Quality Assurance Project Plan For Stormwater Monitoring

Conducted Under the Phase 1 Municipal Stormwater Permit

by

Port of Tacoma

Final

August 2009

Approved by:

Sue Mauermann, Director of Environmental Programs
Port of Tacoma

Quality Assurance Project Plan For Stormwater Monitoring

Conducted Under the Phase 1 Municipal Stormwater Permit

Port of Tacoma

Permittee Number WAR 04-4200

TITLE AND APPROVAL PAGES

Review and Approval

Name/Title/Organization	Signature	Date
Lisa Rozmyn, Port of Tacoma Stormwater Project Manager		8/13/09
Cindy Lin, Port of Tacoma Compliance Manager		8/14/09

Certification

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

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DISTRIBUTION LIST

Title	Name/Affiliation	Telephone No.	version
MS4 Permit Manager	Kurt Fremont/ECY		
MS4 Planner	Julie Lowe		
Taylor Associates	Curtis Nickerson		

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2.0 BACKGROUND

Need and Function of QA/QC

Quality assurance (QA) involves all planned and systematic actions necessary to ensure that activities are performed according to accepted standards and that the resulting data are valid. Quality control (QC) is an integral part of the overall quality assurance function and includes all actions necessary to control and verify that sample collection activities and the resulting data meet established requirements.

Purpose and Overview of this QAPP

The purpose of this Quality Assurance Project Plan (QAPP) document is to present the quality assurance (QA) and quality control (QC) procedures for field activities and laboratory analyses associated with ***stormwater outfall characterization monitoring.*** This monitoring will be conducted by the Port of Tacoma, as required by the National Pollutant Discharge and Elimination System (NPDES) and State Waste Discharge General Permit for Discharges from Large and Medium Municipal Separate Storm Sewer Systems (NPDES Phase I Permit), in Section S8.D.1.d. on page 44, as stated below.

"The Ports of Seattle and Tacoma shall each monitor one outfall or conveyance."

To address this monitoring requirement (S8.D.1.d.), this stormwater monitoring QAPP will be conducted at a single Port of Tacoma outfall location and will include the collection of event based samples for chemical analysis, seasonal "first flush" toxicity testing, and the collection of an annual sediment sample for chemical analysis.

2.1 PHASE 1 MUNICIPAL STORMWATER PERMIT

The Washington State Department of Ecology (Ecology) issued the final *National Pollutant Discharge and Elimination System (NPDES) and State Waste Discharge General Permit for Discharges from Large and Medium Municipal Separate Storm Sewer Systems* (Phase I Permit) on January 17, 2007. The Phase I Permit applies to all entities in Washington State required to have permit coverage under current (Phase I) U.S. Environmental Protection Agency (EPA) stormwater regulations. This includes cities and unincorporated portions of counties whose populations exceed 100,000.

In accordance with the Phase I Permit, permittees are required to develop and implement a comprehensive long-term monitoring program consistent with Special Condition S.8 of the permit. In general, the monitoring program shall include three components:

- Stormwater Monitoring (S.8.D), the subject of this QAPP document,
- Stormwater Management Program (SWMP) Effectiveness Monitoring (S.8.E), and
- Stormwater Treatment and Hydrologic Management Best Management Practices (BMP) Evaluation Monitoring (S.8.F).

Ecology's objective in requiring a monitoring program is to provide a basis for the future reduction of stormwater pollutants. The information developed from monitoring establishes a baseline for evaluation of the effectiveness of stormwater management strategies. It may also assist in the identification of seasonal trends that may influence the interpretation of monitoring results.

2.1.1 Controlling Stormwater Discharges

Variable Nature of Stormwater Presents Monitoring Challenges

Municipal stormwater runoff has a number of unique attributes that make the identification of problems, as well as their associated solutions, difficult to determine.

- First, stormwater contains a wide variety of pollutants, and their concentrations can vary widely depending on storm events, land use and a number of other local and regional parameters.
- In addition, the quality of stormwater runoff can often be difficult to manage due to the seasonal, sporadic nature of surface water discharges, and the character and unpredictability of storm events.
- Further adding to the difficulty of both sampling and controlling stormwater discharges is the fact that most municipal agencies have a large number of stormwater outfalls, with a wide diversity of locations and types of outfalls.

Additional Monitoring Challenges Associated with the Port of Tacoma

Controlling stormwater discharges within the Port of Tacoma presents even additional challenges unique to a Port facility located within industrial areas and diverse maritime business.

- The Port's storm drainage system consists of a series of several independent clusters of facilities that directly serve clusters of land, usually consisting of a few adjacent parcels.

- Most of these individual Port properties directly discharge into adjacent salt water receiving waters or to small short, small diameter drainage systems that travels a short distance before directly discharging into the adjacent marine waters.
- The Port's drainage systems intertwined with drainage systems of the City of Tacoma, City of Fife, and Pierce County.

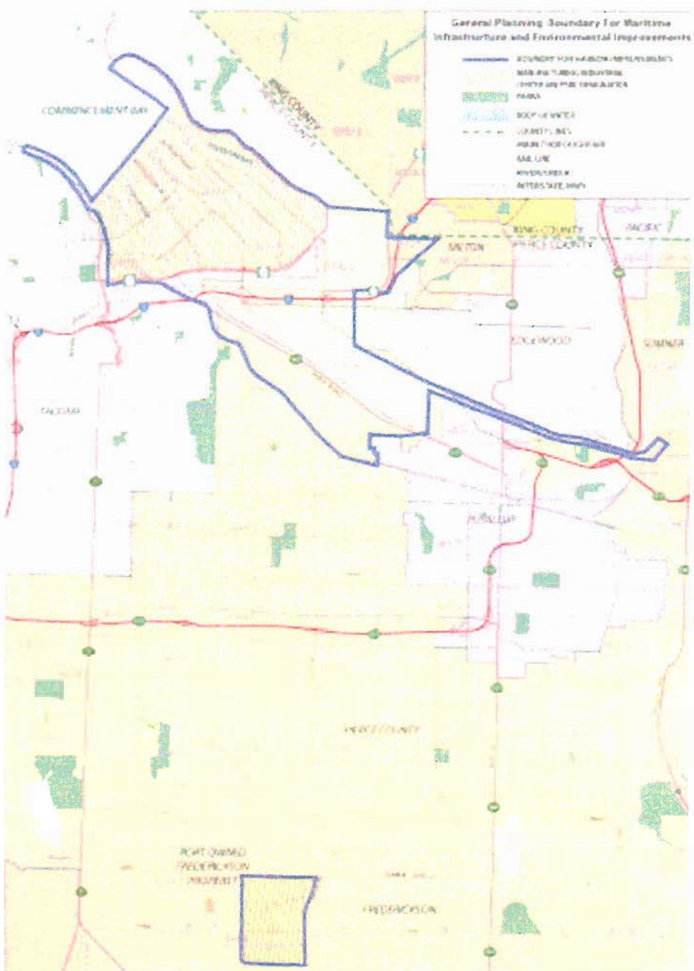


Figure 1. Vicinity map of Port properties

Most Port Lands Are Not Under the "Functional Control" of the Port of Tacoma

The Port of Tacoma (POT) owns approximately 3,430 acres of land: 2,564 acres are located on the Tacoma Tideflats, 121 acres in unincorporated Pierce County, and 745 acres in unincorporated Thurston County. At this time, the Port is actively pursuing divestment of the Thurston County property. For this reason, no analysis for this property is included in this document

Most of these industrial and municipal tenants on the Tacoma Tideflats are already under Industrial NPDES permits of their own, with on-site monitoring requirements specific to their business. These tenants must meet discharge standards independent of those required in the Port's NPDES I Stormwater Permit.

2.1.2 Monitoring Program Required for Stormwater Outfall or Conveyance

Permit Requirement: Establishment of a Long-term Baseline

In accordance with Section S8.D.1.d of the Permit, the Port of Tacoma is required to monitor one stormwater outfall or conveyance. The land use associated with this site is to be representative of 80% of the land area served by the outfall (Section S8D.1.a). The primary objective of this stormwater monitoring program, as described in S.8.D of the Phase I Permit, is to establish a database at one representative site, from which long-term trends can be observed. Data from this long-term monitoring program may be used to characterize stormwater runoff and provide a basis for evaluating the effectiveness of future stormwater control measures.

Required Monitoring Program

Stormwater monitoring, at the selected site, will be consistent with Permit §S.8.D.2., and will include continuous flow monitoring (for the first year). During each of the targeted storm events, the following water quality information will also be collected:

- Flow weighted-composite samples for chemical analyses,
- Grab samples for limited chemical analyses,
- Samples for toxicity testing of seasonal first-flush, and
- Sediment sampling for chemical analyses.

The type, number, and methodology used to select storm events to be monitored and the types of parameters to be analyzed are consistent with Permit §S8.D. and are discussed in the following QAPP.

2.2 Study Area

The Port of Tacoma (Port) owns approximately 2,700 acres of land bordering the Puyallup River, the Hylebos, Blair and Sitcum Waterways, and Commencement Bay: 2,564 acres located on the Tacoma Tideflats and 121 acres in unincorporated Pierce County. A Port parcel map is shown in Figure 2. Port property encompasses a variety of industrial, commercial, shipping terminals, intermodal facilities, vacant land and mitigation/conservation areas that are utilized for shipping, manufacturing, warehousing, distribution and mitigation activities.

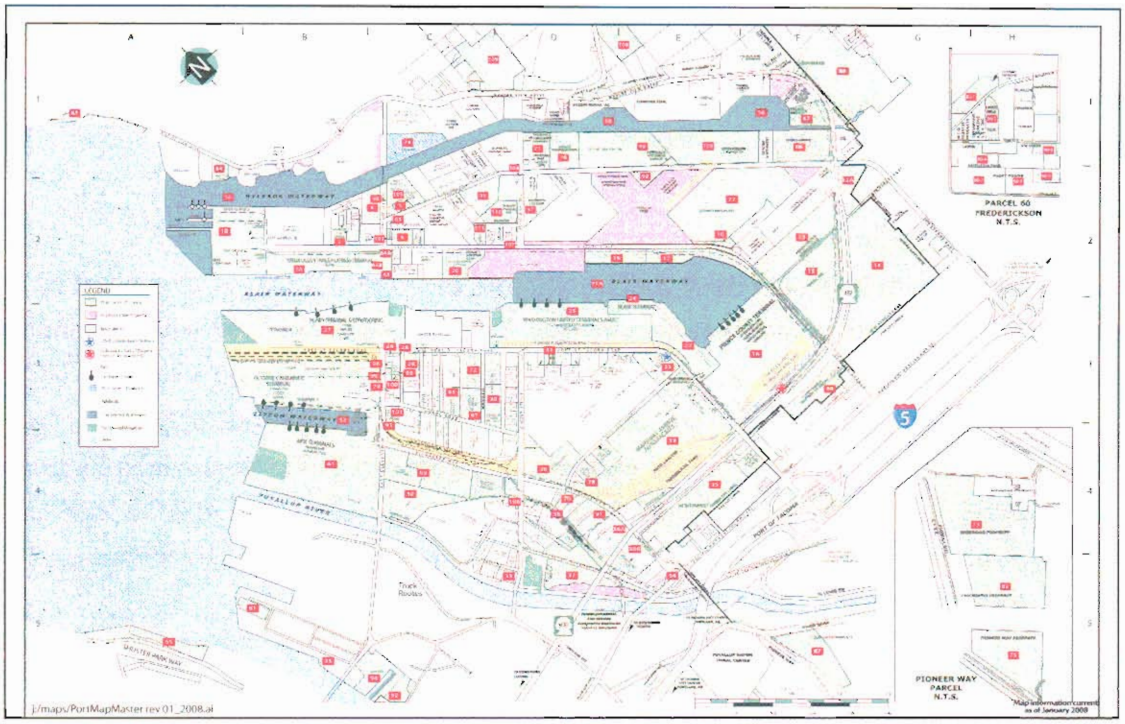


Figure 2. Port of Tacoma property parcel for properties located on the Tacoma Tideflats and unincorporated Pierce County

Potentially Available Monitoring Sites/Areas

Table 1. Port of Tacoma properties categorized by NPDES permit type

Permit Type	Acres	Percentage	Comments
General Permits	1041.6	37.3	Industrial and Boatyard properties included
No Discharge or Sewer Connected	318.7	11.4	
Blair-Hylebos Peninsula	688.5	24.6	Properties located within the Blair-Hylebos Peninsula redevelopment area.
Municipal Permit Area	746.8	26.7	Properties covered under NPDES Phase I Municipal SWMP. Includes Port and tenant operated and maintained properties.
Total:	2795.6		

An analysis of Port properties shown in Table 1 reveals that approximately 746.8 acres (or 26.7%) of properties are covered under the Port's NPDES Phase I Municipal Stormwater Permit and areas where required stormwater monitoring could be performed. The remaining properties either are covered under other NPDES permits, have no discharge or are connected to the municipal sewer system, or are located within the Blair-Hylebos Peninsula redevelopment area. Figure 3 shows the current NPDES parcels by permit type. (This map is also included as an attachment.)

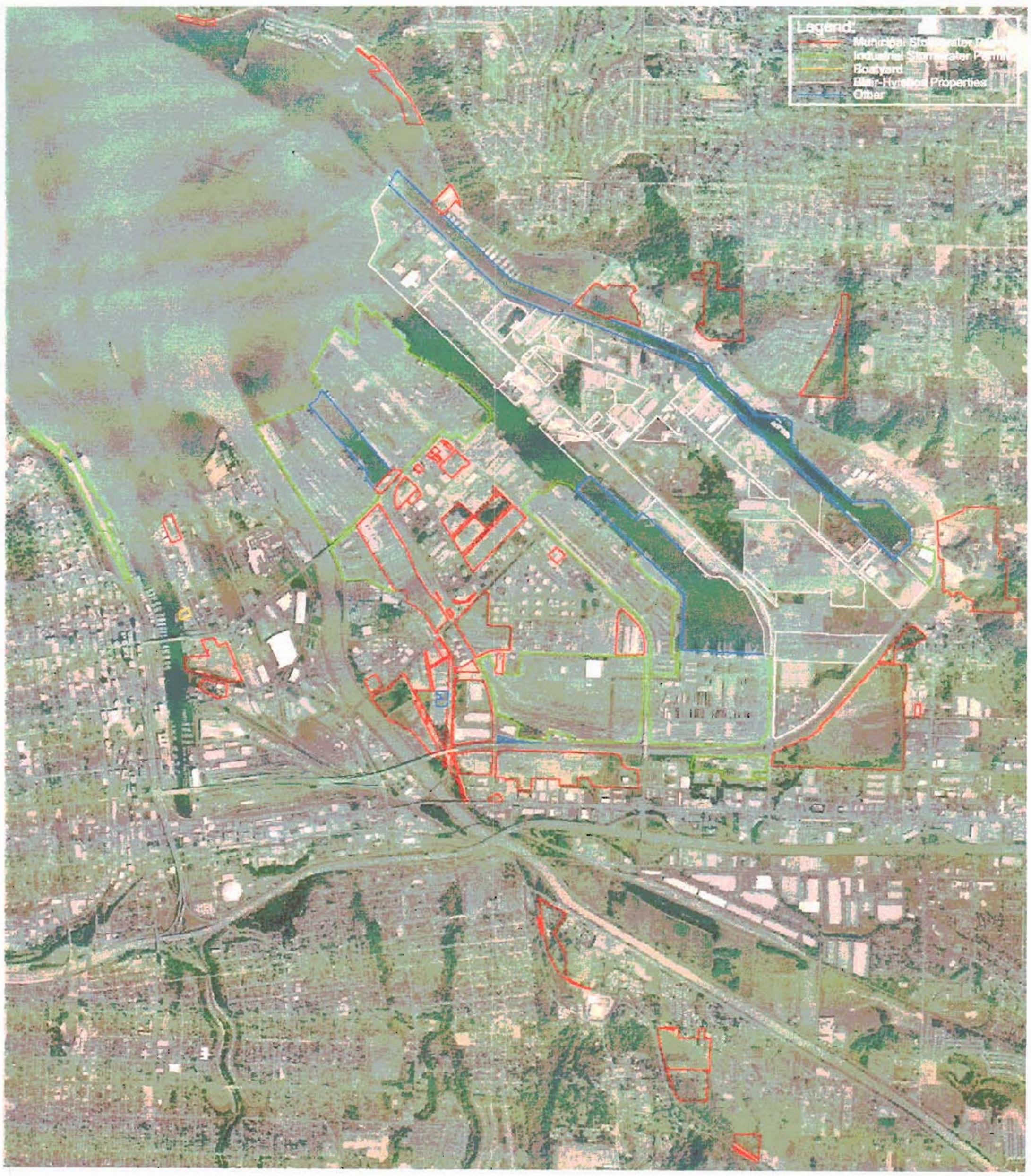


Figure 3. Port parcel map by NPDES type

Properties located within the Blair-Hylebos Peninsula were not considered for monitoring since the peninsula is in the beginning stages of a major redevelopment project that is expected to continue through the year 2012.

Properties falling under the Municipal Permit Areas were further reviewed and categorized by land use activity, as shown in Table 2. The land use evaluation reveals that the predominant use of Municipal Permit properties is vacant or natural areas, however, this land use category would not provide representative data comparable to other Municipal permittees. The next two dominant categories include new auto storage (10.3%) and general parking (7.2%). While new auto storage covers more acreage, general parking includes more than three times as many parcels and therefore is spread out around more of the Port properties. In addition, the higher turnover rate in general parking should generate more pollutants and be more representative of stormwater runoff from Port of Tacoma properties. For these reasons, the general parking land use sub type has been selected as the most appropriate land use from which a representative stormwater drainage basin and outfall can be selected to perform stormwater monitoring. The process used to select a monitoring site from among these properties is described in Section 6.1.

Table 2. Dominant land uses in Port of Tacoma NPDES Phase I Municipal Permit area

Land Use	Acres	Percentage	Comments
Vacant/Natural Areas	493.3	66.1	Includes wetlands, vacant land, landscaped areas, and tidelands
New Auto Storage	77.0	10.3	
General Parking	53.9	7.2	Parking areas exposed to rainfall
Buildings	44.2	5.9	Includes warehouse, commercial, residential, and vacant buildings
Equipment Storage	37.3	5.0	
Container Parking	22.0	2.9	
Other	19.2	2.6	Includes roads, docks, and paved rail areas
Total:	746.8		

3.0 PROJECT DESCRIPTION

This section presents the goals and objectives of the project; describes the boundaries, target populations and practical constraints of the study; and specifies the information and data required to meet the study objectives.

3.1 PROJECT GOALS

The goal of this project is to collect and characterize stormwater and sediment samples from the Port of Tacoma to fulfill the requirements of Section S8 of the NPDES Phase I Municipal Stormwater Permit.

3.2 PROJECT OBJECTIVES

The five objectives of the project include:

1. Identify one stormwater basin and outfall to sample within the Port's property that is representative of Port land use/operations covered by the Municipal NPDES Permit (per Permit §S8.D.1);
2. Collect representative grab and composite water samples during baseflow and storm flow events from the selected outfall (per Permit §S8.D.2.a-c, e, g);
3. Collect a representative sediment sample from the selected outfall (per Permit §S8.D.2.f);
4. Collect a seasonal "first-flush" stormwater sample for toxicity testing[1] (per Permit §S8.D.2.d);
5. Validate and report the sampling results to Ecology (per Permit §S8.H.1.a).

3.3 INFORMATION REQUIREMENTS

Information required to meet the study objectives include:

- Land use and drainage area of selected subbasin (Objective 1),
- Concentrations of constituents of concern in samples collected from the Port's outfall (water and sediment) (Objectives 2-5);
- Continuous record of rainfall data; and specifically, rainfall data prior to and during sampled storm events, including antecedent dry period and total rainfall during each sample event (Objectives 2-5);

[1] Per the Permit modification on June 17, 2009, the Port of Tacoma is not required to conduct toxicity testing until 2011.

- Continuous record of outfall flow data (storm and base flows); and specifically, flow data during sampled storm events (Objectives 2,5);
- Toxicological results and associated analytical constituent concentrations (Objectives 3, 5).

3.4 DATA COLLECTION

The sampling design for stormwater monitoring under S8.D contains three primary components that will be conducted at the selected monitoring site through the remainder of the Phase I Permit cycle:

- Stormwater Sampling
- Toxicity Sampling
- Sediment Sampling

3.4.1 Stormwater Sampling

Per Permit §S.8.D.2.a, a flow-weighted composite and grab sampling techniques will be used to collect stormwater samples from up to eleven qualifying storm events (as defined in Section 6.3) throughout each water year. During each targeted storm event, grab samples will be collected at the stormwater monitoring site during early in the storm (per Permit §S.8.D.2.e).

Continuous flow data will be collected at each selected site during all storm events and for one year to establish rainfall and runoff relationships at each outfall (per Permit §S8.D.2.b). Total annual pollutant loads, and seasonal pollutant loads will be calculated for each required parameter at each monitoring site based on Event Mean Concentrations (EMCs) (per Permit §S8.H.1.a).

3.4.2 Toxicity Sampling

Toxicity sampling will be conducted using composite sampling equipment at each stormwater monitoring site. Storm sampling will occur during the late summer or early fall in an attempt to sample a first-flush storm event (per Permit §S8.D.2.d). In addition to collecting a stormwater sample for toxicity testing, stormwater will also be collected at the same time for chemical analyses. The purpose of the chemical analysis for toxicity testing is to verify the presence of toxic substances. Further, the chemical analysis can also indicate the presence of interferences to the 7-day toxicity test.

3.4.3 Sediment Sampling

Sediments will be collected at the stormwater monitoring site using an in-line sediment trap deployed at the end of the outfall pipe. Collected sediments will be analyzed annually for parameters that have shown to be associated with stormwater discharges.

3.5 TARGET POPULATION

For monitoring programs such as this, observations are made or samples are collected to describe "target populations". In this case, the target populations are characteristics of stormwater coming from Port properties covered under NPDES Phase 1 Municipal Stormwater Permit. Specific characteristics (or target populations) include:

- Stormwater flow (both flow rate and volume),
- Concentrations and loads of specific constituents in stormwater, and
- Concentrations and loads of specific constituent in sediment carried by stormwater.

One representative sub-basin will be sampled to characterize these populations.

3.6 STUDY BOUNDARY

The study area boundaries encompass Port-owned and operated land covered under the jurisdiction of the NPDES Phase 1 Municipal Stormwater Permit.

3.7 PRACTICAL CONSTRAINTS

Practical constraints facing this monitoring project include limitations around site selection, physical characteristics of the monitoring site, operational activities at the monitoring site, equipment limitations and logistical challenges inherent to stormwater sampling.

- Limitation around site selection include:
  - Candidate sites are limited to areas that are not already covered by the Industrial Permit or are Tenant-operated;
  - It is the Port's intention to perform sampling on areas covered by the Municipal Stormwater permit and not those areas covered under an Industrial Stormwater permit. The rationale for this is that the Industrial permitted properties are already under a stormwater monitoring program approved by Ecology, as a condition of their permit.

  - Another challenge that Port's face is that much of their property is under the control of its tenants and not under the direct control of the Port. Due to this restriction, it is the Port's intention to sample Port controlled properties where the Port is in complete control of its municipal stormwater program.
  - The group of candidate sites are small, isolated properties. These properties have small drainage basins with short detention times and the drainage systems are often affected by backwater due to tidal influences.
- Characteristics of the selected site's storm drain system and hydraulics can constrain how monitoring can be conducted. Pipe diameters, slopes, expected water depths, and backwater conditions all constrain what flow measurement methods can be used and how accurately flows can be measured. Storm drain features also constrain where sediment traps can be deployed. For instance, some of the storm drain junction structures (manholes and catch basins) may not have sumps where traditional sediment traps can be deployed. Also, small-diameter storm drain pipes are not ideal for deploying sediment traps.
- Monitoring equipment limitations include the ability of automatic samplers to collect representative samples of stormwater. OEM auto-samplers have a limited sample storage capacity, which limits the frequency and duration of sample collection during an event. When deploying sediment traps, it is difficult to predict how much sediment will be captured by a sediment trap during the expected deployment period. If sediment yields are higher than expected, a trap could fill faster than anticipated. If sediment yields are lower than expected, the trap might not capture enough sediment during the planned deployment period for performance of all desired physical and chemical analyses.
- Stormwater monitoring poses inherent logistical challenges because the activity relies on an event (precipitation) that can only be forecasted in the near-term with limited reliability. Thus, mobilization of field staff for a potential sampling event cannot happen more than a couple of days ahead of a forecasted storm.
- Some chemical parameters required by the permit cannot be collected using automatic samplers. These samples will be collected manually. During an event, staff must be mobilized to collect the manual grab sample on short notice and must visit the site early in the storm to do so. Given that qualifying storm events may begin at night or during weekends or holidays, it may be difficult to schedule staff resources.

3.8 Decision Making

The results of this monitoring effort are not intended for use in making specific decisions nor compliance determination. In a broader context, results will allow regional agencies (e.g., Ecology) to gauge whether comprehensive stormwater management programs are making progress towards the goal of reducing the amount of pollutants discharged in stormwater and protecting water quality.

4.0 ORGANIZATION AND SCHEDULE

The following section identifies the project team, discusses the project schedule, identifies special training required for project implementation, and describes the process of revising this document.

4.1 ROLES AND RESPONSIBILITIES

The table below contains a list of the participants in the major aspects of the project and personnel responsible for updating the QAPP.

Table 3. Project participant roles and responsibilities

Position	Roles and Responsibilities
Department of Ecology Permit Coordinator/ Department of Ecology Southwest Region	Responsible for reviewing and approving QAPP and project deliverables from Port of (Tacoma) to Department of Ecology
Project Manager/ Port of Tacoma	Responsible for overall management of the Port's NPDES compliance activities. Monitors and assesses the quality of work. Responsible for verifying the QAPP is followed and the project is producing data of known and acceptable quality. Ensures adequate training and supervision of all monitoring and data collection activities. Complies with corrective action requirements.
Technical Manager/	Responsible for the development, approval, implementation and maintenance of the QAPP and technical coordination with other project team members.
Quality Assurance Manager/	Responsible for validation and verification of data collected. Develops, facilitates and conducts monitoring system audits
Project Data Manager/	Responsible for the acquisition, verification, and transfer of data
Consultant Project Manager	Responsible for Consultant project management and coordination with project team member and Consultant staff.
Consultant Technical Lead	Manages and oversees monitoring activities and data management conducted pursuant to the QAPP by the Consultant.
Storm Controller	Manages and oversees monitoring activities and sampling decisions for a specific targeted storm event. This position could be filled by the Technical Manager, the Consultant Team Lead, or other Designee.

Analytical Laboratory Project Manager	Responsible for supervision of laboratory personnel involved in generating analytical data for this project. Responsible for oversight of all operations, ensuring that all quality assurance/quality control (QA/QC) requirements are met, and documentation related to the analysis is complete and accurately reported. Enforces corrective action, as required.
Analytical Laboratory Quality Assurance Officer	Monitors the implementation of the Quality Assurance Manual (QAM) and the QAPP within the analytical laboratory to ensure complete compliance with QA objectives as defined by the contract and in the QAPP. Performs validation and verification of data before the report is sent to the Port.
Toxicology Laboratory Project Manager	Responsible for supervision of laboratory personnel involved in generating toxicology data for this project. Responsible for oversight of all operations, ensuring that all quality assurance/quality control (QA/QC) requirements are met, and documentation related to the toxicological analysis is complete and accurately reported. Enforces corrective action, as required.
Toxicology Laboratory Quality Assurance Officer	Monitors the implementation of the Quality Assurance Manual (QAM) and the QAPP within the toxicology laboratory to ensure complete compliance with QA objectives as defined by the contract and in the QAPP. Performs validation and verification of data before the report is sent to the Port.

4.2 SCHEDULE

Table 4 and
Table 5 indicate the *approximate* implementation schedule for permit-related activities for stormwater monitoring.

Table 4. Anticipated project schedule for 2008

Calendar Year 2008				
Activity	**Anticipated Date of Initiation**	**Anticipated Date of Completion**	**Deliverable**	**Deliverable Due Date**
Project Startup Activities	10/12/08	Ongoing	Project planning; monitoring equipment procurement; installation, and testing; staff training	Not reported to Ecology
Continuous flow and precipitation recording	1/1/09	Ongoing	Establish a baseline rainfall/runoff relationship	Not reported to Ecology

Table 5. Anticipated project schedule for 2009-2011

Calendar Years: 2009, 2010, and 2011				
Activity	**Anticipated Date of Initiation**	**Anticipated Date of Completion**	**Deliverable**	**Deliverable Due Date**
Complete project startup activities	Continuing	4/12/2009	Monitoring equipment installation, and testing; staff training	Not Reported to Ecology
Wet-weather storm events	4/12/2009 10/1/2010, 10/1/2011	4/30 each year	Stormwater Monitoring Report(1)	3/31/2010, 3/31/2011 3/31/2012
Dry-weather storm events	5/1 each year	9/30 each year	Stormwater Monitoring Report	3/31/2010, 3/31/2011 3/31/2012
Toxicity Sampling (First flush event)*	8/1/ 2011	9/30 each year(2)	Stormwater Monitoring Report and TI/RE (if applicable)	3/31/2012
Sediment Sampling	4/12/2009 10/1/2009 10/1/2010 10/1/2011	9/30 each year	Stormwater Monitoring Report	3/31/2010, 3/31/2011 3/31/2012
Data Validation	5/2009 11/2010 11/2011	1/30/2010 1/30/2011 1/30/2012	Stormwater Monitoring Report	3/31/2010, 3/31/2011 3/31/2012

(1) toxicity sampling can extend into October if suitable weather conditions exist

(2) Submitted with Annual Report

* Per the Permit modification dated June 17, 2009, the Port of Tacoma will conduct toxicity sampling just once in 2011.

4.3 Special Training Needs/ Certification

Project staff will receive the following training/ certification as appropriate for their role in the project:

- Any field staff involved with monitoring equipment installation or equipment maintenance requiring confined space entry will have completed confined space entry training.
- Any field staff needing to access the monitoring sites will have TWIC card.
- Field staff will receive training in sampling equipment operation, maintenance and calibration procedures.
- Field staff will receive training in all necessary sample collection, sample handling and chain-of-custody for sediment, stormwater grab, and stormwater composite sampling.

4.4 Revisions

Ecology must review and approve this QAPP for Stormwater Monitoring under S8.D. of the Phase I Permit (per Permit §S.8.C.2). Only substantial changes to the Stormwater Monitoring Program will require that the QAPP be revised and re-submitted to Ecology for approval. Changes requiring re-submittal of the QAPP to Ecology are considered external revisions.

Smaller changes to the Stormwater Monitoring Program, not requiring Ecology approval, are considered internal revisions. Justification, summaries, and details of internal revisions will be documented in a QAPP Addendum and will be distributed to all persons on the distribution list by the Project Manager. QAPP Addendums will be compiled and transmitted to Ecology no more frequent than quarterly.

5.0 QUALITY OBJECTIVES

Quality objectives for this project are to obtain data of sufficient quality so that uncertainties are minimized and results are comparable with monitoring data collected by other NPDES Phase I permittees that are required to conduct similar outfall characterization monitoring. These objectives will be achieved through careful attention to sampling, measurement, and quality assurance/quality control (QA/QC) procedures described in this plan.

5.1 DATA QUALITY OBJECTIVES

Data quality objectives (DQOs) are both qualitative and quantitative statements that define the type, quality, and quantity of data necessary to support project decisions. The DQOs for the stormwater monitoring component of the Port of Tacoma's comprehensive long-term monitoring program are as follows:

- The data will be of known precision and accuracy;
- The data will be generated using controlled procedures for field sampling, sample handling, laboratory analysis, and record keeping;
- Reporting limits will be low enough for evaluation against Stormwater Management Program endpoints;
- Data of sufficient quality and quantity will be collected to meet the minimum requirements for calculation of event mean concentration, seasonal pollutant load, and total annual pollutant load calculations; and
- Collected samples will meet the program-specific requirements for representativeness.

The measurement quality objectives for physical and chemical analyses in water and sediments are summarized in Table 6 and Table 7. The data quality parameters used to asses the acceptability of the data include precision, accuracy, representativeness, comparability, and completeness. These parameters are discussed in the following section.

Table 6. Measurement quality objectives for chemical analyses in stormwater

Parameter	Check Stnd/ Lab Control Sample	Lab Replicate	Matrix Spike	Matrix Spike Dup (1)	Surrogate Stnd	Lowest Conc. of Interest (2)
	Accuracy (% Rec)	Precision (RPD)	Accuracy (% Rec)	Precision (RPD)	Accuracy (% Rec)	(units)
Conventionals						
TSS	80-120	20%	NA	NA	NA	1.0 mg/L
Turbidity	80-120	20%	NA	NA	NA	± 0.2 NTU
Conductivity	80-120	20%	NA	NA	NA	± 1 μmho/cm
Chloride (3)	80-120	20%	75-125	NA	NA	0.2 mg/L
BOD_5	80-120	20%	NA	NA	NA	2.0 mg/L
Hardness	80-120	20%	NA	NA	NA	1.0 mg/L
MBAS	80-120	20%	75-125	NA	NA	0.025 mg/L
Bacteria						
Fecal Coliform	NA	20%	NA	NA	NA	1 CFU/100 mL
Nutrients						
Total phosphorus	80-120	20%	75-125	NA	NA	0.01 mg/L
Orthophosphate	80-120	20%	75-125	NA	NA	0.01 mg/L
TKN	80-120	20%	75-125	NA	NA	0.5 mg/L
Nitrate-nitrite	80-120	20%	75-125	NA	NA	0.01 mg/L
Metals						
Total recoverable (Cu, Zn, Pb, Cd, Hg)	80-120	20%	75-125	NA	NA	0.1–5.0 μg/L
Dissolved (Cu, Zn, Pb, Cd, Hg)	80-120	20%	75-125	NA	NA	0.1 μg/L
Organics						
PAHs	50-140	NA	50-140	40%	50-140	0.1 μg/L
Phthalates	50-140	NA	50-140	40%	50-140	1.0 μg/L
Herbicides	50-140	NA	50-140	40%	50-140	0.01–1.0 μg/L
Pesticides, Nitrogen	50-140	NA	50-140	40%	50-140	0.01–1.0 μg/L
Pesticides, Organo-P	50-140	NA	50-140	40%	50-140	0.01–1.0 μg/L
TPH						
NWTPH-Dx	50-150	NA	50-150	50%	50-150	0.25–0.5 mg/L
NWTPH-Gx	50-150	NA	50-150	50%	50-150	0.25mg/L

(1) Matrix spike duplicate percent recovery for organics and TPH targeted at 50-140% and 50-150%, respectively.

(2) Lowest concentration of interest corresponds to reporting limit targets listed in Appendix 9 of the Phase I Municipal Stormwater Permit and in the additional guidance *Alternative Laboratory Methods Approved by Ecology for Use under the Phase I Municipal Stormwater Permit* (Ecology, 2008).

(3) Chloride will not be analyzed in routine stormwater samples since the discharge is to marine water. Chloride may be analyzed for the sample collected during the toxicity testing.

Table 7. Measurement quality objectives for physical and chemical analyses in sediments

Parameter	Check Stnd/ Lab Control Sample	Lab Replicate	Matrix Spike	Matrix Spike Dup(1)	Surrogate Stnd	Lowest Conc. of Interest(2)
	Accuracy (% Rec)	Precision (RPD)	Accuracy (% Rec)	Precision (RPD)	Accuracy (% Rec)	(units)
Conventionals						
Total solids	80-120	20%	NA	NA	NA	NA
Total organic carbon	80-120	20%	75-125	NA	NA	0.10%
Grain Size	NA	5%	NA	NA	NA	NA
Metals						
Total recoverable (Cu, Zn, Pb, Cd, Hg)	80-120	20%	75-125	NA	NA	0.1–5.0 mg/Kg dry
Organics						
PAHs	50-140	NA	50-140	40%	50-140	70 µg/Kg dry
Phthalates	50-140	NA	50-140	40%	50-140	70 µg/Kg dry
Phenolics	50-140	NA	50-140	40%	50-140	70 µg/Kg dry
PCBs	50-140	NA	50-140	40%	50-140	80 µg/Kg dry
Herbicides	50-140	NA	50-140	40%	50-140	1 µg/Kg dry
Pesticides, Organo-P	50-140	NA	50-140	40%	50-140	25–50 µg/Kg dry

(1) Matrix spike duplicate percent recovery for organics targeted at 50-140%.

(2) Lowest concentration of interest corresponds to reporting limit targets listed in Appendix 9 of the Phase I Municipal Stormwater Permit and in the additional guidance *Alternative Laboratory Methods Approved by Ecology for Use under the Phase I Municipal Stormwater Permit* (Ecology, 2008); values expressed on a dry-weight basis.

5.2 Measurement Quality Indicators

Data quality and usability are evaluated in terms of performance criteria. Performance and acceptance are expressed in terms of measurement quality indicators (MQIs). The principal indicators of data quality are precision, accuracy, sensitivity, completeness, comparability, and representativeness. These measures are affected by factors in both the field and laboratory. Each term is explained below.

5.2.1 Precision

Precision is a measure of the agreement or repeatability of a set of replicated results obtained from duplicate analysis made under identical conditions. Precision is estimated from analytical data and cannot be measured directly. Imprecise data are generally a problem because individual samples are not a reliable measure of the mean site conditions making it necessary to gather more data to characterize a given site. Often, poor precision is due to field variability, problems with sampling and sub-sampling procedures, contamination, or poor sensitivity of the laboratory methods. Variability in the field can often be minimized through the use of compositing procedures.

Analytical precision is measured through matrix spike/matrix spike duplicates samples for organic analyses and through laboratory duplicates samples for inorganic analyses. Laboratory duplicates are generally prepared by splitting one sample into two and performing a separate analysis on each split. Matrix spikes and matrix spike duplicates are prepared by adding a known concentration of analyte to a sample or to a laboratory duplicate and determining the concentration of the sample plus the spike. The two values (sample and duplicate, or spike and spike duplicate) are compared to provide an estimate of the precision of the laboratory method. The precision of a duplicate determination can be expressed as the relative percent difference (RPD), and is calculated as:

$$\%RPD = \left[\frac{|X_1 - X_2|}{\frac{(X_1 + X_2)}{2}} \right] \times 100$$

Where:

$\%RPD$ = relative percent difference
X_1 = native sample
X_2 = duplicate sample

Guidelines for project analytical and field precision measurements are discussed in Section 9.0. Analytical precision will be evaluated against quantitative RPD performance criteria presented in Table 6 and Table 7. Currently, no performance criteria have been established for field duplicates, thus data will not be qualified based solely on field duplicate precision.

5.2.2 Accuracy

Accuracy is a measure of the agreement between an experimental determination and the true value of the parameter being measured. Analytical accuracy may be assessed by analyzing known reference materials or by analyzing "spiked" samples with known standards (laboratory control samples, matrix spike, and/or surrogates). Spiking of reference materials into a sample matrix is the preferred technique because it provides a measure of potential matrix effects on analytical accuracy. Factors that influence analytical accuracy include laboratory calibration procedures, sample preparation procedures, and laboratory equipment or deionized water contamination. Accuracy can be expressed as a percentage of the true or reference value, or as a percent recovery in those analyses where reference materials are not available and spiked samples are analyzed. Analytical accuracy, expressed as percent recovery (P), is calculated as

$$P = \left[\frac{(SSR - SR)}{SA} \right] \times 100$$

Where:

P = percent recovery

SSR = spiked sample result

SR = sample result (native)

SA = the spiked concentration added to the spiked sample

Guidelines for laboratory accuracy are discussed in Section 9.0. Analytical accuracy will be evaluated against quantitative laboratory control sample, matrix spike, and surrogate spike (organics) performance criteria presented in Table 6 and Table 7.

5.2.3 Sensitivity

Sensitivity is the measure of the concentration at which an analytical method can positively identify and report analytical results. The sensitivity of a given method is commonly referred to as the detection limit. Although there is no single definition of this term, the following terms and definitions of detection will be used, as appropriate.

- **Instrument detection limit** (IDL) is the minimum concentration that can be measured from instrument background noise.
- **Practical quantification limit** (PQL) or **method reporting limit** is the concentration of the target analyte that the laboratory has demonstrated the ability to measure within specified limits of precision and accuracy during routine laboratory operating conditions. This value is variable and highly dependent on the sample matrix. It is the minimum concentration that will be reported as "unqualified" by the laboratory.
- **Method detection limit** (MDL) is a statistically determined concentration. It is the minimum concentration of an analyte that can be measured and reported with 99 percent confidence that the analyte concentration is greater than zero as determined in the same or similar sample matrix. Due to the lack of information about analytical precision at this level, sample results greater than the MDL, but less than the PQL, will be laboratory qualified as "estimated".

A summary of method detection limits and method reporting limits (practical quantification limits) is included in Section 8.0 for the individual analytical methods required for water and sediments. The lowest concentrations of interest for the analyses in water and sediment are included in Table 6 and Table 7, respectively, and correspond to the reporting limit targets listed in Appendix 9 of the Phase I Municipal Stormwater Permit and in the additional guidance *Alternative Laboratory Methods Approved by Ecology for Use under the Phase I Municipal Stormwater Permit* (Ecology, 2008).

5.2.4 Representativeness

Representativeness is a qualitative measure of the degree to which sample data accurately and precisely represent a characteristic environmental condition, or more specifically site conditions. Representativeness is a subjective parameter and is used to evaluate the efficacy of the sampling plan design. It can be assessed through the analysis of field duplicate samples and other measures. Field variability can be minimized by employing compositing techniques since samples generate an average of site conditions.

Sample will be collected so they are adequately representative of the volume and nature of the monitored parameters of interest. To meet this goal, samples will be collected according to appropriate procedures and should consider the following types of representativeness criteria:

- The rainfall event must be a "target event";
- Grab samples and/or composite samples must meet certain criteria governing the method and timing of the sampling process relative to the storm discharge hydrograph; and
- All analyses must be conducted within method-required holding times.

Samples may be deemed "non-representative" and data rejected if any of these criteria are not met. Target storm event criteria for routine stormwater monitoring and seasonal "first flush" toxicity is described in Section 6.0.

To meet analytical holding times, samples analyses may have to be initiated before all other criteria are confirmed (e.g., confirmation that a rainfall event met the target storm event criteria). For grab samples, the holding time will initiate when the grab sample is collected and placed in the sample bottle. For composite samples, the holding time will initiate when the last sub-sample is collected.

5.2.5 Completeness

Completeness is defined as the percentage of measurements judged to be valid compared to the total number of measurements made or planned for a specific sample matrix and analysis. It includes both targeted sample collection by the field team, and analytical work done by the laboratory. Essentially, it is used to assess how field situations and laboratory problems affected the overall success of the data collection effort. Completeness is calculated using the following formula:

$$Completeness = \frac{Valid\ \ Measurements}{Total\ \ Measurements} \times 100$$

All valid data will be used for this project. Data that has been qualified as estimated because the quality control criteria were not meet will considered valid for the purpose of assessing completeness, whereas data that have been qualified as rejected will not be considered. During the data validation process, an assessment will made of whether the valid data are sufficient to meet the requirements listed in S.8.D of the Phase I Permit. If sufficient valid data are not obtained, corrective actions will be initiated by the project manager or his/her designee.

5.2.6 Comparability

Comparability is qualitative measure designed to express the confidence with which one data set may be compared to another. Sample collection and handling techniques, sample matrix type, and analytical method all affect comparability. Comparability is limited by other MQIs because data sets can be compared with confidence only when precision and accuracy are known. Data from one phase of an investigation or from a separate investigation can be compared to others when similar methods are used and similar data packages are obtained.

6.0 SAMPLING PROCESS DESIGN

This section summarizes the process used to select the monitoring site, describes the monitoring site, and describes the approach for targeting storm events and collecting grab and composite samples. Additionally, the approaches for collecting the seasonal first flush toxicity sample and sediment sampling are described.

6.1 MONITORING SITE SELECTION PROCESS

General parking was identified as the most representative land use for conducting stormwater monitoring required under Section S8.D of the Phase I Permit (See Section 2.2). All parcels containing general parking as a land use were identified and, from these, parcels with more than 25 percent of the area classified as general parking were selected for further review (Table 8).

Table 8: Parcel Evaluation with general parking observed

Parcel ID	Total Area (Acres)	General Parking (% of parcel)	General Parking (Acres)
26	0.42	88	0.37
28	6.04	35	2.11
35	83.72	54	45.58
42	3.56	42	1.49
68	0.22	100	0.22

The Port determined that Parcel ID 42, the Port Adminstrative Building, is the most appropriate property for conducting stormwater monitoring. Approximately 42 percent (or 1.49 acres) of the 3.56 acre property is parking lot, making it the third largest parking area. The two parcels with larger parking areas are Parcel 28 and 35. Parcel 28 is an unused parking lot that is fenced off to any vehicle traffic and Parcel 35 is scheduled to be under construction into 2011, therefore Parcel 42 was selected as most representative of the Port's parking areas.

6.2 MONITORING SITE DESCRIPTION

This section describes the characteristics of the selected stormwater drainage basin and monitoring site as required by Permit §S.8.D.1.a. Figure 3 is a map of the selected drainage basin showing the location of the monitoring site.

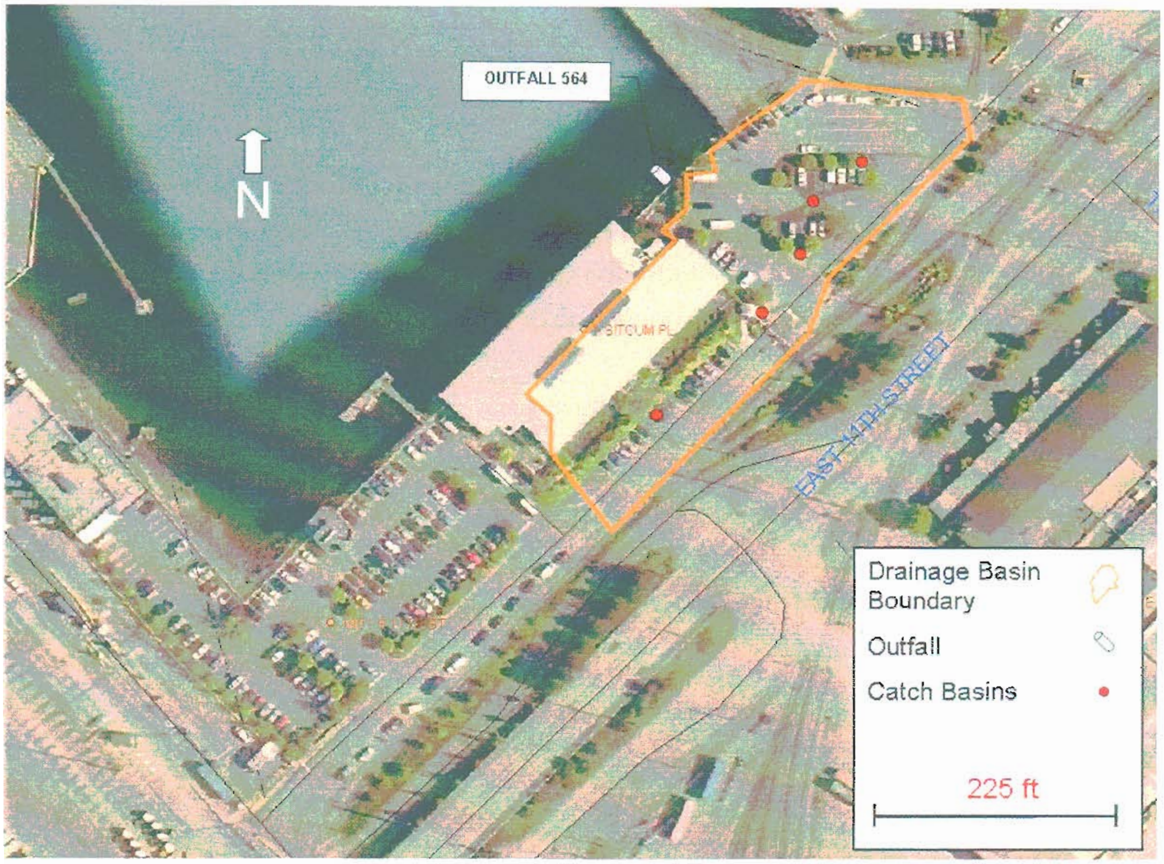


Figure 3. Selected stormwater drainage basin

6.2.1 Selected Drainage Basin

Stormwater monitoring to fulfill requirements of permit section Permit §S.8.D will occur at the Port Administrative Building Complex northeastern drainage basin, which drains to Outfall 564. The outfall discharges directly into the Sitcum Waterway and stormwater for this basin primarily consists of runoff from the Port Administrative Building roof and associated parking lots, and a segment of roadway. The time of concentration is relatively short, requiring the sampling protocols and sample volumes to be adjusted accordingly, as described in following sections. Attributes of the Outfall 564 Drainage Basin are presented in

Table 9.

Table 9. Selected drainage basin attributes

Site Attribute	
Location	Northeastern portion of Port of Tacoma Administration Building Complex grounds
Drainage Area (acres)	1.27
Land Use	100% Commercial
% Impervious	82
Time of Concentration[1]	17 minutes
Rain Gauge Location (latitude/longitude)	47°16'15'57.61"N, 122°24'42.34"W
Yearly Precipitation (in)	38.95

1. Time of concentration calculations are found in Appendix A.

The Outfall 564 Drainage Basin consists primarily of the paved parking lot located immediately northeast of the Port Administration Building, as well as a portion of the building roof, small landscaped areas within and adjacent to the parking lot, and a section of roadway along the southeast side of the building.

The storm drainage system consists of catch basins and roof drains connected to small diameter (6-inch to 8-inch) storm drain pipes. There are no junction structures (e.g. manholes) within this drainage system. The eight-inch diameter outfall pipe discharges to the Sitcum Waterway at a rip-rapped bank located next to the parking lot.

6.2.2 Monitoring Site

Stormwater monitoring will occur at the outlet of Outfall 564. The outfall is an 8-inch diameter PVC pipe, which is exposed for about 12-feet at the shore of Sitcum Waterway. This site is suitable for long-term flow monitoring and water sampling. Some of the monitoring system components, such as the flow meter sensors, sampler line intake and sediment collection device will be installed at the terminus of the outfall pipe, while most of the equipment, such as the auto sampler and flow meter controller/logger will be housed in a secure enclosure in the adjacent upland area.

The outfall pipe is infrequently backwatered by high tides. Predictions of tidal elevations for this area from May 2009 to May 2010 indicate that high tide will be above the outlet pipe invert elevation 2.8 percent of the time (Tides & Currents Pro v. 3.0i, 1993-2001, Nobeltec Corporation; Commencement Bay, 47°15.30' N, 122°25.90'W). To address tidal backwater conditions, a flow-monitoring technology was selected that operates well under backwater conditions (see Section 6.5). Also, to prevent marine water from entering into the outfall pipe a check valve (TideFlex TF-1) will be installed at the end of the outfall pipe. When selecting storms for sampling, attempts will be made to target storm events during periods when the monitoring site is not backwatered from the high tide.

6.2.3 Basin Size to Time of Concentration

The Outfall 564 Drainage Basin encompasses 1.27 acres upstream of the monitoring location. The time of concentration was calculated using methods based on Chapter 3, SCS TR-55 as outlined in the City of Seattle Stormwater Treatment Technical Requirement Manual (City of Seattle, 2000).

The flow path upstream of the monitoring site consists of roof runoff, overland flow in a landscaped/lawn area, and conveyance in stormwater pipes. The path of roof runoff is approximately 52 feet. The landscaping/lawn flow path is approximately 75 feet in length and this segment dominates the time of concentration, consisting of 15 of the 17 minutes. Pipe conveyance is approximately 300 feet.

The calculated time of concentration for the Outfall 564 drainage basin drainage basin is approximately 17 minutes at the monitoring location. Assumptions and applicable equations are shown in Appendix A.

6.3 Qualifying Storm Event

Stormwater samples will be collected and reported based on water year. The water year is defined as October 1st through September 30th of each year. The following storm event criteria will be used to determine qualifying storm events for the collection of composite samples for chemical analysis and toxicity testing (per Permit §S.8.D.2.a,d):

Table 10. Qualifying storm event criteria.

	Wet Season	Dry Season
Seasonal Period	October 1 through April 30	May 1 through September 30
Minimum Amount of Rainfall	0.20" min. no fixed max.	0.20" min. no fixed max.
Rainfall Duration	No fixed min. or max.	No fixed min. or max.
Antecedent Precipitation Conditions	Less than or equal to 0.02" rain in previous 24-hours No rain in previous 6 hours	Less than or equal to 0.02" rain in previous 72-hour No rain in previous 6 hours (See Note 1 for seasonal first-flush antecedent period) [1]
Inter-event Dry Period [2]	6 hours	6 hours

(1) The seasonal first-flush storm event is an event in August or September, with at least a one-week antecedent dry period. This one-week antecedent dry period is defined as less than or equal to 0.02" in the previous 168 hours, ***or*** no recorded measurable ***storm*** flow at the outfall during the 168 hours (flow must be monitored continuously for the entire 168-hour period). If toxicity testing cannot be completed in August or September then a storm can be sampled in October for toxicity testing, irrespective of antecedent dry period (per Permit §S.8.D.2.d)

(2) A storm event can be considered completed once there has been a 6-hour period with no precipitation, however water sampling can continue until there has been a 12-hour period with no precipitation at which time the storm would be considered completed.

6.4 Precipitation Monitoring

Precipitation will be continuously monitored with a tipping bucket rain gage located just north of the Port Maintenance building. A continuous rainfall record will allow the establishment of a rainfall/runoff relationships stormwater monitoring site and the determination and tracking of the number of qualifying storm events throughout the year. Additionally, the rain gage data will allow the validation of the storm event composite samples per criteria presented in Section 6.3.

Field staff will need near real-time rain data to alert them to when antecedent conditions have been met (to start sampling) and to determine when the rainfall event has ended (to retrieve samples). To reduce staff effort required to repeatedly go to the rain gage site and download data, the rain gage will be equipped with telemetry (e.g., hard-line telephone, cellular, radio, or facility wiring) to allow for remote data acquisition via dialing into a modem and/or access via the internet.

The rain gage will be maintained per manufacturer's recommendations (see Section 7.1 for methods). The rain gage will be capable of measuring only liquid precipitation (i.e., rainfall or melted snow); it will not be a heated rain gage capable of melting snow.

6.5 Flow Monitoring

Flow rate at the monitoring site will be continuously monitored and recorded at least for the first year of monitoring, and then during each targeted storm event after that. Flow rate will be determined using an area-velocity flow meter, a Venturi-tube type flow meter or other appropriate flow monitoring technology. Flow data will be downloaded during pre-storm setup, after the end of a sampled storm event, and periodically between targeted events to minimize data gaps (especially for the first year of flow monitoring).

6.6 Stormwater Sample Collection

Two types of stormwater samples will be collected at the monitoring site: 1) manual grab samples, and 2) flow-weighted composite samples[2]. Sixty-seven percent of forecasted qualifying storm events that result in actual qualifying storms throughout the water year will be sampled, with up to a maximum of 11 sampled qualifying storm events per year. Samples will be collected according to the approximate distribution indicated in Table 11 (per Permit §S.8.D.2.a).

Table 11. Approximate yearly distribution of stormwater outfall samples

	Approximate number of samples
Wet Season (October 1 through April 30)	60% to 80 % (a maximum between 7 and 9)
Dry Season (May 1 through September 30)	20% to 40% (a maximum between 2 and 4)

1. "Sample" = one flow-weighted composite sample and one grab sample

Additionally, samples will be analyzed from up to three storm events that do not meet the qualifying criteria (per Permit §S.8.D.2.a).

6.6.1 Grab Sampling

Manual grab sampling is required for samples undergoing analysis for fecal coliform and total petroleum hydrocarbons (TPH) (per Permit §S.8.D.2.e). Grab samples will be collected by manually filling appropriated sample containers directly from the outfall.

[2] For the first-flush toxicity composite sample, a time-paced sample may be used. Refer to Section 6.6.3.

Grab samples will be collected early in a storm event. Attempts will be made to collect the grab sample during the same storm event as the composite sample. However, storm events may start in the middle of the night, on weekends, or during holidays (when automatic samplers can automatically start sampling), when it may be difficult to have field staff available. During such times, the grab samples may be taken during different storm events.

Table 12 indicates the estimated sample volume required for each parameter to be analyzed for in the grab sample.

Table 12. Stormwater grab sample analytes and required volumes.

Parameter/Specific Analyte	Required Sample Volume (mL)[1]
Bacteria	
Fecal Coliform	125 – 375
TPH	
NWTPH-Dx	1000 – 4000
NWTPHH-Gx	80 – 320

(1) Minimum sample volumes correspond to method-specific bottle requirements for parameters obtained by grab samples. Maximum values correspond to sample volumes needed for analysis of field and laboratory QC samples.

Attempts will be made to collect the grab sample at the start of a storm events that meet the qualifying storm event criteria (Section 6.3); however, the grab sample will be collected prior to the confirmation that the storm has met the qualifying rainfall depth. If the grab sample is collected during storm runoff that meets all qualifying storm event criteria (Section 6.3), except for the minimum amount of rainfall, the grab sample will be analyzed and considered a valid sample[3]. Attempts will be made to have fecals and TPH analyzed in the same grab sample. However, if the 48-hour maximum holding time for fecal coliforms cannot be met (for example, due to the laboratory being closed on a weekend or holiday), a separate grab sample could be taken for fecals either later in the storm event, or during a future storm event. See Section 7.2.3 for the procedures to collect grab samples.

[3] This is based on the following reasoning: water quality represented by the grab sample will not be affected by environmental conditions occurring after the time that the grab sample is taken. For example, a grab sample is taken during initial runoff from 0.05 inches of precipitation. This grab sample will be the same whether 0.00 inches of rain falls afterwards (a non-qualifying event), or if 0.15 inches of rain falls afterwards (a qualifying event).

6.6.2 Composite Sampling

Flow-weighted composite samples at the outfall will be collected during qualifying storm events as defined in Section 6.3. The autosampler will be configured to begin sampling at the onset of runoff. Sample flow-weighting will be based on equal sub-sample volumes collected at various time increments. The time increments are determined by the time it takes for a set volume of water to flow past the sampling point.

For storm events lasting less than 24 hours, samples will be collected for at least seventy-five percent of the storm event hydrograph[4]. For storm events lasting longer than 24 hours, samples will be collected for at least seventy-five percent of the hydrograph of the first 24 hours of the storm (per Permit §S.8.D.2.b). Each composite sample will consist of at least ten (10) aliquots. Composite samples with seven (7) to nine (9) aliquots are acceptable if they meet the other sampling criteria (per Permit §S.8.D.2.b).

6.6.2.1. Composite Sample Analytical Parameters and Volume Needs

Flow-weighted composite samples will be analyzed for the following parameters (per Permit §S.8.D.2.b. i-vii):

- BOD_5
- Hardness
- TSS
- Turbidity
- Conductivity
- Chloride[5]
- Orthophosphate
- Total phosphorus
- Nitrate/nitrite
- Total kjeldahl nitrogen
- Phthalates
- Polycyclic aromatic hydrocarbons (PAHs)
- Methlyene Blue Activating Substances (MBAS)
- Metals (total and dissolved zinc, copper, cadmium, lead, and mercury).
- Pesticides including: 2,4-D, MCPP, Triclopyr, Diazinon, Malathion, Chlorpyrifos, Dichlobenil, Prometon and Pentachlorophenol

[4] These percentage requirements are based on the percent of total hydrograph volume. In other words, not based on time or number of attempted aliquots.

[5] Chloride will not be monitored for routine stormwater samples since the outfall discharges directly to marine waters. Chloride may be analyzed in the water sample collected for toxicity testing.

The specific laboratory analyses and analytical limits for each of these parameters are presented in Section 8.3.1 Chemical Analysis Water and Sediment. If the volume of stormwater sample collected from a qualifying storm is insufficient to allow analysis for all parameters listed above, samples will be analyzed for as many parameters as possible in the following priority order (in descending order of priority) (per Permit §S.8.D.2.c):

1. TSS
2. Conductivity
3. MBAS
4. Metals
5. Hardness
6. PAHs
7. Phthalates
8. Pesticides
9. Nutrients
10. BOD_5

If insufficient volume exists to run the next highest priority pollutant, that analysis will be bypassed and analyses run on lower priority pollutants in accordance with the remaining priority order to the extent possible (per Permit §S.8.D.2.c).

Table 13 indicates the estimated sample volume required for each parameter/analyte for the composite sample. A total composite sample volume of at least 8.2 liters is needed and up to 14.0 liters are recommended to run the required analyses. When field and lab QC samples are targeted (see Section 9.0), a composite sample volume of at least 23.8 liters is needed and up to 53.0 liters is recommended.

Table 13. Analytical parameters and required sample volumes for routine stormwater composite samples.

Parameter/Specific Analyte	Required Sample Volume (mL)	
	Min.	Recomm.
Conventionals		
TSS	200	1000
Turbidity	100	500
Conductivity	100	500
BOD_5	1000	1000
Hardness	50	500
MBAS	1000	1000
Nutrients		
Total phosphorus	125	500
Orthophosphate	25	500
TKN	125	500
Nitrate-nitrite	25	500
Metals		
Total recoverable (Cu, Zn, Pb, Cd, Hg)	200	1000

Parameter/Specific Analyte	Required Sample Volume (mL)	
	Min.	Recomm.
Dissolved (Cu, Zn, Pb, Cd, Hg)	200	1000
Organics		
PAHs	1000	1000
Phthalates	1000	1000
Herbicides (2,4-D, MCPP, Triclopyr, Dichlobenil, Pentachlorophenol)	1000	1000
Pesticides, Nitrogen (Prometon)	1000	1000
Pesticides, Organo-P (Diazinon, Malathion, Chlorpyrifos)	1000	1000
Total Volume Needed for Routine Composite Sample:	8.2 L	13.5 L
Total Composite Sample Volume Needed for Field & Lab QC:	23.8 L	53.0 L

6.6.2.2. Sample Collection Materials

For many of the chemical analyses, it is appropriate to collect samples in either plastic or glass containers; however, for the analyses of organic constituents samples must be collected in glass containers. Therefore, all composite water samples will be collected into glass containers equipped with Teflon-lined lids to avoid interferences that could result from using plastic containers for organic parameters. Additionally, auto-sampler suction tubing will be lined with Teflon and apparatuses used to split samples to undergo analysis for organic chemicals will be constructed from Teflon. The exposed surfaces of sampling apparatuses or housings will not contain any of the metals included in the parameter list.

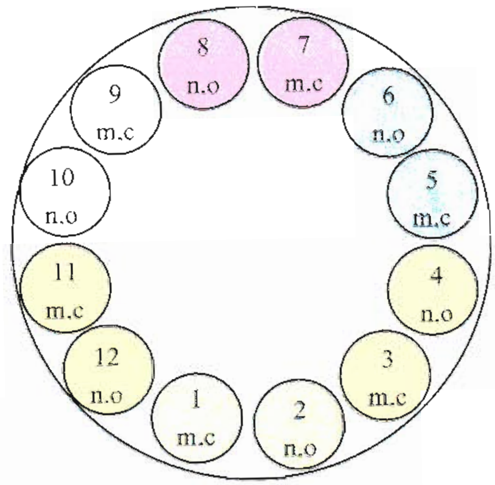
6.6.2.3. Sample Container Preparation

Some of chemical analysis methods call for special preparation of the sample container. For metals analysis, containers must be rinsed with nitric acid. For analysis of organic chemicals, containers must be rinsed with an organic solvent or baked. Special preparation needed for one constituent can cause interferences when analyzing for another constituent (for example, the nitric acid rinse required for metals analysis could interfere with analysis of the sample for nitrogen). To address these issues, multiple glass sample containers that would undergo different preparations should be used to collect replicate water samples of sufficient volume to conduct the required chemical analyses and toxicity testing as described in Section 6.6.2.1 and Section 6.6.3.1.

6.6.2.4. Composite Sample Collection Method

Composite stormwater samples will be collected using commercially available automatic water samplers manufactured for this purpose (e.g. Teledyne-Isco 6700 series samplers, Hach-Sigma 900 series samplers). For this project, these autosampler models could be deployed in an off-the-shelf configuration equipped with four, 1-gallon (3.79 liter) glass bottles, or alternatively, the sampler could be customized to use up to twelve, 1-gallon glass bottles. This custom configuration would better ensure sufficient sample volumes are collected for the required analyses, including toxicity and QC samples, and provide flexibility in targeting a range of rainfall depths, with the intent to minimize the amount of field staff time to frequently check the status of sampling (i.e., bottle capacity remaining during a storm event).

In either the off-the-shelf, or the custom configuration, the autosampler will be programmed to collect paired sequential samples over the course of the storm. This sequential program would allow the possibility of selecting a subset of filled bottles (depending upon total sample volume needed for the targeted event) which represent the targeted hydrograph area and exclusion of a sample bottle largely filled with baseflow at the end of an event. The bottle pairs would consist of a bottle that underwent preparation for metals analysis and a bottle that underwent preparation for organics analyses as described in Section 6.6.2.3. Upon completion of a sampling event, the contents of each bottle type will be combined to produce two composite samples, one to undergo analyses for metals and conventional parameters and the other to undergo analyses for organics and nutrients. A diagram of an example sampler setup for a custom twelve-bottle configuration is shown in Figure 4. See Section 6.8 for further details.



Legend

1: bottle number

m,c: bottles receiving nitric acid rinse; contents to be analyzed for metals, and conventionals

n,o: bottles to receive organic solvent rinse; contents to be analyzed for nutrients and organics

Same colored bottles represent bottle pairs that are filled simultaneously. Bottle pairs are filled sequentially over the course of the storm, resulting in a total of six bottle pairs if all bottles are filled.

Sample Compositing Scheme

(1) The contents from all "m,c" bottles are combined to create a single composite sample for analyses of metals, and conventionals

(2) The contents of all "n,o" bottles are combined to create a single composite sample for analysis of nutrients and organics

Figure 4. Diagram of autosampler 12- bottle configuration for routine flow-weighted composite sampling.

Sampling will be initiated by the auto level enable function, based on an increase in level as measured by the flow meter. Alternatively, the automatic sampler will be manually started based on field staff observation of rainfall and a corresponding increase in runoff flow. The auto enable will be based on the current baseflow level plus a level change beyond the sensitivity (i.e. noise) of the instrument. This level change value is typically 0.03 to 0.1 ft.

The objective of the composite sampling is to sample representative storm runoff. Thus, we will strive to exclude sampling during baseflow occurring after the end of a storm event. Intra-event baseflow (that is, when flow rate falls to the baseflow level between short gaps within one storm event hydrograph) may be sampled if sufficient volume passes to accumulate the pacing volume.

6.6.3 First Flush Toxicity Sampling

A composite sample will be collected for the seasonal first-flush toxicity and chemistry testing. This sample will be collected during August or September with antecedent conditions as stated in Section 6.3. If a sample is unattainable during this time (due to lack of adequate rain, unavailable of organisms, sampler malfunction, etc.), the sample will be attempted a second time. A second sample would also be collected if the first test is invalid or anomalous. Further information regarding invalid or anomalous tests can be found in Section 8, *Sampling Procedures*. A second attempt may occur in October. In October, no antecedent dry period is required prior to sample collection (per Permit §S.8.D.2.d).

6.6.3.1. Toxicity Sample Analytical Parameters and Volume Needs

The following parameters will be analyzed in the stormwater sample collected for the toxicity testing per Permit §S.8.D.2.d.*i*:

- TSS
- Chloride
- Hardness
- MBAS
- Metals including total and dissolved copper, zinc, cadmium, lead, and mercury
- PAHs
- Phthalates
- Pesticides including: 2,4-D, MCPP, Triclopyr, Diazinon, Malathion, Chlorpyrifos, Dichlobenil, Prometon and Pentachlorophenol

Table 14 lists the chemical parameters and required volumes for the toxicity sample. Table 15 lists the required sample volume for toxicity testing. A total composite sample volume of at least 30.7 liters is needed and up to 54.0 liters is recommended to run the required chemical analyses and toxicity testing.

Table 14. Chemical parameters and required volumes for the seasonal first-flush toxicity sample.

Parameter/Specific Analyte	Required Sample Volume (mL)	
	Min.	Recomm.
Conventionals		
TSS	200	1000
Chloride	25	500
Hardness	50	500
MBAS	1000	1000
Metals		
Total recoverable (Cu, Zn, Pb, Cd, Hg)	200	1000
Dissolved (Cu, Zn, Pb, Cd, Hg)	200	1000
Organics		
PAHs	1000	1000
Phthalates	1000	1000
Herbicides (2,4-D, MCPP, Triclopyr, Dichlobenil, Pentachlorophenol)	1000	1000
Pesticides, Nitrogen (Prometon)	1000	1000
Pesticides, Organo-P (Diazinon, Malathion, Chlorpyrifos)	1000	1000
Total Volume Needed for Chemical Analyses:	6.7 L	10.0 L

Unlike the standard flow-weighted composite samples and grab samples, BOD_5, fecal coliform, TPH, turbidity, nutrients and conductivity are not required for analysis of the toxicity sample. Conductivity, pH and hardness will be measured at the toxicity laboratory upon sample receipt.

Table 15. Required sample volume for toxicity testing.

Parameter/Specific Analyte	Required Sample Volume (L)	
	Min.	Preferred(1)
Toxicity		
Environmental Canada Trout Embryo Viability	24.0	44.0

(1) The preferred sample volume includes the extra volume needed to perform additional replicates of 100 percent sample in order to provide tissue for yolk/embryo analysis (if needed).

If sufficient sample volume cannot be collected during the seasonal first-flush event, alternatives have been established for conducting the toxicity test with reduced volumes (see Section 8.0).

6.6.3.2. Toxicity Sample Collection Method

The composite sample will be collected using the same auto sampler configuration as described in Section 6.6.2 and then split into a subsample for the toxicity testing and a subsample for the chemistry analyses. Sampling compositing and splitting procedures are explained in Section 8.0 However, instead of collecting a flow-weighted composite sample (as for the routine outfall composite samples), a time-paced composite sample will be collected for the toxicity sample.

Since the auto samplers have limited bottle capacity volume, it is more difficult to achieve the larger sample volume needed for the toxicity sample if flow-weighting the composite collection. Utilizing a time-paced sample approach will increase the success rate in targeting this infrequent storm event. This approach also allows scheduling of staff to switch out bottles and conduct sample processing/icing, etc. To collect sufficient volume, sample bottles will need to be "swapped out" at least once during the storm event (see Section 7.2.4).

Flow-weight composite sampling for toxicity testing may be attempted if a stable and precise precipitation/ runoff yield relationship can be derived so that a determination of the appropriate sampler flow pacing rate for the targeted storm event can be made with high-confidence.

6.6.4 Baseflow Sampling

Samples of wet-season and dry-season baseflow (if baseflow is present) will be collected from the monitoring site. Water quality data from the baseflow samples will be used in calculating wet season, dry season, and annual pollutant loads (per Permit §S8.D.2.g). Each year, two baseflow samples may be collected in the wet season and one baseflow sample may be collected during the dry season. The antecedent precipitation conditions presented in

Table 10 will define baseflow conditions (i.e. the absence of stormflow) at the monitoring site for the purpose of baseflow sample collection. Baseflow samples will be collected with the same manual grab sampling techniques used for storm event grab sampling. Baseflow samples will be analyzed for the same parameters as the routine stormwater samples (both the grab and composite stormwater samples) listed in Table 12 and Table 13.

6.7 SEDIMENT SAMPLING

Annual sediment monitoring will be conducted for this project. Sediment samples will be collected at the outfall location using an in-line sediment trap or similar collection system. If the required sediment amount is unattainable from these devices, other collection methods may be employed with prior approval by Ecology.

The annual sediment sample collected will be analyzed for the following parameters:

- Total solids (% solids)
- Total organic carbon
- Grain size
- Metals including: total zinc, copper, cadmium, lead, and mercury
- Polycyclic aromatic hydrocarbons (PAHs)
- Phthalates
- Phenolics
- PCBs
- Pesticides including: Pentachlorophenol, Diazinon, Malathion, and Chlorpyrifos

See Section 8.0 for MDLs and analytical methods.

If the amount of sediment sample collected on an annual basis is insufficient to allow analysis for all parameters listed above, samples will be analyzed for as many parameter as possible in the following priority order (in descending order of priority):

1. Grain size
2. Total organic carbon
3. Metals
4. PAHs & Phthalates
5. Phenolics
6. PCBs
7. Pesticides

If insufficient sediment amounts exist to run the next highest priority pollutant, that analysis will be bypassed and analyses run on lower priority pollutants in accordance with the remaining priority order to the extent possible. Grain size analysis will be performed if enough sample is available for all parameters using the grain size method specified in Section 8.0 otherwise grain size will be characterized qualitatively[6].

Table 16 indicates the estimated sample amounts required for each parameter/analyte for the annual sediment. A total sample of at least 220 grams of sediments is needed and up to 1,426 grams is recommended to run the required chemical and physical analyses.

Table 16. Analytical parameters and required sample amounts for annual sediments

Parameter/Specific Analyte	Required Sample Volume (g)	
	Min.	**Recomm.**
Conventionals		
Total solids	10	75
Total organic carbon	5	75
Grain size	25	300
Metals		
Total recoverable (Cu, Zn, Pb, Cd, Hg)	10	75
Organics		
PAHs	20	150
Phthalates / Phenolics	90	300
PCBs	20	150
Herbicides (Pentachlorophenol)	20	150
Pesticides, Organo-P (Diazinon, Malathion, Chlorpyrifos)	20	150
Total Volume Needed for Annual Sediment Sample:	220 g	1425 g

(1) Required sample volumes expressed on a wet-weight basis.

(2) Minimum sample listed for grain size assumes sample consists primarily of fine-grained sediments.

6.8 MONITORING EQUIPMENT INSTALLATION AND SETUP

This section describes the type of monitoring equipment that will be deployed and the general configuration of equipment installation, including the rain gage, flow meter, autosampler and sediment sampler.

6.8.1 Precipitation Monitoring

Precipitation will be continuously monitored with an existing tipping bucket rain gage located on the fence-line just north of the Port Administration Office building A continuous rainfall record will allow the establishment of a rainfall/runoff relationship at

[6] per *Settle Agreement to Resolve Monitoring Issues Raised on Appeal by the Phase I Permittees Under Special Condition S8 of the 2007 Phase I Municipal Stormwater Permit- Attachment A – S8 Settlement*

the stormwater monitoring site, and the determination and tracking of the number of qualifying storm events throughout the year. Additionally, the rain gage data will allow the validation of the storm event composite samples based on the criteria presented in Section 6.3.

Field staff will need near real-time rain data to alert them to when antecedent conditions have been met (to start sampling) and to determine when the rainfall event has ended (to retrieve samples). To reduce staff effort required to repeatedly go to the rain gage site and download data, the rain gage will be equipped with telemetry (e.g., hard-line telephone, cellular, radio, or facility wiring) to allow for remote data acquisition via dialing into a modem and/or access via the internet.

The rain gage will be maintained per manufacturer's recommendations (see Section 7.1 for methods). The rain gage is capable of measuring only liquid precipitation (i.e., rainfall or melted snow); it will not be a heated rain gage capable of melting snow.

6.8.2 Stormwater Monitoring

Stormwater monitoring equipment will be installed at the storm drainage system outfall location. The flow meter sensor(s) and sampler suction line and strainer will be installed within the outfall pipe at the outlet. A secure enclosure will house the other monitoring system components, including the flow meter data logger/controller, the autosampler and system batteries. The equipment enclosure will be located in the upland area either on a patio or in a landscaped area above and adjacent to the outfall pipe. Flow meter sensor cables and sampler tubing will run through conduit pipe from the equipment enclosure to the outfall pipe outlet.

While onsite, field personnel will interface with the monitoring equipment using a laptop computer or other hand-held device equipped with necessary software. The Port may also choose to install a telemetry communication system that would provide for remote communication with the monitoring equipment. The telemetry system would allow for downloading data to offsite computers and remote programming and control of the monitoring instruments.

6.8.3 Monitoring Equipment Preparation and Testing

Prior to initial deployment, the autosampler head and body will be washed with Liqui-nox® and rinsed with tap water. The sampler pump tubing, suction line and strainer will be washed with Liqui-nox®, rinsed with reagent grade water, flushed with methanol, then rinsed again with reagent grade water. The ends of the pump tubing and suction line tubing will be capped using parafilm until deployed.

During equipment installation, the sampler and the flow meter will be programmed and tested. If flow is not available for a test run, a test run may be scheduled later to ensure the equipment is working properly. During sampler programming, field staff will be trained (if needed) to calibrate and program the equipment.

6.8.4 Sediment Sampling Apparatus

Suspended particulate samples will be collected with the use of in-line stormwater sediment traps, with a deployment period not to exceed one year. Construction details and performance of sediment traps is described in Stormwater Sediment Trap Pilot Study (Wilson and Norton, 1996). These sediment traps consist of a glass vessel housed in a stainless steel cup that is held in place by brackets. The sediment traps are typically installed in large-diameter pipes or in the sumps of storm drain junction structures, such a catch basins. Neither of these types of deployment configurations are available at the monitoring site. Instead, the sediment trap will be deployed at the outfall within a T-coupling fitted to end of the pipe. The branch of the coupling will be oriented vertically, pointing downward. The sediment trap will be positioned within the branch, supported by a cap at the end of the coupling. The top of the sediment trap will protrude into the through-flow section of the coupling, operating in a manner similar to deployment in a catch-basin sump. As stormwater flows across the opening of the sediment trap, particulate material will settle into the trap; however, bed-load would not be captured. The sediment trap will be installed so as not to interfere with the operation of the flow meter.

7.0 SAMPLING PROCEDURES

The following sections document activities associated with field instrument operation and maintenance and sample collection. Further detail on the field procedures that will be implemented to ensure quality control for sample collection and handling are provided in Section 9.1.

7.1 PRECIPITATION AND FLOW MONITORING

The rain gage will be downloaded at least twice each month and immediately prior to, during, and following sampled storm events. Field staff will inspect the rain gage monthly and service it as needed. Rain gage calibration will occur using the method and at the frequency recommended.

The flow meter will be inspected and serviced at least twice each month and immediately prior to storm events targeted for sampling. Flow data will be downloaded during these maintenance visits as well as during and following sampled storm events. During maintenance visits and during pre-storm setup visits, the flow meter calibration will be checked and adjusted if necessary.

7.2 STORMWATER SAMPLE COLLECTION

This section documents the procedures to prepare for and conduct stormwater sample collection for both the routine sampling and sampling for toxicity testing.

7.2.1 Procedures for Storm Targeting

At least once each week during periods when storms are to be targeted for sampling, the Port Project Manager, or Consultant Project Manager will check precipitation forecasts for *Tacoma* (for example, NWS - http://www.wrh.noaa.gov/sew/, 180- hour GFS meteogram – http://www.wxmaps.org/) to determine if a storm meeting the minimum storm depth targeting criteria (Section 6.3) might occur during the next 7-day period. If forecasts suggest that a storm meeting the target criteria might occur, the Port Project Manger or designee will contact the Consultant Project Manager, Consultant Technical Lead to decide if the storm should be considered for targeting. If the decision is made to keep tracking the storm, then the Consultant Project Manager or Consultant Technical Lead or designee will continue reviewing forecasts once each day and update the other team members as to the status of the forecast. Seventy-two hours prior to the onset of the candidate storm, the Consultant Project Manager or Consultant Technical Lead or designee will review precipitation forecasts and, in consultation with the other team member mentioned above, make a final "go-no go" decision to target the storm for sampling. If targeting a storm for "first flush toxicity sampling", the Consultant Project Manager or Consultant Technical Lead or designee will contact the Toxicity Laboratory to confirm gamete/egg availability prior to making the final go/no go decision. If the decision is made to target the storm, the Consultant Project Manager or Consultant Technical Lead will designate a "Storm Controller" for the targeted storm event. From that point until all samples related to the storm are delivered to the laboratories, the Storm Controller will be responsible for managing all field activities and sampling decisions related to the targeted storm event. The initial act of the Storm Controller will be to schedule a field team to conduct the pre-storm site setup activities, described in the next section.

During storm targeting periods, Internet-based forecasts will be archived to document targeting decisions.

7.2.2 Pre-storm Site Setup

Within 24 hours prior to the onset of the targeted event, a field team will visit the monitoring site to prepare the monitoring equipment for sampling. Prior to this site visit, the Storm Controller will determine a sampler pacing rate based on the forecasted precipitation quantity, the expected duration of the storm, and expected resulting runoff volume (yield). Prior to deployment, autosampler bottles will have been cleaned by the analytical laboratory as described in Section 6.6.2.3. Bottles will be stored in plastic bags prior to placement into the sampler. The field team will not be deployed unless the antecedent precipitation criteria have been met or in the professional judgment of the Storm Controller are likely to be met (see

Table 10).

During the pre-storm site visit, the field team will check/ modify the auto sampler and flow meter programs, conduct necessary maintenance and calibration activities, place sample bottles into the auto sampler, and start the auto sampler program. All setup, maintenance and calibration activities will be recorded on a field data sheet (Appendix B) along with notes of other relevant site conditions. During pre-storm setup, the following specific tasks will be performed:

(1) Calibrate flow meter using appropriate method for site;

(2) Install new sampler pump tubing if needed and calibrate autosampler sample volume;

(3) Back flush the sampler pump tubing and suction line with one gallon of reagent-grade water;

(4) Inspect sampler strainer and water level sensor for debris and clean if necessary;

(5) Prepare sampler, including removing bottle lids and filling the sampler base with ice;

(6) Confirm sampler and flow meter programs and configuration settings;

(7) Run sampler diagnostics to confirm operation of sampler distributor arm;

(8) Start sampler program and confirm the sampler program is active and is disabled (awaiting a trigger signal from the flow meter to initiate sample collection).

7.2.3 Storm Event Grab Sample Collection

As the targeted storm event approaches, the Storm Controller will monitor the project rain gage to confirm that antecedent conditions are met and determine the start of the storm. During this period, the Storm Controller will be in contact with the field team members to keep them apprised of the status of the impending storm. Once the targeted storm begins (i.e. antecedent conditions are met followed by 0.01" of rain recorded at the project rain gage), the field team will be mobilized to conduct grab sampling. The field team will strive to collect the grab sample within one hour of the onset of storm runoff. The field team will conduct the following task at the site:

(1) Check auto sampler status and replenish ice in base as needed. If problems are discovered, troubleshoot the issue and recover the sampling effort if possible.

(2) Check auto sampler battery voltage and replace battery if necessary;

(3) Download the flow meter and review the flow record for obvious errors;

(4) Collect grab samples by dipping individual containers into flow stream of the stormwater conveyance. Samples will be skimmed from the surface (for total petroleum hydrocarbons) if the flow stream is not well mixed/turbulent.

(5) Collect duplicate grab samples, if scheduled; as per #3

(6) Collect grab sample blank, if scheduled;

(7) Label and store samples on ice for transport to processing area or laboratory.

All activities and pertinent observations will be recorded on the same field data sheet used to document pre-storm setup activities.

7.2.4 Mid-Event Site Visits

Over the course of the targeted storm event, the Storm Controller will track cumulative precipitation and make a judgment of whether or not the sampler bottles are likely to fill up before the storm ends. To make this judgment, the Storm Controller will consider the expected runoff yield from the cumulative rainfall, the sampler pacing rate, and the amount of precipitation forecasted for the remainder of the storm event. If the Storm Controller decides it is likely that the composite sampler bottles may fill prematurely, then the Storm Controller will dispatch a field team to check the status of the sampler, and if necessary, swap in new sample bottles. During the mid-event site visit, the field crew activities will include:

(1) Check the auto sampler status; Determine if the sample bottles should be swapped-out in consultation with the Storm Controller via cell phone if necessary. If the decision is made to swap out the bottles, the field crew will:

   a. Review sampler report and record data;

   b. Cap and label sample containers and store on ice for transport to the sample processing location where they will be stored for later compositing;

   c. Deploy new bottles into the sampler; and

   d. Restart the sample program;

(2) Replenish the ice in the sampler

(3) Check auto sampler battery voltage and replace battery if necessary; and

(4) Download the flow meter and review the flow record for obvious errors.

All activities and pertinent observations will be recorded on the same field data sheet used during previous visits for the particular storm event.

Multiple mid-event site visits may occur during a targeted storm event if necessary to avoid gaps in or truncation of the composite sampling period.

7.2.5 Composite Sample Retrieval

Over the course of the targeted storm, the Storm Controller will monitor near term forecasts and weather conditions to determine when the storm event has ended. Once the storm event has ended, a field team will be mobilized to retrieve the composite sample. Field teams will conduct the following tasks to retrieve the composite sample and demobilize each site after the sampling event is over:

(1) Review sampler report and record data;

(2) Cap and label sample containers and store on ice for transport to the sample processing location;

(3) Collect equipment rinsate blank if scheduled;

(4) Download the flow meter and review the flow record for obvious errors; and

(5) Power-down the autosampler or place in "stand-by" mode.

(6) Deliver samples to the laboratory where they will be filtered for dissolved metals and ortho-phosphorus immediately after compositing.

In general, all samples will be minimally processed in the field to prevent potential contamination from trace pollutants in the atmosphere. Samples will be transported to the analytical laboratory, which is in close proximity to the sample site, where they will be composited and preserved as soon as possible after sample collection. If sample compositing and receiving is required during non-business hours, the Port will coordinate with the laboratory to have staff available. If the laboratory cannot schedule staff to be available, samples will be composited and field filtered as needed at a Port facility.

All activities and pertinent observations will be recorded on the same field data sheet used to document pre-storm setup and grab sampling activities.

7.2.6 Field Sample Validation

Prior to processing the samples and transferring custody to the analytical and toxicology laboratories, the Storm Controller will validate the samples against the criteria presented in Section 6.0. Validation activities for the grab samples and composite samples are presented below.

Grab Sample

- Confirm that required antecedent precipitation conditions existed prior to grab sample collection (

Table 10);

- Review field forms and the storm hydrograph to ensure the grab sample was collected early in the storm event;
- Review field notes to determine whether anomalous condition were encountered that would disqualify the grab sample;
- Inspect the grab sample containers to ensure they are filled correctly.

Composite Sample

- Determine if the sampled storm was a qualifying event (

Table 10). A routine composite sample can still be processed as one of the three targeted samples from a "non-qualifying" event if the antecedent precipitation criterion was met, and the precipitation was more than 0.09" and but less than 0.20".

- Review field notes to determine whether anomalous condition were encountered that would disqualify the composite sample (for example, missed aliquots or sample bottles overfilled);
- Confirm that the composite sample consists of at least ten (10) aliquots. Composite samples with seven (7) to nine (9) aliquots are acceptable if they meet the other sampling criteria (per Permit §S.8.D.2.b).
- Check that sufficient sample volume has been collected to complete laboratory analyses; and
- Review the storm hydrograph and timing of sample aliquot collection to ensure that the composite sample period included at least seventy-five percent of the hydrograph during the first 24 hours of the storm.

7.2.7 Periodic Preventative Maintenance

Periodic preventative maintenance of equipment will occur periodically between storm events to ensure equipment is operating properly. Signs of vandalism, rusting equipment, equipment failure or other maintenance issues will be documented in field notebooks or on field data forms. Approximately every six-months a new sampler suction line will be installed at the monitoring site and the sampler head will be brought into the lab for a thorough cleaning.

7.3 Baseflow Sample Collection

Field staff will collect baseflow samples during pre-storm setup sites visits, as described above in Section 7.2.2., for up to three events per year. In addition to the other activities conducted during a pre-storm site visit, the field team will conduct the following task at the site:

(1) Confirm the presence of baseflow. If baseflow is present then,

(2) Collect grab samples by dipping individual containers into flow stream of the stormwater conveyance. Samples will be skimmed from the surface for total petroleum hydrocarbons if the flow stream is not well mixed/turbulent.

(3) Label and store samples on ice for transport to processing area or laboratory.

All activities and pertinent observations will be recorded on the same field data sheet used to document other pre-storm setup activities.

7.4 Sediment Sample Collection

Suspended particulate samples will be collected with the use of in-line sediment traps. See Section 6.8.4 for further details related to the design, construction, and installation of sediment traps.

Sediment traps will be deployed for a minimum of one year providing an integrated sample collected over a number of episodic events. Teflon bottles may be used in place of glass bottles for the collection of samples if bottle damage or breakage occurs. Crews will occasionally inspect the bottles over the deployment period to ensure that container openings are free of litter and other debris that could limit sample collection. At the end of the deployment period, the collection bottles will be removed from the mounting brackets, capped with screw closures, packaged, and placed in coolers on ice for transport to the contract analytical laboratory for processing. Under no circumstance will samples be frozen prior to being processed, as this may change the particle size distribution prior to analysis. Processing will begin within 24 hours of retrieval.

See Section 8.2.2 Annual Sediment Sample for further information on sediment sample processing; sample amounts, containers, preservation, and analytical hold times; and sample labels and chain-of-custody procedures. See Section 9.1.1 for further information on field QC procedures that will be implemented to ensure quality control for sediment sample collection and handling.

8.0 MEASUREMENT PROCEDURES

This section describes sample processing procedures that will be used for routine composite, toxicity, and sediment samples; and describes chemical and toxicity testing procedures used for the analysis of samples collected during this project.

8.1 LABORATORY SELECTION

The laboratories selected for this program will have the demonstrated ability to achieve acceptable detection/reporting limits for the constituents of interest using standard analytical methods, meet project-specific criteria, and be accredited by the Washington State Department of Ecology. The prime analytical laboratory will be Spectra Laboratories (Tacoma, WA). Spectra may sub-contract certain analyses to other laboratories to meet required methods or detection limits. Appendix C contains information on Spectra Laboratories.

8.2 POST STORM EVENT SAMPLE PROCESSING

This section presents the post-storm event sample processing procedures for routine composite and toxicity samples; annual sediment processing procedures; required sample amounts, containers, preservation, and holding times for chemical and toxicity testing procedures; and chain-of-custody procedures for processed samples.

8.2.1 Routine Composite and Toxicity Samples

At the end of a successful sampling event, composite sample containers (and grab sample bottles) will be transported by the field team crew to the contract analytical laboratory following established sample handling and chain-of-custody procedures. Upon arrival at the analytical laboratory, composite samples will be moved to a designated clean room within the laboratory for further processing.

Post-storm event sampling processing for routine composite samples will consist of first preparing a final composite sample from the available sample container volumes, then splitting the composited sample into representative sub-samples by dispensing sample into the appropriate number and type of pre-cleaned laboratory sample containers for subsequent analysis. Sample processing will be performed using available and accepted devices, and may include the use of churn sample splitters, cone sample splitters, or other available devices or techniques.

Field team crew and/or laboratory staff will follow established SOPs for post-storm event sample handling and processing. All sample processing equipment will be decontaminated prior to use following established procedures. Samples will be properly labeled and formally transferred to the laboratory for analysis following established chain-of-custody procedures, as discussed below.

Required sample amounts, containers, preservatives, and analytical holding times for required chemical analyses are included in Table 17 and Table 18. Analytical methods and method reporting limits for routine chemical analyses are shown in Table 21. In the event that additional analyses are to be performed, such as targeted collection of field and laboratory matrix QC samples, or the laboratory requests additional sample amounts for select parameters, the sample size will be increased as needed. In such cases, sample processing procedures will be adjusted accordingly to accommodate larger initial sample volumes, as discussed below.

Post-storm event sample processing for toxicity will follow similar procedures as for routine stormwater samples with the exception that the chemical and toxicity sample volume requirements will require the processing of a larger initial sample volume. Sample processing procedures will be modified to accommodate larger sample volumes and may include the use multiple sample processing devices in combination (e.g., cone sample splitter in series with duplicate churn sample splitters) or other similar techniques. Toxicity samples, once processed, will need to be transported to the toxicity testing laboratory as soon as practicable in order to meet the 36 hour hold time requirement. Efforts will be made during sample processing and transport to ensure that toxicity sample temperature requirements are met. Toxicity sample hold time and temperature considerations are discussed below.

Toxicity testing temperature and analytical holding time considerations include the following:

<u>Temperature Considerations</u>

Toxicity samples should be cooled to 0–6 °C during collection and sent to the laboratory immediately upon completion. If the sample temperature exceeds 6 °C at receipt by the toxicity testing laboratory, then the WET Coordinator, Randall Marshall (rmar461@ecy.wa.gov or 360-407-6445) will be contacted in accordance with Department of Ecology publication # WQ-R-95-80, *Laboratory Guidance and Whole Effluent Toxicity Test Review Criteria* to get acceptance for the sample temperature deviation. Acceptance will not be given for samples warmer than 14 °C unless the sample is received by the laboratory within one hour after collection. Samples should meet the required temperature stated in the reference listed above.

Analytical Holding Time Considerations

If the maximum holding time of the toxicity sample is exceeded (36 hours), toxicity laboratory staff will contact Ecology's WET Coordinator 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 will be recorded on field data forms or in field notebooks.

8.2.2 Annual Sediment Sample

Sediment collection bottles retrieved at the end of the annual deployment period will be transported to the contract analytical laboratory following established sample handling procedures, as discussed in Section 7.4. Upon receipt at the contract analytical laboratory, the sediment samples will be moved to a designated clean room with the laboratory where the samples will be further processed. All processing will occur with 24 hours of retrieval.

Processing will consist of first decanting off a portion of the overlying water, then centrifuging the remaining slurry to isolate the particulate fraction. After initial sample processing, sediments will be well mixed and transferred to pre-cleaned containers. If replicate samples are collected from the site (e.g., more than one sediment trap or other sampling techniques employed), sediments will be composited into a single sample.

Manipulations of the samples during processing will be accomplished using stainless-steel utensils. All sample processing utensils will be decontaminated prior to use following established procedures. All sample containers will be glass jars with Teflon-lined closures, cleaned to EPA QA/QC specifications (US EPA, 1990). Required sample amounts, containers, preservatives, and analytical holding times for required analyses are included in Table 20. Analytical methods and method reporting limits for analysis of sediments are shown in Table 22.

8.2.3 Sample Amounts, Containers, Preservation, and Holding Times

Samples processed in the laboratory will include those from routine stormwater composites, first-flush stormwater composite for chemical analysis and toxicity testing, and sediments. Typical sample amounts, containers, preservation, and analytical holding times are summarized in Table 17 and Table 18 for each of the above mentioned samples to be collected during this project. A brief discussion is provided below.

The minimum sample amounts are the minimum sample sizes for a single analysis based on the contract analytical laboratory. In some cases, allowances have been made in the minimum sample amounts to account for potential repeat analyses or bottle damage, particularly for the required organic parameters. See discussion below on guidelines for toxicity samples of insufficient volume.

Sub-samples obtained from the sample splitter device will be collected into contaminant-free containers, cleaned to EPA QA/QC specifications (EPA, 1990), according to analytical method specifications. The contract analytical laboratory will provide all appropriate sample containers required for this project.

Certain analytes require chemical preservation in order to minimize potential chemical changes or degradation that could occur in a sample prior to analysis. Samples prepared in the laboratory will be preserved following method-specific requirements for both preservation and storage. No chemical preservatives are required for the sediment samples being collected for this program.

Technical holding times are the maximum length of time allowed between when a sample is collected to when the digestion, extraction, and/or analysis is initiated to ensure analytical accuracy and representativeness. All samples collected for this program will be transported to the laboratory and processed as soon as practicable upon completion of field sampling.

Table 17. Typical sample amounts, containers, preservatives, recommended handling, and holding times for required parameters in routine stormwater composite samples

Parameter	Minimum Amount	Container Type	Handling / Preservation	Holding Time
Conventional Parameters				
Total suspended solids	200 mL	HDPE	Cool to ≤ 6°C	7 days
Turbidity	100 mL	HDPE	Cool to ≤ 6°C	48 hours
Conductivity	100 mL	HDPE	Cool to ≤ 6°C	28 days
BOD_5	1000 mL	HDPE	Cool to ≤ 6°C	48 hours
Hardness (as $CaCO_3$)	50 mL	HDPE	Cool to ≤ 6°C, HNO_3	6 months
Methylene Blue Activating Substances (MBAS)	1000 mL	HDPE	Cool to ≤ 6°C	7 days

Parameter	Minimum Amount	Container Type	Handling / Preservation	Holding Time
Bacteria				
Fecal Coliform	125 mL	Corning Glass	Cool to ≤ 6°C, $Na_2S_2O_3$	24 hours
Nutrients				
Total phosphorus	125 mL	HDPE	Cool to ≤ 6°C, H_2SO_4	28 days
Orthophosphate	25 mL	HDPE	Cool to ≤ 6°C	48 hours
Total Kjeldahl nitrogen	125 mL	HDPE	Cool to ≤ 6°C, H_2SO_4	28 days
Nitrate-nitrite	25 mL	HDPE	Cool to ≤ 6°C, H_2SO_4	28 days
Metals				
Total recoverable (copper, zinc, lead, cadmium)	100 mL	HDPE	Cool to ≤ 6°C, HNO_3	6 months
Total dissolved (copper, zinc, lead, cadmium)	100 mL	HDPE	Cool to ≤ 6°C, Filter, HNO_3	6 months
Total mercury	100 mL	HDPE	Cool to ≤ 6°C, HNO_3	28 days
Dissolved mercury	100 mL	HDPE	Cool to ≤ 6°C, Filter, HNO_3	28 days
Organics				
PAHs	2 – 500 mL	Amber Glass	Cool to ≤ 6°C	7 days
Phthalates	2 – 500 mL	Amber Glass	Cool to ≤ 6°C	7 days
Herbicides (2,4-D, MCPP, Triclopyr, Dichlobenil, Pentachlorophenol)	2 – 500 mL	Amber Glass	Cool to ≤ 6°C	7 days
Pesticides, Nitrogen (Prometon)	2 – 500 mL	Amber Glass	Cool to ≤ 6°C	7 days
Pesticides, Organo-P (Diazinon, Malathion, Chlorpyrifos)	2 – 500 mL	Amber Glass	Cool to ≤ 6°C	7 days
Total Petroleum Hydrocarbons				
NWTPH-Dx	2 – 500 mL	Amber Glass	Cool to ≤ 6°C	7 days
NWTPH-Gx	2 – 40 mL	VOC Vial	Cool to ≤ 6°C, HCl	14 days

Table 18. Typical sample amounts, containers, preservatives, recommended handling, and holding times for required chemical analysis parameters in stormwater composite samples for toxicity testing

Parameter	Minimum Amount	Container Type	Handling / Preservation	Holding Time
Conventional Parameters				
Total suspended solids	200 mL	HDPE	Cool to ≤ 6°C	7 days
Chloride	25 mL	HDPE	Cool to ≤ 6°C	28 days
Hardness (as $CaCO_3$)	50 mL	HDPE	Cool to ≤ 6°C, HNO_3	6 months
Methylene Blue Activating Substances (MBAS)	1000 mL	HDPE	Cool to ≤ 6°C	7 days

Parameter	Minimum Amount	Container Type	Handling / Preservation	Holding Time
Metals				
Total recoverable (copper, zinc, lead, cadmium)	100 mL	HDPE	Cool to ≤ 6°C, HNO_3	6 months
Total dissolved (copper, zinc, lead, cadmium)	100 mL	HDPE	Cool to ≤ 6°C, Filter, HNO_3	6 months
Total mercury	100 mL	HDPE	Cool to ≤ 6°C, HNO_3	28 days
Dissolved mercury	100 mL	HDPE	Cool to ≤ 6°C, Filter, HNO_3	28 days
Organics				
PAHs	2 – 500 mL	Amber Glass	Cool to ≤ 6°C	7 days
Phthalates	2 – 500 mL	Amber Glass	Cool to ≤ 6°C	7 days
Herbicides (2,4-D, MCPP, Triclopyr, Dichlobenil, Pentachlorophenol)	2 – 500 mL	Amber Glass	Cool to ≤ 6°C	7 days
Pesticides, Nitrogen (Prometon)	2 – 500 mL	Amber Glass	Cool to ≤ 6°C	7 days
Pesticides, Organo-P (Diazinon, Malathion, Chlorpyrifos)	2 – 500 mL	Amber Glass	Cool to ≤ 6°C	7 days

(1) Conductivity, pH, and hardness will be measured at the toxicity laboratory upon sample receipt. The hardness sample referenced above is the optional hardness sample collected from the receiving water in order for the laboratory to adjust the sample hardness to match receiving water. Additionally, MBAS should be analyzed within 24-hours to determine analyte presence that can cause interferences with 7-day toxicity test.

Table 19. Targeted freshwater chronic toxicity test, recommended sample amount, container type, preservative, handling, and holding time for stormwater composite toxicity testing

Parameter	Recommended Amount	Container Type	Handling / Preservation	Holding Time
Toxicity				
Environmental Canada Trout Embryo Viability	24 – 44 L (6.4 – 11.6 gal)	Glass	Cool to ≤ 6°C, no preservation	36 hours

(1) Information in this table provided by Nautilus Laboratory, LLC.

(2) Laboratory method based on Environment Canada Biological Test Method: Toxicity Tests using Early Life Stages of Salmonid Species (Rainbow Trout), EPS 1/RM/28, 2nd Edition, July 1998 (with modifications by Canaria, et al., 1998).

Table 20. Typical sample amounts, containers, preservatives, recommended handling, and holding time for required parameters in sediments

Parameter	Minimum Amount	Container Type	Handling / Preservation	Holding Time
Conventional Parameters				
Total solids	10 g, wet	Glass, WM	Cool to ≤ 6°C, no preservation	14 days
Total organic carbon	5 g, wet	Glass, WM	Cool to ≤ 6°C, no preservation	14 days
Grain Size	25 g, wet	Glass, WM	Cool to ≤ 6°C, no preservation	6 months
Metals				
Total recoverable (copper, zinc, lead, cadmium, mercury)	10 g, wet	Glass, WM	Cool to ≤ 6°C, no preservation	6 months
Organics				
PAHs	20 g, wet	Glass, WM	Cool to ≤ 6°C, no preservation	14 days
Phthalates / Phenolics	90 g, wet	Glass, WM	Cool to ≤ 6°C, no preservation	14 days
PCBs	20 g, wet	Glass, WM	Cool to ≤ 6°C, no preservation	14 days
Herbicides (Pentachlorophenol)	20 g, wet	Glass, WM	Cool to ≤ 6°C, no preservation	14 days
Pesticides, Organo-P (Diazinon, Malathion, Chlorpyrifos)	20 g, wet	Glass, WM	Cool to ≤ 6°C, no preservation	14 days

8.2.3.1 Toxicity Sample Volumes and Sample of Insufficient Volume

A sufficient sample for toxicity consists of the following:

- Approximately 6.7 liters (minimum) to 10 liters (recommended) (1.8 to 2.7 gallons) for the analysis of the required chemical analysis (see Table 18), and
- Approximately 44 liters (11.6 gallons) for required toxicity testing and exposure of extra eggs for embryo/yolk testing, if needed. The toxicity test shall have five concentrations and a control with four replicates at each concentration. An additional seven replicates of 100% sample shall be run in order to provide tissue for yolk/embryo analysis if needed. The test concentration series shall be determined using a 0.5 dilution factor.

If the total sample volume after the qualifying storm is less than 44 liters (11.6 gallons), but greater than 24 liters (6.3 gallons) then the volume that was collected will determine changes in the toxicity testing configuration in accordance with the following:

- 38 liters (10 gallons) of sample – base the concentration series on a 0.3 dilution factor.
- 33 liters (8.7 gallons) of sample – base the concentration series on a 0.3 dilution factor and reduce the number of replicates to three.

- 30 liters (7.9 gallons) – reduce the number of extra replicates of 100% sample for yolk/embryo analysis from seven to three and the number of replicates in the test itself to three.
- 26 liters (6.9 gallons) – reduce the number of extra replicates of 100% sample for yolk/embryo analysis from seven to three and base the concentration series on a 0.3 dilution factor.
- 24 liters (6.3 gallons) – reduce the number of extra replicates of 100% sample for yolk/embryo analysis from seven to three, base the concentration series on a 0.3 dilution factor, and reduce the number of replicates in the test itself to three.

If the sample volume falls between the values listed above, then the test configuration must match the next lowest volume and the excess sample used for additional replicates of 100% sample to improve the detection limit for the yolk/embryo analysis. If sample volume is less than 24 liters (6.3 gallons), toxicity sample analysis will not be conducted.

8.2.4 Sample Labels and Chain of Custody

Each sample that is prepared in the laboratory will be labeled for future identification. Sample labels will be prepared for parameter-specific sample bottles prepared in the laboratory. The laboratory(s) will provide labels for all sample containers and labels will be filled out using waterproof ink, placed on the sample containers, and covered with clear plastic shipping tape. At a minimum, each sample label will contain the following information:

- Project name and number,
- Station identification,
- Date and time of sample collection (24-hour clock using Pacific Standard Time),
- Total number of sample bottles for each analysis and the number of each container (e.g., 1/4, 2/4, etc.),
- Sample/QC identification code,
- Analyses to be conducted, and
- Initials of field team.

Chain-of-custody (COC) procedures will be strictly followed to provide an accurate written record of the possession of each sample from the time it is collected in the field through laboratory analysis. The laboratory(s) will provide sufficient copies of blank COC forms. All sample information (i.e., sample date/time, sample matrix, number of containers, etc.), including all required analyses, will be logged onto a COC form after sample processing in the laboratory, and prior to formal transfer of sample containers to the laboratory(s). Any time possession of the samples is transferred, the individual(s) relinquishing and receiving the samples will respectively sign, date, and note the time of transfer on the COC form. This record documents the transfer of custody of samples from the samplers to the laboratory(s).

The person responsible for transfer/transport of the samples to the laboratory(s) will complete and sign the COC. After the COC has been completed, the sampler(s) will retain a copy for future reference, and the COC will be place in a clear zip loc bag and placed in the cooler. Coolers will be sealed with custody tape prior to transfer/transport and the custody seal will be signed and dated by the person transferring/transporting the samples, secured across the lid and body of the cooler, and covered with clear shipping tape.

Upon receipt of the samples, the laboratory(s) will assume responsibility for maintaining sample chain-of-custody, and will follow all applicable internal procedures for sample log-in, storage and holding times, tracking, and control.

8.3 Chemical Analysis and Toxicity Testing Procedures

This section presents the chemical analysis and toxicity testing procedures that will be used for the analysis of stormwater, sediments, and toxicity samples collected during this project.

8.3.1 Chemical Analysis Water and Sediment

This section presents the analytical methods and reporting limits for chemical analysis of required parameters in stormwater and sediments.

8.3.1.1 Analytical Instruments

Analytical instruments used by the laboratory will be maintained and calibrated according to the internal Laboratory Quality Assurance Plan (LQAP), all applicable standard operating procedures (SOPs), the instrument manufacturer's specifications, and any specific method requirements.

8.3.1.2 Analytical Methods and Reporting Limits

The target constituents for this project and corresponding analytical methods, method detection limits, method reporting limits, and reporting limit targets for stormwater and sediments are presented in Table 21 and Table 22.

All analyses will be conducted according to the project QAPP, the contract laboratory LQAP, and any specific analytical SOPs.

Table 21. Target constituents, analytical methods, laboratory method detection and reporting limits, and reporting limit targets for stormwater

Parameter	Laboratory Method (1)	Method Detection Limit (1)	Method Reporting Limit (1)	Reporting Limit Target (2)
Conventional Parameters				
Total suspended solids	SM 2540D	0.99 mg/L	1.0 mg/L	1.0 mg/L
Turbidity	EPA 180.1	0.099 NTU	0.1 NTU	± 0.2 NTU
Conductivity	EPA 120.1	NA	1.0 µmho/cm	± 1 µmho/cm
Chloride*	EPA 300.0	0.008 mg/L	0.2 mg/L	0.2 mg/L
BOD_5	SM 5210B	NA	2.0 mg/L	2.0 mg/L
Hardness (as $CaCO_3$)	SM 2340B(ICP)	0.04 mg/L	0.2 mg/L	1.0 mg/L
Methylene Blue Activating Substances (MBAS)	SM 5540C	0.016 mg/L	0.02 mg/L	0.025 mg/L
Bacteria				
Fecal Coliform	SM 9222D**	NA	1 CFU/100 mL	2 min., 2E6 max.
Nutrients				
Total phosphorus*	EPA 365.3	0.004 mg/L	0.01 mg/L	0.01 mg/L
Orthophosphate*	EPA 365.3	0.003 mg/L	0.01 mg/L	0.01 mg/L
Total Kjeldahl nitrogen	SM 4500-Norg C	0.22 mg/L	0.5 mg/L	0.5 mg/L
Nitrate-nitrite*	SM 4500-NO_3 E	0.005 mg/L	0.01 mg/L	0.01 mg/L
Metals				
Total recoverable copper *	EPA 200.8	0.006 µg/L	0.02 µg/L	0.1 µg/L
Dissolved copper*	EPA 200.8	0.006 µg/L	0.02 µg/L	0.1 µg/L
Total recoverable zinc	EPA 200.8	0.20 µg/L	1.0 µg/L	5.0 µg/L
Dissolved zinc	EPA 200.8	0.20 µg/L	1.0 µg/L	1.0 µg/L
Total recoverable lead*	EPA 200.8	0.005 µg/L	0.02 µg/L	0.1 µg/L
Dissolved lead*	EPA 200.8	0.005 µg/L	0.02 µg/L	0.1 µg/L
Total recoverable cadmium*	EPA 200.8	0.005 µg/L	0.02 µg/L	0.2 µg/L
Dissolved cadmium*	EPA 200.8	0.005 µg/L	0.02 µg/L	0.1 µg/L
Total mercury*	EPA 1631E	0.00008 µg/L	0.001 µg/L	0.1 µg/L
Dissolved mercury*	EPA 1631E	0.00008 µg/L	0.001 µg/L	0.1 µg/L
Organics				
PAHs	EPA 8270D SIM			0.1 µg/L
Naphthalene		0.0017 µg/L	0.1 µg/L	
2-Methylnaphthalene		0.0070 µg/L	0.1 µg/L	
Acenaphthylene		0.0041 µg/L	0.1 µg/L	
Acenaphthene		0.0056 µg/L	0.1 µg/L	
Dibenzofuran		---	0.1 µg/L	
Fluorene		0.0036 µg/L	0.1 µg/L	
Phenanthrene		0.0038 µg/L	0.1 µg/L	
Anthracene		0.0040 µg/L	0.1 µg/L	
Fluoranthene		0.0058 µg/L	0.1 µg/L	

Parameter	Laboratory Method [(1)]	Method Detection Limit [(1)]	Method Reporting Limit [(1)]	Reporting Limit Target [(2)]
Pyrene		0.0173 µg/L	0.1 µg/L	
Benzo(a)anthracene		0.0122 µg/L	0.1 µg/L	
Chrysene		0.0051 µg/L	0.1 µg/L	
Benzo(b)fluoranthene		0.0062 µg/L	0.1 µg/L	
Benzo(k)fluoranthene		0.0135 µg/L	0.1 µg/L	
Benzo(a)pyrene		0.0065 µg/L	0.1 µg/L	
Indeno(1,2,3-cd)pyrene		0.0208 µg/L	0.1 µg/L	
Dibenz(a,h)anthracene		0.0120 µg/L	0.1 µg/L	
Benzo(a,h,i)perylene		0.0254 µg/L	0.1 µg/L	
1-Methylnaphthalene		0.0070 µg/L	0.1 µg/L	
Pentachlorophenol [(3)]	EPA 604 or 8041	0.044 µg/L	0.1 µg/L	
Phthalates	EPA 8270D			1.0 µg/L
Dimethyl phthalate		0.19 µg/L	1.0 µg/L	
Diethyl phthalate		0.19 µg/L	1.0 µg/L	
Di-n-butyl phthalate		0.22 µg/L	1.0 µg/L	
Butyl benzyl phthalate		0.5 µg/L	1.0 µg/L	
Bis(2-ethylhexyl) phthalate		0.33 µg/L	1.0 µg/L	
Di-n-octyl phthalate		0.56 µg/L	1.0 µg/L	
Herbicides				0.01 – 1.0 µg/L
2,4-D*[(3)]	EPA 8321B	---	0.080 µg/L	
MCPP* [(3)]	EPA 8321B	---	0.080 µg/L	
Triclopyr*[(3)]	EPA 8321B	---	0.080 µg/L	
Dichlobenil*	EPA 8270D	---	0.30 µg/L	
Pentachlorophenol [(3)]	EPA 604 or 8041	0.044 µg/L	0.1 µg/L	
Pesticides, Nitrogen				0.01 – 1.0 µg/L
Prometon*	EPA 8270D	---	0.30 µg/L	
Pesticides, Organo-P	EPA 8270D			0.01 – 1.0 µg/L
Diazinon*		---	0.30 µg/L	
Malathion*		---	0.30 µg/L	
Chlorpyrifos*		---	0.30 µg/L	
Total Petroleum Hydrocarbons				
NWTPH-Dx	NWTPH-Dx	0.065 mg/L	0.10 mg/L	0.25 – 0.50 mg/L
NWTPH-Gx	NWTHP-Gx	0.041 mg/L	0.10 mg/L	0.25 mg/L

*Spectra will subcontract the following analyses: chloride, total phosphorus, orthophosphate (Columbia Analytical); nitrate-nitrite (Analytical Resources); total and dissolved copper, lead, cadmium, mercury (Columbia Analytical); herbicides/pesticides (Pacific Agricultural Laboratory).

** See Section 8.3.1.3 – Alternative Analytical Methods.

(1) Laboratory methods, method detection limits, and method reporting limits (PQLs) are based on information provided by Spectra Laboratories (July 2009) and are subject to revision.

(2) Reporting limit targets based on information listed in Appendix 9 of the Phase I Municipal Stormwater Permit and in the additional guidance *Alternative Laboratory Methods Approved by Ecology for Use under the Phase I Municipal Stormwater Permit* (Ecology, 2008).
(3) Alternative methods and/or MRLs are currently being assessed for approval by Ecology pending method detection limit studies from the lab. If methods are not approved by Ecology, samples will be subcontracted to a different laboratory that can meet required method and MDL.

Table 22. Target constituents, analytical methods, laboratory method detection and reporting limits, and reporting limit targets for sediments

Parameter	Laboratory Method (1)	Method Detection Limit (1)	Method Reporting Limit (1)	Reporting Limit Target (2)
Conventional Parameters				
Total solids	SM 2540B	NA	0.1%	NA
Total organic carbon	SM 5310B	0.02%	0.02%	0.10%
Grain Size**	ASTM D422	NA	NA	NA
Metals				
Total recoverable copper	EPA 6020	0.014 mg/Kg	0.1 mg/Kg	0.1 mg/Kg
Total recoverable zinc	EPA 6020	0.02 mg/Kg	0.1 mg/Kg	5.0 mg/Kg
Total recoverable lead	EPA 6020	0.016 mg/Kg	0.1 mg/Kg	0.1 mg/Kg
Total recoverable cadmium	EPA 6020	0.016 mg/Kg	0.1 mg/Kg	0.1 mg/Kg
Total mercury	EPA 7471B	0.04 mg/Kg	0.05 mg/Kg	0.1 mg/Kg
Organics				
PAHs				70 µg/Kg dry
Naphthalene	EPA 8270D SIM*	0.056 µg/Kg	3.3 µg/Kg	
2-Methylnaphthalene	EPA 8270D SIM*	0.232 µg/Kg	3.3 µg/Kg	
Acenaphthylene	EPA 8270D SIM*	0.136 µg/Kg	3.3 µg/Kg	
Acenaphthene	EPA 8270D SIM*	0.188 µg/Kg	3.3 µg/Kg	
Dibenzofuran	EPA 8270D SIM* (MDL/MRL scan mode)	27 µg/Kg	33 µg/Kg	
Fluorene	EPA 8270D SIM*	0.12 µg/Kg	3.3 µg/Kg	
Phenanthrene	EPA 8270D SIM*	0.126 µg/Kg	3.3 µg/Kg	
Anthracene	EPA 8270D SIM*	0.133 µg/Kg	3.3 µg/Kg	
Fluoranthene	EPA 8270D SIM*	0.192 µg/Kg	3.3 µg/Kg	
Pyrene	EPA 8270D SIM*	0.578 µg/Kg	3.3 µg/Kg	
Benzo(a)anthracene	EPA 8270D SIM*	0.401 µg/Kg	3.3 µg/Kg	
Chrysene	EPA 8270D SIM*	0.169 µg/Kg	3.3 µg/Kg	
Benzo(b)fluoranthene	EPA 8270D SIM*	0.205 µg/Kg	3.3 µg/Kg	
Benzo(k)fluoranthene	EPA 8270D SIM*	0.45 µg/Kg	3.3 µg/Kg	
Benzo(a)pyrene	EPA 8270D SIM*	0.216 µg/Kg	3.3 µg/Kg	
Indeno(1,2,3-cd)pyrene	EPA 8270D SIM*	0.693 µg/Kg	3.3 µg/Kg	

Parameter	Laboratory Method (1)	Method Detection Limit (1)	Method Reporting Limit (1)	Reporting Limit Target (2)
Dibenz(a,h)anthracene	EPA 8270D SIM*	0.4 µg/Kg	3.3 µg/Kg	
Benzo(a,h,i)perylene	EPA 8270D SIM*	0.846 µg/Kg	3.3 µg/Kg	
1-Methylnaphthalene	EPA 8270D SIM*	0.23 µg/Kg	3.3 µg/Kg	
Pentachlorophenol	EPA 8041-ECD	—	—	
Phthalates	EPA 8270D*			70 µg/Kg dry
Dimethyl phthalate		6.28 µg/Kg	33 µg/Kg	
Diethyl phthalate		6.19 µg/Kg	33 µg/Kg	
Di-n-butyl phthalate		7.49 µg/Kg	33 µg/Kg	
Butyl benzyl phthalate		16.7 µg/Kg	33 µg/Kg	
Bis(2-ethylhexyl) phthalate		10.9 µg/Kg	33 µg/Kg	
Di-n-octyl phthalate		18.7 µg/Kg	33 µg/Kg	
Phenolics	EPA 8270D*			70 µg/Kg dry
Phenol		9.49 µg/Kg	33 µg/Kg	
2-Chlorophenol		8.53 µg/Kg	33 µg/Kg	
2-Methylphenol		14.4 µg/Kg	33 µg/Kg	
4-Methylphenol		22.9 µg/Kg	33 µg/Kg	
2-Nitrophenol		12.6 µg/Kg	33 µg/Kg	
2,4-Dimethylphenol		14.2 µg/Kg	33 µg/Kg	
2,4-Dichlorophenol		13.7 µg/Kg	33 µg/Kg	
4-Chloro-3-methylphenol		14.4 µg/Kg	33 µg/Kg	
2,4,6-Trichlorophenol		10.5 µg/Kg	33 µg/Kg	
2,4,5-Trichlorophenol		25.9 µg/Kg	33 µg/Kg	
2,4-Dinitrophenol		23.1 µg/Kg	66 µg/Kg	
4-Nitrophenol		30.1 µg/Kg	66 µg/Kg	
4,6-Dinitro-2-methylphenol		22.0 µg/Kg	66 µg/Kg	
Pentachlorophenol		9.33 µg/Kg	66 µg/Kg	
PCBs	EPA 8082			80 µg/Kg dry
Aroclor 1016		0.01 µg/Kg	0.1 µg/Kg	
Aroclor 1221		0.01 µg/Kg	0.1 µg/Kg	
Aroclor 1232		0.01 µg/Kg	0.1 µg/Kg	
Aroclor 1242		0.01 µg/Kg	0.1 µg/Kg	
Aroclor 1248		0.01 µg/Kg	0.1 µg/Kg	
Aroclor 1254		0.01 µg/Kg	0.1 µg/Kg	
Aroclor 1260		0.01 µg/Kg	0.1 µg/Kg	
Herbicides				
Pentachlorophenol (3)	EPA 8041 or 8270D SIM	1.47 µg/Kg	3.3 µg/Kg	1.0 ug/Kg
Pesticides, Organo-P**	EPA 8270D GCMS/MS			
Diazinon		study in progress	2 µg/Kg	50 µg/Kg dry

Parameter	Laboratory Method (1)	Method Detection Limit (1)	Method Reporting Limit (1)	Reporting Limit Target (2)
Malathion		study in progress	2 µg/Kg	25 µg/Kg dry
Chlorpyrifos		study in progress	2 µg/Kg	25 µg/Kg dry

* Sample preparation procedures to follow: 3550, 3640, 3660G, and 3620.

** Grain-size and organo-P analyses will be subcontracted by Spectra to Columbia Analytical.

(1) Laboratory methods, method detection limits, and method reporting limits (PQLs) are based on information provided by Spectra Laboratories (July 2009) and are subject to revision.

(2) Reporting limit targets based on information listed in Appendix 9 of the Phase I Municipal Stormwater Permit and in the additional guidance *Alternative Laboratory Methods Approved by Ecology for Use under the Phase I Municipal Stormwater Permit* (Ecology, 2008).

(3) Alternative methods and/or MRLs are currently being assessed for approval by Ecology pending method detection limit studies from the lab. If methods are not approved by Ecology, samples will be subcontracted to a different laboratory that can meet required method and MDL.

8.3.1.3 Alternative Analytical Methods

Alternative analytical methods not listed in Appendix 9 of the Phase I Municipal Stormwater Permit and in the additional guidance *Alternative Laboratory Methods Approved by Ecology for Use under the Phase I Municipal Stormwater Permit* (Ecology, 2008) may be used with prior approval by Ecology. Alternative analytical methods proposed for this project that have been approved by Ecology are listed below along with a brief discussion explaining their use for this project.

Alternative analytical methods listed in Table 21 for stormwater that have been approved by Ecology include the following: (1) fecal coliform by SM 9222D and (2) total Kjeldahl nitrogen by SM 4500-Norg D.

Fecal coliform bacterial densities may be determined either by the multiple-tube procedure (SM 9221E) or by the membrane filtration (MF) technique (SM 9222D). Ecology has approved the use of the MF technique only when caution is taken for samples with higher turbidity (greater than 25 NTU); if turbidity is greater than 25 NTU Ecology advises the use SM 9221E method. The MF technique is advantageous for the following reasons: (1) it provides direct enumeration of the fecal coliform group without enrichment or subsequent testing; (2) is highly reproducible; (3) can be used to test relatively large sample volumes and is applicable to a wide-range water sources, including stormwater; and (4) usually yield numerical results more rapidly that the multiple-tube fermentation procedure. A drawback to the procedure is that it can produce lower results than those produced by the multiple-tube procedure, particularly for chlorinated wastewater effluents, due to chlorination-induced stress of microorganisms.

Lower recoveries have also been attributed to disinfection and toxic materials that may be present in these same waters. As a result, the MF technique is not recommended for use with chlorinated wastewater, and, if used, requires that a parallel MF/MPN evaluation be conducted.

Based on the discussion above, and the fact that chlorinated water and/or wastewater source are not expected within the project drainage area, the MF technique is proposed for the analysis of fecal coliform bacteria if turbidity is less than 25 NTU. For samples with turbidity greater than 25 NTU the SM 9221E method may be used. Further, sodium thiosulfate, a standard preservative, will be added to all grab sample bottles prior to sterilization by the laboratory in the event that the sampled stormwater contains residual chlorine or other halogens. Further, ethylenediaminetetraacetic acid (EDTA) can be added to sample bottles prior to sterilization if sample results indicate that stormwater contains trace elements such as copper, nickel, zinc at concentrations greater than 10 µg/L (Myers et. al, 1997).

Total Kjeldahl nitrogen can be determined by SM 4500-Norg B, C, or D. SM 4500-Norg B and C are based on the macro- and semi-micro-Kjeldahl distillation methods, respectively, whereas SM 4500-Norg D is based on the block digestion and flow injection analysis technique. The macro-Kjeldahl method is applicable for sample containing low or high concentrations of organic nitrogen but requires large sample volumes for samples containing low concentrations. The semi-micro-Kjeldahl method is applicable to samples containing high concentrations of organic nitrogen. The block digestion method is a micro method with an automated analysis step with the capability of measuring organic nitrogen at relatively low concentrations (0.1 mg/L).

For this project, the block digestion method is proposed for use since the reporting limits for this method are expected to be similar to the target reporting limits listed in Appendix 9 of the Phase I Permit.

Alternative analytical methods listed in Table 22 for sediments that have been approved by Ecology include the following: total mercury by EPA Method 7471A (*Mercury in Solid or Semisolid Waste - Manual Cold-Vapor Technique*).

Appendix 9 of the Phase I Permit failed to include total mercury in the required list of analytes in sediment. However, it was subsequently listed by Ecology in the additional guidance *Alternative Laboratory Methods Approved by Ecology for Use under the Phase*

I Municipal Stormwater Permit. Currently, the alternatively approved method for total mercury in sediments is EPA Method 245.5 (*Determination of Mercury in Sediments by Cold-Vapor Atomic Absorption Spectrometry*). EPA Method 7471A and 245.5 are similar methods suitable for the analysis of sediments. If the contract analytical laboratory performs EPA Method 7471A with a method reporting limit that is sufficiently lower than the reporting limit target then this method should be considered adequate for the analysis of total mercury in sediments.

8.3.2 Toxicity Testing Procedures

This section presents an overview of the freshwater chronic toxicity test that will be used for seasonal "first-flush" stormwater samples. Toxicity testing specifications are presented for invalid or anomalous tests, follow-up actions when toxicity is detected, and yolk testing.

8.3.2.1 Analytical Instruments

Instruments used by the laboratory for routine physical and chemical measurements will be maintained and calibrated according to the internal Laboratory Quality Assurance Plan (LQAP), all applicable standard operating procedures (SOPs), the instrument manufacturer's specifications, and any specific method requirements.

9.3.2.2 Toxicity Testing Method

The freshwater chronic toxicity test for this project and corresponding test method, method detection limit, method reporting limit, and reporting limit target for seasonal first flush stormwater toxicity testing is presented in Table 23.

Chronic toxicity testing will be conducted according to the project QAPP, the contract laboratory LQAP, and any test-specific SOPs.

Table 23. Targeted freshwater chronic toxicity test, test method, laboratory method detection and reporting limits, and reporting limit target for seasonal first flush stormwater toxicity testing

Parameter	Laboratory Method	Method Detection Limit	Method Reporting Limit	Reporting Limit Target
Toxicity				
Environmental Canada Trout Embryo Viability	EPS 1/RM/28	NA	NA	NA

(1) Laboratory method based on Environment Canada Biological Test Method: Toxicity Tests using Early Life Stages of Salmonid Species (Rainbow Trout), EPS 1/RM/28, 2nd Edition, July 1998 (with modifications by Canaria, et al., 1998).
(2) Reporting limit target based on information listed in Appendix 9 of the Phase I Municipal Stormwater Permit.

Procedures for the 7-day toxicity test are illustrated in the following references:

- Environment Canada. 1998. Biological Test Method: Toxicity Tests Using Early Life Stages of Salmonid Fish (Rainbow Trout). Environmental Protection Series 1/RM/28 Second Edition.
- Canaria, E.C., J.R. Elphick, and H.C. Bailey. 1999. A Simplified Procedure for Conducting Small Scale Short-Term Embryo Toxicity Tests with Salmonids. *Env. Toxicol.* 14, 301-307.

At the end of the 7-day test or exposure period, the surviving eggs will be placed into glass vials. Eggs are then visually tested for viability. Nonviable eggs are described as eggs failing to complete morphogenesis. The endpoint of this test includes:

- Eggs that did not survive during exposure to the stormwater sample,
- Eggs that inhibited development, and
- Eggs that were not successfully fertilized initially

Bench sheets will be developed during the 7-day test and included in the final data report.

An EC_{50} will 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 will be used. If an EC_{50} is 100% sample or less, then the permit requires follow-up actions. Information on follow-up actions can be found in Section 7.0.

8.3.2.3 Invalid or Anomalous Tests

Invalid toxicity tests may occur if the laboratory does not follow the test protocol or when the results do not meet the test acceptability criteria in the test protocol. The laboratory will usually identify invalid tests and arrange to repeat them. Ecology will also identify invalid tests when the laboratories do not. Anomalous test results happen when the laboratory appears to have 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.* Only Ecology may identify a test result as anomalous. Invalid or anomalous tests will be repeated with freshly sampled stormwater in accordance with Section 3.0.

If a test is found invalid or anomalous, the Permittee will keep the results on file and report the information in the Annual Stormwater Monitoring Report. A second attempt for toxicity testing is necessary (see Section 3.0).

8.3.2.4 Follow-up Actions When Toxicity Detected

Follow-up actions when toxicity is detected ($EC_{50} \leq 100\%$ sample) are based upon an evaluation of sample chemistry compared to an existing library of fish embryo toxicity test results (Trout Library).

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

- Preserve terminated organisms for up to six months.
- Compare the chemical analytical results to the Trout Library to determine the presence of a detected toxicant within sixty (60) days after final validation of the data.
- Determine, through a good faith effort, if the presence of a detected parameter is within the range reported in the Trout Library that may adversely affect fish embryos and if so, review the source literature found in the trout library.

The results of the toxicity testing, and documentation of follow-up actions, will be submitted to Ecology with the appropriate Annual Stormwater Monitoring Report. Section 12.3 describes the contents of reporting on toxicity.

The follow-up actions when toxicity is detected should also anticipate potentially adding other chemicals to the parameter list for future sampling. Chemicals found by yolk analysis may be worth measuring in stormwater to allow a quantitative comparison to the Trout Library. The list of PAHs, pesticides, and other chemicals analyzed may be expanded for future samples if additional analyses may possibly help resolve toxicant identity. The list of analyses should be expanded only if knowledge of industrial or commercial activity within the drainage area suggests the presence of a chemical which the fish embryo toxicity library (Trout Library) shows could be toxic to this life stage or if a potentially toxic chemical has been found in the yolk.

If a possible chemical contaminant of concern is not determined by library comparison and literature review, then a Gas Chromatograph/Mass Spectrometer (GC/MS) analysis of the eggs from the highest test concentrations will be performed, as described below.

8.3.2.5 Gas Chromatograph/Mass Spectrometer (GC/MS) Yolk Testing

If the concurrent chemical analyses of the sample do not detect any chemicals at concentrations known to adversely affect fish embryos, then a Gas Chromatograph/Mass Spectrometer (GC/MS) analysis of the yolks from the highest test concentration (usually 100%) is needed. The GC/MS need not be quantitative but only capable of identifying stormwater contaminants present in the embryo or yolk.

Procedures for GC/MS extraction of yolk/embryos may vary between laboratories. The approved toxicity laboratory will be consulted for methods and procedures for this analysis. Example procedures include, but are not limited to the following:

- Washington State Department of Ecology Manchester Environmental Laboratory, Standard Operating Procedures for Micro-Acetonitrile Back Extraction Clean-up of Fish Tissue, Version 1.0, 2006
- Puget Sound Water Quality Action Team, Recommended Guidelines for Sampling Marine Sediment, Water Column and Tissue in Puget Sound, April 1997
- Environmental Protection Agency, SW-846, Method 3500B, Organic Extraction and Sample Preparation, 1996
- U.S. Geological Survey, EPA Extraction and Lipid Separation of Fish Samples for Contaminant Analysis and Lipid Determination, Standard Operating Procedure # HC521A, Great Lakes Science Center, Ann Arbor, Michigan, Version 1, 1995
- Washington State Department of Health, Human Health Evaluation of Contaminants In Puget Sound Fish, 2006

To be most useful, a yolk/embryo analysis should not be restricted to the list of chemical parameters required by the Phase I Permit. The GC/MS should capture and identify as many chemicals as it reasonably can. The Trout Library has many more chemicals than the required parameters, and will be useful for comparing GC/MS results. Yolk analysis need not be quantitative because the Trout Library is based upon water and not tissue concentrations. The presence of a chemical within the yolk/embryo means that the exposure can be considered significant enough to warrant checking the Trout Library to see if the chemical might be toxic to the embryo life stage. If the GC/MS analysis of the yolks and embryos does not find any candidate toxicants, then the number of replicates at 100% sample will be increased to provide more tissue to the laboratory and lower the detection limits for possible toxicants.

If a chemical detected in the yolk/embryo testing is added to the list of parameters measured in stormwater samples, its analysis will be quantitative so that concentrations can be compared to fish embryo toxicity data. Ecology will be entering the results of the chemical analyses and trout embryo toxicity testing into a database for evaluation over the long term. 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 overall goal of toxicity data is to update our understanding of stormwater toxicity and provide information upon which to base adaptive stormwater management. As long as this goal is being met, confirmation of toxicant identity is not necessary.

9.0 QUALITY CONTROL

Quality control (QC) requirements and schedules for field and laboratory activities are presented for this project. Project quality control (QC) procedures will include the collection and analysis of field QC samples and the use of standard laboratory QC analyses. The overall quality of data generated for this project will be evaluated in terms of the MQIs specified in Section 5.2, in order to ensure that project data quality objectives are met.

9.1 FIELD QUALITY CONTROL

Field quality control requirements for this project will include recommended procedures for sampling and field measurement equipment, field documentation, sample collection, field QC samples, and corrective actions for field activities.

9.1.1 Field Quality Control Procedures

Preventative maintenance of the flow meter, automatic sampler, on-site rain gage, and field instrumentation will be preformed as specified by the manufacturer. The sampler and flow meter will be calibrated to the manufacturer's recommendations.

Original field records will be maintained in designated binders for all monitoring and field related activities using project-specific forms and established procedures. Recommended field documentation includes stormwater station maintenance logs, sampling equipment checklists, station visit checklists, field data logs, work permits for confined spaces, station set-up/shut-down checklists, chain of custody forms, and other required documentation. All entries in field notebooks will be written in waterproof ink. When errors are made on accountable documents, the person who made the error will make the correction by crossing a line through the error and entering the correct information. All corrections will be initialed and dated.

The sampling efforts for this program will employ the following field QC procedures to ensure consistency, reduce contamination, and ensure representative samples:

- Collect composite water samples using an automatic sampler.
- Collect samples in certified contaminant-free or properly decontaminated containers.
- Store sampling containers in clean, sealed boxes or bags prior to use.

- Use "clean hands/dirty hands" sampling techniques (that is, one team member performs "dirty tasks" such as lifting manhole covers and handling samplers with batteries, while the other member performs "clean tasks" such as handling sample intake lines and sample bottles).
- Use EPA's "clean techniques" guidance document for trace metals (USEPA 1995), adapted to meet equipment and sampling constraints.
- Periodically clean and replace Teflon-lined sampler tubing and strainers as necessary.
- Backflush sampler tubing with deionized water immediately prior to sampling event.
- Cool automatic samplers with ice when ambient temperatures require.
- Hold samples on ice in coolers during retrieval and delivery to laboratory.
- Deliver samples to laboratory with proper chain of custody, and within recommended holding times.

Field QC samples will be targeted for collection during storm events to be determined by the Consultant Project Manager or Consultant Technical Lead. QC samples require special labeling and tracking procedures. All field duplicate samples will be collected in an identical manner to the primary "parent" field samples and receive an independent sample identification code. All blank samples (e.g., field, equipment, and processing blanks) will be appropriately labeled. The various types of field control samples, field procedures for collecting these samples, and corrective measures are further discussed below.

Field corrective actions will be taken during this project to ensure the overall management of the project. The corrective action process will consist of identifying a problem, acting to eliminate the problem, monitoring the effectiveness of the corrective action, verifying that the problem has been eliminated, and documenting the corrective action. Examples of corrective actions are correcting chain-of-custody forms; correcting problems in sample collection, packing, shipping, field record keeping; or additional training in sampling. Additional activities may include resampling or evaluating and amending sampling procedures.

9.1.2 Field Control Samples

Field QC samples are used to assess sample collection procedures; environmental conditions during sample collection, storage, and transport to the laboratory(s); and the adequacy of equipment and sampling container decontamination. A rule-of-thumb of ten percent will be used for collection of field QC samples. This number is based on the total number of samples anticipated to be collected on an annual basis. Additional field QC samples may be needed to meet data quality objectives and quality control goals established within this QAPP. The types of field QC samples that will be collected for this project to meet QAPP objectives include the following:

- Field duplicate samples
- Field blanks
- Field equipment (rinsate) blanks
- Temperature blanks
- Trip blanks

Field duplicate, field blanks, field equipment blanks, and trip blanks will be analyzed for the same parameters as the manual grab and flow-weighted composite samples, as outlined in Table 12 and Table 13. If the volume of QC sample collected is insufficient to allow analysis for all parameters, samples will be analyzed for as many parameters as possible following the priority order listed in Section 6.6.2.1

9.1.2.1. Field Duplicates

The purpose of collecting and analyzing field duplicates is to demonstrate the precision of sampling and analytical processes. In general, a replicate or duplicate sample is defined as two (or more) samples collected at the same time and place and represent a way to estimate the total random variability (precision) of individual results. In this case, the field duplicate sample can be used to measure whether environmental conditions are changing faster (are more variable) than the repeatability of the sampling procedure.

Field duplicates will be collected at the rate of approximately ten percent of all storm events sampled, and analyzed along with the associated environmental sample. For this project, a single field duplicate sample will be targeted for collection on an annual basis (water year). Field duplicates will consist of an "internal" duplicate, which will include a replicate (composite stormwater) sample collected at the same time using a single autosampler configuration. The autosampler will be programmed to collect sequential aliquots of stormwater and deliver them to two separate sets of parameter-specific bottles, specifically bottles designated for the collection of trace metals and conventional parameters (acid cleaned) and those for the collection of organics and nutrients (organic free). Additionally, field duplicates will be collected for those parameters that require grab samples (i.e., fecal coliform and TPH) by filling an additional set of grab sample bottles in rapid succession. Field duplicate samples will be assigned a unique sample identifier added to the sample identification.

Field duplicate results are typically used as a qualitative evaluation of sampling precision and are not used as a basis for qualifying data or accepting/rejecting data. However, if the relative percent difference of field duplicate results is greater than twenty-five percent, the sampling crew should be notified so that the source of sampling variability can be identified (if possible) and corrective measures taken prior to the next sampling event. This will not be applicable to grab samples collected for fecal coliform due to the inherent variability with bacteriological analyses.

9.1.2.2. Field Blanks

Field blanks will be collected in order to check for possible contamination of laboratory-cleaned autosampler containers, as well as possible cross-contamination during transportation and storage of the samples. Deionized water, provided by the contract analytical laboratory, will be poured into a randomly selected set of sample containers on site. The set of containers will consist of one bottle each from the parameter-specific bottle groups used for routine flow-weighted stormwater composite sampling, specifically bottles designated for the collection of trace metals and conventional parameters (acid cleaned) and those for the collection of organics and nutrients (organic free). The blank samples will be assigned a unique sample identification code, labeled, and analyzed by the contract analytical laboratory for the analytes of interest. Field blanks will be collected during two storm events on an annual basis (water year), which corresponds to an approximate frequency of ten percent.

If any analytes of interest are detected at levels greater than the method reporting limit for a particular parameter, the field sampling crew should be notified so that the source of contamination can be identified (if possible) and corrective measures taken prior to the next sampling event. If the concentration in the associated samples is less than ten times the value in the field blank, the results for the environmental samples may be unacceptably affected by contamination and should be qualified as appropriate. If contamination is detected, and analyte method blank results rule out the laboratory as a source of contamination, then field blanks must be collected at a rate of 100% of samples until the source of contamination is eliminated (if possible).

9.1.2.3. Field Equipment Blanks

Equipment (rinsate) blanks are collected to check for potential contamination of sampling and processing equipment and are used to assess the effectiveness of cleaning or decontamination procedures. The equipment blank may also detect contamination from the surroundings, from containers, or from cross-contamination during transportation and storage. Equipment blanks will also be collected from any equipment used to composite samples in the field and during post-storm event processing at the contract analytical laboratory (Section 8.2.1 Routine Composite and Toxicity Samples).

Composite sampler equipment blanks will be collected during equipment set up, prior to the beginning of a storm event. The sampler will be accessed prior to the event and the sampler strainer and intake tubing will be decontaminated followed by a system rinse whereby deionized water is pumped through the entire system using the sampler pump. Blanks will be obtained by allowing the autosampler to fill a set of sample containers with deionized water provided by the contract analytical laboratory, using the same procedures used for routine stormwater composite samples. The set of containers will consist of one bottle each from the parameter-specific bottle groups described previously. Blanks will be collected during two storm events on an annual basis (water year), which corresponds to an approximate frequency of ten percent. In order to check for potential contamination, blanks will be collected early in the sampling season and during a mid-season storm event. The blank samples will be assigned a unique sample identification code, labeled, and analyzed by the contract analytical laboratory for the analytes of interest.

Equipment blanks will be collected for processing equipment used for preparing the post-storm event composite samples and sub-samples. The equipment used for this project for post-storm event processing is described in Section 8.2.1 Routine Composite and Toxicity Samples. Pre-cleaned processing equipment will be rinsed with deionized water provided by the contract analytical laboratory. The rinsate will be collected into designate laboratory sample container, assigned a sample identification code, labeled, and analyzed by the contract laboratory. Processing equipment blanks will be collected twice on an annual basis (water year), which corresponds to an approximate frequency of ten percent.

If any analytes of interest are detected at levels greater than the method reporting limit for a particular parameter, the field sampling and/or sample processing crew should be notified so that the source of contamination can be identified (if possible) and corrective measures taken prior to the next sampling event. If the concentration in the associated samples is less than ten times the value in the equipment or processing blank, the results for the environmental samples may be unacceptably affected by contamination and should be qualified as appropriate. If contamination is detected, and analyte method blank results rule out the laboratory as a source of contamination, then equipment or processing blanks must be collected at a rate of 100% of samples until the source of contamination is eliminated (if possible).

9.1.2.4. Temperature Blanks

Temperature blanks are prepared in the field using distilled or deionized water and placed in sampler cooler(s) and transported to the laboratory. The laboratory can use this blank to check the temperature of the samples upon receipt. Temperature blanks will be prepared in a designated laboratory container, assigned a sample identification code, labeled, and checked upon receipt. Temperature blanks will be submitted with all environmental samples delivered or shipped to the contract laboratory(s) for all storm events monitored during this project.

If the temperature measured by the laboratory exceeds the method-specific temperature requirement for a particular parameter, the field sampling crew should be notified so that corrective measures can be taken prior to the next sampling event.

9.1.2.5. Trip Blanks

Trip blanks are usually prepared by the contract analytical laboratory and are carried (unopened) into the field during a sampling event. These samples are typically only utilized when the parameters of interest include volatile organic compounds (VOCs) and will not be required for the parameters discussed in this QAPP.

Table 24 describes the guidelines for project field QC samples, including the type, frequency, acceptance limits, and corrective actions.

Table 24. Summary of project field quality control requirements

Field QC Sample	Frequency	Control Limit	Corrective Action(s)
Field duplicate	Once annually	Not applicable; qualitative evaluation only.	Review, modify sample collection procedures
Field blank (sample containers)	Twice annually	Analyte concentration less than reporting limit	Compare analyte method blank results to rule out lab contamination; review modify sample collection/equipment decontamination procedures; evaluate

Field QC Sample	Frequency	Control Limit	Corrective Action(s)
			any analyte results that are <10 times blank concentration
Equip. blank (autosampler)	Twice annually	Analyte concentration less than reporting limit	Compare analyte method blank results to rule out lab contamination; review modify sample collection/equipment decontamination procedures; evaluate any analyte results that are <10 times blank concentration
Equip. blank (post-storm event processing)	Twice annually	Analyte concentration less than reporting limit	Compare analyte method blank results to rule out lab contamination; review modify sample processing/equipment decontamination procedures; evaluate any analyte results that are <10 times blank concentration
Temperature blank	Each sample delivery or shipment	Temperature at or below method-specific limits	Review, modify sample collection, transport, and storage procedures
Trip blank	NA	NA	NA

(1) The type and frequency of field QC samples collected annually as part of the routine stormwater monitoring should satisfy QA/QC requirements for the annual sediment monitoring. In the event that sufficient sediment sample is collected, a single field duplicate will be collected and submitted for analysis.
(2) Field QC samples included above will not be collected for seasonal toxicity testing, with the exception of temperature blanks.

9.2 Laboratory Quality Control

The contract analytical laboratory will perform all chemical and physical analyses requested. In addition to performing the analysis, the laboratory will make every effort to meet holding times and target reporting limits for each analysis. Specific QA/QC policies and procedures followed by the contract analytical laboratory are to be detailed in the laboratory's Quality Assurance Plan (LQAP). The following section summarizes the laboratory QA/QC procedures that will be used to assess data quality throughout sample analysis.

9.2.1 Laboratory Control Samples

Routine analysis of laboratory quality control samples is necessary to validate the quality of the data produced. The type of QC analyses, frequency, and procedures depend on the analytical method and/or the QA/QC protocols required for a specific project. When all laboratory QC sample results are acceptable, the specific analysis is considered to be "in-control" and the data suitable for their intended use. Conversely, laboratory QC sample results that do not meet the specified acceptance criteria indicate that the procedure may not be generating acceptable data and corrective action may be necessary to bring the process back "in-control".

The specific procedures and frequencies for analytical quality control samples are to be detailed for each analytical method in the contract laboratory's Quality Assurance Plan (LQAP). Typical laboratory QC samples include (but are not limited to) the following:

- Method blanks,
- Laboratory control samples,
- Laboratory matrix replicates (inorganic/conventional parameters)
- Matrix spikes,
- Matrix spike duplicates (organic parameters),
- Standardized reference materials, and
- Other quality indicators

9.2.1.1. Method Blanks

A method blank is an aliquot of water or solid sample matrix that is free of target analyte and is processed as part of a sample batch. The purpose of analyzing method blanks is to demonstrate that contaminants or compounds of interest are not introduced into samples during laboratory processing. Method blanks will be prepared and analyzed by the contract analytical laboratory at a rate of at least one per twenty samples or one per analytical batch (whichever is more frequent). Method blanks will consist of laboratory-prepared blank water processed along with the batch of environmental samples, and will contain all reagents and undergo all procedural steps as a regular environmental sample for each analysis. An acceptable method blank is required prior to the analysis of field samples from a preparation batch.

For this project, an acceptable method blank result will be assumed as one that contains no target analyte at a concentration greater than one-half the contract analytical laboratory's reporting limit. An exception would include common laboratory contaminants, which may exceed the method detection limits (for select organic analytes) but may not be present at concentrations greater than five times the method reporting limit. If the results for a single method blank exceed the acceptance criteria, the source(s) of contamination should be corrected following established laboratory procedures. If necessary, the associated samples should be reprocessed and reanalyzed; however, this will not apply in situations where the analyte is detected in the samples at levels ≥ 20 times the method blank level. Remaining sample volume, analytical hold times, and relative sample concentrations will determine whether samples can be reanalyzed. If reanalysis is not possible, the associated sample results should be qualified, as appropriate.

9.2.1.2. Laboratory Control Samples

A laboratory control sample is an aliquot of water or solid matrix free of target analytes to which selected (method specific) target analytes are added in known quantities. The purpose of analyzing laboratory control samples is to demonstrate the accuracy of the analytical method. Laboratory control samples will be prepared and analyzed by the contract analytical laboratory at a rate of at least one per twenty samples or one per analytical batch (whichever is more frequent). For this project, laboratory control samples will consist of laboratory fortified method blanks prepared at a concentration that falls within the analytical calibration range, but at a concentration different than the standards use to establish the analytical calibration curve.

Following analysis the percent recovery of each added analyte is calculated and compared to acceptance criteria (historic control limits established by contract laboratory). If the recovery of any analyte is outside the acceptable range for accuracy, the analytical process is not being preformed adequately for that analyte and corrective actions may be required. If necessary, the sample batch should be prepared again, and the laboratory control sample reanalyzed. If reanalysis is not possible, the associated sample results should be qualified, as appropriate.

9.2.1.3. Laboratory Matrix Replicates

The purpose of analyzing replicates is to demonstrate the precision of the analytical method. Replicates are two or more identical analyses performed on subsamples of the same environmental sample at the same time, and should be performed on samples that are expected to contain measurable concentrations of target analyte. For inorganic analyses, a minimum of one replicate set will be processed by the contract analytical laboratory for each analytical batch. Laboratory matrix replicates will also be analyzed for field duplicate samples collected as part of this program, at the targeted frequency specified above. Field sample collection procedures will be modified to ensure the collection of sufficient sample volumes to prepare replicate aliquots from field duplicate samples. Replicate samples are not routinely performed for organic parameters. Instead, analytical precision is evaluated through the analysis of duplicate matrix spike samples.

If the relative percent difference for any analyte is greater than the precision criteria, the analytical process is not being performed adequately for that analyte and corrective actions may be required (procedure evaluation), unless the excessive difference between the replicate samples is clearly matrix related. In cases where matrix problems are not suspect, the sample batch may be prepared again and laboratory replicates reanalyzed. If reanalysis is not possible, the associated sample results should be qualified, as appropriate.

9.2.1.4. Matrix Spikes

A matrix spike is an environmental sample to which known quantities of selected (method specific) target analyte have been added. The matrix spike is processed as part of an analytical batch and is used to measure the efficiency and accuracy of the analytical process for a particular sample matrix. Matrix spikes will be prepared and analyzed by the contract analytical laboratory at a rate of at least one per twenty samples or one per analytical batch (whichever is more frequent). Matrix spikes will also be analyzed for field duplicate samples collected as part of this program. Field sample collection procedures will be modified to ensure the collection of sufficient sample volumes to prepare matrix spike aliquots from field duplicate samples.

Following analysis the percent recovery of each spiked analyte is calculated and compared to specified acceptance criteria. If the recovery of any spiked analyte is outside the acceptable range for accuracy, the analytical process is not being performed adequately for that analyte and corrective actions may be required. If recovery of laboratory control samples for any organic analysis is acceptable, the analytical process is being performed adequately for that analyte, and the problem is most likely attributable to the sample matrix. Matrix spikes with unacceptable recovery values for inorganic analyses will be reprocessed and reanalyzed. If reanalysis results still fail to meet acceptance criteria, it will be assumed that that the sample matrix is affecting the recovery values. If matrix problems cannot be corrected, or reanalysis is not possible, the associated sample results should be qualified, as appropriate.

9.2.1.5. Matrix Spike Duplicates

A matrix spike duplicate is prepared in an identical manner to the matrix spike. Matrix spike duplicate analyses are often used to measure method precision and accuracy. In this case, the relative percent difference for recovery of a spiked analyte is calculated and compared to acceptance criteria. Matrix spike/matrix spike duplicate analyses will be performed only for required organic analyses, whereas matrix spike and laboratory replicate samples will be performed for required inorganic analyses. Matrix spike/matrix spike duplicates will be prepared and analyzed by the contract analytical laboratory for organic analysis at a rate of at least one pair per twenty samples or one pair per analytical batch (whichever is more frequent). Matrix spike duplicates will also be analyzed for field duplicate samples collected as part of this program.

If relative percent difference values between matrix spike duplicates do not meet acceptance criteria, but spike recovery values are acceptable, no re-extraction or analysis will be required. It will be assumed that the sample is not homogenous, causing poor analytical precision. If relative percent difference values between matrix spike duplicates do not meet acceptance criteria, and recovery values in one or both replicates in not acceptable, the sample and associated matrix spike replicates will be reprocessed and reanalyzed, provided sufficient sample volume is available and/or holding time remaining. If the reanalysis results are not within acceptance limits, it will be assumed that the sample is not homogenous, causing poor analytical precision.

9.2.1.6. Standardized Reference Material

A standard reference material is analyzed and certified by an outside organization to contain known quantities of select target analytes independent of analytical methods. These materials are normally purchased from suppliers outside of the contract analytical laboratory and are supplied with acceptance criteria. Analysis of standard reference materials is used to assess the overall accuracy of the laboratory's analytical process, and are routinely analyzed with each batch of sample for wet chemistry (conventionals analysis) samples. External reference samples are analyzed after instrument calibration and prior to sample analysis. Compound recovery values not within the specified limit indicate the need to evaluate either the calibration standards or instrumentation. These corrective actions will be conducted, as necessary, following procedures outlined in the contract laboratory's Quality Assurance Plan.

9.2.1.7. Other Quality Indicators

In addition to analyzing the quality control samples outlined previously, various indicators are added to environmental samples to measure the efficiency and accuracy of the contract analytical laboratory's analytical processes. Surrogate standards are added to extractable organic samples prior to extraction to monitor extraction efficiency. Internal standards are added to metals digestates for ICP-MS analyses and to organic samples or extracts prior to analysis to verify instrument operation.

The calculated recovery of surrogate analyses is compared to historic control limits maintained by the analytical laboratory to aid in assessing analytical efficiency for a given sample matrix. When these analyses fail to meet specific acceptance criteria, corrective actions are conducted consistent with the contract laboratory's Quality Assurance Plan.

Table 25 describes the guidelines for project analytical laboratory QC samples, including the type, frequency, acceptance limits, and corrective actions. Specific details on laboratory QC analyses, including corrective actions, are to be included in the contract analytical laboratory's Quality Assurance Plan.

Table 25. Summary of project laboratory quality control requirements

QC Procedure	Analysis	Frequency	Control Limit	Corrective Action(s)
Method Blank	Inorganics	5% or 1 per analysis batch	Analyte conc. ≤ PQL/MRL	Eval. procedure; identify contamination source; pot. batch/sample reanalysis; evaluate/qualify data <10x blank conc.
	Conventionals	Method specific; 5% or 1 per anal. batch, if req'd	Analyte conc. ≤ PQL/MRL	Eval. procedure; identify contamination source; pot. batch/sample reanalysis; evaluate/qualify data <10x blank conc.
	Organics/TPH	5% or 1 per anal. batch	Analyte conc. ≤ PQL/MRL (except common lab contaminants ≤ 5x PQL/MRL)	Eval. procedure; identify contamination source; pot. batch/sample reanalysis; evaluate/qualify data <5-10x blank conc.
LCS or SRM	Inorganics	5% or 1 per anal. batch	80-120% recovery, or CCL	Eval. procedure; recalibrate; pot. batch/sample reanalysis; evaluate/qualify affected data.
	Conventionals	Method specific; 5% or 1 per anal. batch, if req'd	Analyte-specific recoveries; usually 80-120% recovery	Eval. procedure; recalibrate; pot. batch/sample reanalysis; evaluate/qualify affected data.
	Organics/TPH	5% or 1 per anal. batch	Analyte-specific recoveries; usually 50-140 (organics) and 50-150 (TPH) for LCL or CCL	Eval. procedure; recalibrate; pot. batch/sample reanalysis; evaluate/qualify affected data.
Matrix Spike	Inorganics	5% or 1 per anal.	75-125% recovery	Eval. procedure and assess pot.

QC Procedure	Analysis	Frequency	Control Limit	Corrective Action(s)
		batch; field duplicate (1/yr)		matrix effects; pot. batch/sample reanalysis; evaluate/qualify affected data.
	Conventionals	Method specific; 5% or 1 per anal. batch, if req'd; field dup.	Analyte specific recoveries; usually 75-125% recovery	Eval. procedure and assess pot. matrix effects; pot. batch/sample reanalysis; evaluate/qualify affected data.
	Organics/TPH	5% or 1 per anal. batch; field dup.	Analyte-specific recoveries; usually 50-140 (organics) and 50-150 (TPH)	Eval. LCS or SRM recoveries to assess pot. matrix effects; evaluate/qualify affected data.
Sample / Spike Replicates	Inorganics	Duplicates @ 5% or 1 per anal. batch; field dup.	20% RPD	Eval. procedure and assess pot. matrix effects; pot. batch/sample reanalysis; evaluate/qualify affected data.
	Conventionals	Duplicate / triplicate @ 5% or 1 per anal. batch; field dup.	20% RPD/RSD	Eval. procedure and assess pot. matrix effects; pot. batch/sample reanalysis; evaluate/qualify affected data.
	Organics/TPH	Matrix spike duplicates @ 5% or 1 per anal. batch; field dup.	40% RPD (organics) 50% RPD (TPH)	Eval. procedure and assess pot. matrix effects; pot. batch/sample reanalysis; evaluate/qualify affected data.

(1) Definition of terms used: CCL – certified control limits; LCL – laboratory control limits; MRL – method reporting limit; PQL – practical quantitation limit; RPD – relative percent difference; RSD – relative standard deviation.

9.3 Toxicity Testing Quality Assurance

The contract toxicological laboratory will perform the freshwater chronic toxicity test and related chemical analyses requested. Specific QA/QC policies and procedures followed by the laboratory are to be detailed in the laboratory's Quality Assurance Plan (LQAP).

Toxicity tests should meet quality assurance criteria in the most recent versions of the Environment Canada manual EPS 1/RM/28 and the Department of Ecology Publication #WQ-R-95-80, *Laboratory Guidance and Whole Effluent Toxicity Test Review Criteria*. In general, the toxicity test shall have five concentrations and a control with four replicates at each concentration. An additional seven replicates of 100 percent sample shall be run in order to provide tissue for yolk/embryo analysis if needed. The test concentration series shall be determined using a 0.5 dilution factor.

10.0 DATA MANAGEMENT PROCEDURES

There are three types of data that will be generated for this component of the Port's long term stormwater monitoring program: (1) field activity data, including sample collection and monitoring equipment maintenance activities; (2) field monitoring data, including flow and precipitation data; and (3) laboratory data, including water quality, toxicity and sediment quality data. Records for all monitoring information, including all calibration and maintenance records and all original recordings for continuous monitoring instrumentation, and records of all data used to complete the application for this permit will be retained for at least five years. This will be extended during the course of any unresolved litigation regarding the discharge of pollutants or when requested by Ecology.

10.1.1 Field Activity Data

Field activity data will be recorded in the field notebook. The field notebook will include the following data sheets: completed storm data field sheets, chain of custody forms, maintenance inspection field sheets, and the maintenance activity log. Copies of these field data sheets are in Appendix B. The Consultant Technical Lead is responsible for updating and storing the field notebook. The field notebook will be photocopied monthly, and the copy stored at the Port.

10.1.2 Field Monitoring Data

Field data to be collected include flow and precipitation data. Flow data includes water level, and flow rate. Flow data will be downloaded at the site by field staff onto a project designated laptop computer and stored in a database. Rainfall data will be downloaded remotely using a telephone modem and imported into the project data base as needed by the Consultant Technical Lead. The site manager is responsible for maintaining and backing-up the project database. The project database will be backed up weekly, with back-up files stored at the Port.

10.1.3 Laboratory Data

All laboratory reports will be transmitted electronically and via hard copy to the Port Project Manager and Consultant Technical Lead. Data reported electronically by the Analytical and Toxicology laboratories will be transferred to Excel spreadsheets comprising the project water quality database. The Port Project Manager and Consultant Technical Lead will compile and manage the water quality database and back up the database each time new laboratory data is entered. The laboratory reports will be included as appendices in the annual reports.

11.0 ASSESSMENT/OVERSIGHT

Assessment and oversight activities will be performed to determine whether the QC measures identified in the QAPP are being implemented and documented as required. Audits and reviews are the tools to implement this process. For example, during a review, the auditor may check that a monitoring station has been correctly sampled or that the field QC samples were collected at the appropriate frequency. During an audit or review, the auditor may check for:

- Adherence to the site-specific plans
- Documentation of the process or system
- Proper identification, resolution, and documentation of nonconformance with the
- process or system
- Correction of identified deficiencies
- Assessments and Response Actions

11.1 Assessments and Response Actions

The need for an audit can be determined independently by the project manager, at the recommendation of the Port of Tacoma, or at the recommendation Ecology. Assessment activities may include surveillance, inspection, peer review, management system review, readiness review, technical systems audit, performance evaluation, and data quality assessment. The Project Manager, with assistance from the Quality Assurance Manager will be responsible for initiating audits, selecting the audit team, and overseeing audit implementation. Audits of the analytical laboratories will be performed in accordance with the laboratory subcontract. The Project Manager, Quality Assurance Manager or designee, in compliance with the subcontract, will perform laboratory audits.

Field audits also may be conducted by the Quality Assurance Manager, Project Manager, or a designee.

11.1.1 Laboratory Performance and Systems Audits

Laboratory systems may be audited in accordance with project requirements. Contracted laboratories must submit a Laboratory Quality Assurance Plan (QAP). The QAP must include relevant standard operating procedures, a description of the laboratory's internal procurement policies, and its corrective action program. The laboratory audits will address at least the following questions:

- Is the laboratory operation being performed as required by the subcontract?
- Are internal laboratory operations being conducted in accordance with the laboratory
- QAP?
- Are the laboratory analyses being performed in accordance with method requirements?

Any nonconformance noted during an audit will result in a corrective action.

11.1.2 Field Team Performance and System Audits

The Quality Assurance Manager or a designated representative may conduct audits of the field activities in accordance with the project requirements. The audit will address at least the following questions:

- Are sampling operations being performed as stated in the QAPP and SOPs?
- Are the sample labels being filled out completely and accurately?
- Are the COC records complete and accurate?
- Are the field notebooks being filled out completely and accurately?
- Are the sampling activities being conducted in accordance with the QAPP and SOPs?
- Are the documents generated in association with the field effort being stored as described in the QAPP and SOPs?

The generation and documentation of field data also will be audited. The audits will focus on verifying that proper procedures are followed so that subsequent sample data will be valid. Any nonconformance noted during an audit will result in corrective action.
The results of the assessment and oversight activities will be reported to the Project Manager, who has ultimate responsibility for ensuring that the corrective action response is completed, verified, and documented.

12.0 REPORTING

Three types of report will be generated in relation to the stormwater monitoring activities covered in this QAPP. These report types are,

1. Storm Files,
2. Status Reports to Management, and
3. Annual Stormwater Monitoring Reports

The first two types of reports are not required by the Permit, but will be used at the discretion of the Project Manager as internal reports to track the progress of the stormwater sampling program. The third type of report, the Stormwater Monitoring Report, is required by the Permit to be included as a section in the overall Annual Report (Permit §S9. A-D,G). Copies of the Annual Stormwater Monitoring Report will be retained for at least five years. This will be extended during the course of any unresolved litigation regarding the discharge of pollutants or when requested by Ecology. Each of the three types of reports is described in the following sections.

12.1 STORM FILES

Storm files are internal documents (in other words, not required by the Permit) to track the results and details of each stormwater sampling event. The assemblage of storm files throughout the water year will be utilized for the efficient and accurate development of certain components of the Annual Stormwater Monitoring Report (Section 12.3).

A typical storm file may include the following information and components:

- Stormwater hydrograph, showing runoff flow rate and rainfall and when samples were collected.
- Validation sheet indicating how the storm event and the samples collected have met the criteria listed in Section 6.0.
- Copies of pertinent sampling field sheets, maintenance inspection field sheets, and maintenance activity logs
- Copies of sample chain-of-custody forms
- Documentation of weather tracking and forecasts
- Any supporting documents, calculations, or discussion of anomalies or issues that will be needed for later data analysis and reporting.

Storm files will be prepared shortly after each successful sample event.

12.2 Status Reports to Management

Status reports to track stormwater monitoring program progress may be prepared and submitted to the Project Manager as frequently as quarterly. A typical status report may include the following information and components:

- A summary of the number of successful valid samples to date for the water year (indicating the number in the wet and dry seasons) and where the project is at in relationship to the overall proposed schedule,
- Summary of the quality control and validation review of the analytical data reports (water quality and sediment), and
- Discussion of any stormwater monitoring program issues that may need to be addressed.

12.3 Annual Stormwater Monitoring Report

The Annual Stormwater Monitoring Report (Permit §S8.H.) is a required component of the Annual Report (Permit §S9.G.). The Annual Stormwater Monitoring Report will compile sampling results from the previous water year[7]. Table 26 below summarizes the period of monitoring results that will be included in each Annual Stormwater Monitoring Report for the life of the Permit.

Table 26. Data collection period included in each annual report

Report Date	Includes Sampling Results from
March 31, 2010	April 2009 through September 2009
March 31, 2011	October 2009 through September 2010
March 31, 2012	October 2010 through September 2011
Next permit cycle	October 2011 through March 2012 (end of permit)

Each Annual Stormwater Monitoring Report will include the following three components, as required by Permit §S.8.H.1:

1. Stormwater monitoring summary,
2. Data and QA/QC report, and
3. Pollutant loading calculations.

Each of the three report components is described below.

[7] The first Annual Stormwater Monitoring Report submitted under this QAPP will include data from only a portion of the water year.

12.3.1 Stormwater Monitoring Summary

This component will include a summary of the location, land use, drainage area, and hydrology for the basin that was monitored. Additionally, this component of the report may include any new basin information that was not presented in the QAPP. For example, this discussion may include any basin changes that would affect hydrology or pollutant loadings or how baseflow or backwater conditions at the site have affected sample collection.

12.3.2 Data Report and QA/QC Report

This component will explain and discuss the monitoring program results for the water year. The overall goal of this component will be to present data and analyses; to document data completeness, representativeness, quality, and usability; and to discuss any data anomalies or issues.

The data report section may, for example, include the following:

- A summary of to what degree the sampled storm events met criteria listed in Section 6.0,
- A summary of the total number of qualifying storm events during that water year, the number of storm event samples attempted, and the total number of storm events successfully sampled.
- Hydrographs for each successfully sampled storm showing flow rate, rainfall, and indication of sample aliquot collection (from Storm Files)
- Analytical results tables for each sample event
- Analytical results tables for sediment samples
- Toxicity testing reports, and
- Description of any significant changes made, or to be made, to the sampling program.

The data QA/QC section will include a summary and discussion of,

- Field quality control procedures and data quality indicator results (Section 9.1), and
- Laboratory quality control procedures and the degree to which measurement quality objectives were met (Section 9.2).

The above data QA/QC information may be a compilation of data validation memos for each sampling event, along with a summary that applies to the entire reporting period. This section will also discuss any planned changes or deviations from the current QAPP that address QA/QC issues or procedures.

12.3.3 Pollutant Loading Calculations

Per Permit §S8.H.a.iv., both wet and dry season pollutant loads will be calculated. The annual (water year) pollutant load will be the sum of the wet and dry season pollutant loads. Pollutant loads will be calculated using runoff volume based on continuous flow monitoring and from flow-weighted-composite sample analytical data.

The procedure for calculating pollutant loadings is detailed in Appendix D.

Other water quality monitoring data collected from the project monitoring station will be reported in the Annual Report (per Permit §S8.H.2). Additionally, other non-permit required stormwater monitoring conducted during the reporting period will be described in the Annual Report (per Permit §S8.H.2).

13.0 DATA REVIEW VERIFICATION AND VALIDATION

This section addresses data review, verification, and validations activities that occur after the data collection phases are complete. Implementation of these procedures determines whether the data conform to the specified criteria, thus satisfying the program objectives.

13.1 DATA REVIEW, VERIFICATION, AND VALIDATION SUMMARY

Five types of data will be generated for this program: rainfall, flow, water quality (stormwater and baseflow), sediment quality, and stormwater toxicity. Data review involves examination of the data for errors or omissions. Data verification is the systematic process that involves examination of the QC results for compliance with acceptance criteria. Data validation involves the examination of the complete data package to determine whether the procedures in the QAPP were followed.

All data obtained from field and laboratory measurements will be reviewed and verified for conformance to project requirements, and then validated against the data quality objectives that are listed in Section 5.0. Only those data that are supported by appropriate quality control data and meet the measurement performance specification defined for this program will be considered acceptable and used in the project. The data review, verification, and validation procedures for each data type are discussed below.

Verification and validation procedures will be based, as needed, on the guidance provided by the EPA (2002) in Guidance on Environmental Data Verification and Data Validation, EPA QA/G-8. These procedures include, for example, how computer entries are compared to field data sheets, data gaps are identified, calculations are checked, raw data are examined for outliers or nonsensical readings, and so forth.

The Quality Assurance Manager is responsible for ensuring that field data are properly reviewed and verified for integrity. On a monthly basis, and after each successfully sampled storm event, the Data Manager or designee will review rainfall and flow data for gross errors such as spikes or data gaps to determine completeness of the data set. Rainfall and flow measurements will be checked by comparing the hyetograph and hydrograph. The Quality Assurance Manager will also validate that stormwater samples were collected in accordance with criteria included in this QAPP (Section 6.0).

The staff and management of the respective field, laboratory, and data management tasks are responsible for the integrity, validation, and verification of the data each task generates or handles throughout each process. The Laboratory Quality Assurance Offices are responsible for ensuring that laboratory data (water quality, sediment and toxicology) are scientifically valid, defensible, of acceptable precision and accuracy, and reviewed for integrity. The Data Manager will be responsible for ensuring that all data are properly reviewed and verified, and submitted in the required format to the project database. The Quality Assurance Manager is responsible for validating a minimum of 10 percent of the data produced in each task. Finally, the Project Manager, with the concurrence of the Quality Assurance Manager, is responsible for validating that all data to be reported meet the objectives of the project and are suitable for reporting.

13.2 VERIFICATION AND VALIDATION METHODS

This section presents example methods that may be used for the data verification and validation process. The records needed for, general methods and process for completion of, and the reporting of verification and validation are discussed. Specific methods, as documented via SOPs or data reports, will be further developed as the project proceeds.

13.2.1 Data Verification Inputs

Records that may be used as inputs for the data verification process a presented in Table 27.

Table 27. Example data verification inputs

Operation	Common Records	Sources for Record Specifications
Monitoring and Sample Collection	Field logs, Chain of Custody forms (COC), database of flow and rainfall records	QAPP, Standard Operating Procedures for sample collection, pre-printed COC form instructions, project electronic database.
Sample Receipt	COC forms from field personnel, receiver's copy of shipping bill, internal laboratory receipt forms, internal laboratory COC forms, laboratory documented temperature logs	QAPP, laboratory SOP for sample receipt, pre-printed COC instructions
Sample Preparation	Analytical services requests,	QAPP, reference method, laboratory

	internal laboratory receipt forms, internal laboratory COC forms, laboratory refrigerator or freezer logs, preparation logs or bench notes, manufacturer's certificates for standards or solutions	SOP for analysis method, pre-printed instructions on internal forms and worksheets
Sample Analysis	Analytical services requests, internal laboratory receipt forms, internal laboratory COC forms, laboratory refrigerator or freezer logs, manufacturer's certifications for standards or solutions, instrument logs or bench notes, instrument readouts (raw data), calculation worksheets, quality control (QC) results, analytical reports from the lab to the client.	QAPP, reference method, laboratory SOP for analysis method, pre-printed instructions on internal forms and worksheets
Records review	Internal laboratory checklists	QAPP, laboratory SOP for analysis method or laboratory QA Plan

Source: US EPA 2002

13.2.2 Data Verification Implementation Methods

Following are expected data verification methods to be used by the Quality Assurance Manager. Additional verification methods may be developed as the project progresses. A checklist of what verification was completed and when it was completed should be systematically documented throughout the project.

Rainfall and flow records

- Identify data gaps and determine if the gaps can be filled with estimated or alternate data. Document the process for filling in data gaps.
- Identify data anomalies or spikes. Are certain data outside the limits of reality? Document the process for dealing with data anomalies. For example, data were deleted or interpolated across.
- Cross check data sets against field sheets and calibration records. Determine if data set needs to be adjusted based on, for example, instrument calibration or field staff observations.

- Expected patterns/yield for that basin/area – based on previous project or historic data. Comparison of hyetograph to the hydrograph – is there a flow response to rainfall?

Analytical (water and sediment quality) results

- Determine if maximum holding times were exceeded (for each parameter)
- Completeness and missing data: do the analytical results match what the field sheets and COCs have listed for samples collected?
- Correct analytical method used by laboratory?
- Correct detection limit achieved by laboratory?
- Matrix spike recovery within laboratory's limits?
- Laboratory duplicate within laboratory's limits?
- Expected trends: Is the result realistic for each individual parameter? Is the data point an outlier when compared to existing project data?

13.2.3 Data Verification Outputs

There are two general outputs of from the data verification process:

1. The verified data, and
2. data verification records.

The verified data are the final data sets that will proceed on to the Data Usability Assessment (Section 14.0). These data sets will be in the format as described in Section 10.0). Data verification records will list the date when the Quality Assurance Manager has completed the verification process, indicate the methods used, and discuss relevant data issues. Data verification records could be included in, for example, the Status Reports to Management or the Data QA/QC report section of the Annual Stormwater Monitoring Report, as described in Section 12.3.

Any changes to the results as originally reported by the laboratory or by continuously recorded electronic data (*e.g.*, flow or rainfall) should either be accompanied by a note of explanation from the data verifier or the laboratory, indicated by an appropriate flag, or reflected in a revised laboratory data report. Data verification records can also include a narrative that identifies technical non-compliance issues or shortcomings of the data produced during the field or laboratory activities.

14.0 DATA QUALITY (USABILITY) ASSESSMENT

Data Quality Assessment (DQA) is completed after data verification and validation is done. If the Data Quality Objectives stated in this QAPP are met, then the data will be useable in meeting project objectives. If the Data Quality Objectives stated in this QAPP are not met, a determination must be made of whether the quantity and quality of the data are sufficient to meet project objectives. Anomalies in the data set will be identified and assessed, and their impact on meeting project objectives will be discussed in the pertinent Stormwater Annual Report.

The main goals of the DQA will be to determine if the resulting project data set,:

1. Meets the quantity of samples required by the Permit (S8.D2) to be collected (QAPP Section 7.0XXX).
2. Is representative of stormwater runoff conditions in the selected municipal drainage basin,
3. Includes sample results that have met storm event and sample criteria, as required by the Permit, and
4. Is sufficient to calculate the wet season and dry season pollutant loads (Section 12.3.3)

Table 28. Example DQA table.

Number of qualifying storm events in water year 20XX	Number of storm event samples attempted		Number of storm event samples that pass DQA		Percent of required samples collected for water year 20XX
	Wet Season	Dry Season	Wet Season	Dry Season	

15.0 REFERENCES

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APPENDIX A: TIME OF CONCENTRATION CALCULATION

Port of Tacoma: Phase I Stormwater Monitoring

Estimate Calculation for Time of Concentrations

Method based on: Stormwater Treatment Technical Requirements Manual, Issued Nov 2000. City of Seattle, Seattle, WA

Time of Concentration

sheet flow <300' TC=(0.42*(n*L)^0.8)/(P2^0.527*s^0.4)

P = 2-year, 24-hour rainfall (in): 2.00 (Stormwater Management Manual for Western Washington, Aug. 2001)

shallow concentrated flows: TC=L/(60*V) V=k*(s^0.5)

All three basins have stormwater piping

k= time of concentration velocity factor

sheet flow	Basin	"Outfall 564"	Flow From Roof
length, feet	L=	52	
	n=	0.011	
	P=	2.00	
slope, ft/ft	s=	0.2	estimated based on building photos
	Tt=	0.4	
sheet flow			Landscaping Area
length, feet	L=	75	
	n=	0.15	short prairie grass and lawns
	P=	2.00	
slope, ft/ft	s=	0.007	
	Tt=	15.0	
shallow flow	k=	42	Pipe flow
length, feet	L=	301	
	s=	0.007	
avg. velocity	v=	3.42	
	Tt=	1.5	
	TC=	16.8	

Estimation of pipe slope based on surface gradient

Basin Slopes	Residential	
Length	301	
Elev high	5	all elevations estimated from Google Earth
Elev low	3	
	0.007	

Estimation of landscaping slope

Basin Slopes	Residential	
Length	75	
Elev high	5	all elevations estimated from Google Earth
Elev low	4.5	
	0.007	

APPENDIX B: FIELD DATA SHEETS

Port of Tacoma - Phase I Stormwater Monitoring Consultant

Station:

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pages per station

Section 1. Storm Setup and Inspection			
Personnel:	Weather:	Arrival Date/Time:	
Carry-over maintenance to do prior to set-up:			done?
Channel Condition OK, Observations (oil/sheen, floatables, turbidity, suspended solids, discoloration, odor...)?			
Battery Voltage		Changed? Y N	New voltage
Flow Meter/ Data Logger		**Sampler Data**	
Logger Desiccant Canisters OK? (Y/N)		Sample Tubing & Strainer OK?	
Flow Meter Desiccant OK? (Y/N)		Time Display OK? (Yes/No)	
Flowmeter Cable Secure?		Internal Sampler Tubing OK?	
Flow sensor OK? (Free of debris)		Tubing Replaced? (Yes/No)	
Measured water level		Sampler Calibrated? (Yes/No)	
Flow meter water level/ recalibrated? (Y/N)		Backflushed with DI?	
Flow Rate		Suction line & quick connect attached?	
Flow Data Downloaded & Reviewed? (Y/N)		Lids off bottles?	
Enable level re-set? (Y/N) / Enable level:		Ice Deployed?	
Pacing re-set? (Y/N) / Pacing (gal.):		Distrubutor arm check?	
Time enable? (Y/N) / start time? Interval?		Program Used:	
Sampler Enable Latch Re-set? (as applicable)		Program Reviewed (Yes/No)	
Notes:		Start Program, Last screen...	

Section 2. Grab Sample Collection/ Initial Station Check			
Personnel:	Weather:	Arrival Date/Time:	
Grab Sample Data		**Notes:**	
Runoff Present?			
Grab Collection Time (date/time)			
Grab Sample Volume Collected			
Grab Sample Bottle ID			
Grab Duplicates Collected?			
Grab Blank Collected?			
Sample Observations-notify storm controller if sample turbidity, TSS, odor, color, foam, or sheen look out of the ordinary:			
Storm Contoller notified (Y or N/A)?:			
Flow Meter/ Data Logger			
Channel Condition OK, Observations (oil/sheen, floatables, turbidity, suspended solids, discoloration, odor..)?			
Battery Voltage		Changed? Y N	New voltage
Flow sensor OK? (Free of debris)		Flow Data Downloaded & Reviewed? (Y/N)	
Sampler Data			
Equipment running correctly?		Comp sample volume OK?	
Ice OK?		Sample Observations-notify storm controller if sample turbidity, TSS, odor, color, foam, or sheen look out of the ordinary:	
Sample Tubing & Strainer OK?			
On Composite... (Bottle #/ Aliq #)			
Need to swap base? (If Y, complete next fields)		Storm Controler Notified? (Y/N)	
Sampler Report Downloaded & Reviewed?		**Sampler Reset**	
Composite Begin Time (date/time)		Lids off new bottles?	
Last Aliquot Taken (date/time, bott #, aliq #)		Distrubutor arm check?	
Aliquots missed/NLD (date/time/bott #/aliq #)		Program Used:	
		Program Reviewed (Yes/No)	
Comp Bottles Labeled? (Sta & date)		Start Program, Last screen...	

******************No more than 1 visit worth of information per section should be recorded on any one field sheet******************

Port of Tacoma - Phase I Stormwater Monitoring

Consultant

Station:

Page:___of___
pages per station

Section 3. Mid-Event Site Visit			
Personnel:	Weather:	Arrival Date/Time:	
Flow Meter/ Data Logger			
Channel Condition OK, Observations (oil/sheen, floatables, turbidity, suspended solids, discoloration, odor…)?			
Battery Voltage		Changed? Y N	New voltage
Flow sensor OK? (Free of debris)		Flow Data Downloaded & Reviewed? (Y/N)	
Sampler Data			
Equipment running correctly?		Comp Sample Volume Collected (%)	
Ice OK?		Sample Observations-notify storm controller if sample turbidity, TSS, odor, color, foam, or sheen look out of the ordinary:	
Sample Tubing & Strainer OK?			
On Composite... (Bottle #/ Aliq #)			
Need to swap base? (If Y, complete next fields)		Storm Controler Notified? (Y/N)	
Sampler Report Downloaded & Reviewed?		Sampler Reset	
Composite Begin Time (date/time)		Lids off new bottles?	
Last Aliquot Taken (date/time, bott #, aliq #)		Distrubutor arm check?	
Aliquots missed/NLD (date/time/bott #/aliq #)		Program Used:	
		Program Reviewed (Yes/No)	
Comp Bottles Labeled? (Sta. & date)		Start Program, Last screen…	
Notes:			

Section 4. Mid-Event Site Visit			
Personnel:	Weather:	Arrival Date/Time:	
Flow Meter/ Data Logger			
Channel Condition OK, Observations (oil/sheen, floatables, turbidity, suspended solids, discoloration, odor…)?			
Sampler Battery Voltage		Changed? Y N	New voltage
Flow sensor OK? (Free of debris)		Flowmeter Data Downloaded & Reviewed? (Y/N)	
Sampler Data			
Equipment running correctly?		Comp Sample Volume Collected (%)	
Ice OK?		Sample Observations-notify storm controller if sample turbidity, TSS, odor, color, foam, or sheen look out of the ordinary:	
Sample Tubing & Strainer OK?			
On Composite... (Bottle #/ Aliq #)			
Need to swap base? (If Y, complete next fields)		Storm Controler Notified? (Y/N)	
Sampler Report Downloaded & Reviewed?		Sampler Reset	
Composite Begin Time (date/time)		Lids off new bottles?	
Last Aliquot Taken (date/time, bott #, aliq #)		Distrubutor arm check?	
Aliquots missed/NLD (date/time/bott #/aliq #)		Program Used:	
		Program Reviewed (Yes/No)	
Comp Bottles Labeled? (Sta. & date)		Start Program, Last screen…	
Notes:			

Section 5. Sample Collection/Post Storm		
Personnel:	Weather:	Arrival Date/Time:
Flow Data Downloaded and Reviewed?		
Composite Begin Time (date/time)		
Last Aliquot Taken (date/time, bott #, aliq #)		
Comp Bottles Labeled? (Sta. & date)		
Comp Sample Volume Collected		
Aliquots missed/NLD (date/time/bott #/aliq #)		
Channel Condition OK, Observations (oil/sheen, floatables, turbidity, suspended solids, discoloration, odor…)?		
Sample Observations-notify storm controller if sample turbidity, TSS, odor, color, foam, or sheen look out of the ordinary:		
Storm Contoller notified (Y or N/A)?:	Which parameter?:	
Notes:		

APPENDIX C: ANALYTICAL LABORATORY INFORMATION

The State of Washington
Department of Ecology

This is to certify that

Spectra Laboratories
Tacoma, WA

has complied with provisions set forth in Chapter 173-50 WAC and is hereby recognized by the Department of Ecology as an ACCREDITED LABORATORY for the analytical parameters listed on the accompanying Scope of Accreditation. This certificate is effective February 2, 2009, and shall expire February 1, 2010.

Witnessed under my hand on February 4, 2009.

Stewart M. Lombard
Lab Accreditation Unit Supervisor

Laboratory ID
C1271

Scope of Accreditation

Spectra Laboratories

Tacoma, WA

is accredited by the State of Washington Department of Ecology to perform analyses for the parameters listed below using the analytical methods indicated. This Scope of Accreditation may apply to any of the following matrix types: non-potable water, drinking water, solid and chemical materials, and air and emissions. Accreditation for all parameters is final unless indicated otherwise in a note. Accreditation is for the latest version of a method unless otherwise specified in a note. EPA refers to the U.S. Environmental Protection Agency. SM refers to American Public Health Association's publication, Standard Methods for the Examination of Water and Wastewater, 18th, 19th or 20th Edition, unless otherwise noted. ASTM stands for the American Society for Testing and Materials. PSEP stands for Puget Sound Estuary Program. Other references are detailed in the notes section.

Matrix Type/Parameter Name	Reference	Method Number	Notes
Drinking Water			
Alkalinity, Total	SM	2320 B	
Cyanide, Total	SM	4500-CN E	
Fluoride	SM	4500-F C	
Nitrate	SM	4500-NO3 D	
Nitrite	SM	4500-NO2 B	1
Solids, Total Dissolved	SM	2540 C	
Specific Conductance	EPA	120.1	
Sulfate	EPA	375.4	
Turbidity	EPA	180.1	
Aluminum	EPA	200.8	4
Antimony	EPA	200.8	4
Arsenic	EPA	200.8	4
Barium	EPA	200.8	4
Beryllium	EPA	200.8	4
Cadmium	EPA	200.8	4
Calcium	EPA	200.8	4
Chromium	EPA	200.8	4
Copper	EPA	200.8	4
Iron	EPA	200.8	4

Matrix Type/Parameter Name	Reference	Method Number	Notes
Lead	EPA	200.8	4
Magnesium	EPA	200.8	4
Manganese	EPA	200.8	4
Nickel	EPA	200.8	4
Selenium	EPA	200.8	4
Silver	EPA	200.8	4
Sodium	EPA	200.8	4
Thallium	EPA	200.8	4
Zinc	EPA	200.8	4
Heterotrophic Plate Count	SM	9215 B	4
Total & Fecal Coli - count	SM	9222 B/9221 E1	4
Total Coli/Ecoli - count	SM	9222 B/9221 F	4
Total Coli/Ecoli - detect Colilert	SM	9223	4
Non-potable Water			
Alkalinity, Total	SM	2320 B	
Ammonia	SM 19/20	4500-NH3 D	
Anionic Surfactants	SM	5540 C	
Biochemical Oxygen Demand, BOD/CBOD	SM	5210 B	
Chemical Oxygen Demand (COD)	EPA	410.4(7.3)	
Chloride	SM	4500-Cl- C	
Chlorine Residual, Total	SM	4500-Cl G	
Cyanide, Total	SM	4500-CN E	
Cyanide, Weak Acid Dissociable	SM	4500-CN I	4
Cyanides, Amenable to Chlorination	SM	4500-CN G	4
Dissolved Oxygen	SM	4500-O G	
Fluoride	SM	4500-F C	
Hexane Extractable Material	EPA	1664	
Nitrate	SM	4500-NO3 D	1
Nitrite	SM	4500-NO2 B	
Nitrogen, Total Kjeldahl	SM	4500-Norg C	

Matrix Type/Parameter Name	Reference	Method Number	Notes
Orthophosphate	SM	4500-P E	1
Phenolics, Total Recoverable	EPA	420.1	
Phosphorus, Total	SM	4500-P E	
Solids, Total	SM	2540 B	
Solids, Total Dissolved	SM	2540 C	
Solids, Total Suspended	SM	2540 D	
Specific Conductance	EPA	120.1	
Sulfate	EPA	375.4	
Sulfide	SM	4500-S2 F	
Total Organic Carbon	SM	5310 B	
Turbidity	EPA	180.1	
Aluminum	EPA	200.7	
Aluminum	EPA	200.8	
Antimony	EPA	200.8	
Antimony	EPA	200.7	
Arsenic	EPA	200.7	
Arsenic	EPA	200.8	
Barium	EPA	200.7	1
Barium	EPA	200.8	
Beryllium	EPA	200.8	
Beryllium	EPA	200.7	
Cadmium	EPA	200.7	
Cadmium	EPA	200.8	
Calcium	EPA	200.7	
Calcium	EPA	200.8	
Chromium	EPA	200.8	
Chromium	EPA	200.7	
Cobalt	EPA	200.7	
Copper	EPA	200.8	
Copper	EPA	200.7	

Matrix Type/Parameter Name	Reference	Method Number	Notes
Hardness, Total (as CaCO3)	EPA	200.7	1
Iron	EPA	200.7	
Iron	EPA	200.8	
Lead	EPA	200.7	
Lead	EPA	200.8	
Magnesium	EPA	200.7	
Magnesium	EPA	200.8	
Manganese	EPA	200.7	
Manganese	EPA	200.8	
Molybdenum	EPA	200.7	
Molybdenum	EPA	200.8	
Nickel	EPA	200.7	
Nickel	EPA	200.8	
Potassium	EPA	200.7	
Potassium	EPA	200.8	
Selenium	EPA	200.7	
Selenium	EPA	200.8	
Silica	EPA	200.7	
Silver	EPA	200.7	
Silver	EPA	200.8	
Sodium	EPA	200.7	
Sodium	EPA	200.8	
Thallium	EPA	200.7	
Thallium	EPA	200.8	
Vanadium	EPA	200.8	
Vanadium	EPA	200.7	
Zinc	EPA	200.8	
Zinc	EPA	200.7	
Organochlorine Pesticides	EPA	608	4
Polychlorinated Biphenyls	EPA	608	4

Matrix Type/Parameter Name	Reference	Method Number	Notes
BNA Extr (Semivolatile) Organics	EPA	625	3
Volatile Organic Compounds	EPA	624	
E. coli - count	SM	9213 D	4
Enterococcus/Fecal Strep	SM	9230 C2a	4
Fecal Coliform - count	SM	9222 D	4
Heterotrophic Plate Count	SM	9215 B	4
Total & Fecal Coli - count	SM	9221 B,C,E1	4
Total & Fecal Coli - count	SM	9222 B/9221 E1	4
Total Coli/Ecoli - count	SM	9222 B/9221 F	4
Solid and Chemical Materials			
Total Chlorine (Fuels)	EPA	9076	
Aluminum	EPA	6010	
Antimony	EPA	6010	
Arsenic	EPA	6010	
Barium	EPA	6010	
Beryllium	EPA	6010	1
Boron	EPA	6010	
Cadmium	EPA	6010	
Calcium	EPA	6010	
Chromium	EPA	6010	
Chromium, Hexavalent	EPA	7196	
Cobalt	EPA	6010	
Copper	EPA	6010	
Iron	EPA	6010	
Lead	EPA	6010	
Magnesium	EPA	6010	
Manganese	EPA	6010	
Molybdenum	EPA	6010	
Nickel	EPA	6010	
Potassium	EPA	6010	

Matrix Type/Parameter Name	Reference	Method Number	Notes
Selenium	EPA	6010	
Silver	EPA	6010	
Sodium	EPA	6010	
Thallium	EPA	6010	
Tin	EPA	6010	
Vanadium	EPA	6010	
Zinc	EPA	6010	
Organochlorine Pesticides	EPA	8081	4
Polychlorinated Biphenyls	EPA	8082	4
Total Pet Hydrocarbons - Diesel	WDOE	NWTPH-Dx	5
BNA Extr (Semivolatile) Organics	EPA	8270	
Total Pet Hydrocarbons - Gasoline	WDOE	NWTPH-Gx	5
Volatile Organic Compounds	EPA	8260	
Ignitability, Pensky-Martin	EPA	1010	

Accredited Parameter Note Detail

(1) Provisional pending acceptable proficiency testing (PT) results (WAC 173-50-110). (2) Method modified to use alternative digestion procedure. (3) Method modification consists of one extraction only at a pH of less than 2. (4) Provsional pending successful resolution of the deficienices outlined in the June 9, 2009 on-site audit report. (5) Washington Department of Ecology Analytical Methods for Petroleum Hydrocarbons, No. ECY 97-602, June 1997.

S M Lombard
Authentication Signature

June 9, 2009
Date

Stewart M. Lombard, Lab Accreditation Unit Supervisor

APPENDIX D:
POLLUTANT LOADING CALCULATIONS

Stormwater Pollutant Loading Calculations
(based on Seattle Public Utility's method, as revised September 29, 2008)

The total annual load is the sum of base flow loading and stormwater runoff loading. For the purposes of this analysis, base flow loading is defined as the annual mass of a chemical constituent that infiltrates the stormwater drainage system from groundwater and shallow subsurface stormwater flow and enters the drainage system from surface flows such as springs or irrigation. Base flow is determined using the storm event criteria and is generally defined as flow contributed from non-storm sources.

Stormwater runoff loading is defined as the annual mass of a chemical constituent exported from flow that is derived from storm events. Because the chemical composition of base flow water is expected to be different from that of stormwater runoff water due to infiltration, biological processes that occur within the ground, or the source of the base flow, separate calculations may need to be performed to determine the annual base and storm flow loadings, respectively.

The loadings will be expressed as total pounds and as pounds per acre draining to the stormwater outfall.

For each parameter monitored and each storm event in which a sample was collected, follow the steps below to calculate the annual water year, dry season, and wet season EMC and stormwater loading.

Step 1. Determine representative volumes for each sampled event:

Step 1a. Determine the total volume, stormwater and base flow, $V_{i,t}$, representing each sampled storm event, i.

Step 1b. Separate the base flow from the hydrograph for each sampled event and determine the base flow for each sampled event, $V_{i,b}$, and the stormwater volume representing the sampled event, V_i.

Step 2. Determine representative loads for each sampled event:

Step 2a. Calculate a total load for each sampled storm event, $L_{i,t}$. Multiply each storm event mean concentration, EMC_i by the volume associated with that sample (Step 1a), $V_{i,t}$.

$$L_{i,t} = EMC_i x V_{i,t}$$

Step 2b. If applicable, calculate a base flow load for each sampled event, $L_{i,b}$. Multiply the base flow concentration for the appropriate season, C_d or C_w, by the base flow volume, $V_{i,b}$, for each sampled event (Step 1b).

$$L_{i.b} = C_d x V_{i.b} \quad \text{OR} \quad L_{i.b} = C_w x V_{i.b}$$

Step 2c. Calculate the stormwater load for each sampled event, ℓ_i. Subtract the base flow load (Step 2b), $L_{i,b}$, from the total event load (Step 2a), $L_{i,t}$.

$$\ell_i = L_{i.t} - L_{i.b}$$

Step 3. Estimate annual water year and seasonal loads in pounds and pounds per acre for sampled events:

Step 3a. Calculate an annual water year, dry season, and wet season total load, L_t, representing the samples collected by summing the respective loads for the period (Step 2a), where n is the number of storms sampled.

$$L_t = \sum_{i=1}^{n} L_{i.t}$$

Step 3b. If applicable, calculate an annual water year, dry season, and wet season base flow load, L_b , representing the samples collected by summing the respective loads for the period (Step 2b).

$$L_b = \sum_{i=1}^{n} L_{i.b}$$

Step 3c. Calculate an annual water year, dry season, and wet season stormwater load, L, representing the samples collected by summing the respective loads for the period (Step 2c).

$$L = \sum_{i=1}^{n} \ell_i$$

Step 4. Estimate annual water year and seasonal EMCs for sampled events:

Step 4a. Calculate a flow-weighted average annual, dry season, and wet season total stormwater EMC, $\overline{EMC_t}$, representing the storms sampled. Divide the total load for the respective period (Step 3a) by the sum of the volumes that were associated with each sampling period (Step 1a).

$$\overline{EMC_t} = \frac{\sum_{i=1}^{n} L_{i,t}}{\sum_{i=1}^{n} V_i} = \frac{L_t}{\sum_{i=1}^{n} V_i}$$

Step 4b. If applicable, calculate an annual water year, dry season, and wet season base flow EMC, $\overline{EMC_b}$. Divide the base flow load for the respective period (Step 3b) by the sum of the volumes that were associated with each sampling period (Step 1b).

$$\overline{EMC_b} = \frac{\sum_{i=1}^{n} L_{i,b}}{\sum_{i=1}^{n} V_{i,b}} = \frac{L_b}{\sum_{i=1}^{n} V_{i,b}}$$

Step 4c. Calculate a flow-weighted average annual water year, dry season, and wet season stormwater EMC representing the storms sampled, $\overline{EMC}$. Divide the stormwater load for the respective period (Step 3c) by the sum of the volumes that were associated with each sampling period (Step 1c).

$$\overline{EMC} = \frac{\sum_{i=1}^{n} \ell_i}{\sum_{i=1}^{n} V_i} = \frac{L}{\sum_{i=1}^{n} V_i}$$

Step 5. Estimate annual water year and seasonal loads representing the entire period in pounds and pounds per acre using a ratio estimator:

The basis of ratio estimators is the assumption that the ratio of load to flow for the entire year should be the same as the ratio of load to flow on the days concentration was measured. Therefore:

$$\frac{L_e}{\left(\sum_{i=1}^{m} V_i\right)} = \left(\frac{\sum_{i=1}^{n} \ell_i}{\sum_{i=1}^{n} V_i}\right)$$

Where;

L_e = estimate of annual stormwater load

ℓ_j= estimate of load for storm i (step 2c)

n = number of storms sampled

m = number of storms in the period

V_i = Storm volume of storm event i

$\overline{EMC}$ =average event mean concentration of sampled events

Step 5a. Estimate an annual water year, dry season, and wet season total stormwater load, L_{et}, representing the period total (stormwater and base flow) storms event volume.

$$L_{et} = \frac{\sum_{i=1}^{n} L_{i,t}}{\sum_{i=1}^{n} V_i}\left(\sum_{i=1}^{m} V_{i,t}\right) = \overline{EMC_t}\left(\sum_{i=1}^{m} V_{i,t}\right)$$

Step 5b. If applicable, estimate an annual water year, dry season, and wet season base flow load, L_{eb}, representing the period storm event volume base flow.

$$L_{eb} = \frac{\sum_{i=1}^{n} L_{i,b}}{\sum_{i=1}^{n} V_{i,b}}\left(\sum_{i=1}^{m} V_{i,b}\right) = \overline{EMC_b}\left(\sum_{i=1}^{m} V_{i,b}\right)$$

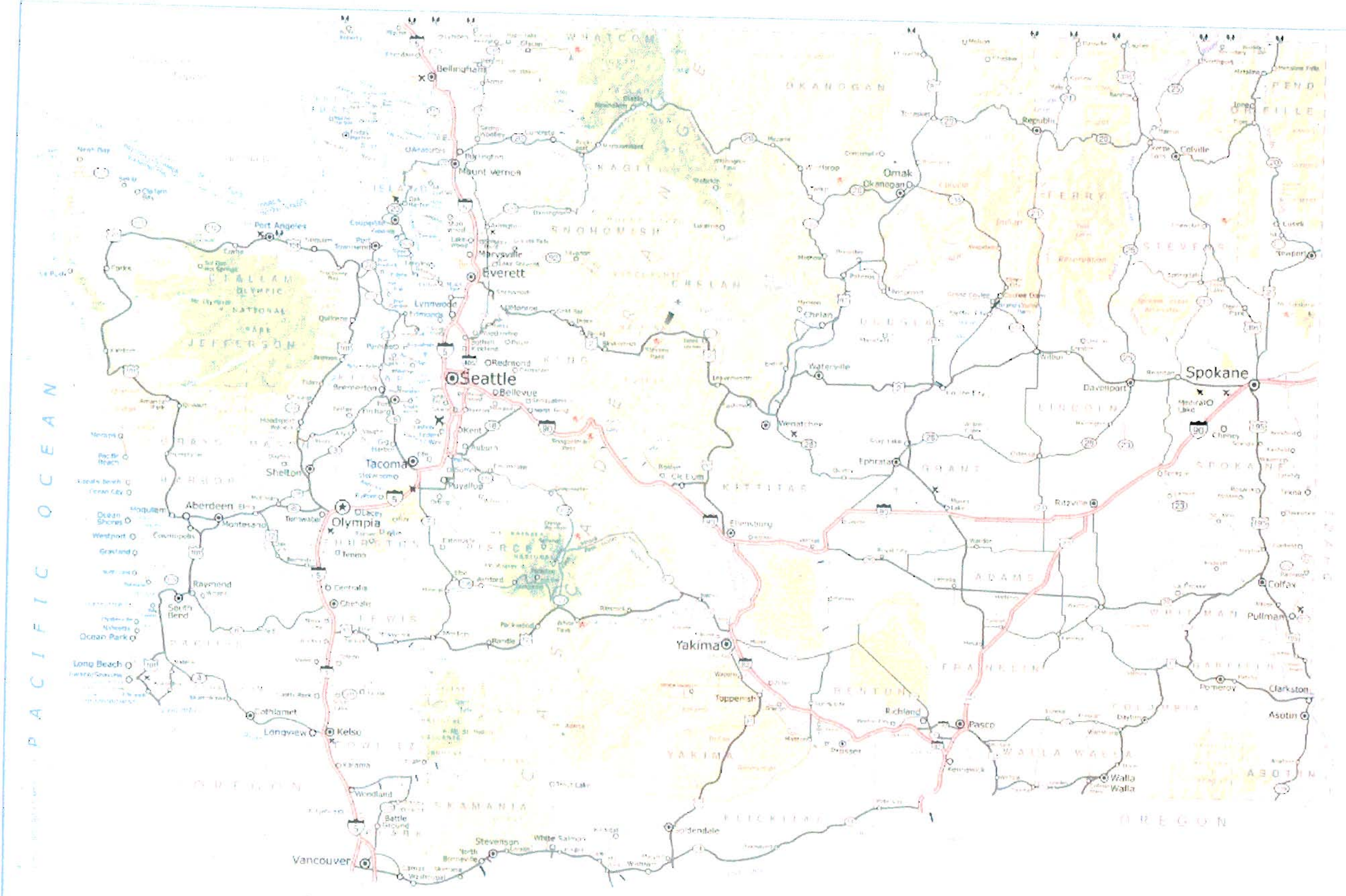
Step 5c. Estimate an annual water year, dry season, and wet season stormwater load, L_e, representing the period stormwater event volume.

$$L_e = \left(\frac{\sum_{i=1}^{n} \ell_i}{\sum_{i=1}^{n} V_i}\right)\left(\sum_{i=1}^{m} V_i\right) = \overline{EMC}\left(\sum_{i=1}^{m} V_i\right)$$

Step 5d. Assess the assumption that the concentration per sampled storm event was positively related to volume per sampled storm event.

ATTACHMENT A


Legend:
Municipal
Industrial
Boatyard
Blair-Hylebos
Other


PACIFIC OCEAN
Bellingham
Mount Vernon
Port Angeles
Everett
Lynnwood
Seattle
Bellevue
Redmond
Kent
Tacoma
Puyallup
Olympia
Shelton
Aberdeen
Montesano
Raymond
South Bend
Ocean Park
Long Beach
Centralia
Chehalis
Longview
Kelso
Vancouver
Stevenson
White Salmon
Goldendale
Yakima
Toppenish
Ellensburg
Cle Elum
Wenatchee
Waterville
Chelan
Omak
Okanogan
Republic
Colville
Ephrata
Ritzville
Davenport
Spokane
Cheney
Colfax
Pullman
Pomeroy
Clarkston
Asotin
Walla Walla
Pasco
Richland
Prosser
OKANOGAN
SNOHOMISH
CHELAN
KITTITAS
GRANT
ADAMS
LINCOLN
FERRY
STEVENS
BENTON
FRANKLIN
LEWIS
SKAMANIA
YAKIMA
OREGON