid. Herbicides shall be sampled and analyzed only if applied in the monitoring site drainage area.
vii. Phthalates
viii. Total solids

8. Reporting for Baseline Monitoring of Highways
    a. The Annual Stormwater Monitoring Report shall include the following information for each sampled storm event:
        i. Sample event identification (date, time, location);
        ii. Tabular water quality data and summary results for each monitored parameter including sediments;
        iii. Antecedent dry period, inter-event period and total precipitation depth; and
        iv. A graphical representation of the storm's hyetograph and hydrograph, with aliquot collection points spatially located throughout the hydrograph; the sampled time period (% of hydrograph sampled), total runoff time period and total runoff volume.
    b. WSDOT shall include in each Annual Stormwater Monitoring Report the following information for each site once sampling begins:
        i. Rainfall/runoff relationship established using continuous flow records and precipitation data;
        ii. For the 2013 Annual Stormwater Monitoring Report, submit the following for each parameter:
            1) Mean and median Event Mean Concentrations (EMCs) only from sampled storm events; and
            2) Total annual pollutant load and the seasonal pollutant load for the wet and dry seasons only from sampled storm events.
        iii. For all other Annual Stormwater Monitoring Reports, WSDOT shall submit the following for each parameter:
            3) Mean and median EMCs only from sampled storm events;
            4) Total annual pollutant load and the seasonal pollutant load for the wet and dry seasons for both sampled and estimated unsampled storm events.
            5) The method used to estimate loads for unsampled events shall be applied to previously submitted data and continue for remaining years of the permit cycle.
            6) Any proposed changes to the monitoring program that could affect future data results.
    c. WSDOT shall express the loadings as total pounds and as pounds per acre.

C. Seasonal First Flush Toxicity Testing

WSDOT shall test the seasonal first flush for toxicity in accordance with the criteria and procedures described in this section. This toxicity testing is for screening purposes only and is not effluent characterization or compliance monitoring under WAC 173-205.

1. Toxicity Storm Event Criteria
   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 October, irrespective of antecedent dry period, if unsuccessful in August or September).

2. Toxicity Sample Collection Criteria
   WSDOT shall collect adequate sample volume to perform both the toxicity test and the chemical analysis test described below. If sample volume for the toxicity test is equal to or less than 2 liters, do not attempt a toxicity test. Priority parameters are listed in S7.C.4 and volume requirements are listed in Appendix 6.
3. Toxicity Site Selection
   a. Once each year WSDOT shall test the seasonal first flush for toxicity from 3 untreated highway runoff monitoring locations. Samples shall be collected from the edge of the pavement or from a location within a pipe conveyance system as long as in the latter case the stormwater has not passed through a treatment BMP, a vegetated area, or the soil column. The following test sites shall be sampled:
      i. One highly urbanized site (≥100,000 AADT)
      ii. One urbanized site (≤100,000 and ≥30,000 AADT)
      iii. One rural site (≤30,000 AADT)
   b. Once each year WSDOT shall test the seasonal first flush for toxicity from 3 BMP effluent locations. BMPs shall be selected and designed in accordance with the HRM. One BMP site shall be categorized as an enhanced treatment BMP for metals removal. The BMPs shall be tested at the following sites:
      i. One highly urbanized site (≥100,000 AADT)
      ii. One urbanized site (≤100,000 and ≥30,000 AADT)
      iii. One rural site (≤30,000 AADT)
4. Parameters to be Sampled and Analyzed
   At each monitoring site, WSDOT shall collect a sample for chemical analysis and a sample for the toxicity test using the same sampling methods, at the same time and location. Parameter details, analytical methods and reporting limits are presented in Appendix 5. Chemicals below reporting limits after two years of data analysis may be dropped from the list of parameters. The following parameters shall be collected and analyzed, as indicated in order of priority if insufficient volume exists:
   a. Total and dissolved metals: copper, zinc, cadmium and lead
   b. Herbicides (listed in S7.B.4 and if only applied in the monitoring site drainage area).
   c. Total suspended solids
   d. Chlorides
   e. Hardness
   f. Methylene blue activated substances (MBAS)
   g. PAHs
   h. Phthalates
   i. TPH: NWTPH-Gx and NWTPH-Dx (collected as a grab sample)

5. Sampling Method

   WSDOT shall collect time or flow-weighted composite samples. If WSDOT is unsuccessful in completing a toxicity test despite documented, good faith efforts or due to an invalid or anomalous test result, WSDOT shall make a second sampling attempt if sufficient time remains to meet the toxicity storm event criteria. If the second attempt is also unsuccessful, WSDOT shall document its efforts in its annual stormwater monitoring report and shall not be required to conduct further sampling and analysis efforts under S7.C for that calendar year.

6. Laboratory Testing Procedures

   WSDOT shall follow toxicity testing procedures for *Hyalella azteca* 24-hour test per ASTM E1192-97. Toxicity tests must meet quality assurance criteria in the most recent versions of ASTM E1192-97 and the Department of Ecology Publication #WQ-R-95-80, Laboratory Guidance and Whole Effluent Toxicity Test Review Criteria. The laboratory must conduct water quality measurements on all samples and test solutions for toxicity testing as specified in the most recent version of Department of Ecology publication #WQ-R-95-80, *Laboratory Guidance and Whole Effluent Toxicity Test Review Criteria.* Sample volume, replicates, control and concentrations and required test conditions for the 24-hour survival test (ASTM E1192-97) are included in Appendix 6.

7. Follow up Actions

   If the EC_{50} from any valid and non-anomalous test is 100% stormwater or less, WSDOT shall conduct follow-up actions. WSDOT shall prepare a study design to further refine the knowledge of toxicant concentrations in stormwater discharged to receiving waters from WSDOT's roads and highways. WSDOT shall use the findings from this study to determine which highway site(s) warrant further investigation. The study design shall include a mapping of site-specific MS4s, any installed or planned structural BMPs, proposed sampling and analysis and a description of the toxicity pathways to receiving water. If necessary to produce knowledge from the study useful in source control or BMP improvement, WSDOT shall include a toxicity identification/reduction evaluation (TI/RE) in the study design. The TI/RE shall be based upon instructions in WAC 173-205-100.

8. Reporting for Annual First Flush Toxicity Testing

   WSDOT shall submit the following information for each sampling event at each site:

   a. WSDOT shall report an EC_{50} for each test. WSDOT shall submit all reports for toxicity testing in accordance with the most recent version of Department of Ecology Publication # WQ-R-95-80, *Laboratory Guidance and Whole Effluent Toxicity Test Review Criteria.* Toxicity reports shall be included in each Annual Stormwater Monitoring Report beginning in 2013 with the following information:
      i. Reports shall contain bench sheets, and reference toxicant results if required for the protocol, for test methods.

ii. WSDOT shall submit toxicity test reports, bench sheets, and reference toxicity results in electronic format for entry into Ecology's database and shall submit a hardcopy.
iii. WSDOT shall calculate the EC_{50} by the trimmed Spearman-Karber procedure. WSDOT may apply Abbott's correction to the data before deriving this point estimate.

D. Baseline Monitoring of Rest Areas, Maintenance Facilities and Ferry Terminals

1. Monitoring Site Selection

   WSDOT shall conduct stormwater discharge monitoring to collect baseline water quality data. Monitoring locations shall be located to capture runoff from most of the site and down gradient of the major pollutant generating activities for each facility. WSDOT shall sample the following land uses:

   a. Two High-Use Rest Areas
   b. Six Maintenance Facilities, one in each WSDOT region;
   c. One High-Use Ferry Terminal

2. Parameters Sampled and Analyzed in Stormwater

   The following parameters shall be sampled, analyzed and reported in untreated water. Chemicals below method detection limits after two years of data analysis may be dropped from the list of parameters. Parameter details, analytical methods and reporting limits are presented in Appendix 5.

   a. Rest areas (as indicated in order of priority if insufficient volume exists):
      i. TPH: NWTPH-Dx and NWTPH-Gx (grab)
      ii. Total and dissolved metals: copper, zinc, cadmium and lead
      iii. PAHs
      iv. TSS
      v. Herbicides (listed in S7.B.4 only for those that WSDOT applies on-site, stores on-site, or applies by vehicles parked on-site)
      vi. Nutrients: Total phosphorus, nitrate/nitrite, ortho-phosphorus, and total Kjeldahl nitrogen
      vii. Chlorides
      viii. Phthalates
      ix. Fecal coliform (grab)
      x. Temperature (collected from runoff in-situ or as a grab sample)
   b. Maintenance facilities (as indicated in order of priority if insufficient volume exists):
      i. Total suspended solids
      ii. TPH: NWTPH-Dx and NWTPH-Gx (grab)
      iii. PAHs
      iv. Herbicides (listed in S7.B.4 only for those that WSDOT applies on-site, stores on-site, or applies by vehicles parked on-site)
      v. Nutrients: Total phosphorus, ortho-phosphorus, nitrate/nitrite and total Kjedahl nitrogen (where fertilizers are applied on-site, stored on-site or applied by vehicles parked on-site)
      vi. Total and dissolved metals: copper, zinc, cadmium and lead

vii. Methylene blue activated substances (MBAS)
viii. Chlorides

c. Ferry Terminal (as indicated in order of priority if insufficient volume exists):
   i. PAHs
   ii. TPH: NWTPH-Dx and NWTPH-Gx (collected as a grab sample)
   iii. Total and dissolved metals: copper, zinc, cadmium and lead
   iv. MBAS
   v. Total suspended solids
   vi. Fecal coliform (grab)
   vii. Temperature (collected from runoff in-situ)

3. Sampling Method

   WSDOT shall collect samples using composite samplers or by manual compositing grab samples. A composite sample shall consist of a minimum of five individual stormwater grab samples equally spaced in time and collected within the first hour of runoff.

4. Sample Timing and Frequency

   WSDOT shall conduct sampling as early in the runoff event as practical but not later than 20 minutes after the onset of runoff at the monitoring location.

   a. WSDOT shall collect samples from a minimum of seven storm events throughout the calendar year.
      i. WSDOT shall sample at least five qualifying storm events during the wet season. Wet season samples shall be collected over a time frame exceeding 28 consecutive days.
      ii. WSDOT shall sample at least one qualifying storm event during the dry season
      iii. Additionally, WSDOT shall collect a sample that represents the seasonal first-flush event no earlier than August 1. The seasonal first-flush sample must have a one-week antecedent dry period.
   b. Storm Event Criteria

      A qualifying storm event during the wet season in Western Washington (October 1 through April 30) and wet season in Eastern Washington (October 1 through June 30) shall meet the following conditions:

      i. Rainfall depth: 0.20-inch minimum, no fixed maximum
      ii. Rainfall duration: No fixed minimum or maximum
      iii. Antecedent dry period: less than 0.02-inch rain or no surface runoff in the previous 24 hours
      iv. Inter-event dry period: 6 hours

      A qualifying storm event during the <u>dry</u> season in Western Washington (May 1 through September 30) and dry season in Eastern Washington (July 1 through September 30) shall meet the following conditions:

      v. Rainfall depth: 0.20-inch minimum, no fixed maximum
      vi. Rainfall duration: No fixed minimum or maximum
      vii. Antecedent dry period: less than 0.02-inch rain in previous 72 hours

viii. Inter-event dry period: 6 hours

5. Reporting requirements for Baseline Monitoring of Rest Areas, Maintenance Facilities and Ferry Terminals

   a. WSDOT shall submit an Annual Stormwater Monitoring Report with the following information for each sampled storm event beginning in 2013:

      i. Sample event identification (date, time, location)
      ii. Tabular water quality data and summary results for each monitored parameter;
      iii. Antecedent dry period, inter-event period and total precipitation depth; and
      iv. The time period of sample collection.

   b. WSDOT shall include in each Annual Stormwater Monitoring Report any proposed changes to the monitoring program that could affect future data results for each *site.*

E. Monitoring the Effectiveness of Stormwater Treatment and Hydrologic Management Best Management Practices (BMPs)

1. WSDOT shall conduct a full-scale monitoring program to evaluate the effectiveness and operation and maintenance requirements of stormwater treatment and hydrologic management BMPs. Any BMPs listed in its Highway Runoff Manual (HRM) may be selected. Stormwater treatment and hydrologic BMPs not listed in the HRM, require engineering designs, specifications, and approval from a professional engineer.

2. WSDOT shall monitor at least two treatment BMPs, at no less than two sites per BMP. Monitoring shall continue until statistical goals are met (defined by Ecology's publication, "Guidance for Evaluating Emerging Stormwater Treatment Technologies, Technology Assessment Protocol" (TAPE). If the statistical goals are not achieved within the term of this permit, Ecology will consider continuing the monitoring effort in the next permit cycle.

   a. WSDOT may choose BMPs it has already started evaluating prior to issuance of this permit, provided the study meets the guidelines outlined below. WSDOT shall complete the evaluation during this permit cycle.
   b. WSDOT shall obtain written approval from Ecology for the BMPs WSDOT proposes to evaluate.
   c. WSDOT shall select BMPs from the following categories:
      i. Basic Treatment
      ii. Enhanced Treatment
      iii. Metals/Phosphorus Treatment
      iv. Oil Control
   d. WSDOT shall also select one flow reduction strategy BMP (such as LID) that is in use or planned for installation. Monitoring of a flow reduction strategy shall include continuous rainfall and surface runoff monitoring. Flow reduction strategies shall be monitored through either a paired study or against a predicted outcome.

3. For BMPs monitored under this section, WSDOT shall test BMPs that have been designed and installed in accordance with HRM unless Ecology approves of an alternate design in the QAPP review.
4. WSDOT shall use appropriate sections of Ecology's TAPE (available on Ecology's website) for preparing, implementing, and reporting the results of the BMP evaluation program.
   a. WSDOT shall use USEPA publication number 821-B-02-001, "Urban Stormwater BMP Performance Monitoring," as additional guidance for preparing the BMP evaluation monitoring and shall collect information pertinent to fulfilling the "National Stormwater BMP Data Base Requirements" in section 3.4.3. of that document.
   b. WSDOT shall determine mean and median effluent concentrations, and shall determine percent removals for each BMP type with a statistical goal of 90-95% confidence and 75-80% power for the parameters for which the facility is approved in the HRM. The initial QAPP shall commit to a monitoring program designed to achieve the statistical goal, but shall target collection of at least 12 influent and 12 effluent samples per year.
5. WSDOT shall monitor the following parameters at each test site:
   a. For Basic, Enhanced, or Phosphorus Treatment BMPs: total suspended solids, particle size distribution, pH, total phosphorus, ortho-phosphate, hardness, and total and dissolved copper and zinc.
   b. For Oil Control BMPs: pH, NWTPH-Dx and –Gx, and visible oil sheen
6. WSDOT shall sample the accumulated sediment at each test site for Basic, Enhanced, Phosphorus treatment, or Oil Control BMPs for the following parameters: total solids, particle size (grain size), total volatile solids, NWTPH-Dx, total phosphorous, and total cadmium, copper, lead, and zinc.
7. Reporting requirements for Stormwater Treatment and Hydrologic Management Best Management Practice (BMP) Evaluation Monitoring beginning with the 2013 Stormwater Monitoring Report WSDOT shall include the following information for *each sampling event from each site*:
   a. Sample event identification (date, time, location)
   b. Tabular water quality data and summary results for each monitored parameter;
   c. Antecedent dry period, enter-event period and total precipitation depth;
   d. A graphical representation of storm hyetograph and hydrograph for both the influent and effluent, with each aliquot collection point spatially located throughout the hydrograph; the sampled time period (% of hydrograph sampled), total runoff time period and total runoff volume.
8. Beginning with the 2013 monitoring annual report and annually thereafter until statistical goals are met, WSDOT shall include in each Annual Report for BMP Evaluation Monitoring the following information for each *site*:
   a. Status of implementing the monitoring program and a description of Stormwater Treatment and Hydrologic Management BMP Evaluation Monitoring programs that are still in progress at the end of the reporting year

b. WSDOT shall compute and report cumulative (including previous years) performance data for each treatment BMP test site, and for both sites of the same treatment BMP type, consistent with the guidelines in appropriate sections of Ecology's guidance for "Evaluation of Emerging Stormwater Treatment Technologies" and USEPA publication number 821-B-02-001, "Urban Stormwater BMP Performance Monitoring," including information pertinent to fulfilling the "National Stormwater BMP Data Base Requirements" in section 3.4.3. of that document.
c. Status of cumulative (including previous years) performance data in terms of statistical goals for each test site and for both test sites of the same treatment BMP type;
d. Status of performance data concerning flow reduction performance for the hydrologic reduction BMP; and
e. Any proposed changes to the monitoring program that could affect future data results.

9. A final report on each BMP monitored shall be submitted once the monitoring statistical goals are met. The final report shall include an analysis of the performance data collected on the BMPs as described in the appropriate sections of Ecology's TAPE (available on Ecology's website).

Appendix C Toxicity Guidance

This Toxicity Guidance is copied directly from the WSDOT stormwater permit's Appendix 6 (Ecology, 2009a).

TOXICITY GUIDANCE

Guidance for Sampling and Toxicity Testing Required in S.7.C. of the WSDOT Municipal Stormwater Permit (WSDOT Permit)

This guidance document provides additional information to the requirements listed in S.7.C of the WSDOT Permit. S.7.C requires first-flush toxicity sampling at six stormwater monitoring locations. This Appendix contains guidance and multiple planning steps to ensure quality toxicity data is adequately collected. This Appendix should be used *in addition* to any required QAPP content demonstrated in Ecology's *Guidelines for Preparing Quality Assurance Project Plans for Environmental Studies (2004)*. This Appendix includes guidance and references for:

- Sampling Strategies
- Attempts at toxicity
- Volume, Temperature and Holding Times
- Invalid and Anomalous Test Procedures
- Laboratory Testing Procedures and Quality Assurance
- Follow-up Actions
- Submittals
- Toxicity Identification/Reduction Evaluation Guidance
- Additional Resources and References for Toxicity Sampling

Sampling Strategies

Toxicity is required to be monitored at BMP effluent locations and from the edge of pavement. WSDOT may use the same sites for toxicity monitoring as other sites selected for monitoring throughout S7, but must meet the requirements pertinent each section. For example, if WSDOT uses an edge of pavement site to meet both S7.B and S7.C requirements, a flow-weighted sample must be collected for a first-flush storm. In this situation, WSDOT will receive credit for the sample if flow-weighted composite sampling techniques are used, the same sample stream of water is used as the sample volume and the storm event qualifies under both S7.B and S7.C. Any other variations from sampling requirements listed in S7.B or S7.C must be included in the QAPP submitted for Ecology review and approval.

In order to catch the first flush, storm forecasting models or advanced equipment should be used for adequate notification of incoming storms. WSDOT must then notify the toxicity laboratory 2 days prior to the date of the forecasted storm event. A general timeline should be well defined in the required QAPP for planning purposes to describe procedures for field staff communication with the laboratory. Any potential site constraints or logistical problems should be noted in the QAPP and documented by WSDOT.

The chemical analysis sampling requires analyzing the list of parameters specified in Section S.7.C. of the WSDOT Permit. In order to obtain the needed volume for the toxicity test and the full list of chemical parameters, WSDOT may use modified samplers, multiple samplers or establish field practices for replacing bottles. Attempts to obtain sufficient volumes should be indicated in the QAPPs. If using more than one sampler, the samplers should be programmed the same and the sample should be collected from the same representative sample stream.

Further, for the chemistry analysis sample, MBAS results are needed to determine if toxicity is due to detergents or surfactants used in pesticide mixtures. MBAS testing will detect anionic surfactants, but if toxicant identity is unknown and nonionic surfactants are possible, then a cobalt thiocyanate activating substances (CTAS) test should also be done.

Attempts at Toxicity

Toxicity sampling should be conducted using composite sampling equipment at selected stormwater monitoring locations as indicated in the WSDOT Permit. Composite samplers should be used to collect samples for both toxicity testing (*H. azteca*) and chemical analysis sampling (TSS, chlorides, hardness, MBAS, Metals, pesticides, PAHs, phthalates and TPH). Samples should be collected during the seasonal first-flush occurring between August 1st and September 30th each year. During this time period, if a sample is unattainable, or if the first attempt is found to be invalid or anomalous, a second attempt is required. A second attempt may occur later than September 30th and after this date; no antecedent dry period is required prior to sample collection.

Volume, Temperature and Holding Times

Volume for Toxicity and Chemical Analysis

A sufficient sample for toxicity consists of the following:

- Approximately 6 liters (1.5 gallons) of sample water is needed for the toxicity test, and,
- A maximum of 14 liters (3.7 gallons) of sample water is needed to analyze the chemical parameters. This estimate includes a maximum volume for herbicides; however, herbicide analysis is only required at those sites where herbicides are used.

Table 1. Volume Estimate Table

	Recommended Quantity	Suggested Container Type	Holding Time	Preservation
Hyalella azteca 24-hour acute test (ASTM E1192-97)	1.5 gallons (6 liters)	glass	36 hours	Cool to 6º
Chemical Parameters				
Metals: Total Cu, Zn, Cd, Pb	350 ml	500 ml HDPE	6 months	HNO_3
Metals: Dissolved Cu, Zn, Cd, Pb	350 ml	500 ml Teflon, polyethylene, polycarbonate or polypropylene	6 months	Filter[1], the HNO_3
Herbicides	2 gallons	1 gallon glass	7 days	Cool to 4º
Total suspended solids	1000 ml	500 ml polyethylene	7 days	Cool to 4º
Chlorides	100 ml	500 ml polyethylene	28 days	Cool to 4º
Hardness	100 ml	125 ml poly	6 months	H_2SO_4

Methylene blue activated substances	250 ml	1-liter Amber glass	48 hours	Cool to 4º
PAHs[2]	1 gallon	1-gallon glass	7 days	Cool to 4º
Phthalates[2]	1 gallon	1-gallon glass	7 days	Cool to 4º
TPH (NWTPH-Gx*)	120 ml	(3) 40- ml glass vials	14 days	HCL
TPH-(NWTPH-Dx*)	1 gallon + 40 ml	1 gallon glass jar + 1 40 ml glass vial	7 days	HCL

Notes:
[1]Samples for dissolved metals should be field filtered as soon as practical after the last aliquot is taken in the composite sampler.
[2]PAHs should include at a minimum: acenaphthene, acenaphthylene, anthracene, benzo[a]anthracene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[ghi]perylene, benzo[a]pyrene, chrysene, dibenzo[a,h]anthracene, fluoranthene, fluorine, indeno[1,2,3-cd]pyrene, naphthalene, phenanthrene and pyrene
[2]Phthalates should include at a minimum: *bis*(2-Ethylhexyl)phthalate, Butyl benzyl phthalate, Di-n-butyl phthalate, Diethyl phthalate, Dimethyl phthalate and Di-n-octyl phthalate.
*Not to be collected in the sample volume collection through a composite sampler.

Chemistry analysis volume requirements can vary between laboratories and sites (depending on whether or not herbicides are required for analysis). To reduce the estimated volumes listed in Table 1, some parameters may be combined into single containers. The data for Table 1 was provided by Manchester Environmental Laboratory and Nautilus Laboratory. For information on analytical methods and reporting limits, see Appendix 5.

Replicates, Volumes, and, Concentrations and Controls Required for H. Azteca

A minimum of 2 liters is need for the toxicity test. If a volume less than 2 liters are collected, do not proceed with the toxicity test or analysis of chemical parameters. Ideally, 6 or more liters should be attained for the toxicity test. Table 2 provides guidance on replicates, sample concentrations and control for sample volumes between 2 and 6 liters.

Table 2. Replicates, Volumes, Concentrations and Control for the H. Azteca 24-hour Acute Test

Sample Volume Obtained	# of Replicates w/Volume	# of Sample Concentrations and a Control
6000 ml	4 of 250 ml each	5
3000 ml	4 of 125 ml each	5
2400 ml	4 of 100 ml each	5
2000 ml	4 of 100 ml each	4

If the sample volume available for toxicity testing is between the values above, then the instructions for the next lower sample volume shall be followed and the excess sample shall be stored for possible use in toxicant identification if the chemical analyses above do not find a likely toxicant. WSDOT is encouraged to collect as much sample as possible so that excess is available for follow-up actions if toxicity is detected.

If the total sample volume for the toxicity sample after the qualifying storm is less than needed, the number of replicates may be dropped to 3 and the lowest test concentration (6.25% sample) dropped from the test.

Sample Temperature

During sample collection, WSDOT must cool the chemical analysis sample between 0 - 4ºC and 0 – 6ºC for the toxicity sample. The samples should be sent to the laboratory immediately after field collection procedures. For the toxicity sample, if the sample temperature exceeds 6ºC at receipt by the laboratory, then the WET Coordinator, Randall Marshall (rmar461@ecy.wa.gov or 360-407-6445) may be contacted to propose acceptance for the sample temperature deviation. Acceptance is based on the Department of Ecology publication # WQ-R-95-80, *Laboratory Guidance and Whole Effluent Toxicity Test Review Criteria* and will not be given for samples warmer than 14º C unless the sample is received by the laboratory within one hour after collection.

Holding Time

If the maximum holding time of the toxicity sample is exceeded (36 hours), staff will contact Ecology's WET Coordinator (rmar461@ecy.wa.gov or 360-407-6445) for conditional acceptance. Sample holding times in excess of 72 hours will not be accepted by the laboratory or Ecology. The date and time of test initiation should be recorded on field data forms or in field notebooks.

Invalid and Anomalous Test Procedures

Invalid toxicity tests are the result of the laboratory not following the test protocol or the test results not meeting the test acceptability criteria in the test protocol. If the control has less than 90% survival, the test is invalid and needs to be repeated on an additional sample meeting the terms of S8.C. The laboratory will usually identify invalid tests and inform WSDOT of the need to repeat them. The Department of Ecology will also identify invalid tests when a laboratory does not do so and will inform WSDOT in writing to attempt to collect an additional sample meeting the terms of S8.C. and retest for toxicity.

The concentration- response relationship may also be declared anomalous in accordance with Appendix D of Ecology's *Laboratory Guidance and Whole Effluent Toxicity Test Review Criteria*. Anomalous test results happen when the laboratory has conducted the toxicity test in accordance with the test protocol, but the results are considered unreliable according to the anomalous test identification criteria in Ecology Publication # WQ-R-95-80, *Laboratory Guidance and Whole Effluent Toxicity Test Review Criteria*. The criteria for identification of anomalous test results help screen for adverse effects which are not caused by toxicity. Only the Department of Ecology may identify a test result as anomalous. If the Department determines the test results are anomalous, the Department may require the Permittee to attempt to collect a second toxicity test sample if the Department believes sufficient time remains to collect a sample meeting the toxicity storm event criteria.

WSDOT will be notified in writing if it is required to attempt to collect an additional sample meeting the terms of S8.C. Additional samples must include enough volume to repeat the analyses for the list of chemical parameters or to conduct a toxicity identification evaluation (TIE) if the sample is toxic. If WSDOT wishes to do a TIE instead of chemical analysis of the additional sample, a TIE plan must be prepared and approved in advance. If WSDOT is unable to collect and test a second sample, it must document its efforts in the annual report. WSDOT shall not be required to make more than two sample attempts for toxicity testing described in S8.C.

<u>Laboratory Testing Procedures and Quality Assurance</u>

Laboratory Testing Procedures

Conductivity, pH, dissolved oxygen and hardness will be measured at the toxicity laboratory upon sample receipt of the toxicity sample. An additional hardness sample may be collected from the receiving water by the permittee in order for the toxicity laboratory to adjust the sample hardness to match receiving water hardness. The permittee is encouraged to monitor receiving streams for pH, dissolved organic carbon, and common ions so the biotic ligand model can be used to estimate receiving water toxicity due to metals in the storm water. For the toxicity sample collected, the following testing procedures are illustrated in the following reference:

> *ASTM E 1192-97: Standard Guide for Conducting Acute Toxicity Tests on Aqueous Ambient Samples and Effluents with Fishes, Macroinvertebrates and Amphibians.*

An EC_{50} should be calculated for each test result using the Spearman-Karber Method. Abbot's correction may be applied to the data before deriving the point estimations. A minimum of five concentrations and a control should be used. If an EC_{50} is 100% sample or less, then the permit requires follow-up actions.

Required Test Conditions for 24-Hour Survival Test (ASTM E 1192-97)

<u>Test Organism</u>: *Hyalella azteca*

<u>Test Chamber</u>: 250 - 500 mL

<u>Volume</u>: 100 - 250 mL

<u>Reps</u>: 4

<u>Concentrations</u>: 5 plus control, standard 0.5 dilution series. If volume collected is low, 6.25% concentration will be dropped.

<u>Substrate</u>: square of nitex screen

<u># animals per rep</u>: 10

<u>Age</u>: 7 - 14 days, 1 - 2 day range in age

<u>Feeding</u>: Feed ground cereal leaf prior to testing. No feeding during testing.

<u>Temperature</u>: 23 degrees

<u>Aeration</u>: if below 4.0 mg/L

<u>Light</u>: 16/8

<u>Test Acceptability Criteria</u>: ≥ 90% survival in control

<u>Control and Dilution Water</u>: moderately hard synthetic water

<u>Hardness Modification</u>: Storm water sample hardness may be adjusted to match

Laboratory Quality Assurance

Toxicity tests must meet quality assurance criteria in the most recent versions of:

- Department of Ecology Publication #WQ-R-95-80, *Laboratory Guidance and Whole Effluent Toxicity Test Review Criteria*.

Follow-up Actions

If the EC_{50} from any valid and non-anomalous test is 100% stormwater or less, the following procedures are required:

- Chemical analytical results must be compared to the EPA's EcoTox database and the science literature to determine the presence of a detected toxicant within sixty (60) days after final validation of the data
- If a possible chemical contaminant(s) of concern is determined by the EPA database and science literature review, WSDOT shall prepare and submit a report summarizing:
    - The toxicity and chemical analysis results compared to EPA's EcoTox data
    - The review of relevant sources of literature
    - Summarize the possible chemical contaminant(s) of concern and explain how WSDOT's stormwater management program actions are expected to reduce stormwater toxicity

The follow-up actions when toxicity is detected should also anticipate adding a toxicity identification evaluation (TIE) to future testing events if the list of chemical analytical results did not point to a likely toxicant. Because test duration is 24 hours, any excess sample should be fresh enough for use in a TIE. WSDOT is encouraged to prepare a TIE plan in advance to allow time for review and approval by the department. The TIE plan should be based upon the relevant procedures in the EPA TIE guidance found at http://www.epa.gov/npdes/pubs/owm0330.pdf and http://www.epa.gov/npdes/pubs/owmfinaltretie.pdf

WSDOT should enter the results of the chemical analyses into a database. This database can be an important resource for follow-up actions work. Examination of results at the same outfall over time and from different outfalls from around the state may reveal patterns of chemical analytical results related to toxicity test results. The follow-up actions when toxicity is detected should take this possibility into account if identification of toxicants is not successful after two years.

The permit requires that follow-up actions results are included in the annual report. The goal of the follow-up actions is to update the annual report with progress information when toxicity is detected and to update or implement WSDOT's Stormwater Management Program to reduce toxicity. Confirmation of toxicant identity is not necessary as long as this goal is being met.

Submittals

The Permittee shall submit all reports for toxicity testing in accordance with the most recent version of Department of Ecology Publication # WQ-R-95-80, *Laboratory Guidance and Whole Effluent Toxicity Test Review Criteria.* The Permittee shall prepare and submit a report in each Annual Report including the following information:

- Any invalid or anomalous test results, good faith attempts to collect the required volume, and any unsuccessful second attempts
- Bench sheets for toxicity tests
- An analytical report for the chemistry analysis
- A toxicity data analytical report (if available in electronic format, this is the preferred submittal method to Ecology)
- Reference toxicant results for test methods
- An explanation of how WSDOT's Stormwater Management Program is expected to reduce stormwater toxicity (if applicable)
- A description of the pathway to receiving water
- A description of any existing or planned BMPs within that pathway to receiving water

Toxicity Identification/Reduction Evaluations (TI/RE) Methodology and Guidance:

Since the *Hyalella* test in the permit is only 24 hours in duration, the lab will have time to begin a TI/RE on leftover sample held at 4º C since the beginning of the test. WAC 173-205-100(2)(b) says that a TI/RE must be based upon the procedures in the EPA documents referenced below but that any procedure that is not necessary may be excluded and that any procedure may be modified or added if it will improve the ability to identify or reduce toxicity. In addition, a TI/RE plan should be implemented with flexibility so that resources can be shifted when results begin to reveal promising directions and not squandered blindly following a plan.

United States Environmental Protection Agency. 1989. Generalized methodology for conducting industrial toxicity reduction evaluations (TREs). Cincinnati OH: Risk Reduction Laboratory. EPA/600/2-88/070.

United States Environmental Protection Agency. 1991. Methods for aquatic toxicity identification evaluations: phase I toxicity characterization procedures. second edition. Duluth MN: Environmental Research Laboratory. National Effluent Toxicity Assessment Center Technical Report 18-90. EPA/600/6-91/003.

United States Environmental Protection Agency. 1993. Methods for aquatic toxicity identification evaluations. Phase II toxicity identification procedures for samples exhibiting acute and chronic toxicity. Washington DC: Office of Research and Development. EPA/600/R-92/080.

United States Environmental Protection Agency. 1993. Methods for aquatic toxicity identification evaluations. phase III toxicity confirmation procedures for samples exhibiting acute and chronic toxicity. Washington DC: Office of Research and Development. EPA/600/R-92/081.

United States Environmental Protection Agency. 2001. Clarifications Regarding Toxicity Reduction and Identification Evaluations in the National Pollutant Discharge Elimination System Program. Washington DC: Office of Wastewater Management.

Ausley LW, Arnold RW, Denton DL, Goodfellow WL, Heber M, Hockett R, Klaine S, Mount D, Norberg-King T, Ruffier P, Waller WT. 1998. Application of TIEs/TREs to whole effluent toxicity: principles and guidance. A report by the Whole Effluent Toxicity TIE/TRE Expert Advisory Panel. Pensacola FL: Society of Environmental Toxicology and Chemistry (SETAC).

<u>Examples of TI/REs with *Hyalella azteca* and metals toxicity information</u>:

Anderson BS, JW Hunt, BM Phillips, PA Nicely, KD Gilbert, V de Vlaming, V Connor, N Richard, RS Tjeerdema. 2003. Ecotoxicologic impacts of agriculture drain water in the Salinas River (California, USA). *Environ Toxicol Chem* 22:2375–2384.

Borgmann U, Y Couillard, P Doyle, DG Dixon. 2005. Toxicity of sixty-three metals and metalloids to *Hyalella azteca* at two levels of water hardness. *Environ Toxicol Chem* 24:641-652

Wheelock CE, JL Miller, MJ Miller, BM Phillips, SA Huntley, SJ Gee, RS Tjeerdema, BD Hammock. 2006. Use of carboxylesterase activity to remove pyrethroid-associated toxicity to *Ceriodaphnia dubia* and *Hyalella azteca* in toxicity identification evaluations. *Environ Toxicol Chem* 25:973-984.

Schubauer-Berigan MK, JR Dierkes, PD Monson, GT Ankley. 1993. pH-dependent toxicity of Cd, Cu, Ni, Pb and Zn to *Ceriodaphnia dubia*, *Pimephales promelas*, *Hyalella azteca* and *Lumbriculus variegatus*. *Environ Toxicol Chem* 12:1261-1266.

<u>Additional Resources/References for Toxicity Sampling</u>

1. Ecology's Laboratory Guidance and Whole Effluent Toxicity Test Review Criteria, June 2005.
2. ASTM E 1192-97: Standard Guide for Conducting Acute Toxicity Tests on Aqueous Ambient Samples and Effluents with Fishes, Macroinvertebrates and Amphibians.

Appendix D Traffic Control Safety Guidelines

Safety Guidelines

All WSDOT personnel and contracted individuals will follow the guidelines set forth in the WSDOT publication *Work Zone Traffic Control Guidelines* (WSDOT, September 2009b). Personnel sampling stormwater runoff near roadways will be trained in the following safety guidelines and requirements.

Personal Protective Equipment (PPE)

All personnel will wear and maintain the appropriate PPE as specified by WSDOT. This includes an ANSI or MUTCD-approved type II or better retroreflective safety vest and hard hat. Weather and work-appropriate clothing will be worn for the work zone. Hearing and eye protection may be advised, depending on site conditions.

Personal Attributes

All personnel will remain alert, keep a positive and safety-conscious attitude, and be responsible for their own safety as well as that of their co-workers. It is imperative to be mindful of what is happening around the work zone.

Pre-Activity Safety Plan (PASP)

All personnel will be involved with completing and reviewing the detailed pre-activity safety plan for stormwater field work before setting up the work zone. An example PASP is displayed on the following page as a guidance document for field work.

Short-Duration Work Zones

Short-duration work zones can be described as any activity where work duration lasts less than or up to 60 minutes. Most of the stormwater sampling or equipment-checking operations will be short duration. Any work that may take longer (such as station installation) will require WSDOT to develop a tailored work plan to best suit the operation. Refer to TCP-5, TCD-16, and the "Short Duration Don'ts and Do's" from Section 3-8 in the *Work Zone Traffic Control Guidelines*, for short-duration site setup specifications on and near shoulders of multilane highways.

Safety Equipment Needed

1 – Road Work Ahead sign

1 – Shoulder Work sign

8 – 24-inch retroreflective cones

1 – Traffic Warning Light (vehicle mounted) visible from 1,000 feet away

WSDOT vehicle used to provide space for personnel

PRE-ACTIVITY SAFETY PLAN

STORMWATER FIELD WORK

Date:_________ Employee:___________________ PASP#____

1. Complete pre-travel checklist prior to travel.
2. Upon reaching the field site, team lead: evaluates work area, completes site description (below), and completes hazard assessment checklist (on back).
3. Team lead assembles field crew and reviews / discusses the Pre-activity Safety Plan controls for each safety hazard identified on the completed hazard assessment checklist.
4. Team lead maintains completed safety hazard checklist until all have returned to work station and/or have check in with their supervisor. Save document for the next person that might visit.

Site Information	Purpose of Site Visit	PPE's
Site Name: ______________________________		☐ Vest
Field Contact:____________________________	**Pre-Travel Checklist**	☐ Hard Hat
Phone #: (____) _____ - _________	☐ Environmental Safety Hazard Assessment and Mitigation Booklet	☐ Eye Protection
Location: SR_____MP_____ County ______________	☐ Washington State Hospital List	☐ Gloves
Nearest Medical Facility: ____________________	☐ Pre-Trip Vehicle Inspection and Familiarization	☐ Work Boots
Map Attached	☐ 1st Aid Kit	☐ Hearing Protection
Traffic Control Needed	☐ Flares/Triangles/Signs	☐ Hip Boots or waders
Check-in Person :_______________________	☐ Emergency Contact Phone List	☐ PFD
Remote Location?	☐ Beacons/signage/traffic cones available in vehicle	☐ Throw rope bag
Cell Phone Service Phone Available	☐ Check SR View for parking possibilities (http://www.srview.wsdot.wa.gov/home.htm)	☐ Sun block
Scan Calling Card		☐ Insect repellent
First Aid planning***		☐ Other:
Known conditions/allergy medication available?		___________
Action planned ______________________		

PARKING ISSUES

Park in areas that provide safe entrance and exit of the work area, do not create potential conflicts with other vehicles and equipment or fire hazard on tall grass.

1. Parking on roadside or near traffic. **(<2 ft. from fog line more than 15 minutes)** ☐ **Yes** ☐ **No**	**1. When stopped on shoulder or roadway use beacon lights per WAC 204-38* requirements.** **2. Follow the signage and work provisions in the M54-44* for short/long duration work zones.** **3. When backing in a vehicle larger than a sedan, you must honk twice before backing (Work Zone Safety)**	**Parking on roadside or near traffic.** **(<15 ft. from fog line more than 15 minutes)** ☐ **Yes** ☐ **No**	**1. Position cones behind vehicle if there is limited visibility or curves in road** **2. Field vehicles should be equipped with appropriate signage for a shoulder closure.** **3. Lane closures will need to be coordinated through Traffic Control.**

* *Details pending*. WAC 204-38 is available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=204-38

** *Details pending*. M 54-44 is available at http://www.wsdot.wa.gov/Publications/Manuals/M54-44.htm

*** The PASP's shouldn't include medical information, but hazards like bee stings or poison oak should be identified. If employees elect to volunteer medical information to their supervisor and/or crew, that's allowed, but the supervisor and/or crew shouldn't be soliciting that information and it **should not be recorded on this form**. If a worker who is diabetic volunteers that information to co-workers or their supervisor, you can discuss options when a blood sugar episode happens, but if they choose not to let anybody know, it's their prerogative.

Task/Hazard	Control	Site Specific Comments	Requirements
2. Working near moving traffic □ Yes □ No	1. Face oncoming traffic while on foot. 2. Be aware of or develop emergency escape routes. 3. Always wear appropriate high visibility apparel, minimum is ANSI class II vest. 4. Avoid working alone.		□ Vest needed □ Hard Hat
3. Walking over uneven terrain. □ Yes □ No	1. Be aware of loose material, unstable slopes, excavation drop-offs, tripping hazards (ruts, holes, etc.), uneven ground and other obstructions. 2. Move carefully in areas with the potential for slips, trips, or falls. 3. Wear appropriate footwear with adequate traction and support.		□ Work boots □ Leather gloves (Optional but recommended in areas where blackberries are dominant)
4. Working on or around rip-rap □ Yes □ No	1. Evaluate rip-rap for loose, rolling, or unstable rocks. 2. Wear hard hat and evaluate need for leather gloves when loose or unstable rock conditions exist or when there is potential for falling rocks.		□ Work boots and gloves
5. Working in or around areas of shallow or slowly moving water □ Yes □ No	1. Evaluate water depth hazard. 2. Evaluate slippery/steep/hidden water edge conditions and need for avoidance or uphill partner. 3. Evaluate large woody debris hazard at the work site and downstream of it. 4. Assess depth of mud and evaluate safe exit. 5. Evaluate potential rescue options that are safe for the rescuer. When warranted, establish person with throw rope bag down slope of work area and between work area and any downstream hazard.		□ Hip boots or waders
6. Working around bridges, signs, light fixtures, power lines □ Yes □ No	1. Continuously assess potential for falling rock or other overhead hazards, especially in windy weather. 2. When possible, avoid, restrict time in, or work during times of least activity in hazard areas. 3. When in hazard area, wear hard hat, gloves, and safety glasses along with approved vest and footwear.		□ Hard hat, gloves, boots
7. Harmful / poisonous plants □ Yes □ No	1. Be aware of what poison ivy/oak/Giant Hogweed/Cow Parsnip/Water Hemlock/Wild Parsnip looks like (http://poisonivy.aesir.com/ has many images and information). 2. Be aware of potential for injury from vegetation around you, such as thorns from blackberries or the sharp edges of reed canary grass. 3. Bring hand-pruners and glasses to prevent injury in thick brush and briers.		□ Hand pruners □ Eye protection □ Gloves
8. Potential for transients or human biohazards □ Yes □ No	1. Avoid confrontations with transients. 2. Avoid contact with human waste, needles, or other drug paraphernalia. 3. Request assistance from maintenance to remove hazard, when necessary.		
9. Poisonous snake or large carnivore hazard	1. When working in a snake or large carnivore area, consider two or more people for site visits. 2. When in carnivore habitat, make your presence known by talking, whistling, etc. 3. Stay in sight of partner or in radio contact.		□ Two people on site □ Radios

□ Yes □ No			
10. Isolated sites / 'bad neighborhoods' □ Yes □ No	1. Consider whether location warrants two people or a team to minimize exposure time. 2. Have cell phone or check-in plan in case of emergency.		□ Two people on site □ Cell phone
11. Risk of insect / invertebrate problems □ Yes □ No	1. Determine if field staff are allergic to bees or yellow jackets. Bring appropriate first aid. Confirm location of nearest hospital. 2. Listen and look for bees frequently in the air and on the surface. When spotted, inform others in the field of the location. Evaluate carefully flagging location for future visits.		□ Person with allergy?
12. Working around natural overhead hazards. □ Yes □ No	1. Assess potential for falling rock, snags or other overhead hazards. 2. When possible, avoid or restrict time in the hazard area. 3. When in hazard area, wear hard hat, gloves, and safety glasses along with approved vest and footwear. 4. Request assistance from maintenance to remove hazard, if possible.		□ Hard hat, gloves, boots
13. Working around fall hazards** □ Yes □ No	1. Do not work in the fall hazard area without appropriate safety equipment and training. 2. Observe fall protection rules in WAC 296-155 Part C-1.* Prepare a fall protection plan, WSDOT form 750-001, prior to performing the work		□ Fall protection plan needed
14a. Inclement weather (Hot)** □ Yes □ No	**1. In very warm conditions, consider field partner.** 2. Wear weather-appropriate clothing. **3. Rest as needed; take off hat and vests on breaks.** **4. Replenish fluids – drink one quart per hour.** 5. Bring sunscreen and hat for sun protection. 6. Stay in sight of partner or in radio contact. **7. Evaluate team for heat-related illness and monitor for need of medical attention.**	**Temperature thresholds where 1, 3, 4, & 7 apply:** $\geq 89^0$ for light clothing; $\geq 77^0$ for heavier clothes (jacket, sweatshirt, coveralls, etc.); and $\geq 52^0$ for non-breathing clothes (vapor barrier clothing or chemical resistant suits)	□ Two people on site □ Radios □ Hat, sunscreen
14b. Inclement weather (Cold) □ Yes □ No	1. In very cold/snow/stormy conditions, consider field partner. 2. Wear appropriate clothing – gloves, hat, thermal underwear, heavy jacket. 3. Stay in sight of partner or in radio contact 4. Is the vehicle equipped with chains/traction tires?		□ Two people on site □ Appropriate attire □ Vehicle equipped with appropriate cold weather gear
15. Bridge Work □ Yes □ No	1. Reference controls for: -Walking over uneven terrain -Working around a stream		□ Hard hat

	-Working around natural/manmade overhead hazards -Working around fall hazards 2. Coordinate with Maintenance personnel when working from bridge structures. Follow site specific PASP as required. 3. Box girder bridges may have confined spaces requiring training.		
16. Working on a site with confined spaces. □ Yes □ No	1. Avoid all confined spaces (*Has limited or restricted entry or exit. Examples of spaces with limited or restricted entry are tanks, vessels, silos, storage bins, hoppers, vaults, excavations, and pits.)* without specialized equipment and training. 2. Observe confined space rules in WAC 296-809***		
17. Construction equipment and activities □ Yes □ No	1. PPE's required as necessary (Hearing protection, eye protection, hardhat for overhead work, etc) 2. Coordinate with PEO and/or Contractor to ensure compliance with their safety plans as applicable.		□ Hearing and/or eye protection, hard hat
18. Working around a stream defined as a water hazard (currents greater than 10cfs or deeper than 1-ft) □ Yes □ No	1. Evaluate potential rescue options that are safe for the rescuer. 2. Evaluate need for additional support from maintenance, bridge boat, or dive crews. 3. When appropriate, establish person with throw rope bag down slope of work area and any downstream in-channel hazard. 4. Evaluate the potential for loose material and unstable stream banks, and slippery/steep/hidden water edge conditions.		□ Throw rope bag □ Hip boots or waders □ PFD
19. Working in a stream defined as a water hazard □ Yes □ No	1. No wading under hazard conditions without safety equipment and training or specialized crews. 2. For in-water work, wear hip waders, tight-fitting neoprene chest wader, or equivalent. In rocky areas, boots with slip resistant felt-like material soles are recommended. 3. Wear personal flotation device in swift/deep water conditions. 4. Be aware of unstable/loose surfaces/hidden holes or objects under water.		□ Hip boots or waders
20. Machete	1. Wear PPE (gloves, boots, heavy clothing, and eye protection); keep hands dry, rest as needed.		□ Gloves, boots, heavy clothing, eye protection

* WAC 296-155 is available at: Fall Restraint and Fall Arrest-Chapter 296-155-Part C-1

** http://www.lni.wa.gov/Safety/Rules/Policies/PDFs/WRD1015.pdf

*** WAC 296-809 is available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=296-809

Excerpt from the *Work Zone Traffic Control Guidelines*, Section 3.8, (WSDOT, 2009b)

Short Duration Don'ts and Do's:

Don't –

- Take "short cuts" or hurry to accomplish work. Determination of all work zone hazards is a must.
- Run across or "dodge" traffic in live lanes.
- Work in a live lane under adverse traffic conditions or without proper traffic control in place . . . even if it is only for a few minutes or a few seconds.
- Assume that shoulder areas are automatically safe. Distracted, aggressive or impaired drivers may encroach. Also, oversize loads may present a hazard.
- Turn your back to oncoming traffic if possible.
- Put yourself in an unexpected location that may surprise a driver.

Do –

- Use the work vehicle as protection and warning whenever possible.
- Take advantage of any resources providing protection and warning without causing additional exposure. (TMAs, buffer/shadow vehicles, PCMSs, etc.)
- Plan ahead. Poor planning is not a valid excuse for lack of equipment, devices or awareness of traffic conditions.
- Find the safest available location to park or unload equipment.
- Avoid high traffic volume hours and locations. Plan ahead for better traffic conditions or consider alternate work operations.
- Work on the same side of the road as the work vehicle and warning beacon whenever possible.

Appendix E Highway Monitoring Site Photographs

Figure 18 Pilchuck EOP interceptor and DCP.

Figure 19 Everett DCP and EOP interceptor.

Figure 20 I-90 Pines curbing (in blue) will intercept stormwater runoff from freeway. Red lines indicate where HDPE conveyance pipe will bring water from curb to the DCP to be mounted inside the Pines Maintenance Facility.

Figure 21 SR-9 EOP interceptor install location (DCP to be mounted in designated location). Blue lines indicate location of EOP interceptor and conveyance piping.

Appendix F Toxicity Study Results and Follow-Up Actions

Toxicity Details and Follow-Up Actions

First flush toxicity testing using the *Hyalella azteca* 24-hour test is required under S7.C of the permit. After each toxicity test is complete, the laboratory or Ecology will inform WSDOT when the results are invalid and need to be repeated. Ecology will inform WSDOT if test results are anomalous. In order to make determinations on test validity and reliability of results, Ecology will need the test record submitted as a CETIS export as soon as possible after test completion. If the results are invalid or anomalous, Ecology may require WSDOT to collect an additional first flush toxicity sample. Annually, toxicity results will be summarized in a report to Ecology. WSDOT will also maintain all toxicity data and associated reports.

Results of the toxicity testing will be reported as the median effect concentration (EC_{50}), which is a calculated estimation of the % stormwater that causes 50% of the organisms to show an effect. S7.C.7 of the permit requires follow-up actions if the EC_{50} is 100% stormwater or less. The permit follow-up action is stated as "WSDOT shall prepare a study design to further refine the knowledge of toxicant concentrations in stormwater discharged to receiving waters from WSDOT's roads and highways." Specific components that must be included in the study design are outlined in Table F-1.

The permit requires the results of all follow-up actions to be included in the annual report. The goal of the follow-up actions is to update the annual report with progress information when toxicity is detected and to update or implement WSDOT's SWMP to reduce toxicity. Confirmation of the identity of toxicants is not necessary as long as this goal is being met.

Table F-1. Toxicity follow-up study design if the EC_{50} is 100% sample or less.

Action Item		Description	Source
1.1	Mapping of site-specific MS4s		S7.C.7*
1.2	Installed or planned structural BMPS		S7.C.7
1.3	Proposed sampling and analysis		S7.C.7
1.4	Description of toxicity pathways to receiving water		S7.C.7
2.0	If necessary to produce knowledge from the study useful in source control or BMP improvement, WSDOT will include a toxicity identification/reduction evaluation (TI/RE) in the study design.	The TI/RE shall be based upon instructions in WAC 173-205-100. The TI/RE process includes the action items 1.1-1.4 and 2.1 and may include items 2.2-2.3 if needed.	S7.C.7
2.1	Compare to EcoTox Database	Chemical results from the seasonal first flush stormwater toxicity monitoring event must be compared to EPA EcoTox database and the science literature within 60 days of data validation.	Appendix 6*
2.1.1	If a likely toxicant is identified in item 2.1 a summary report on EcoTox to Ecology	The report to Ecology will summarize: • The toxicity and chemical analysis results compared to EPA's EcoTox data • The review of relevant sources of literature • The possible chemical contaminant(s) of concern and explain how WSDOT's stormwater management program actions are expected to reduce stormwater toxicity	Appendix 6
2.2	Search facility records that may explain the toxicity	This search may include operating records for herbicide application, spill reports, or weather records	WAC 173-205-100
2.2.1	If an issue is identified in item 2.2 a summary report on facility records will be submitted to Ecology	The report to Ecology will summarize: • The relevant data used to identify the issue. • The possible chemical contaminant(s) of concern and explain how WSDOT's stormwater management program actions are expected to reduce stormwater toxicity	WAC 173-205-100
2.3	If item 2.1 does not identify a toxicant or group of toxicants likely to be causing toxicity a toxicant identification plan may be developed to aid in the identification process. The plans focus will be to add steps to future toxicity sampling efforts required by the permit, that provide additional information for toxicant identification.[1]	The toxicity identification plan will follow WAC 173-205-100 and include a study design using any elements of EPA's TIE process that are practical in meeting S7.C.7 of the permit. The plan may also include elements not in EPA's TIE process.	S7.C.7 and Appendix 6

[1] Additional testing will only be conducted if adequate sample volume remains after toxicity and chemistry aliquots required in the permit are removed.

* Ecology, 2009a.

Toxicity Identification/Reduction Evaluation (TI/RE)

The TI/RE is meant to be a general process for addressing the cause of toxicity. The result of this process may be changes to maintenance procedures or BMPs that aim to reduce the toxicity. Table F-1 summarizes the follow-up steps to be used for this process. While toxicant identification may improve source control or BMPs, it is not necessary to implement actions to reduce toxicity.

Toxicant Identification

The first method of toxicity identification that will be utilized if the EC_{50} is 100% or less is to compare the chemistry data from the same storm event to EPAs EcoTox database and the scientific literature. If a likely toxicant or group of toxicants is identified through this method, no further actions will be performed to identify the toxicant. WSDOT will perform this action anytime the EC_{50} is 100% or less and report the findings to Ecology as specified in action item 1.5.1.1.

If the toxicant of concern is not identified after action item 1.5.1 is conducted, then additional identification procedures may be implemented. WSDOT will consult with NewFields and Ecology to determine what additional procedures are appropriate for the situation. Elements of EPA's TIE process or other guidance may be followed but will be tailored to the specific conditions of the monitoring effort under the NPDES permit. Additional testing will only be conducted if all other toxicity testing and chemistry analyses can also be performed with the sample volume available.

An example of appropriate additional identification testing may be to run an EDTA treated stormwater sample concurrently with permit-required testing. EDTA treatment is used in EPA's TIE process to determine whether metals are the cause of toxicity. While this additional step uses EPA phase I TIE guidance, it is not a full TIE. The information gained from this additional step would then be used to inform future toxicity testing.

Receiving Water Monitoring

Receiving water may be sampled for hardness at the same time as the stormwater. This will be determined on a case-by-case basis by the Project Manager.

The permit toxicity guidance (see Appendix C) encourages the permittee to make two extra efforts to characterize the potential receiving water when conducting a toxicity test.

- The first extra effort stated by the permit is "An additional hardness sample may be collected from the receiving water by the permittee in order for the toxicity laboratory to adjust the sample hardness to match receiving water hardness." This is recommended because the toxicity of a metal in a low hardness stormwater sample can greatly exceed its toxicity in a receiving water with a higher hardness. If a receiving water body is receiving runoff directly from the selected BMP effectiveness and highway characterization monitoring sites, then a hardness sample will be collected either before the planned storm event sampling date or during the storm event.

- The second extra effort stated by the permit is "The permittee is encouraged to monitor receiving streams' pH, dissolved organic carbon, and common ions so the biotic ligand model can be used to estimate receiving water toxicity due to metals in the stormwater." Common ions include Ca, Mg, Na, K, SO_4 and Cl (HydroQual, Inc., 2007).

Appendix 6 of the permit (copied to this QAPP as Appendix C) requires that permittees follow a list of test conditions derived from *ASTM E 11-92-97: Standard Guide for Conducting Acute Toxicity Tests on Aqueous Ambient Samples and Effluents with Fishes, Macroinvertebrates, and Amphibians.*

Monitoring the receiving water for pH, dissolved organic carbon, and common ions would only occur if a receiving water body is directly receiving runoff from the selected BMP effectiveness and highway characterization monitoring sites. The Project and Program Managers will decide whether there are sufficient resources to pursue receiving water monitoring.

Reference

HydroQual Inc. June 2007. Biotic Ligand Model, Windows Interface, Version 2.2.3., *User's Guide and Reference Manual*. 1200 MacArthur Blvd. Mahwah, NJ 07430. (201) 529-5151

Appendix G Storm Tracking

Storm Tracking Sheet

Pre-Storm

Date:	
Time:	
Source of Forecast (web, news, etc.):	
Location of Forecasted Storm (region):	
Monitoring Sites in Area of Anticipated Storm:	
Predicted Rainfall:	
Predicted Storm Duration:	
Seasonal First Flush or Toxicity Sample Planned? **Y / N**	

1. Attach a copy of the forecast to this sheet. If initial observation was from television news, access their website and print a copy of their forecast.

2. Contact the Field Lead for the "*Go*" decision.

3. If deployment is OK'd, contact field staff and inform them of the storm characteristics and duration.

4. Contact laboratories and notify of intent to sample.

5. Monitor the telemetry files for stations in the region of the storm event. Notify field staff of storm status and if rain begins to fall on-site.

Mid-Storm

Time of first rainfall on site:	
Field teams on-site for first rainfall? **Y / N**	
Grab/composite samples collected? **Y / N**	

6. Upon successful sample collection, notify labs of sample delivery.
If no successful samples collected notify labs.

Post-Storm

Time of last rainfall on-site:	
Samples processed and sent to lab? **Y / N**	
Verify reset of station parameters via telemetry files? **Y / N**	

COMMENTS:

Appendix H Packing Checklists and Field Forms

PRE/POST FIELD TRIP CHECKLIST

Before Embarking in the Field

All Staff Must –

1. Arrange for lodging (if necessary).
2. Update outlook calendar indicating location and duration of trip.
3. Notify Field Lead or contacts (if necessary).
4. Prepare field plan form with emergency contact information for specific trip location and duration.
5. Be sure to check vehicle and equipment checklists and perform a pre-trip vehicle inspection before embarking.

Pre-Trip Vehicle Inspection

1. Inspect tires for wear/damage on both sides of sidewall. Be sure to check tire pressure as well.
2. Check fluid levels (oil, transmission, windshield washer, radiator) before embarking in order to minimize possible breakdowns. Refer to the vehicle log to check and see if maintenance is due before embarking.
3. Make sure that the vehicle safety equipment is packed and that a spare tire, jack, and lug wrench are in the vehicle and in working order.
4. If any of these listed items are not in satisfactory working order, please notify the Field Lead as soon as possible. Do not embark with a vehicle that is in need of service or may be damaged.
5. Be sure to pack plenty of water and be sure that the standard first aid/emergency gear is packed.

Pre-Trip Equipment Prep

1. Assemble the required amount of precleaned autosampler tubing (amount varies per site and per trip).
2. Assemble the right size and required amount of precleaned autosampler bottles for site visit.
3. Pack sample bottles, filters, sample tags, forms, and coolers (with ice packs) needed for trip.
4. Pack extra gloves and plastic bags for equipment storage and handling.
5. Pack pole sampler (if needed) and all necessary grab sampling equipment.

<u>Proceed with Field Excursion as Planned</u>

Upon Return from the Field

End of Day –

1. If staying at a hotel, notify your contact person each evening that you are finished with field sampling so they do not initiate the rescue protocol. If your trip is only a day trip, refer to end of trip protocol.

End of Trip –

1. Pack and send samples to lab (if samples have been taken).
2. Upon return from the field, please unload your gear and equipment.
3. Don't forget to download DCP files to your laptop or desktop.
4. Unload spent batteries from vehicle and inspect for damage/leaks.
5. Place spent batteries on appropriate chargers after servicing them.
6. Hang any wet gear in their designated locations to dry.
7. Clean and store tubing and bottles in their designated locations to prevent contamination/damage.
8. Clean the interior of the vehicle (if needed).
9. Close field plan and notify contact person that your trip is over.

Vehicle and Equipment Checklist

Vehicle Equipment

This equipment should be present any time the vehicle is used.

- Cell Phone and charger

Vehicle Folder

- Mileage logs
- Emergency information
- Fuel card
- Maps

Safety Equipment

- First aid kit
- MUTCD-compliant type II or better Safety Vests (2)
- Road Cones (28" retro refl.)
- Signs (RWA, shoulder work)
- MUTCD-compliant Hard Hats (2)
- Orange Strobe (1,000 ft. visibility)

Tools / Other

- Mechanic's toolbox
- Shovel
- Loppers/clippers/machete
- Tire chains
- Spare keys
- Jack, jack handle, adequate spare tire
- Flashlight
- Lighter (for shrink tubing)
- Electrical tool box
- Pens
- Pencils
- Notepaper
- Flagging tape
- Orange spray paint
- Spare bucket
- Bubble level for weirs
- Tool for clearing sediment from interceptors

Field Gear

Field Equipment Box

- Survey pins and hammer
- Laser level
- Stadia rod and bubble level
- Thermistor
- Spare batteries for thermistor and laser
- Multi-meter (for batteries)
- Logger Menu Flow Chart
- Station/site keys
- Other keys as needed
- Appropriate DCP batteries

Station Visit Folder

- Station Visit Sheets (storm, servicing, COC)
- Station Visit Thumb Drive
- Autosampler forms
- Sample tags
- Maps/station directions
- SOPs

Autosampler Gear

- Replacement tubing
- Replacement bottles
- Replacement batteries
- DI water
- Filters for samples
- Pump for filtering samples

Personal Equipment

- Water
- Food
- Spare dry clothes
- Rain gear
- Sunscreen
- Gloves
- Boots
- Notebook w/extra Station Visit Sheets

Storm Event Field Form

Field staff name		Date
Station name/ID Number		Time
Storm event number	Weather observation	
Qualified storm? ☐ Unknown ☐ Yes ☐ No		
First flush sampling? ☐ Yes ☐ No	Toxicity sampling? ☐ Yes ☐ No	

Volume/depth of composite sample measured in carboy	
Visible Sheen?	☐ Yes ☐ No

Composite Sample			
Pre-sample collection		**Post-sample collection**	
Equipment inspected			
Tubing damaged/clogged	☐ Yes ☐ No		
Tubing replaced	☐ Yes ☐ No	Sample bottle problems	☐ Empty ☐ Low ☐ Damaged ☐ Spillage
Gas bubbler checked	☐ Yes ☐ No		
O-line connection checked	☐ Yes ☐ No	*Sample bottles*	
Data logger program checked	☐ Yes ☐ No	Labeled	☐ Yes ☐ No
Clean bottles placed in sampler	☐ Yes ☐ No	Preservation added	☐ Yes ☐ No
Autosampler program checked	☐ Yes ☐ No	Readied for transportation	☐ Yes ☐ No
		COC form filled out	☐ Yes ☐ No
		Sample line rinsed	☐ Yes ☐ No
		Clean bottles inserted	☐ Yes ☐ No
		Autosampler program reset	☐ Yes ☐ No

Grab Sample	
Sample type	☐ Hand ☐ Pole
Labeled	☐ Yes ☐ No
Preservation added	☐ Yes ☐ No
Placed in correct transportation container	☐ Yes ☐ No
COC documents filled out	☐ Yes ☐ No
Number of grab samples collected	
Flow conditions	RISING PEAK FALLING NONE

Rain Gage	
Inspected	☐ Yes ☐ No
Debris removed	☐ Yes ☐ No
Data downloaded	☐ Yes ☐ No
Cleared	☐ Yes ☐ No
Reset	☐ Yes ☐ No

Replicates / Blanks	Wet / Dry
Composite field replicate	
Grab field replicate	
Transfer blank (autosampler containers)	
Transfer blank (sample containers)	
Transfer blank (autosampler samples)	
Equipment blank (grab samples)	
Transport blank (unopened)	

Stage	
Logger	
Staff plate or weir	

Appendix I Chain of Custody

Laboratory Analyses Required

Page ____ of ____

Project Name: ______________________________

SIC: ___ ___ ___ ___ ___ Program: ______________________________

Send Results to: ____________________ Mail Stop: ______________

☐ Preliminary Investigation ☐ For HW Designation

☐ Monitoring ☐ For NPDES

Date Results needed by: ______________

Name/Reference # of QAPP for this project: ______________________

Sampling		Field Station Identification	Manchester Lab Sample Number	Matrix Code	Source Code	No. of Containers	General Chemistry	Micro	Metals	Organic Chemistry
Date: Year: ☐ Mo Day	Time: (Military) 0001 - 2400 Hr Mn						Alkalinity; Conductivity; pH; Turbidity; ☐ Chloride ☐ Sulfate; Fluoride; Total Suspended Solids; Total Dissolved Solids; ☐ Total Solids ☐ % Sol ☐ % Vol Sol; TOC; DOC; BOD5; Oil & Grease (HEM); Ammonia; Nitrate/Nitrite; Total Phosphorus; Orthophosphate; TPN; Chlorophyll ☐ filters	Fecal Coliform ☐ MF ☐ MPN; Total Coliform ☐ MF ☐ MPN; E. Coli ☐ MF ☐ MPN; % Klebsiella; Enterococcus	PP Mets; Mercury (Hg) ☐ low level; Hardness; Individual Elements (please list) ☐ Total ☐ Dissolved	VOA; BTEX; TPHG; TPHD; HCID Only (Hydrocarbon ID); PCB arochlors; ☐ Pest 1 ☐ w/PCB arochlors; ☐ Pest 2 ☐ w/PCB arochlors; ☐ Pest 3 ☐ w/PCB arochlors; Carbamates; PESTMS; Herbicides; PBDE; BNA; PAH

Project Officer: ______________

Phone Number: ______________

Cell Number: ______________

Samplers: ______________

____

____

Recorder: ______________

Chain of Custody Record

Relinquished By:	Received By:	Yr	Mo	Da	Hr	Mn	Seal I.D.	Condition of Seals	Comments (Temperature, Preserv., etc.)

Comments: ____

ECY 040-115 (Rev. 10/05)

Appendix J Particle Size Distribution Method (Ecology, 2002)

Particle Size Distribution

(Excerpt from TAPE, 2008)

Wet sieve protocol and mass measurement
(Recommended by the TRC Subcommittee)

The intent of providing this protocol is to allow more analytical flexibility for vendors while setting reasonable expectations in terms of results. The purpose of requiring Particle Size Distribution (PSD) analysis in the TAPE protocols is to collect consistent information on particle size that will aid in evaluating system performance. PSD measurements will provide a frame of reference for comparing variability in performance between storms and between different sites. These measurements are an important tool with which to assess performance because performance is likely to be affected by particle size. For example, it is likely that performance will drop with a substantial increase in fine soil particles. Conversely, it is anticipated that performance will be high with sandy sediments.

This protocol is intended for use with the laser diffraction Particle Size Distribution (PSD) analysis. Laser diffraction methods are effective for particles smaller than 250 µm. Therefore, particles greater than 250 µm must be removed with a sieve prior to PSD analysis. These large-sized particles will be analyzed separately to determine the total mass of particulates greater than 250 µm. This protocol functions as a supplement to the existing protocols provided by the manufacturers of laser diffraction instruments such that the larger-sized particles in the sample can also be measured.

The mass measurement for the larger-sized particles will also separate out particles between 499 to 250 µm in order to be consistent with the *Guidance for Evaluating Emerging Stormwater Treatment Technologies* definition of TSS (total suspended particles <500 µm).

NOTE: The Technical Review Committee (TRC) recognizes the fact that applying a mathematical constant for density would provide a rough estimate of mass. However, there is concern that the potential error associated with the results due to different soil types and structure might be large.

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Wet Sieving and Mass Measurement
for Laser Diffraction Analysis

Wet sieving

Sample Collection/Handling

Samples should be collected in HDPE or Teflon containers and held at 4°C during the collection process. If organic compounds are being collected, the sample containers should be glass or Teflon.

Preservation/holding time

Samples should be stored at 4°C and must be analyzed within 7 days (EPA, 1998). Samples may not be frozen or dried prior to analysis, as either process may change the particle size distribution.

Sonication

Do not sonicate samples prior to analysis to preserve particle integrity and representativeness. Laboratories using laser diffraction will have to be notified not to sonicate these samples at any time during the analysis. It is recommended that this request also be written on the chain-of-custody form that the analytical laboratory receives in order to assure that sonication is omitted.

Laboratory Procedures

Equipment

__ 2 liters of stormwater sample water (total sample required for analysis (ASTM D 3977))

__ Drying oven (90°C ±2 degrees)

__ Analytical balance (0.01 mg accuracy)

__ Desiccator (large enough diameter to accommodate sieve)

__ Standard sieves - larger than 2" diameter may be desirable

__ 500 µm (Tyler 32, US Standard 35)

__ 250 µm (Tyler 60, US Standard 60)

__ Beakers - plastic (HDPE)

__ Funnel (HDPE - Large enough diameter to accommodate sieve)

__ Wash bottle

__ Pre-measured reagent-grade water

Sample processing

- Dry 250 µm and 500 µm mesh sieves in a drying oven to a constant weight at 90 ± 2_□C.
- Cool the sieves to room temperature in a desiccator.
- Weigh each sieve to the nearest 0.01 mg.
- Record the initial weight of each dry sieve.
- Measure the volume of sample water and record.

- Pour the sample through a nested sieve stack (the 500 µm sieve should be on the top and the sieve stack should be stabilized in a funnel and the funnel should be resting above/inside a collection beaker).
- Use some of the pre-measured reagent-grade water in wash bottle to thoroughly rinse all soil particles from sample container so that all soil particles are rinsed through the sieve.
- Thoroughly rinse the soil particles in the sieve using a pre-measured volume of reagent-grade water.
- The particles that pass through the sieve stack will be analyzed by laser diffraction Particle Size Distribution (PSD) analysis using the manufacturers recommended protocols (with the exception of no sonication).
- Particles retained on the sieve (>250 µm) will not be analyzed with the laser diffraction PSD.
- Dry each sieve (500 µm and 250 µm) with the material it retained in a drying oven to a constant weight at 90 ± 2°C. The drying temperature should be less than 100°C to prevent boiling and potential loss of sample (PSEP, 1986).
- Cool the samples to room temperature in a desiccator.
- Weigh the cooled sample with each sieve to the nearest 0.01 mg.
- Subtract initial dry weight of each sieve from final dry weight of the sample and sieve together.
- Record weight of particles/debris separately for each size fraction (> 500 µm and 499 - 250 µm).
- Document the dominant types of particles/debris found in this each size fraction.

Laser diffraction (PSD)

PSD results are reported in ml/L for each particle size range. Particle size gradations should match the Wentworth grade scale (Wentworth, 1922).

Mass Measurement

Equipment

__ Glass filter - 0.45 µm (pore size) glass fiber filter disk (Standard Method D 3977) (larger diameter sized filter is preferable)

__ Drying oven (90°C ±2 degrees)

__ Analytical balance (0.01 mg accuracy)

__ Wash bottle

__ Reagent-grade water

Procedure

- Dry glass filter in drying oven at 90 ± 2°C to a constant weight.
- Cool the glass filter to room temperature in a desiccator.
- Weigh the 0.45 µm glass filter to the nearest 0.01mg.
- Record the initial weight of the glass filter.
- Slowly pour the laser diffraction sample water (after analysis) through the previously weighed 0.45 µm glass filter and discard the water.
- Use reagent-grade water in wash bottle to rinse particles adhering to the analysis container onto glass filter
- Dry glass filter with particles in a drying oven at 90 ± 2°C to a constant weight.
- Cool the glass filter and dried particles to room temperature in a desiccator.

- Weigh the glass filter and particles to the nearest 0.01mg.
- Subtract the initial glass filter weight from the final glass filter and particle sample weight.
- Record the final sample weight for particles <250 μm in size.

Quality Assurance

Dried samples should be cooled in a desiccator and held there until they are weighed. If a desiccator is not used, the particles will accumulate ambient moisture and the sample weight will be overestimated. A color-indicating desiccant is recommended so that spent desiccant can be detected easily. Also, the seal on the desiccator should be checked periodically, and, if necessary, the ground glass rims should be greased or the "O" rings should be replaced.

Handle sieves with clean gloves to avoid adding oils or other products that could increase the weight. The weighing room should not have fluctuating temperatures or changing humidity. Any conditions that could affect results such as doors opening and closing should be minimized as much as possible.

After the initial weight of the sieve is measured, the sieve should be kept covered and dust free. Duplicate samples should be analyzed on 10% of the samples for both wet sieving and mass measurements.

Reporting

Visual observations should be made on all wet sieved fractions and recorded. For example if the very coarse sand fraction (2,000-1,000 μm) is composed primarily of beauty bark, or cigarette butts, or other organic debris this should be noted. An option might also be for a Professional Geologist to record the geological composition of the sediment as well.

References

ASTM. 1997. *Standard test methods for determining sediment concentration in water samples*. Method D 3977. American Society for Testing and Materials, Philadelphia, PA.

PSEP. 1986. *Recommended Protocols for measuring conventional sediment variables in Puget Sound*. Prepared by Tetra Tech, Inc. for U.S. Environmental Protection Agency and Puget Sound Water Quality Authority. Tetra Tech Inc., Bellevue, WA.

U. S. EPA. 1998. Analysis of total suspended solids by EPA Method 160.2. Region 9, Revision 1. SOP 462. 12 pp

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