Quality Assurance Project Plan for WSDOT Roadway Stormwater Treatment Evaluation: Best Management Practices

March 2014 Revision

Prepared by

Environmental Assessment Program,

Washington State Department of Ecology

and

Environmental Services Office,

Stormwater and Watersheds Program

Washington State Department of Transportation

Washington State Department of Transportation

Author and Contact Information

Washington State Department of Transportation
Environmental Services Office
Stormwater and Watersheds Program
P.O. Box 47332
Olympia, WA 98504-7332
www.wsdot.wa.gov/

and

Washington State Department of Ecology
Environmental Assessment Program
P.O. Box 47600
Olympia, WA 98504-7710
www.ecy.wa.gov/

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- Ashley Carle – Stormwater Monitoring Specialist, WSDOT Stormwater and Watersheds Program
- Brandon Slone – Stormwater Monitoring Specialist, WSDOT Stormwater and Watersheds Program
- Karl Miller – Stormwater Monitoring Logistics Support, WSDOT Stormwater and Watersheds Program
- Don Fisher – Infrastructure and Telemetry Specialist, WSDOT Stormwater and Watersheds Program

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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.C and S7.E of the permit, which require WSDOT to conduct seasonal first flush toxicity testing, and effectiveness monitoring of stormwater treatment and hydrologic management best management practices (BMPs). The QAPP has been created to guide implementation of a monitoring program that will meet the requirements of the 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 delegated NPDES permit development and issuance authority to the Washington State Department of Ecology (Ecology). Ecology oversees implementation at the state level.

Three Quality Assurance Project Plans (QAPPs) were prepared by Ecology's Environmental Assessment Program (EAP) for WSDOT to meet permit monitoring requirements. This QAPP describes a monitoring plan that was used to conduct seasonal first flush toxicity testing and effectiveness monitoring of stormwater treatment and hydrologic management best management practices (BMPs) to meet the 2009 NPDES State Waste Discharge Permit for Municipal Stormwater requirements (Ecology, 2009a). Other QAPPs describe stormwater monitoring for WSDOT highways, maintenance facilities, rest areas, and a ferry terminal.

Stormwater monitoring provides information for WSDOT to include in its *Highway Runoff Manual* (HRM) (WSDOT, 2011a). WSDOT's stormwater management approach utilizes BMPs to help meet the permit requirement to "reduce pollutants in discharges to the maximum extent practicable" (Ecology, 2009a). The BMPs assessed under this QAPP include:

- Vegetative filter strips (VFS)
- Modified VFS
- Compost-amended VFS (CAVFS)

This QAPP was 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 support representative, accurate, and complete results. Additional information is provided in the appendices:

- Appendix A provides a glossary of terms and acronyms used herein.
- 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 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 were required to conduct monitoring under their NPDES permits. In 1999, federal Phase II stormwater requirements were published that expanded coverage to smaller urbanized areas.

In 1995, Ecology issued three NPDES municipal separate stormwater permits that required 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 permits: 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 expanded permit coverage with issuance of a Phase I stormwater permit for Clark County. Phase I 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 for the cities of Seattle and Tacoma, and Clark, King, Pierce, and Snohomish counties, 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 applied 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.

On August 1, 2012, Ecology issued an updated 2013–2018 Phase I permit, which became effective on August 1, 2013, with the Port of Seattle, Port of Tacoma, University of Washington at Seattle, Seattle School District #1, Metropolitan Park District of Tacoma, Washington State Military Department, and Tacoma Community College identified as Phase I secondary permittees. Concurrently, Ecology issued the Phase II municipal stormwater permits.

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. 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 modified on May 1, 2009; May 5, 2010; and March 7, 2012. WSDOT's permit was effective through March 6, 2014.

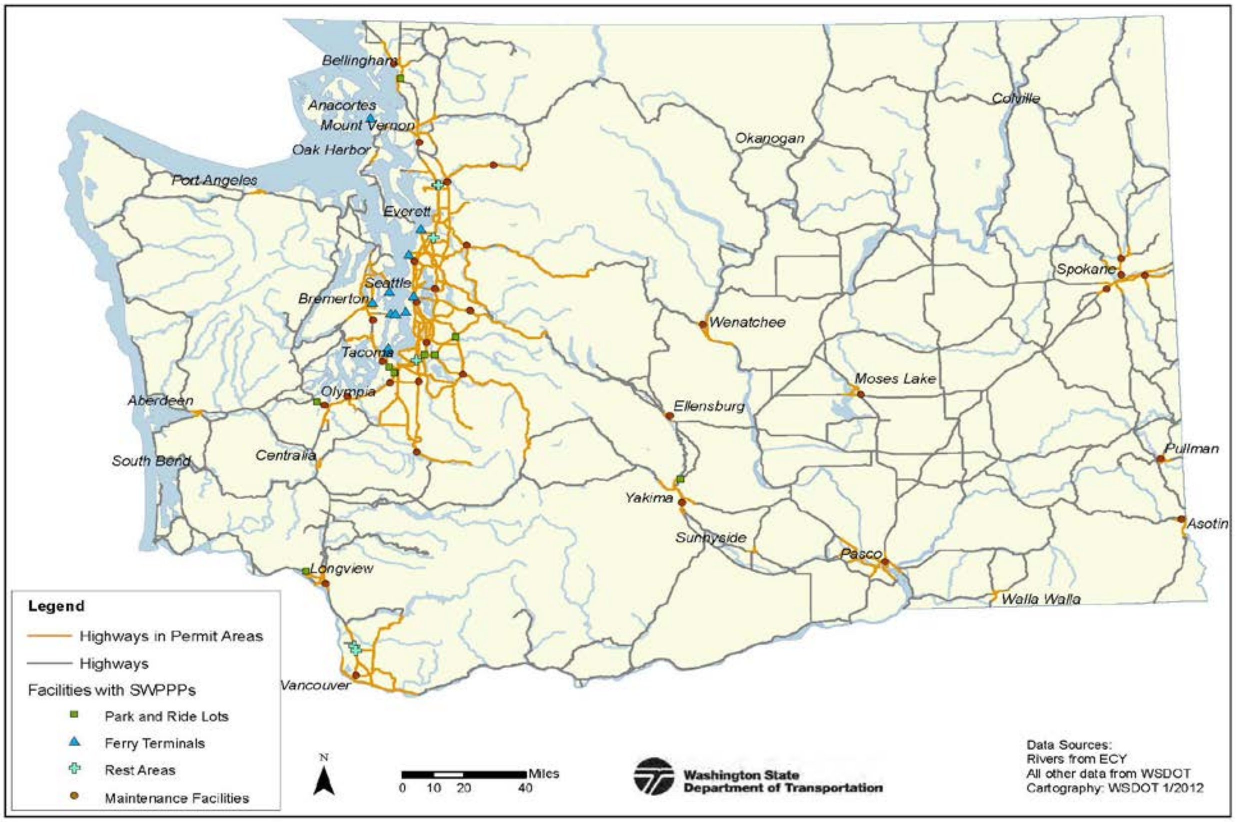


Figure 1 WSDOT highways and facilities located in Phase I and Phase II permit areas.

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).
- Maintenance facilities, rest areas, 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.E and S7.C of the permit related to BMP effectiveness evaluation and seasonal first flush toxicity testing. It also describes how monitoring will be conducted to gather stormwater data from the influent and effluent of each BMP. Monitoring includes collecting representative environmental data such as temperature, rainfall, and discharge measurements to meet permit requirements and determine which storms qualify for collection of stormwater samples. Stormwater sampling will be attempted year round and once annually for seasonal first flush toxicity, using hand grab and composite autosampling techniques.

This QAPP describes how WSDOT:

- Targets storm events
- Monitors rainfall
- Collects samples
- Identifies sampling points
- Configures monitoring stations
- Verifies and validates results to ensure quality data
- Manages and reports data

This sampling program is designed to monitor real time continuous rainfall, temperature, and stormwater hydrology at each of the sites year round. Grab samples, composite samples for storm runoff, and annual seasonal first flush toxicity samples are collected to complement the continuous monitoring.

2-2 BMP Types

WSDOT has been managing stormwater from impervious surfaces statewide since the late 1990s. WSDOT uses BMPs for controlling and managing stormwater. BMPs are structural devices, maintenance procedures, management practices, and activities used to prevent or reduce the harmful effects of stormwater runoff, such as pollution, erosion, and flooding (WSDOT, 2011a). WSDOT continues to develop and monitor BMPs to improve the efficacy of road shoulder flow control and treatment of runoff in a cost-effective manner.

The HRM recommends using low-impact development (LID) techniques that use the site's terrain, vegetation, and soil features to promote infiltration so that the landscape retains more of its natural hydrologic function. This is in contrast to techniques that concentrate the flow of stormwater through pipes, drains, and other conveyance channels. The most common LID method utilized by WSDOT to preserve and employ the benefits of terrain, vegetation, and soil features for stormwater sheet flow are vegetated filter strips.

2-2.1 Vegetated Filter Strips (VFS)

Following is a description of a VFS from the HRM (WSDOT, 2011a):

> *Runoff treatment to remove pollutants can be best accomplished before concentrating the flow. A vegetated filter strip provides a very efficient and cost-effective runoff treatment option. Vegetated filter strips function by slowing runoff velocities and filtering out sediment and other pollutants and by providing some infiltration into underlying soils. Vegetated filter strips consist of gradually sloping areas that run adjacent to the roadway. As highway runoff sheets off the roadway surface, it flows through the grass filter. The flow can then be intercepted by a ditch or other conveyance system and routed to a flow control BMP or outfall.*

Figure 2 shows an example VFS. WSDOT uses VFS BMPs frequently because they can often be placed on existing road embankments without acquiring additional right of way. A VFS can be used for pretreatment as well as primary treatment. Additionally, a VFS does not create habitat for mosquitoes like other BMP options. A VFS fulfills one of the four runoff treatment targets in the HRM: *basic treatment,* which is focused on the removal of total suspended solids from runoff (WSDOT, 2011a).

VFSs provide other functionality besides total suspended solids removal. The National Cooperative Highway Research Program describes filter strips as "highly effective at controlling water quality from stormwater runoff by reducing pollutant concentrations of total suspended solids, heavy metals, polycyclic aromatic hydrocarbons (PAHs), and phosphorus" (TRB, 2006). Several studies support the mass retention capabilities of VFSs for heavy metals (Dorman et al., 1996; Kaighn and Yu, 1996; Ebihara et al., 2009).

Figure 2 VFS on the shoulder embankment of State Route 9 near Marysville, WA.

2-2.2 Amended Vegetated Filter Strips

Adding soil amendments, particularly compost, to a VFS can increase its functionality. Compost is an excellent filtration medium, which provides treatment for highway runoff. Compost has a high cation exchange capacity (CEC) that chemically traps dissolved heavy metals and binds them to the compost material. Oils, grease, and floatables are also removed from stormwater as it is filtered through the compost (WSDOT, 2011a). This extra functionality addresses an additional treatment: *enhanced treatment* (removal of dissolved metals). In addition to a VFS, WSDOT is monitoring an experimental modified VFS, and the Ecology-approved compost-amended vegetated filter strip (CAVFS). The CAVFS is used for comparison with the experimental modified VFS.

The experimental modified VFS and Ecology-approved CAVFS have compost amendments that improve soil quality and texture, and thus improve infiltration. The compost amendments bind to dissolved metals, while biota in organic soil break down and neutralize the surface runoff pollutants. Soil amendments also have a very high capacity to hold moisture (up to one and one half times their weight) and can significantly reduce off-site flows (WSDOT, 2011a). In a modified VFS, the compost amendment is a 3-inch layer of compost applied to the top of the soil. A CAVFS is a VFS with a layer of compost tilled into the top layer of the soil, producing a final organic content of 10 percent.

Preliminary data from an unpublished WSDOT study suggest that CAVFS may be effective in mitigating the impacts of stormwater runoff by reducing runoff volumes (87 percent reduction), peak discharge rates (88 percent reduction), and flow durations (78 percent reduction) (WSDOT, on file, 2010a). However, the study's authors suggest further investigation into the performance of CAVFS and VFS to verify these conclusions. An additional study supports WSDOT's findings that VFS treated with compost prior to vegetation growth have significantly lower erosion and runoff rates compared to untreated or unvegetated areas (Persyn et al., 2002).

The modified VFS is an experimental BMP consisting of a 3-inch-thick layer of compost blend applied evenly over the top of a standard mowed VFS to enhance treatment capabilities. This layer is then hydroseeded with a WSDOT HRM-specified seed blend. The potential advantages of using a modified VFS instead of a CAVFS include reducing construction costs, since the compost amendment in a modified VFS requires minimal ground disturbance and can be applied on steeper slopes. Additionally, a compost blanket may be applied to a broader area and applied early in the road construction process as erosion control. However, this is an experimental BMP type; therefore, WSDOT does not have data regarding the water quality improvement potential of a modified VFS. Gathering data as a part of permit compliance contributes knowledge about the functionality of modified VFS BMPs.

WSDOT's reasons for monitoring compost-amended BMPs are as follows:

1. Compost amendments have been found to provide *enhanced treatment*, with a higher rate of dissolved metals removal when compared to other treatment options. Additionally, compost increases the moisture-holding ability of the BMP, generally improving vegetation growth and infiltration of stormwater.
2. Compost amendments can be applied at relatively low cost, broadening the statewide applicability for this treatment option.
3. Studies about compost-amended BMPs serve a dual purpose: combining the stormwater research interests of the agency with monitoring required for permit compliance.
4. Effectiveness of the experimental modified VFS can be investigated and compared to CAVFS and VFS.

3 Project Description

3-1 Project Goals

The goal of this QAPP is to describe the monitoring program intended to collect high-quality data that characterizes BMP effectiveness in reducing stormwater runoff pollutants and flows. The monitoring program is implemented in accordance with requirements of the following:

- S7.E of the permit: Monitoring the Effectiveness of Stormwater Treatment and Hydrologic Management Best Management Practices (BMPs)
- S7.C of the permit: Seasonal First Flush Toxicity Testing
- Appendix C: Toxicity Guidance from the Permit
- Guidance for Evaluating Emerging Stormwater Treatment Technologies, Technology Assessment Protocol – Ecology (TAPE) (Ecology, 2008a)

Specifically, this QAPP addresses chemical and hydrological monitoring at the pavement edge (PE), 2- and 4-meter locations within the BMPs, and the seasonal first flush toxicity testing of treated highway runoff. This information, along with other data, is 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, 2011a).

Monitoring the selected BMPs will provide improved understanding of how characteristics of compost amendments, applied to Ecology-approved BMPs, affect treatment performance. This information will be incorporated into future versions of the HRM for both retrofit and new construction projects, if experimental modified VFSs become approved for use by Ecology.

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

S7.E of the permit requires WSDOT to conduct a full-scale monitoring program to evaluate the effectiveness, operation, and maintenance requirements of stormwater treatment and hydrologic management BMPs. The permit specifies that WSDOT select BMPs according to the type, location, treatment level, and design standards in the HRM.

S7.C of the permit requires WSDOT to test the chemistry and toxicity of stormwater runoff on the biological endpoint *Hyalella azteca*, a small aquatic crustacean. Permit-required monitoring is summarized in Table 1.

Table 1 Permit requirements for stormwater monitoring (Ecology, 2009a).

Category	Description
BMP Type	S7.E.2.c states that WSDOT may select between the following BMP treatment types for monitoring: • Basic (removal of suspended solids) • Enhanced (removal of metals) • Metals/Phosphorus (removal of metals and phosphorus) • Oil Control (removal of oil) S7.C.3.b states that one BMP site shall be an enhanced treatment BMP for metals removal. The CAVFS is considered an enhanced metal treatment and oil control BMP. The permit (S7.E.2.d) states, "WSDOT shall also select one flow reduction strategy BMP (such as LID) that is in use or planned for installation." The BMPs selected fulfill the flow reduction requirement in the permit and will be monitored in a paired study design.
BMP Quantity	S7.E.2 requires WSDOT to monitor at least two treatment BMPs, at no less than two sites per BMP. The BMP monitoring on Interstate 5 (I-5) northbound in the Everett area and I-5 southbound at Pilchuck Creek satisfy this requirement.
BMP Location	For seasonal first flush toxicity testing, S7.C.3.b requires the BMPs to be located at the following AADTs (annual average daily traffic): • One highly urbanized site (≥100,000 AADT) • One urbanized site (≤100,000 and ≥30,000 AADT) • One rural site (≤30,000 AADT) BMP studies on I-5 and State Route 9 (SR 9) satisfy these requirements.
Sampling Method	Monitoring guidelines in TAPE call for sampling using automatic samplers, except for chemical constituents that require manual grab samples. The automatic flow-weighted composite sampling scheme described in TAPE (p. 17) will consist of composite samples collected over at least 75% of each storm's total runoff volume, a minimum of 10 sample aliquots for a qualified storm event, and the storm must be at least 1 hour in duration. In accordance with S7.C.5, annual seasonal first flush toxicity samples will be collected either by flow-weighted or time-weighted programmed automatic composite samplers. If toxicity is collected by time-weighted composite, then these data cannot be used to meet TAPE criteria.
Sample Timing and Frequency	WSDOT will conduct sampling as early in the runoff event as feasible. At least 12 influent and 12 effluent samples will be monitored each year. Sampling will continue until the permit-required statistical goals of 90-95% confidence and 75-80% power are met for the parameters for which the BMP is approved in the HRM. If permit-required statistical goals are not achieved within the term of this permit, Ecology will consider continuing the monitoring effort in the next permit cycle. Additionally, WSDOT will collect a sample for toxicity testing that represents the seasonal first flush event no earlier than August 1. If the first sampling attempt is unsuccessful despite good faith efforts or due to invalid or anomalous test results, a second attempt to collect a seasonal first flush toxicity sample will be made if storm event criteria can be met. If the second attempt is unsuccessful, further sampling is not required.
Storm Event Criteria (BMP Effectiveness Monitoring)	Storm event criteria are specified by TAPE for BMP effectiveness monitoring. TAPE storm event guidelines are: • Minimum storm quantity for the total rainfall should be ≥ 0.15 inches. • Storm start/end (antecedent dry period) should be 6 hours minimum with less than 0.04 inches of rain. • Minimum storm duration should be ≥ 1 hour. • Minimum storm intensity to qualify as a rain event is specified as "none," provided above guidelines are met. Average intensities should exceed 0.03 inches per hour for at least half the sampled storms.
Storm Event Criteria (Seasonal First Flush Toxicity Testing)	Seasonal first flush toxicity samples shall be collected annually with at least a one-week antecedent dry period in August or September. If attempts in August or September are unsuccessful, an additional attempt should be made in October irrespective of the antecedent dry period.
Parameters	Permit-required sampling parameters for BMP effectiveness evaluation and seasonal first flush toxicity testing are listed in Table 11.

3-3 Data Collection

To characterize site hydrology, data collection began before September 2011 at some locations. Monitoring continued through the five-year permit cycle and includes the following information to meet the permit objectives:

- 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 autosamplers, a data logger, and associated equipment is installed at each BMP effectiveness monitoring site.

Rainfall data are 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 record measurement data from the autosampler and all other associated monitoring equipment, such as the rain gage, stage measuring device(s), and temperature meter. Data from the logger is manually downloaded and telemetered to WSDOT.

Additional sampling and data collection information is presented in Chapter 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:

- TAPE (Ecology, 2008a) specified 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 BMP effluent sites)

The BMP effectiveness monitoring program is designed to target collection of at least 12 influent and 12 effluent samples. A maximum 35 total sample events are required for this protocol, based on guidance in TAPE (Ecology, 2008a).

The statistical goal is to calculate the mean and median effluent concentrations and determine percent removals for each BMP type based on a 90–95 percent confidence and 75–80 percent power for the parameters for which the facility is approved in the HRM. To satisfy permit requirements, a seasonal first flush toxicity sample is also required to be collected annually.

3-3.2 Qualifying Sample Criteria

The TAPE protocol (Ecology, 2008a) defines "representative" storms that must be monitored when determining performance of treatment BMPs. Storm event criteria are established to: ensure adequate flow is discharged, allow some build-up of pollutants during dry weather intervals, and ensure the storm is representative (that is, typical for the area in terms of intensity, quantity, 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 1 lists the qualifying criteria to ensure the storm event sampled is representative. Samples are collected from at least 75 percent of the runoff volume and consist of a minimum of ten aliquots.

3-3.3 Sampling Locations

To conserve resources, BMP effectiveness monitoring sites were co-located with highway runoff characterization sites to satisfy multiple permit monitoring requirements. However, there are several differences between the requirements for BMP effectiveness and highway characterization monitoring, including:

1. Storm event criteria:
   - Highway characterization rainfall quantity of 0.20-inch minimum.
   - BMP effectiveness rainfall quantity of 0.15-inch minimum.
2. Highway characterization requires several additional parameters to be measured.
3. Antecedent dry period:
   - BMPs: 6 hours, with less than 0.04 inches of rain.
   - Highway characterization: 24 hours in the wet season and 72 hours in the dry season, with less than 0.02 inches of rain.
4. Storm Duration:
   - BMPs: At least 75 percent of the storm's total runoff volume must be sampled regardless of storm length.
   - Highway characterization: For storms lasting longer than 24 hours, at least 75 percent of the hydrograph of the first 24 hours must be sampled.

Given these differences in criteria, the most inclusive criteria are followed for combined sites to allow all data to be used for BMP effectiveness and for the relevant subset of data to satisfy highway characterization permit requirements. Storm events where only one set of criteria (those of the more broadly defined BMP effectiveness) are met are sampled at combined sites, but the data are only used to meet permit requirements for BMP effectiveness monitoring. Where the permit and TAPE conflict, the more inclusive value is used. In this case, WSDOT deploys for sampling at joint highway/BMP sites when a rainfall depth of 0.15-inch or greater is forecast, as long as other criteria are met.

3-4 Practical Constraints for BMP 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 puts forth good faith efforts to collect and meet permit requirements. 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 (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 monitored highway segment (applicable to highway characterization and BMP effectiveness co-located monitoring sites) and the areas that drain to the sheet flow collectors. The collectors intercept stormwater sheet flow and concentrate the flow to enable sampling. BMP monitoring sites were selected based on WSDOT ownership of the BMP, representative drainage areas, safety of sampling, and permit-required annual average daily traffic (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, making it difficult to collect samples through the required 75 percent of the storm event hydrograph. Another challenge is the ambiguity of forecasting rain, particularly in western Washington. Storm forecasts are dynamic, and local weather patterns change quickly. A third study design challenge is the large stormwater volumes required to analyze all the permit-specified parameters 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

The selection of BMPs to monitor under the permit were governed by multiple factors, such as:

- BMPs must meet "current" HRM design standards; the 2008 HRM was the current version at the time of permit issuance.
- Locating suitable BMPs within specific traffic levels to match the toxicity requirements proved to be more difficult than expected for the rural AADT requirements.

In all, more than 20 BMP locations were considered for monitoring. Most of the BMPs 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), or they did not meet permit criteria; for example, the media filter drain represents a BMP of importance to WSDOT, but suitable locations meeting the AADT criteria were not found, or for other BMP types, influent and effluent paired sampling could not be established.

The solution to a shortage of BMPs that met both the permit monitoring requirements and WSDOT's interests for monitoring was found by coordinating two programs' interests. These programs at WSDOT are:

- The Highway Runoff Program, which conducts research to inform future guidelines and design specifications in the HRM.
- The Stormwater and Watersheds Program, which conducts stormwater monitoring for permit compliance.

WSDOT prioritized monitoring certain BMPs to gather information on effectiveness that met the needs of both programs. Some current research interests and permit monitoring priorities for BMPs are: media filter drains, compost-amended biofiltration swales, and compost-amended vegetated filter strips.

These two programs work together to monitor stormwater BMPs for permit compliance and to inform the HRM.

3-4.4 Challenges of the Study Design

The BMPs selected for monitoring include vegetated filter strips (VFS), compost-amended VFS (CAVFS), and the modified VFS. All three BMPs are infiltration-type BMPs that are designed to treat sheet flow runoff by infiltration. By incorporating the runoff into a soil or compost matrix, water quantity is reduced and water quality is improved. These BMPs are discussed in greater detail in Section 2-2.

Practical Constraints for Biofiltration BMPs

TAPE requires stormwater sediment samples to be collected from the BMPs to assess accumulation of sediment or sediment treatment. However, collecting sediment from infiltration-type BMPs such as VFS and CAVFS that use grass and soil, or compost, grass, and soil as filtration media poses a challenge. Sampling representative stormwater sediment is not feasible since there is no technique to ensure the collected sediment represents only stormwater-carried sediment and not components of the BMP's filtration media (soil or compost). Therefore, sediment samples from BMPs are not collected.

A further constraint that may affect sampling success is related to how well the chosen BMP types function to slow runoff velocities, which trap sediment and other pollutants, and provide some infiltration and biological uptake. Depending on the size of the storm and environmental conditions, effluent may or may not be discharged.

3-4.5 Logistical Challenges

Some of the logistical challenges associated with this project include:

- Monitoring small, flashy drainage areas that contribute to the BMPs.
- The complexity and variability of stormwater discharge.
- Requirements to collect samples from at least 75 percent of the entire runoff volume per storm event.
- The geographic distribution between monitoring site locations.
- Unpredictable environmental conditions at sites.
- Groundwater characteristics and fluctuating site hydrology.
- Limitations due to laboratory staff availability and hours of operation.
- Sampling equipment programming limitations.

Drainage Area Logistical Challenges

The drainage areas for the selected monitoring locations are small. Sizing of WSDOT's pavement edge (PE) sheet flow collectors was based on previous studies (WSDOT, on file, 2009a). The smaller drainage areas introduced challenges due to flashier runoff characteristics. This results in a higher probability for missed sample collection.

Stormwater Discharge Logistical Challenges

The PE sheet flow collectors are designed to receive adequate amounts of runoff for sampling. However, since one of the purposes of the three BMP types selected is flow reduction and infiltration, reduced volumes are expected for sampling at the 2-meter and 4-meter monitoring locations. This reduced sample volume makes it difficult to collect enough sample for analysis, particularly for toxicity sampling, which requires large sample volumes.

Storm Duration Logistical Challenges

To meet the requirements under TAPE, permit samples must be collected to represent at least 75 percent of the total runoff volume for each storm event. This presents a challenge for storms that last many days. The resulting quantity of stormwater must be kept cooled and available throughout the event so samples can be filtered and preserved when the runoff event ends (filtration ideally occurs within 15 minutes of the last aliquot collection).

Geographic and Climatic Logistical Challenges

BMP monitoring sites are located 90 miles or more from where the WSDOT sampling team is based in Tumwater. Samples are sometimes missed due to needed station preparation time and the amount of driving time necessary to reach the BMPs, even if the field sampling teams stay in hotels near the sites. 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 qualifying storms.

Successful sampling and monitoring requires a well-developed, automated field data collection system and supporting monitoring team. WSDOT maintains a field crew that deploys to the field location or a local hotel when a promising forecast occurs during the work week.

Telemetered data reporting and automated sample collection are utilized to accomplish the monitoring goals by improving the successful rate of storm event sampling. Nonetheless, travel times and storm dynamics are major factors contributing to missing some of the holding times for filtration of dissolved metals and orthophosphate.

Environmental Logistical Challenges

Damage from storm events (such as washouts or flooding) or the immediate environment (such as trees falling or traffic accidents) may present limitations for stormwater monitoring. Site equipment design and implementation will attempt to identify, remove, or prevent equipment damage or safety hazards. By utilizing telemetry, WSDOT is able to identify malfunctions, errors, and damaged equipment from the hourly transmissions at each monitoring station. Field staff is dispatched as soon as feasible to repair or replace damaged equipment. The monitoring budget includes a 25 percent contingency to cover equipment repair and replacement costs.

Laboratory Logistical Challenges

Several of the sample parameters have short holding times that require laboratories to process samples possibly within eight hours of sample collection. Many laboratories do not maintain staffing levels 24 hours a day, seven days a week. Some labs have limited working hours on weekends and holidays. As a result, the days and times of the sampling program may be limited to the following schedule:

- Sample during weekdays until noon on Fridays.
- Do not sample on Saturdays, Sunday mornings, and state holidays.
- Sampling late (after 3:00 p.m.) on Sundays is a possibility.

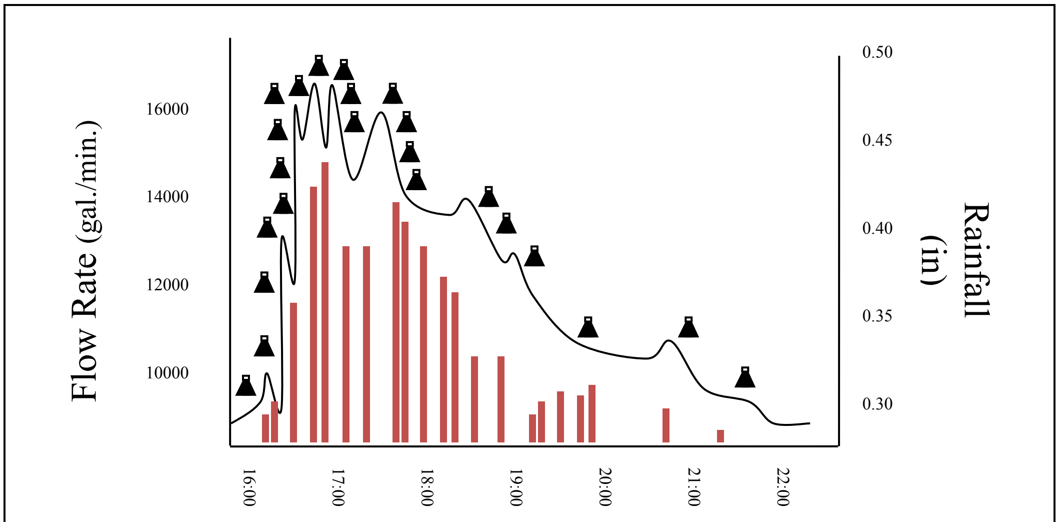
Therefore, a potential qualifying event that lands on a Sunday night or Monday should be forecast Friday, accompanied by laboratory and field crew tentative notification.

Instrumentation and Programming Logistical Challenges

Automatic samplers are programmed to collect flow-weighted composite samples for water quality monitoring and flow- or time-weighted composite samples for toxicity parameters. Figure 3 shows how samples of equal volume are collected at equal increments of flow volume in a flow-weighted compositing scheme. Figure 4 shows how samples of equal volume are collected at equal increments of time in a time-weighted compositing scheme (Ecology, 2009b).

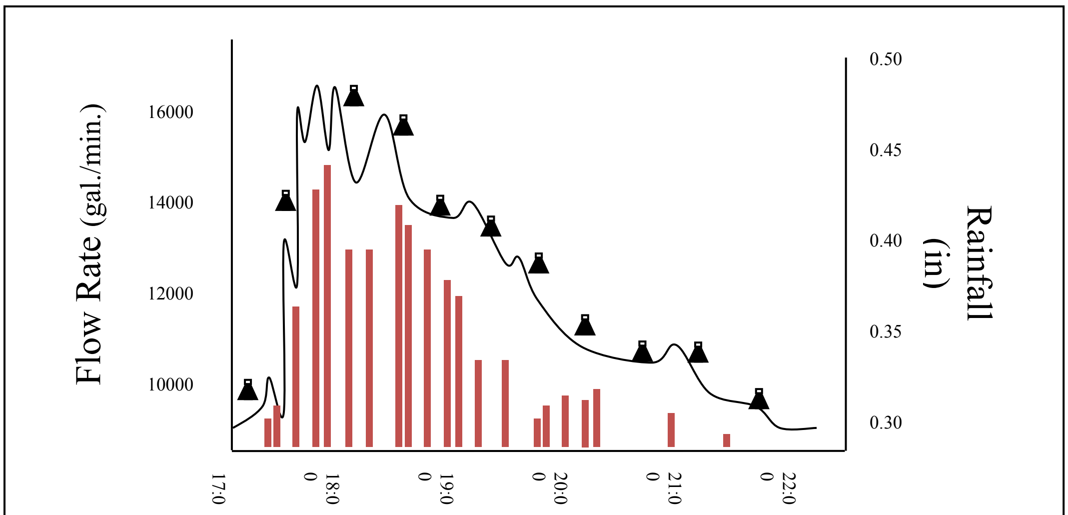
The potential for human programming errors is a possibility when operating any monitoring equipment. While some testing has been conducted prior to sampling, there is a continual need to monitor and adjust programming to meet permit requirements given site conditions. Care is taken to follow standard operating procedures (SOPs) in an effort to minimize human programming errors. Field staff 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 the stations may turn the data logger and automatic sampler off and inhibit monitoring. To avoid power loss, field staff visit each station on a six to eight-week rotational maintenance schedule or more frequently for storm event sampling. During scheduled maintenance trips, batteries and solar panels are maintained according to standard operating procedures.



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

Figure 3 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 4 Time-weighted compositing schemes.

4 Organization and Schedule

This chapter describes the roles and responsibilities of the key team participants, including internal members of WSDOT's Stormwater and Watersheds Program and external participants. 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 presented in Table 2, along with a detailed description of the lines of authority and reporting between those individuals and organizations. WSDOT staff may delegate their responsibilities to other staff when they are not present or are busy with other priority tasks. If responsibilities are delegated, staff are responsible for ensuring their responsibilities are carried out properly in their absence.

4-1.1 Training

Field staff receive training in proper sampling and field analysis for each SOP or guidance document they use. Field staff demonstrate to the Field Lead their ability to properly operate the automatic samplers and retrieve the samples on an annual basis. The Field Lead determines whether each field staff member is adequately trained and prepared to operate sampling equipment and collect samples.

WSDOT will self-assess implementation of stormwater monitoring by field staff, at least annually, to verify proper methods and techniques are used. In addition, a follow-up meeting at the end of the water year will be organized to discuss methods and procedures, if needed. Stormwater monitoring staff receive training for working in wet, cold, and poor-visibility conditions. Staff are exposed to traffic hazards, confined spaces, and slippery conditions. It is a WSDOT requirement that field staff receive appropriate work zone safety training.

Monitoring crews must receive training on site-specific traffic control plans for sites that expose them to traffic hazards. An example of traffic control safety guidelines for use while conducting monitoring or maintenance activities at field sites is presented in Appendix D. The guidelines were adapted from WSDOT's *Work Zone Traffic Control Guidelines* (WSDOT, 2009b). Some traffic control plans may need to be modified in the future due to the changing and developing nature of WSDOT's road construction. The safety plans specify personal protective gear and include a daily Pre-Activity Safety Plan (PASP) for Stormwater Field Work form to be filled out on each site visit.

Table 2 Organization of project staff and responsibilities.

Roles	Responsibilities
WSDOT Stormwater and Watersheds Program Staff	
Monitoring and Research Coordinator	Manages WSDOT compliance activities; verifies the QAPP is followed and the project produces data of known and acceptable quality; ensures adequate field training and supervision of monitoring staff; complies with corrective action requirements.
Quality Assurance Officer	Develops the quality management system (QMS) for stormwater monitoring; oversees QMS operations; reviewes monitoring reports for quality assurance; identifies whether QA/QC goals are met; ensures data verification and validation procedures are followed in accordance with the QMS.
Water Quality Data Steward	Assists with acquisition of hydrologic data from telemetered systems and chemistry data from contract laboratories; verifies and transfers data collected into databases; manages laboratory contracts.
Monitoring Field Lead	Manages and oversees stormwater monitoring activities, weather forecasting, sampling decisions, and equipment maintenance; manages field teams. Oversees field data collection, verification, and submittal.
Monitoring Data Management and Logistics Lead	Assists with acquisition and analysis of stormwater data from telemetered systems and contract analytical laboratories. Oversees the management of logistical support for the stormwater monitoring field team.
Stormwater Monitoring Logistics Support	Provides logistical support for monitoring, including cleaning and preparation of sampling equipment and delivery of equipment to field crews. Performs data-related tasks, verifies and archives field forms, and provides technical assistance to members of the monitoring team, as needed.
Stormwater Monitoring Specialists	Collects and processes field composite and grab samples. Coordinates sampling activities in WSDOT regions; assists with weather forecasting and laboratory notifications; and assists with document development and reporting. Maintains monitoring stations.
Infrastructure and Telemetry Specialist	Designs, fabricates, installs, maintains, and calibrates monitoring data collection platforms. Assists in sample collection and sample processing, as needed.
Field Sampling	WSDOT region staff assists in collecting and processing field composite and grab samples, as needed.
ECOLOGY Staff	
Permit Coordinator	Reviews and approves QAPPs and project deliverables from WSDOT to Ecology for NPDES municipal stormwater permit implementation.
Permit Monitoring Coordinator	Reviews monitoring proposals and provides advice and comments for QAPP development.
Project Manager (WSDOT Contractor)	Lead author for QAPP development and site design; assisted site setup; coordinated technical lead duties and analytical contracts from August 2009 to April 2011.

EAP = Ecology's Environmental Assessment Program
QAPP = Quality Assurance Project Plan

4-2 Schedule

Table 3 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 (WQP).

Table 3 Key deadlines for QAPPs and reports.

Date Due	Description
September 6, 2010	Draft QAPPs due from WSDOT to Ecology's WQP. *(Draft was submitted September 2, 2010.)*
October 31, 2010	First stormwater monitoring report on status of preparations to meet S7.A through S7.E. *(Report was submitted October 27, 2010.)*
November 30, 2010	Ecology's WQP reviews the Draft QAPPs within 90 days and responds with comments to WSDOT. Since Ecology's WQP did not meet the 90-day review period (returned QAPPs to WSDOT on January 3, 2011), the QAPP approval deadline was extended by the equivalent number of days per permit condition S7.G.
April 16, 2011	Deadline for Ecology approval of the revised QAPP. *(Deadline was extended from March 6 to April 16, 2011.)*
September 6, 2011	Final QAPPs due to Ecology's WQP, with all revisions complete. *(QAPP was submitted September 2, 2011.)*
September 6, 2011	Full implementation of the monitoring program to begin collection of toxicity monitoring data for reporting.[1]
October 1, 2011	Collection of monitoring data for reporting to begin.[1]
October 31, 2011	Second stormwater monitoring report due on status of preparations to meet S7.A through S7.E. *(Report was submitted October 25, 2011.)*
October 31, 2012	Third stormwater monitoring report due on status of preparations to meet S7.A through S7.E. *(Report was submitted October 23, 2012.)*
October 31, 2013	Fourth stormwater monitoring report due, covering data collected from October 1, 2011 to September 30, 2012, as described in S8.F. This is the first time a detailed monitoring report will be submitted with the annual report. BMP effectiveness interim results will not be included. Only toxicity results from BMP monitoring will be discussed. *(Report was submitted October 31, 2013.)*
March 6, 2014	A Final Water Quality Monitoring Report for each program outlined in S7 is due to Ecology's WQP. BMP effectiveness interim results will not be included. Only toxicity results from BMP monitoring are discussed. *(Report was submitted March 6, 2014.)*
Date to be determined	A final report on each BMP monitored will be submitted once the monitoring statistical goals are met. This may or may not occur after the Final Water Quality Monitoring Report is due.

[1] State government hiring and equipment purchase freezes in 2010 and 2011 delayed implementation of the WSDOT monitoring program. On October 20, 2011, WSDOT notified Ecology that it would be unable to fully comply with monitoring program implementation timelines and that toxicity sampling would be deferred until August 2012. In a G20 notification letter to Ecology on January 13, 2012, WSDOT proposed a phased approach to monitoring program implementation and an extension to timelines defined in the permit. Full implementation of the BMP effectiveness monitoring program began at the following sites on the dates listed below:

May 1, 2012

- Southbound I-5 Pilchuck study sites, north of the city of Arlington near the Stillaguamish River and Pilchuck Creek

June 15, 2012

- Northbound I-5 Everett study sites, City of Everett
- SR 9 Marysville study sites, City of Marysville

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 chapter discusses quality assurance (QA) elements of the stormwater monitoring program. Biological and chemical toxicity guidance (see Appendix C) and quality assurance criteria are also discussed.

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

5-1 Data Quality Objectives

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

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

5-2 Measurement Quality Objectives

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). QC refers to data collection, management, and analysis. It is a set of standard operating procedures for the field and laboratory that are used to evaluate and control the accuracy of measurement data (see Section 10 for more information). QA 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 includes EPA, Ecology, laboratory experience, and best professional judgment. The hierarchy of guidelines that are followed, in descending order, are:

1. Permit (Ecology, 2009a) and TAPE (Ecology, 2008a) for BMP stations
2. 40 CFR 136.3 (July 1, 2009, revision)
3. Guidance documents referred to in the permit
4. Other guidance documents from:
   - Ecology, such as 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, 2002b).
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 shown in Appendix G, Tables G-7, G-11, G-15, and G-19, which represent how data are verified by contracted laboratories and assessed for sensitivity, accuracy, precision, and comparability by WSDOT's data validation contractors. Failure to meet the MQOs may result in data being qualified or rejected. Further descriptions are discussed in the following sections.

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

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 analyses 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. Refer to Chapter 9, Measurement Procedures, for more information.

Ecology originally specified reporting limits and analytical methods in the permit's Appendix 5, and they are restated in Appendix G, Tables G-7, G-11, G-15, and G-19, with subsequent Ecology-approved variances. MQOs that were not stated in the permit's Appendix 5 were gathered from other sources, such as the Manchester Environmental Laboratory's *Lab Users Manual*, 9th Edition (MEL, 2008), and the EPA's published guidelines for the Contract Laboratory Protocols (CLP) for inorganic and organic data (USEPA, 2008 and 2010).

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 is 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 is assessed by comparing known volumes of water to the rain gage's measurements.
- Bias in stage measurements is 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 are checked by observing temperature readings to check for frozen water.
- Bias from sediment accumulation behind weirs is managed with regular cleaning and removal of debris that has settled behind the weirs.

Field Sample Bias and Blanks

Field or transport blank results greater than the reporting limit (RL) are flagged as blank contamination (B). The associated project samples collected with the blank sample are scrutinized by the Quality Assurance Officer upon receipt of the laboratory report. Depending on the type of blank collected (transport, transfer, or equipment rinsate), the Field Lead is 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 are flagged as an estimate (J). Data flagged with a *B* and qualified as *J* due to blank contamination are not considered valid for TAPE compliance. If the associated project samples exceed five times the blank concentration, they are flagged as rejected (R).

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. When they do, 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 five times the de facto reporting limit are flagged by the laboratory as blank contamination (B). Associated project data are reviewed and qualified as undetected (U) or an estimate (J), and a member of the data management team is alerted to the contamination. Common laboratory contaminants within ten times the de facto reporting limit are flagged as blank contamination (B), per CLP guidance. WSDOT determines how many samples are affected and if 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 Appendix G, Tables G-7, G-11, G-15, and G-19. Percent recovery for matrix spikes is 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 is calculated using Equation 2 (USEPA, 2010).

Equation 2: Percent recovery for LCS

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

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. Careful site selection, installation, and maintenance of all associated monitoring equipment improves representativeness of the hydrologic data. Rainfall patterns, stormwater conveyance features, and surrounding land uses are elements considered in the identification of monitoring locations. Hydrologic monitoring is conducted over a sufficient length of time to ensure data are collected during representative climatic conditions for the region. “Target events” are triggered by rainfall amounts, so the monitored runoff is representative of the specified storm criteria.

Representativeness of the water quality data from WSDOT BMP effectiveness monitoring sites is ensured by targeting the sampling criteria set forth in S7.B, S7.C, and S7.E of the permit and listed in Table 1. These data systematically do not include very low-volume storms or the long, intermittent storms typical of the Pacific Northwest due to permit-specified storm criteria.

Representativeness of the samples is evaluated by analysis of composite field duplicates and grab field replicates. Field variability found in composite duplicates may be different from the field variability found in replicate grab samples due to differences in handling. Any sample data may be deemed “non-representative” and rejected by the Quality Assurance Officer or data management team if any of these criteria are not met.

The representativeness of the seasonal first flush toxicity data is ensured by employing consistent and standard sampling procedures. If sampling requirements are not met in the first two qualified seasonal first flush storm events, the representativeness of seasonal first flush characteristics is considered unmet and this type of sampling is 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 are evaluated using field and laboratory duplicate sample analyses. Poor precision of field duplicates and replicates may be due to heterogeneity of the stormwater, which has been a fairly common problem in stormwater characterization studies. Field duplicates and replicates may be evaluated at the targeted relative percent difference (RPD) or relative standard deviation (RSD) listed in Appendix G, Tables G-7, G-11, G-15, and G-19. Other reasons for poor precision may include contamination, problems with sampling, or poor sensitivity of the analytical methods. Bias and blanks 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 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 samples 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

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

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 preparation (field and laboratory) procedures, and laboratory equipment or deionized water contamination.

Accuracy is calculated as the percent recovery (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 are set to the number of storm events required by TAPE. Completeness of data gathered is 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 management team.

If sampling requirements cannot be met in the first two qualified seasonal first flush storm events for toxicity sampling, the conditions are considered unmet and sampling is discontinued. This data set is not considered incomplete if the conditions in the permit for attempts are met and WSDOT made the attempts in good faith.

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 are 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 chapter addresses the experimental design, monitoring methods, site descriptions, and site development for data collection. A monitoring site refers to the physical locality and the monitoring station refers to the sample collection location. Detailed drawings are provided in Appendix H. Tables containing technical and design information are provided in Appendix I.

6-1 Selected BMP Effectiveness Monitoring Sites

WSDOT combined permit-required monitoring for BMP effectiveness with permit-required highway runoff characterization monitoring to reduce the number of monitoring sites, conserve resources, and reduce travel time between sites. Table 4 and Figure 5 describe the selected BMP locations of interest. The Interstate 5 (I-5) monitoring sites are located in western Washington, and serve a dual purpose for highway characterization and BMP monitoring.

At the State Route (SR) 9, Marysville monitoring site, an annual effluent toxicity sample was also collected from a 4-meter collector to meet the rural AADT requirements for toxicity testing. No other samples were collected from the 4-meter collector.

Table 4 BMP effectiveness monitoring sites.

BMP Type	Traffic Designation[1]	AADT[2]	Site Location	Sample Location Code	Sample Location Description	Monitoring Type[3]
VFS[4]	urbanized	76,000	I-5, Pilchuck, MP 210.71	Pilchuck-01	pavement edge (PE)	highway/BMP
				Pilchuck-02	2 meter (m) collector	BMP
				Pilchuck-03	4m collector	BMP
	highly urbanized	126,000	I-5, Everett, MP 197.27	EVE-01	PE	highway/BMP
				EVE-02	2m collector	BMP
				EVE-03	4m collector	BMP
CAVFS	urbanized	76,000	I-5, Pilchuck, MP 210.78	Pilchuck-04	2m collector	BMP
				Pilchuck-05	4m collector	BMP
Modified VFS[4] (compost blanket)	urbanized	76,000	I-5, Pilchuck, MP 210.85[5]	Pilchuck-06	PE collector	BMP
				Pilchuck-07	2m collector	BMP
				Pilchuck-08	4m collector	BMP
	highly urbanized	126,000	I-5, Everett, MP 197.35[5]	EVE-04	PE	highway/BMP
				EVE-05	2m collector	BMP
				EVE-06	4m collector	BMP
VFS	rural	20,000	SR 9, Marysville, MP 17.92[5],[6]	SR9-01	PE	Highway
				SR9-02	4m collector	toxicity testing, only

[1] Traffic designations come from S7.B.3 of the permit (Ecology, 2009a).

[2] Annual Average Daily Traffic (AADT) values were obtained from the "Annual Traffic Report" (WSDOT, 2013).

[3] Monitoring types include highway runoff characterization and BMP effectiveness monitoring sites. The BMP effluent location at the SR 9, Marysville monitoring site is used to collect samples for toxicity testing only.

[4] Provides a paired study design for LID comparison.

[5] Toxicity samples were taken at the PE influent and 4m BMP effluent locations.

[6] Monitoring site was used for highway runoff characterization and BMP effluent toxicity sampling only. The site was not part of the BMP effectiveness evaluation studies.

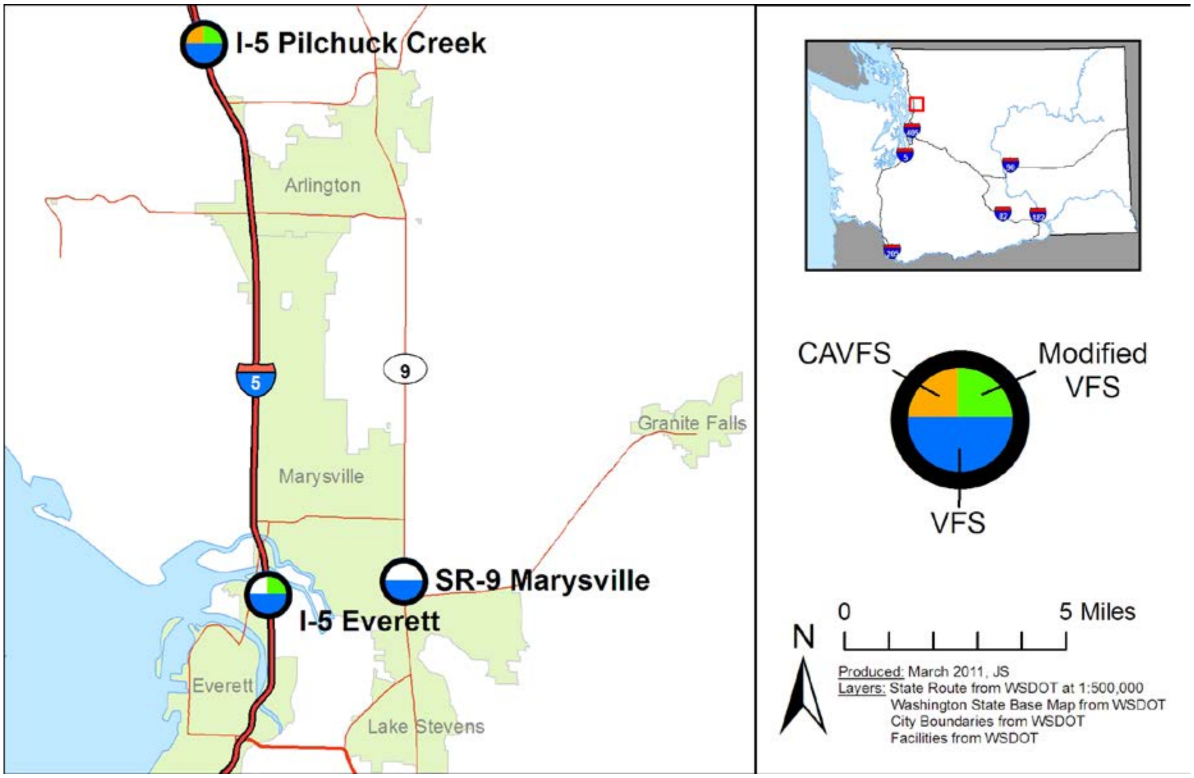


Figure 5 BMP types and locations for WSDOT stormwater monitoring.

6-1.1 BMP Types

The following BMP types were selected for monitoring:

- Vegetated filter strips (VFS)
- Compost-amended VFS (CAVFS)
- Modified VFS

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

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

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

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

6-1.2 BMP Set

A BMP set is a combination of sheet flow collectors (pavement edge, 2-meter effluent, and 4-meter effluent) monitored together at a study site. The difference in treatment (both runoff flows and pollutant concentrations) between the pavement edge (PE), 2-meter effluent, and 4-meter effluent stations is calculated. Additionally, a BMP set may consist of only two sheet flow collectors monitored for comparison, such as a 2-meter effluent to 4-meter effluent combination, or a PE to 4-meter effluent combination.

The 2-meter effluent station is part of the study design since many highways in highly urbanized areas have only a few meters of shoulder, and much of the pollutant load reduction is expected to be achieved in the 2-meter segment.

The 4-meter effluent station is part of the study design to evaluate additional treatment of the BMP if available room exists on the road shoulder embankment. Sampling from the 2-meter and 4-meter collector locations provides an opportunity to evaluate whether performance is enhanced by increasing the flow path through the BMP.

6-1.3 Road and BMP Slopes

Current design guidelines limit VFS to embankments with lateral slopes between 2 and 33 percent (WSDOT, 2011a). These slopes ensure sheet flow runoff from adjacent impervious surfaces is maintained, and sedimentation and infiltration rates are maximized. Concentrated flows from steeper gradients can cause erosion and reduce VFS potential to treat stormwater.

For steep slope areas, or areas where physical constraints make it impossible to install CAVFS, a modified VFS with a compost blanket applied may provide a practical alternative. More research is needed before slope limits in VFS guidelines can be modified. BMP effectiveness monitoring at the study sites along I-5 provide pollutant removal and flow attenuation data to inform the HRM and stormwater managers at WSDOT.

6-1.4 BMP Locations

Five of the six BMPs monitored under this QAPP are located at the two I-5 monitoring sites. Sites located on I-5 are along the highway shoulders at milepost (MP) 197 northbound (north of Everett) and MP 210 southbound (near Pilchuck Creek). Plans for the I-5 modified vegetated filter strip study were developed based on approval from Ecology's Water Quality Program (WQP) (May, 2010) for permit monitoring.

The sixth location, a rural VFS, is north of Lake Stevens, near Marysville, on SR 9. This BMP serves as a highway runoff characterization and BMP effluent toxicity testing site. The SR 9 Marysville monitoring site is not part of the VFS BMP effectiveness evaluation.

Table 4 lists the BMPs that are monitored, and Figure 5 shows their locations. Site-specific BMP design and supporting materials are available in Appendix I.

Monitoring sites used to fulfill the BMP effectiveness and highway characterization monitoring requirements of the permit are combined to conserve efforts and costs, and to reduce the hazards of having field staff on the side of the road at additional locations. Monitoring is conducted at the pavement edge (PE) to characterize highway runoff and "influent" to BMP treatment. BMP "effluent" is captured at two locations down the embankment: at 2-meter and 4-meter distances from the roadway shoulder pavement edge.

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

The attributes of the I-5 modified vegetated filter strip study include the following:

1. CAVFS qualifies for use as an *enhanced treatment* (dissolved metals treatment) BMP; modified VFSs are tested for the same parameters under the permit's classification of an *enhanced treatment* BMP.
2. I-5 north of Everett meets the "highly urbanized" AADT highway monitoring requirement.
3. I-5 near Pilchuck Creek meets the "urbanized" AADT highway monitoring requirement.
4. Provides a paired study for comparison of an LID treatment approach.
5. Supports WSDOT stormwater research priorities.
6. WSDOT research funds help pay for the project, and the timeline fits well within the permit monitoring schedule.

6-2.1 I-5 Everett Descriptions (Highly Urbanized)

Two monitoring sites are along northbound I-5 near Everett on the eastern shoulder of the freeway in Snohomish County, just north of the Snohomish River. These sites can be accessed along the shoulder of I-5 near MP 197. The AADT of I-5 (northbound only) at these monitoring sites is listed as 126,000. Surrounding land uses include industrial and agricultural activities.

Figure 6 shows two BMP monitoring sets. The first BMP set is in the lower half of the figure, which consists of the pavement edge (PE) influent, 2-meter effluent, and 4-meter effluent stations for the VFS at MP 197.27. The modified VFS BMP set (PE, 2-meter, and 4-meter) is located at MP 197.35, at the top of the figure.

The first "highly urbanized" VFS BMP is the southernmost of two on this section of I-5. The center of the PE sheet flow collector is located at MP 197.27. The 2-meter and 4-meter effluent runoff collectors for the standard VFS are located at MP 197.26 and MP 197.28, respectively.

The second "highly urbanized" modified VFS BMP is the more northern BMP on this section of I-5, with the center of the PE collector located at MP 197.35. The 2-meter and 4-meter effluent runoff collectors are located at MP 197.34 and MP 197.36, respectively.

All sheet flow collector pipes receive runoff from three traffic lanes and a paved shoulder. The drainage areas are shown in Figure 6, with additional site-specific drainage area characteristics and measurements further described in Tables 5 and 6.

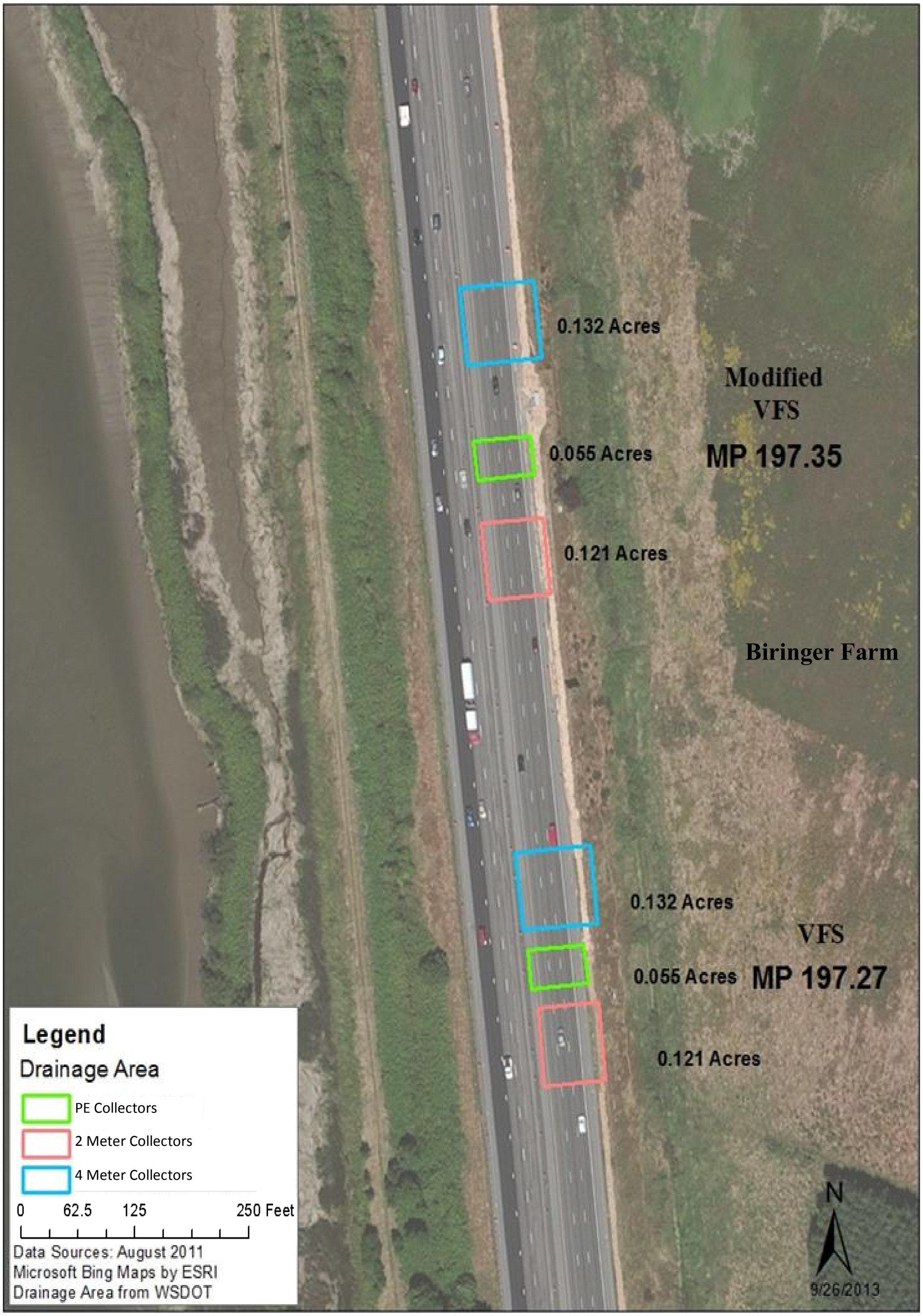


Figure 6 I-5 Everett BMP monitoring sites.

6-2.2 I-5 Pilchuck Creek Description (Urbanized)

The southbound I-5 Pilchuck monitoring site is located just north of the Stillaguamish River and Pilchuck Creek. The AADT at this location is 76,000 (southbound only) and qualifies for the "urbanized" AADT designation. The monitoring site can be accessed from the shoulder of the highway or from Old Highway 99, which runs parallel to I-5. Surrounding land uses include rural residential and agricultural activities.

Figure 7 shows three BMP monitoring sets. The first set is in the lower half of the figure, which consists of a pavement edge (PE) influent, 2-meter effluent, and 4-meter effluent monitoring stations for the VFS at MP 210.71. The modified VFS set (PE, 2-meter, and 4-meter) is located at MP 210.85, at the top of the figure.

In the middle of Figure 7 at MP 210.78 is a CAVFS that includes 2- and 4-meter effluent monitoring stations, only. The PE sheet flow collector at the modified VFS BMP (MP 210.85) serves as a surrogate influent sampling location for the CAVFS. The purpose of the CAVFS BMP is to compare the results from the 2- and 4-meter effluent monitoring stations to the modified VFS effluent stations and evaluate pollutant loads between these two types of BMPs.

The first "urbanized" VFS BMP is the southernmost of the three on this section of I-5. The center of the PE sheet flow collector is located at MP 210.71. The 2-meter effluent and 4-meter effluent runoff collectors for the VFS are located at MP 210.70 and MP 210.72, respectively.

The second "urbanized" CAVFS BMP is located between the VFS and modified VFS, with the center of the 2-meter effluent and 4-meter effluent runoff collectors at MP 210.77 and MP 210.79, respectively.

The third "urbanized" modified VFS BMP is the more northern BMP on this section of I-5, with the center of the PE collector located at MP 210.85. The 2-meter effluent and 4-meter effluent runoff collectors are at MP 210.84 and MP 210.86, respectively.

All sheet flow collector pipes receive runoff from two of the three southbound lanes of traffic and the paved westernmost shoulder. The drainage areas are shown in Figure 7, with additional site-specific drainage area characteristics and measurements further described in Tables 5 and 6.

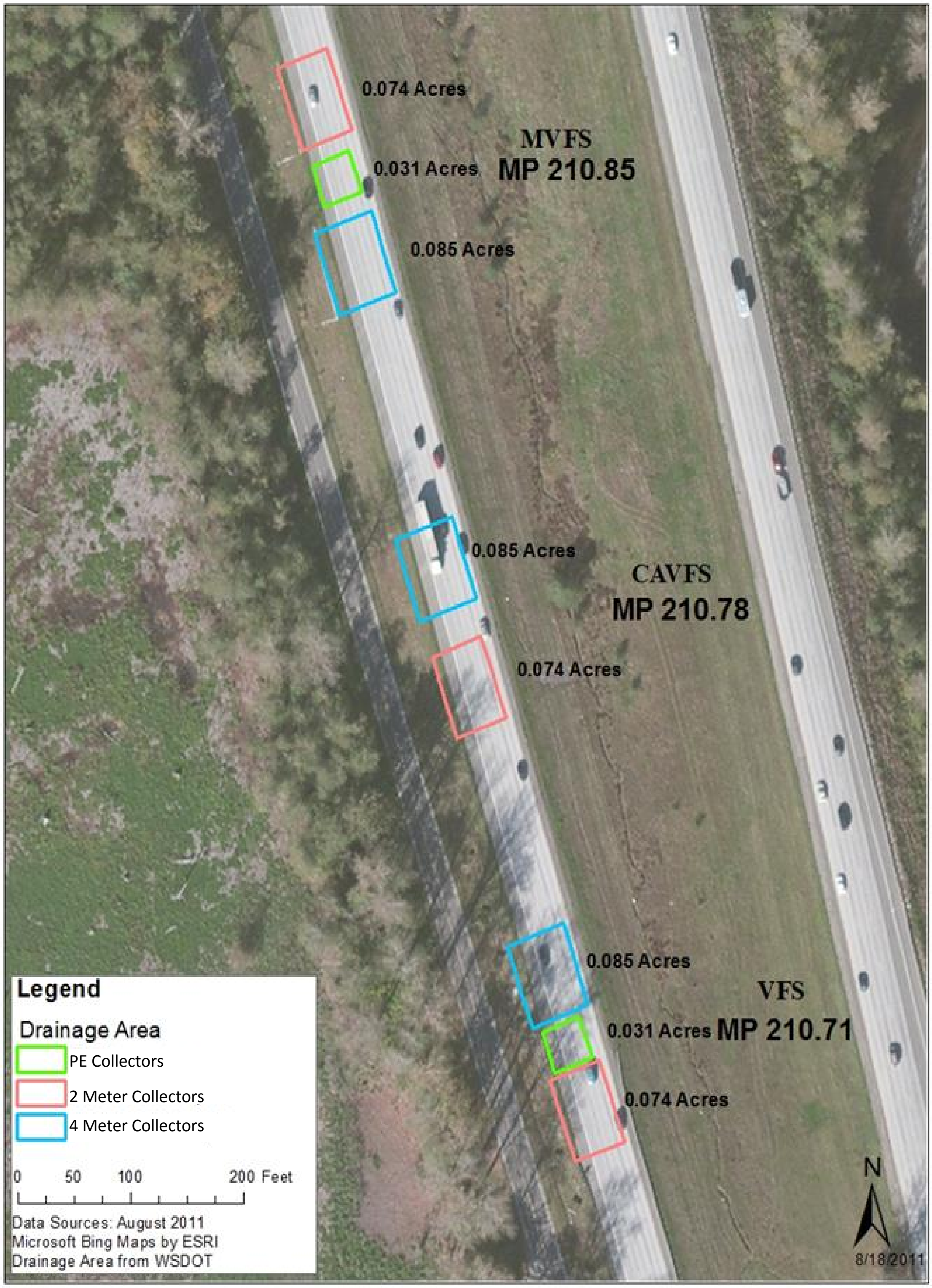


Figure 7 I-5 Pilchuck BMP monitoring site.

6-3 SR 9 Marysville

The SR 9 Marysville monitoring site is north of Lake Stevens on the eastern edge of the city of Marysville. The AADT level at this site is under 30,000, which is the maximum allowable AADT for a "rural" designation required by S7.C of the permit. This monitoring site serves multiple purposes by providing opportunities for highway runoff characterization and BMP effluent toxicity testing at the same location. However, this site is not part of the VFS BMP effectiveness evaluation. Attributes of the SR 9 Rural VFS Study include:

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

6-3.1 SR 9 Marysville Description (Rural)

Recent work to improve the intersection of SR 9 with East Sunnyside Road includes installation of several stormwater treatment BMPs. A VFS at the SR 9 Marysville monitoring site location receives sheet flow runoff from the west side of the highway just south of the intersection with East Sunnyside Road. The AADT at this location is 20,000 and qualifies for the "rural" AADT designation. The surrounding land uses include rural residential and light industrial activities.

Figure 8 shows the BMP monitoring set, which consists of the pavement edge (PE) sheet flow collector and 4-meter effluent monitoring stations for the VFS at MP 17.92. The 4-meter station at SR 9 is used for toxicity testing only.

All sheet flow collector pipes receive runoff from one and a half lanes of highway and a paved shoulder. Runoff from SR 9 enters the VFS and sheet flows across to a continuous flow biofiltration swale, where it collects and continues to a detention pond. Only the embankment VFS is studied as part of the permit monitoring effort. The drainage areas are shown in Figure 8, with additional site-specific drainage area characteristics and measurements further described in Tables 5 and 6.

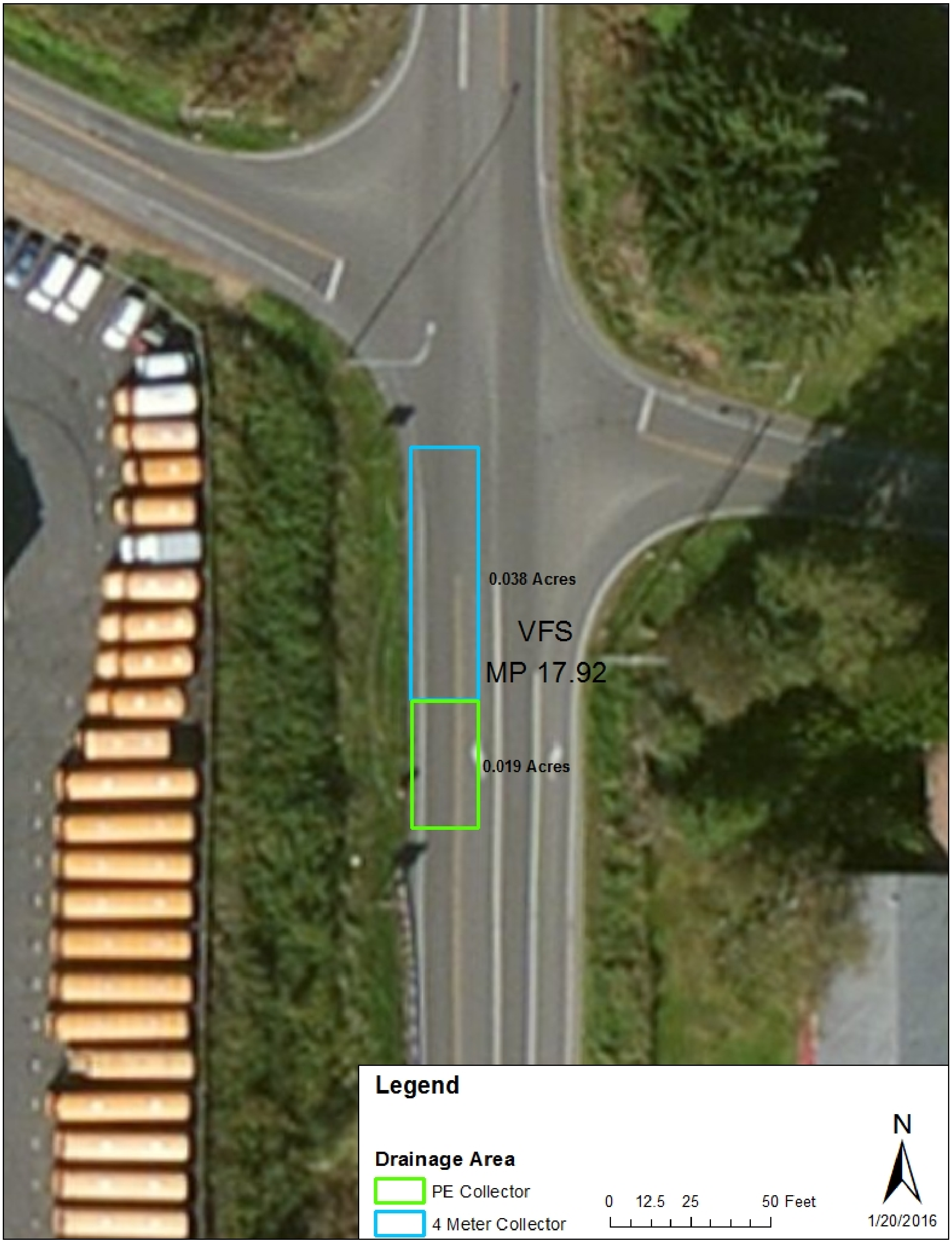


Figure 8 SR 9 Marysville BMP monitoring site.

6-4 BMP Design Details

6-4.1 Drainage Area Characteristics

Drainage areas conveying water to the BMP sampling locations were defined using WSDOT's Design Office's Computer Aided Design (CAD) files and verified using the Geographic Information System (GIS) Workbench (WSDOT, 2011b). Mapping and documenting conveyance systems is an ongoing effort at WSDOT. Using as-built and design drawing CAD files in combination with aerial imagery and other agency data layers accessed through the GIS Workbench, allows staff to verify collection system information. The drainage areas and associated roadway engineering information are used to calculate the runoff time of concentration (for PE collector stations) and model peak flow rates for each station.

Time of concentration is defined as the time necessary for stormwater runoff to reach the outlet of a subbasin from the most remote point in the drainage area (WSDOT, 2011a). Lateral and longitudinal flow lengths and slopes were obtained from as-built CAD files. The lateral roadway slopes of shoulders and traveling lanes were combined to estimate an average slope.

Time of concentration (T_c) for stormwater runoff sheet flow is shown in Equation 5, using methodology from the Soil Conservation Service (SCS) Technical Release 55 (SCS, 1986) to meet permit requirements for highway runoff monitoring (S7.B.3 and S7.B.6).

Equation 5: Time of Concentration

$$T_{c\ Tot.} = \frac{0.007(nL_T)^{0.8}}{\sqrt{R} \times (s)^{0.4}}$$

Where:

- $T_{c\ Tot.}$ = Total time of concentration (hours)
- n = *Manning's roughness coefficient* for concrete or asphalt (0.011)
- L_T = Total flow length of longest path (ft.)
- R = 2-yr., 24-hr. rainfall (in)
- s = slope of flow path (ft./ft.)

Table 5 lists each BMP's influent (PE sheet flow collector) drainage area characteristics and times of concentration ($T_{c\ Tot.}$) for the 2-year, 24-hour rainfall event. Estimated $T_{c\ Tot.}$ values for the PE collectors were used to inform preliminary autosampler threshold programming until long-term rainfall runoff relationships could be established for each monitoring site.

Table 5 PE drainage area characteristics and $Tc_{Tot.}$ estimates for the 2-year, 24-hour rainfall event.

Pavement Edge Collector Monitoring Site Location	Flow Length of Longest Path to PE DCP L_T (ft.)[1]	Drainage Area A (ac)[2]	TR-55 Method Time of Concentration $Tc_{Tot.}$ (hr.)[8]	TR-55 Method Input Variables[6]: Manning roughness coefficient *n*	Flow length of longest roadway distance to PE L_o (ft.)	Flow length of longest PE distance to DCP L_1 (ft.)	2-yr., 24-hr. Rainfall *R* (in)[5]	Lateral slope of flow path on roadway to PE s_o (ft./ft.)	Longitudinal slope of PE flow path to DCP s_1 (ft./ft.)[7]	Roadway flow time of concentration to PE Tc_o (hr.)	PE flow time of concentration to DCP Tc_1 (hr.)
I-5 Everett, MP 197.27	99.37	0.054	0.101	0.011	60.00	39.37	1.76	0.017	0.0002	0.019	0.082
I-5 Everett, MP 197.35	99.37	0.054	0.101	0.011	60.00	39.37	1.76	0.017	0.0002	0.019	0.082
I-5 Pilchuck, MP 210.71	73.37	0.031	0.018	0.011	34.00	39.37	2.09	0.028	0.044	0.009	0.009
I-5 Pilchuck, MP 210.85[4]	73.37	0.031	0.018	0.011	34.00	39.37	2.09	0.028	0.044	0.009	0.009
SR 9 Marysville MP 17.92[3]	60.37	0.019	0.013	0.011	21.00	39.37	2.21	0.050	0.045	0.005	0.008

[1] Lane and shoulder widths are measured from as-builts. Lane width is 12 feet and shoulder width varies between five and 12 feet (FHWA, 2007). The longest path is estimated as (width of roadway) + (length of PE) or ($L_T = L_o + L_1$).

[2] Drainage areas are the width of the roadway multiplied by the length of the PE (39.37 ft.). ($A = L_o \times L_1$). Then convert ft^2 to acres.

[3] Values are from field measurements and WSDOT documentation.

[4] Site not used for highway characterization. BMP PE only.

[5] 2-year, 24-hour rainfall values accessed on 5/30/2014, using WSDOT's GIS Workbench – PRISM model operated by Oregon Climate Service, used in conducting spatial mapping of precipitation for selected recurrence intervals. This data set is also used to derive MGSFlood™ model outputs (MGSFlood™, 2011).

[6] Equation (3-3) on p. 3-3 of the 1986 USDA *Urban Hydrology for Small Watersheds* TR55. Second Edition, Publication No. 210-VI-TR55 (SCS, 1986).

[7] Longitudinal slope of PE flow path to DCP was determined using As-built plan sets and is assumed to be equivalent to the longitudinal slope of the roadway since PE collectors are installed parallel to the roadway.

[8] Total Time of Concentration equals the (Roadway flow Time of Concentration to PE) + (PE flow Time of Concentration to DCP) or, ($Tc_{Tot.} = Tc_o + Tc_1$).

6-4.2 MGSFlood™ Design Flow Rates

In accordance with 2008 TAPE (Ecology, 2008a) guidance, BMP sizing must be based on an Ecology-approved continuous simulation model with the goal of treating at least 91 percent of the runoff volume. Design storm flow rates were generated for each monitoring site location to estimate the peak flow of water under multiple storm event scenarios. MGSFlood™ (MGSFlood, 2011) is an Ecology-approved continuous simulation model and was used for this purpose.

MGSFlood™ Model Output

Flow rates shown in Table 6 represent larger storm events that occur periodically. These flow rates were calculated in MGSFlood™ using 15-minute time steps. The following information was used to populate the model:

- PE collector pipes at the Everett, Marysville, and Pilchuck sampling locations are 39.37 feet long.
- Impervious and pervious drainage area calculations were determined as described in Section 6.4-1.
- BMP effluent sheet flow collector pipes at all sites, for the embankment 2-meter and 4-meter monitoring locations, are 78.74 feet long.

"As-built" design plans for BMP effectiveness monitoring sites are contained in Appendix H.

Table 6 BMP peak flow calculations for design storms.

Monitoring Site Location	(Impervious) Collector L (ft.)	Roadway W (ft.)	Roadway Lateral Slope (% Grade)	Drainage Area (Acres)	(Pervious – Grass) Collector L (ft.)	Grass W (ft.)	Embankment Lateral Slope (% Grade)	Drainage Area (Acres)	Design Storm Peak Flow Rates (cfs)[1] 2 YR	10 YR	25 YR	50 YR	100 YR	200 YR
I-5 MP 197.27 (Everett)														
PE Collector	39.37	60	1.67	0.054	–	–	–	–	0.020	0.029	0.037	0.047	0.054	0.056
2-Meter Collector	78.74	60	1.67	0.108	78.74	6.56	27.03	0.012	0.041	0.062	0.079	0.097	0.116	0.119
4-Meter Collector	78.74	60	1.67	0.108	78.74	13.12	27.03	0.024	0.042	0.064	0.084	0.100	0.123	0.126
I-5 MP 197.35 (Everett)														
PE Collector	39.37	60	1.67	0.054	–	–	–	–	0.020	0.029	0.037	0.047	0.054	0.056
2-Meter Collector	78.74	60	1.67	0.108	78.74	6.56	25.97	0.012	0.041	0.062	0.079	0.097	0.116	0.119
4-Meter Collector	78.74	60	1.67	0.108	78.74	13.12	25.97	0.024	0.042	0.064	0.084	0.100	0.123	0.126
I-5 MP 210.71[3] (Pilchuck)														
PE Collector	39.37	34	2.78	0.031	–	–	–	–	0.012	0.018	0.022	0.027	0.033	0.034
2-Meter Collector	78.74	34	2.78	0.061	78.74	6.56	25.00	0.012	0.025	0.039	0.049	0.058	0.072	0.075
4-Meter Collector	78.74	34	2.78	0.061	78.74	13.12	25.00	0.024	0.026	0.041	0.053	0.064	0.079	0.082
I-5 MP 210.85[2][3] (Pilchuck)														
PE Collector	39.37	34	2.78	0.031	–	–	–	–	0.012	0.018	0.022	0.027	0.033	0.034
2-Meter Collector	78.74	34	2.78	0.061	78.74	6.56	27.03	0.012	0.025	0.039	0.049	0.058	0.072	0.075
4-Meter Collector	78.74	34	2.78	0.061	78.74	13.12	27.03	0.024	0.026	0.041	0.053	0.064	0.079	0.082
I-5 MP 210.78[3] (Pilchuck)														
2-Meter Collector	78.74	34	2.78	0.061	78.74	6.56	25.97	0.012	0.025	0.039	0.049	0.058	0.072	0.075
4-Meter Collector	78.74	34	2.78	0.061	78.74	13.12	25.97	0.024	0.026	0.041	0.053	0.064	0.079	0.082
SR 9 MP 17.92 (Marysville)														
PE Collector	39.37	21	5.00	0.019	–	–	–	–	0.007	0.011	0.014	0.016	0.020	0.021
4-Meter Collector	78.74	21	5.00	0.038	78.74	13.12	25.00	0.024	0.017	0.028	0.035	0.045	0.055	0.056

[1] The flow rates for the Everett, Pilchuck, and Marysville sites were calculated in MGS Flood V4.28 (MGS Flood, 2011) using 15-minute time steps.

[2] Site at MP 210.85 is primarily sampled as a BMP effectiveness PE. Alternately, the site is used for highway characterization sampling, as needed. Use as a highway characterization sampling location is identified on the chain of custody (COC) when applicable.

[3] Value for embankment lateral slope was estimated.

6-4.3 Compost Properties

Description of the Compost

Both the modified VFS and CAVFS BMPs call for compost amendment. The organic content of the compost and site soils varies. The HRM states that, when built, the CAVFS BMP should have a final organic content of 10 percent.

Specifications for compost soil amendments in Section 5-4.3.2 of the HRM state that compost material should be aged and cured according to Section 9-14.4 (8) in the *Standard Specifications*. Mature high-quality compost should be stable and derived from organic waste materials. Desirable compost qualities include:

- Earthy smell that is not sour, sweet, or ammonia-like
- Brown to black in color
- Mixed particle sizes
- Stable temperature and does not get hot when rewetted
- Crumbly texture

The HRM states that compost materials must meet the definition for "composted materials" in Section 9-14 of the *Standard Specifications* (WSDOT, 2010b) and WAC 173-350-220. Please refer to these manuals for specific details on compost selection, composition, and definitions.

6-4.4 Soil Properties

Site-specific BMP soil properties and water quality model information were collected according to the schedule in Table 7. Appendix I provides additional site characteristics and information.

Table 7 Soil characterization schedule.

Date	Activity
April 2011	Soil borings of each BMP were drilled.
May 2011	Laboratory analysis for K_{sat},[1] CEC,[2] and soil gradation of all BMP native site soils complete.
September 2011	Geotechnical Evaluation Report for BMP Effectiveness Stormwater Monitoring Sites on I-5 and SR-9 (WSDOT, 2011c).

[1] K_{sat}: saturated hydraulic conductivity

[2] CEC: cation exchange capacity

7 Sampling Process Design

7-1 BMP Effectiveness

This chapter addresses sampling experimental design to ensure data collection and monitoring methods satisfy requirements of the permit, and data of known quality are generated from this monitoring effort.

Sampling process design was developed from monitoring requirements identified in the permit and recommended procedures in the Technology Assessment Protocol (TAPE) (Ecology, 2008a). Further guidance was provided by EPA's *Urban Stormwater BMP Performance Monitoring* (USEPA, 2002c).

As previously described, specific objectives of this monitoring study are:

- Quantify the treatment performance of each BMP for reducing both runoff pollutant concentrations and loads.
- Determine the effectiveness of each BMP at treating the applicable water quality design flow.
- Determine whether the treatment performance of each BMP varies in relation to storm event characteristics and/or other operational considerations.

The VFS BMPs have the ability to infiltrate water to underlying soils. The modified VFS and CAVFS BMPs have the additional benefits of reduced flows and pollutant concentrations due to higher surface roughness, greater retention and infiltration, sorption of contaminants, improved vegetation health, and reduction of invasive weeds (WSDOT, 2011a).

7-1.1 Modified VFS and CAVFS Study Goals

WSDOT applied compost to VFSs at two locations along I-5 north of Everett. At each location, an existing nonmodified VFS is used for data comparison and as a control. This study evaluates the benefits of a compost blanket versus tilled-in compost for improving the water quality and quantity treatment performance of a VFS. The study compares a modified VFS (MVFS), which is a standard VFS with three inches of compost applied as a blanket to the surface of the soil, and a compost-amended VFS (CAVFS), which has three inches of compost mix tilled into the top 12 inches of soil. For both BMPs, hydroseeding occurred after compost amendments were applied. Compared to the CAVFS installation, an MVFS reduces costs for stormwater retrofits and can be applied to many more situations where heavy equipment to till the soil cannot be used.

To serve as a "worst case" scenario, the Pilchuck location was chosen for the CAVFS installation because the soils are not as permeable as soils at the Everett site. Results from monitoring the CAVFS will be used to inform the *Highway Runoff Manual* (HRM).

The study design compares the pollutant-removal effectiveness and flow-reduction potential of a VFS, CAVFS, and MVFS. Comparing influent and effluent results will demonstrate each BMP's performance and effectiveness at reducing pollutant concentrations and flow.

Results from these side-by-side comparisons will be used to update the HRM, inform the agency's highway stormwater management programs, and satisfy the flow-reduction strategy monitoring requirements in S7.E.2.d of the permit. There are several BMP effectiveness questions this monitoring effort intends to answer:

- How effective is each BMP at attenuating stormwater flows and reducing stormwater pollutant concentrations?
- How do performance data compare for each BMP as defined in the HRM?
- What is the runoff attenuation or water quality benefit of the 4-meter effluent monitoring station versus the 2-meter effluent monitoring station for each BMP?

Table 8 lists the BMP design elements, attributes of the BMPs, and anticipated outcomes. This table is representative of the types of questions that will be addressed during analyses of the BMP's 2-meter and 4-meter effluent monitoring results.

Table 8 BMP design elements and monitoring outcomes.

VFS	Modified VFS (compost blanket)	CAVFS	Questions
Storm Event Runoff Volume Differences from PE and 4m[1] *(flow control effect)*			
Volume Reduction (V1)	Volume Reduction (V2)	Volume Reduction (V3)	V1 < V2 V1 < V3
Water Quality Difference from PE and 4m *(water quality effect)*			
Water quality improvement (WQI1)	Water quality improvement (WQI2)	Water quality improvement (WQI3)	WQI1 < WQI2 WQI1< WQI3
Potential Outcomes			
No infiltration improvements due to compost amendment.			V1 = V2 V1 = V3
Compost-amended BMPs promote infiltration more than unamended VFS, due to the promotion of infiltration and/or a greater hydraulic conductivity, and may hold rain and spray water.			V1 < V2 V1 < V3
The two methods of compost amendment behave differently for flow volume reduction.			V2 ≠ V3
Compost-amended BMPs remove more pollutants than VFS.			WQI1 < WQI2 WQI1 < WQI3
The two methods of compost amendment behave differently for water quality improvement.			WQI2 ≠ WQI3

[1] The information contained in this table fulfills the flow reduction strategy requirement in S7.E.2.d of the permit (Ecology, 2009a).

Data from these studies will provide evidence to determine whether a modified VFS with compost applied as a blanket is a practical use of WSDOT stormwater treatment BMP planning and resources. In addition, the findings will add information to the "feedback loop" that Ecology hopes will improve BMP application, design criteria, and performance. Since the compost blanket is a slight variation from HRM specifications, information gathered as part of this effort may be used to meet TAPE requirements for approval as an effective BMP.

7-1.2 Monitoring Set-Up for BMPs

The collector pipe design, carried over from a previous study (WSDOT, 2009a), is the mechanism used to capture sheet flow runoff from the highway pavement and effluent from the BMP soil matrix. This collector is a high-density polyethylene (HDPE) pipe with a one-quarter to one-half section removed; the pipe is buried parallel to the roadway and mortared to either the pavement edge (PE) or hillside at a level that water from sheet flow runoff can freely enter.

Figure 9 shows a cross-sectional view of the collector pipe at the PE. The collector itself is sloped horizontally downhill slightly toward the pipe weirs and sampling equipment.

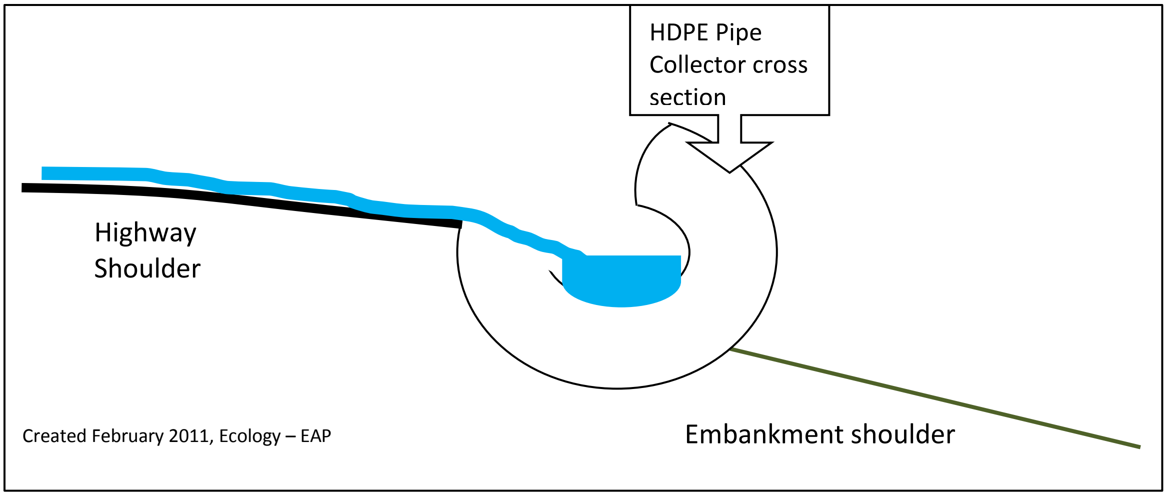


Figure 9 Cross section of the PE sheet flow collector.

The 2-meter and 4-meter effluent sheet flow collectors are recessed into the BMP, below the surface level of the soil, and oriented to collect the surface runoff flowing through the BMP, as shown in Figure 10. Stormwater sheet flow at both the 2-meter and 4-meter effluent locations is collected from the treated layer of the BMP, and not from the soil column below. Any groundwater interactions observed during the monitoring period are recorded by field staff on field forms. Although stormwater treatment is occurring in the embankment soils, monitoring is aimed at quantifying only the treatment from the BMP itself. Similar to the PE collector, the 2-meter and 4-meter collectors are sloped horizontally downhill slightly toward the pipe weirs and sampling equipment to promote directional flow for measurement.

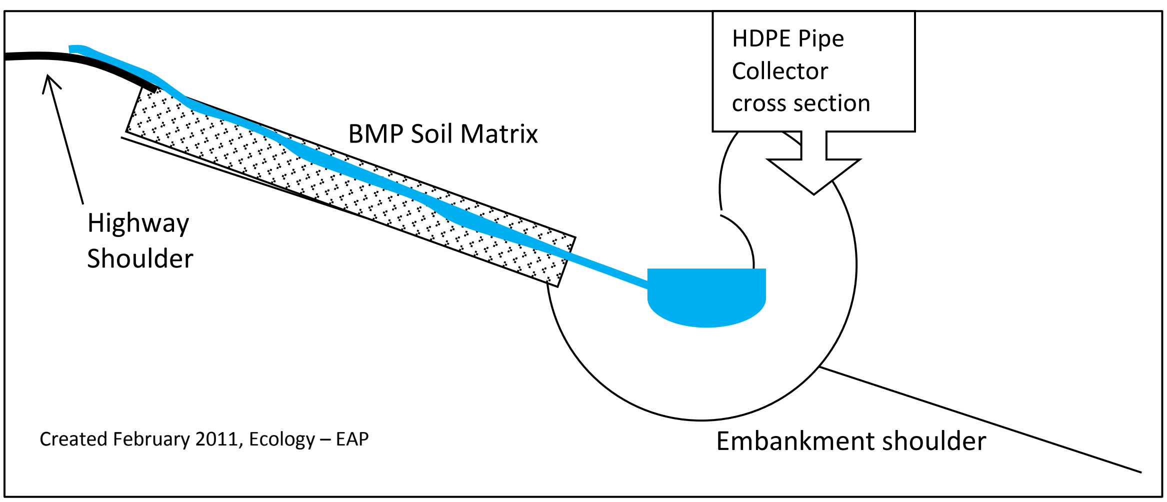


Figure 10 Cross section of the BMP sheet flow collector.

Figure 11 shows the general sampling layout of the collectors at the combined highway runoff and BMP effectiveness monitoring sites (Pilchuck and Everett). This diagram illustrates how the collectors concentrate and convey sheet flow runoff from the highway, through the BMP, and transports the stormwater horizontally downslope through an HDPE pipe to the weir for flow measurement.

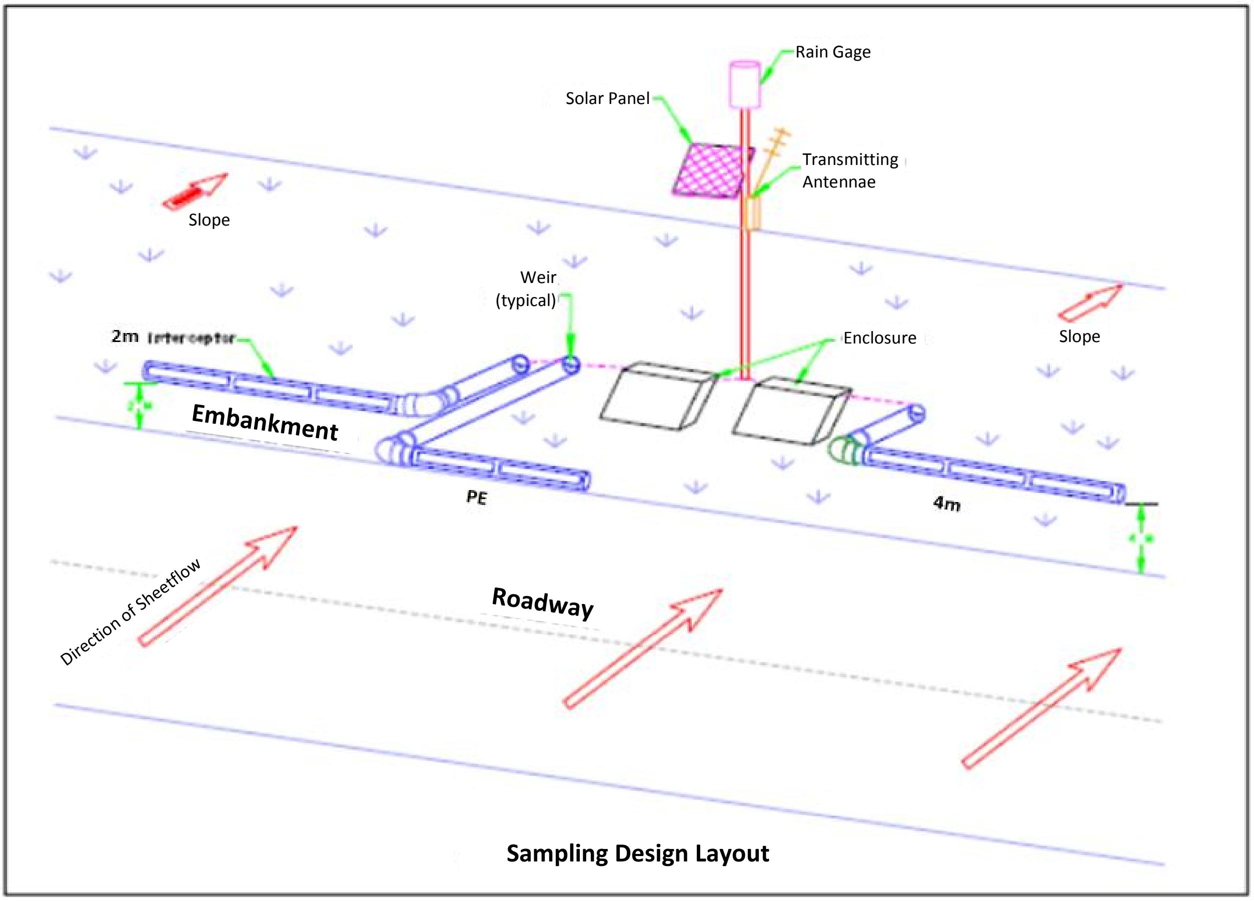


Figure 11 Sampling design layout with PE collector, 2-meter and 4-meter collectors, and sampling equipment.

Photos of the data collection platform at the Everett MVFS, including the pipes, weirs, and concrete pads, are shown in Figure 12.

Figure 12 Everett MVFS DCP with views of sampling and gaging pipe equipment.

Figures 13, 14, and 15 are line drawings of the Everett, Pilchuck, and SR 9 monitoring sites, respectively. The I-5 Everett and Pilchuck VFS and MVFS BMPs are monitored by a set of three monitoring stations: a PE station, 2-meter station (2 meters downslope), and 4-meter station (4 meters downslope), as shown in Figures 13 and 14. A collector is placed at each station to capture flow. At the Pilchuck monitoring site, the CAVFS BMP has a similar set of runoff collection stations, except there is not a PE station (see Figure 14).

The SR 9 rural VFS has a similar set of runoff collection stations, except there is not a 2-meter (mid-BMP) monitoring station (see Figure 15). The 4-meter station at SR 9 is used for toxicity testing only. BMP effluent characterization monitoring does not take place at this site.

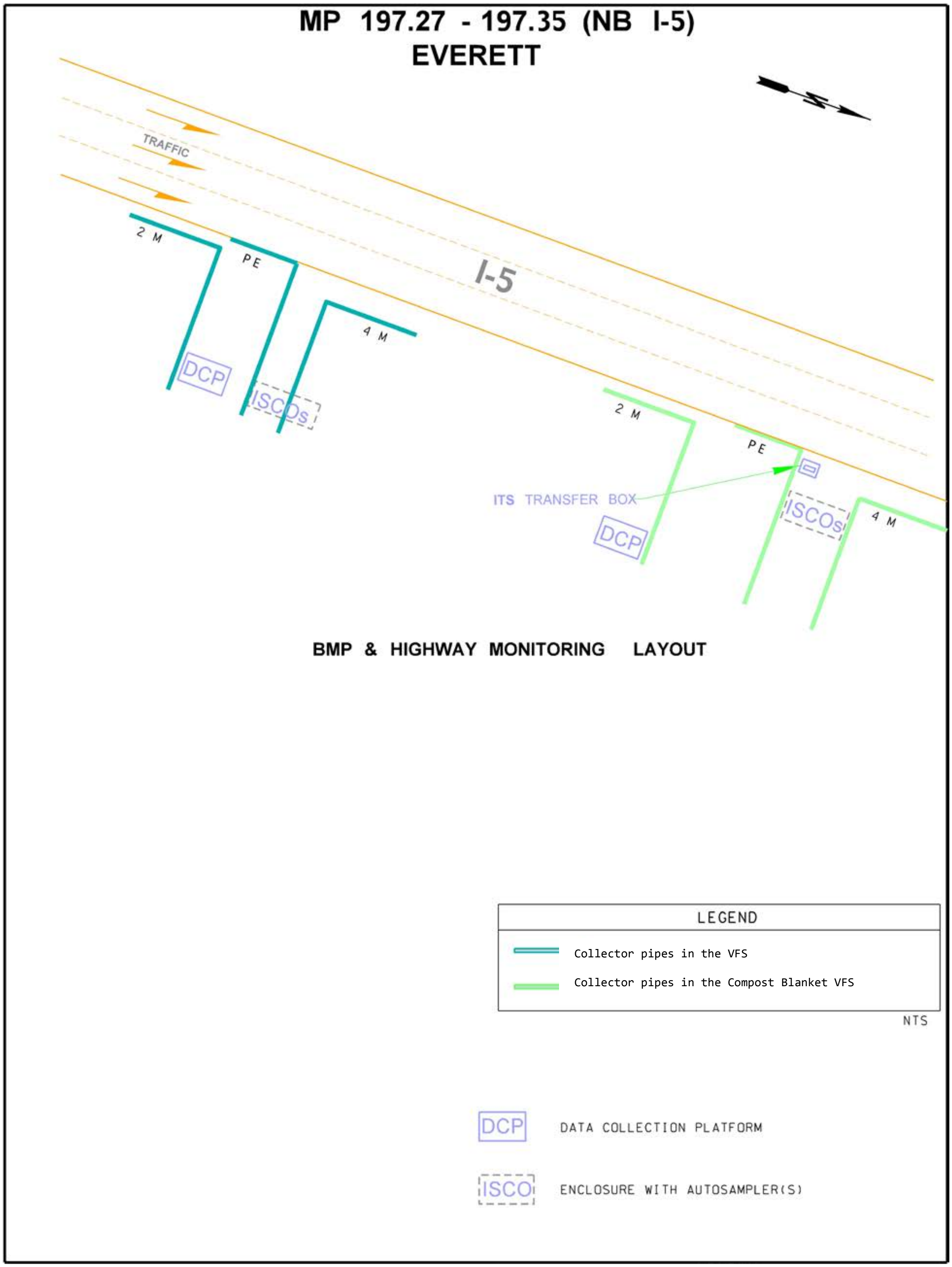


Figure 13 Line drawings of Everett monitoring stations.

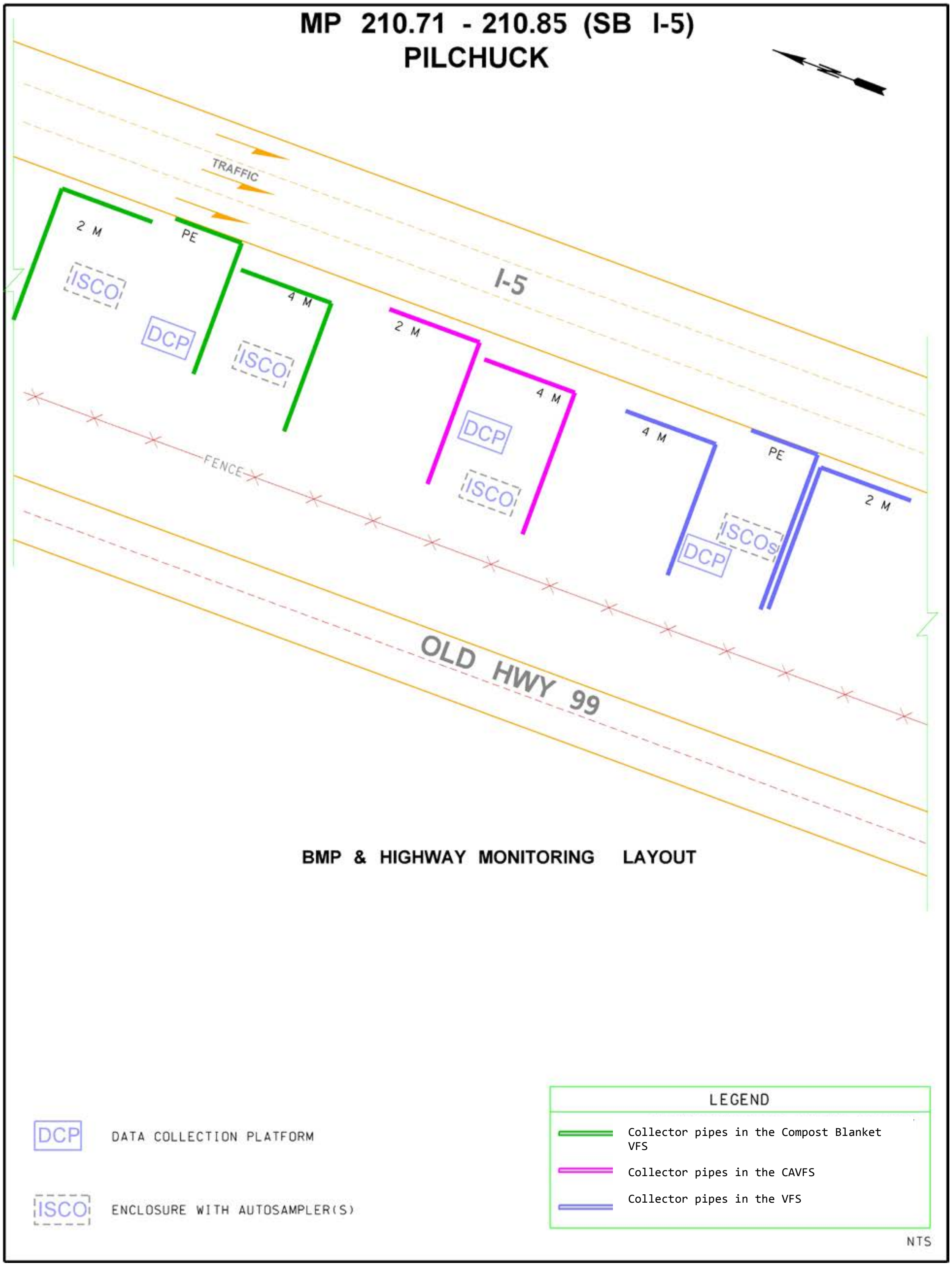


Figure 14 Line drawings of Pilchuck monitoring stations.

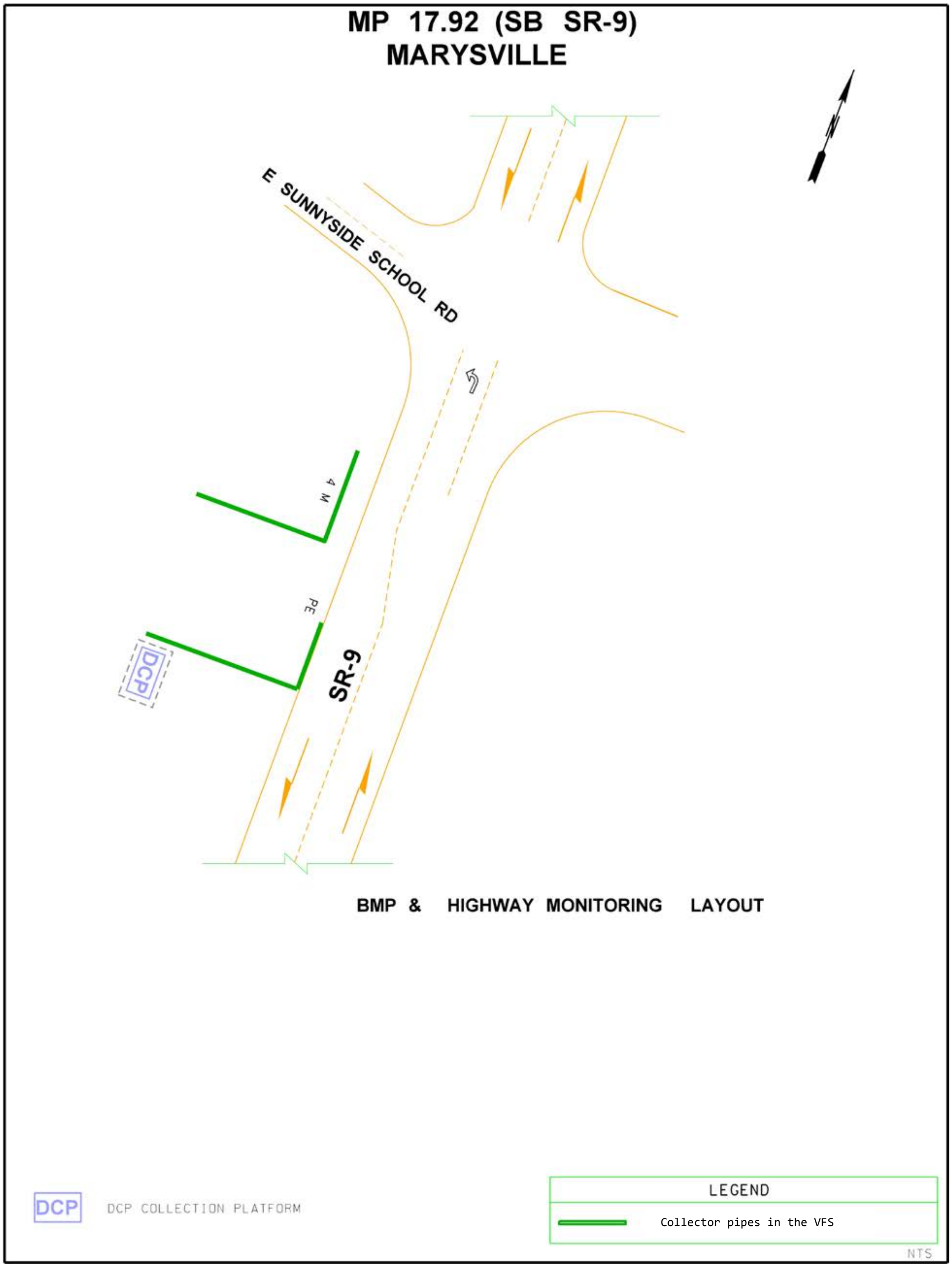


Figure 15 Line drawings of SR 9 near Marysville monitoring stations.

7-2 Monitoring Overview

The preliminary site monitoring assessment included:

- Geotechnical investigations to determine infiltration rates, soil horizons and layers, and soil type (WSDOT, 2011c).
- Early TSS and particle size distribution (PSD) samples, per TAPE (Ecology, 2008a) guidance.

A broad overview of the BMP effectiveness monitoring methods and procedures is further described in this section. Influent and effluent monitoring stations were established to measure stormwater quantity and quality at the selected BMPs. Table 9 lists the parameter categories, sampling frequency, and methods. Actual parameters are discussed below.

Table 9 Overview of monitoring at WSDOT BMP sites.

Parameter Category	Sampling Frequency	Sampling Method	Telemetered Data
Rainfall	Continuous, year round	Rain gage	Yes
Stage (Flow)	Continuous, year round	Stage measuring device	Yes
Temperature	Continuous, year round	In situ probe	Yes
Chemical	Discrete storm events	Autosampler	No
pH	Discrete storm events	Grab sample	No
Toxicity	Annually	Autosampler	No

7-2.1 Methods of Sampling

Continuous Samples

Rainfall, temperature, and stormwater flow are continuously monitored at all BMP locations. A data collection platform (DCP) is located at each monitoring site. The DCP consists of a 12-volt battery, data logger, autosampler(s), and attached peripheral probes for water temperature, rainfall, and stage at the weir or flume. Following TAPE (Ecology, 2008a) guidelines, data loggers are programmed to record measurements every five to 15 minutes, depending on the parameter. Each data logger is equipped with a satellite antenna to telemeter data. These five to 15-minute data blocks are saved to the internal logger memory and transmit at one-hour intervals year round to establish a site-specific characterization. Field crews also manually download data from the data loggers during scheduled maintenance visits. Hydrographs and hyetographs created from the collected rain gage and discharge data compare and relate the two parameters.

Grab Samples

Grab samples are typically collected manually or measured in situ with a probe. Grab samples are collected for pH, and annually for TPH-Dx and TPH-Gx during toxicity sampling. TPH is collected manually while pH is measured using a probe. Grab samples are collected following Ecology's *Standard Operating Procedure for Collecting Grab Samples from Stormwater Discharges* (Ecology, 2009c), and probe measurements are taken following the WSDOT *Standard Operating Procedure for Using Portable Meters* (WSDOT, 2011d).

Annual seasonal first flush toxicity sampling has only one grab sample requirement for TPH-Dx and TPH-Gx, which are discussed further in the Appendix C, Toxicity Guidance.

Ecology and WSDOT agreed that annual sediment grab samples would not be collected to meet permit requirements (S7.E.6). This type of sampling was not deemed applicable for LID-type BMPs by Ecology and WSDOT. Sediment data is not collected or used for TAPE due to the inherent difficulty of separating stormwater sediments from the soils or compost at a location mid-BMP. Therefore, sediment grab samples are not used for mass balance calculations.

Composited Samples

The permit specifies that stormwater runoff must be collected by flow-weighted compositing. Refrigerated autosamplers such as an ISCO Avalanche® or a similar product are used to collect stormwater samples during a qualifying storm event. The data logger is preprogrammed to control the flow-weighted runoff autosampler to comply with TAPE (Ecology, 2008a) specifications identified in Table 1. Autosamplers are programmed to begin sampling at the predetermined rates required for the collection of at least 75 percent of the event hydrograph. Sample collection into autosampler bottles is triggered by a four-step threshold system. The four thresholds are:

- Time – to ensure TAPE-specified antecedent dry periods are met.
- Rainfall – to ensure a storm event is occurring.
- Presence of runoff – to ensure water is flowing through the conveyance system.
- Water temperature – to avoid sampling during freezing conditions.

Water temperature, rainfall, and stage are measured using external probes connected to the data logger. Time is measured using a GPS-synched internal clock in the data logger. If these four thresholds do not meet the programming criteria, samples are not collected.

Each monitoring station is equipped with a refrigerated compositor and a precleaned bottle for sample containment. Stations can support different bottle configurations and types, depending on sample volume requirements, planned duplicates and replicates, blanks, or anticipated storm size. Guidance in Ecology's *Standard Operating Procedure for Automatic Sampling for Stormwater Monitoring* and WSDOT's *Standard Operating Procedure for Field Sampling with Autosamplers* is followed, as applicable (Ecology, 2009b; WSDOT, 2011e).

7-2.2 Monitoring Timeline

A general timeline for the BMP monitoring program is presented in Table 10.

Table 10 Timeline for BMP monitoring.

Timeline	Event	Purpose
Spring 2011	Runoff concentrations for TSS and PSD measured at each BMP influent station	Required testing by TAPE to better understand the potential success of the BMP to treat the runoff
Spring 2011	Geotechnical assessment	Site soils characterization
Summer 2011	Equipment purchased and installation begins	Beta testing at each site for full-scale monitoring
Spring 2012	Phased implementation of the BMP effectiveness monitoring program begins	Permit-required monitoring
Spring 2013 – Ongoing	Self-assessment and audits	Permit compliance, stormwater monitoring project management, and oversight

7-2.3 Parameters

S7.C.4, S7.E.5, and S7.E.6 of the permit specify the parameters to be monitored at each BMP monitoring site for effectiveness and toxicity monitoring. The parameters for effectiveness and toxicity monitoring are listed in Table 11.

Stormwater samples are collected by grab and composited techniques, as required by the permit. If insufficient sample quantity is collected for BMP effectiveness monitoring, 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 follows parameter and volume requirements shown in Table 13. Toxicity sampling is further discussed in Section 7-3, Annual Seasonal First Flush Toxicity Monitoring.

Table 11 Water quality parameters to be monitored (Ecology, 2009a).

Effectiveness Monitoring	Seasonal First Flush Toxicity Testing (BMP effluent)[1]
Total recoverable and dissolved metals (Cu, Zn)	*Hyalella azteca* 24-hr acute toxicity test
TSS	Total recoverable and dissolved metals (Cu, Zn, Cd, and Pb)
Hardness	Herbicides (if used in drainage area)[2]
pH	TSS
Nutrients: total phosphorus, orthophosphate	Chlorides
Particle size distribution (PSD)	Hardness
Nitrate/Nitrite[3]	Methylene blue active substances (MBAS)
TKN[3]	Polycyclic aromatic hydrocarbons (PAHs)
	Phthalates
	Total petroleum hydrocarbon: NWTPH-Dx and NWTPH-Gx[4]
	Conductivity[5]
	Dissolved oxygen[5]
	pH[5]
	Total sulfate[5]
	Alkalinity as $CaCO_3$[5]
	Dissolved organic carbon (DOC)[5]
	Cobalt thiocyanate active substances (CTAS)[5]
	Dissolved Ca, Mg, Na, and K[5]

[1] Hardness, conductivity, dissolved oxygen, and pH will be measured on seasonal first flush toxicity samples upon receipt by the toxicity laboratory, according to the method.
[2] Limited to the herbicides listed in the permit and used by WSDOT in the drainage area. Currently, glyphosate only.
[3] Not required by the permit but may be collected to support HRM research purposes.
[4] Grab samples.
[5] Not required by the permit but may be collected in support of the Biotic Ligand Model, to be used for toxicity follow-up reporting activities.

Herbicides

The permit requires herbicide sampling at BMP sites for toxicity monitoring. In addition, the permit requires herbicide sampling “only if applied in the monitoring site drainage area.” The drainage area for the BMP sites is assumed to mean only the area contributing runoff to the pavement edge and sheet flow collectors.

Based on WSDOT's records of usage, the herbicides listed in the 2009 permit that were used at the selected BMP 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)
- Pilchuck I-5 MP 210.78: Glyphosate (nonaquatic formula)
- Pilchuck I-5 MP 210.85: Glyphosate (nonaquatic formula)
- Marysville SR 9 MP 17.92: Glyphosate (nonaquatic formula)

WSDOT checks the herbicide application reports annually to stay up to date on the application of herbicides near the monitoring locations, to adaptively manage sampling to meet permit requirements. These yearly reviews are used to update the list of herbicides to be monitored at each site. Updates to the list of herbicides and fertilizers are made when necessary.

S7.B.4 of the permit provides the list of herbicides that WSDOT needs 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 study design for seasonal first flush toxicity sampling from three highway pavement edge (PE) influent and three BMP 4-meter effluent monitoring stations. The toxicity sampling process design was developed from monitoring requirements identified in the permit and recommended procedures from Ecology and the American Society for Testing and Materials (ASTM, 2014).

7-3.1 Toxicity Target Population

S7.C.1 of the permit requires that WSDOT collect six toxicity screening samples, three from PE stations and three from BMP effluent stations, at least once per monitoring year in August or September. Samples are 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.

Seasonal toxicity samples are tested for screening purposes only. If a qualifying event is missed, or the initial sample is invalid or has an anomalous test result, a second sampling attempt is made.

A second attempt is made only if sufficient time remains to meet the toxicity storm event criteria. If the second attempt is unsuccessful, then no additional attempts are made that calendar year.

7-3.2 Toxicity Monitoring Requirements

Annually, one seasonal first flush toxicity sample is collected from each of the influent and effluent BMP monitoring stations listed in Table 12. The PE collector is sampled for the influent, and the 4-meter sheet flow collector is sampled for the effluent.

Table 12 Toxicity monitoring stations for BMP effluents.

BMP Type	Location of BMP
Modified VFS	Northbound I-5 at Everett (MP 197.35)
Modified VFS	Southbound I-5 at Pilchuck (MP 210.85)
VFS	Southbound SR 9 near Marysville (MP 17.92)

Collecting sufficient volume for toxicity sampling from the relatively small discharge areas contributing runoff at these monitoring sites may prove difficult. The total volume required for toxicity testing and associated chemical analyses is in the range of 6.81 liters, without any extra volume for chemical duplicates. If a minimum volume of 2.0 liters (1.14 liters for toxicity at 4 replicates at 5 concentrations and 100 mL per replicate and 0.81 liters for metals, herbicides, chloride, and hardness) is not collected, then the sample is discarded. Table 13 lists the parameters tested when the volume collected is between 2.0 and 6.81 liters, as well as the parameter priority, in descending order, when the volume collected is less than 6.81 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 is reserved for use during the follow-up actions outlined in Appendix J.

Once the samples reach the laboratory, the toxicity lab measures conductivity, dissolved oxygen, and pH for each site.

Toxicity autosamplers are preset and deployed by field staff just before the qualifying storm in order to collect a composited toxicity sample. Grab samples are obtained as early in the storm event as feasible.

A decision is 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 may provide larger volumes for the average storm; however, the chemistry data cannot be used for dual-purpose BMP monitoring if not collected by the flow-weighted sampling program. Seasonal first flush toxicity samples are collected in a glass sample collector in accordance with standard composite sample collection methods and materials.

TPH-Gx and TPH-Dx grab samples for toxicity testing are collected into an appropriate sample container and sent to a laboratory for measurement. The method of grab sample collection may vary due to access to the discharged stormwater: a container may be held by hand or may be transferred, via a sterilized bailer, from the effluent to a sample container. Refer to the *Standard Operating Procedures for Collecting Grab Samples from Stormwater* (Ecology, 2009c) for further details on this method.

Table 13 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
2.0–2.39	1.95	1.14	4 reps., 5 concentrations, 100 mL per replicate	0.81	Metals, Herbicides,[2] Chloride, Hardness
2.4–2.99	2.45			1.31	Metals, Herbicides,[2] Chloride, Hardness
3.0–5.99	3.71	1.40	4 reps., 5 concentrations, 125 mL per replicate	2.31	Metals, Herbicides,[2] TSS, Chloride, Hardness
	4.71			3.31	Metals, Herbicides,[2] TSS, Chloride, Hardness, MBAS, CTAS
	5.71			4.31	Metals, Herbicides,[2] TSS, Chloride, Hardness, MBAS, CTAS, PAHs, Phthalates
>6.0	6.81	2.50	4 reps., 5 concentrations, 250 mL per replicate	4.31	Metals, Herbicides,[2] TSS, Chloride, Hardness, MBAS, CTAS, PAHs, 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.

WSDOT must notify the toxicity laboratory two days prior to the date of the forecasted storm event and upon successful sample collection.

A collected 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 Whole Effluent Toxicity (WET) Coordinator must be contacted for conditional acceptance of a sample temperature deviation. Acceptance of a temperature deviation is based upon Ecology's "Laboratory Guidance and Whole Effluent Toxicity Test Review Criteria" (Ecology, 2008b). Temperature deviations are not 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 is 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 rainwater sample in addition to a receiving water sample, which is collected and sent to the laboratory for comparative toxicity testing, and provided to Ecology to aid in an invalid or anomalous test determination. Other parameters suggested for monitoring, permit-suggested toxicant identification testing, and required follow-up actions are discussed in Appendix J.

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 Tables 11 and 13.

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 J. These follow-up actions include suggested monitoring for identifying the toxicant if still unknown. An additional parameter, cobalt thiocyanate active substances (CTAS), may be analyzed if the toxicant identity is unknown and nonionic surfactants may be present.

8 Sampling Procedures

This chapter describes the methods and procedures for identifying, organizing, collecting, maintaining, and processing samples, equipment, and data in the field. Any field sampling for this project follows these specific guidelines.

8-1 Storm Event Targeting Procedures

Satellite imagery and model predictions are 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 are evaluated by the Field Lead (or delegate) to determine potential qualifying storm events. As candidate storms approach, radar observations and reports from land-based weather stations are used to track and evaluate storm progress. These land-based weather stations include universities, news organizations, or state and national agencies, and they are accessed through the Internet.

To qualify for permit compliance, the minimum rainfall criterion of 0.15 inch, with a 6-hour antecedent dry period, must be met. Autosamplers and WSDOT field crews may initiate sampling before the minimum rainfall has accumulated so that at least 75 percent of the storm event hydrograph can be sampled.

Only storms forecast with a 75 percent chance of qualifying precipitation amounts and qualifying antecedent dry periods are selected for attempted stormwater sampling. However, storms as low as 50 percent may be selected as needed. Once a storm is determined to be a candidate for measurement, the Field Lead (or delegate) notifies the appropriate staff, including laboratory staff, and initiates mobilization for stormwater sampling as soon as feasible.

Snowmelt and snowmelt accompanied by rainfall are not considered to be qualifying events for the following reasons:

- The build-up and concentration of chemical constituents on snow could represent multiple storm events.
- Snow-removal activities or incomplete melting of snow could alter the amount of precipitation that drains into the stormwater system from a single event.
- Snow-removal activities may concentrate snow in large piles that melt over a long period of time, or remove the snow from the site entirely, which could alter the location and release of contaminants that may be present in the snow.
- The possible alteration of the runoff flow path by snow and ice could mean that the runoff is not representative of the entire site.
- There is difficulty in predicting whether there will be enough melting snow during the storm event to collect a sample from the stormwater system.
- Snow and ice storms themselves present a greater safety hazard to field crews traveling to the sampling location and conducting the sampling.

These factors confound sampling results, making them unrepresentative of a single storm event. Therefore, snowmelt and snowmelt accompanied by rainfall are not monitored.

Storm event targeting procedures and further explanations regarding staff training are documented in the *Standard Operating Procedure and Decision Matrix for Targeting Storm Events* (WSDOT, 2011f). This SOP describes the decision process for identifying and mobilizing for qualifying storm events.

Storm event notification for each monitoring station is sent and recorded using the WSDOT Storm Event Reporting and Forecasting (SERF) database application by the Field Lead or delegate. The daily forecast rainfall summary information and deployment decisions for each monitoring site are saved to a WSDOT database. A diagram of the series of decisions and events for sampling is shown in Figure 16.

Once the sampling decisions have been issued, the Field Lead (or delegate) notifies 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 at or just below the rainfall quantity threshold) not to deploy the sampling team for sampling, and records the justification.

8-2 Pre-Event Preparation Procedures

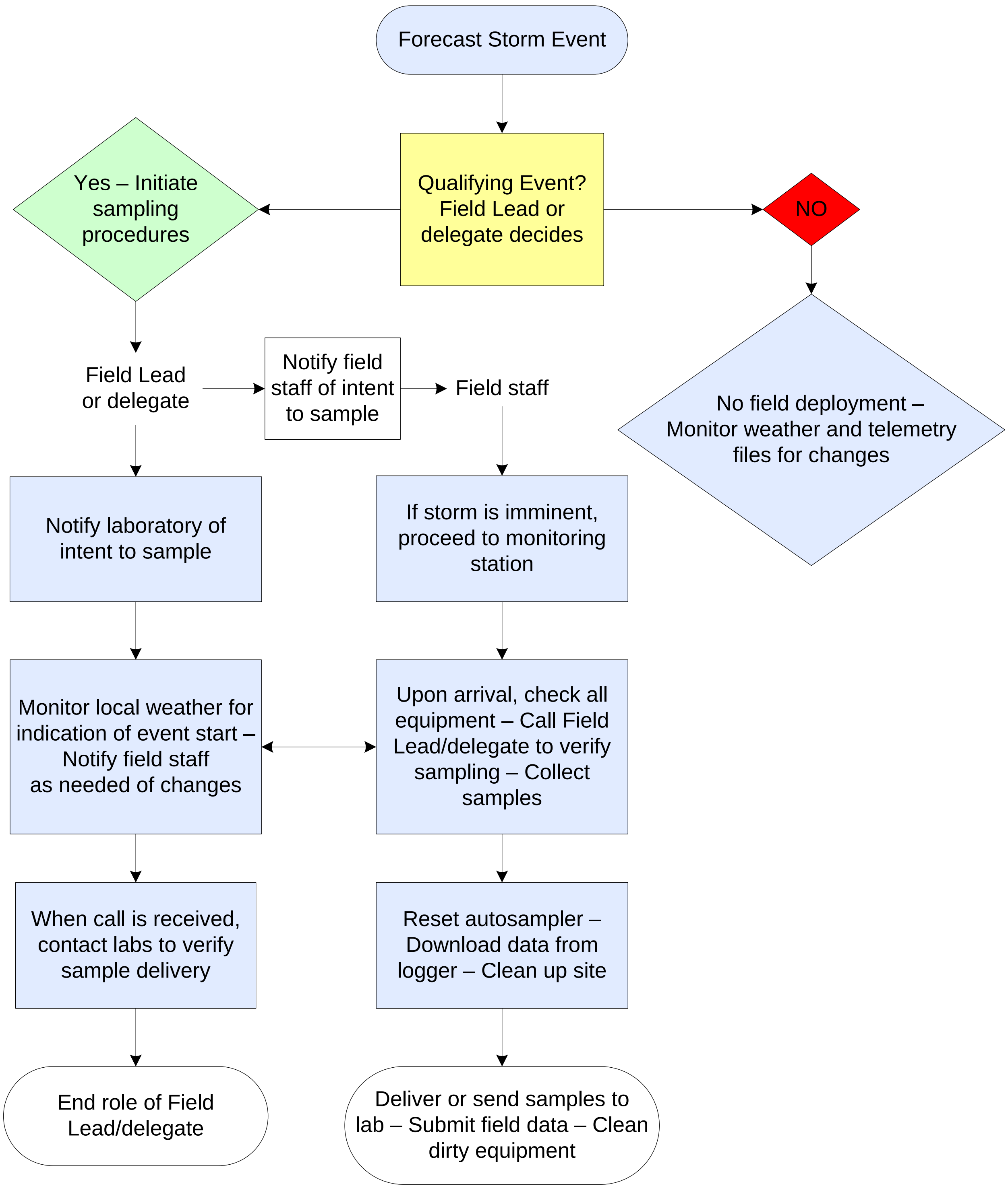


Figure 16 WSDOT sampling procedures flow diagram.

8-2.1 Trip Preparation

When a storm has been categorized as "qualified" by the Field Lead (or delegate), it may be necessary to travel to the site before the rain begins in order to be ready for grab sampling. This may require significant time allocations for commutes or for hotel arrangements prior to storm events in certain areas. Packing lists and trip checklists with detailed instructions are followed. (Example lists are included in Appendix K.) Field staff are responsible for packing all necessary equipment for site maintenance, sampling, and sample shipping prior to deployment. Due to the potential for short-notice storm events, travel vehicles are staged and ready.

Monitoring the telemetered data and weather from a mobile Internet-capable device assists in the timing of field deployment, whether from the office or from a hotel. Deployment timing depends on the predicted level of rainfall and runoff, when field staff can realistically access the site(s) while safely following site traffic control plans (TCPs) and working-hour logistics. After each sampling event, autosamplers are either reset or disabled while waiting for the next sampling event; therefore, crews are prepared to ready the sampler and exchange bottles and equipment as necessary.

8-2.2 Laboratory Notification

The Field Lead (or delegate) notifies the assigned laboratory or laboratories of the intent to sample 72 to 24 hours prior to the submittal of samples. This notice includes which samples are expected to be collected, when samples will arrive at their respective laboratories, and the expected method of transport. If the sampling trip is to collect toxicity samples, the field technician is responsible for notifying the appropriate laboratories 48 hours in advance of the storm event for toxicity testing.

On occasion, laboratory notice may fall outside these times due to the unpredictability of storm events and/or field conditions. Changes to the predicted sampling notification, such as some samples not being collected or a change in delivery date, are sent to the laboratories and involved parties as soon as feasible. The Field Lead (or delegate) is also generally in communication with the laboratory courier or responsible parties for delivering the samples to the laboratory.

8-2.3 Site Preparation

Upon arrival at the monitoring site, field technicians visually inspect sampling equipment activity in progress. If field crews arrive before the storm begins, they:

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

Any alterations are recorded in the field notes.

8-3 Monitoring and Maintenance Procedures

8-3.1 Precipitation Measurement

At each monitoring site, pole-mounted tipping bucket rain gages are installed to represent on-site rainfall. Rain gages are installed in a secure, level fashion where no buildings, trees, overpasses, or other objects obstruct or divert rainfall prior to entering the rain gage. To the best of WSDOT's ability, rain gage placement follows National Weather Service specifications (🖰 http://www.weather.gov/om/coop/standard.htm). Rain gages are calibrated prior to the onset of permit monitoring and are 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 are inspected, cleared of debris, and maintained in accordance with manufacturers' specifications. Rain gage data are downloaded from the data logger for each storm event or during maintenance checks.

8-3.2 Discharge Measurement

Discharge is calculated by the data logger using stage values combined with equations specific to the gaging device (weir or flume). Discharge data are plotted with the rainfall data in a site-specific relationship. V-notch 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 at al, 1982; USEPA, 2002c), though weirs tend to be more influenced by debris than flumes (Church et al., 2003).

- Equations for v-notch (Thel-Mar type) pipe weirs are derived specifically for each weir and are provided by the manufacturer.
- Discharge equations for Parshall flumes are provided by the specific manufacturer and vary based on throat size.

Refer to the USGS Water Supply Paper 2175 (Rantz et al., 1982), the weir manufacturer's specified calibration/conversion sheets (Thel-Mar-type weirs, etc.), and EPA's *Urban Stormwater BMP Performance Monitoring* guidance manual (USEPA, 2002c) for standard flume and weir equations and descriptions of flume and weir applications.

Flow Monitoring Equipment

Pipes are fitted with v-notch Thel-Mar-type removable weirs (as shown in Figure 17) to serve as the primary gaging index for discharge calculation. Thel-Mar-type v-notch weirs were selected to improve the accuracy of stage height readings during lower-flow storm events.

Stormwater sampled by the autosampler is gathered from a collection device that is mounted at the pipe outlet. Grab samples are taken from the end of the pipe when flow is present or from within the PE collector. Peripheral sensors are fitted within a pipe extension (stilling well) before the pipe outlet to measure temperature and stage.

Gas bubblers and/or pressure transducers are installed in the stilling wells behind the weirs and are zeroed to the primary gaging index (weir or flume). These instruments record the stage of water flowing through the weirs and are connected to data loggers to record water level measurements. DC power from solar panels and batteries is used to power these instruments. Stormwater monitoring equipment is housed in protective enclosures near each monitoring site. These enclosures are installed on concrete pads or anchored securely to the ground via driven anchors.

Sample tubing and sensor cables are routed to the enclosures in protective conduit. Routine maintenance and calibration procedures are described in WSDOT's *Standard Operating Procedure for Equipment Maintenance and Cleaning* (WSDOT, 2012).

Figure 17 6-inch Thel-Mar-type v-notch weir (left) and 1-inch throated Parshall flume (right).

8-3.3 Grab Sampling and Portable Meters

Manual collection of stormwater grab samples for total petroleum hydrocarbons (TPH) begins as early in the runoff event as feasible for seasonal first flush toxicity sampling only. Field staff may need to be on site before the storm begins in order to prepare for grab sampling. Grab samples are collected by hand directly into sample bottles following guidance in the *Standard Operating Procedure for Collecting Grab Samples from Stormwater Discharges* (Ecology, 2009c).

Hand-held portable meters are used to measure pH for BMP effectiveness monitoring, and optionally in support of the Biotic Ligand Model during seasonal first flush toxicity testing. Care is taken not to interfere with the autosampler during composite sample collection. Portable meter measurements are collected post-event by testing water in the TSS bottle or from water remaining in the sample carboy after sample collection.

8-3.4 Composited Sample Retrieval

At the end of a targeted storm event, field staff verify whether the event met permit criteria for storm qualification (rainfall quantity and number of aliquots collected over the runoff hydrograph) before determining whether they process or dispose of samples. The autosampler continues refrigerating the samples until field staff are able to recover the sampled stormwater. At the end of a qualifying storm event, data loggers automatically resume their programming and await the next qualifying event.

Field staff wear nitrile gloves at all times during sample collection and follow standard health and safety procedures. Preservation and filtration of samples (if needed) occur as soon as feasible after composited samples have been collected.

Upon completion of sampling, prefabricated labels are filled out and samples are placed in coolers for transport. Sample coolers contain some type of cooling medium, such as ice packs, to ensure temperatures remain below the laboratory-required temperatures for specific parameter analyses. Samples are packed in such a manner as to minimize sample bottle breakage. Chain of custody (COC) forms are filled out completely and sent with the coolers. Appendix M contains examples of the COC forms.

Collection of blanks occurs as scheduled and is included in the transport of coolers.

The autosampler is then inspected, cleaned, restocked, and reprogrammed according to the *Standard Operating Procedure for Field Sampling with Autosamplers* (WSDOT, 2011e) specific to WSDOT's program for field crew training. Ecology's *Standard Operating Procedure for Automatic Sampling for Stormwater Monitoring* (Ecology, 2009b) serves as additional guidance. An important aspect of cleaning and restocking the autosampler is switching the tubing if signs of damage are observed.

8-3.5 Field Filtration

Prefiltration Holding Time

If it is determined that samples need to be processed on site rather than delivered to the lab for processing, staff attempt to filter orthophosphate and dissolved metals in the field within 15 minutes of final aliquot collection. If filtering occurs between 15 minutes and 24 hours, the sample is *J* qualified as an estimate. If filtering occurs after 24 hours for both orthophosphate and the dissolved metals, then the sample is rejected and labeled with an *R* in the electronic data deliverable (EDD) sent by the laboratory. Field sampling efforts, including filtration and other activities, are documented on a field sampling form (see example in Appendix L).

Metals Sample Field Collection/Handling Procedures

A modified version of EPA's "clean hands/dirty hands" protocol for low-level detection of metals (USEPA, 1996) is used as a guideline during sample collection. Accordingly, the laboratory precleans laboratory bottles for metals, as required for the analytical method. WSDOT staff 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 staff put on 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 used during sampling is described in detail as follows:

Dirty Hands (visibly clean gloves):

- Open the cooler with sample bottles
- Remove double-bagged sample bottle from cooler and unseal outer bag
- Remove tubing and churner, which will be double-wrapped in foil
- Remove bagged filtration kit from cooler and unseal bag
- Prepare hand pump
- Program ISCO for sampling
- Use hand pump to filter water through filter kit
- Place filled sample bottles in cooler

Clean Hands (fresh set of gloves):

- Unseal inner bag containing sample bottles
- Remove bottles and unscrew caps
- Remove filter kit from sealed bag
- Remove and hold filter kit lid while filling
- Steady filter kit with clean hand (use a dirty hand to operate hand pump to pump sample water through the filter kit)
- Churn water in bottle while filling filter cup
- Fill sample bottles

8-3.6 Field Sample and Hydrology Verification

Before sending the samples to the laboratory, field staff are required to fill out field sampling forms (see example form in Appendix L). Additionally, field staff verify that the storm event met the permit requirements for storm sampling (rainfall quantity and number of aliquots collected over the runoff hydrograph). However, when in doubt, field staff will send the cooler to the laboratory as soon as possible. The Field Lead (or delegate) will call the laboratory to cancel the analysis if the storm event did not meet permit criteria. Communication between field staff and the Field Lead (or delegate) is critical and requires cellular phones.

Field staff determine the final volume of the sample captured and number of aliquots sampled. If insufficient sample volume is collected for analysis of all parameters, parameters are analyzed according to the priority list of parameters to be measured. Upon shipment of samples to the laboratory, field staff return to the Tumwater headquarters location, or the field station, and submit their field notes and copies of COC forms to the Field Lead for review.

The Field Lead reviews collected storm reports, hydrographs, field notes, COC forms, and maintenance forms for completeness and to determine whether any data quality errors were made. If errors are found, notice is 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.

Hydrology data are reviewed regularly to determine if any drift or gaging errors occurred during the storm event and to ensure at least 75 percent of the storm event hydrograph has been sampled. Potential errors are identified either by field staff during a storm event or through post-storm assessment of the hydro/hyetographs. This data is used to verify that rainfall requirements are being met once samples are collected. The information is also used to verify that stations are operating successfully. A data shift may be applied to a rating if warranted to better fit the runoff hydrograph to actual measurements and account for instrument drift.

8-3.7 Data Collection

Each station's data logger is preprogrammed to continuously collect temperature, stage, and rainfall data, as well as composite samples when threshold requirements are met.

Temperature, rainfall, and stage data are collected and logged every 5 to15 minutes and transmitted via telemetry every hour to the WSDOT hydrology database. Since a large portion of logged data is not transmitted hourly, field staff routinely download the entire data set and transfer the data to the hydrology database. Upon receipt of telemetry transmission or data logger download and transfer to the central database, data are qualified, tabulated, and stored until they are able to be reviewed and finalized by the Data Management and Logistics Lead. The downloaded data logger information serves as the master version and is used for data verification and reporting.

8-3.8 Equipment Maintenance and Cleaning

At a minimum, servicing of scientific instrumentation follows manufacturers' methods and is conducted as needed by trained staff. Generally, maintenance consists of equipment inventories, inspections, testing, and replacement of worn or missing components. Routine site maintenance visits occur every six to eight weeks. Prestorm preparation occurs every other week or prior to a potential storm event, as needed. Refer to the *Standard Operating Procedure for Equipment Maintenance and Cleaning* (WSDOT, 2012) for specifics on instrument cleaning, station visits, and maintenance. For specific equipment maintenance, refer to operators' manuals.

Equipment Decontamination

Stormwater equipment used to collect samples is only used after cleaning in accordance with the procedures below, which are based on EPA guidelines (USEPA, 1992). After drying, equipment is wrapped in aluminum foil and/or stored in polyethylene bags until used in the field. Suction tubing is swapped annually or if contamination is noted via blank sampling or visible observation. All sampling equipment and containers are prepared prior to the sampling event. The autosampler glass carboy, metals and orthophosphate filters, or other materials coming into contact with the sampled stormwater, are decontaminated prior to each use or certified as precleaned from the equipment source.

All equipment to be decontaminated is cleaned by sequentially:

1. Washing in nonphosphate detergent and hot tap water
2. Rinsing with hot tap water
3. Rinsing with 10 percent nitric acid (approximately pH of 2), 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 or hexane (if sampling for organics)
7. Air drying in clean area free of contaminants

8-3.9 Adaptive Management

As increasing experience is gained with monitoring, a process called “adaptive management” is employed for minor or major changes. Relatively small changes to the monitoring program do 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 that differ from those listed in 40 CFR 136, the permit, or this QAPP

9 Measurement Procedures

This chapter describes the laboratory selection process, sample processing procedures, sample labeling and chain of custody, analytical methods, and reporting limits. For monitoring performed under WSDOT's 2009 permit, criteria from the permit, TAPE (Ecology, 2008a) protocols, and 40 CFR 136 (July 1, 2009 revision) are referenced and used as the baseline for the chemical analyses described in this QAPP. The methods and procedures in this QAPP will remain in effect until permit reissuance. Upon permit reissuance in March 2014, criteria from the new permit, most recent versions of TAPE, and 40 CFR 136 will be incorporated into the monitoring program as needed.

9-1 Laboratory Selection

Laboratories were selected by WSDOT based on their 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 may be selected to ensure sample completeness.

Laboratories are required to report analytical results to WSDOT according to contract specifications. Each laboratory provides all sample and quality control data in standardized laboratory reports suitable for evaluating the project data as described in the Laboratory Data Package Deliverables List (Appendix E) and Electronic Data Deliverables Specification (Appendix F). Raw data will be kept at the laboratory for a minimum of five years.

9-1.1 Laboratories

Laboratories selected by WSDOT are accredited and capable of meeting reporting limits and holding times set forth by the permit and 40 CFR 136, unless noted in this QAPP. Appendix G, Table G-1, 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

9-2 Sample Processing Procedure

This section presents the post-storm event sample-processing procedures for stormwater samples.

9-2.1 Sample Amounts and Containers

The samples collected are analyzed for the parameters required by the permit. Parameter-specific sample volumes, holding times, container specifications, and preservation are described in Appendix G, Tables G-8, G-12, G-16, and G-20, for each target parameter. Tables were created from the *Lab Users Manual* (MEL, 2008), Table II of 40 CFR 136.3 (July 1, 2009 revision), and specified methods within the permit. If toxicity is found in stormwater during seasonal first flush toxicity sampling, testing for additional parameters is conducted. Appendix C provides details for this testing.

Sample Volumes

Each autosampler holds a 2.5 gallon/9.5 liter glass carboy to collect composited stormwater for BMP effectiveness samples unless otherwise specified. Sample amounts listed in Appendix G, Tables G-8, G-12, G-16, and G-20, 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 duplicates and replicates are collected according to the established schedule.

Sample Containers

For some samples, commercially available precleaned sample containers are used and the record of certification from the suppliers are maintained. The sample container shipment documentation includes a record of the batch numbers for the precleaned sample containers. With this documentation, containers can be traced to the supplier, and container wash analysis results can be reviewed. For other samples, laboratories clean and reuse sample containers. Containers are cleaned to EPA QA/QC specifications (USEPA, 1992). Precleaned sample containers (bottles and carboys) are used for sampling.

Silicone peristaltic pump tubing is routed through a specially designed Teflon® lined lid to deposit pumped stormwater into the glass carboy. Several parameters are analyzed from the same composite sample; therefore, sample splitting is required. Sample splitting takes place in the lab unless otherwise specified. Conditions or circumstances may require the use of rosettes containing individual bottles, instead of one large bottle.

Processing of Grab and Composite Samples

Parameters that require preservatives or field filtration from the composite and/or grab samples may be processed in the field or at the laboratory. Processing of composited samples consists of homogenizing the bottle’s contents and splitting the composite sample into appropriate precleaned laboratory containers for subsequent analysis.

Sample spitting occurs mainly in the laboratory with an approved sample splitter (Bel-Art churn splitter, Dekaport cone splitter, etc.). Sample splitting may be performed in the field using the automatic sampler head and tubing. Field sample splitting involves replacing the inlet tubing with a precleaned section of tubing and reversing the autosampler pump to fill lab bottles. Contents of the glass carboy are agitated following composite churning guidelines (at least 10 complete churns before pumping the sample) during the reverse pumping purge. Agitation is done by placing the churn splitter through the opening in the glass carboy lid and churning the contents in a controlled, rapid up and down motion, keeping the churner under the water surface to minimize cavitation.

If insufficient sample volume is present to perform churn splitting, the composite sample is agitated-only and poured into the respective sample bottles. If the agitation-only method is used, field staff note each sample collected in this fashion for verification purposes.

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

After the storm event, data collected during the storm is assessed to determine whether the storm qualified according to permit specifications. If the storm event did not qualify, the samples may be discarded. The composite sample bottle (glass carboy) is then recovered from the data collection platform (DCP) and sent to the laboratory for cleaning, in preparation for the next storm event. If the criteria have been met, field crews collect samples from the chilled composite sample carboy and process them as defined in the SOPs and reference documents (Ecology, 2009b; WSDOT, 2011e). Regardless of storm event qualification, all glass carboys that have come into contact with sample water or have been exposed to potential contamination are replaced with laboratory-cleaned carboys in the automatic composite samplers.

Sample Preservation

Some of the parameters being analyzed (TP, metals, hardness, and others) require chemical preservation to maintain the integrity of the samples and prevent them from degrading prior to laboratory analysis. If preservation is required, the laboratory includes the appropriate preservation chemical in sample bottles. Filtration is required before preservation for orthophosphate and dissolved metals and is conducted as specified in this QAPP.

When field processing occurs, samples for orthophosphate and dissolved metals are filtered through a disposable 0.45 µm glass fiber filter using vacuum pressure created by a peristaltic or hand pump. Prior to filtering the sample, a small amount of sample water is rinsed through the filter and container. After rinsing and discarding, the filter kit is filled with sample water and filtered following a “modified clean hands-dirty hands” procedure. Filtered samples are distributed into the laboratory sample bottles. Disposable filter set-ups are used for each sampling event and discarded after use.

Sample cooling 4º to 6ºC or less, but not freezing, is necessary for the preservation of most of the parameters to be analyzed. Collected samples are transferred from the field station to the lab in a chilled cooler to maintain temperature requirements.

Sample Holding Times

Holding times are the maximum allowable length of time between sample collection and laboratory manipulation. The holding time for parameters collected by the autosampler is 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 is packaged in an appropriate container and labeled by field staff. Accompanying forms are completed, and the samples are shipped or delivered to the appropriate labs according to holding time limitations. If holding times cannot be met, the sample may be discarded or flagged accordingly. Data are recorded and sent to the Field Lead for review. Refer to Appendix G, Tables G-8, G-12, G-16, and G-20, for sample holding times.

If necessary, the Field Lead (or delegate) coordinates with the analytical laboratory to ensure samples can be transported, received, and processed during nonbusiness hours. Sample containers are 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

To ensure proper handling, composite bottle lids are labeled to identify sampling point locations. If samples are processed in the field, staff use bottle labels to identify sample locations and the parameters in the sample bottles that need to be analyzed. Labels are attached to the surface of the sample bottles prior to sampling, and tags with duplicate information are tied to the neck of the bottles after obtaining samples. Laboratory-prepared bottles are labeled to identify the cleanliness and/or preservative contents for each bottle. Labels are prepopulated to the extent possible, but may be edited and completed in the field. Labels are completed in pencil or permanent pen and placed on sample containers. Sample labels contain the following information, which is also written on the chain of custody forms (see below):

1. Station name/identification
2. Analysis to be performed
3. Date and time of sampling
4. Sample ID or coding information
5. Preferred collection order with regard to other parameters
6. Sample numbers (1 of 3, 2 of 3, etc.)
7. Name/initials of field tech performing the sampling
8. Name of contact person for data issues (Data Management and Logistics Lead)

9-3.2 Chain of Custody

Chain of custody (COC) can be defined as a systematic procedure for tracking a sample or datum. 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 (see Appendix M) accompanies each composite bottle or sampling cooler. Individuals who manipulate or handle samples are required to log their activities on the form. Definitions of custody from the *Lab 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 samples, it assumes responsibility for samples and maintenance of the COC forms. The laboratory then conducts 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

The selected parameters, analytical methods, and reporting limits are listed in Appendix G.

9-4.2 Laboratory Instrumentation

Maintenance of laboratory equipment is required to be conducted in a manner specified by the manufacturer or by the quality assurance guidelines established by the chosen laboratory. Instrumentation maintenance and service records are to meet or exceed manufacturers' specifications.

10 Quality Control Procedures

This chapter discusses quality control (QC) procedures implemented to provide data of known quality that meet the requirements of the WSDOT permit. Quality control procedures encompass field collection and laboratory processing for collected samples. These procedures are monitored throughout the duration of the study. The quality of raw, unprocessed, and processed data is subject to review using established protocols in Section 5-2, Measurement Quality Objectives.

10-1 Field Quality Control Procedures

10-1.1 Standard Operating Procedures (SOPs)

Standard operating procedures (SOPs) (listed in Table 14) are followed in the field to ensure quality control for field sampling; equipment maintenance; documentation; sample collection; blank, duplicate, or replicate sample collection; and appropriate action for correcting and documenting potential field errors. The quality control schedule for monitoring is shown in Table 15. To ensure the quality and consistency of sample collections, equipment maintenance and sample collection SOPs are followed by all staff conducting these procedures. Future SOPs or SOP addenda may be added as new methods, procedures, and technologies improve to supplement this list and improve the quality of data collection.

Table 14 Standard Operating Procedures.

SOPs Published by Ecology
ECY001 – Collecting Grab Samples from Stormwater Discharges (Ecology, 2009c)
ECY002 – Automatic Sampling for Stormwater Monitoring (Ecology, 2009b)
ECY004 – Calculating Pollutant Loads for Stormwater Discharges (Ecology, 2009d)
EAP029 – Metals Sampling (Ecology, 2010b)
SOPs Developed by WSDOT
Equipment Maintenance and Cleaning (WSDOT, 2012)
Decision Matrix for Targeting Storm Events (WSDOT, 2011f)
Field Sampling with Autosamplers (WSDOT, 2011e)
Using Portable Meters (WSDOT, 2011d)

10-1.2 Field Instrument Quality Control

In order to maintain data quality, field equipment undergoes routine cleaning, calibrations, and maintenance at the recommended frequency specified by each manufacturer.

10-1.3 Documentation

Field data sheets are printed on Rite-in-the-Rain® water-resistant forms or recorded in weather-resistant tablet PCs to allow ease of use during storm events. Forms and documentation include station visit/maintenance sheets, COC forms, and weather qualification reports (see Appendices K, L, and M for examples of field forms). All entries on paper field documents are made in pencil or permanent pen and list the appropriate information as specified in the SOP.

Field staff submit completed forms to the Field Lead or a member of the field team who did not participate in completing the form. The Field Lead (or an alternate field team member) preliminarily reviews the document for errors and completeness. Any preliminary errors are crossed out and rewritten. All corrections are initialed and dated when made. Field documents are then submitted to data management staff for a more detailed verification.

Once completed field forms are submitted, data management staff verify information on the forms against data in WSDOT's hydrologic database. The reviewer checks for discrepancies in sample start/end and duration times, number of aliquots collected, and any potential disqualifiers to the validity of generated data and field forms. After verifying all information to be complete, data management staff digitize, name, and submit field forms to WSDOT's central filing location.

If field sampling or procedural errors are discovered, action is taken to manage and correct those errors. Corrections may occur via 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 B and J for guidance on corrective and follow-up actions for seasonal first flush toxicity sampling.

10-1.4 Composite Field Duplicate/Grab Field Replicate Samples

Composited field duplicate samples are collected at a rate of 10 percent of the total samples collected each water year. Field duplicates are collected by splitting composited samples. If a storm produces heavy runoff, excess volume may be programmed into data loggers to provide enough sample volume for field duplicates. A schedule is maintained so that field crews know when to collect field duplicate samples at each site. Parameters measured in the field sample are also measured in the duplicate sample for a particular storm event.

Grab field replicates are collected following a schedule similar to the composited field duplicates, 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 are also collected at a rate of 10 percent of the total samples.

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

The sampling schedule may be adjusted to meet the field duplicate and replicate frequencies early in the fall/winter sampling season to prepare for a dry spring/summer season. The Field Lead and data management team continually manage field duplicate and replicate collections to achieve the 10 percent goal, and communicate with the field crews so they know when field duplicates and/or replicates should be collected.

10-1.5 Field Blanks

Field blanks include equipment rinsate blanks, transport blanks, and transfer blanks. These terms are defined in the Glossary. Field blanks are used to determine whether contamination occurred during sampling. All blank samples are submitted blind to laboratories for analysis. Blank collection is scheduled to occur soon after a preceding sampled storm event, with the purpose of accurately representing potential contamination associated with previous sampling.

Equipment rinsate blanks are collected at all sites once each water year. Equipment rinsate blanks consist of laboratory-supplied, contaminant-free water that is run through the autosampler system into a clean sample bottle. Specifically, the autosampler pump pulls deionized water from the area of usual sample water collection, through the sample tubing system, and into the composite sample carboy. Staff then collect samples from the carboy using normal sampling procedures and clean sampling equipment. After blank samples are collected, staff replace used polyethylene sample tubing, which delivered sample water to the autosampler, with clean polyethylene tubing. For grab samples, staff collect transfer blanks using site-specific methods by either manually pouring or using a bailer to collect deionized water and transfer it into clean grab sample bottles.

Additional field blanks are collected if sample procedures or site conditions change. Blanks may also be collected during field self-assessments to ensure procedures to reduce contamination are followed. Field blanks accompany field samples sent to the laboratory.

If contamination is discovered, additional field blanks are used to determine the source of the contamination. Field blanks collected to determine the contamination source may include:

- A *tubing equipment blank* collected after an autosampler's Teflon® tubing is replaced to determine whether contamination is from the tubing.
- A *filter blank* collected from the filtration apparatus used to filter metals and orthophosphate.
- A *transfer blank* collected by pouring laboratory-provided deionized water into a clean sample bottle to determine whether field contamination is present and unrelated to the equipment.
- A *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.

If contamination is detected in field blanks, the Quality Assurance Officer or member of the data management team determines whether samples collected with the field blanks should be qualified. If sample results are less than or equal to five times contamination levels found in the field blanks, it is assumed that contamination in the sampling system may have strongly biased the sample results. These results are flagged with a *J* and qualified as an estimate.

A schedule of storm events with planned field duplicates and replicates, blanks, or other QC samples is maintained and followed as part of the stormwater sampling program. Information from Table 15 is used to develop the schedule.

Table 15 Field quality control schedule.*

Field Sample Collected	Frequency[2]	Control Limit	Corrective Action
Composited field duplicate	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	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 of the permit.
[2] Frequencies will be maintained for the monitoring program in its entirety.

*The table is based in part on an EPA QA and SOP website (USEPA, 2014).

10-2 Laboratory Quality Control Procedures

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

Laboratory QC procedures and results are closely monitored throughout the duration of the permit-mandated sampling. For guidance on seasonal first flush toxicity quality control procedures, refer to Appendices B and J. The quality of laboratory data is subject to review via the established protocols in Section 5-2, Measurement Quality Objectives.

The schedule for laboratory QC samples is shown in Table 16 and at a minimum includes:

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

Table 16 Laboratory quality control schedule.

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% (sediment)	
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 and 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.

10-2.1 Laboratory Instrument Calibration

Laboratory instrumentation meets or exceeds manufacturers' specifications for use and maintenance. Equipment maintenance is conducted in a manner specified by the manufacturer or by the QA guidelines established by the chosen laboratory.

10-2.2 Laboratory Duplicate/Splits

Laboratory duplicate samples are to be analyzed regularly to verify that the laboratory's analytical methods maintain their precision. Laboratories perform random duplicate selection on submitted samples that meet volume requirements. After a sample is randomly selected, the laboratory homogenizes the sample and divides it into two identical split samples. To verify method precision, identical analyses of lab splits are 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) that are spiked in the laboratory with method-specific target analytes, and then analyzed under the same conditions as the field samples. 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 are prepared and analyzed at a rate of one pair for every 20 samples (five percent) collected, or one pair for each analytical batch, whichever is most frequent. (Batch matrix spikes may be performed on other samples not related to this monitoring effort.) The ms/msd samples are 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, and 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 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 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 accompany the field samples through analysis.

Instrument Blank

An instrument blank is used to "zero" analytical equipment used in the laboratory's methods. Instrument blanks usually consist of reagent-grade deionized water and any other method-appropriate reagents.

11 Data Management Procedures

WSDOT's stormwater monitoring program collects and manages data from three sources: telemetered instrument data, field observations and measurements, and laboratory analysis of field samples. All data are managed and stored by WSDOT. Relevant post-processed data are finalized and incorporated into annual reports and electronic reports. Reports and data are submitted to Ecology in the format required by the permit.

11-1 Telemetered Data Management

Telemetered data are transmitted from each station hourly and are managed by WSDOT and stored in a database. Telemetered data are verified internally and augmented with data downloaded from the data logger to fill any potential data gaps. Telemetered data verification activities include:

- Identifying inconsistencies such as excessive dry, wet, warm, or cold periods that do not match observed conditions;
- Measurements in conflict with other nearby rain gage readings and any measurements that appear unrealistic and out of the norm; and
- Manual download of data from the data logger during each site maintenance visit, which occur every six to eight weeks.

11-2 Field Data Management

Field checklists and forms are completed in the field during sampling and maintenance visits. All documentation is verified internally and reviewed for completeness and identification of potential errors. Documents are organized and stored in the appropriate central storage, which is determined by the WSDOT Data Management and Logistics Lead.

Data downloaded from the field data loggers are uploaded to a centralized dedicated location at WSDOT. After uploading data, field staff send the data management team an email that the data have been moved to the storage folder for processing. The data management team imports, verifies, and processes those data via WSDOT's database.

11-3 Laboratory Data

Finalized analytical data are sent to WSDOT from each laboratory. Laboratory reporting times must adhere to contract terms. Data are submitted as an electronic data deliverable (EDD) (see Appendix F), as well as a hardcopy or PDF report. Hardcopies or PDFs are mailed or emailed to the Data Management and Logistics Lead (or delegate) at WSDOT. Initial verification by the data management team is performed to identify errors or missing data and is reported to the responsible laboratory for amendment or correction. Finalized laboratory reports are independently reviewed and validated by contracted data validators. Validated electronic analytical data are incorporated into WSDOT's database, while hard copy data sheets and reports are filed in WSDOT's central data storage.

The toxicity data submitted to WSDOT by the labs are formatted for Ecology's Comprehensive Environmental Toxicity Information System™ (CETIS) database.

11-4 Self-Assessment and Audits

Self-assessment and audits are conducted to ensure this QAPP is being implemented correctly and the quality of data is acceptable. A review of procedures implemented in the field, laboratory, or by contractors may be conducted annually. If quality assurance (QA) issues are identified during self-assessment and audit processes, corrective actions are implemented, as necessary. The sections below summarize steps to be carried out in connection with these activities.

Self-assessment and audits may include, but are not limited to, workflow and specific procedural review, field visits, laboratory visits, technical oversight, inspection, data quality assessment, and contract performance review. Audits of the analytical laboratories or other contractors adhere to specifications in contract agreements.

During self-assessment and/or audits, the following may be reviewed and confirmed:

- Sampling locations were correctly sampled.
- There is documentation of monitoring site visits, with chain of custody or maintenance forms.
- Standard operating procedures (SOPs) were followed.
- Analytical methods were followed.
- Contract terms were adhered to.
- There is proper identification, assessment, and correction of deficiencies and nonconformances.

11-5 Deficiencies, Nonconformances, and Corrective Action

Deficiencies are defined herein as unauthorized deviations from procedures documented in the QAPP, SOPs, or other WSDOT guidance, as well as deviations from contract terms. Incidents of nonconformance are deficiencies that severely affect the data quality and render it unacceptable or indeterminate. Deficiencies may include, but are not limited to: incomplete or lost documentation associated with field sampling and analytical work; instrument malfunctions or miscalibration; blanks contamination; quality control sample failures within the allotted time for collection; and any non-agreed-upon deviations from contract terms.

Verification activities are performed to detect potential deficiencies in the telemetered data collected for this project. Data downloaded directly from the data loggers are compared with telemetered data to identify potential quality assurance (QA) issues. This includes, but is not limited to, an examination of the data record for gaps, anomalies, or inconsistencies among the precipitation data from automated monitoring stations.

Any data generated from calibration checks that were performed at a particular monitoring station are also 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 reviews, a site visit is performed immediately to troubleshoot the problem and to implement corrective actions. Any QA issues detected through these reviews are documented in the electronic data record. For specific deficiencies, anomalous data, or corrective action relating to seasonal first flush toxicity sampling, refer to Appendix C for more details.

Analytical data validation follows criteria contained in Appendix G, Tables G-5, G-9, G-13,and G-17, to ensure all data are consistent, correct, and complete, as well as assign final analytical data usability qualifiers. Results of analytical data validation are documented in QA worksheets for each batch of samples. Final EDDs, containing the validated data set, are then uploaded to WSDOT's database. If QA issues are identified, the data management team or Quality Assurance Officer determines whether response actions are required. Response actions 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 defined in Appendix G, Tables G-5, G-9, G-13, and G-17.

Deficiencies detected throughout data management activities are documented in accordance with the procedures identified above. The Quality Assurance Officer, in consultation with the Project Manager, determines whether the deficiency constitutes a nonconformance. If it is determined that a nonconformance exists, the Quality Assurance Officer decides the disposition of the nonconforming data and any necessary corrective action(s). All deficiencies, nonconformances, and corrective actions are documented in annual monitoring reports for the project.

12 Data Verification, Validation, and Usability

12-1 Data Verification

Data verification refers to the process of data review that occurs throughout the data collection process. Data verification is defined by Kammin (2010) as:

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

WSDOT stormwater monitoring staff implement data verification processes. Field data inputs, completed chain of custody (COCs) forms, laboratory reports, bench sheets, certifications, and process documentation are reviewed to see whether they met requirements. If poor data quality trends or significant problems are identified, corrective action(s) are implemented to improve the data quality.

Verification procedure documentation provides WSDOT a data assessment toolbox and programmatic approach to ensure quality goals. Initial data verification focuses on reviewing data records, laboratory reports, field reports, and COCs. This review also looks at qualified or flagged analytical data and evaluates their impact on the overall data quality objectives. If the analytical data do not meet the statistical data review criteria, then the analytical result is not included in the data analysis. The preliminary review may incorporate the statistical review methods described later in this section. 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, 2002b).

Any changes to the results as originally reported by the laboratory are either accompanied by a note of explanation from the data verifier or 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

Data analysis includes calculating the permit-required (S.7.E.4.b) mean and median effluent concentrations and percent removals. The permit specifies that the statistical goals are to meet 75–80 percent power with 90–95 percent confidence for the parameters for which the BMP is approved in the *Highway Runoff Manual* (HRM).

A statistical data review is conducted to identify outliers and other abnormalities in the data. Outliers or data that are anomalous with the entire data set are analyzed for their causative agent, and require review of data collection, laboratory analysis, data input and recording, quality assurance and quality control (QA/QC), and data verification.

The data are plotted to identify additional outliers or confirm outliers and abnormal data. Outlying data are 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 are not included in the data analysis.

Data analyses are performed to evaluate the water quality treatment performance of each of the monitored BMPs following procedures identified by Ecology's Technology Assessment Protocol (TAPE) and the Environmental Protection Agency (EPA) in *Urban Stormwater BMP Performance Monitoring: A Guidance Manual for Meeting the National Stormwater BMP Database Requirements* (USEPA, 2002c). The specific procedures that are used in these analyses are:

- Statistical analyses to compare influent and effluent concentrations and loads.
- Calculations of pollutant-removal efficiency.
- Statistical analyses to determine the power and confidence of percent removals.
- Calculations of "achievable" and "relative" pollutant-removal efficiency.
- Calculations of pollutant-removal efficiency based on regression of influent and effluent pollutant loads.
- Comparisons of the cumulative probability distribution for influent and effluent pollutant concentrations and loads.

12-1.2 Nondetects

Nondetected analytical data results are addressed through use of statistical methods commonly agreed upon by the group of Phase I permittees. The Ecology *Standard Operating Procedure for Calculating Pollutant Loads from Stormwater* (Ecology, 2009d) includes instructions for evaluating nondetect data with a summary and comparison of the following acceptable methods: Substitution Half-U, Maximum Likelihood Estimation, Regression on Order Statistics, Robust Regression on Order Statistics, or Kaplan Meier (Non-parametric).

12-2 Data Validation

Data validation goes beyond data verification to examine the data for usability. Validation is defined by Kammin (2010) 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 data set.*

Ecology considers the following three key criteria to determine whether analytical data validation has actually occurred: use of raw or instrument data for evaluation, use of third-party assessors, and use of EPA's *National Functional Guidelines* 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 are useable for project objectives. This statement of usability (or Usability Statement) 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 is 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 are identified and their impacts on the data assessed in each annual Stormwater Monitoring Report.

Two main aspects of the Usability Statement are: (1) determining if the sampled stormwater runoff is representative, and (2) ensuring sample results met the storm and sample criteria.

13 Reports

In accordance with the schedule presented in Chapter 4, Organization and Schedule, four types of reports are generated in relation to the Stormwater Monitoring Program's activities covered by this QAPP. Table 17 outlines the monitoring report requirements as stated in the permit for each report. Data sets required to be submitted to Ecology are in Excel format and included in the reports as tables or data summaries. All required reports are submitted to Ecology in both paper and electronic formats. The reports due are as follows:

1. Stormwater Monitoring Status Report (due October 31 of 2010-2012).
2. Report for Stormwater Treatment and Hydrologic Management Best Management Practice (BMP) Evaluation Monitoring (due October 31, 2013, and annually thereafter).
3. Final Water Quality Monitoring Report (due March 6, 2014).
4. Final BMP Effectiveness Technical Evaluation Report (due when statistical goals are met, as specified by Ecology's 2008 TAPE Protocols).

13-1 Stormwater Monitoring Status Report

For the reports submitted in 2010, 2011, and 2012, reporting requirements included the status of preparations to meet requirements in S7.A through S7.E of the permit, which were included in the annual *NPDES Municipal Stormwater Permit Annual Report*. In October 2013, a separate *Report for Stormwater Treatment and Hydrologic Management Best Management Practice (BMP) Evaluation Monitoring* was submitted to Ecology. All required reports are submitted in both paper and electronic formats.

13-2 Report for Stormwater Treatment and Hydrologic Management Best Management Practice Evaluation Monitoring

The annual detailed data report for *Stormwater Treatment and Hydrologic Management Best Management Practice Evaluation Monitoring* (submitted October 2013) includes information specified by S7.E.7, S7.C.8, and S8.F of the permit. Table 17 outlines the detailed monitoring data report requirements as stated in the permit. Data sets required to be submitted to Ecology will be in Excel format and included in the reports as tables or data summaries. The following subsections 13-2.1 to 13-2.3 describe further details about supporting data collection and reporting efforts for BMP effectiveness monitoring.

Table 17 Requirements for the annual Stormwater Treatment and Hydrologic Management Best Management Practice Evaluation Monitoring Reports beginning October 2013 (Ecology, 2008a and b; Ecology, 2009a).

Category	Source	Reporting Requirement
Each Sampling Event from Each Site	Permit Section S7.E.7	Sample event identification (date, time, and location).
		Tabular water quality data and summary results for each monitored parameter.
		Antecedent dry period, inter-event period, and total precipitation quantity.
		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.
Each Site	Permit Section S7.E.8	Status of implementing the monitoring program and a description of Stormwater Treatment and Hydrologic Management BMP Evaluation Monitoring programs still in progress at the end of the reporting year.
		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.
		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.
		Status of performance data concerning flow reduction performance for the hydrologic reduction BMP.
		Any proposed changes to the monitoring program that could affect future data results.
First Flush Toxicity Sampling Event	Permit Section S7.C.8	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,[1] *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] Ecology, 2008b.

13-2.1 Field Notes

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

- Station name
- 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 and type of grab/composite samples taken
- Records of the order of sample collection
- Maintenance activity logs
- Maintenance inspection field sheets

13-2.2 Event Records

Records of the storm event are 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

13-2.3 TAPE and National Stormwater BMP Database Requirements

S7.E.4 of the permit requires use of Ecology's 2008 *Guidance for Evaluating Emerging Stormwater Treatment Technologies, Technology Assessment Protocol – Ecology* (TAPE) for preparing, implementing, and reporting the results of the BMP evaluation program, as well as a collection of data pertinent to fulfilling the National Stormwater BMP database requirements outlined in Section 3.4.3 of EPA's manual *Urban Stormwater BMP Performance Monitoring* (USEPA, 2002c).

For specific data and reporting requirements, access Ecology's website (https://fortress.wa.gov/ecy/publications/summarypages/0210037.html) and USEPA's downloadable spreadsheet, where all data fields can be found under Final Stormwater BMP Database Data Entry Spreadsheets (http://www.bmpdatabase.org/data-entry.html).

13-3 Final Water Quality Monitoring Report

A Water Quality Monitoring Report was due March 6, 2014. It included a complete discussion of each monitoring program outlined in S7 and S8.F of the permit. The report was required to include the following items:

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

13-4 Final BMP Effectiveness Technical Evaluation Report

A final BMP Effectiveness Technical Evaluation Report on each BMP monitored shall be submitted once the monitoring statistical goals, as specified in Ecology's 2008 TAPE protocols, 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 2008 TAPE protocols (see Section 13-2.3 for Ecology's website).

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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).

audit – A systematic and independent examination to determine whether quality activities and related results comply with planned arrangements and whether these arrangements are implemented effectively and are suitable to achieve objectives (USEPA, 2000 & 2002a).

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) (Ecology, 2004; Kammin, 2010).

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 (Ecology, 2004; Kammin, 2010).

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 (Ecology, 2004; Kammin, 2010).

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, 2002b). 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 (Ecology, 2004; Kammin, 2010).

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, 2002b). 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 (split 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) – 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).

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, 2014).

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) (USEPA, 2012).

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 (Ecology, 2004; Kammin, 2010).

Pavement Edge (PE) collector – A 6-inch HDPE pipe or similar device that is set up to concentrate runoff from an impervious roadway. PE collectors act as conveyance systems for stormwater from the road surface to pass through a flow measurement device and allow for composite sampling.

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) (USEPA, 2004).

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 (Ecology, 2004; Kammin, 2010).

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 independently collected 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) (USEPA, 2010a).

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).

self-assessment – The assessments of work conducted by individuals, groups, or organizations directly responsible for overseeing and/or performing the work (USEPA, 2002b).

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, 2011a).

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/Abbreviations and Units of Measurement

Acronyms	Abbreviations
%D	percent difference
$\%D_f$	percent drift
%R	percent recovery
%RI	percent relative intensity
%RSD	percent relative standard deviation
%S	percent solids
40 CFR	Title 40 of the Code of Federal Regulations
AADT	annual average daily traffic
AMU	atomic mass unit
BMP	best management practice
B/N	base and neutral compound
CB	catch basin
CCAL	continuing calibration
CCB	continuing calibration blanks
CCV	continuing calibration verification
CFR	Code of Federal Regulations
CL	control limit
CLP	contract laboratory program
COC	chain of custody
CRA	reporting limit check sample analysis
CTAS	cobalt thiocyanate active substance
CWA	Clean Water Act
DCP	data collection platform
DFTPP	Decafluorotripheylphosphine
DOC	dissolved organic carbon
DQI	data quality indicator
DQO	data quality objective
Dup	laboratory duplicate
EAP	Environmental Assessment Program
Ecology	Washington State Department of Ecology
EIM	Environmental Information Management database
EMC	event mean concentration
EPA	U.S. Environmental Protection Agency
et al.	and others
GC/MS	gas chromatography coupling with mass spectrometry
HPLC/MS	high performance liquid chromatography with mass spectrometry
HRM	*Highway Runoff Manual*
HT	holding time
ICAL	initial calibration
ICB	initial calibration blanks
ICP	inductively coupled plasma
ICP/AES	inductively coupled plasma-atomic emission spectrometry
ICP/MS	inductively coupled plasma-mass spectrometry
ICS	interference check sample

Acronyms	Abbreviations
ICSA	interference check sample solution A
ICSAB	interference check sample solution AB
ICV	initial calibration verification
IDL	instrument detection limit
LCL	lower control limit
LCS	laboratory control sample
LCSD	laboratory control sample duplicate
LID	low-impact development
MBAS	methylene blue active substance
MDL	method detection limit
MEL	Washington State Department of Ecology, Manchester Environmental Laboratory
MQO	measurement quality objective
MS	matrix spike
MSD	matrix spike duplicate
MS4	municipal separate storm sewer system
N/A	not applicable
NB	Northbound
NewFields	NewFields Northwest, LLC
n/m	narrow mouth
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NWS	National Weather Service
OP	*ortho*-phosphate
OWS	oil and water separator
PAHs	polycyclic aromatic hydrocarbons
PASP	pre-activity safety plan
PE	pavement edge
PPE	personal protective equipment
PS	post-digestion spike
PSD	particle size distribution
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
QL	quantitation limit
r	correlation coefficient
r^2	coefficient of determination
RF	response factor
RL	reporting limit
RPD	relative percent difference
RRF	relative response factor
RRT	relative retention time
RSD	relative standard deviation
RT	retention time
RTW	retention time window
RV	recreational vehicle
SB	Southbound
SDG	sample delivery group

Acronyms	Abbreviations
SIM	selective ion monitoring
SOP	standard operating procedure
SRM	standard reference material
Surr.	surrogate spike compound
SWMP	Stormwater Management Program
SWPPP	Stormwater Pollution Prevention Plan
TAPE	Guidance for Evaluating Emerging Stormwater Treatment Technologies, Technology Assessment Protocol – Ecology, 2008a
TCE	Trichloroethane
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 hydrocarbon
TSS	total suspended solids
UCL	upper control limit
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WAC	Washington Administrative Code
w/m	wide mouth
WQP	Water Quality Program
WSDOT	Washington State Department of Transportation
Units of Measurement	
°C	degrees centigrade
CFU/100mL	colony forming units per 100 milliliters
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
µg/Kg	micrograms per kilogram (parts per billion)
µg/L	micrograms per liter (parts per billion)
µm	micrometer
µS/cm	microsiemens per centimeter
oz	ounce

Appendix B: Section 7 A-E of the 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*:

   1. Sample event identification (date, time, location)
   2. Tabular water quality data and summary results for each monitored parameter;
   3. Antecedent dry period, enter-event period and total precipitation depth;
   4. 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 from the Permit

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	HNO3
Metals: Dissolved Cu, Zn, Cd, Pb	350 ml	500 ml Teflon, polyethylene, polycarbonate or polypropylene	6 months	Filter[1], the HNO3
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	H2SO4
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.

Laboratory Testing Procedures and Quality Assurance

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)

Test Organism: *Hyalella azteca*

Test Chamber: 250 - 500 mL

Volume: 100 - 250 mL

Reps: 4

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

Substrate: square of nitex screen

animals per rep: 10

Age: 7 - 14 days, 1 - 2 day range in age

Feeding: Feed ground cereal leaf prior to testing. No feeding during testing.

Temperature: 23 degrees

Aeration: if below 4.0 mg/L

Light: 16/8

Test Acceptability Criteria: ≥ 90% survival in control

Control and Dilution Water: moderately hard synthetic water

Hardness Modification: 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).

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

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.

Additional Resources/References for Toxicity Sampling

- Ecology's Laboratory Guidance and Whole Effluent Toxicity Test Review Criteria, June 2008b: http://www.ecy.wa.gov/biblio/9580.html
- 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 and Pre-Activity Safety Plan

Traffic Control Safety Guidelines

All WSDOT personnel and contracted individuals will follow the safety 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 reviewing the detailed pre-activity safety plan and completing a Daily PASP for stormwater field work before setting up the work zone. An example PASP and Daily PASP is displayed on the following pages 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 not 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:______________________________		☐ Hard Hat
Phone #: (____) _____ - _________	**Pre-Travel Checklist**	☐ Eye Protection
Location: SR_____MP_____ County _______________	☐ Environmental Safety Hazard Assessment and Mitigation Booklet	☐ Gloves
Nearest Medical Facility: _____________________ Map Attached	☐ Washington State Hospital List	☐ Work Boots
Traffic Control Needed	☐ Pre-Trip Vehicle Inspection and Familiarization	☐ Hearing Protection
Check-in Person :________________________	☐ 1st Aid Kit	☐ Hip Boots or waders
Remote Location?	☐ Flares/Triangles/Signs	☐ PFD
Cell Phone Service Phone Available	☐ Emergency Contact Phone List	☐ Throw rope bag
Scan Calling Card	☐ Beacons/signage/traffic cones available in vehicle	☐ Sun block
First Aid planning***	☐ Check SR View for parking possibilities (http://www.srview.wsdot.wa.gov/home.htm)	☐ Insect repellent
Known conditions/allergy medication available?		☐ Other:_________
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*. M54-44 is available at http://www.wsdot.wa.gov/publications/manuals/m54-44.htm

*** The PASPs 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
1. Machete	1. Wear PPE (gloves, boots, heavy clothing, and eye protection); keep hands dry, rest as needed.		□ Gloves, boots, heavy clothing, eye protection
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 □ Yes □ No	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
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 with Stormwater chemicals? □ Yes □ No	1. Review MSDS forms for chemicals in cooler. - Wear appropriate PPEs as specified in MSDS form for each chemical. 2. Know where appropriate spill or burn response kits are located and be familiar with their operation. 3. Handle chemicals appropriately as specified in MSDS. - Practice safe and careful handling of sampling containers that contain chemicals.		□ Nitrile Gloves □ Eye protection □ Protective clothing (if needed)
14. 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
15a. 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:** ≥89^0 for light clothing; ≥77^0 for heavier clothes (jacket, sweatshirt, coveralls, etc.); and ≥52^0 for non-breathing clothes (vapor barrier clothing or chemical resistant suits)	□ Two people on site □ Radios □ Hat, sunscreen

15b. 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
16. Bridge Work □ Yes □ No	1. Reference controls for: -Walking over uneven terrain -Working around a stream -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.		□ Hard hat
17. 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***		
18. 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
19. 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
20. 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

* WAC 296-155 is available at: http://app.leg.wa.gov/WAC/default.aspx?cite=296-155

** 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, 2009)

Short Duration Work Zone 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: Laboratory Data Package Deliverables List, Version 1.1

Laboratory Data Package Deliverables List

A. Introduction

This document presents deliverable requirements for laboratory reports submitted by analytical laboratories in support of the Washington State Department of Transportation (WSDOT) Stormwater Monitoring Program (Program). To ensure all laboratory reports submitted for the Program are legally defensible and technically sound, these requirements have been developed, in general, following United States Environmental Protection Agency (EPA) protocols (EPA 2009, EPA 2010 & 2012) with modifications to be consistent with current industry standard practices. The following sections specify general requirements that apply to each laboratory report and specific reporting parameters required for various types of analytical methodologies (i.e., organic analyses, metals analysis, and conventional chemical parameters).

B. General Requirements

The following requirements apply to laboratory reports at all deliverable levels (i.e., levels 2a, 2b, 3, and 4, as defined in EPA 2009; for its purposes, WSDOT has combined EPA levels 3 and 4 into level 3+4):

1. Report must be legible.
2. Submit one laboratory report for one sample delivery group (SDG). In cases where multiple analyses are performed in one SDG, reports for individual analyses should be compiled into one laboratory report before submittal to WSDOT, in the following order, as applicable:
    a. Semi-volatile organic compounds by SW846 Method 8270D-Full scan (or acceptable analogous method);
    b. Phthalates by SW846 Method 8270D-Selective Ion Monitoring (SIM) (or acceptable analogous method);
    c. Polycyclic aromatic hydrocarbons (PAHs) by SW846 Method 8270D–SIM (or acceptable analogous method);
    d. Phenolics by SW846 Method 8270D–SIM (or acceptable analogous method);
    e. Herbicides by SW846 Method 8270D–SIM (or acceptable analogous method);
    f. Glyphosate by EPA Method 547–SIM (or acceptable analogous method);
    g. Total petroleum hydrocarbon (TPH)-Gasoline by Method NWTPH-Gx (Washington State Department of Ecology [Ecology], 1997 Publication No. 97-602) (or acceptable analogous method);
    h. TPH-Diesel by Method NWTPH-Dx (Ecology, 1997 Publication No. 97-602) (or acceptable analogous method);
    i. Total and dissolved metals by EPA Methods 200.8 & 200.7 (or acceptable analogous method);
    j. Hardness as $CaCO_3$ by Standard Method 2340B (or acceptable analogous method);
    k. Conventional chemical parameters by EPA Methods 300.0 Rev. 2.1 (1993), 351.2, and PSEP (USEPA, 1997); Standard Methods 2320 B-97, 2540G, 2540D, 4500H^+B, 4500-PG, 4500-PF, 4500-NO_3^-I, 5540C, 5540D, 9221E, 9222D; ASTM D422, E1192-97; and Laser Diffraction (or acceptable analogous methods).

3. Include a cover page signed and dated by the laboratory Director, the laboratory Quality Assurance (QA) Officer, or his/her designee to certify the eligibility of the reported contents and the conformance with applicable analytical methodology.
4. Include definitions of abbreviations, data flags, and data qualifiers used in the report.
5. The laboratory is expected to meet the project-specific reporting limits (RLs) (reporting limits are specified in the Program's Quality Assurance Project Plan (QAPP) or laboratory contract) or describe in the case narrative the reason the reporting limits could not be achieved. Laboratory reports should include the following reporting limits:
    a. The practical quantitation limit (PQL) based on the lowest validated standard in calibration curve for each result. Report the PQL in the electronic file in the "Practical_quantitation_limit" column.
    b. The method detection limit (MDL) for each analyte that has a MDL.
6. Note in the case narrative any modifications to the laboratory standard operating procedures (SOPs) for the method analysis, quality assurance and quality control (QA/QC) activities performed, and results specific to the analysis performed.
7. Include in the sample identification (ID):
    a. Provide the WSDOT Field ID and Lab ID (and Subcontract ID, if applicable) associated with all sample results, as appropriate.
    b. Provide the lab's internal sample ID associated with all results OR a table that cross-references results with the laboratory's internal sample ID.
    c. Clearly identify QC samples and results to include: blanks, lab control samples, surrogates and internal standards, lab duplicates, and matrix spike (MS) and matrix spike duplicates (MSD). If QC samples are reanalyzed, these results need to be clearly identified as such.
8. Include in the sample results:
    a. Required: Lab name, analytical method, matrix, sample weight/volume or weight/weight with units, project name, SDG number, WSDOT sample ID, lab sample ID, date received, date analyzed, concentration units, and comments.
        i. For each result: Analyte Chemical Abstracts Service registry number (CAS number) (unless no CAS number exists), analyte name, concentration or other applicable measure, and data flags where applicable.
    b. If applicable: % solids, date extracted.
9. Include in the QC analyses:
    a. Laboratory control sample (LCS) and LCS duplicate (LCSD) (if matrix spike duplicate analysis is not performed on a WSDOT sample) results, including spiking concentration, spiked results, percent recovery (%R), relative percent difference (RPD), and laboratory acceptance criteria for %R and RPD.
    b. MS and results, including parent sample concentration, spiking concentration, spiked results, %R, RPD, and laboratory acceptance criteria for %R and RPD. In cases where MS/MSD analyses were not performed on a project sample, LCS/LCSD analyses should be performed and reported instead.

c. Laboratory duplicate results, including parent sample concentration, duplicate result, RPD, and laboratory acceptance criteria for RPD.
d. Provide results of certified reference material using the same units as for the samples. Provide certificate for certified reference materials.
e. Provide results of method blanks.
    i. If a target analyte is detected in a method blank, all associated sample results should be flagged with "B."
    ii. If laboratory contamination is identified as the result of a high method blank measurement, the source of contamination and corrective actions taken to prevent future contamination should be noted in the case narrative. If the source is identified after the report is issued, the report should be re-issued or a memo indicating the source and corrective actions should be provided to WSDOT.
    iii. Clearly identify samples associated with each method blank.

10. Include the completed chain of custody (COC) document, signed and dated by parties who are acquiring and receiving samples. Format may be in hard copy or Portable Document Format (PDF).
11. Include the completed sample receipt document with record of cooler temperature and sample conditions upon receipt at the laboratory. Anomalies such as inadequate sample preservation, inconsistent bottle counts, sample container breakage, a communication record, and corrective actions in response to the anomalies should be documented and incorporated in the sample receipt document. The document should be initialed and dated by personnel who complete the sample receipt document.
    a. Use of a checklist with checks related to sample condition/integrity as well as a comment section to document anomalies and corrective actions is ideal.
    b. As a minimum requirement, this can be done on the COC form, as long as anomalies are clearly documented and writings are legible; if no anomalies are identified, a conclusion statement (as simple as "Samples ALL OK") is warranted.
12. Include a case narrative that addresses any anomalies or QC outliers in relation to sample receiving, preparation, and analysis on samples in the SDG. The narrative should be presented separately for each analytical method and each sample matrix in the same order as listed in Item 1.
13. Number all pages in the report. Any insertion of pages after the laboratory report is issued should be paginated with the starting page number suffixed with letters (e.g., pages inserted between pages 134 and 135 should be numbered 134A, 134B, etc.).
14. Submit any resubmitted or revised report pages to WSDOT with a cover page stating the reason(s) and scope of resubmission or revision, and signed by the laboratory director, QA Officer, or the designee.

C. Requirements for Organic Compound Analyses

The following specifies information to be tabulated and reported for analyses of organic compounds, including gas chromatography (GC) coping with flame ionization detector (FID) or mass spectrometer (GC/MS) or atomic emission spectrometer (AES), and high-performance liquid chromatography (HPLC) coping with ultraviolet detector or mass spectrometer (HPLC/MS).

1. Sample results (each sample) – GC Column ID, cleanup methods used, initial sample volume or weight, final extract volume, extraction methods, injection volume, dilution factor, and concentration units.
2. Instrument run log – The run log should list, in chronological order, all analytical runs on field samples, QC samples, calibrations, and calibration verification analyses in the SDG with data file name (and/or legible laboratory codes) and analysis date/time for each analytical run.
3. Original sample preparation and analyst worksheet – Initialed and dated by analyst and reviewer.
4. GC/MS or HPLC/MS tune report – Including ion abundance ratios and criteria for all required ions.
5. Initial calibration summary – Including data file name for each calibration standard file; response factor (RF) or calibration factor (CF) for each calibration standard, and each target and surrogate compound; and average RF or CF, percent relative standard deviation (%RSD), correlation coefficient, or coefficient of determination for each target compound and surrogate compounds.
6. Calibration verification summary – Including true amount, calculated amount, and percent difference (%D), or percent drift (%Df), as applicable, for all target compounds.
7. Surrogate spike results with laboratory acceptance criteria for %R.
8. Internal standard (as applicable) results – Internal standard responses are added in field samples, QC analyses, and associated calibration verification analyses.
9. All instrument printouts and raw data – Including quantitation report, GC or HPLC chromatograms, and ion spectra for the analyses of field samples, QC samples, initial calibrations, calibration verification, and mass spectrometer tuning.

Refer to EPA 2012 for specific information to be reported in each item. If required information is not reported in tabulated forms, the information should be organized and sufficient for data validation. Refer to Table E-1 for items required for each validation package by validation level.

Table E-1 Items required for Organic Compound Analyses by validation package requested.

Validation Level Requested	General Requirements – Required Items	Organic Compound Analysis – Required Items
Level 2a	All	Items 1, 2, 3, 7, and 8
Level 2b	All	All except Item 9
Level 3+4	All	All

D. Requirements for Metals Analyses

The following requirements apply to metals analyses by inductively coupled plasma (ICP) coping with mass spectrometer (ICP/MS) or atomic emission spectrometry (ICP/AES) methodology.

1. Dissolved metals samples – Indicate if sample was digested.
2. Instrument run log – The run log should list, in chronological order, all analytical runs on field samples, QC samples, calibrations, and calibration verification analyses in the SDG with analysis date/time for each analytical run.
3. Original sample preparation and analyst worksheet – Initialed and dated by analyst and reviewer.
4. ICP/MS tune report – Including mass spectrometer stability check and resolution check results.

5. Initial calibration summary – Including results for all target analytes for each calibration standard and linear regression correlation coefficients for all target analytes.
6. Initial and continuing calibration verification (ICVs and CCVs) summary – Including true values, result values, and %R for all target analytes. The ICV/CCVs should be properly identified (or numbered) to be sufficiently related to in the run log.
7. Preparation blanks – Initial and continuing calibration blank (ICB/CCB) results. Each ICB and CCB should be properly identified (or numbered) to be sufficiently related to in the run log.
8. ICP inter-element interference check sample results – Including true values, result values, and %R values for proper interferents and target analytes in solution A and solution AB.
9. Internal standard responses for each internal standard in field samples, QC analyses, and associated calibration blank.
10. All instrument printouts and raw data for the analyses of field samples, QC samples, initial calibrations, calibration verifications, and ICP/MS tuning.

Refer to EPA 2010 for specific information to be reported in each item. If required information could not be reported in tabulated forms, the information should be organized and sufficient for data validation. Refer to Table E-2 for items required for each validation package by validation level.

Table E-2 Items required for Metals Analyses by package requested.

Validation Level Requested	General Requirements – Required Items	Metals Analysis – Required Items
Level 2a	All	Items 1, 2, 3, 7 (preparation blank only), and 8
Level 2b	All	All except Item 10
Level 3+4	All	All

E. Requirements for Conventional Chemistry Parameters Analyses

The following requirements apply to the analyses of conventional chemical parameters (total suspended solids, nitrate/nitrite, total chloride, total sulfate, total phosphorus, ortho-phosphate, total Kjeldahl nitrogen, total organic carbon, dissolved organic carbon, methylene blue active substances, cobalt thiocyanate active substances, etc.):

1. Instrument run log – The run log should list, in chronological order, all analytical runs on field samples, QC samples, calibrations, and calibration verification analyses in the SDG with analysis date/time for each analytical run.
2. Original sample preparation and analyst worksheet – Initialed and dated by analyst and reviewer.
3. Initial calibration summary (as applicable) – Including results for all target analytes for each calibration standard and linear regression correlation coefficients for all target analytes.
4. Initial and continuing calibration verification (ICV and CCV) summary (as applicable) – Including true values, result values, and %R for all target analytes. The ICVs/CCVs should be properly identified (or numbered) to be sufficiently related to in the run log.

5. Preparation blanks – Initial and continuing calibration blank (ICB/CCB) results (as applicable). Each ICB and CCB should be properly identified (or numbered) to be sufficiently related to in the run log.
6. All instrument printouts and raw data for the analyses of field samples, QC samples, initial calibrations, calibration verifications, and analyst notebook.

Refer to EPA 2010 for specific information to be reported in each item. If required information could not be reported in tabulated forms, the information should be organized and sufficient for data validation. Refer to Table E-3 for items required for each validation package by validation level.

Table E-3 Items required for Conventional Chemistry Parameters Analyses by package requested.

Validation Level Requested	General Requirements – Required Items	Conventionals Analysis – Required Items
Level 2a	All	Items 1, 2, and 5 (preparation blank only)
Level 2b	All	All except Item 6
Level 3+4	All	All

F. References

United States Environmental Protection Agency (EPA). 1997. Puget Sound Estuary Protocols; *Recommended Guidelines for Measuring Organic Compounds in Puget Sound Water, Sediment and Tissue Samples*. April 1997.

_______2009. *Guidance for Labeling Externally Validated Laboratory Analytical Data for Superfund Use*, EPA 540-R-08-005. January 13, 2009.

_______2010. *Contract Laboratory Program Statement of Work for Inorganic Superfund Methods (Multi-Media, Multi-Concentration)*, ISM01.2. January 2010.

_______2012. *Contract Laboratory Program Statement of Work for Organic Superfund Methods (Multi-Media, Multi-Concentration)*, SOM02.X. November 2012 Draft.

Appendix F: Electronic Data Deliverables Specification, Version 1.0

1. Introduction

Electronic results must be submitted in the format specified below. Tables F-3 through F-5 represent the specifications for each field in the EDD. Data must be entered following these specifications into an Excel compatible format.

2. Format Information

Format Name: WSDOT_SWv1*

Format Version: 1.0

Based on EPAR2 Format Version: 2.02.47

*This format is still under revision; therefore, some minor changes may be made as the database is developed.

Table F-1 Cell color coding.

Required for entry
Conditionally required for entry
Optional

Table F-2 Table descriptions.

Table	Table Name	Purpose
F-3	WSDOTSMP_v1	Entering sample information, labs are required to use this to add QC samples. Field sample data will be entered by WSDOT.
F-4	WSDOTTRSQC_v1	Entering result information
F-5	WSDOTBAT_v1	Entering batch information. This sheet links the samples together in a batch. Data is the same as TRSQC_v1 sheet except test_batch_type and test_batch_id, which link the samples and QC together.

Table F-3 WSDOTSMP_v1.

Field Name	Data Type	Key	Default	Comment	Laboratory Notes	Required?
data_provider	Text(20)	Y		The organization that is submitting data.		Yes
storm_ID	Text(40)	Y	Unknown	Unique ID for Storm forecast.	Use default value = "Unknown" for lab-created samples	Use Specified Value
sys_sample_code	Text(40)	PK		Unique sample identifier. Each sample at a facility must have a unique value, including spikes and duplicates. You have considerable flexibility in the methods used to derive and assign unique sample identifiers, but uniqueness throughout the database is the only restriction enforced by EQuIS®.	sample ID	Yes
sample_name	Text(30)			Additional sample identification information as necessary. Is not required to be unique (i.e., duplicates are OK).		Optional
sample_matrix_ code	Text(3)	Y		Code that distinguishes between different types of sample matrix. For example, soil samples must be distinguished from groundwater samples, etc. See the matrix valid values table for valid codes.	"WTR" or "SED"	Yes
sample_type_code	Text(3)	Y		Code which distinguishes between different types of samples. For example, normal field samples must be distinguished from laboratory method blank samples, etc. Use sample_type valid values table.		
sample_source	Text(10)	Y	FIELD	This field identifies where the sample came from: either Field or Lab.	will always = "Lab" for lab-created samples	Use Specified Value

Table F-3 WSDOTSMP_v1 (continued).

Field Name	Data Type	Key	Default	Comment	Laboratory Notes	Required?
parent_sample_code	Text(40)			The value of "sys_sample_code" that uniquely identifies the sample that was the source of this sample. For example, the value of this field for a duplicate sample would identify the normal sample of which this sample is a duplicate.	Required if the sample has a parent sample such as a matrix spike or laboratory duplicate, the parent sample must exist in the EQuIS database (i.e., cannot be a sample from another project)	Conditionally Required
sample_start_date	Date Time	Y		Date and time sample was collected or made (in "MM/DD/YYYY HH:MM:SS" format for EDD).	Enter the date the sample was created or used; a default time of "12:00" may be used	Yes
sampling_ company_ code	Text(10)	Y		Name or initials of sampling company (not controlled vocabulary).	Make the same as the data_provider_code	Yes
composite_yn	Text(1)	Y	N	Is sample a composite sample? "Y" for yes or "N" for no.	Use default value = "N" for lab-created samples	Use Specified Value
comment	Text (255)			Comments or observations during sampling event.		Optional

Table F-4 WSDOTTRSQC_v1.

Field Name	Data Type	Key	Default	Comment	Laboratory Notes	Required?
sys_sample_code	Text(40)	PK		Unique sample identifier. Each sample at a facility must have a unique value, including spikes and duplicates. You have considerable flexibility in the methods used to derive and assign unique sample identifiers, but uniqueness throughout the database is the only restriction enforced by EQuIS®.	Field ID supplied by WSDOT or sample ID added using WSDOTSMP_v1 sheet	Yes
lab_anl_method_name	Text(35)	PK	Unknown	Laboratory analytical method name or description. A controlled vocabulary column, valid values can be found in the appendix in table lab_anl_method_name.	Pick from valid values	Yes
lab_receipt_date	Date Time			Date and time that sample was received at laboratory (in "MM/DD/YYYY HH:MM:SS" format for EDD).		Yes
lab_receipt_temp	Numeric			Receipt at lab.		Yes
lab_receipt_ temp_ units	Text(15)			Units of measurement for the result. Controlled vocabulary, valid values deg C and deg F.		Yes
analysis_date	Date Time	PK		Date and time of sample analysis in "MM/DD/YYYY HH:MM:SS" format. May refer to either beginning or end of the analysis as required by EPA.		Yes
total_or_dissolved	Text(1)	PK	T	Must be either "D" for dissolved or filtered [metal] concentration, or "T" for everything else ("N" may also be used if Not Applicable).	"D" or "T" or "N"	Yes
test_type	Text(10)	PK	INITIAL	Type of test. Valid values include "Initial," "Reextract1," "Reextract2," "Reextract3," "Reanalysis," "Dilution1," "Dilution2," and "Dilution3."		Yes

Table F-4 WSDOTTRSQC_v1 (continued).

Field Name	Data Type	Key	Default	Comment	Laboratory Notes	Required?
lab_matrix_code	Text(3)			Code that distinguishes between different types of sample matrix. For example, soil samples must be distinguished from groundwater samples, etc. See matrix valid value table in the appendix. The matrix of the sample as analyzed may be different from the matrix of the sample as retrieved (e.g., leachates), so this field is available at both the sample and test level.	"W" for water or "SE" for sediment	Yes
analysis_location	Text(2)	Y	FI	Must be either Field Instrument, Mobile Laboratory, or Fixed Laboratory	"Fixed Laboratory"	Specified Value
basis	Text(10)	Y	NA	Must be either "Wet" for wet_weight basis reporting, "Dry" for dry_weight basis reporting, "AFDW" for ash-free dry weight basis reporting, or "NA" for tests for which this distinction is not applicable. The EPA prefers that results are reported on the basis of dry weight where applicable.	"Wet," "Dry," "AFDW," or "NA"	Yes
container_id	Text(30)			May be used for bar coding purposes.		optional
dilution_factor	Numeric		1.0	Effective test dilution factor.	Default is no dilution "1.0"	Yes
prep_method	Text(20)			Laboratory sample preparation method name or description. A controlled vocabulary (i.e., see Prep_mthd_var valid values in the appendix). For metals, must be acid prep.	Required if separate prep method used than the analysis method	Conditionally Required
prep_date	Date Time			Beginning date and time of sample preparation in "MM/DD/YYYY HH:MM:SS" format.		Yes
leachate_method	Text(15)			Laboratory leachate generation method name or description. The method name should be sufficient to reflect operation of the laboratory (see analysis method discussion).	If conducting leaching method, this is required	Conditionally Required

Table F-4 WSDOTTRSQC_v1 (continued).

Field Name	Data Type	Key	Default	Comment	Laboratory Notes	Required?
leachate_date	Date Time			Beginning date and time of leachate preparation in "MM/DD/YYYY HH:MM:SS" format.	If conducting leaching method, this is required	Conditionally Required
lab_name_code	Text(20)			Unique identifier of the laboratory as defined by the EPA. Controlled vocabulary; see lab valid value table in the appendix.	Value will be provided by WSDOT	Yes
qc_level	Text(10)			Describes QC level.		optional
lab_sample_id	Text(20)			Laboratory LIMS sample identifier. If necessary, a field sample may have more than one LIMS lab_sample_id (maximum one per each test event).		Yes
percent_moisture	Text(5)			Percent moisture of the sample portion used in this test; this value may vary from test to test for any sample. Numeric format is "NN.MM" (i.e., 70.1% could be reported as "70.1" but not as "70.1%").	Required if percent solids was measured on the sample – This field may change to percent solids in future versions	Conditionally Required
subsample_ amount	Text(14)			Amount of sample used for test.		Yes
subsample_ amount_ unit	Text(15)			Unit of measurement for subsample amount. Controlled vocabulary; see Unit valid values table in appendix.		Yes
analyst_name	Text(30)			Name or initials of analyst.		Yes
instrument_id	Text(50)			Identifies instrument used for analysis.		optional
comment	Text (255)			Comments about the test as necessary.		optional
preservative	Text(20)			Sample preservative used.	Required if preservative deviated from QAPP-specified preservative	Conditionally Required
final_volume	Numeric			The final volume of the sample after sample preparation. Include all dilution factors.		Yes
final_volume_unit	Text(15)			The unit of measure that corresponds to the final_volume.		Yes
cas_rn	Text(15)	PK		Use values in analyte valid value table.		Yes

Table F-4 WSDOTTRSQC_v1 (continued).

Field Name	Data Type	Key	Default	Comment	Laboratory Notes	Required?
chemical_name	Text(75)	Y		Use the name in the analyte valid value table.		Yes
result_value	Numeric			Analytical result reported at an appropriate number of significant digits. Report non_detects as the Method Detection Limit.		Yes
result_type_code	Text(10)	Y	TRG	Must be either "TRG" for a target or regular result, "TIC" for tentatively identified compounds, "SUR" for surrogates, "IS" for internal standards, or "SC" for spiked compounds.		Yes
reportable_result	Text(10)	Y	Yes	Must be either "Yes" for results that are considered to be reportable, or "No" for other results. This field has many purposes. For example, it can be used to distinguish between multiple results where a sample is retested after dilution. It can also be used to indicate which of the first or second column result should be considered primary. The proper value of this field in both of these two examples should be provided by the laboratory (only one result should be flagged as reportable).		Yes
lab_qualifiers	Text(10)			Qualifier assigned by the laboratory.		Yes
validator_ qualifiers	Text(10)			Qualifier assigned by the validation firm.	Required if verification or validation uses different qualifier	Conditionally Required
interpreted_ qualifiers	Text(10)			Qualifier assigned by the validation firm reason. This is a controlled vocabulary column; valid values can be found in the qualifiers table in appendix.	Must match lab or validator qualifier	Yes
method_ detection_limit	Text(20)			Method Detection Limit.		Yes

Table F-4 WSDOTTRSQC_v1 (continued).

Field Name	Data Type	Key	Default	Comment	Laboratory Notes	Required?
reporting_ detection_limit	Numeric			Concentration level above which results can be quantified with confidence. It must reflect conditions such as dilution factors and moisture content. Required for all results for which such a limit is appropriate. Detection limit type must be populated. The reporting_detection_limit column must be reported as the sample-specific detection limit.		optional
reporting_detection_limit_type	Text (9)			Type of detection limit reported.		optional
practical_quantitation_limit	Text(20)			The lowest level that can be reliably measured by routine operating conditions within specified limits of precision and accuracy.		Yes
result_unit	Text(15)			Units of measurement for the result. Controlled vocabulary; see Units valid value table in the appendix.		Yes
detection_limit_ unit	Text(15)			Units of measurement for the detection limit(s). Controlled vocabulary; see Units valid value table in the appendix. This field is required if a reporting_detection_limit is reported.		Yes
result_comment	Text (255)			Result-specific comments.		optional
qc_original_conc	Numeric			The concentration of the analyte in the original (unspiked) sample. Might be required for spikes and spike duplicates (depending on user needs). Not necessary for surrogate compounds or LCS samples (where the original concentration is assumed to be zero).	Required if pertains to QC sample	Conditionally Required

Table F-4 WSDOTTRSQC_v1 (continued).

Field Name	Data Type	Key	Default	Comment	Laboratory Notes	Required?
qc_spike_added	Numeric			The concentration of the analyte added to the original sample. Might be required for spikes, spike duplicates, surrogate compounds, LCS, and any spiked sample (depending on user needs).	Required if pertains to QC sample	Conditionally Required
qc_spike_ measured	Numeric			The measured concentration of the analyte. Use zero for spiked compounds that were not detected in the sample. Might be required for spikes, spike duplicates, surrogate compounds, LCS, and any spiked sample (depending on user needs).	Required if pertains to QC sample	Conditionally Required
qc_spike_recovery	Numeric			The percent recovery calculated as specified by the laboratory QC program. Always required for spikes, spike duplicates, surrogate compounds, LCS, and any spiked sample. Report as percentage multiplied by 100 (e.g., report "120%" as "120").	Required if pertains to QC sample	Conditionally Required
qc_dup_original_ conc	Numeric			The concentration of the analyte in the original (unspiked) sample. Might be required for spike or LCS duplicates only (depending on user needs). Not necessary for surrogate compounds or LCS samples (where the original concentration is assumed to be zero).	Required if pertains to QC sample	Conditionally Required
qc_dup_spike_ added	Numeric			The concentration of the analyte added to the original sample. Might be required for spike or LCS duplicates, surrogate compounds, and any spiked and duplicated sample (depending on user needs). Use zero for spiked compounds that were not detected in the sample. Required for spikes, spike duplicates, surrogate compounds, LCS, and any spiked sample. Also complete the qc-spike-added field.	Required if pertains to QC sample	Conditionally Required

Table F-4 WSDOTTRSQC_v1 (continued).

Field Name	Data Type	Key	Default	Comment	Laboratory Notes	Required?
qc_dup_spike_ measured	Numeric			The measured concentration of the analyte in the duplicate. Use zero for spiked compounds that were not detected in the sample. Might be required for spike and LCS duplicates, surrogate compounds, and any other spiked and duplicated sample (depending on user needs). Also complete the qc-spike-measured field.	Required if pertains to QC sample	Conditionally Required
qc_dup_spike_ recovery	Numeric			The duplicate percent recovery calculated as specified by the laboratory QC program. Always required for spike or LCS duplicates, surrogate compounds, and any other spiked and duplicated sample. Also complete the qc-spike-recovery field. Report as percentage multiplied by 100 (e.g., report "120%" as "120").	Required if pertains to QC sample	Conditionally Required
qc_rpd	Text(8)			The relative percent difference calculated as specified by the laboratory QC program. Required for duplicate samples as appropriate. Report as percentage multiplied by 100 (e.g., report "30%" as "30").	Required if pertains to QC sample	Conditionally Required
qc_spike_lcl	Text(8)			Lower control limit for spike recovery. Required for spikes, spike duplicates, surrogate compounds, LCS, and any spiked sample. Report as percentage multiplied by 100 (e.g., report "60%" as "60").	Required if pertains to QC sample	Conditionally Required
qc_spike_ucl	Text(8)			Upper control limit for spike recovery. Required for spikes, spike duplicates, surrogate compounds, LCS, and any spiked sample. Report as percentage multiplied by 100 (e.g., report "60%" as "60").	Required if pertains to QC sample	Conditionally Required
qc_rpd_cl	Text(8)			Relative percent difference control limit. Required for any duplicated sample. Report as percentage multiplied by 100 (e.g., report "25%" as "25").	Required if pertains to QC sample	Conditionally Required

Table F-5 WSDOTBAT_v1.

Field Name	Data Type	Key	Default	Comment	Laboratory Notes	Required?
sys_sample_code	Text(40)	PK		Unique sample identifier. Each sample must have a unique value, including spikes and duplicates. Laboratory QC samples must also have unique identifiers. The laboratory and the EQuIS® Chemistry user have considerable flexibility in the methods they use to derive and assign unique sample identifiers, but uniqueness throughout the database is the only restriction enforced by EQuIS® Chemistry.	See TRSQC Sheet	Yes
lab_anl_method_ name	Text(35)	PK		Laboratory analytical method name or description. A controlled vocabulary column; valid values can be found in the appendix in table ab_anl_method_name.	See TRSQC Sheet	Yes
analysis_date	Date Time	PK		Date and time of sample analysis in "MM/DD/YYYY HH:MM:SS" format. May refer to either beginning or end of the analysis as required by EPA.	See TRSQC Sheet	Yes
total_or_dissolved	Text(1)	PK	T	Must be either "D" for dissolved or filtered [metal] concentration, or "T" for everything else.	See TRSQC Sheet	Yes
test_type	Text(10)	PK	INITIAL	Type of test. Valid values include "Initial," "Reextract1," "Reextract2," "Reextract3," "Reanalysis," "Dilution1," "Dilution2," and "Dilution3."	See TRSQC Sheet	Yes
test_batch_type	Text(10)	PK		Lab batch type. Valid values include "Prep," "Analysis," and "Leach." This is a required field for all batches.		Yes
test_batch_id	Text(20)	Y		Unique identifier for all lab batches.		Yes

Appendix G: Stormwater Monitoring: Chemical Data Validation Guidance & Criteria, Version 1.2

The Washington State Department of Transportation's (WSDOT's) *Stormwater Monitoring: Chemical Data Validation Guidance and Criteria* is an independent publication and is not affiliated with, nor has it been authorized, sponsored, or otherwise approved by a referenced product's parent company or manufacturer.

Stormwater monitoring work is conducted in response to requirements of WSDOT's NPDES Municipal Stormwater Permit (Ecology, 2009a). Instructions presented herein are adapted from published information or were developed by technical experts. Their primary purpose is for internal use by WSDOT's Stormwater Monitoring Group. Described procedures may vary from those used by other WSDOT groups.

WSDOT's stormwater monitoring procedures do not supplant official published definitions or methods.

Distribution of this document does not constitute an endorsement of a particular procedure or method. Any reference to specific equipment, software, manufacturers, or suppliers is for descriptive purposes only and does not constitute an endorsement of a particular product or service by the authors or WSDOT.

Although WSDOT follows these guidelines in most cases, there may be instances in which WSDOT uses an alternative methodology, procedure, or process.

WSDOT Stormwater Monitoring: Chemical Data Validation Guidance and Criteria

Introduction

This document contains chemistry data validation protocols and criteria prepared for WSDOT's NPDES Stormwater Monitoring program, as requested. The levels of laboratory deliverables—Levels 2a, 2b, 3, and 4—defined herein are based on USEPA *Guidance for Labeling Externally Validated Laboratory Analytical Data for Superfund Use* (EPA, 2009). This system was selected as the basis for validation because the NPDES program is mandated by the USEPA. WSDOT will combine USEPA levels 3 and 4 into one level referred to as 3+4 and hereto use the reference "WSDOT validation levels" to indicate some deviation from the USEPA levels. USEPA validation levels 2a, 2b, and 3+4 are respectively equivalent to those commonly referred to as Level II, III, and IV by other environmental compliance programs and WSDOT's contract with Cardno TEC.

Validation protocols and criteria presented herein are limited to the chemistry parameters required for this monitoring program. Table G-1 lists laboratories and contact information of entities performing the referenced analytical work. Analytical methods or techniques irrelevant to the scope of this program (e.g., mercury by cold vapor atomic absorption technique) have been omitted.

This document is organized into groups of monitoring parameters based on the types of analytical methodologies, as follows:

- Conventional chemistry parameters,
- Metals analysis by ICP and ICP/MS,
- Organic compounds analysis by GC and HPLC, and
- Semi-volatile organic compounds analysis by GC/MS and HPLC/MS methods.

Each group of parameters consists of four tables:

- Validation criteria and respective actions,
- Analysis methods for each of the analytes in the group,
- Sample container, preservation, and holding time requirements, and
- Quality control criteria for the validation.

Table G-1 Laboratories Selected for Sample Analyses.

Laboratory Name	Abbreviation	Contact
Washington State Department of Ecology's Manchester Environmental Laboratory	MEL	Nancy Rosenbower – (360) 871-8827 nros461@ecy.wa.gov
Test America Laboratories, Inc.	TestAmerica	Pam Johnson – (253) 922-2310 x130 Pam.Johnson@testamericainc.com
Anatek Labs, Inc.	Anatek	Kathy Sattler – (509) 838-3999 kathy@anateklabs.com
AmTest Laboratory	AmTest	Kathleen Fugiel – (425) 885-1664 kathyF@amtestlab.com
Analytical Resources, Inc.	ARI	Mark Harris – (206) 695-6210 markh@arilabs.com
NewFields Northwest, LLC	NewFields	Brian Hester – (360) 297-6040 bhester@newfields.com
Washington State Department of Transportation	WSDOT	Fred Bergdolt – (360) 570-6648 bergdof@wsdot.wa.gov

Validation Guidelines

Table G-2a Quality Control Parameters for Various WSDOT Data Validation Levels (Level 2a).

Quality Control Elements	Level 2a			
	Conventional Chemistry Parameters	Metals (ICP/AES & ICP/MS)	Organics (GC & HPLC)	Semi-Volatile Organics (GC/MS & HPLC/MS)
Holding Time and Sample Management	√	√	√	√
Gas Chromatography Coupling with Mass Spectrometry (GC/MS) or High-Performance Liquid Chromatography with Mass Spectrometry (HPLC/MS) Instrument Tuning	N/A	N/A	N/A	
Inductively Coupled Plasma-Mass Spectrometry (ICP/MS) Tuning	N/A		N/A	N/A
Initial Calibration (ICAL)				
Initial Calibration Verification (ICV)				
Continuing Calibration Verification (CCV)				
Initial Calibration Blank and Continuing Calibration Blank (ICB/CCB)			N/A	N/A
Blanks(1)	√	√	√	√
Surrogate Spikes	N/A	N/A	√	√
Multiple Results for One Sample	√	√	√	√
Inductively Coupled Plasma (ICP) Interference Check Sample	N/A		N/A	N/A
Matrix Spike (MS), Matrix Spike Duplicate (MSD), Laboratory Duplicate, or Post-Digestion Spike (PS)	√	√	√	√
Laboratory Control Sample (LCS), Laboratory Control Sample Duplicate (LCSD), and/or Standard Reference Material (SRM)	√	√	√	√
Serial Dilution	N/A		N/A	N/A
Internal Standards	N/A		N/A	
Field Duplicate	√	√	√	√
Reporting Limit Check Sample Analysis (CRA)	N/A		N/A	N/A
Project Reporting Limits (RL)	√	√	√	√
Target Analyte/Compound Identification	N/A	N/A		
Target Analyte/Compound Quantitation				
System Performance				
Overall Data Usability Assessment	√	√	√	√

Table G-2a Notes:
N/A – Not applicable
"√" – Indicates the QC parameter is to be reviewed
☐ Indicates the QC parameter is not reviewed in the validation process
Source: USEPA, 2009

[1] Blanks reviewed for Level 2a are limited to method blanks and field-collected blanks (field blank, trip blank, etc.). Blanks reviewed for Level 2b and Level 3+4 combined are subjected to all blanks, including instrument blanks and initial and continuing calibration blanks.

Table G-2b Quality Control Parameters for Various WSDOT Data Validation Levels (Level 2b).

Quality Control Elements	Level 2b			
	Conventional Chemistry Parameters	Metals (ICP/AES & ICP/MS)	Organics (GC & HPLC)	Semi-Volatile Organics (GC/MS & HPLC/MS)
Holding Time and Sample Management	√	√	√	√
Gas Chromatography Coupling with Mass Spectrometry (GC/MS) or High-Performance Liquid Chromatography with Mass Spectrometry (HPLC/MS) Instrument Tuning	N/A	N/A	N/A	√
Inductively Coupled Plasma-Mass Spectrometry (ICP/MS) Tuning	N/A	√	N/A	N/A
Initial Calibration (ICAL)	√	√	√	√
Initial Calibration Verification (ICV)	√	√	N/A	√
Continuing Calibration Verification (CCV)	√	√	√	√
Initial Calibration Blank and Continuing Calibration Blank (ICB/CCB)	√	√	N/A	N/A
Blanks[1]	√	√	√	√
Surrogate Spikes	N/A	N/A	√	√
Multiple Results for One Sample	√	√	√	√
Inductively Coupled Plasma (ICP) Interference Check Sample	N/A	√	N/A	N/A
Matrix Spike (MS), Matrix Spike Duplicate (MSD), Laboratory Duplicate, or Post-Digestion Spike (PS)	√	√	√	√
Laboratory Control Sample (LCS), Laboratory Control Sample Duplicate (LCSD), and/or Standard Reference Material (SRM)	√	√	√	√
Serial Dilution	N/A	√	N/A	N/A
Internal Standards	N/A	√	√	√
Field Duplicate	√	√	√	√
Reporting Limit Check Sample Analysis (CRA)	N/A	√	N/A	N/A
Project Reporting Limits (RL)	√	√	√	√
Target Analyte/Compound Identification	N/A	N/A		
Target Analyte/Compound Quantitation				
System Performance				
Overall Data Usability Assessment	√	√	√	√

Table G-2b Notes:
N/A – Not applicable
"√" – Indicates the QC parameter is to be reviewed
☐ Indicates the QC parameter is not reviewed in the validation process
Source: USEPA, 2009

[1] Blanks reviewed for Level 2a are limited to method blanks and field-collected blanks (field blank, trip blank, etc.). Blanks reviewed for Level 2b and Level 3+4 combined are subjected to all blanks, including instrument blanks and initial and continuing calibration blanks.

Table G-2c Quality Control Parameters for Various WSDOT Data Validation Levels (Levels 3+4 Combined).

Quality Control Elements	Levels 3+4 Combined			
	Conventional Chemistry Parameters	Metals (ICP/AES & ICP/MS)	Organics (GC & HPLC)	Semi-volatile Organics (GC/MS & HPLC/MS)
Holding Time and Sample Management	√	√	√	√
Gas Chromatography Coupling with Mass Spectrometry (GC/MS) or High-Performance Liquid Chromatography with Mass Spectrometry (HPLC/MS) Instrument Tuning	N/A	N/A	N/A	√
Inductively Coupled Plasma-Mass Spectrometry (ICP/MS) Tuning	N/A	√	N/A	N/A
Initial Calibration (ICAL)	√	√	√	√
Initial Calibration Verification (ICV)	√	√	N/A	√
Continuing Calibration Verification (CCV)	√	√	√	√
Initial Calibration Blank and Continuing Calibration Blank (ICB/CCB)	N/A	√	N/A	N/A
Blanks[1]	√	√	N/A	N/A
Surrogate Spikes	√	√	√	√
Multiple Results for One Sample	N/A	N/A	√	√
Inductively Coupled Plasma (ICP) Interference Check Sample	√	√	√	√
Matrix Spike (MS), Matrix Spike Duplicate (MSD), Laboratory Duplicate, or Post-Digestion Spike (PS)	N/A	√	N/A	N/A
Laboratory Control Sample (LCS), Laboratory Control Sample Duplicate (LCSD), and/or Standard Reference Material (SRM)	√	√	√	√
Serial Dilution	√	√	√	√
Internal Standards	N/A	√	N/A	N/A
Field Duplicate	N/A	√	√	√
Reporting Limit Check Sample Analysis (CRA)	√	√	√	√
Project Reporting Limits (RL)	√	√	√	√
Target Analyte/Compound Identification	N/A	N/A	√	√
Target Analyte/Compound Quantitation	√	√	√	√
System Performance	√	√	√	√
Overall Data Usability Assessment	√	√	√	√

Table G-2c Notes:
N/A – Not applicable
"√" – Indicates the QC parameter is to be reviewed
Indicates the QC parameter is not reviewed in the validation process
Source: USEPA, 2009

[1] Blanks reviewed for Level 2a are limited to method blanks and field-collected blanks (field blank, trip blank, etc.). Blanks reviewed for Level 2b and Level 3+4 combined are subjected to all blanks, including instrument blanks and initial and continuing calibration blanks.

Table G-3 Chemical Data Qualifier Definitions.[1]

Qualifier	Definition
U	The analyte was analyzed for, but was not detected at a level greater than or equal to the level of the reporting limit.
J	The analyte was positively identified and the associated numerical value is approximate; either certain quality control criteria were not met or the concentration of the analyte was below the reporting limit.
NJ	The analysis indicates the presence of an analyte that has been "tentatively identified" and the associated numerical value represents its approximate concentration.
UJ	The analyte was not detected at a level greater than or equal to the reporting limit, and the reported reporting limit may be inaccurate or imprecise.
R	The sample result is unusable because certain quality control criteria were not met.
H	The preparation or analysis was performed past the technical holding time, but data quality may not be significantly affected.
DNR	Do not report this result for the analyte. The result for the analyte was to be reported from an alternative analysis.

Table G-3 Notes:

[1] 2008, USEPA. *Contract Laboratory Program National Functional Guidelines for Superfund Organic Methods Raw Data Review*. Publication No. 540-R-08-01. June 2008. http://www.epa.gov/superfund/programs/clp/guidance.htm

2010, USEPA. *Contract Laboratory Program National Functional Guidelines for Inorganic Data Review*. Publication No. 540-R-10-011. January 2010. http://www.epa.gov/superfund/programs/clp/guidance.htm

Table G-4 Chemical Data Qualification Reason Codes.

QC Element	Code	Description
Holding Time and Sample Management	PB	Bottle (broken or incorrect)
	PC	Chain of custody issue
	PH	Holding time issue
	PP	Chemical preservation issue
	PT	Temperature preservation issue
	PV	Headspace in volatiles VOA vial
Gas Chromatography Coupling with Mass Spectrometry (GC/MS) or High Performance Liquid Chromatography with Mass Spectrometry (HPLC/MS) Instrument Tuning	IT	Instrument tuning Issue
Inductively Coupled Plasma-Mass Spectrometry (ICP/MS) Tuning		
Initial Calibration (ICAL)	CA	Calibration issue
Initial Calibration Verification (ICV)		
Continuing Calibration Verification (CCV)		
Initial Calibration Blank and Continuing Calibration Blank (ICB/CCB)		
Blanks[1]	BE	Equipment blank contamination/Trip blank contamination
	BF	Field blank contamination
	BL	Laboratory blank contamination
	BM	Missing blank Information
	BN	Negative laboratory blank contamination
Surrogate Spikes	SS	Surrogate issue
Multiple Results for One Sample	DNR	Do not report, other result more technically sound (overall assessment)
Inductively Coupled Plasma (ICP) Interference Check Sample	II	ICP interference issue
Matrix Spike (MS), Matrix Spike Duplicate (MSD), Laboratory Duplicate, or Post-Digestion Spike (PS)	DL	Laboratory duplicate RPD issue (duplicate, matrix spike duplicate, laboratory control sample duplicate)
	SM	Matrix spike/matrix spike duplicate recovery issue
	PS	Post-digestion spike issue
Laboratory Control Sample (LCS), Laboratory Control Sample Duplicate (LCSD), and/or Standard Reference Material (SRM)	SL	Laboratory control sample/laboratory control sample duplicate recovery issue
Serial Dilution	SD	Serial dilution issue
Internal Standards	IS	Internal standard issue
Field Duplicate	DF	Field duplicate issue
RL Check Sample Analysis (CRA)	RL	Reporting limit issue
Project Reporting Limits (RL)		
Target Analyte/Compound Identification	TI	Target analyte/compound identification issue
Target Analyte/Compound Quantitation	TQ	Target analyte/compound quantitation issue
	DC	Dual column RPD issue
System Performance	N/A	
Overall Data Usability Assessment	N/A	
Does Not Fit in QC Element Category	MD	Missing deliverables
	MI	Inappropriate analytical method for this
	MQ	No QC results related to this data

A – Conventional Parameters

Table G-5 Data Validation Criteria for Conventional Chemistry Parameters.

QC Element *Subelement*	2a	2b	3+4	Acceptance Criteria	Action (use best professional judgment) (-): Nondetected Compounds – (+): Detected Compounds
Holding Times and Sample Management	√	√	√	• Cooler temperature: ≤6°C • Meets preservation and holding time requirements in Table G-8	• Cooler temperature >6°C: Transit time <24 hours, no action • Cooler temperature >6°C: Transit time >24 hours, J(+)/UJ(-) or J(+)/R(-) as justified, based on level of exceedance and type of analyte • Preservation requirements not met: J(+)/UJ(-) or J(+)/R(-) as justified, based on type of analyte and required holding time • Holding time ≤2x required holding time: J(+)/UJ(-) or J(+)/R(-) as justified, based on type of analyte and severity of holding time exceedance • Holding time >2x required holding time: R(+/-) • Dissolved organic carbon not filtered or pH in water not analyzed within 15 minutes: H(+/-) • pH in water analyzed >24 hours: R(+/-) • Dissolved organic carbon filtered >24 hours: R(+/-) • Fecal coliform not analyzed within 8 hours but within 24 hours: H(+/-) • Fecal coliform analyzed >24 hours: R(+/-)
Initial Calibration (ICAL)		√	√	• Where applicable to method: • At least one blank and five standards to establish ICAL curve • Linear regression correlation coefficient (r) >0.995	• ICAL not established: R(+/-) • ICAL not properly established: Narrate and/or use professional judgment to further qualify data based on the nature of nonconformance, type of analyte, and sample results • r <0.995: J(+)/UJ(-)
Initial Calibration Verification (ICV)		√	√	• Independent source analyzed immediately after calibration. • ICV %R = 90-110% • For NO_2/NO_3, chloride, sulfate, total phosphorus, *ortho*-phosphate, and TKN, a low-level standard is analyzed prior to sample analysis • Low-level standard %R = 70-130%	• ICV %R <90%: J(+)/UJ(-) • ICV %R >110%: J(+) • Low-level standard %R <70%, sample result >2xRL: No action • Low-level standard %R <70%, sample result <2xRL: J(+)/UJ(-) • Low-level standard %R >130%, sample result >2xRL: No action • Low-level standard %R >130%, sample result <2xRL: J(+)
Continuing Calibration Verification (CCV)		√	√	• Where applicable to method: • Every ten samples, immediately following ICV/ICB and end of analytical sequence • CCV %R = 90-110%	• CCV not performed properly: Narrate and use professional judgment to evaluate data usability, based on the nature of nonconformance, the type of analyte, and sample results • CCV %R <90%: J(+)/UJ(-) • CCV %R >110%: J(+)
Initial Calibration Blank and Continuing Calibration Blank (ICB/CCB)		√	√	• Where applicable to method: • After each ICV and CCV every ten samples and end of analytical sequence • ICB/CCB concentration absolute value should be <RL	• ICB/CCB <RL, sample results ≤RL: U at RL • ICB/CCB <RL, sample results >RL: J if sample ≤5x method blank; no action if sample result >5x method blank • ICB/CCB ≥RL, sample result ≤RL: U at RL • ICB/CCB ≥RL: J if sample result >RL but ≤10x blank; no action if sample result >10x blank • ICB/CCB grossly contaminated: R(+/-) • Negative ICB/CCB results: J(+)/UJ(-) if sample result <absolute value of 10x ICB/CCB

Table G-5 Data Validation Criteria for Conventional Chemistry Parameters (continued).

QC Element Subelement	2a	2b	3+4	Acceptance Criteria	Action (use best professional judgment) (-): Nondetected Compounds – (+): Detected Compounds
Blanks – *Method Blank*	√	√	√	• One per matrix per batch (not to exceed 20 samples) • Less than RL, or all associated sample results >10x the detection in the method blank	• Method blank result <RL, sample results ≤RL: U at RL • Method blank result <RL, sample results >RL: J if sample ≤5x method blank; no action if sample result >5x method blank • Method blank result ≥RL, sample result ≤RL: U at RL • Method blank result ≥RL: J if sample result >RL but ≤10x method blank; no action if sample result >10 method blank • Method blank grossly contaminated: R(+/-) • Negative method blank results: J(+)/UJ(-) if sample result < absolute value of 10x method blank
Blanks – *Field Blank Equipment Rinsate Blank*	√	√	√	• Frequency as per QAPP or as needed	• Same as method blank
Multiple Results for One Sample	√	√	√	• Report only one result per analyte	• "DNR" results that should not be used to avoid reporting multiple results for one sample
Matrix Spike (MS) or Matrix Spike Duplicate (MSD) – *Recovery*	√	√	√	• Refer to Table G-7 for specific control criteria • No action if sample result >4x spiking level	• Use professional judgment whether all samples in the same batch should be qualified; if lack of accuracy measurement associated with sample analysis, J(+)/UJ(-) all samples in the batch • %R <30%: J(+)/R(-) • %R ≥ 30% but <LCL: J(+)/UJ(-) • %R >UCL: J(+)/no action (-)
MS/MSD, Laboratory Duplicate, or Laboratory Control Sample (LCS)/Laboratory Control Sample Duplicate (LCSD) – *RPD*	√	√	√	• Frequency: One MS/MSD, MS/Laboratory Duplicate, or LCS/LCS per matrix per batch • RPD <20% for samples >5x RL • Difference <RL for samples >RL and <5x RL (may use RPD <35%, Diff <2x RL for solids)	• Narrate if frequency not met • Use professional judgment whether all samples in the same batch should be qualified • If lack of precision measurements associated with sample analysis, J(+)/UJ(-) all samples in the batch • RPD or concentration difference outside control criteria: J(+)/UJ(-)
LCS, LCSD, and/or Standard Reference Material (SRM) – *Recovery*	√	√	√	• One per matrix per batch • Refer to Table G-7 for specific control criteria	• %R <LCL: J(+)/R(-) all samples in the batch • %R > UCL: J(+) all samples in the batch • If %R <50%: R(+/-) all samples in the batch • If LCS/LCSD RPD >20%: J(+) all samples in the batch
Field Duplicates	√	√	√	• Solids: RPD <50% or absolute difference <2x RL (for results <5x RL) • Aqueous: RPD <35% or absolute difference <1x RL (for results <5x RL)	• Criteria not met: J(+)/UJ(-) in both samples
Project Reporting Limits (RL)	√	√	√	• Reported RL should be ≤RL listed in Table G-7, unless justified to raise the RL	• Narrate if analyte is not detected and the reported RL exceeded those listed in Table G-7 • If RL is raised as a result of dilution or matrix effects, evaluate if the dilution or interference is justified; document the finding and resolution in Data Validation Report

Table G-5 Data Validation Criteria for Conventional Chemistry Parameters (continued).

QC Element Subelement	2a	2b	3+4	Acceptance Criteria	Action (use best professional judgment) (-): Nondetected Compounds – (+): Detected Compounds
Analyte Quantitation			√	• Perform re-calculation on ICAL, CCV, QC analyses, and sample results to verify that there are no transcription or reduction errors (dilutions, percent solids [%S], sample weights, etc.) on one or more samples	• Determine if there is any need to qualify data that are not qualified based on the QC criteria previously discussed • Contact the laboratory via WSDOT Project Manager if discrepancies are identified • Document findings and resolutions
System Performance			√	• Examine the raw data for any anomalies (baseline shifts, negative absorbance, omissions, illegibility, etc.)	• Determine if there is any need to qualify data that are not qualified based on the QC criteria previously discussed • Contact the laboratory via WSDOT Project Manager if discrepancies are identified • Document findings and resolutions
Overall Data Usability Assessment – *Level 2a*	√			• Check for data points with multiple qualifiers • Check for analytes with multiple results	• Determine the final data qualifier for a data point in case multiple qualifiers are assigned to the data point • Determine the optimal result to be reported for an analyte if multiple results were available for the analyte
Overall Data Usability Assessment – *Level 2b*		√		• Check for data points with multiple qualifiers • Check for analytes with multiple results • Verify that results fall within the calibrated range(s)	• Determine the final data qualifier for a data point in case multiple qualifiers are assigned to the data point • Determine the optimal result to be reported for an analyte if multiple results were available for the analyte • Contact the laboratory via WSDOT Project Manager if discrepancies are identified • Document findings and resolutions
Overall Data Usability Assessment – *Levels 3+4*			√	• Check for data points with multiple qualifiers • Check for analytes with multiple results • If reduced volumes were used, verify that appropriate methods and amounts were used in preparing the samples for analysis • Verify that results fall within the calibrated range(s)	• Determine the final data qualifier for a data point in case multiple qualifiers are assigned to the data point • Determine the optimal result to be reported for an analyte if multiple results were available for the analyte • Contact the laboratory via WSDOT Project Manager if discrepancies are identified • Document findings and resolutions

Table G-5 Notes:
Sources: USEPA, 1983; USEPA, 1996; USEPA, 2010; WSDOT(a); WSDOT(b); WSDOT(c); APHA.

Table G-6 Laboratories and Methods of Analysis for Conventional Chemistry Parameters.

	Parameter	Monitoring Type						Methods	Laboratory (see Table G-1)
		Highways	BMP	Toxicity	Rest Areas	Ferry Terminals	Maintenance Facilities		
Water Samples									
General Chemistry	Total Chloride	R		R	R		R	USEPA 300.0 Rev. 2.1 (1993) (Ion Chromatography)	MEL
General Chemistry	Total Sulfate			O				USEPA 300.0 Rev. 2.1 (1993) (Ion Chromatography)	MEL
General Chemistry	Conductivity[1]	O	O	O	O	O	O	Direct Measure	WSDOT
General Chemistry	Alkalinity as $CaCO_3$			O				SM 2320 B-97 (Titration)	MEL
General Chemistry	Particle Size Distribution (PSD)[6]	O	R	O				ASTM D3977-97/TAPE (Laser Diffraction)	ARI
General Chemistry	pH[1][6]	O	R	O	O	O	O	SM 4500H^+B (Electrometric)	WSDOT
General Chemistry	Temperature[1]	R			R	R	O	Direct measure	WSDOT
General Chemistry	Total Suspended Solids (TSS)	R	R	R	R	R	R	SM 2540D[2] (Filtration & Dry Weight)	MEL
General Chemistry	Dissolved Organic Carbon (DOC)			O				SM 5310B (High Temp. Combustion)	MEL
Microbial	Fecal Coliform	R			R	R		SM 9221E (MPN) or SM 9222D (MF)[3]	MEL AmTest Anatek
Surfactants	Methylene Blue Active Substances (MBAS)			R		R	R	SM 5540C (Cationic Transfer/Spectrophotometry)	AmTest
Surfactants	Cobalt Thiocyanate Active Substances (CTAS)			O				SM 5540D (Cationic and Anionic Transfer/Spectrophotometry)	AmTest
Nutrients	Nitrate/Nitrite[4]				R		IF	SM 4500-NO_3^- I (Cadmium Reduction/Flow Injection)	MEL
Nutrients	Ortho-phosphate (OP)[5]	R	R		R		IF	SM 4500-P G (Flow Injection)	MEL TestAmerica
Nutrients	Total Kjeldahl Nitrogen (TKN)[4]				R		IF	USEPA 351.2 (Semi-Automated Colorimetry)	TestAmerica
Nutrients	Total Phosphorus (TP)[5]	R	R		R		IF	SM 4500-P F (Ascorbic Acid Reduction)	MEL
Toxicity	*H. azteca* 24-hr acute toxicity test[1]			R				ASTM E1192-97 (Acute Toxicity)	NewFields

Table G-6 Laboratories and Methods of Analysis for Conventional Chemistry Parameters (continued).

	Parameter	Monitoring Type: Highways	BMP	Toxicity	Rest Areas	Ferry Terminals	Maintenance Facilities	Methods	Laboratory (see Table G-1)
Sediment Samples									
General Chemistry	Particle Size (grain size)	R						ASTM D422 (Sieve/Hydrometer/Hygroscopic Moisture Analyses)	TestAmerica
General Chemistry	Total Organic Carbon (TOC)	R						PSEP[7]	MEL
General Chemistry	Total Solids (%)	R						SM 2540G (Dry Weight)	MEL

Table G-6 Notes:

R = Required parameter. (Permit-required parameter; parameters are sampled in order of priority as specified in the Permit. This means not all parameters will be sampled for each sampling event if volumes are not adequate to conduct all the analyses.)

IF = Required if conditions listed in the parameter footnote are met.

O = Optional parameter. (Not Permit-required, but included to aid in interpretation of data. The Project Manager will decide whether to collect this data and include data in official documents.)

SM = Standard Methods: http://www.standardmethods.org/

USEPA = United States Environmental Protection Agency Method:
http://water.epa.gov/scitech/methods/cwa/methods_index.cfm

ASTM = American Society of Testing and Materials Method: http://www.astm.org/SITEMAP/index.html

TAPE = Technology Assessment Protocol – Ecology 2008a, *Guidance for Evaluating Emerging Stormwater Treatment Technologies per Washington State Department of Ecology*:
https://fortress.wa.gov/ecy/publications/summarypages/0210037.html

MPN = most probable number

MF = membrane filter

[1] Validation criteria for this parameter are not included in this document.

[2] TAPE (Ecology, 2008a) requires TSS samples not to exceed 500 microns. A US Standard sieve (#35) or equivalent device may be used for sieving at the lab.

[3] 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 membrane filtration with a count of CFU, and Anatek selected SM9221E most probable number with a calculation of CFU. However, laboratories may use the non-preferred method if sample- or condition-specific issues arise.

[4] Required at all Rest Area sites. Required for Maintenance Facility locations where fertilizers are applied on-site, stored on-site, or applied by vehicles parked on-site.

[5] Required at all Highway, BMP, and Rest Area sites. Required for Maintenance Facility locations where fertilizers are applied on-site, stored on-site, or applied by vehicles parked on-site.

[6] Required for shared Highway and BMP monitoring sites for TAPE (Ecology, 2008a) compliance and/or toxicity sampling.

[7] Method is from the USEPA Puget Sound Estuary Protocols document, *Recommended Guidelines for Measuring Organic Compounds in Puget Sound Water, Sediment and Tissue Samples*. April 1997.

Table G-7 Method Quality Objectives for Conventional Chemistry Parameters.

	Parameter	Reporting Limit (RL)	Lab Duplicate[1] (RPD)	Matrix Spike (MS)/MS Duplicate (MSD)[2] (% Rec)	MS/MSD[3] (RPD)	Lab Control Sample (LCS) (% Rec)
Water Samples[4]						
General Chemistry	Total Chloride	0.2 mg/L	≤20%	75-125	≤20%	90-110
General Chemistry	Total Sulfate	0.3 mg/L[7]	≤20%	75-125	≤20%	90-110
General Chemistry	Conductivity[9]	0.01 µS/cm[7]	N/A	N/A	N/A	N/A
General Chemistry	Alkalinity as $CaCO_3$	5 mg/L[7]	≤20%	N/A	N/A	80-120
General Chemistry	Particle Size Distribution (PSD)[10]	N/A	≤20%	N/A	N/A	N/A
General Chemistry	pH[9][10]	0.2 units	≤5%	N/A	N/A	N/A
General Chemistry	Temperature[9]	0.1ºC[7]	N/A	N/A	N/A	N/A
General Chemistry	Total Suspended Solids (TSS)	1.0 mg/L	≤20%	N/A	N/A	80-120
General Chemistry	Dissolved Organic Carbon (DOC)	1.0 mg/L[7]	≤20%	75-125	≤20%	80-120
Microbial	Fecal Coliform	2 min., $2x10^6$ max CFU/100 mL	≤20%	N/A	N/A	N/A
Surfactants	Methylene Blue Active Substances (MBAS)	0.025 mg/L	≤35%	67-133	N/A	80-120
Surfactants	Cobalt Thiocyanate Active Substances (CTAS)	0.05 mg/L[7]	≤20%	80-120	≤20%	80-120
Nutrients	Nitrate/Nitrite[5]	0.01 mg/L	≤20%	75-125	≤20%	80-120
Nutrients	*Ortho*-phosphate (OP)[6]	0.01 mg/L	≤20%	75-125	≤20%	80-120
Nutrients	Total Kjeldahl Nitrogen (TKN)[5]	1.0 mg/L[7]	≤20%	75-125	≤20%	90-110
Nutrients	Total Phosphorus (TP)[6]	0.01 mg/L	≤20%	75-125	≤20%	80-120
Toxicity	*H. azteca* 24-hr acute toxicity test[9]	N/A	N/A	N/A	N/A	N/A
Sediment Samples:[4]						
General Chemistry	Particle Size (grain size)[8]	N/A	≤20% RSD[11]	N/A	N/A	N/A
General Chemistry	Total Organic Carbon (TOC)	0.1%	≤20%	75-125	N/A	80-120
General Chemistry	Total Solids (%)[8]	N/A	≤20%	N/A	N/A	N/A

Table G-7 Notes:

CFU = colony forming units

RSD = relative standard deviation

[1] The relative percent difference (RPD) must be ≤ the indicated percentage for results that are >5x reporting limit (RL). Concentration difference values must be ≤2x RL for values that are ≤5x RL.

[2] For inorganics, the *Contract Laboratory Program Functional Guidelines* states 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] The matrix spike duplicate RPD criteria apply when original and duplicate results are ≥5x RL. Concentration difference of 1x RL applies to precision evaluation if either or both original and duplicate results are <5x RL.

Table G-7 Notes (continued):

[4] Unless otherwise noted, method quality objectives (matrix spike & LCS values) are based on current performance-based statistics provided by the analytical laboratories. The values are subject to change as the laboratories update their performance control limits as required by the accreditation programs.

[5] Required at all Rest Area sites. Required for Maintenance Facility locations where fertilizers are applied on-site, stored on-site, or applied by vehicles parked on-site.

[6] Required at all Highway, BMP, and Rest Area sites. Required for Maintenance Facility locations where fertilizers are applied on-site, stored on-site, or applied by vehicles parked on-site.

[7] The RL used is based on laboratory recommendations on achievable RLs.

[8] The Measurement Quality Objectives (MQOs) were taken from the Ecology, 2008b, Sediment Sampling and Analysis Plan Appendix: www.ecy.wa.gov/pubs/0309043.pdf

[9] Validation criteria for this parameter are not included in this document.

[10] Required for shared Highway and BMP monitoring sites for TAPE (Ecology, 2008a) compliance and/or toxicity sampling.

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

Table G-8 Quantity, Container, Preservation, and Holding Time Requirements for Conventional Chemistry Parameters.

	Parameter	Minimum Quantity Needed for Analysis	Quantity Needed for QC Samples	Container	Preservative[1][2]	Holding Time[3]
Water Samples						
General Chemistry	Total Chloride	100 mL	MS & Dup = 100 mL each	500 mL w/m poly bottle (HDPE)	Cool to ≤6°C[13]	28 days
General Chemistry	Total Sulfate	100 mL	MS & Dup = 100 mL each	500 mL w/m poly bottle (HDPE)	Cool to ≤6˚C	28 days
General Chemistry	Conductivity[4]	300 mL	Dup = 300 mL	500 mL HDPE,[13] glass, or Teflon®	Cool to ≤6˚C	Immediately if direct measure; otherwise, 28 days[13]
General Chemistry	Alkalinity as $CaCO_3$	500 mL (fill bottle full)	Dup = 500 mL	500 mL w/m poly bottle (HDPE)	Cool to ≤6˚C; fill bottle completely, do not agitate sample[13]	14 days
General Chemistry	Particle Size Distribution (PSD)[5]	2 liters	Dup = 2 liters	(2 X 1 liter) HDPE, glass, or Teflon® container	Cool to ≤6˚C	7 days
General Chemistry	pH[4][5]	100 mL (fill bottle full)	Dup = 500 mL	500 mL HDPE,[13] glass, or Teflon®	Cool to ≤6°C[13]	Immediately if direct measure; otherwise, analyze within 15 minutes
General Chemistry	Temperature[4]	N/A	N/A	N/A	N/A	Immediately if direct measure
General Chemistry	Total Suspended Solids (TSS)	1 Liter	Dup = 1 Liter	1 L w/m poly bottle (HDPE)	Cool to ≤6˚C	7 days
General Chemistry	Dissolved Organic Carbon (DOC)	50 mL	MS & Dup = 50 mL each	60 mL n/m poly bottle (HDPE)	Filter;[9] then add 1:1 HCl to pH<2; cool to ≤6°C	28 days
Microbial	Fecal Coliform	250 mL	Dup = 250 mL	250 mL glass or polypropylene autoclaved bottle	Fill the bottle to the shoulder;[8] cool to<10°C	6 hours + 2 hours at the lab
Surfactants	Methylene Blue Active Substances (MBAS)	400 mL	Dup = 400 mL	1L HDPE bottle	Cool to ≤6°C	48 hours
Surfactants	Cobalt Thiocyanate Active Substances (CTAS)	400 mL	Dup = 400 mL	1L HDPE bottle	Cool to ≤6°C	48 hours

Table G-8 Quantity, Container, Preservation, and Holding Time Requirements for Conventional Chemistry Parameters (continued).

	Parameter	Minimum Quantity Needed for Analysis	Quantity Needed for QC Samples	Container	Preservative[1][2]	Holding Time[3]
Nutrients	Nitrate/Nitrite[6]	125 mL	MS & Dup = 125 mL each	125 mL clear w/m poly bottle (HDPE)	H_2SO_4 to pH<2; cool to ≤6°C	28 days
Nutrients	*Ortho*-phosphate (OP)[7]	30 mL	MS & Dup = 125 mL total	125 mL amber w/m poly bottle (HDPE)	Filter within 15 minutes of collection;[9] cool to ≤6°C	48 hours
Nutrients	Total Kjeldahl Nitrogen (TKN)[6]	125 mL	MS & Dup = 125 mL each	125 mL clear w/m poly bottle (HDPE) (do not combine with other nutrients)[13]	H_2SO_4 to pH<2; cool to ≤6°C	28 days
Nutrients	Total Phosphorus (TP)[7]	50 mL	MS & Dup = 50 mL each	60 mL clear n/m poly bottle (HDPE)	$H_2SO_4$to pH<2; cool to ≤6°C	28 days
Toxicity	*H. azteca* 24-hr acute toxicity test[4]	2 liters	none	(4 L) cube container	Cool to ≤6°C	<36 hours; or <72 hours with approval from Ecology
Sediment Samples						
General Chemistry	Particle Size (grain size)	300 wet g	None if jar filled[10]	8 oz plastic jar	Cool to 4˚C; Do not freeze[11]	6 months
General Chemistry	Total Organic Carbon (TOC)	25 wet g	None if jar filled[10]	2 oz glass jar	Cool to 4°C/; May freeze at -18°C at lab[11]	14 days; 6 months if frozen[11]
General Chemistry	Total Solids (%)[12]	10 wet g	None if jar filled[10]	2 oz glass jar	Cool to 4°C/; May freeze at -18°C at lab[11]	7 days; 6 months if frozen[11]

Table G-8 Notes:

w/m = wide mouth
n/m = narrow mouth
MS = matrix spike
MSD = matrix spike duplicate
Dup = laboratory duplicate
QC = quality control
poly = polyethylene or polypropylene

Some of the parameters can be batched in one sample container, e.g., total chloride and sulfate.

[1] Preservation needs to be done in the field, unless otherwise noted. Ice will be used to cool samples to approximately 6°C.
[2] Preservation per 40 CFR 136, edition 7-1-09, unless noted.
[3] Holding times per 40 CFR 136, edition 7-1-09, unless noted.
[4] Validation criteria for this parameter are not included in this document.
[5] Required for shared highway and BMP monitoring sites for TAPE (Ecology, 2008a) compliance and/or toxicity sampling.
[6] Required at all Rest Area sites. Required for Maintenance Facility locations where fertilizers are applied on-site, stored on-site, or applied by vehicles parked on-site.
[7] Required at all Highway, BMP, and Rest Area sites. Required for Maintenance Facility locations where fertilizers are applied on-site, stored on-site, or applied by vehicles parked on-site.
[8] At the lab, a reducing agent may be added as a preservative if an oxidant such as chlorine is present.
[9] 0.45 micron pore size filters.
[10] If the sampling containers are filled ¾ full (for freezing), no additional sample is needed for QC.
[11] Puget Sound Estuary Protocols (USEPA, 1997b).
[12] 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.
[13] Criteria specified in the 2008 MEL document "Manchester Environmental Laboratory, Lab User's Manual, 9th edition."

B – Metals by ICP/AES and ICP/MS Methods

Table G-9 Data Validation Criteria for Metal by ICP/AES and ICP/MS Methods.

QC Parameter *Subelement*	2a	2b	3+4	Acceptance Criteria	Action (use best professional judgment) (-): Nondetected Compounds – (+): Detected Compounds
Holding Times and Sample Management	√	√	√	• Cooler temperature: ≤6°C • Meets preservation and holding time requirements refer to Table G-12	• Cooler temperature >6°C: Transit time <24 hours, no action • Cooler temperature >6°C: Transit time >24 hours, J(+)/UJ(-) if justified • Preservation requirements not met: J(+)/UJ(-) • Holding time not met: J(+)/UJ(-) if justified • Dissolved metals not filtered within 15 minutes but filtered and preserved within 24 hours of collection: H(+/-) • Dissolved metals not filtered and preserved within 24 hours: R(+/-)
Inductively Coupled Plasma-Mass Spectrometry (ICP/MS) Tuning		√	√	• Performed prior to initial calibration • Tuning solution should contain proper tuning elements required by the method • Scan tuning solution at least five times consecutively, and %RSD <5% • Peak widths should be within manufacturer's specification • Mass resolution should be <0.1 AMU	• Tuning analysis not performed: R(+/-) • Tuning analysis not properly performed: Narrate and/or further qualify data • Resolution of mass calibration >0.1 AMU: J(+)/UJ(-) • %RSD >5%: J(+)/UJ(-)
Initial Calibration (ICAL)		√	√	• At least one blank and five standards to establish ICAL curve • Linear regression correlation coefficient (r) >0.995 • y-Axil intercept ≤RL	• ICAL not established: R(+/-) • ICAL not properly established: Narrate and/or further qualify data • r <0.995: J(+)/UJ(-) • y-Axil intercept >RL: J(+)/UJ(-)
Initial Calibration Verification (ICV)		√	√	• Independent source analyzed immediately after calibration • ICV %R = 90-110%	• %R <75%: J(+)/R(-) • %R =75-89%: J(+)/UJ(-) • %R = 111-125%: J(+) • %R >125%: R(+)
Continuing Calibration Verification (CCV)		√	√	• Every ten samples, immediately following ICV/ICB and end of analytical sequence • CCV %R = 90-110%	• CCV not performed properly: Narrate and/or further qualify data • CCV %R <75%: J(+)/R(-) • CCV %R =75-89%: J(+)/UJ(-) • CCV %R = 111-125%: J(+) • CCV %R >125%: R(+)

Table G-9 Data Validation Criteria for Metal by ICP/AES and ICP/MS Methods.

QC Parameter *Subelement*	2a	2b	3+4	Acceptance Criteria	Action (use best professional judgment) (-): Nondetected Compounds – (+): Detected Compounds
Initial Calibration Blank and Continuing Calibration Blank (ICB/CCB)		√	√	Where applicable to method: • After each ICV and CCV every ten samples and end of analytical sequence • ICB/CCB concentration absolute value should be <RL	• ICB/CCB <RL, sample results ≤RL: U at RL • ICB/CCB <RL, sample results >RL: J if sample ≤5x method blank; no action if sample result >5x method blank • ICB/CCB ≥RL, sample result ≤RL: U at RL • ICB/CCB ≥RL: J if sample result >RL but ≤10x blank; no action if sample result >10x blank • ICB/CCB grossly contaminated: R(+/-) • Negative ICB/CCB results: J(+)/UJ(-) if sample result <absolute value of 10x method blank
Blanks – *Preparation Method Blank*	√	√	√	• One per matrix per batch (not to exceed 20 samples) • Less than RL, or all associated sample results >10x the detection in the method blank	• Method blank result <RL, sample results ≤RL: U at RL • Method blank result <RL, sample results >RL: J if sample ≤5x method blank; no action if sample result >5x method blank • Method blank result ≥RL, sample result ≤RL: U at RL • Method blank result ≥RL: J if sample result >RL but ≤10x method blank; no action if sample result >10 method blank • Method blank grossly contaminated: R(+/-) • Negative method blank results: J(+)/UJ(-) if sample result < absolute value of 10x method blank
Blanks – *Field Blank Equipment Rinsate Blank*	√	√	√	• Frequency as per project QAPP or as needed	• Same as method blank
Multiple Results for One Sample	√	√	√	• Report only one result per analyte	• "DNR" results that should not be used to avoid reporting multiple results for one sample
Inductively Coupled Plasma (ICP) Interference Check Sample – *Interference Check Sample Solution A (ICSA) and Interference Check Sample Solution AB (ICSAB)*		√	√	• Beginning and end of each analytical sequence or every 8 hours • ICSAB %R 80%-120% • ICSA Absolute value < RL	• For samples with Al, Ca, Fe, and Mg >ICSA levels only • R(+/-) if %R <50% • J(+) if %R > 120% • J(+)/UJ(-) if %R= 50% to 79%

Table G-9 Data Validation Criteria for Metal by ICP/AES and ICP/MS Methods.

QC Parameter *Subelement*	2a	2b	3+4	Acceptance Criteria	Action (use best professional judgment) (-): Nondetected Compounds – (+): Detected Compounds
Matrix Spike (MS), Matrix Spike Duplicate (MSD), or Post-Digestion Spike (PS) – *Recovery*	√	√	√	• If matrix spike performed, post-digestion spike is required • Refer to Table G-11 for specific control criteria • No action if sample result >4x spiking level • If matrix spike %R is outside 75-125%, perform post-digestion spike at 2x the sample concentration	• If PS not performed with MS, then narrate • Determine if all samples in the same batch should be qualified • If lack of accuracy measurement associated with sample analysis, J(+)/UJ(-) all samples in the batch • MS %R <30% and PS not performed or PS %R <75%: J(+)/R(-) • MS%R <30% and PS %R >75%: J(+)/UJ(-) • %R ≥ 30% but <75%: J(+)/UJ(-) • %R >125%: J(+)
MS/MSD, Laboratory Duplicate, or Laboratory Control Sample (LCS)/Laboratory Control Sample Duplicate (LCSD) – *RPD*	√	√	√	• Frequency: One MS/MSD, MS/Laboratory Duplicate, or LCS/LCS per matrix per batch • RPD <20% for samples >5x RL • Difference <RL for samples >RL and <5x RL (RPD <35%, Diff <2x RL for solids)	• Narrate if frequency not met • Use professional judgment whether all samples in the same batch should be qualified • If lack of precision measurements associated with sample analysis, J(+)/UJ(-) all samples in the batch • RPD or concentration difference outside control criteria: J(+)/UJ(-)
LCS, LCSD, and/or Standard Reference Material (SRM) – *Recovery*	√	√	√	• One per matrix per batch • Refer to Table G-10 for specific control criteria	• %R <LCL: J(+)/R(-) • %R > UCL: J(+) • If %R <50%: R(+/-)
Serial Dilution		√	√	• Perform a 5x dilution on one sample per matrix per batch • %D for the original and diluted analysis should be <10% for original sample concentration >50x MDL (ICP); >100x MDL (ICP/MS)	• J(+)/UJ(-) if %D >10% and the analyte concentration is >50x MDL (ICP) or >100x MDL (ICP/MS)
Internal Standards – *ICP/MS*		√	√	• Proper number of internal standards - Li (the Li6 isotope); Sc; Y; Rh; Tb; Ho; Lu; or Bi are added to all field and laboratory quality control samples • The Percent Relative Intensity (%RI) in the sample shall fall within 60-125% of the response in the calibration blank	• Internal standards not added to samples: R(+/-) • %RI outside the 60-125% limit: J(+)/UJ(-)

Table G-9 Data Validation Criteria for Metal by ICP/AES and ICP/MS Methods.

QC Parameter *Subelement*	2a	2b	3+4	Acceptance Criteria	Action (use best professional judgment) (-): Nondetected Compounds – (+): Detected Compounds
Field Duplicates	√	√	√	• Solids: RPD <50% or absolute difference <2x RL (for results <5x RL) • Aqueous: RPD <35% or absolute difference <1x RL (for results <5x RL)	• Criteria not met: J(+)/UJ(-) in both samples
Reporting Limit Check Sample Analysis (CRA)		√	√	• 2x RL analyzed at beginning of analytical sequence • Not required for Al, Ba, Ca, Fe, Mg, Na, K • %R = 70%-130% (50%-150% Sb, Pb, Tl)	• R(-)/J(+) <2x RL if %R <50% (<30% Sb, Pb, Tl) • J(+) <2x RL, UJ(-) if %R 50-69% (30%-49% Sb, Pb,Tl) • J(+) <2x RL if %R 130%-180% (150%-200%Sb, Pb, Tl) • R(+) <2x RL if %R >1 80% (200% Sb, Pb, Tl)
Project Reporting Limits (RL)	√	√	√	• Reported RL should be ≤RL listed in Table G-11, unless justified to raise the RL	• Narrate if analyte is not detected and the reported RL exceeded those listed in Table G-11 • If RL is raised as a result of dilution or matrix effects, evaluate if the dilution is justified; document the finding and resolution in Data Validation Report
Target Analyte Quantitation			√	• If reduced volumes were used, verify that appropriate methods and amounts were used in preparing the samples for analysis • Perform recalculation on ICAL, CCV, QC analyses, and sample results to verify that there are no transcription or reduction errors (dilutions, percent solids [%S], sample weights, etc.) on one or more samples	• Contact the laboratory via WSDOT Project Manager if discrepancies are identified • Document findings and resolutions
System Performance			√	• Examine the raw data for any anomalies (baseline shifts, negative absorbance, omissions, illegibility, etc.)	• Determine if there is any need to qualify data that are not qualified based on the QC criteria previously discussed • Contact the laboratory via WSDOT Project Manager if discrepancies are identified • Document findings and resolutions
Overall Data Usability Assessment – *Level 2a*	√			• Check for data points with multiple qualifiers • Check for analytes with multiple results	• Determine the final data qualifier for a data point in case multiple qualifiers are assigned to the data point • Determine the optimal result to be reported for an analyte if multiple results were available for the analyte

Table G-9 Data Validation Criteria for Metal by ICP/AES and ICP/MS Methods.

QC Parameter *Subelement*	2a	2b	3+4	Acceptance Criteria	Action (use best professional judgment) (-): Nondetected Compounds – (+): Detected Compounds
Overall Data Usability Assessment – *Level 2b*		√		• Check for data points with multiple qualifiers • Check for analytes with multiple results • Verify that results fall within the calibrated range(s)	• Determine the final data qualifier for a data point in case multiple qualifiers are assigned to the data point • Determine the optimal result to be reported for an analyte if multiple results were available for the analyte • Contact the laboratory via WSDOT Project Manager if discrepancies are identified • Document findings and resolutions
Overall Data Usability Assessment – *Level 3+4*			√	• Check for data points with multiple qualifiers • Check for analytes with multiple results • Verify that results fall within the calibrated range(s)	• Determine the final data qualifier for a data point in case multiple qualifiers are assigned to the data point • Determine the optimal result to be reported for an analyte if multiple results were available for the analyte • Contact the laboratory via WSDOT Project Manager if discrepancies are identified • Document findings and resolutions

Table G-9 Notes:
Sources: USEPA, 1983; USEPA, 1996; USEPA, 2010; WSDOT(a); WSDOT(b); WDSDOT(c).

Table G-10 Laboratories and Methods of Analysis for Metals

	Parameter	Monitoring Type: Highways	BMP	Toxicity	Rest Areas	Ferry Terminals	Maintenance Facilities	Methods	Laboratory (see Table G-1)
Water Samples									
Metals	Dissolved Cadmium (Cd)	R		R	R	R	R	USEPA 200.8 (ICP/MS)	MEL
	Dissolved Copper (Cu)	R	R	R	R	R	R		
	Dissolved Lead (Pb)	R		R	R	R	R		
	Dissolved Zinc (Zn)	R	R	R	R	R	R		
	Dissolved Calcium (Ca)			O				USEPA 200.7 Rev. 4.4 (1994) (ICP/AES)	
	Dissolved Magnesium (Mg)			O					
	Dissolved Sodium (Na)			O					
	Dissolved Potassium (K)			O					
	Total Cadmium (Cd)	R		R	R	R	R	USEPA 200.8 (ICP/MS)	
	Total Copper (Cu)	R	R	R	R	R	R		
	Total Lead (Pb)	R		R	R	R	R		
	Total Zinc (Zn)	R	R	R	R	R	R		
Inorganics	Hardness as $CaCO_3$	O	R	R	O	O	O	SM 2340B (ICP/AES and calculation)	
Sediment Samples									
Metals	Total Cadmium (Cd)	R						USEPA 200.8 (ICP/MS)	MEL
	Total Copper (Cu)	R							
	Total Lead (Pb)	R							
	Total Zinc (Zn)	R							

Table G-10 Notes:

R = Required parameter. (Permit-required parameter; parameters are sampled in order of priority as specified in the Permit. This means not all parameters will be sampled for each sampling event if volumes are not adequate to conduct all the analyses.)

IF = Required conditions listed in the parameter footnote are met.

O = Optional parameter. (Not Permit-required, but included to aid in interpretation of data. The Project Manager will decide whether to collect this data and include data in official documents.)

SM = Standard Methods: http://www.standardmethods.org/

USEPA = United States Environmental Protection Agency Method:
http://water.epa.gov/scitech/methods/cwa/methods_index.cfm

ICP/AES = inductively coupled plasma-atomic emission spectrometry

ICP/MS = inductively coupled plasma-mass spectrometry

Table G-11 Method Quality Objectives for Metals.

	Parameter	Reporting Limit (RL)	Lab Duplicate[1] (RPD)	Matrix Spike (MS)/MS Duplicate (MSD)[2] (% Rec)	MS/MSD[3] (RPD)	Lab Control Sample (LCS) (% Rec)
Water Samples[4]						
Metals	Dissolved Cadmium (Cd)	0.1 µg/L	≤20%	75-125	≤20%	85-115
	Dissolved Copper (Cu)	0.1 µg/L	≤20%	75-125	≤20%	85-115
	Dissolved Lead (Pb)	0.1 µg/L	≤20%	75-125	≤20%	85-115
	Dissolved Zinc (Zn)	5.0 µg/L[5]	≤20%	75-125	≤20%	85-115
	Dissolved Calcium (Ca)	0.025 mg/L[5]	≤20%	75-125	≤20%	85-115
	Dissolved Magnesium (Mg)	0.025 mg/L[5]	≤20%	75-125	≤20%	85-115
	Dissolved Sodium (Na)	0.025 mg/L[5]	≤20%	75-125	≤20%	85-115
	Dissolved Potassium (K)	0.25 mg/L[5]	≤20%	75-125	≤20%	85-115
	Total Cadmium (Cd)	0.2 µg/L	≤20%	75-125	≤20%	85-115
	Total Copper (Cu)	0.1 µg/L	≤20%	75-125	≤20%	85-115
	Total Lead (Pb)	0.1 µg/L	≤20%	75-125	≤20%	85-115
	Total Zinc (Zn)	5.0 µg/L	≤20%	75-125	≤20%	85-115
Inorganics	Hardness as $CaCO_3$	1.0 mg/L	≤20%	75-125	≤20%	85-115
Sediment Samples[4]						
Metals	Total Cadmium (Cd)	0.1 mg/Kg dry	≤20%	75-125	≤20%	85-115
	Total Copper (Cu)	0.1 mg/Kg dry	≤20%	75-125	≤20%	85-115
	Total Lead (Pb)	0.1 mg/Kg dry	≤20%	75-125	≤20%	85-115
	Total Zinc (Zn)	5.0 mg/Kg dry	≤20%	75-125	≤20%	85-115

Table G-11 Notes:

[1] The relative percent difference (RPD) must be ≤ the indicated percentage for results that are >5x reporting limit (RL). Concentration difference values must be ≤2x RL for values that are ≤5x RL.

[2] The *Contract Laboratory Program Functional Guidelines* states 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] The matrix spike duplicate RPD criteria apply when original and duplicate results are ≥5x RL. Concentration difference of 1x RL applies to precision evaluation if either or both original and duplicate results are <5x RL.

[4] Method quality objectives (matrix spike & LCS values) are based on *Contract Laboratory Program Functional Guidelines* for inorganic data review (USEPA, 2010).

[5] The RL used is based on laboratory recommendations on achievable RLs.

Table G-12 Quantity, Container, Preservation, and Holding Time Requirements for Metals.

	Parameter	Minimum Quantity Needed for Analysis	Quantity Needed for QC Samples	Container	Preservative[1][2]	Holding Time[3]
Water Samples						
Metals	Dissolved Cadmium (Cd)	100 mL	MS & Dup = 100 mL each	500 mL HDPE bottle[4] with Teflon® lid	Filter within 15 minutes of collection;[5] then add HNO_3 to pH <2;[6] cool to ≤6°C[8]	6 months
	Dissolved Copper (Cu)	100 mL	MS & Dup = 100 mL each	500 mL HDPE bottle[4] with Teflon® lid	Filter within 15 minutes of collection;[5] then add HNO_3 to pH <2;[6] cool to ≤6°C[8]	6 months
	Dissolved Lead (Pb)	100 mL	MS & Dup = 100 mL each	500 mL HDPE bottle[4] with Teflon® lid	Filter within 15 minutes of collection;[5] then add HNO_3 to pH <2;[6] cool to ≤6°C[8]	6 months
	Dissolved Zinc (Zn)	100 mL	MS & Dup = 100 mL each	500 mL HDPE bottle[4] with Teflon® lid	Filter within 15 minutes of collection;[5] then add HNO_3 to pH <2;[6] cool to ≤6°C[8]	6 months
	Dissolved Calcium (Ca)	100 mL	MS & Dup = 100 mL each	500 mL HDPE bottle[4] with Teflon® lid	Filter within 15 minutes of collection;[5] then add HNO_3 to pH <2;[6] cool to ≤6°C[8]	6 months
	Dissolved Magnesium (Mg)	100 mL	MS & Dup = 100 mL each	500 mL HDPE bottle[4] with Teflon® lid	Filter within 15 minutes of collection;[5] then add HNO_3 to pH <2;[6] cool to ≤6°C[8]	6 months
	Dissolved Sodium (Na)	100 mL	MS & Dup = 100 mL each	500 mL HDPE bottle[4] with Teflon® lid	Filter within 15 minutes of collection;[5] then add HNO_3 to pH <2;[6] cool to ≤6°C[8]	6 months
	Dissolved Potassium (K)	100 mL	MS & Dup = 100 mL each	500 mL HDPE bottle[4] with Teflon® lid	Filter within 15 minutes of collection;[5] then add HNO_3 to pH <2;[6] cool to ≤6°C[8]	6 months
	Total Cadmium (Cd)	100 mL	MS & Dup = 100 mL each	500 mL HDPE bottle[4] with Teflon® lid	HNO_3 to pH <2;[6] cool to ≤6°C[8]	6 months
	Total Copper (Cu)	100 mL	MS & Dup = 100 mL each	500 mL HDPE bottle[4] with Teflon® lid	HNO_3 to pH <2;[6] cool to ≤6°C[8]	6 months
	Total Lead (Pb)	100 mL	MS & Dup = 100 mL each	500 mL HDPE bottle[4] with Teflon® lid	HNO_3 to pH <2;[6] cool to ≤6°C[8]	6 months
	Total Zinc (Zn)	100 mL	MS, & Dup = 100 mL each	500 mL HDPE bottle[4] with Teflon® lid	HNO_3 to pH <2;[6] cool to ≤6°C[8]	6 months
Inorganics	Hardness as $CaCO_3$	100 mL	Dup = 100 mL	125 mL w/m polypropylene bottle	H_2SO_4 to pH<2; cool to ≤6°C[8]	6 months

Table G-12 Quantity, Container, Preservation, and Holding Time Requirements for Metals (continued).

	Parameter	Minimum Quantity Needed for Analysis	Quantity Needed for QC Samples	Container	Preservative[1][2]	Holding Time[3]
Sediment Samples						
Metals	Total Cadmium (Cd)	10 wet g	None if jar filled[7]	4 oz glass jar[4]	Cool to ≤6°C[8]	6 months
	Total Copper (Cu)	10 wet g	None if jar filled[7]	4 oz glass jar[4]	Cool to ≤6°C[8]	6 months
	Total Lead (Pb)	10 wet g	None if jar filled[7]	4 oz glass jar[4]	Cool to ≤6°C[8]	6 months
	Total Zinc (Zn)	10 wet g	None if jar filled[7]	4 oz glass jar[4]	Cool to ≤6°C[8]	6 months

Table G-12 Notes:
QC = quality control
w/m = wide mouth
n/m = narrow mouth
MS = Matrix spike
MSD = Matrix spike duplicate
Dup = Laboratory duplicate

Only 500 mL for an aqueous sample and 100 g for a solid sample is needed for multiple metals analyses on one sample.

[1] Preservation needs to be done in the field, unless otherwise noted. Ice will be used to cool samples to approximately 6°C.
[2] Preservation per 40 CFR 136, edition 7-1-09, unless noted.
[3] Holding times per 40 CFR 136, edition 7-1-09, unless noted.
[4] Containers cleaned in accordance with OSWER Cleaning Protocol #9240.0-05 (MEL, 2008).
[5] Filtered with a 0.45 µm mesh membrane.
[6] Preserved in lab within 24 hours of arrival.
[7] If the sampling containers are filled ¾ full (for freezing), no additional sample is needed for QC.
[8] Criteria specified in the 2008 MEL document "Manchester Environmental Laboratory, Lab User's Manual, 9th edition."

C – Organic Parameters by GC and HPLC Methods

Table G-13 Data Validation Criteria for Organic Parameters by GC and HPLC Methods.

QC Element *Subelement*	2a	2b	3+4	Acceptance Criteria	Action (use best professional judgment) (-): Nondetected Compounds – (+): Detected compounds
Holding Times and Sample Management	√	√	√	• Cooler temperature: <6°C • Refer to Table G-16 for preservation and holding time requirements	• Cooler temperature >6°C: Transit time <24 hours, no action • Cooler temperature >6°C: Transit time >24 hours, J(+)/UJ(-) or J(+)/R(-) as justified • Cooler temperature >15°C for TPH-Gasoline: J(+)/R(-) • Preservation requirements not met: J(+)/UJ(-) or J(+)/R(-) as justified, based on type of analyte and required holding time • Holding time ≤2x required holding time: J(+)/UJ(-) • Holding time >2x required holding time: R(+/-)
Initial Calibration (ICAL)		√	√	• Established with 5 standards at minimum (6 standards if quadratic fit is used) • %RSD<20% for average response factor or average calibration factor • Linear regression correlation coefficient (r) >0.995 • Coefficient of Determination (r^2 value) >0.99 for non-linear (quadratic) fit • For methods NWTPH-Dx and NWTPH-Gx, %D for each standard should stay within ±15% of the true value	• ICAL not established: R(+/-) • ICAL not properly established: Narrate and/or further qualify data • J(+) if %RSD >20%, r-value <0.99, or r^2 value <0.99 • Use professional judgment if %D outside criteria (±15% of the true value), based on sample results and CCV recovery
Continuing Calibration Verification (CCV)		√	√	• Percent difference (%D) or percent drift (%Df) within ±20%, or %R = 80-120% • For method NWTPH-Dx, %D and %Df should be within ±15%, or %R = 85-115%	• CCV not performed properly: Narrate and/or use professional judgment to further qualify data • J(+) if %D, %Df, or %R >UCL • J(+)/UJ(-) if %D, %Df, or %R <LCL

Table G-13 Data Validation Criteria for Organic Parameters by GC and HPLC Methods.

QC Element *Subelement*	2a	2b	3+4	Acceptance Criteria	Action (use best professional judgment) (-): Nondetected Compounds – (+): Detected compounds
Blanks – *Method Blank* *Trip Blank* *Field Blank* *Instrument Blank* *Equipment Rinsate Blank*	√	√	√	• One method blank per matrix per batch (less than 20 samples) • Detection <RL	• Blank <RL, sample <RL: U at the RL • Blank <RL, sample >RL but <5x blank detection: J • Blank ≥ RL, sample <RL: U at the RL • Blank ≥ RL, sample ≥RL but <blank detection: U • Blank ≥ RL, sample ≥RL but <5x blank detection: J • Blank ≥ RL, sample ≥5x blank detection: No action
Surrogate Spikes	√	√	√	• Added to every field and QC samples • Within control limits, refer to Table G-15	• J(+)/UJ(-) If %R <LCL • J(+) If > UCL J(+)/R(-) if any %R <10% • No action if 2 or more surrogates are used and only one is <LCL or >UCL • No action if %R is outside control limit due to demonstrated matrix effects (e.g., high target and/or non-target chemical levels, acceptable dilution analysis)
Multiple Results for One Sample	√	√	√	Report only one result per analyte	• "DNR" results that should not be used to avoid reporting multiple results for one sample
Matrix Spike (MS) or Matrix Spike Duplicate (MSD) – *Recovery*	√	√	√	• Perform as requested • Refer to Table G-15 for control limits	• Qualify parent sample only unless other QC indicates systematic problems • J(+) if both %R >UCL • J(+)/UJ(-) if both %R <LCL • J(+)/R(-) if both %R <10% • No action if only one %R outlier and %R deviation from control limit is <10% • No action if parent sample concentration >5x the amount spiked
MS/MSD or Laboratory Duplicate – *RPD*	√	√	√	• Perform as requested • Refer to Table G-15 for control limits	• Qualify parent sample only unless other QC indicates systematic problems • J(+) if RPD (or absolute concentration difference) >control limit
Laboratory Control Sample, Laboratory Control Sample Duplicate, and/or Standard Reference Material (SRM) – *Recovery*	√	√	√	• One set per matrix per batch unless MS/MSD are performed • Refer to Table G-15 for control limits	• Qualify all samples in the batch • J(+) if both %R >UCL • J(+)/UJ(-) if both %R <LCL • J(+)/R(-) if both %R <10% • No action if only one %R outlier and %R deviation from control limit is <10%
LCS/LCSD – *RPD*	√	√	√	• One set per matrix per batch unless MS/MSD are performed • Refer to Table G-15 for control limits	• Qualify all samples in the batch • J(+)/UJ(-) if RPD (or absolute concentration difference) >control limit

Table G-13 Data Validation Criteria for Organic Parameters by GC and HPLC Methods.

QC Element *Subelement*	2a	2b	3+4	Acceptance Criteria	Action (use best professional judgment) (-): Nondetected Compounds – (+): Detected compounds
Internal Standards (if used)		√	√	• Internal standard area within 50% to 200% of that for CCV	• J(+) if internal standard >100% • J(+)/UJ(-) if internal standard <50% • J(+)/R(-) if internal standard <25%
Field Duplicates	√	√	√	Solids: • RPD <50% or absolute difference <2x RL (for results <5x RL) • Aqueous: • RPD <35% or absolute difference <1x RL (for results <5x RL)	• If control criteria not met: J(+)/UJ(-)
Project Reporting Limits (RL)	√	√	√	• Reported RL should be ≤RL listed in Table G-15, unless justified to raise the RL	• Narrate if analyte is not detected and the reported RL exceeded those listed in Table G-16 • If RL is raised as a result of dilution or matrix effects, evaluate if the dilution or interference is justified. Document the finding and resolution in Data Validation Report
Target Compound Identification			√	• Analyte within RTW on both columns • Quantitated using ICAL response calibration factor • Higher value from either column reported • %D between columns (40%)	• J(+) if RPD>40% • R(+) if retention time window criterion not met • NJ(+) if no confirmation with second column or second analysis (not applicable for NWTPH-Dx and NWTPH-Gx)
Target Compound Quantitation			√	• Perform re-calculation on ICAL, CCV, QC analyses, and sample results to verify that there are no transcription or reduction errors (dilutions, percent solids [%S]), sample weights, etc.) on one or more samples	• Contact the laboratory via WSDOT Project Manager if discrepancies are identified • Document findings and resolutions
System Performance			√	• Examine the raw data for any anomalies (baseline shifts, negative absorbance, omissions, illegibility, etc.)	• Determine if there is any need to qualify data that are not qualified based on the QC criteria previously discussed • Contact the laboratory via WSDOT Project Manager if discrepancies are identified • Document findings and resolutions
Overall Data Usability Assessment – *Level 2a*	√			• Check for data points with multiple qualifiers • Check for analytes with multiple results	• Determine the final data qualifier for a data point in case multiple qualifiers are assigned to the data point • Determine the optimal result to be reported for an analyte if multiple results were available for the analyte

Table G-13 Data Validation Criteria for Organic Parameters by GC and HPLC Methods.

QC Element *Subelement*	2a	2b	3+4	Acceptance Criteria	Action (use best professional judgment) (-): Nondetected Compounds – (+): Detected compounds
Overall Data Usability Assessment – *Level 2b*		√		• Check for data points with multiple qualifiers • Check for analytes with multiple results • Verify that results fall within the calibrated range(s) • Verify that the RL is supported with adequate concentration of ICAL standards (RL should be ≥lowest concentration of ICAL standards)	• Determine the final data qualifier for a data point in case multiple qualifiers are assigned to the data point • Determine the optimal result to be reported for an analyte if multiple results were available for the analyte • Contact the laboratory via WSDOT Project Manager if discrepancies are identified • Document findings and resolutions
Overall Data Usability Assessment – *Level 3+4*			√	• Check for data points with multiple qualifiers • Check for analytes with multiple results • Verify all retention times (RTs) are within the determined RT window • If reduced volumes were used, verify that appropriate methods and amounts were used in preparing the samples for analysis • Verify that results fall within the calibrated range(s) • Verify that the RL is supported with adequate concentration of ICAL standards (RL should be ≥lowest concentration of ICAL standards)	• Determine the final data qualifier for a data point in case multiple qualifiers are assigned to the data point • Determine the optimal result to be reported for an analyte if multiple results were available for the analyte • Determine if there is any need to qualify data that are not qualified based on the QC criteria previously discussed • Contact the laboratory via WSDOT Project Manager if discrepancies are identified • Document findings and resolutions

Table G-13 Notes:
Sources: USEPA, 1990; USEPA, 1996; USEPA, 2008; WSDOT(a); WSDOT(b); WDSDOT(c); Ecology, 1997; APHA.

Table G-14 Laboratories and Methods of Analysis for Organic Parameters by GC and HPLC Methods.

	Parameter	Monitoring Type: Highways	BMP	Toxicity	Rest Areas	Ferry Terminals	Maintenance Facilities	Method	Laboratory (see Table G-1)
Water Samples									
Organics	Total Petroleum Hydrocarbon (TPH)- Diesel (NWTPH-Dx)	R		R	R	R	R	NWTPH-Dx – Ecology, 1997 Publication No. 97-602 (GC/FID)(GC/MS)(GC/AED)	MEL
Organics	TPH-Gas (NWTPH-Gx)	R		R	R	R	R	NWTPH-Gx – Ecology, 1997 Publication No. 97-602 (GC/FID)(GC/PID)(GC/MS)(GC/AED)	MEL TestAmerica
Organics	Herbicides – Glyphosate[1] (nonaquatic formula)	IF		IF	IF		IF	USEPA 547 (HPLC)	TestAmerica
Sediment Samples									
Organics	TPH-Diesel (NWTPH-Dx)	R						NWTPH-Dx – Ecology, 1997 Publication No. 97-602 (GC/FID)(GC/MS)(GC/AED)	MEL

Table G-14 Notes:

R = Required parameter. (Permit-required parameter; parameters are sampled in order of priority as specified in the Permit. This means not all parameters will be sampled for each sampling event if volumes are not adequate to conduct all the analyses.)

IF = Required conditions listed in the parameter footnote are met.

O = Optional parameter. (Not Permit-required, but included to aid in interpretation of data. The Project Manager will decide whether to collect this data and include data in official documents.)

USEPA = United States Environmental Protection Agency Method:
http://water.epa.gov/scitech/methods/cwa/methods_index.cfm

Ecology = Washington State Department of Ecology Method: http://www.ecy.wa.gov/biblio/97602.html (Ecology, 1997); USEPA 1997

[1] Required at Highway and Toxicity locations where herbicides listed are applied near the monitoring site vicinity. Required for Maintenance Facility locations where herbicides listed are applied or stored on-site, or applied by vehicles parked on-site.

Table G-15 Method Quality Objectives for Organic Parameters by GC and HPLC Methods.

	Parameter	Reporting Limit	Lab Duplicate[1] (RPD)	MS/MSD (% Rec)	MS/MSD[2] (RPD)	LCS/Surrogate Spike (% Rec)
Water Samples[5]						
Organics	**Total Petroleum Hydrocarbon (TPH):**					
	TPH-Gas (NWTPH-Gx)	0.25 ug/L	≤40%	70-130	≤40%	70-130
	TPH-Gasoline Surrogates:					
	1,4-Difluorobenzene	N/A	N/A	N/A	N/A	70-130
	1,4-dibromo-2-methyl-Benzene	N/A	N/A	N/A	N/A	70-130
	Trifluorotoluene[6]	N/A	N/A	N/A	N/A	50-150
	4-Bromofluorobenzene[6]	N/A	N/A	N/A	N/A	50-150
	TPH- Diesel (NWTPH-Dx)	0.50 ug/L	≤40%	70-130	≤40%	70-130
	TPH-Diesel Surrogates:					
	Pentacosane	N/A	N/A	N/A	N/A	50-150
	Herbicide:					
	Glyphosate[3] (nonaquatic formula)	25 ug/L[4]	≤30%	70-130	≤30%	70-130
Sediment Samples						
Organics	**TPH:**					
	TPH-Diesel (NWTPH-Dx)	25.0-100.0 mg/Kg dry[5]	N/A	N/A	N/A	70-130
	TPH Diesel Surrogate:					
	Pentaconsane	N/A	N/A	N/A	N/A	50-150

Table G-15 Notes:

[1] The relative percent difference (RPD) must be ≤ the indicated percentage for results that are >5x reporting limit (RL). Concentration difference values must be ≤2x RL for values that are ≤5x RL.

[2] The matrix spike duplicate RPD criteria apply when original and duplicate results are ≥5x RL. Concentration difference of 1x RL applies to precision evaluation if either or both original and duplicate results are <5x RL.

[3] Required at Highway and Toxicity locations where herbicides listed are applied near the monitoring site vicinity. Required for Maintenance Facility locations where herbicides listed are applied or stored on-site, or applied by vehicles parked on-site.

[4] Results for glyphosate analysis between the RL of 25 ug/L and method detection limit (MDL) of 2.5 ug/L will be reported. These results will be qualified as estimates.

[5] Method quality objectives (matrix spike & LCS values) are based on current performance-based statistics provided by the analytical laboratories. The values are subject to change as the laboratories update their performance control limits as required by the accreditation programs.

[6] TPH-Gasoline surrogates used by TestAmerica only.

Table G-16 Quantity, Container, Preservation, and Holding Time Requirements for Organic Parameters by GC and HPLC Methods.

	Parameter	Minimum Quantity Needed for Analysis	Quantity Needed for QC Samples	Container	Preservative[1][2]	Holding Time[3]
Water Samples						
Organics	Total petroleum hydrocarbon (TPH)-Diesel (NWTPH-Dx)	1 Liter	Dup = 1 Liter	1 liter amber n/m glass jar with Teflon® lined lids	Cool & store at 4˚C; holding time to extraction increased if HCl to pH=2[6]	14 days to extraction for preserved water; 7 days to extraction for unpreserved water[6]
Organics	TPH-Gas (NWTPH-Gx)	120 mL (fill vials full)	Dup = 120 mL	(3) 40 mL glass VOA vials with Teflon® coated septum-lined screw tops	Cool & store at 4˚C; holding time to extraction increased if HCl to pH=2[6]	14 days to extraction for preserved water; 7 days to extraction for unpreserved water[6]
Organics	Glyphosate[4] (nonaquatic formula)	60 mL	MS = 60 mL MSD= 60 mL	60 mL screw cap glass bottles with a Teflon® faced silicone septa	Cool to ≤6°C[5]; store in dark; pH 5-9 unless extracted within 72 hours of collection	7 days until extraction; 40 days after extraction
Sediment Samples						
Organics	TPH-Diesel (NWTPH-Dx)	100 wet g	None if jar filled	8 oz glass jar	Cool to ≤6˚C; May freeze at -18°C at lab[6]	14 days until extraction (1 yr. if stored frozen at -18°C); 40 days after extraction[6]

Table G-16 Notes:
w/m = wide mouth
n/m = narrow mouth
MS = matrix spike
MSD = matrix spike duplicate
Dup = laboratory duplicate
QC = quality control

[1] Preservation needs to be done in the field, unless otherwise noted. Ice will be used to cool samples to approximately 6°C.
[2] Preservation per 40 CFR 136, edition 7-1-09, unless noted.
[3] Holding times per 40 CFR 136, edition 7-1-09, unless noted.
[4] Required at Highway and Toxicity locations where herbicides listed are applied near the monitoring site vicinity. Required for Maintenance Facility locations where herbicides listed are applied or stored on-site, or applied by vehicles parked on-site.
[5] At the lab, a reducing agent may be added as a preservative if an oxidant such as chlorine is present.
[6] Preservation per Ecology, 1997 Publication No. 97-602 Washington State Department of Ecology Method: http://www.ecy.wa.gov/biblio/97602.html; USEPA, 1997

D – Semi-Volatile Organic Compounds by GC/MS and HPLC/MS Methods

Table G-17 Data Validation Criteria for Semi-Volatile Organic Compounds by GC/MS and HPLC/MS Methods.

QC Element	2a	2b	3+4	Acceptance Criteria	Action (use best professional judgment) (-): Nondetected Compounds – (+): Detected Compounds
Holding Times and Sample Management	√	√	√	• Cooler temperature: <6°C • Refer to Table G-20 for preservation and holding time requirements	• Cooler temperature >6°C: Transit time <24 hours, no action • Cooler temperature >6°C: Transit time >24 hours: J(+)/UJ(-) or J(+)/R(-) as justified, based on type of analyte and holding time • Preservation requirements not met: J(+)/UJ(-) or J(+)/R(-) as justified, based on type of analyte and required holding time • Holding time ≤2x required holding time: J(+)/UJ(-) • Holding time >2x required holding time: R(+/-)
Gas Chromatography Coupling with Mass Spectrometry (GC/MS) or High-Performance Liquid Chromatography with Mass Spectrometry (HPLC/MS) Instrument Tuning		√	√	• DFTPP for GC/MS • Polyethylene glycol or equivalent for HPLC/MS • Beginning of each 12-hour period • Method or manufacturer acceptance criteria	• Tune analysis not performed: R(+/-) all analytes in all samples • Tune result did not meet criteria: Use professional judgment
Initial Calibration (ICAL)		√	√	• Established with 5 standards at minimum • %RSD<20% for average response factor (RF) or average calibration factor • Correlation coefficient (r value) >0.99 for linear regression • Coefficient of determination (r2 value) >0.99 for nonlinear (quadratic) fit • RF >0.05 • A mid-point second source standard (ICV) be analyzed immediately after ICAL; percent difference (%D) should be within ±30%	• J(+) if %RSD >20%, r value <0.99, or r2 value <0.99 • ICV %D <LCL: J(+)/UJ(-) • ICV %D >UCL: J(+) • Use professional judgment if RF <0.05, based on sample results and CCV recovery; no action if sample detected and CCV acceptable

Table G-17 Data Validation Criteria for Semi-Volatile Organic Compounds by GC/MS and HPLC/MS Methods.

QC Element	2a	2b	3+4	Acceptance Criteria	Action (use best professional judgment) (-): Nondetected Compounds – (+): Detected Compounds
Initial Calibration Verification (ICV)		√	√	• ICV performed • Percent difference (%D) or percent drift (%D_f) within ±30%, or %R = 70-130%	• Narrate if ICV not performed • J(+) if %D, %Df, or %R >UCL • J(+)/UJ(-) if %D, %Df, or %R <LCL • Use professional judgment if RF <0.05, based on sample results and CCV recovery: No action if sample detected and CCV acceptable
Continuing Calibration Verification (CCV)		√	√	• Percent difference (%D) or percent drift (%Df) within ±20%, or %R = 80-120% • RF >0.05	• J(+) if %D, %Df, or %R >UCL • J(+)/UJ(-) if %D, %Df, or %R <LCL • Use professional judgment if RF <0.05, based on sample results and CCV recovery: No action if sample detected and CCV acceptable
Blanks – *Method Blank* *Trip Blank* *Field Blank* *Instrument Blank* *Equipment Rinsate Blank*	√	√	√	• One method blank per matrix per batch (less than 20 samples) • Detection <RL	• Blank <RL, sample <RL: U at the RL • Blank <RL, sample >RL but <5x blank detection: J • Blank ≥ RL, sample <RL: U at the RL • Blank ≥ RL, sample ≥RL but <blank detection: U • Blank ≥ RL, sample ≥RL but <5x blank detection: J • Blank ≥ RL, sample ≥5x blank detection: No action
Surrogate Spikes	√	√	√	• Added to every field and QC samples • Within control limits refer to Table G-19	• J(+)/UJ(-) If %R <LCL • J(+) If > UCL J(+)/R(-) If any %R <10% • No action if 2 or more surrogates are used and only one is <LCL or >UCL • No action if %R is outside control limit due to demonstrated matrix effects (e.g., high target and/or non-target chemical levels, acceptable dilution analysis)
Multiple Results for One Sample	√	√	√	• Report only one result per analyte	• "DNR" results that should not be used to avoid reporting multiple results for one sample
Matrix Spike (MS) or Matrix Spike Duplicate (MSD) – *Recovery*	√	√	√	• Perform as requested. • Refer to Table G-19 for control limits	• Qualify parent sample only unless other QC indicates systematic problems • J(+) if both %R >UCL • J(+)/UJ(-) if both %R <LCL • J(+)/R(-) if both %R <10% • No action if only one %R outlier and %R deviation from control limit is <10% • No action if parent sample concentration >5x the amount spiked
MS/MSD or Laboratory Duplicate – *RPD*	√	√	√	• Perform as requested. • Refer to Table G-19 for control limits	• Qualify parent sample only unless other QC indicates systematic problems • J(+) if RPD (or absolute concentration difference) >control limit

Table G-17 Data Validation Criteria for Semi-Volatile Organic Compounds by GC/MS and HPLC/MS Methods.

QC Element	2a	2b	3+4	Acceptance Criteria	Action (use best professional judgment) (-): Nondetected Compounds – (+): Detected Compounds
Laboratory Control Sample, Laboratory Control Sample Duplicate, and/or Standard Reference Material (SRM) – *Recovery*	√	√	√	• One set per matrix per batch unless MS/MSD are performed • Within control limits refer to Table G-19	• If criteria were not met, qualify all samples in the batch • J(+) if both %R >UCL • J(+)/UJ(-) if both %R <LCL • J(+)/R(-) if both %R <10% • No action if only one %R outlier and %R deviation from control limit is <10%
LCS/LCSD – *RPD*	√	√	√	• One set per matrix per batch unless MS/MSD are performed • Within control limits, refer to Table G-19	• If criteria were not met, qualify all samples in the batch • J(+)/UJ(-) if RPD (or absolute concentration difference) >control limit
Internal Standards		√	√	• Added to all samples • Acceptable range: Internal standard area 50% to 200% of CCAL area • RT within 30 seconds of CC RT	• J(+) if > 200% • J(+)/UJ(-) if <50% • J(+)/R(-) if <25% • RT>30 seconds, narrate
Field Duplicates	√	√	√	• Solids: • RPD <50% or absolute difference <2x RL (for results <5x RL) • Aqueous: • RPD <35% or absolute difference <1x RL (for results <5x RL)	• If criteria were not met, J(+)/UJ(-)
Project Reporting Limits (RL)	√	√	√	• Reported RL should be ≤RL listed in Table G-19 unless justified to raise the RL	• Narrate if analyte is not detected and the reported RL exceeded those listed in Table G-19 • If RL is raised as a result of dilution or matrix effects, evaluate if the dilution or interference is justified; document the finding and resolution in Data Validation Report
Target Compound Identification			√	• Verify all retention times (RTs) are within the determined RT window • Examine chromatograms and ion spectra to verify detections of target analytes • RRT within 0.06 of standard RRT • Ion relative intensity within 30% of standard • All ions in standard at >10% intensity must be present in sample	• Narrate; further qualify data as needed • Contact the laboratory via WSDOT Project Manager if discrepancies are identified • Document findings and resolutions

Table G-17 Data Validation Criteria for Semi-Volatile Organic Compounds by GC/MS and HPLC/MS Methods.

QC Element	2a	2b	3+4	Acceptance Criteria	Action (use best professional judgment) (-): Nondetected Compounds – (+): Detected Compounds
Target Compound Quantitation			√	• Perform re-calculation on ICAL, CCV, QC analyses, and sample results to verify that there are no transcription or reduction errors (dilutions, percent solids [%S], sample weights, etc.) on one or more samples	• Contact the laboratory via WSDOT Project Manager if discrepancies are identified • Document findings and resolutions
System Performance			√	• Examine the raw data for any anomalies (baseline shifts, negative absorbance, omissions, illegibility, etc.)	• Determine if there is any need to qualify data that are not qualified based on the QC criteria previously discussed • Contact the laboratory via WSDOT Project Manager if discrepancies are identified • Document findings and resolutions
Overall Data Usability Assessment – *Level 2a*	√			• Check for data points with multiple qualifiers • Check for analytes with multiple results	• Determine the final data qualifier for a data point in case multiple qualifiers are assigned to the data point • Determine the optimal result to be reported for an analyte if multiple results were available for the analyte
Overall Data Usability Assessment – *Level 2b*		√		• Check for data points with multiple qualifiers • Check for analytes with multiple results • Verify that results fall within the calibrated range(s) • Verify that the RL is supported with adequate concentration of ICAL standards (RL should be ≥lowest concentration of ICAL standards)	• Determine the final data qualifier for a data point in case multiple qualifiers are assigned to the data point • Determine the optimal result to be reported for an analyte if multiple results were available for the analyte • Contact the laboratory via WSDOT Project Manager if discrepancies are identified • Document findings and resolutions
Overall Data Usability Assessment – *Level 3+4*			√	• Check for data points with multiple qualifiers • Check for analytes with multiple results • If reduced volumes were used, verify that appropriate methods and amounts were used in preparing the samples for analysis • Verify that results fall within the calibrated range(s) • Verify that the RL is supported with adequate concentration of ICAL standards (RL should be ≥lowest concentration of ICAL standards)	• Determine the final data qualifier for a data point in case multiple qualifiers are assigned to the data point • Determine the optimal result to be reported for an analyte if multiple results were available for the analyte • Determine if there is any need to qualify data that are not qualified based on the QC criteria previously discussed • Contact the laboratory via WSDOT Project Manager if discrepancies are identified • Document findings and resolutions

Table G-17 Notes:

Sources: USEPA, 1983; USEPA, 1996; USEPA, 2008; WSDOT(a); WSDOT(b); WSDOT(c).

Table G-18 Laboratories and Methods of Analysis for Semi-Volatile Organic Compounds by GC/MS and HPLC/MS.

	Parameter	Monitoring Type						Methods	Laboratory (see Table G-1)
		Highways	BMP	Toxicity	Rest Areas	Ferry Terminals	Maintenance Facilities		
Water Samples									
Herbicides	*2,4-D, clopyralid, picloram, triclopyr (ester formula only)*[1][7]	IF		IF	IF		IF	USEPA SW-846 Method 8270D (GC/MS)	MEL
	Diuron[1]	IF		IF	IF		IF	USEPA SW-846 Method 8270D (GC/MS) with confirmation by SW-846 Method 8321B (HPLC/TS/MS) if detected	
	Dichlobenil[1]	IF		IF	IF		IF	USEPA SW-846 Method 8270D (GC/MS) different extraction from other herbicides	
Semi-Volatile Organics	PAH compounds[2]	R		R	R	R	R	USEPA SW-846 Method 8270D (GC/MS)	
	Phthalates[3]	R		R	R			USEPA SW-846 Method 8270D (GC/MS)	
	Base/Neutral/Acid extractable semi-volatile compounds (BNAs)-Full List[8]							USEPA SW-846 Method 8270D (Manchester Modified) (GC/MS)	
	Visible Oil Sheen[4]	R						Observation	WSDOT
Sediment Samples									
Herbicides	*Dichlobenil clopyralid, picloram, triclopyr (ester formula only)*[5][7]	IF						USEPA SW-846 Method 8270D (GC/MS)	MEL
Semi-Volatile Organics	PAH compounds[2]	R						USEPA SW-846 Method 8270D (GC/MS)	
	Phenolics[6]	R						USEPA SW-846 Method 8270D (GC/MS)	
	Phthalates[3]	R						USEPA SW-846 Method 8270D (GC/MS)	

Table G-18 Notes:

R = Required parameter. (Permit-required parameter; parameters are sampled in order of priority as specified in the Permit. This means not all parameters will be sampled for each sampling event if volumes are not adequate to conduct all the analyses.)

IF = If required conditions listed in the parameter footnote are met.

O = Optional parameter. (Not Permit-required, but included to aid in interpretation of data. The Project Manager will decide whether to collect this data and include data in official documents.)

Table G-18 Notes (continued):

* SM: 🖱 http://www.standardmethods.org/
SW: 🖱 http://www.epa.gov/osw/hazard/testmethods/sw846/online/index.htm
EPA: 🖱 http://water.epa.gov/scitech/methods/cwa/methods_index.cfm
ASTM: 🖱 http://www.astm.org/SITEMAP/index.html
Ecology: 🖱 http://www.ecy.wa.gov/biblio/97602.html; USEPA 1997

[1] Required at Highway and Toxicity locations where herbicides listed are applied near the monitoring site vicinity. Required for Maintenance Facility locations where herbicides listed are applied or stored on-site, or applied by vehicles parked on-site.

[2] 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, fluorene, indeno[1,2,3-cd]pyrene, naphthalene, phenanthrene, and pyrene.

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

[4] Validation criteria for this parameter are not included in this document.

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

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

[7] WSDOT is required to report only on the ester formula of triclopyr. Triclopyr will be extracted with the other herbicides; however, this method involves hydrolyzing the sample prior to analysis (all forms of triclopyr are transformed into one form). Therefore, more than just the ester formula may be quantified in the result. If triclopyr is found consistently, WSDOT and MEL will discuss whether it is reasonable to analyze for the ester formula only.

[8] BNAs include: Phenol, Bis(2-Chloroethyl)Ether, 2-Chlorophenol, 1,3-Dichlorobenzene, 1,4-Dichlorobenzene, 1,2-Dichlorobenzene, Benzyl Alcohol, 2-Methylphenol, Bis(2-chloro-1-methylethyl) ether, N-Nitrosodi-n-propylamine, 4-Methylphenol, Hexachloroethane, Nitrobenzene, Isophorone, 2-Nitrophenol, 2,4-Dimethylphenol, Bis(2-Chloroethoxy)Methane, Benzoic Acid, 2,4-Dichlorophenol, 1,2,4-Trichlorobenzene, Naphthalene, 4-Chloroaniline, Hexachlorobutadiene, 4-Chloro-3-Methylphenol, 2-Methylnaphthalene, 1-Methylnaphthalene, Hexachlorocyclopentadiene, 2,4,6-Trichlorophenol, 2,4,5-Trichlorophenol, 2-Chloronaphthalene, 2-Nitroaniline, Dimethyl phthalate, 2,6-Dinitrotoluene, Acenaphthylene, 3-Nitroaniline, Acenaphthene, 2,4-Dinitrophenol, 4-Nitrophenol, Dibenzofuran, 2,4-Dinitrotoluene, Diethyl phthalate, Fluorene, 4-Chlorophenyl-Phenylether, 4-Nitroaniline, 4,6-Dinitro-2-Methylphenol, N-Nitrosodiphenylamine.
1,2-Diphenylhydrazine, Triethyl citrate, 4-Bromophenyl phenyl ether, Hexachlorobenzene, Tris(2-chloroethyl) phosphate(TCEP), Pentachlorophenol, Phenanthrene, Anthracene, Caffeine, 4-nonylphenol, Carbazole, Di-N-Butylphthalate, Triclosan, Fluoranthene, Pyrene, Bisphenol A, Retene, Butyl benzyl phthalate, Benz[a]anthracene, 3,3'-Dichlorobenzidine, Chrysene, Bis(2-Ethylhexyl) Phthalate, Di-N-Octyl Phthalate, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Benzo(a)pyrene, 3B-Coprostanol, Cholesterol, Indeno(1,2,3-cd)pyrene, Dibenzo(a,h)anthracene, Benzo(ghi)perylene.

Table G-19 Method Quality Objectives for Semi-Volatile Organic Compounds by GC/MS and HPLC/MS Methods.

	Parameter	Reporting Limit	Lab Duplicate[1] (RPD)	MS/MSD (% Rec)	MS/MSD[3] (RPD)	LCS/Surrogate Spike[2] (% Rec)
Water Samples[10]						
Semi-Volatile Organics	***Herbicides:[4]***					
	Triclopyr (*total formula*)[7]	0.0625 µg/L	≤40%	40-130	≤40%	40-130
	2,4-D	0.0625 µg/L		40-130		40-130
	Clopyralid	0.0625 µg/L		40-130		40-130
	Picloram	0.0625 µg/L		40-130		40-130
	Diuron	0.05 µg/L		30-130		30-130
	Dichlobenil	0.033 µg/L		34-150[9]		44-139
	Herbicide Surrogates:					
	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
	Direct Observation:					
	Visible Oil Sheen[6]	Yes/No	n/a	n/a	n/a	n/a
	PAH Compounds:					
	Acenaphthene	0.1 µg/L	≤40%	55-97	≤40%	40-112
	Acenaphthylene	0.1 µg/L	≤40%	48-103	≤40%	30-126[9]
	Anthracene	0.1 µg/L	≤40%	51-113	≤40%	30-127[9]
	Benzo[a]anthracene	0.1 µg/L	≤40%	59-137	≤40%	38-147
	Benzo[b]fluoranthene	0.1 µg/L	≤40%	53-99	≤40%	42-133
	Benzo[k]fluoranthene	0.1 µg/L	≤40%	33-122	≤40%	38-131
	Benzo[ghi]perylene	0.1 µg/L	≤40%	38-131	≤40%	30-122[9]
	Benzo[a]pyrene	0.1 µg/L	≤40%	42-110	≤40%	30-129[9]
	Chrysene	0.1 µg/L	≤40%	51-116	≤40%	37-128
	Dibenzo[a,h]anthracene	0.1 µg/L	≤40%	30-129[9]	≤40%	30-134[9]
	Fluoranthene	0.1 µg/L	≤40%	60-107	≤40%	42-123
	Fluorene	0.1 µg/L	≤40%	50-150	≤40%	50-150
	Indeno[1,2,3-cd]pyrene	0.1 µg/L	≤40%	37-135	≤40%	30-129[9]
	Naphthalene	0.1 µg/L	≤40%	41-97	≤40%	41-105
	Phenanthrene	0.1 µg/L	≤40%	30-105[9]	≤40%	30-105[9]
	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	30-136[9]
	Acenaphthylene-D_8	N/A	N/A	N/A	N/A	30-139[9]
	Fluorene-D_{10}	N/A	N/A	N/A	N/A	43-112
	Anthracene-D_{10}	N/A	N/A	N/A	N/A	30-132[9]
	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	30-120[9]
	Phthalates:					
	Bis(2-Ethylhexyl)phthalate	1.0 µg/L	≤40%	61-131	≤40%	80-128
	Butyl benzyl phthalate	1.0 µg/L	≤40%	80-128	≤40%	30-150[9]
	Di-n-butyl phthalate	1.0 µg/L	≤40%	73-148	≤40%	70-150[9]
	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

Table G-19 Method Quality Objectives for Semi-Volatile Organic Compounds by GC/MS and HPLC/MS Methods.

	Parameter	Reporting Limit	Lab Duplicate[1] (RPD)	MS/MSD (% Rec)	MS/MSD[3] (RPD)	LCS/Surrogate Spike[2] (% Rec)
Semi-Volatile Organics	***Phthalate Surrogates:***					
	Dimethylphthalate-D_6	N/A	N/A	N/A	N/A	50-150
	Base/Neutral/Acid Extractable Semi-Volatile Compounds (BNAs)-Full List:					
	Phenol	0.33 µg/L[8]	≤40%	30-100[9]	≤40%	41-100[9]
	Bis(2-Chloroethyl)Ether	0.17 ug/L[8]	≤40%	65-110	≤40%	65-110
	2-Chlorophenol	0.33 µg/L[8]	≤40%	46-104	≤40%	66-109
	1,3-Dichlorobenzene	0.08 µg/L[8]	≤40%	30-100[9]	≤40%	30-100[9]
	1,4-Dichlorobenzene	0.08 µg/L[8]	≤40%	30-100[9]	≤40%	30-100[9]
	1,2-Dichlorobenzene	0.08 µg/L[8]	≤40%	30-100[9]	≤40%	30-100[9]
	Benzyl Alcohol	0.83 µg/L[8]	≤40%	30-100[9]	≤40%	30-100[9]
	2-Methylphenol	0.83 µg/L[8]	≤40%	30-100[9]	≤40%	55-117
	bis(2-chloro-1-methylethyl) ether	0.08 µg/L[8]	≤40%	63-105	≤40%	63-105
	N-Nitrosodi-n-propylamine	0.08 µg/L[8]	≤40%	46-124	≤40%	60-128
	4-Methylphenol	0.83 µg/L[8]	≤40%	30-100[9]	≤40%	43-127
	Hexachloroethane	0.08 µg/L[8]	≤40%	30-100[9]	≤40%	30-79[9]
	Nitrobenzene	0.08 µg/L[8]	≤40%	48-113	≤40%	67-108
	Isophorone	0.17 ug/L[8]	≤40%	46-100[9]	≤40%	50-103
	2-Nitrophenol	0.17 ug/L[8]	≤40%	51-115	≤40%	64-115
	2,4-Dimethylphenol	0.83 µg/L[8]	≤40%	58-122	≤40%	59-127
	Bis(2-Chloroethoxy)Methane	0.08 µg/L[8]	≤40%	46-124	≤40%	65-116
	Benzoic Acid	1.67 µg/L[8]	≤40%	30-100[9]	≤40%	30-100[9]
	2,4-Dichlorophenol	0.83 µg/L[8]	≤40%	49-125	≤40%	66-115
	1,2,4-Trichlorobenzene	0.08 µg/L[8]	≤40%	30-100[9]	≤40%	30-100[9]
	Naphthalene	0.08 µg/L[8]	≤40%	34-114	≤40%	34-114
	4-Chloroaniline	3.33 µg/L[8]	≤40%	30-150[9]	≤40%	30-150[9]
	Hexachlorobutadiene	0.08 µg/L[8]	≤40%	30-100[9]	≤40%	30-100[9]
	4-Chloro-3-Methylphenol	0.83 µg/L[8]	≤40%	50-133	≤40%	60-129
	2-Methylnaphthalene	0.08 µg/L[8]	≤40%	30-112[9]	≤40%	30-112[9]
	1-Methylnaphthalene	0.08 µg/L[8]	≤40%	33-110	≤40%	33-110
	Hexachlorocyclopentadiene	0.33 µg/L[8]	≤40%	30-100[9]	≤40%	30-100[9]
	2,4,6-Trichlorophenol	0.33 µg/L[8]	≤40%	66-118	≤40%	51-141
	2,4,5-Trichlorophenol	0.33 µg/L[8]	≤40%	56-130	≤40%	46-141
	2-Chloronaphthalene	0.17 ug/L[8]	≤40%	30-127[9]	≤40%	30-127[9]
	2-Nitroaniline	1.67 µg/L[8]	≤40%	30-145[9]	≤40%	64-136
	Dimethyl phthalate	0.17 ug/L[8]	≤40%	73-126	≤40%	74-122
	2,6-Dinitrotoluene	0.33 µg/L[8]	≤40%	71-130	≤40%	65-131
	Acenaphthylene	0.08 µg/L[8]	≤40%	46-118	≤40%	46-118
	3-Nitroaniline	0.33 µg/L[8]	≤40%	30-123[9]	≤40%	30-150[9]
	Acenaphthene	0.08 µg/L[8]	≤40%	30-150[9]	≤40%	30-150[9]
	2,4-Dinitrophenol	0.83 µg/L[8]	≤40%	71-139	≤40%	42-135
	4-Nitrophenol	0.83 µg/L[8]	≤40%	30-100[9]	≤40%	30-134[9]
	Dibenzofuran	0.17 ug/L[8]	≤40%	47-126	≤40%	47-126

Table G-19 Method Quality Objectives for Semi-Volatile Organic Compounds by GC/MS and HPLC/MS Methods.

Parameter	Reporting Limit	Lab Duplicate[1] (RPD)	MS/MSD (% Rec)	MS/MSD[3] (RPD)	LCS/Surrogate Spike[2] (% Rec)
2,4-Dinitrotoluene	0.33 µg/L[8]	≤40%	71-118	≤40%	64-136
Diethyl phthalate	0.17 ug/L[8]	≤40%	79-117	≤40%	77-123
Fluorene	0.08 µg/L[8]	≤40%	50-134	≤40%	50-134
Base/Neutral/Acid Extractable Semi-Volatile Compounds (BNAs)-Full List (continued):					
4-Chlorophenyl-Phenylether	0.08 µg/L[8]	≤40%	58-110	≤40%	47-113
4-Nitroaniline	0.33 µg/L[8]	≤40%	30-150[9]	≤40%	30-150[9]
4,6-Dinitro-2-Methylphenol	1.67 µg/L[8]	≤40%	80-128	≤40%	67-133
N-Nitrosodiphenylamine	0.17 ug/L[8]	≤40%	30-150[9]	≤40%	30-150[9]
1,2-Diphenylhydrazine	0.08 µg/L[8]	≤40%	50-150	≤40%	50-150
Triethyl citrate	0.33 µg/L[8]	≤40%	35-143	≤40%	30-123[9]
4-Bromophenyl phenyl ether	0.17 ug/L[8]	≤40%	61-136	≤40%	47-113
Hexachlorobenzene	0.08 µg/L[8]	≤40%	52-129	≤40%	53-114
Tris(2-chloroethyl) phosphate (TCEP)	0.08 µg/L[8]	≤40%	50-150	≤40%	50-150
Pentachlorophenol	0.08 µg/L[8]	≤40%	52-140	≤40%	64-140
Phenanthrene	0.17 ug/L[8]	≤40%	63-126	≤40%	63-126
Anthracene	0.17 ug/L[8]	≤40%	66-121	≤40%	66-121
Caffeine	0.17 ug/L[8]	≤40%	30-100[9]	≤40%	62-114
4-nonylphenol	0.33 µg/L[8]	≤40%	30-150[9]	≤40%	77-150[9]
Carbazole	0.17 ug/L[8]	≤40%	59-139	≤40%	59-139
Di-N-Butylphthalate	0.08 µg/L[8]	≤40%	73-148	≤40%	70-150[9]
Triclosan	0.08 µg/L[8]	≤40%	43-150[9]	≤40%	54-126
Fluoranthene	0.17 ug/L[8]	≤40%	72-124	≤40%	72-124
Pyrene	0.17 ug/L[8]	≤40%	64-140	≤40%	64-140
Bisphenol A	0.33 µg/L[8]	≤40%	30-150[9]	≤40%	30-150[9]
Retene	0.17 ug/L[8]	≤40%	73-136	≤40%	75-135
Butyl benzyl phthalate	0.33 µg/L[8]	≤40%	80-150	≤40%	30-150[9]
Benzo[a]anthracene	0.17 ug/L[8]	≤40%	84-130	≤40%	84-130
3,3'-Dichlorobenzidine	0.17 ug/L[8]	≤40%	30-150[9]	≤40%	30-150[9]
Chrysene	0.17 ug/L[8]	≤40%	82-128	≤40%	82-128
bis(2-Ethylhexyl) Phthalate	0.17 ug/L[8]	≤40%	61-131	≤40%	80-128
Di-N-Octyl Phthalate	0.83 µg/L[8]	≤40%	61-148	≤40%	75-135
Benzo(b)fluoranthene	0.08 µg/L[8]	≤40%	71-140	≤40%	71-140
Benzo(k)fluoranthene	0.08 µg/L[8]	≤40%	73-141	≤40%	73-141
Benzo(a)pyrene	0.08 µg/L[8]	≤40%	70-145	≤40%	70-145
3B-Coprostanol	1.67 µg/L[8]	≤40%	30-150[9]	≤40%	30-150[9]
Cholesterol	1.67 µg/L[8]	≤40%	30-150[9]	≤40%	30-140[9]
Indeno(1,2,3-cd)pyrene	0.08 µg/L[8]	≤40%	61-139	≤40%	61-139
Dibenzo(a,h)anthracene	0.08 µg/L[8]	≤40%	65-130	≤40%	65-130
Benzo(ghi)perylene	0.17 µg/L[8]	≤40%	61-141	≤40%	61-141
2-Fluorophenol	N/A	N/A	N/A	N/A	30-150[9]
Phenol-D_5	N/A	N/A	N/A	N/A	30-150[9]
2-Chlorophenol-D_4	N/A	N/A	N/A	N/A	44-112
Bis(2-Chloroethyl)Ether-D_8	N/A	N/A	N/A	N/A	50-150
1,2-Dichlorobenzene-D_4	N/A	N/A	N/A	N/A	30-150[9]

Table G-19 Method Quality Objectives for Semi-Volatile Organic Compounds by GC/MS and HPLC/MS Methods.

	Parameter	Reporting Limit	Lab Duplicate[1] (RPD)	MS/MSD (% Rec)	MS/MSD[3] (RPD)	LCS/Surrogate Spike[2] (% Rec)
	Base/Neutral/Acid Extractable Semi-Volatile Compounds (BNAs)-Full List (continued):					
	4-Methylphenol-D_8	N/A	N/A	N/A	N/A	50-150
	Nitrobenzene-D_5	N/A	N/A	N/A	N/A	50-118
	2-Nitrophenol-D_4	N/A	N/A	N/A	N/A	30-120[9]
	2,4-Dichlorophenol-D_3	N/A	N/A	N/A	N/A	50-150
	4-Chloroaniline-D_4	N/A	N/A	N/A	N/A	30-120[9]
	2-Fluorobiphenyl	N/A	N/A	N/A	N/A	30-116[9]
	Dimethylphthalate-D_6	N/A	N/A	N/A	N/A	50-150
	Acenaphthylene-D_8	N/A	N/A	N/A	N/A	50-150
	4-Nitrophenol-D_4	N/A	N/A	N/A	N/A	30-120[9]
	Fluorene-D_{10}	N/A	N/A	N/A	N/A	50-150
	4,6-Dinitro-2-methylphenol-D_2	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	57-134
	Terphenyl-D_{14}	N/A	N/A	N/A	N/A	42-145
	Benzo(a)pyrene-D_{12}	N/A	N/A	N/A	N/A	50-150
Sediment Samples[10]						
Semi-Volatile Organics	***Herbicides:[11]***					
	Dichlobenil	70 µg/Kg dry[8]	N/A	30-140	35%	30-140
	Clopyralid	70 µg/Kg dry[8]	N/A	30-140	35%	30-140
	Picloram	70 µg/Kg dry[8]	N/A	30-140	40%	30-140
	Triclopyr (*total formula*)[7]	70 µg/Kg dry[8]	N/A	30-140	40%	30-140
	Herbicide Surrogates:					
	2,4-Dichlorophenylacetic acid	N/A	N/A	N/A	N/A	30-140
	PAH Compounds:					
	Acenaphthene	70 µg/Kg dry	N/A	50-150	40%	50-150
	Acenaphthylene	70 µg/Kg dry	N/A	50-150	40%	50-150
	Anthracene	70 µg/Kg dry	N/A	50-150	40%	50-150
	Benzo[a]anthracene	70 µg/Kg dry	N/A	50-150	40%	50-150
	Benzo[a]pyrene	70 µg/Kg dry	N/A	50-150	40%	50-150
	Benzo[b]fluoranthene	70 µg/Kg dry	N/A	50-150	40%	50-150
	Benzo[ghi]perylene	70 µg/Kg dry	N/A	50-150	40%	50-150
	Benzo[k]fluoranthene	70 µg/Kg dry	N/A	50-150	40%	50-150
	Chrysene	70 µg/Kg dry	N/A	50-150	40%	50-150
	Dibenzo[a,h]anthracene	70 µg/Kg dry	N/A	50-150	40%	50-150
	Fluoranthene	70 µg/Kg dry	N/A	50-150	40%	50-150
	Fluorene	70 µg/Kg dry	N/A	50-150	40%	50-150
	Indeno[1,2,3-cd]pyrene	70 µg/Kg dry	N/A	50-150	40%	50-150

Table G-19 Method Quality Objectives for Semi-Volatile Organic Compounds by GC/MS and HPLC/MS Methods.

Parameter	Reporting Limit	Lab Duplicate[1] (RPD)	MS/MSD (% Rec)	MS/MSD[3] (RPD)	LCS/Surrogate Spike[2] (% Rec)
Naphthalene	70 µg/Kg dry	N/A	50-150	40%	50-150
Phenanthrene	70 µg/Kg dry	N/A	50-150	40%	50-150
Pyrene	70 µg/Kg dry	N/A	50-150	40%	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
Phenols:					
Phenol	70 µg/Kg dry	N/A	50-150	40%	50-150
Benzyl alcohol	70 µg/Kg dry	N/A	50-150	40%	50-150
2-methylphenol	70 µg/Kg dry	N/A	50-150	40%	50-150
4-methylphenol	70 µg/Kg dry	N/A	50-150	40%	50-150
2,4-dimethyphenol	70 µg/Kg dry	N/A	50-150	40%	50-150
pentachlorophenol	70 µg/Kg dry	N/A	50-150	40%	50-150
Benzoic acid	70 µg/Kg dry	N/A	50-150	40%	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
Phthalates:					
bis(2-Ethylhexyl)phthalate	70 µg/Kg dry	N/A	50-150	40%	50-150
Butyl benzyl phthalate	70 µg/Kg dry	N/A	50-150	40%	50-150
Di-n-butyl phthalate	70 µg/Kg dry	N/A	50-150	40%	50-150
Diethyl phthalate	70 µg/Kg dry	N/A	50-150	40%	50-150
Dimethyl phthalate	70 µg/Kg dry	N/A	50-150	40%	50-150
Di-n-octyl phthalate	70 µg/Kg dry	N/A	50-150	40%	50-150
Phthalate Surrogates:					
Dimethylphthalate-D_6	N/A	N/A	N/A	N/A	50-150

Table G-19 Notes:

[1] The relative percent difference (RPD) must be ≤ the indicated percentage for values that are >5x reporting limit (RL). Concentration difference value must be 2x RL for values that are ≤5x RL.

[2] For PAHs and phthalates, both deuterated and non-deuterated monitoring compounds are the surrogate standards.

[3] The matrix spike duplicate RPD criteria apply when original and duplicate results are ≥5x reporting limit. Concentration difference of 1xRL applies to precision evaluation if either or both original and duplicate results are <5x reporting limit.

[4] Required at Highway and Toxicity monitoring locations where herbicides listed are applied near the monitoring site vicinity. Required for Maintenance Facility monitoring locations where herbicides listed are applied or stored on-site, or applied by vehicles parked on-site. This list may decrease based on usage records from WSDOT. This list will be updated annually.

[5] 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.

[6] Validation criteria for this parameter are not included in this document.

Table G-19 Notes (continued):

[7] WSDOT is required to report only on the ester formula of triclopyr. Triclopyr will be extracted with the other herbicides; however, this method involves hydrolyzing the sample prior to analysis (all forms of triclopyr are transformed into one form). Therefore, more than just the ester formula may be quantified in the result. If triclopyr is found consistently, WSDOT and MEL will discuss whether it is reasonable to analyze for the ester formula only.

[8] The RL was not specified in the Permit. The RL used is based on laboratory recommendations on achievable RLs.

[9] The control limit has been adjusted to cope with project-specific accuracy control goals and is based on a recommendation of industry standard. A minimum lower control limit (LCL) of 30%, a minimum upper control limit (UCL) of 100% and a maximum UCL of 150% has been set forth as project accuracy control goals. The control limits have been adjusted accordingly as denoted.

[10] Unless otherwise annotated, method quality objectives (duplicates, matrix spike, & LCS values) are based on current performance-based statistics provided by Manchester Environmental Laboratory (Ecology, 2011 & 2012). The values are subject to change as the laboratories update their performance control limits as required by the accreditation programs.

[11] Dichlobenil, clopyralid, picloram, and triclopyr are the only herbicides required for testing in sediments under the Permit. This list may decrease if the herbicides are not found to be used within the drainage area by WSDOT. This list will be updated annually.

Table G-20 Quantity, Container, Preservation, and Holding Time Requirements for Semi-Volatile Organic Compounds by GC/MS and HPLC/MS Methods.

	Parameter	Minimum Quantity Needed for Analysis	Quantity Needed for QC Samples	Container	Preservative[1][2]	Holding Time[3]
Water Samples						
Semi-Volatile Organics	Herbicides – Dichlobenil, Diuron[4]	1 Liter	MS & MSD = 1 Liter each	1 Liter amber glass bottle with Teflon® lid	Cool to ≤6˚C; Adjust to pH 5-9 or extract within 72 hours	7 days until extraction; 40 days after extraction
	Herbicides – 2,4-D, clopyralid, picloram, triclopyr *(total formula)*[4][5]	1 Liter	MS & MSD = 1 Liter each	1 Liter amber glass bottle with Teflon® lid	Cool to ≤6˚C; Adjust to pH 5-9 or extract within 72 hours	7 days until extraction; 40 days after extraction
	PAH compounds[6]	1 Liter	MS & MSD = 1 Liter each	1 Liter amber glass bottle with Teflon® lid	Store in dark; cool to ≤6˚C[13]	7 days until extraction; 40 days after extraction
	Phthalates[7]	1 Liter	MS & MSD = 1 Liter each	1 Liter amber glass bottle with Teflon® lid	Store in dark; cool to ≤6˚C[13]	7 days until extraction; 40 days after extraction
	Base/Neutral/Acid extractable semi-volatile compounds (BNAs)[8]	1 Liter	MS & MSD = 1 Liter each	1 liter amber glass bottle with Teflon® lined lids	Store in dark; cool to ≤6˚C[13]	7 days until extraction, 40 days after extraction
	Visible Oil Sheen[9]	N/A	N/A	N/A	N/A	N/A
Sediment Samples						
Semi-Volatile Organics	Herbicides – Dichlobenil clopyralid, picloram, triclopyr *(total formula)*[5][10][12]	100 wet g	None if jar filled[15]	8 oz glass jar	Cool to ≤6°C; standard: may freeze at -18°Cat lab[14]	14 days until extraction (1 yr. if stored frozen at -18°C); 40 days after extraction[14]
	PAH[6]	100 wet g	None if jar filled[15]	8 oz glass jar	Cool to ≤6°C; standard: may freeze at -18°Cat lab[14]	14 days until extraction (1 yr. if stored frozen at -18°C); 40 days after extraction[14]
	Phthalates[7]	100 wet g	None if jar filled[15]	8 oz glass jar	Cool to ≤6°C; standard: may freeze at -18°C at lab[14]	14 days until extraction (1 yr. if stored frozen at -18°C); 40 days after extraction[14]
	Phenolics[11]	100 wet g	None if jar filled[15]	8 oz glass jar	Cool to ≤6°C; standard: may freeze at -18°C at lab[14]	14 days until extraction (1 yr. if stored frozen at -18°C); 40 days after extraction[14]

Table G-20 Notes:

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 to cool samples to approximately 6°C.

[2] Preservation per 40 CFR 136, edition 7-1-09, unless noted.

[3] Holding times per 40 CFR 136, edition 7-1-09, unless noted.

[4] Required at Highway and Toxicity locations where herbicides listed are applied near the monitoring site vicinity. Required for Maintenance Facility locations where herbicides listed are applied or stored on-site, or applied by vehicles parked on-site.

[5] WSDOT is required to report only on the ester formula of triclopyr. Triclopyr will be extracted with the other herbicide; however, this method involves hydrolyzing the sample prior to analysis (all forms of Triclopyr are transformed into one form). Therefore, more than just the ester formula may be quantified in the result. If triclopyr is found consistently, WSDOT and MEL will discuss whether it is reasonable to analyze for the ester formula only.

[6] 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, fluorene, indeno[1,2,3-cd]pyrene, naphthalene, phenanthrene, and pyrene.

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

[8] BNAs include: Phenol, Bis(2-Chloroethyl)Ether, 2-Chlorophenol, 1,3-Dichlorobenzene, 1,4-Dichlorobenzene, 1,2-Dichlorobenzene, Benzyl Alcohol, 2-Methylphenol, Bis(2-chloro-1-methylethyl) ether, N-Nitrosodi-n-propylamine, 4-Methylphenol, Hexachloroethane, Nitrobenzene, Isophorone, 2-Nitrophenol, 2,4-Dimethylphenol, Bis(2-Chloroethoxy)Methane, Benzoic Acid, 2,4-Dichlorophenol, 1,2,4-Trichlorobenzene, Naphthalene, 4-Chloroaniline, Hexachlorobutadiene, 4-Chloro-3-Methylphenol, 2-Methylnaphthalene, 1-Methylnaphthalene, Hexachlorocyclopentadiene, 2,4,6-Trichlorophenol, 2,4,5-Trichlorophenol, 2-Chloronaphthalene,
2-Nitroaniline, Dimethyl phthalate, 2,6-Dinitrotoluene, Acenaphthylene, 3-Nitroaniline, Acenaphthene, 2,4-Dinitrophenol, 4-Nitrophenol, Dibenzofuran, 2,4-Dinitrotoluene, Diethyl phthalate, Fluorene, 4-Chlorophenyl-Phenylether, 4-Nitroaniline, 4,6-Dinitro-2-Methylphenol, N-Nitrosodiphenylamine, 1,2-Diphenylhydrazine, Triethyl citrate, 4-Bromophenyl phenyl ether, Hexachlorobenzene, Tris(2-chloroethyl) phosphate(TCEP), Pentachlorophenol, Phenanthrene, Anthracene, Caffeine, 4-nonylphenol, Carbazole, Di-N-Butylphthalate, Triclosan, Fluoranthene, Pyrene, Bisphenol A, Retene, Butyl benzyl phthalate, Benz[a]anthracene,
3,3'-Dichlorobenzidine, Chrysene, Bis(2-Ethylhexyl) Phthalate, Di-N-Octyl Phthalate, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Benzo(a)pyrene, 3B-Coprostanol, Cholesterol, Indeno(1,2,3-cd)pyrene, Dibenzo(a,h)anthracene, Benzo(ghi)perylene.

[9] Validation criteria for this parameter are not included in this document.

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

[11] Phenolics: Phenol, 2-Methylphenol, 4-Methylphenol, 2,4-Dimethyphenol, pentachlorophenol, benzyl alcohol, and benzoic acid.

[12] Dichlobenil requires a separate extraction from the other three herbicides (clopyralid, picloram, and triclopyr).

[13] At the lab, a reducing agent may be added as a preservative if an oxidant such as chlorine is present.

[14] USEPA (1997).

[15] If the sampling containers are filled ¾ full (for freezing), no additional sample is needed for QC.

Appendix G References

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_____2009. *Washington State Department of Transportation Municipal Stormwater Permit, National Pollution Discharge Elimination System and State Waste Discharge Permit for Large and Medium Municipal Separate Storm Sewer Systems.* Washington State Department of Ecology. Olympia, Washington. Permit No. WAR043000A. Issuance Date February 4, 2009.

_____2011 & 2012. *Manchester Environmental Laboratory Performance Criteria. Internal spreadsheet files.* Washington State Department of Ecology, Olympia, WA. Accessed February 2011 and December 2012.

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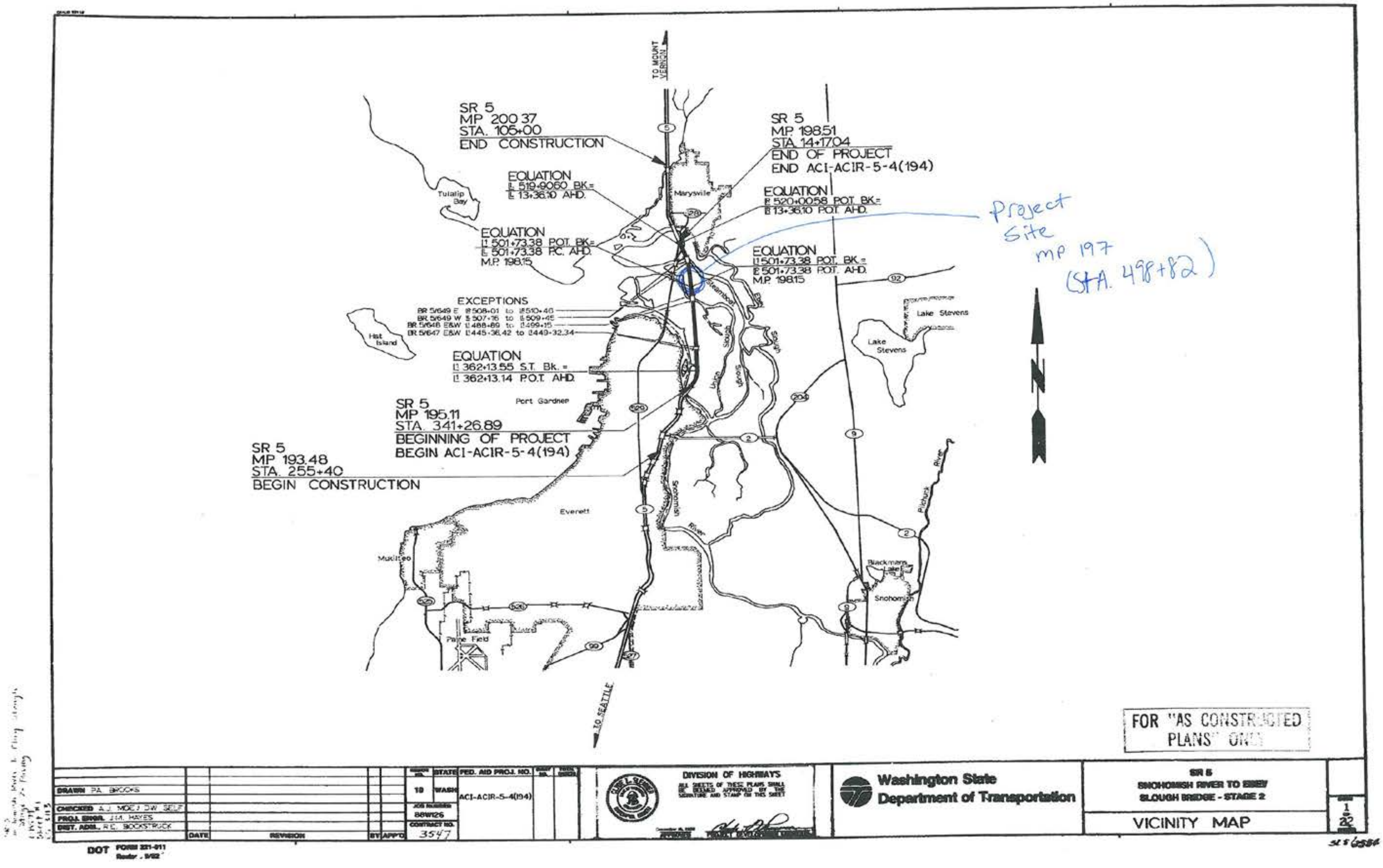
_____2011a. QAPP for Baseline Monitoring of WSDOT Highway Run-off. Working draft, February 2011.

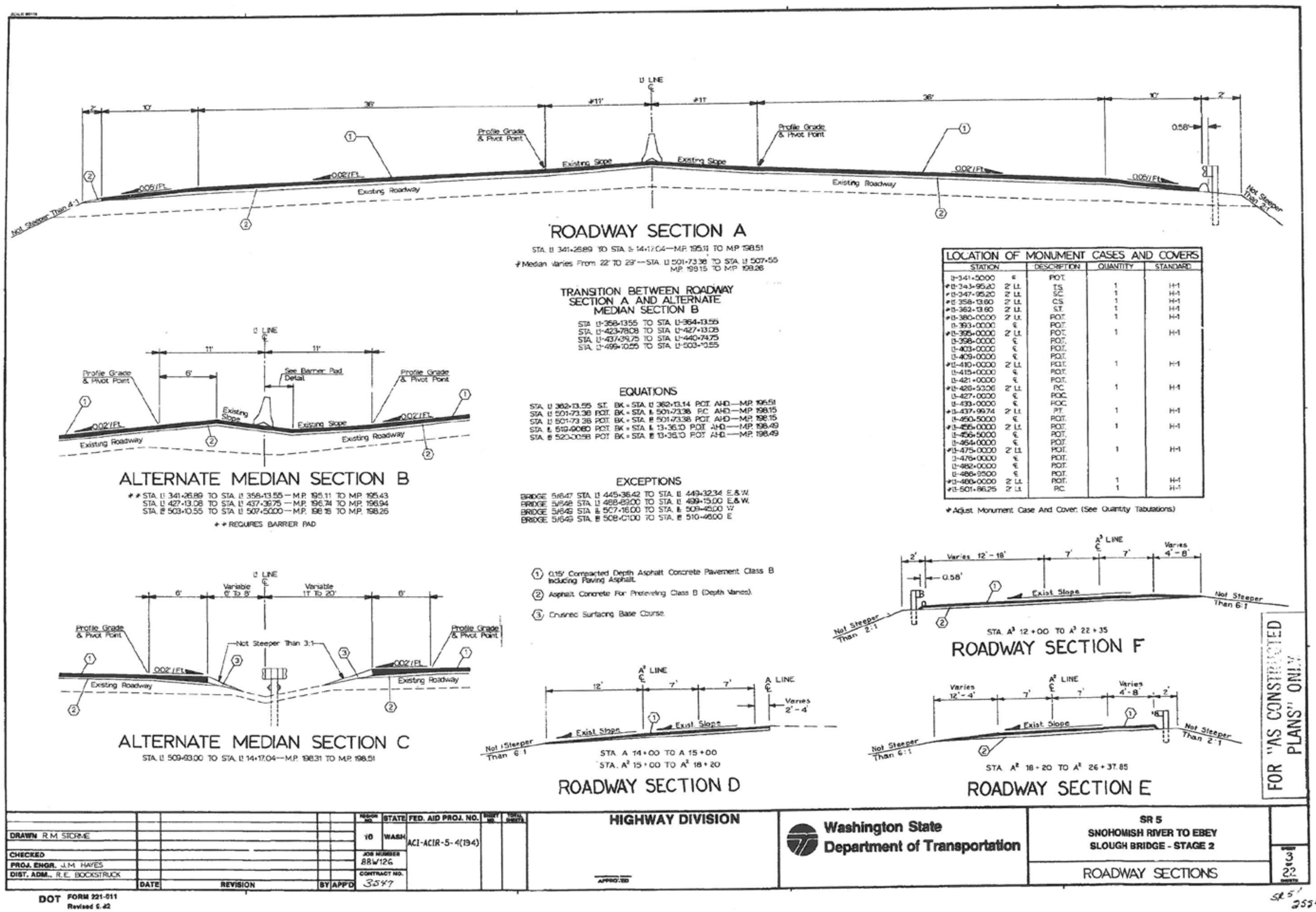
_____2011b. QAPP for Baseline Monitoring of WSDOT Maintenance Facilities, Rest Area, and Ferry Terminals. Working draft, February 2011.

_____2011c. QAPP for WSDOT Roadway Stormwater Treatment Evaluation: Best Management Practices. Working draft, March 2011.

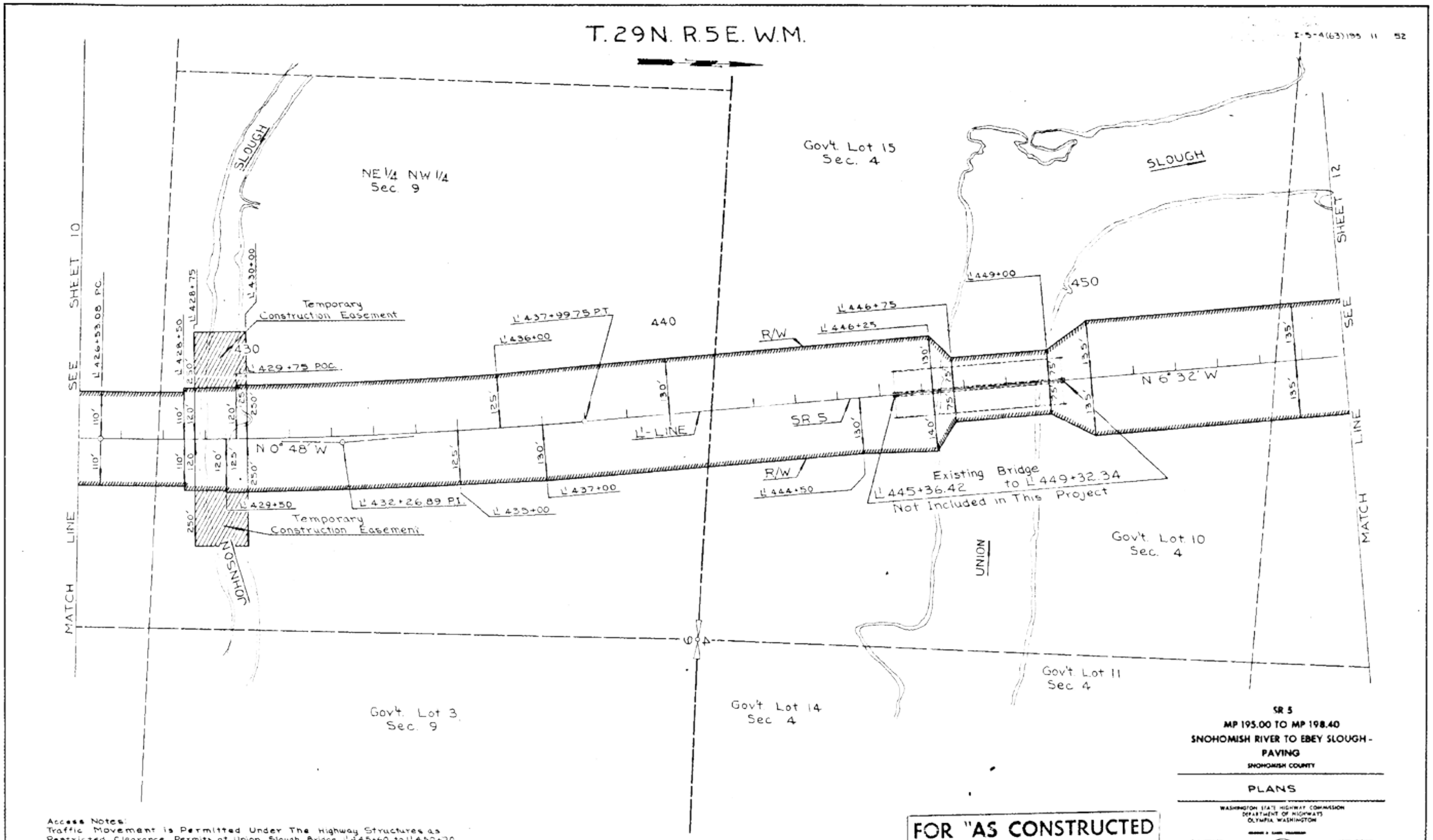
Appendix H: Highway System "As-Built" Design Plans

I-5 Northbound MP 197





ROADWAY SECTION A
TRANSITION BETWEEN ROADWAY SECTION A AND ALTERNATE MEDIAN SECTION B
EQUATIONS
EXCEPTIONS
LOCATION OF MONUMENT CASES AND COVERS
ALTERNATE MEDIAN SECTION B
** REQUIRES BARRIER PAD
ALTERNATE MEDIAN SECTION C
ROADWAY SECTION D
ROADWAY SECTION E
ROADWAY SECTION F
FOR "AS CONSTRUCTED PLANS" ONLY
HIGHWAY DIVISION
Washington State Department of Transportation
SR 5
SNOHOMISH RIVER TO EBEY SLOUGH BRIDGE - STAGE 2
ROADWAY SECTIONS
DRAWN R.M. STORME
CHECKED
PROJ. ENGR. J.M. HAYES
DIST. ADM. R.E. BOCKSTRUCK
DOT FORM 221-011



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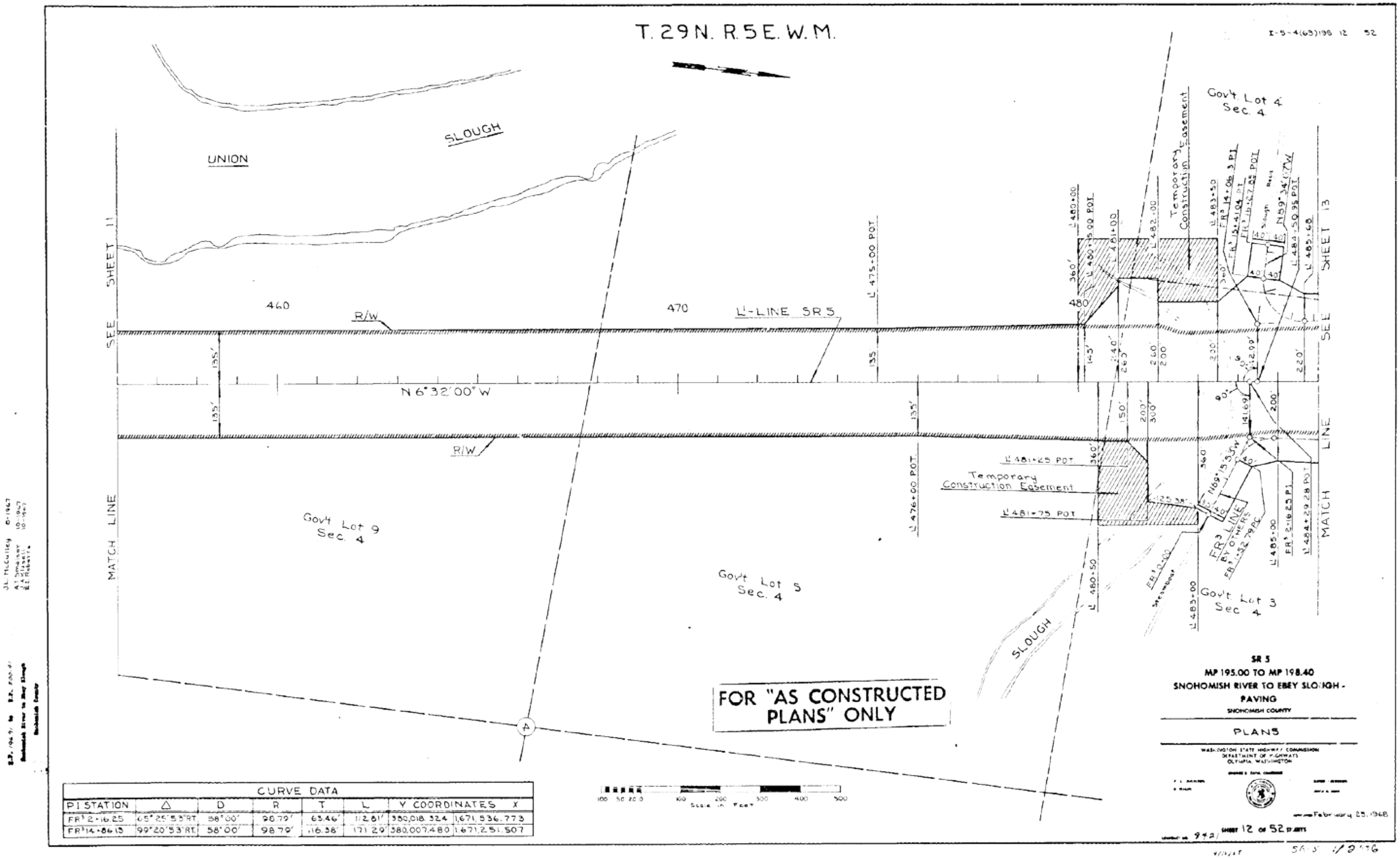

CURVE DATA							
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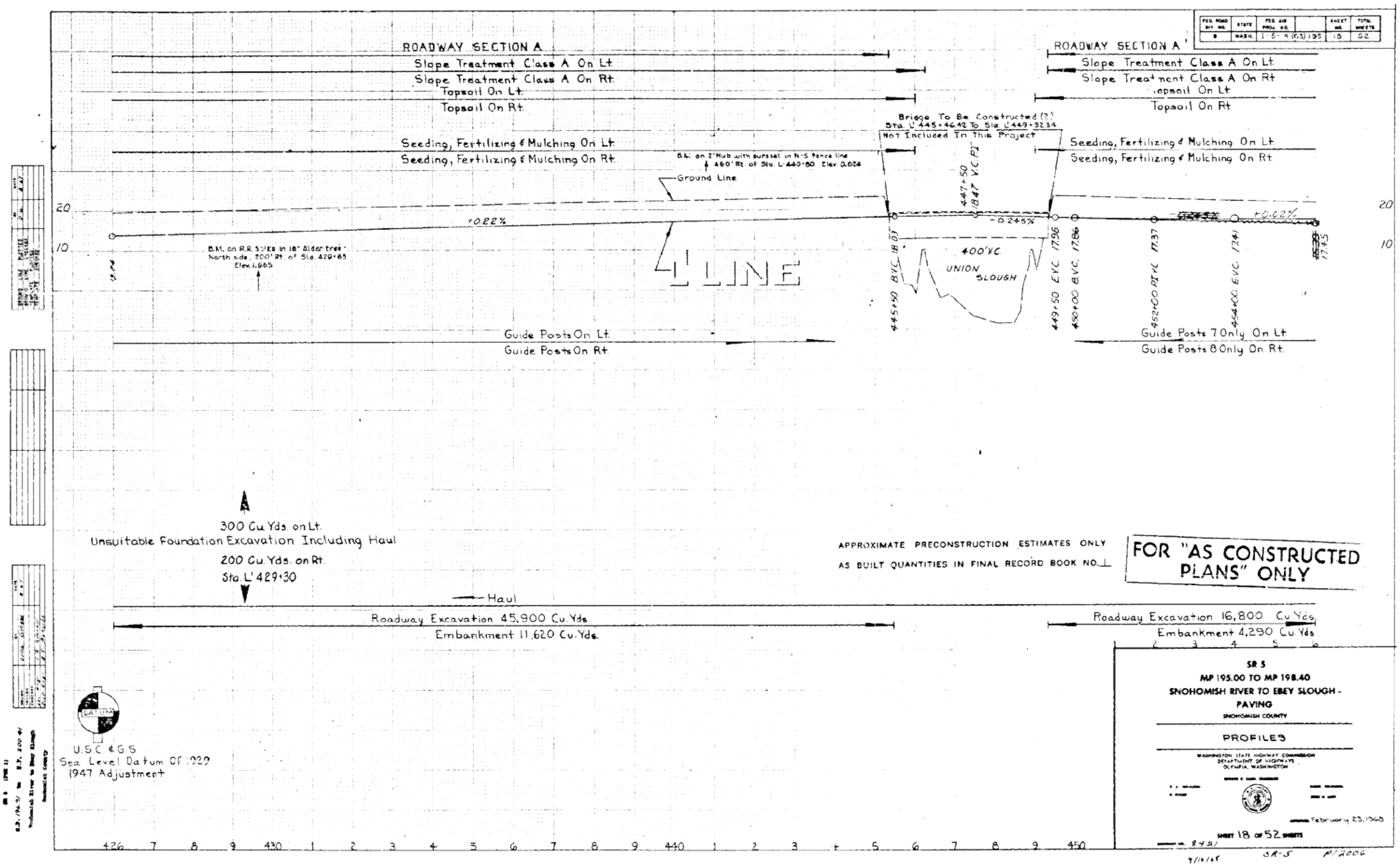
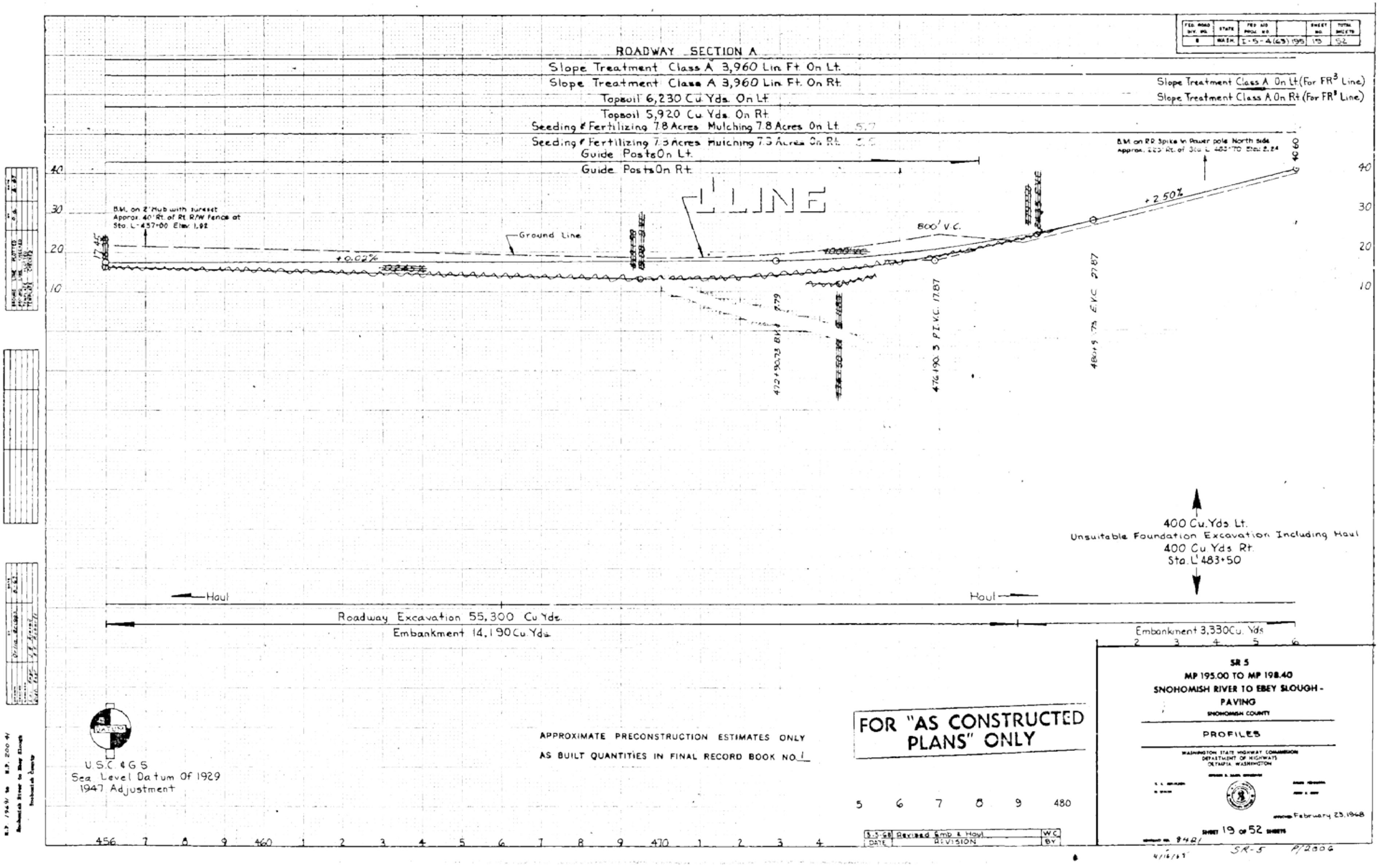
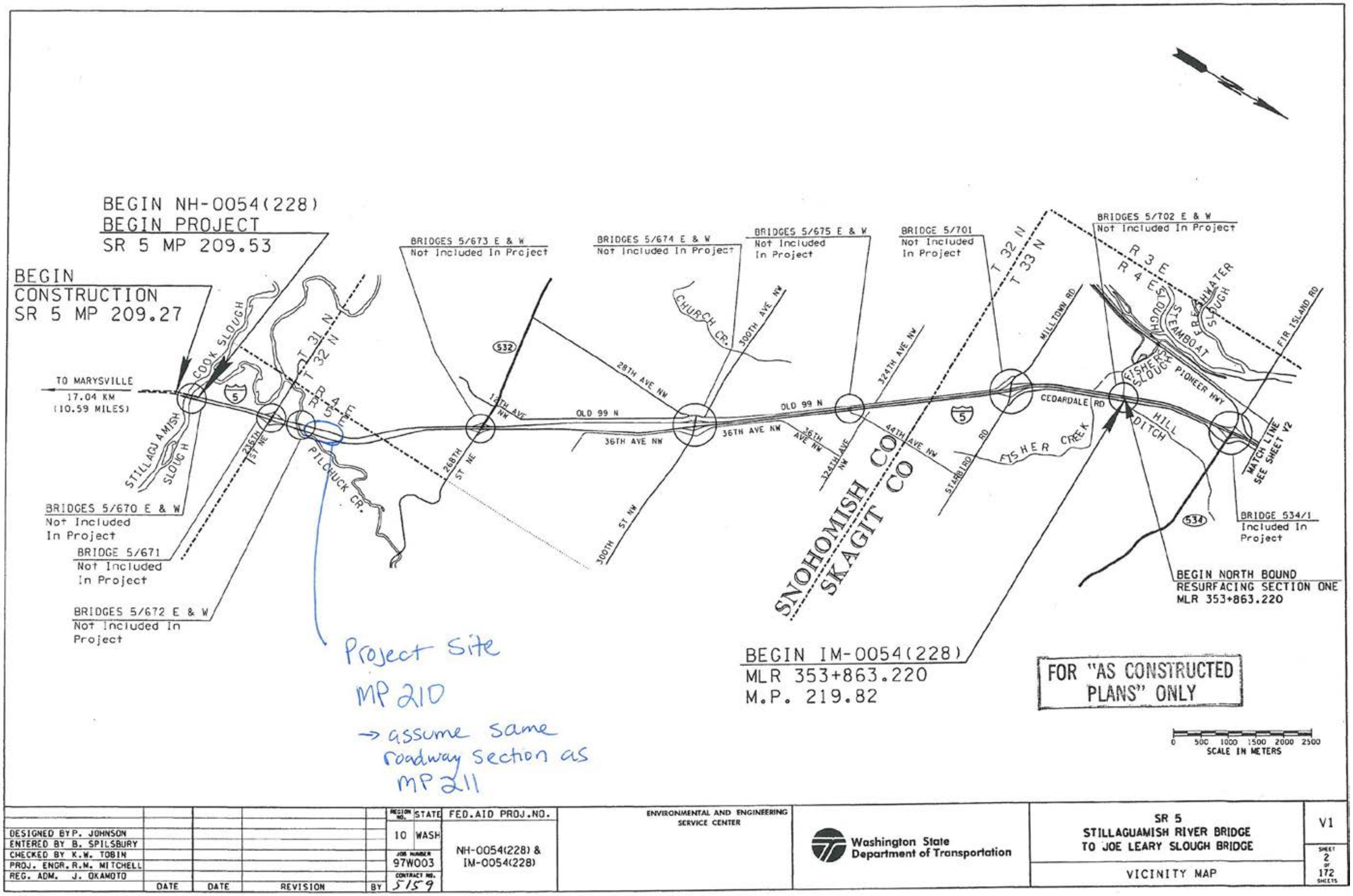
FR³ 14+86.13	99°20'53"RT.	58°00'	98.79'	116.38'	171.29'	380,007.480	1,671,251.507

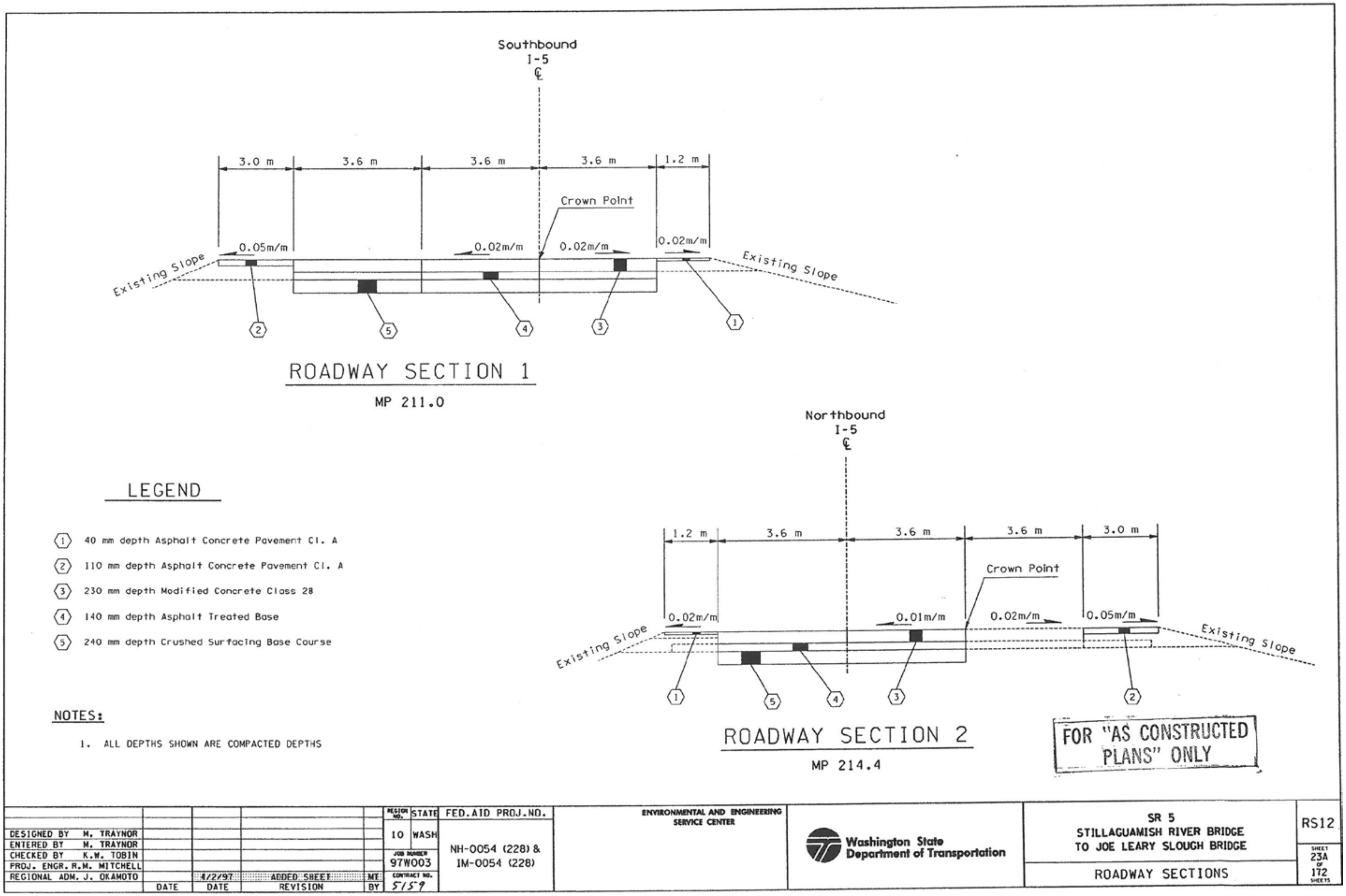

ROADWAY SECTION A
Slope Treatment Class A On Lt.
Slope Treatment Class A On Rt.
Topsoil On Lt.
Topsoil On Rt.
Seeding, Fertilizing & Mulching On Lt.
Seeding, Fertilizing & Mulching On Rt.
ROADWAY SECTION A'
Bridge To Be Constructed (2)
Sta. L' 445+46.42 To Sta. L' 449+32.34
Not Included In This Project
Ground Line
+0.22%
-0.245%
+0.62%
400' VC
UNION SLOUGH
L' LINE
445+50 BVC 18.07
447+50 18.47 V.C. PI
449+50 EVC 17.96
450+00 BVC 17.86
452+00 PI VC 17.37
454+00 EVC 17.41
Guide Posts On Lt.
Guide Posts On Rt.
Guide Posts 7 Only On Lt.
Guide Posts 8 Only On Rt.
300 Cu. Yds. on Lt.
Unsuitable Foundation Excavation Including Haul
200 Cu. Yds. on Rt.
Sta. L' 429+30
APPROXIMATE PRECONSTRUCTION ESTIMATES ONLY
AS BUILT QUANTITIES IN FINAL RECORD BOOK NO. 1
FOR "AS CONSTRUCTED PLANS" ONLY
Haul
Roadway Excavation 45,900 Cu. Yds.
Embankment 11,620 Cu. Yds.
Roadway Excavation 16,800 Cu. Yds.
Embankment 4,290 Cu. Yds.
U.S.C. & G.S.
Sea Level Datum Of 1929
1947 Adjustment
SR 5
MP 195.00 TO MP 198.40
SNOHOMISH RIVER TO EBEY SLOUGH - PAVING
SNOHOMISH COUNTY
PROFILES
WASHINGTON STATE HIGHWAY COMMISSION
DEPARTMENT OF HIGHWAYS
OLYMPIA, WASHINGTON
February 23, 1968
SHEET 18 OF 52 SHEETS
WASH. I-5-4 (63) 195
426 7 8 9 430 1 2 3 4 5 6 7 8 9 440 1 2 3 4 5 6 7 8 9 450



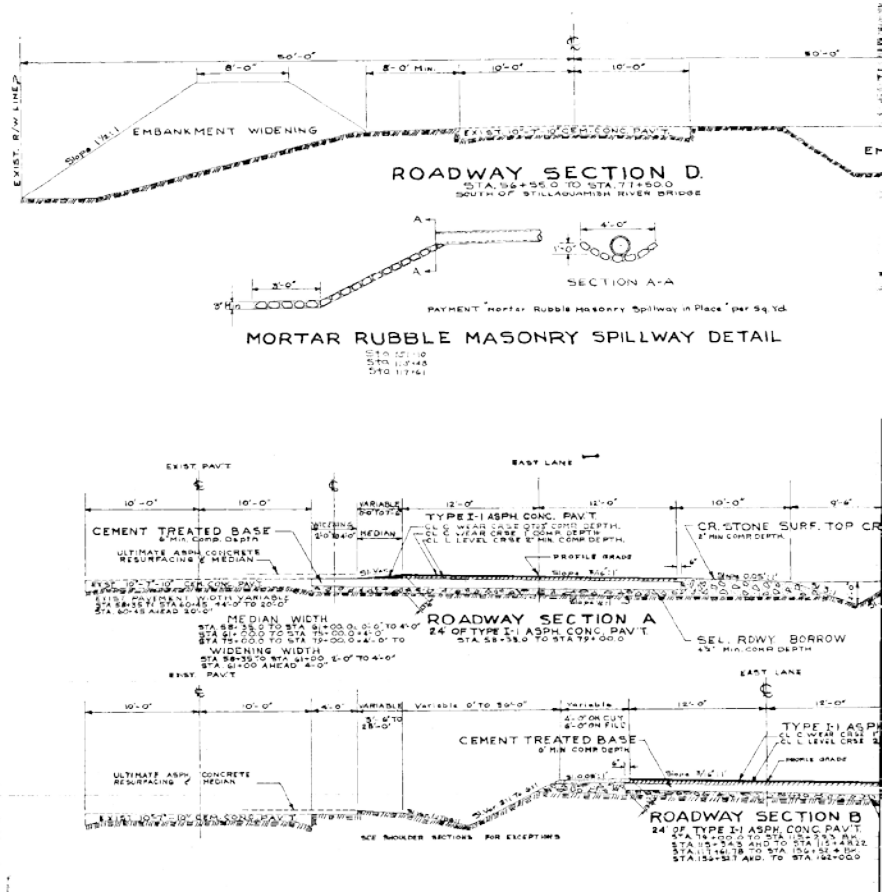
ROADWAY SECTION A
Slope Treatment Class A 3,960 Lin Ft. On Lt.
Slope Treatment Class A 3,960 Lin Ft. On Rt.
Topsoil 6,230 Cu Yds. On Lt.
Topsoil 5,920 Cu Yds. On Rt.
Seeding & Fertilizing 7.8 Acres Mulching 7.8 Acres On Lt.
Guide Posts On Lt.
Guide Posts On Rt.
Slope Treatment Class A On Lt (For FR3 Line)
Slope Treatment Class A On Rt (For FR3 Line)
"L" LINE
Ground Line
+0.02%
+2.50%
800' V.C.
400 Cu. Yds Lt.
Unsuitable Foundation Excavation Including Haul
400 Cu Yds Rt.
Sta. L 483+50
Haul
Roadway Excavation 55,300 Cu Yds.
Embankment 14,190 Cu Yds.
Embankment 3,330 Cu Yds
U.S.C. & G.S.
Sea Level Datum Of 1929
1947 Adjustment
APPROXIMATE PRECONSTRUCTION ESTIMATES ONLY
AS BUILT QUANTITIES IN FINAL RECORD BOOK NO. 1
FOR "AS CONSTRUCTED PLANS" ONLY
SR 5
MP 195.00 TO MP 198.40
SNOHOMISH RIVER TO EBEY SLOUGH - PAVING
SNOHOMISH COUNTY
PROFILES
WASHINGTON STATE HIGHWAY COMMISSION
DEPARTMENT OF HIGHWAYS
OLYMPIA, WASHINGTON
February 23, 1968
SHEET 19 OF 52 SHEETS
Revised Emb & Haul
DATE
REVISION
BY
SR-5

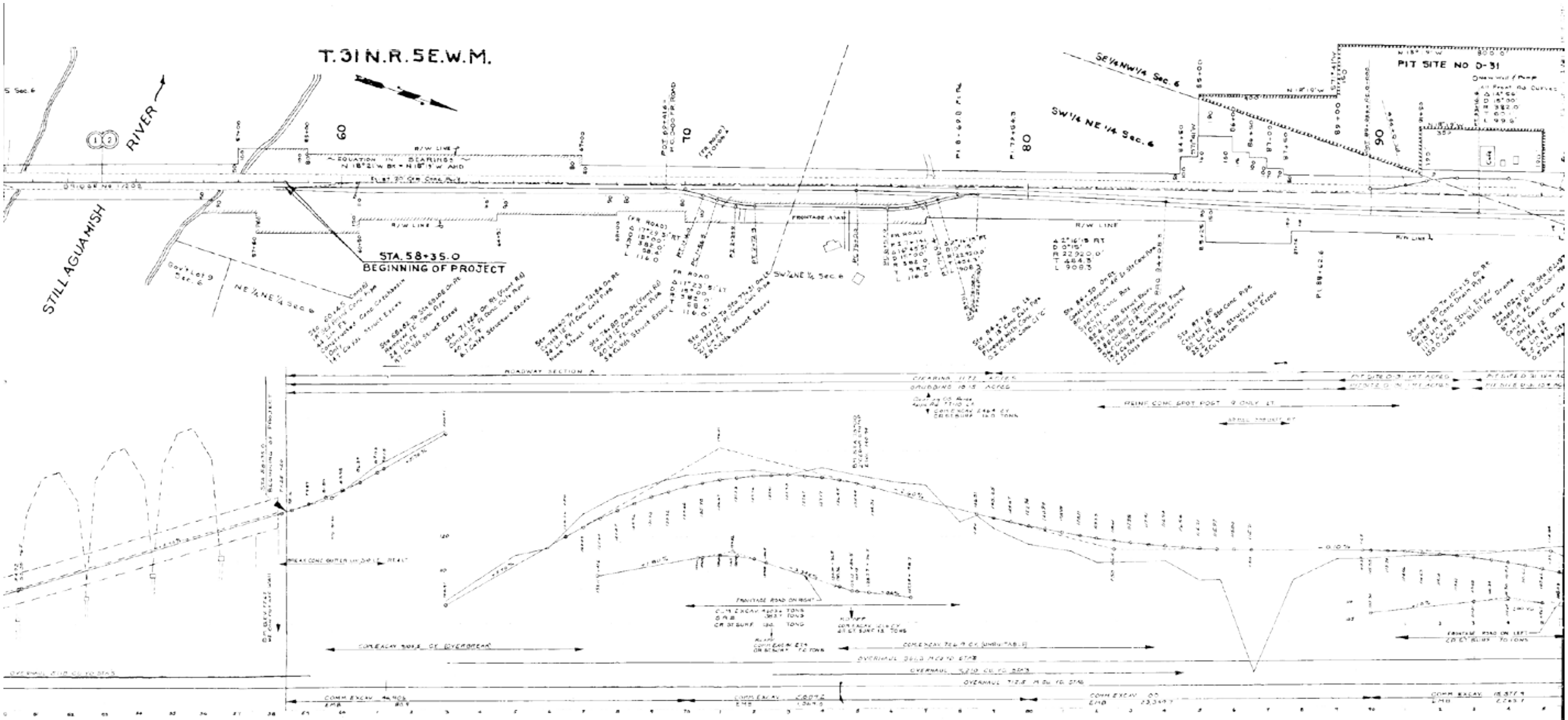
I-5 Southbound MP 210

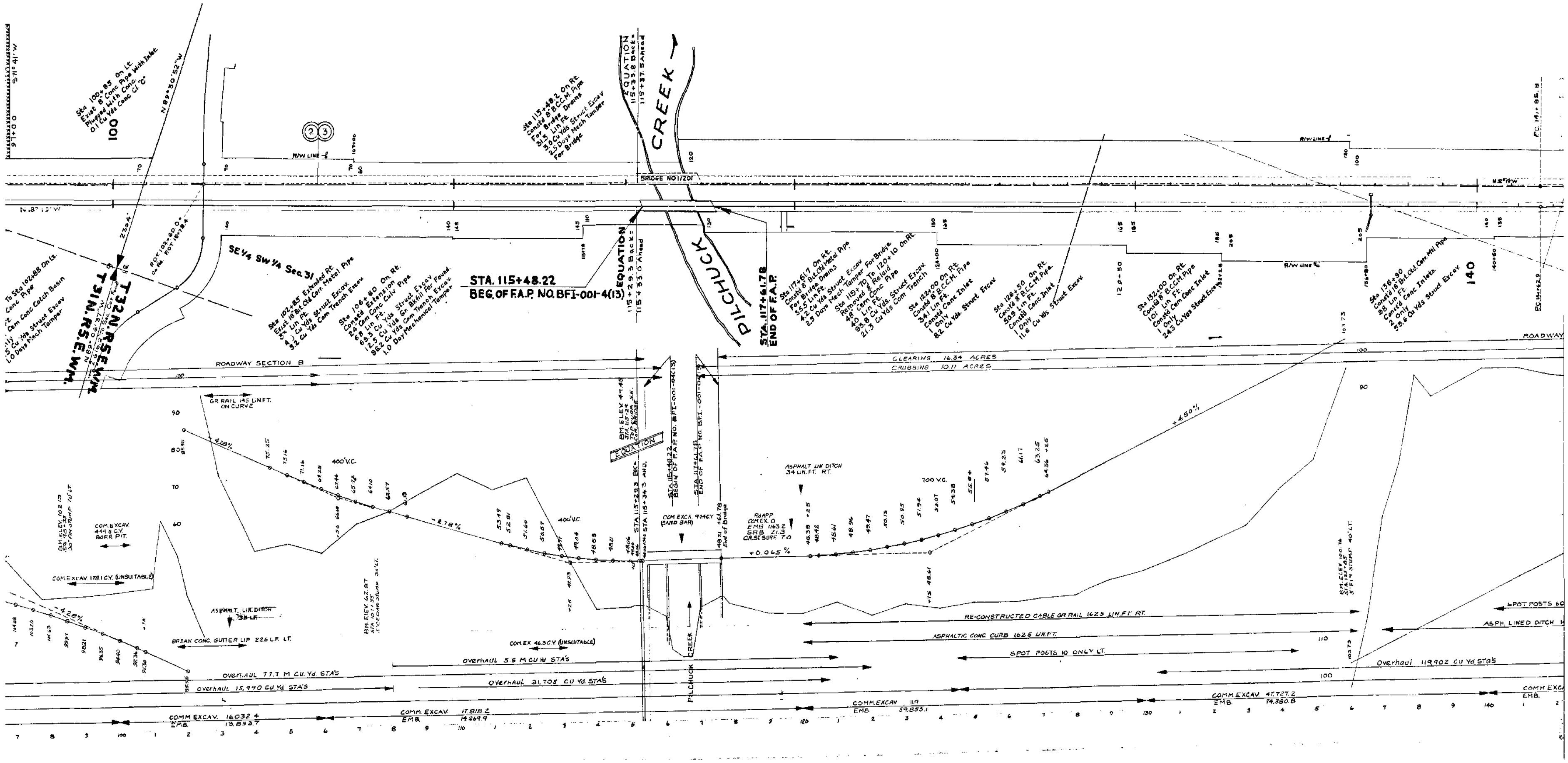



Southbound
I-5
3.0 m
3.6 m
3.6 m
3.6 m
1.2 m
Crown Point
0.05m/m
0.02m/m
0.02m/m
0.02m/m
Existing Slope
Existing Slope
ROADWAY SECTION 1
MP 211.0
Northbound
I-5
1.2 m
3.6 m
3.6 m
3.6 m
3.0 m
Crown Point
0.02m/m
0.01m/m
0.02m/m
0.05m/m
Existing Slope
Existing Slope
ROADWAY SECTION 2
MP 214.4
LEGEND
1 40 mm depth Asphalt Concrete Pavement Cl. A
2 110 mm depth Asphalt Concrete Pavement Cl. A
3 230 mm depth Modified Concrete Class 28
4 140 mm depth Asphalt Treated Base
5 240 mm depth Crushed Surfacing Base Course
NOTES:
1. ALL DEPTHS SHOWN ARE COMPACTED DEPTHS
FOR "AS CONSTRUCTED PLANS" ONLY
DESIGNED BY M. TRAYNOR
ENTERED BY M. TRAYNOR
CHECKED BY K.W. TOBIN
PROJ. ENGR. R.M. MITCHELL
REGIONAL ADM. J. OKAMOTO
DATE
4/2/97
DATE
ADDED SHEET
REVISION
MT
BY
REGION NO. 10
STATE WASH
JOB NUMBER 97W003
CONTRACT NO. 5159
FED. AID PROJ. NO.
NH-0054 (228) &
IM-0054 (228)
ENVIRONMENTAL AND ENGINEERING SERVICE CENTER
Washington State Department of Transportation
SR 5
STILLAGUAMISH RIVER BRIDGE
TO JOE LEARY SLOUGH BRIDGE
ROADWAY SECTIONS
RS12
SHEET 23A OF 172 SHEETS

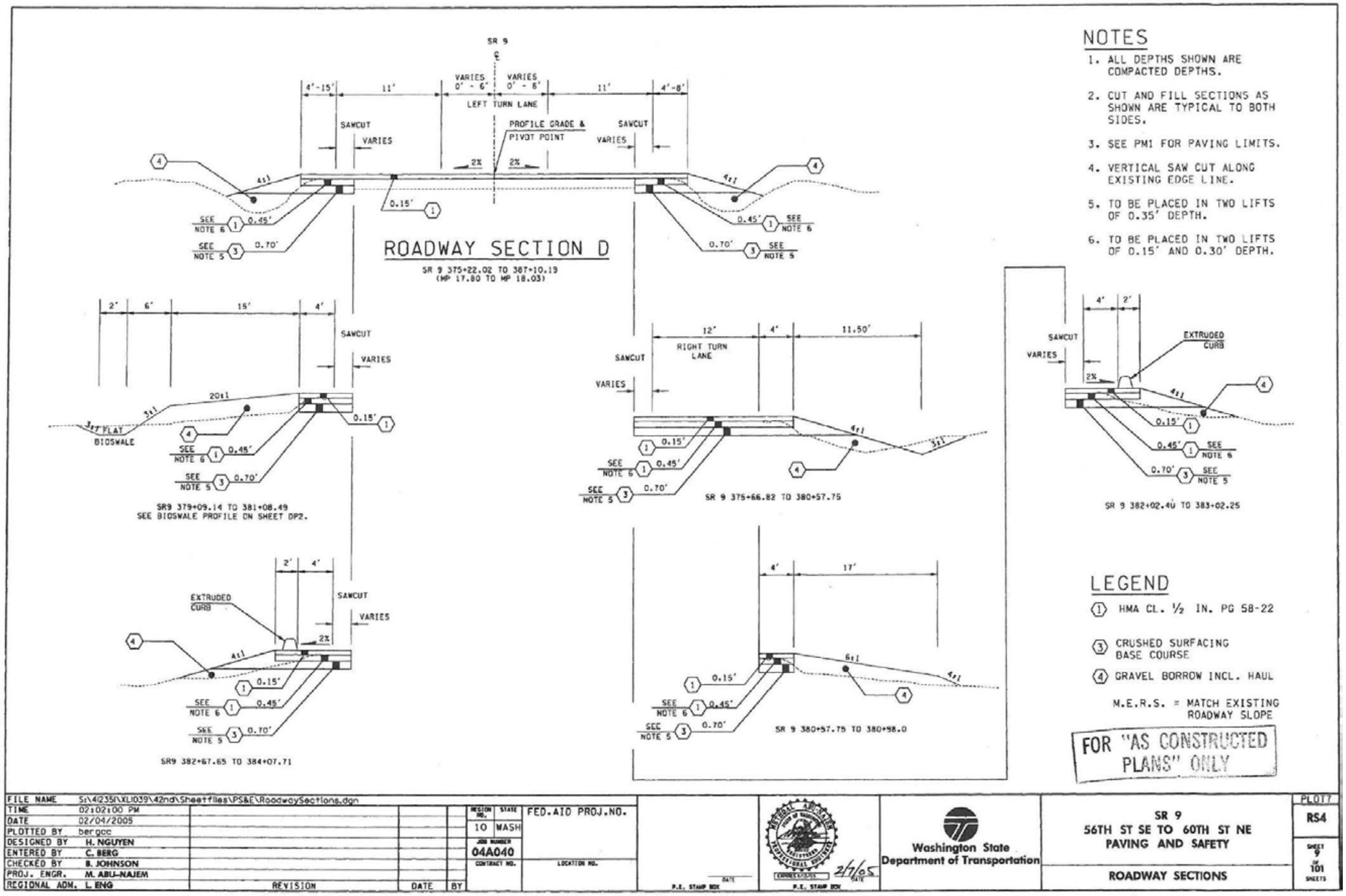
PROGRESS PROFILE
PRIMARY STATE HIGHWAY NO. 1
STILLAGUAMISH RIVER BRIDGE
TO JCT. S. S. H. NO. 1-Y
SNOHOMISH COUNTY

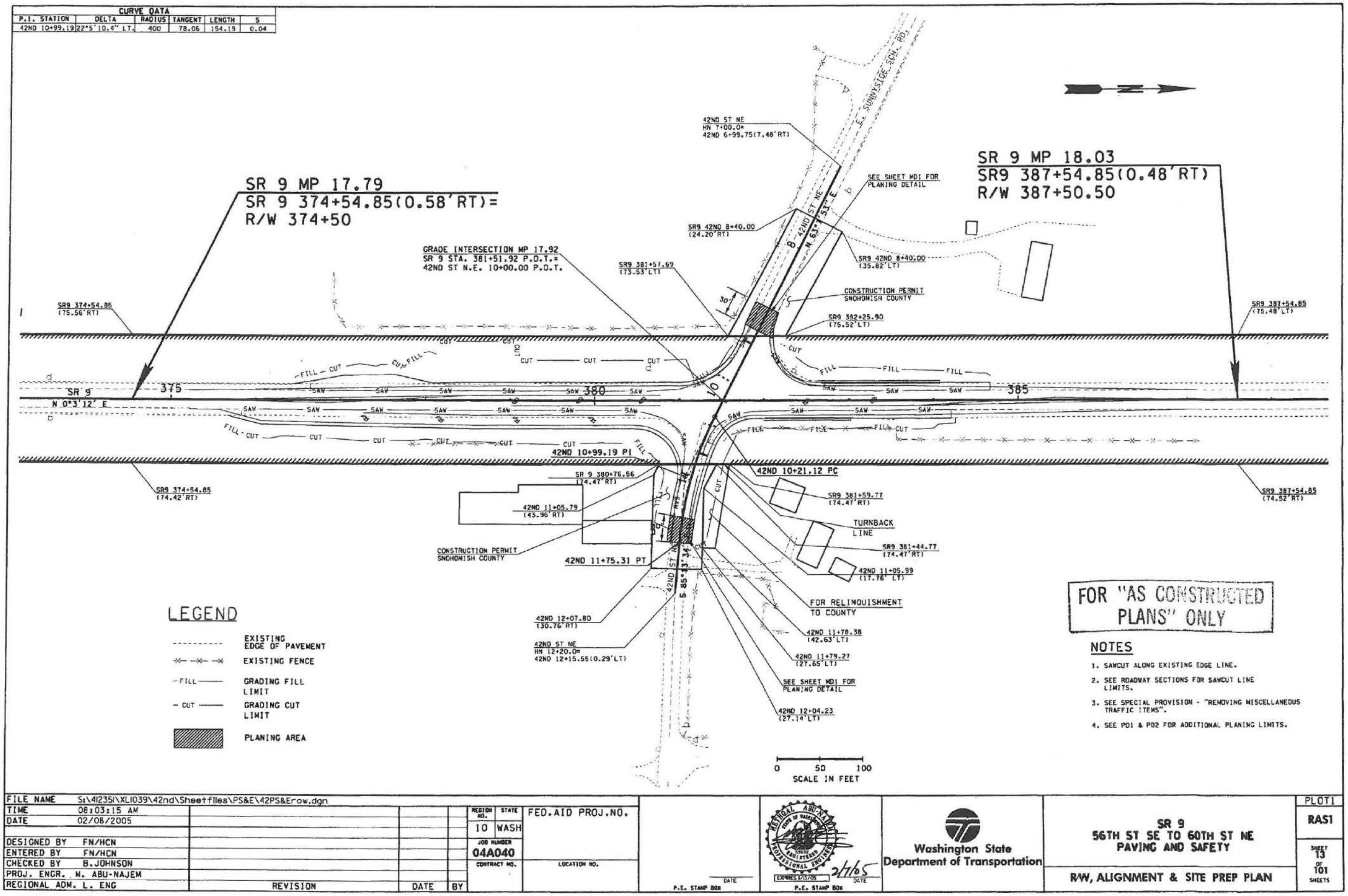



T.31N.R.5E.W.M.
STILLAGUAMISH
RIVER
STA. 58+35.0
BEGINNING OF PROJECT
PIT SITE NO D-31
SW1/4 NE1/4 Sec. 6
SE1/4 NW1/4 Sec. 6


PILCHUCK CREEK
STA. 115+48.22
BEG. OF F.A.P. NO. BFI-001-4(13)
STA. 117+61.78
END OF F.A.P.
EQUATION
T.32N.R.5E.W.M.
T.31N.R.5E.W.M.
SE1/4 SW1/4 Sec.31
BRIDGE NO 1/201
ROADWAY SECTION B
CLEARING 16.34 ACRES
GRUBBING 10.11 ACRES
RE-CONSTRUCTED CABLE GR RAIL 1625 LIN FT RT
ASPHALTIC CONC CURB 1625 LIN FT
SPOT POSTS 10 ONLY LT

SR 9 Southbound MP 18

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SR 9 MP 17.79
SR 9 374+54.85(0.58'RT)=
R/W 374+50
SR 9 MP 18.03
SR9 387+54.85(0.48'RT)
R/W 387+50.50
GRADE INTERSECTION MP 17.92
SR 9 STA. 381+51.92 P.O.T.=
42ND ST N.E. 10+00.00 P.O.T.
42ND 10+99.19 PI
42ND 10+21.12 PC
42ND 11+75.31 PT
CONSTRUCTION PERMIT
SNOHOMISH COUNTY
TURNBACK LINE
FOR RELINQUISHMENT TO COUNTY
SEE SHEET MD1 FOR PLANING DETAIL
FOR "AS CONSTRUCTED PLANS" ONLY
LEGEND
EXISTING EDGE OF PAVEMENT
EXISTING FENCE
GRADING FILL LIMIT
GRADING CUT LIMIT
PLANING AREA
NOTES
1. SAWCUT ALONG EXISTING EDGE LINE.
2. SEE ROADWAY SECTIONS FOR SAWCUT LINE LIMITS.
3. SEE SPECIAL PROVISION - "REMOVING MISCELLANEOUS TRAFFIC ITEMS".
4. SEE PD1 & PD2 FOR ADDITIONAL PLANING LIMITS.
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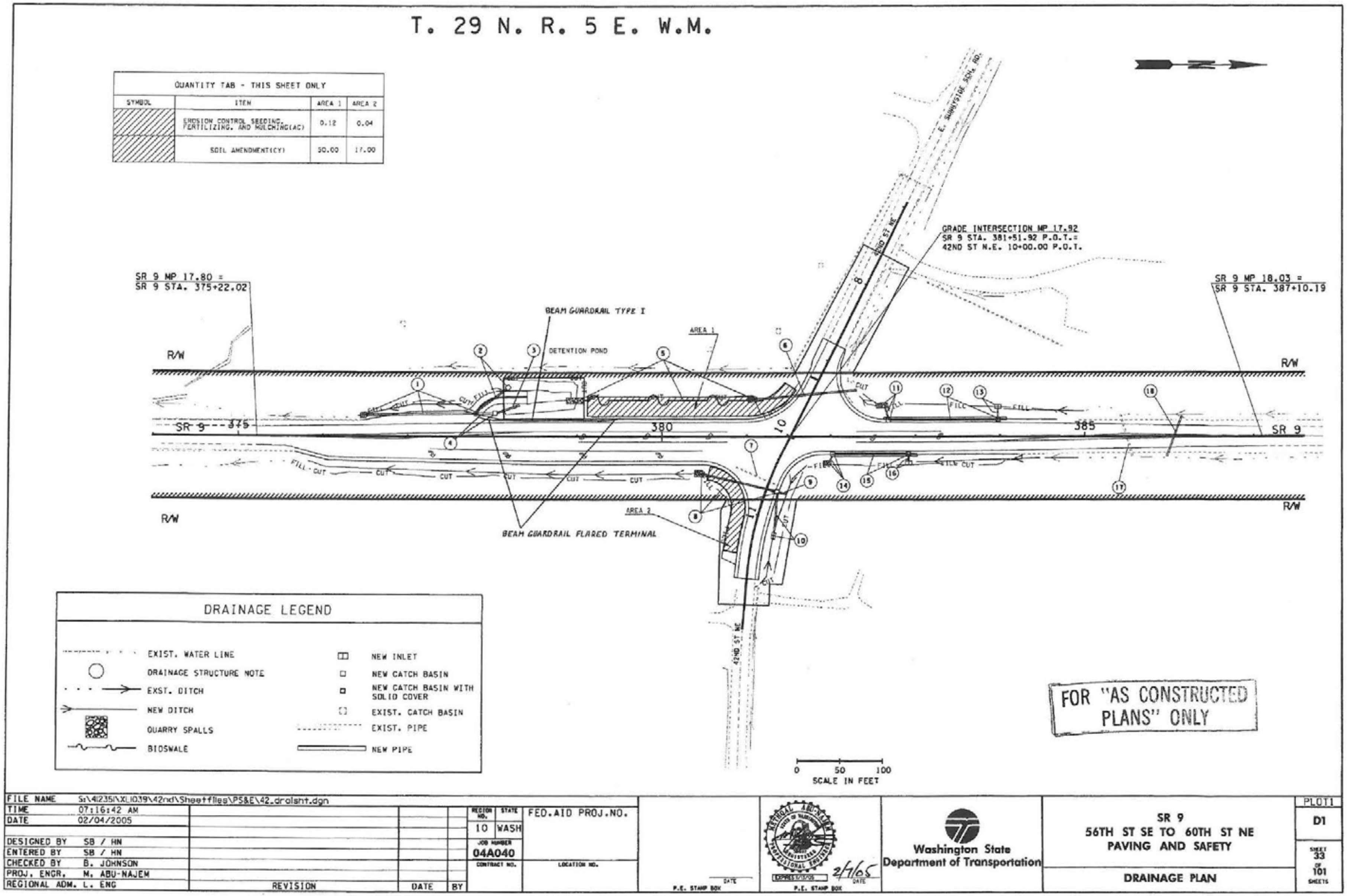
TIME 08:03:15 AM
DATE 02/08/2005
DESIGNED BY FN/HCN
ENTERED BY FN/HCN
CHECKED BY B.JOHNSON
PROJ. ENGR. M. ABU-NAJEM
REGIONAL ADM. L. ENG
REVISION
FED.AID PROJ.NO.
10 WASH
04A040
Washington State Department of Transportation
SR 9
56TH ST SE TO 60TH ST NE
PAVING AND SAFETY
R/W, ALIGNMENT & SITE PREP PLAN
PLOT1
RAS1
SHEET 13 OF 101 SHEETS


T. 29 N. R. 5 E. W.M.
QUANTITY TAB - THIS SHEET ONLY
SYMBOL
ITEM
AREA 1
AREA 2
EROSION CONTROL SEEDING, FERTILIZING, AND MULCHING(AC)
0.12
0.04
SOIL AMENDMENT(CY)
50.00
17.00
GRADE INTERSECTION MP 17.92
SR 9 STA. 381+51.92 P.O.T.=
42ND ST N.E. 10+00.00 P.O.T.
SR 9 MP 17.80 =
SR 9 STA. 375+22.02
SR 9 MP 18.03 =
SR 9 STA. 387+10.19
BEAM GUARDRAIL TYPE I
DETENTION POND
AREA 1
AREA 2
BEAM GUARDRAIL FLARED TERMINAL
R/W
SR 9
42ND ST NE
DRAINAGE LEGEND
EXIST. WATER LINE
DRAINAGE STRUCTURE NOTE
EXST. DITCH
NEW DITCH
QUARRY SPALLS
BIOSWALE
NEW INLET
NEW CATCH BASIN
NEW CATCH BASIN WITH SOLID COVER
EXIST. CATCH BASIN
EXIST. PIPE
NEW PIPE
FOR "AS CONSTRUCTED PLANS" ONLY
SCALE IN FEET
FILE NAME
TIME 07:16:42 AM
DATE 02/04/2005
DESIGNED BY SB / HN
ENTERED BY SB / HN
CHECKED BY B. JOHNSON
PROJ. ENGR. M. ABU-NAJEM
REGIONAL ADM. L. ENG
REVISION
DATE
BY
10
WASH
FED.AID PROJ.NO.
04A040
Washington State Department of Transportation
SR 9
56TH ST SE TO 60TH ST NE
PAVING AND SAFETY
DRAINAGE PLAN
D1
33
101

Appendix I: BMP Design Specifications and Soil Properties

BMP Design Specifications

The following tables I-1, I-2, and I-3 provide detailed information about the monitoring sites' characteristics and BMP Engineering Specifications. Information is primarily based on the HRM and the size of previously monitored unimproved embankments.

Table I-1 Technical details of BMPs at I-5 Northbound MP 197, Everett.

Technical Elements	Modified VFS	VFS
Land use	Highway paved surface	Highway paved surface
Imperviousness of contributing area	100%	100%
Drainage areas	See Table 6.	
Sizing		
Volume	"In western Washington, the on-line design flow for runoff treatment is the flow rate derived from a continuous model (such as MGSFlood or WWHM) that calculates the flow rate from the drainage basin below which 91% of the average annual runoff volume occurs" (2008 HRM, pp 5-36; also, see Table 6.)	
Flow rate		
Hydraulic loading rate		
Depth	3" compost blanket will be applied to the existing road shoulder fill material	The VFS design is based on land cover (Manning's "n" coefficient for grass) and residence time. The depth of flow over a VFS is 1 inch at the design flow rate.
Length	78.74 feet	78.74 feet
Width	6.56 and 13.12 feet (2 and 4 meters)	6.56 and 13.12 feet (2 and 4 meters)
Depth of ponded water	1-inch maximum	1-inch maximum
Detention time	(to be learned by this study)	HRM design calls for 9 minutes (at 13.12 feet)
Soils/Groundwater		
Groundwater presence	None detected to 12 ft below ground surface (bgs)[1]	
Control of run-on water	n/a	
Site soils	Approximately 12" of fill material, above the road base soil materials[1] (WSDOT, 2011b) Fill layer (uppermost) – Alluvial fine-grained silty sand to 5 feet below ground surface underlain by olive-gray, fine-grained silty sand to 10 feet bgs, and dark gray, fine-grained silty sand to the bottom of the boring at 11 feet bgs[1]	
Impermeable liner	n/a	n/a
Estimated infiltration losses	(to be learned by this study)	
Cation exchange capacity	(WSDOT, 2011b)	
Size gradation		
Compost mix	Will meet HRM specs	n/a
Design losses from compost	(to be learned by this study)	n/a
Media Description		
Vegetative species	Orchard grass (*Dactylis glomerata*),velvet grass (*Holcus lanatus*), hairy cat's ear (*Hypochaeris radicata*), tall fescue (*Schedonorus phoenix*), perennial ryegrass (*Lolium perenne*), English plantain (*Plantago lanceolata*) bluegrass (*Poa* spp.), Crane's bill (*Geranium molle*), and sheep sorrel (*Rumex acetosella*)[1]	
Sand thickness	n/a	n/a
Artificial media thickness	n/a	n/a
Compost thickness	3-inch compost blanket	n/a
Monitoring Locations		
Inlets	At pavement edge collector	At pavement edge collector
Outlets	6.56 and 13.12 ft (2 & 4 m) collector discharge point	6.56 and 13.12 ft (2 & 4 m) collector discharge point
Mid-BMP sediment	n/a	n/a
Sediment depth	n/a	n/a

bgs = below ground surface

[1] From WSDOT, 2010.

Table I-2 Technical details of BMPs at I-5 Southbound MP 210, Pilchuck.

Technical Elements	Modified VFS	VFS	CAVFS
Land use	Highway paved surface	Highway paved surface	Highway paved surface
Imperviousness of contributing area	100%	100%	100%
Drainage areas	See Table 6.		
Sizing			
Volume	"In western Washington, the on-line design flow for runoff treatment is the flow rate derived from a continuous model (such as MGSFlood or WWHM) that calculates the flow rate from the drainage basin below which 91% of the average annual runoff volume occurs" (2008 HRM, pp 5-36; also, see Table 6.)		CAVFS are designed to infiltrate and/or filter 91% or more of the total runoff volume
Flow rate			
Hydraulic loading rate			
Depth	3" compost blanket will be applied to the existing road shoulder fill material	The VFS design is based on land cover (Manning's "n" coefficient for grass) and residence time. The depth of flow over a VFS is 1 inch at the design flow rate.	3" of compost will be tilled in to the existing road shoulder fill material to a depth of 12"
Length	78.74 feet	78.74 feet	78.74 feet
Width	6.56 and 13.12 feet (2 and 4 meters)	6.56 and 13.12 feet (2 and 4 meters)	6.56 and 13.12 feet (2 and 4 meters)
Depth of ponded water	1-inch maximum	1-inch maximum	1-inch maximum
Detention time	(to be learned by this study)	HRM design calls for 9 minutes (at 13.12 ft)	The CAVFS design is not based on residence time
Soils/Groundwater			
Groundwater presence	No	No	Yes
Control of run-on water	n/a	n/a	n/a
Site soils	(WSDOT, 2011b)	Fill layer (~5 ft) densely compacted silty, gravelly sand with cobbles and a trace of clay – Soil under fill is stratified pebble, cobble, and boulder gravel	(WSDOT, 2011b)
Impermeable liner	n/a	n/a	n/a
Estimated infiltration losses	(to be learned by this study)		
Cation exchange capacity	(WSDOT, 2011b)		
Size gradation			
Compost mix	Will meet HRM specs	n/a	Will meet HRM specs
Design losses from compost	(to be learned by this study)	n/a	CAVFS are designed to infiltrate and/or filter 91% or more of the total runoff volume
Media Description			
Vegetative species	Vanilla grass (*Anthoxanthum odoratum*), vetch (*Vicia americana*), tall fescue (*Schedonorus phoenix*), hairy cat's ear (*Hypochaeris radicata*), velvet grass (*Holcus lanatus*), oxeye daisy (*Leucanthemum vulgare*), St. Johnswort (*Hypericum perforatum*), red clover (*Trifolium pratense*), alfalfa (*Medicago sativa*), Canada thistle (*Cirsium arvense*), wild carrot (*Daucus carota*), English plantain (*Plantago lanceolata*), hop clover (*Trifolium campestre*) [1]		
Sand thickness	n/a	n/a	n/a
Artificial media thickness	n/a	n/a	n/a
Compost thickness	3-inch compost blanket	n/a	Will meet HRM specs
Monitoring Locations			
Inlets	See VFS	At pavement edge collector	See VFS
Outlets	6.56 and 13.12 ft (2 & 4 m) collector discharge point	6.56 and 13.12 ft (2 & 4 m) collector discharge point	6.56 and 13.12 ft (2 & 4 m) collector discharge point
Mid-BMP sediment	n/a	n/a	n/a
Sediment depth	n/a	n/a	n/a

bgs = below ground surface

[1] From WSDOT, 2010.

Table I-3 Technical details of SR 9 MP 18 near Marysville.

Technical Elements	VFS
Drainage Area Details	
Land use	Highway paved surface
Imperviousness of contributing area	100%
Drainage area	See Table 6.
Sizing	
Volume	"In western Washington, the on-line design flow for runoff treatment is the flow rate derived from a continuous model (such as MGSFlood or WWHM) that calculates the flow rate from the drainage basin below which 91% of the average annual runoff volume occurs" (2008 HRM, pp 5-36; also, see Table 6.)
Flow rate	
Hydraulic loading rate	
Depth	The VFS design is based on land cover (Manning's "n" coefficient for grass) and residence time. The depth of flow over a VFS is 1 inch at the design flow rate.
Length	78.74 feet
Width	13.12 feet (4 meters)
Depth of ponded water	1-inch maximum
Detention time	HRM design calls for 9 minutes (at 13.12 ft)
Soils/Groundwater	
Groundwater presence	No
Control of run-on water	n/a
Site soils	Tokul 72; hydrologic soil group C
Impermeable liner	n/a
Estimated infiltration losses	(to be learned by this study)
Cation exchange capacity	(WSDOT, 2011c)
Size gradation	
Compost mix	n/a
Design losses from compost	n/a
Media Description	
Vegetative species	Till grass
Sand thickness	n/a
Artificial media thickness	n/a
Compost thickness	n/a
Monitoring Locations	
Inlets	At pavement edge collector
Outlets	13.12 ft (4 m) collector discharge point
Mid-BMP sediment	n/a
Sediment depth	n/a

Soil Cores and Lab Results

For further site-specific details, see: WSDOT, 2011c. Geotechnical Evaluation Report for BMP Effectiveness Stormwater Monitoring Sites on I-5 and SR 9. The report is available for review; please contact Fred Bergdolt at 360-570-6648 to obtain a copy.

Appendix J: Toxicity Details 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 J-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 J-1 Toxicity follow-up study design if the EC50 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(s) of toxicity. The result of this process may be changes to maintenance procedures or BMPs that aim to reduce the toxicity. Table J-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 EPA's 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 any time the EC_{50} is 100% or less and report the findings to Ecology as specified in action item 2.1.1.

If the toxicant of concern is not identified after action item 2.1 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 be conducted only 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, but does not require, 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 respective toxicity in a receiving water with a higher hardness. If a receiving water body is directly receiving runoff 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). 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.

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.*

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 K: Packing Lists and Trip Checklists

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
- Water (during dry season)

Vehicle Folder

- Mileage logs
- Emergency information
- Fuel card
- Maps
- PASP & HASP binder
- Contact lists
- SOP binder
- Quick Pass (Bainbridge)
- Tablet + MiFi

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)
- Confined Space Entry Equipment
    - Trash pump w/ hose
    - Harness
    - Tripod
    - Ventilator
    - Winch
    - 4 gas meter w/ rope
    - CSE form
    - Road Cones (28" retro refl.)

Tools / Other

- Mechanic's toolbox
- Electrical tool box (w/ multi-meter)
- Shovel
- Loppers/clippers/machete
- Tire chains
- Spare keys
- Manhole/grate lid puller
- Jack, jack handle, adequate spare tire
- Flashlight
- Lighter (for shrink tubing)
- Pens
- Ladder
- Pencils
- Notepaper
- Flagging tape
- Orange spray paint
- Spare bucket
- Bubble level
- Tool for clearing sediment from collectors
- Back up lock
- Conduit & pipe glue
- Fish tape
- File/sandpaper
- "Thumb gum"
- Socket wrench kit (9/16 for peizos)
- Wire
- camera

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)
- Spare FTS cables
- Spare data logger
- Spare antenna
- Spare thermistor
- Logger Menu Flow Chart
- Station/site keys
- Other keys as needed
- Appropriate DCP 12V batteries
- 5 and 10 mL pipette + tips
- 1000 graduated cylinder
- Compass
- Appropriate sized Nitrile gloves
- Water level indicator

Station Visit Folder

- Station Visit Sheets
- Station Visit Thumb Drive
- Maps/station directions
- SOPs
- Equipment manuals/vendor contact information

Autosampler Gear

- Replacement (clean):
    - suction tubing and/or pump tubing
    - strainers
    - desiccant(s)
    - bottle w/ lid
    - batteries
    - cooler(s)
- Lab provided DI water
- Forms, etc. for regional staff restock

Personal Equipment

- Water
- Food
- Spare dry clothes
- PPE gear bag (rain gear, boots, gloves, headlamp, hard hat, ear plugs, vest)
- Sunscreen

Appendix L: Field Sampling Forms

BMP SAMPLING FIELD FORM

Zack Holt *SW Field Lead* 360-480-1523/ HoltZ@wsdot.wa.gov	Ashley Carle *SW Assistant* 360-628-7334/ CarleAs@wsdot.wa.gov	Brandon Slone *SW Assistant* 360-628-6103/ SloneBr@wsdot.wa.gov

Lead Sampler: Other Sampling Staff Present:

Site Name:

Phase 2 & 3 (ISCO/ Composite — **Use Local Military Time for COC, bottle labels and tags. ((Subtract 7 hrs. during daylight saving time(Summer) or subtract 8 hrs. during standard time(Winter))**

"Program Done" Date/Time (from ISCO): ___/____/____ _____:_____

Number of aliquots taken by ISCO:

Phase 2 & 3 Sample ID (from bottle label): _______-______-_____-___________ (Site, Pipe No., Type, YYMMDD)

Phase 2 & 3 Duplicate Sample ID (from bottle label): _______-______-_____-___________ (Site, Pipe No., Type, YYMMDD)

Phase 2 (ISCO/Composite)

Filter Date/Time (from Datalogger): ___/____/____ _____:_____ ☐Orthophosphate ☐Duplicate

Duplicate Filter Date/ Time (from Datalogger): ___/____/____ _____:_____ ☐Dissolved Metals ☐Duplicate

☐Total Metals/Hardness ☐Duplicate

pH (from TSS sample):_________ Method (circle one): Strip Meter

Phase 3 (ISCO/Composite)

Date/Time Staff finished collecting samples (from Datalogger): ___/____/____ _____:_____

☐TSS ☐Duplicate

☐PSD ☐Duplicate

☐Total Phosphorus/Nitrates/TKN ☐Duplicate

Questions

Site prepped for sampling? (Pipe Cleared of Sediment Etc.)	Y	N		NOTES
Briefly describe weather during sample collection:				
How full was the ISCO jar (%)? :				
Color of water in ISCO jar:				
Describe debris in ISCO jar (If any):				
Wet filter w/ sample water before filtering Dissolved metals/OrthoPhos. samples?	Y	N	N/A	NOTES
Hang Tags completed and attached to filled sample bottles?	Y	N		NOTES
C.O.C.s completed in pen, placed in cooler and relinquished?	Y	N	N/A	NOTES
Cooler tightly packed with ice packs and/or bagged ice and taped shut?	Y	N	N/A	NOTES
Red "Environmental Sample" label filled in and used to seal cooler?	Y	N	N/A	NOTES
New ISCO jar with clean lid installed?	Y	N	N/A	NOTES
Reconnected ISCO suction tubing?	Y	N	N/A	NOTES
Possible contamination? (Note in comments below)	Y	N		
Cooler shipped to lab or left at drop location for pick up?	Y	N	N/A	
Sampling Field Form and any notes scanned and sent to Field Crew?	Y	N	N/A	NOTES

Comments (Continue on back if necessary):

TOXICITY SAMPLING FIELD FORM

Zack Holt *SW Field Lead* 360-480-1523/ HoltZ@wsdot.wa.gov	Ashley Carle *SW Assistant* 360-628-7334/ CarleAs@wsdot.wa.gov	Brandon Slone *SW Assistant* 360-628-6103/ SloneBr@wsdot.wa.gov

Lead Sampler: Other Sampling Staff Present:

Site Name:

Phase 1 (Grab Samples and pH) — **NOTE: Please convert time/date from this form to Local Time for COC, bottle labels and tags. (Subtract 7 hrs. during daylight saving time(Summer) or subtract 8 hrs. during standard time(Winter))**

Sample Date/Time (from Data Logger): ☐TPH-Gx

Phase 1 Sample ID (from bottle label): ☐TPH-Dx

Phase 1 Duplicate Sample ID (from bottle label)

pH: ____ Source (circle one): Grab TSS Sample Method (circle one): Strip Meter

Phase 2 &3 (ISCO/Composite)

"Program Done" Date/Time (from ISCO):

Number of Samples taken by ISCO:

Phase 2 & 3 Sample ID (from bottle label):

Phase 2 & 3 Duplicate Sample ID (from bottle label):

Phase 2 (ISCO/Composite)

Filter Date/Time (from Datalogger): ☐Dissolved Metals

Duplicate Filter Date/Time (from Datalogger): ☐Total Metals

Phase 3 (ISCO/Composite)

Date/Time Staff finished collecting samples (from Datalogger):

☐Glyphosate	☐Hardness	☐PAH/Phlalates	☐TKN
☐TSS	☐MBAS	☐Nitrates/ites	☐Hyalella azteca
☐Chlorides	☐PAH/SIM		

Questions

Site prepped for sampling?	Y	N		NOTES
Briefly describe weather during sample collection:				
How full was the ISCO jar (%)? :				
Color of water in ISCO jar:				
Briefly describe debris in ISCO jar (If any):				
Visible sheen in water that Grab Samples were taken from?	Y	N		NOTES
Hydrochloric Acid added to TPH-Gx vials?	Y	N	N/A	NOTES
Wet filter w/ sample water before filtering Dissolved metals samples?	Y	N	N/A	NOTES
Hang Tags completed and attached to filled sample bottles?	Y	N		NOTES
C.O.C.s completed in pen, placed in cooler and relinquished?	Y	N		NOTES
Cooler tightly packed with ice packs and/or bagged ice and taped shut?	Y	N		NOTES
Red "Environmental Sample" label filled in and used to seal cooler?	Y	N		NOTES
New ISCO jar with clean lid installed?	Y	N	N/A	NOTES
Reconnected ISCO suction tubing?	Y	N	N/A	NOTES
Possible contamination? (Note in comments below)	Y	N		
Cooler shipped to lab or left at drop location for pick up?	Y	N	N/A	
Sampling Field Form and any notes left for pick up by Field Crew?	Y	N	N/A	NOTES

Sampling Notes and Comments (Continue on back if necessary):

Appendix M: Chain of Custody

Project Name:	**WSDOT NPDES Stormwater Monitoring**	**Turn Around Time**	**Net 30 Days**
Mailing Address:	**P.O. Box 47332** **Olympia, WA 98504**	**Physical Address:**	**2214 RW Johnson Boulevard SW** **Tumwater, WA 98512**
Send Results and Data Questions To:	**Brad Archbold, Logistics Lead** **Office: (360) 570-6636** **Cell: (360) 485-8962** **ArchboB@wsdot.wa.gov**	**Contact for Field Related Questions:**	**Zack Holt, Field Lead** **Office: (360) 570-2580** **Cell: (360) 480-1523** **holtz@wsdot.wa.gov**

						MEL							TA	ARI						
Sample Type	Sample ID	Laboratory Sample Number	Sample Collection Date/Time	Matrix	Number of Containers	Total Cu, Zn	Dissolved Cu, Zn	Orthophosphorus	TSS	Hardness	Total Phosphorus	Nitrates/Nitrites	TKN	PSD						
Comp			___/___/20___ ___:___	Water																
			___/___/20___ ___:___	Water																
			___/___/20___ ___:___	Water																
			___/___/20___ ___:___	Water																

	Recorder	Samplers	Filtered Date/Time	Sent to Lab Date/Time	Storm Qualified? (circle one)	Number of Coolers	Cooler Temp.
			___/___/20___ ___:___	___/___/20___ ___:___	Yes No		
	Relinquished by:	Received By:	Date/Time	Seal I.D.	Condition of Seals	Comments:	
1			___/___/20___ ___:___				
2			___/___/20___ ___:___				
3			___/___/20___ ___:___				
4			___/___/20___ ___:___				

Comments: