Port of Seattle

Procedure Manual

FOR

Stormwater Monitoring

at

Sea-Tac International Airport

in compliance with
NPDES PERMIT WA-002465-1

Revision 6
April 22, 1999
Effective March 1, 1999

Port of Seattle Environmental Services

#424

Table of Contents

List of Figures

List of Tables

1. Purpose

This manual describes the procedures that the Port of Seattle will follow to collect samples and report analytical data to fulfill the requirements of the NPDES Stormwater permit number WA-002465-1 for the Seattle-Tacoma International Airport (STIA). This revised Procedure Manual is submitted to the Washington Department of Ecology (Ecology)to incorporate the major modification to the NPDES permit, issued January 25, 1999. These changes to the permit affect sampling and reporting frequency only. The previous version of this manual (December 18, 1998) was submitted to Ecology on December 30, 1998 (POS 1998a.)

1.1. Organization

The following personnel are responsible for the Port's STIA Stormwater Monitoring Program:

Surface Water Program Manager: Tom Hubbard, Aviation Program Management Group, Port of Seattle.

Stormwater Monitoring Program Manager: Scott Tobiason, Environmental Services, Port of Seattle.

Field Technician: Consultant, reporting to and assisted by Scott Tobiason.

2. Revisions

This version of the manual replaces the December 18, 1998 version (POS, 1998b). This revision incorporates sampling requirements changed by the major permit modification, issued January 25, 1999 (WDOE, 1999.). The Port elected to make these changes effective beginning March 1, 1999, the next quarter after the modification was issued. See the following quarterly monitoring section. This revision is valid until the current permit expires, or until the permit or Procedures Manual is modified. The Port may also revise this manual by simple addenda as necessary. Noteworthy changes include:

- sampling frequency changed from monthly to quarterly at 4 outfalls;
- monthly DMR reporting periodschanged to quarterly; and
- Figure 1 replaced with updated version.

3. Applicability

This manual applies only to storm sampling procedures required to meet the obligations of NPDES permit condition S2.B that apply to the Sea-Tac International Airport (STIA) storm drainage system (SDS). This manual does not apply to any monitoring requirements for

- the STIA Industrial Waste Treatment Plant (IWTP) or Industrial Waste System (IWS),
- experimental best management practices (BMPs), or
- construction project erosion and sediment control monitoring.

4. Stormwater Monitoring Requirements

This section outlines the stormwater monitoring requirements specified in the Special, Conditions of the NPDES permit, and how they are expressed in STIA's monitoring program.

4.1. Monitoring Goals and Objectives

The Port's primary monitoring goal is to obtain representative stormwater samples at each outfall that are reasonably comparable over time and space. Data from these samples will satisfy the quarterly, semi-annual, and annual reporting obligations required by the permit.

To meet this goal, the Port's objective is to take samples that meet certain criteria during the runoff resulting from a defined target storm event. The Port's intent is that storm samples and target storm events will meet the criteria and guidelines described in Section 5. Generally, the Port will take a grab sample, plus a flow-weighted composite sample from stormwater discharges at each outfall or monitoring location on a particular occasion. Only certain parameters required by the permit will be analyzed in the grab sample, while other required parameters will be analyzed in the flow-weighted composite sample. Composite stormwater samples represent average water quality analyte concentrations occurring during the discharge period monitored.

4.2. Sampling Locations

The permit's Special Condition S2.B requires sampling at 14 "outfalls". Figure 1 shows the STIA stormwater subbasins and the approximate locations of sampling stations. Each stormwater subbasin is identified by an alphanumeric designation that identifies its general location; e.g. "SDE4" denotes the *East Side* storm drain including all *four* lines tributary to that outfall. That is, SDE4 includes tributary networks SDE3, SDE2, and SDE1. As discussed below, sampling locations are not necessarily at the final "outfall", but the term "outfall" may be used synonymously to indicate the sampling location. Table 1 outlines the specific sampling locations.

The Port has mapped and identified manholes, inlets, outfalls and other storm drain appurtenances on several mechanical drawings (STIA-9656 C1-C6). These drawings were revised in December 1996. Information in Table 1 is consistent with the latest drawings.

The permit specifies the latitude and longitude of outfall locations, which are generally the outfall sampling points. The sampling points are located downstream of Port property within each subbasin. At these sampling locations the stormwater discharges best represent the total runoff accumulated from STIA industrial activity within the respective subbasin, while minimizing the input of runoff from non- industrial activity on both Port and non-Port property. However, some sampling locations unavoidably receive runoff from non-Port property believed to high bias certain measures of water quality (POS, 1997.)

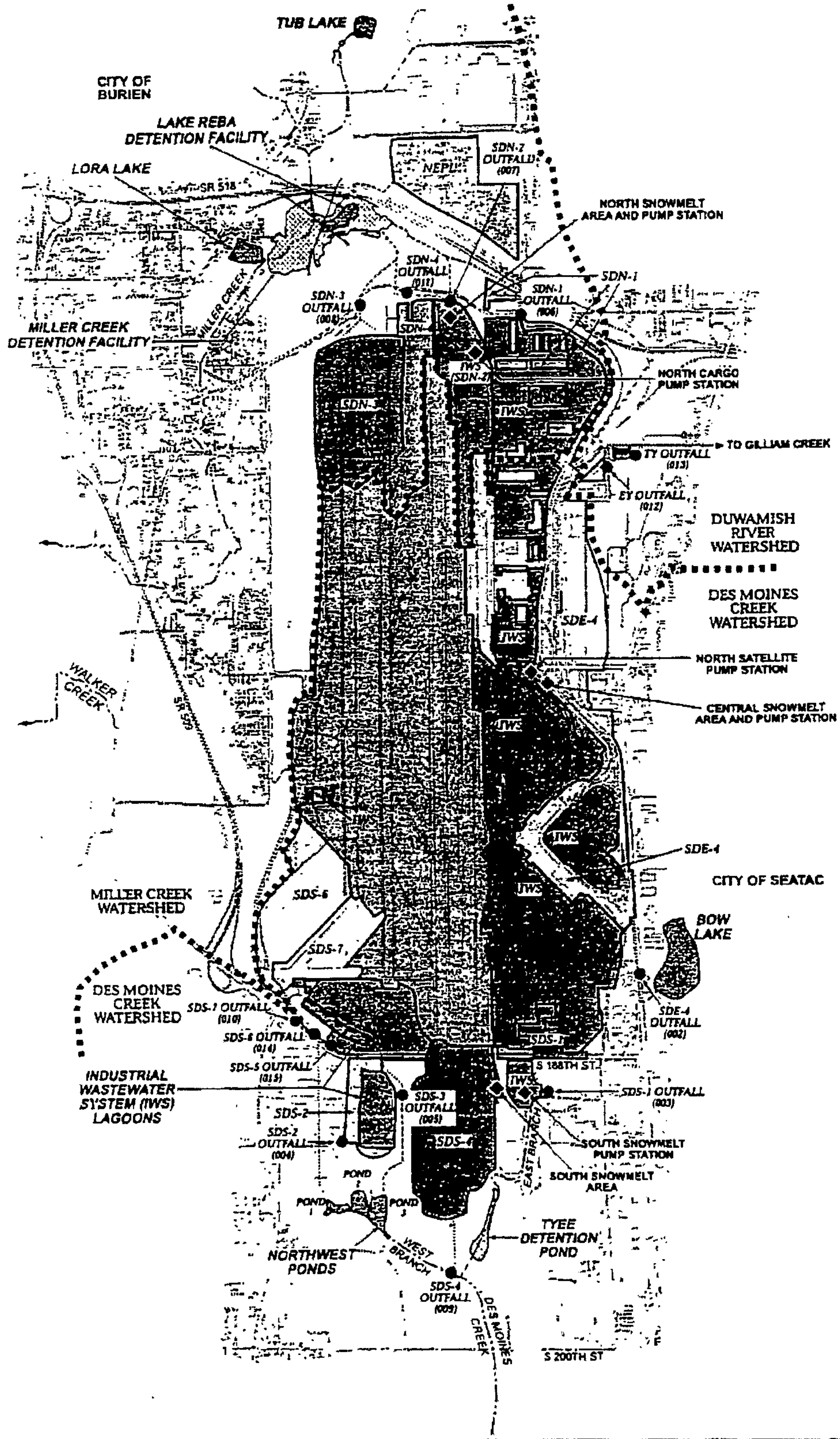
Sampling locations have not changed since June 1994, except for the following subbasins: SDN1 (outfall 006), SDN2 (outfall 007), and subbasin SDW3 (outfall 010). Because highway SR518 runoff elevated certain pollutant concentrations in samples from manhole SDN1-27 (POS, 1997), the sampling point was moved to manhole SDN1-22, upstream of the discharge of this non-STIA runoff. The Port moved the monitoring point for SDW3 from the outfall to the first manhole upstream (SDW3-24) to prevent backwater effects from non-STIA drainage; there are no other storm drain inputs in SDW3 below this manhole.

Some sampling locations have a certain amount of backwater or standing water between storms. Backwater is typically present at outfall structures or channels at monitoring locations for SDS3 (005), SDS4 (009), D (015), and SDN3 (008). Catch basins or manhole structures contain standing water at the SDN2 (007), SDN4 (011), EY (012), and TY (013) sampling points. The risk is that early and/or late samples from a storm discharge could over-represent this standing or backwater and therefore not be representative samples of the discharge itself. The backwater can be from non-Port sources or can go stagnant between storms. This unfavorable situation is generally unavoidable because upstream locations engender confined spaces or exclude a portion of the subbasin's runoff. Hence sampling routines will be adjusted accordingly (see Section 6.5.) As mentioned above, the station for SDW3 (010) was moved upstream to avoid sampling backwater, believed responsible for certain elevated results in earlier samples taken in the final outfall's backwater.

Table 1 Sampling Locations

Outfall (Subbasin)	Sampling Location
002 (SDE4)	outlet pipe of Manhole SDE4-47 (confined space, 20' deep)
003 (SDS1)	Immediately at outfall; SDS1-125
004 (SDS2)	Culvert outlet under clear-zone access road near gate at corner of 16th Avenue South and South 192nd Street.
005 (SDS3)	Immediately at outfall: SDS3-31
006 (SDN1)	outlet pipe of Manhole SDN1-22, (confined space, 20' deep) at SW corner of intersection of 24th Ave. S. and S. 154th St.
007 (SDN2)[1]	outlet pipe of North Snowmelt pump station vault (previously SDN2-37)
008 (SDN3)	Immediately at SDN3 outfall (below SDN5-11) South 154th Street.
009 (SDS4)	Immediately at outfall SDS4-78 into Des Moines Creek
010 (SDW3)	outlet pipe of Manhole SDW3-24
011 (SDN4)	outlet pipe of manhole SDN8-41[2] (confined space, 11' deep)
012 (Engineering Yard)	outlet pipe of final catch basin in the yard
013 (Taxi Yard)	outlet pipe of final catch basin in the yard
014 (Subbasin B,)	First drain inlet upstream of outfall in ditch along South 188th Street. Outfall is about 50 feet East of gate W40.
015 (Subbasin D)	Outfall SDS3- 39A, in ditch along South 188th Street, near IWTP.

1. Two pump stations divert the majority of runoff to the IWS from what was previously "SDN2". Discharges to the SDS via the SDN2 outfall occur only when the pump stations are turned off, or during bypasses that exceed pump capacities.
2. The structure is designated SDN8-41 on the stormwater maps, but it is part of the SDN4 system, immediately upstream of final outfall. There are no other inputs below the sampling station. The final outfall has a highly unsuitable hydraulic section (too steep and too short) for effective flow monitoring.



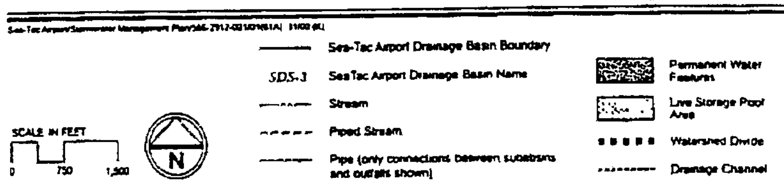


Figure 2-2
NPDES Drainage Subbasins, Snowmelt Areas and Pump Stations, and Permitted Outfalls

5

Figure 1 Stormwater Monitoring Subbasin Map (previous page, insert hardcopy from jpeg file)

4.3. *Sampling Requirements*

Table 2 outlines the sampling frequency and water quality analytes required by permit Special Condition S2.B.1-S2.B.4 for each outfall. Grab samples will be analyzed as applicable at each outfall for TPH, and fecal coliforms. The flow-weighted composite sample will be analyzed for the remaining required parameters. Generally, samples will be taken using automatic samplers, or in special cases by manual means, as described in Sections 5 and 6.

Table 2 Monitoring Frequency and Water Quality Analyte Requirements

Outfall (subbasin)	Monitoring Frequency	Analytes from a "grab" sample	Analytes from a "composite" sample	Permit requirement
002 (SDE4) 005 (SDS3) 006 (SDN1) 011 (SDN4)	**quarterly:** (min 1storm event per qtr, 8 per year)	TPH[1], fecal coliforms	TSS, turbidity, BOD_5, TRCu, TRPb, TRZn	S2.B.1
002 (SDE4) 005 (SDS3)[2] 011 (SDN4)003 (SDS1) 007 (SDN2)	**Quarterly:** One deicing/anti-icing event per quarter[3]	ethylene glycol and propylene glycol ("total glycols")[4]	BOD_5[2], ethylene glycol and propylene glycol ("total glycols")	S2.B.1.c, d S2.B.4
003 (SDS1) 004 (SDS2) 008 (SDN3) 009 (SDS4) 010 (SDW3) 014 (B) 015 (D)	**Annually:** (1 storm event per year)	TPH[1], fecal coliforms	TSS, turbidity, TRCu, TRPb, TRZn	S2.B.2
007 (SDN2) 012 (EY) 013 (TY)	**Semi-annually:** (2 storm events per year)	TPH[1]	TSS	S2.B.3
007 (SDN2)	**Continuous**	flow[5]	flow[5]	S2.B.4.c

1. TPH by method NWTPH-Dx
2. SDS3 (only) must be sampled for BOD_5[2] during any month where a runway deicing event occurs.
3. Not required in June, July, or August. Sampled only if and when deicing takes place. See Section 4.5 below. Deicing monitoring may be concurrent with regular storm monitoring.
4. Grab sample shall be taken during first 60 minutes of discharge event at SDS1 and SDN2 only.
5. Report bypasses on DMRs by indicating "yes".

4.4. Monitoring Schedule

The permit does not specify a specific monitoring schedule other thanquarterly, semi-annually, or annually as Table 2 identifies above. Quarters are defined as:

- a **winter quarter** from December through February,
- a **spring quarter** from March through May,
- a **summer quarter** from June through August, and
- a **fall quarter** from September through November.

4.4.1. Quarterly monitoring

The major permit modification, issued January 25, 1999 requires 8 samples to be collected on a quarterly basis at four outfalls (SDE4, SDS3, SDN1 and SDN4) with at least one sample collected per quarter. Thus, the remaining four samples can be taken anytime during a particular monitoring year at the Port's discretion.

4.5. Deicing events

4.5.1. Monitoring Requirements

In the permit, deicing event monitoring requirements appear in three places in Special Condition S2.B, and apply to five outfalls. This permit requirement does not distinguish between aircraft and ground deicing; therefore the Port defines these two different events below. The Port will sample outfalls only if there is a qualifying deicing event within the particular subbasin. Section 6.7 describes how the Port will accomplish deicing event monitoring.

4.5.1.1.Monthly monitoring

Permit special condition S2B.1, footnote "d", states "...shall be measured monthly at outfalls 002 (SDE4), 005 (SDS3), and 011 (SDN4) except for the months of June, July, and August. Glycol monitoring is not required at outfall 006 (SDN1). Sampling shall occur, to the extent practicable, during a precipitation event that coincides with a de-icing or anti-icing event." There are also requirements (S2.B.1, footnote c) to monitor at outfall SDS3 (005) for a "runway deicing event in those months in which a runway deicing event occurs." Because the minimum sampling frequency is listed as "eight/year" in the modified permit, the Port understands the intent is that deicing event monitoring is to be conducted on a quarterly basis, with a minimum of one deicing event sample per quarter.

4.5.1.2. Quarterly monitoring

In addition, there are quarterly deicing event monitoring requirements under condition S2.B.4 for outfalls SDS1 (003), and SDN2 (007): "Ethylene glycol and propylene glycol shall be measured at outfalls 003 (SDS1) and 007 (SDN2) in the three quarters December-February, March-May, and September-November. Sampling shall occur during a precipitation event that coincides with a de-icing/anti-icing event. This monitoring requirement may be eliminated after four sampling events at each outfall with Department approval." For outfall 003, samples may be taken during baseflow, snowmelt, or any precipitation event that coincides with a deicing event."

4.5.2. Deicing Event Definitions

The Port segregates and defines STIA "deicing events" as follows:

- aircraft deicing and anti-icing: a glycol-based treatment applied to remove or prevent ice accumulation on *aircraft* surfaces, with treatment applied at a specific gate(s) in a particular drainage subbasin, and
- ground deicing and anti-icing: specific chemicals applied to *ground* surfaces such as runways, taxiways, and vehicle roadways to remove and/or prevent ice buildup. These events will be referred to collectively as ground deicing events. The Port does not use glycol-based treatments to deice any ground surfaces.

4.5.3. Aircraft Deicing and Anti-icing: Subbasins Monitored

The Port will monitor and report analytical glycol data for aircraft deicing and anti-icing events as defined above. Because aircraft are not deiced within subbasin SDE4, SDS1, SDS3, and SDN4, the Port will not sample these outfalls unless for some unusual reason aircraft deicing takes place in one of these subbasins.

Only subbasin SDN2 (006) could be subject to direct aircraft deicing, and *only* if aircraft are deiced in the North Cargo area on a day with rainfall intense enough (greater than 6-month, 24-hour design intensity) to cause the North Cargo Pump station to bypass peak flows from this IWS area to SDS outfall SDN2. The Port will attempt to sample this very rare situation, and this will be the only candidate event for glycol sampling at SDN2. Ongoing pump station performance monitoring will attest to the rarity of this sequence of events.

4.5.4. Ground Deicing: Subbasins Monitored

Because the Port does not use glycols for deicing or anti-icing any runway, taxiway, ramp, or other ground surfaces, it does not make sense for the Port to monitor and sample for glycols during ground deicing events. The permit explicitly requires "runway deicing event" monitoring *only* for outfall 005 (SDS3), see Table 2. In this case, the composite sample will be analyzed for BOD5 and glycols. Glycol will be analyzed even though there are no direct sources of glycols in SDS3. The Glycol data will be reported on the DMRs. The Port considers that the use of sand only does not constitute a "deicing event".

4.6. *Supplemental Monitoring Data*

In accordance with permit Special Condition S2.B, paragraph 1, the Port shall submit the data items listed below for each sampled storm event. These data will be included in the Annual Stormwater Monitoring Report for each storm event monitored:

- "date and duration,
- the number of dry hours preceding the storm event,
- total rainfall during the storm event (inches),
- maximum flow rate during the rain event (gallons per minute), and
- the total flow from the rain event (gallons)."

The Annual Report "shall also include a monthly summary of daily rainfall...."

4.7. *Reporting: DMRs*

The Port shall submit Discharge Monitoring Reports (DMRs) in accordance with NPDES permit Special Condition S3.B. DMRs shall be completed and submitted to Ecology no later than the 30th of the month following the reporting period. The Port shall report stormwater monitoring results for only those outfalls where samples and storm events meet the criteria described in Section 5. Other data will be reported in the Annual Stormwater Monitoring Report. Section 7.3 describes how the Port will complete DMRs.

Ecology provided electronic DMR forms, which the Port converted to forms compatible with the Port's Discharge Monitoring Tracking System (DMTS) electronic reporting system. DMTS is a nationally available software tool supplied by EarthSoft, Inc. for NPDES data management and reporting. Currently the Port uses DMTS as a stand-alone module, and will integrate it with the EQUIS relational database under development.

The sampling requirements appear in Table 2 with reporting periods and corresponding DMR submittals as follows:

- **Quarterly:** due and submitted every three months by the 30th of the month following the end of the quarter. Quarters are December-February, March-May, June-August, September-November, and quarterly DMRs will be submitted by the 30th of March, June, September, and December, respectively. Sampling is required at least once quarterly for outfalls SDE4 (002), SDS3 (005), SDN1 (006), and SDN4 (011), plus for SDS1 and SDN2 during "deicing/anti-icing events", except for the "summer quarter" June-August.

- **Semi-annual periods:** submitted every six months by the 30th of the month following the end of the semi-annuum. Periods are March-August, September-February, and semi-annual DMRs will be submitted by the 30th of September, and March respectively. Sampling is required at least once semi-annually for the EY, TY, and SDN2.

> **Annual periods:** submitted every 12 months by the 30th of the month following the end of the annuum. Annual periods are March-February, and annual DMRs will be submitted once a year by the 30th of March. Sampling is required at least once annually for outfalls SDS1, SDS2, SDS4, SDN3, SDW3, B, and D.

4.8. Record Keeping and Recording Results

In accordance with permit Special Condition S3.C, the Port shall retain all records "for a minimum of three years." For certain circumstances, the Port shall retain records throughout the period of any unresolved litigation. These records include, but are not limited to:

- field logs and field notebooks for each monitoring event,
- discharge data, including computer files and hardcopy printouts where available,
- rain gage data files and hardcopy printouts where available,
- sampling chains of custody, and
- analytical laboratory results reports.

In accordance with permit Special Condition S3.D, the Port shall record the following information for each measurement or sample taken:

"(1) the date, exact place and time of sampling;
(2) the individual who performed the sampling or measurement;
(3) the dates the analyses were performed;
(4) who performed the analyses;
(5) the analytical techniques or methods used; and
(6) the results of all analyses."

The Port implements these requirements by compiling pertinent information in the Stormwater Monitoring Log, Chain of Custody form, and analytical results reports for each monitoring event. See Section 6. All analytical results are entered, stored, retrieved and processed using the Port's ACCESS relational database.

4.9. Representative Sampling

In accordance with permit Special Condition S2.G, the Port shall take samples and measurements so that they are "representative of the volume and nature of the monitored parameters, including representative sampling of any unusual discharge or discharge condition…" Section 6 describes the procedures the Port follows in collecting representative stormwater samples. The Port will not report data from non-representative samples on the DMRs, but will include any and all such data in the Annual Report.

Non-Representative samples and/or data include but are not limited to the following:

1. Flow-weighted composite samples taken from a rainfall event less than the target storm depth.
2. Analyte data from samples that have exceeded the maximum recommended holding times.
3. Grab and/or flow-weighted composite samples that do not meet the criteria of Section 5.

4.10. Test Procedures

In accordance with permit Special Condition S2.G, for all stormwater monitoring required by the permit the Port shall use analytical methods that conform to 40 CFR part 136 or to the 19th edition *of Standard Methods for the Examination of Water and Wastewater* (APHA, 1995) unless otherwise specified in the permit or approved in writing by the Department. Ethylene and propylene glycol analysis shall be according to the method approved by Ecology for Aquatic Research, Incorporated, on June 30, 1997.

4.11. Flow Measurement

In accordance with permit Special Condition S2.H, the Port shall use appropriate devices and methods consistent with accepted practices for all flow (discharge) measurements. These devices include but are not limited to:

- ISCO model 4150 Area-Velocity flowmeters that gage discharge directly,
- ISCO model 3230 and 4230 bubbler flowmeters that gage discharge indirectly using the Manning Equation, or other accepted empirical relation, and
- empirical, calibrated stage-discharge equations for weirs, flumes, etc.

The Port shall calibrate, install, and maintain these devices or procedures to ensure measurement accuracy consistent with industry or manufacturer's standards. Calibration frequency shall be in conformance with manufacturer's recommendations or at a minimum of at least once per year. See Section 6.4

4.12. Laboratory Accreditation

In accordance with permit Special Condition S2.I, the Port shall use an analytical laboratory accredited under the provisions of WAC 173-50 for preparing all stormwater data. Measurements of rainfall, "flow (discharge), temperature, settleable solids, conductivity, pH, and internal process control parameters are exempted from this requirement." The Port may elect to measure pH, turbidity, dissolved oxygen, conductivity, glycols, or other parameters in the field using hand held instruments or kits, but these data will not be reported on the DMRs but may be reported in the Annual Report if appropriate.

4.13. Additional Monitoring

In accordance with permit Special Condition S3.E, if the Port "monitors any pollutant more frequently than required by this permit using the test procedures and locations specified by Special Condition S2 of this permit, then the results of this monitoring shall be included in the calculation and reporting of the data submitted" in the DMRs.

For any other stormwater data taken "using methods and/or locations other than those specified in Special Condition S2, the Port must include notice of this monitoring with the (DMRs) for the month in which the monitoring occurred..." This "additional" data may include but is not limited to:

1. non-representative sample data
2. Source tracing sample data
3. Special study sample data

The Port will attach appropriate notice to the DMRs acknowledging "additional" sampling. Data from additional monitoring will be reported in the Annual Stormwater Monitoring Report.

4.14. Annual Stormwater Monitoring Summary Report

In accordance with permit Special Condition S2.E, the Port shall compile, analyze, and present all stormwater data for the preceding 12-month period, July 1 through June 30, in an Annual Stormwater Monitoring Report. "The Report will present the analytical data, the Port's conclusions as to what is being learned from the data, and any new initiatives to be undertaken as part of the (SWPPP)." The Port will submit the report to Ecology by October 1. The Port has already completed and submitted four Annual Stormwater Monitoring Reports (POS, 1995, 1996b, 1997, and 1998c).

5. Monitoring Criteria

5.1. Representativeness criteria

The Port intends to perform all permit-required monitoring in such a manner that samples are adequately "representative of the volume and nature of the monitored parameters", per permit requirements (S2.F). To meet this goal, samples must be taken according to the following protocols and must meet specific representativeness criteria. In general the criteria follow according to this hierarchy and in this order:

1. First: the rainfall even must be a "target storm", and
2. second: the grab and composite samples must meet certain criteria governing the method and timing of the sampling process relative to the storm discharge hydrograph, and
3. third, the samples must not exceed maximum recommended holding times (see Section 6.8.1)

Samples may be rejected and deemed "non-representative" if they do not meet each of these criteria using best professional judgment. In order to meet maximum recommended holding times, the Port may elect to begin sample analysis before these sample checks can be made. In the event these samples do not meet the representativeness criteria, results will be deemed non-representative, and will *not* be reported on the DMRs. All stormwater data taken pursuant to the permit and this manual, including non-representative sample data, will be reported in the Annual Stormwater Report with data segregated appropriately.

5.2. Target Storm Events

The Port intends to monitor storm events that meet certain representativeness criteria. These "target storm" criteria are:

1. 0.20 inches or more total precipitation depth during a discrete rainfall event, and
2. a 24-hour antecedent period having no discrete rainfall events greater than 0.10".

The Port defines a <u>discrete rainfall event</u> (synonymous with "storm event") as that period of accumulated, measurable rainfall depth greater than 0.10" that is separated by more than 12 hours from the previous or next recorded measurable rainfall event. If within a particular rainfall sequence, there are one or more periods of rainfall cessation each less than or equal to 12 hours, the entire rainfall sequence is considered one storm event. There are no restrictions or criteria for total event duration, rainfall intensities, nor maximum rainfall depth.

If a particular rainfall event was sampled and the event did not meet these criteria, any sample results will be deemed non-representative and will not be reported on the DMRs. Instead, the results will be reported only in the Annual Stormwater Report.

In order to collect storm samples effectively during the dry season (May 1 to September 30), the Port may monitor storm events differently from the above criteria. Because certain subbasins have a high percentage of pervious surfaces, a 0.20" storm meeting the other criteria above may produce little or no runoff. Therefore, the Port will monitor certain outfalls until enough total rainfall produces a discharge suitable for sampling. In other words, unsuitable "storms" may be in fact the only events producing runoff during the dry season. This procedure allows the opportunity to avoid the paradox of not sampling and not reporting data in a period for which there has in fact been a discharge.

This scenario occurred at outfall 008 (SDN3) during the summer of 1996, where several storms of about 0.25" did not produce runoff significant enough to sample. This subbasin finally produced runoff after a 0.66" total rainfall over several days, yet there had been 48-hour antecedent rainfall of 0.35" from a discrete rainfall event. This sequence did not meet the target storm criteria, yet it produced the only runoff from SDN3 during the summer quarter. This phenomenon is due to the "variable source area" concept where pervious surfaces begin to generate runoff as they become increasingly saturated (Dunne et. al., 1975). Subbasin SDN4 (outfall 014) and others with a majority of pervious cover will be assumed to produce similar effects and storms may be targeted accordingly using best professional judgment.

5.3. Sampling Protocols and Criteria

Generally, the Port will utilize automatic stormwater samplers and flowmeters to take all samples for permit compliance and any other study. Automatic equipment permits sample collection at multiple sites concurrently, provides consistency, and reduces hazards to personnel by eliminating hazardous confined-space entry during storm runoff. Confined spaces prohibit personnel from direct access to the stormwater discharges for 6 subbasins, seeTable 3 At these locations, sample tubing and flowmeter probes are only accessible for installation and maintenance during safe, dry-weather periods. Sampling at the final "daylight" outfall in four of these subbasins would include an unreasonable amount of offsite, non-Port runoff. Safety will not be compromised during sampling opportunities.

Both grab and composite samples will be taken in washed glass bottles, using automatic samplers and Teflon sample intake tubing. Flow-weighted composites may be taken by automatic sampler, or by manual means as described in Section 6. To provide representative samples, the Port will strive to take grab and composite samples from the same storm discharge event at a particular outfall.

5.3.1. Grab samples

The Port will strive to take grab samples after the onset of the target storm discharge hydrograph, and at a point during the rising limb of the discharge hydrograph. This practice often gives an estimate of concentrations in the "first flush" of the storm discharge. Grab samples can be either taken manually or automatically. Constituents analyzed in the grab sample include TPH, and fecal coliforms as applicable at each outfall. See Table 2.

Because subsequent rainfall and runoff has no bearing on a grab sample taken at the onset of runoff, samples taken from storms with total rainfall less than the target amount are still representative. Often, grab sample analysis is begun before the event has ceased and total rainfall depths are known. Despite non-representative composites that result in these cases (because there is insufficient rainfall to meet the target depth), the grab sample data is still useful and can be aggregated with other grab samples as long as sampling protocols and representativeness criteria are met.

Automatic samplers will take grab samples in bottle 1 (and in bottle 2 when necessary) beginning when the sampler's "enable conditions" are satisfied. These "enable conditions" are sensed and transmitted by the accompanying flowmeter, and signal the onset of the target storm discharge hydrograph and may include depth, velocity, rainfall, or any logical combination thereof. Section 6.5.2 describes enable conditions and parameters for sampler programming.

Automatic grab samples will consist of a single aliquot or 4 individual 930-ml aliquots taken at 5-minute intervals. In certain cases, this multi-aliquot procedure ensures sufficient volume for analysis in the event that discharge depths drop below a level sufficient for effective automatic sample collection. Often in previously dry pipes, discharge depths can vary rapidly during the beginning of a storm resulting in levels too shallow to submerge the sampler's intake line.

Certain monitoring locations may have baseflow (groundwater) or backwater adequate enough to submerge intake tubing, however and samplers may be programmed to take the entire grab sample at one time. In this case, samplers may be programmed to delay the grab sample until enough runoff has flushed-out any backwater in a manhole or catch basin. When possible, the Port will take duplicate grab samples manually to corroborate data with automatic grab samples.

5.3.1.1.Representativeness criteria

Given a storm event that meets targeting criteria (Section 5.2), the Port's objective is that grab samples should meet the following representativeness criteria:

1. The grab sample should be taken after the onset of the storm hydrograph and not during prior baseflow, backwater or standing water if physically present and/or indicated by the flow data.
2. The grab sample should be taken during the first 30 minutes of discharge.
3. When #2 above is not possible for any reason, grab samples should at least be taken during the rising limb of the discharge hydrograph.
4. Grab samples taken from an event that is less than the target rainfall depth shall be considered representative and reportable, as long as the above three criteria are satisfied.

5.3.2. Flow-weighted composite samples

The Port's goal will be to take flow-weighted composite samples during the discharge produced by the target storm in each subbasin. Sampler configuration and programming allow compositing to continue over a fairly wide range of storm depths. See Section 6.5.2. Composites will typically consist of 10 to 30 equal-volume sample aliquots of 120 ml each taken at predetermined discharge or "flow-pacing" intervals. The Port's preferred method is to utilize automatic samplers to complete the composite samples. However, isolated cases may require manual or semi-automatic composite samples as described in Section 6.5.2

~~1.1.1.1.~~5.3.2.1. Representativeness criteria

Given a storm event that meets targeting criteria (Section 5.2), the Port's objective is that flow-weighted composite samples should meet the following representativeness criteria:

1. sample aliquots shall be taken over at least a three hour period, or
2. sample aliquots shall be taken over the entire storm hydrograph if either the rainfall hyetograph or discharge hydrograph is less than three hours in duration, and
3. sample aliquots shall be collected during at least two hours of the rising limb of the discharge hydrograph, and
4. sample collection can continue until the target storm depth is met, and
5. sample aliquots should not extend into the baseflow period after cessation of the storm hydrograph.

The Field Technician and Stormwater Monitoring Program Manager will review the discharge hydrograph to verify that samples meet these criteria. In order to meet maximum recommended holding times, the Port will use best professional judgment and may begin sample analysis before these sample checks can be made. In the event these samples do not meet the representativeness criteria, results will be deemed non-representative, and will not be reported on the DMRs, but will instead be reported in the Annual Stormwater Report.

6. Monitoring Procedures

Generally, the Port will persevere to fulfill required monitoring in a particular reporting period until the storm and sampling criteria are met for each applicable outfall. Sampling for a particular reporting period may continue into the next period if for example repeated difficulties with weather forecasts and equipment performance cause difficulty in meeting the criteria of Section 5.

6.1. Safety

Because stormwater sampling may take place at any time of the day, and any day of the week, certain safety precautions should be taken while performing fieldwork. The minimum personal protective equipment (PPE) listed below should be worn as appropriate during all fieldwork including equipment deployment and programming, and sample collection. In addition to this list, confined space entry requires special PPE and procedures described in Section 6.1.1.

- eye protection,
- steel-toed boots, and
- hearing protection.

Airport security does not allow access to the Air Operations Area (AOA) during low-visibility conditions or other emergency conditions possible during the inclement weather often associated with deicing or storm monitoring. Therefore, during restricted access periods or other times where safety could be compromised, samples may not be taken at applicable outfalls. The Port will err on the side of safety if any conditions are in doubt.

6.1.1. Confined space entry

Because 6 stormwater monitoring locations are below grade in confined spaces such as manholes, specific confined-space entry procedures must be followed. The Port's Health and Safety manual describes these procedures in detail. Personnel entering confined spaces must receive training prior to performing confined space entries. At a minimum, all confined space entries shall be conducted using the following:

- personal protective equipment listed above,
- hard hat, coveralls, rubber gloves,
- properly charged and calibrated personal air monitors, such as the Phd II,
- confined space permits,
- safety harness and fall protection and retrieval tripod,
- adequate ventilation, such as a blower,
- at least 2 assistants on the surface,
- traffic control where appropriate, and
- any other item or procedure specified by the Port's Health and Safety manual.

Table 3 lists the stormwater monitoring locations requiring confined-space entry to access remote monitoring equipment. Equipment deployed regularly in these confined spaces includes sampler intake tubing and strainers, flow measurement probes, and anchoring rings such as the ISCO scissor rings. This equipment must be serviced periodically during installation, or for cleaning and calibration. These confined spaces should not be entered during storm runoff periods. Automatic samplers or other remote means are the only acceptable methods available for sample retrieval during storm runoff periods.

Table 3 Confined Spaces: Monitoring Locations

Outfall name (number)	Location/structure[1]	Structure Type	Depth below surface, feet[2]
SDE4 (002)	SDE4-47	manhole	20
SDW3 (010)	SDW3-24	manhole, no ladder	8
SDN1 (006)	SDN1-22,	manhole	20
SDN2 (007)	SDN2-37	manhole	8
SDN4 (011)	SDN8-40	manhole	12
TY (013)	not designated	drain inlet	9

1. Structure designations are from drawing ST1A-9656, last updated 12/96. See also Table 1.
2. Approximate depths to the working area, which is above standing water in the sumps at SDN2-37, SDN4, and the TY drain inlet.

6.2. *Targeting Storms*

The Field Technician and Stormwater Monitoring Program Manager may use several resources to identify suitable target storm events. Several resources available on the Internet allow rapid determination of quantitative precipitation forecasts, antecedent rainfall conditions and general weather patterns likely to result in target storm events. These include:

- National Weather Service (NWS) Seattle Weather Forecast Office homepage (http://www..seawfo.noaa.gov/),
- the Sea-Tac Airport Meteogram (http://www.atmos.washington.edu/cgi-bin/latest.cgi?meteogram/SEA),
- the 2+ day outlook with meteogram (http://wxp.atms.purdue.edu/mos/meteogram/mos_met_SEA.gif)
- 11+ day outlook with meteogram (http://grads.iges.org/pix/seamrf3.gif), and
- "layman's forecast": (http://www.intellicast.com/weather/sea/)

In addition, over the telephone, NWS personnel can often provide estimates of anticipated rainfall amounts.

6.3. *Rainfall Measurement*

The Port measures rainfall with an ISCO 674L tipping-bucket raingage mounted on the rooftop of the Air Cargo 4 building. This raingage measures rainfall by counting the number of times a small arm tips after collecting 0.01" rainfall. The gage records the number of tips during a five-minute period and records data on an ISCO 4150 data logger. The sampling technician downloads the raingage after each monitored event, or at least once every 28 days. The raingage software can compress the data in any multiple of 5 minutes, allowing rapid evaluation of hourly or daily rainfall.

6.4. *Flow Measurement*

The Port uses ISCO flowmeters to gage discharges, send enabling and flow-pacing triggers, and record hydraulic and sample event data. Most sampling stations use model 4150 area-velocity flowmeters where high velocities or backwater form during storm discharge. This type of programmable flowmeter estimates discharge directly as the product of cross sectional area and velocity. Given the pipe dimensions, the 4150 probe's pressure transducer records depths that the flowmeter's computer translates into cross-sectional area. The probe also gages velocities using the Doppler principal with a reflected ultrasound pulse. Other less demanding hydraulic monitoring situations use Model 3230 or 4230 bubbler-type flowmeters and Manning or empirical stage-discharge equations.

6.5. *Automatic Stormwater Monitoring*

The Port utilizes ISCO Model 3700 automatic samplers and various models of ISCO flowmeters to implement the stormwater monitoring program. Typically, the Port's sampling stations use glass bottles and Teflon sample intake tubing for all samples. Grab samples will be taken in glass bottles, regardless of sampling method.

~~1.1.1.~~6.5.1.sampler configuration

The Port will configure ISCO automatic samplers using either of the "storm", "flow", or "time" programming options depending upon the sampling objective. See Table 4 below. The sampler will generally use the "storm" routine, where it first collects a grab sample, then continues to collect a flow-weighted composite sample over the course of the discharge. During deicing events with little or no precipitation, the Port may use samplers to collect time-composite samples. Certain situations may require the sampler to collect multiple discrete samples of constant volume that are manually flow-proportional composited according to AppendixA

Typically, the Port will use the four, 3.8L glass bottle configuration using the "storm" program. Using this routine, the flowmeter is programmed to "enable" the sampler depending upon discharge hydrograph conditions. Once enabled, the sampler takes the grab sample in bottle 1, and begins to take 120ml aliquots for the flow-weighted composite in bottles 2-4. The time interval between these aliquots is not programmable but is a function of the site-specific flow-pacing interval selected and the runoff hydrograph for the storm being monitored. Each of bottles 2-4 is an identical sample that can be combined into a single sample of sufficient volume, if necessary, or used as a QC duplicate sample.

6.5.2. Sampler Programming

6.5.2.1.sampler enable

The flowmeter is usually programmed to "enable" the sampler based upon depth of flow. Generally, the flowmeter is programmed to send this enable signal when the depth reaches 0.10 foot (1.2 inches) if the pipe is dry before the storm. If non-stormwater (baseflow or standing water) is present before the target storm begins, the enable level is set to 0.05 to 0.10 foot above it. The enable level should not be set at less than these values for two reasons: 1) lower levels are usually unreliable indicators of the beginning of a storm hydrograph, and 2) the equipment (especially 4150 flowmeters) is less accurate below 0.10 foot. Enable conditions can also be programmed as a function of velocity, total discharge, rainfall, time, and combinations thereof.

Table 4 Typical Sampler Configuration

Sampling Objective	Program Option	number of bottles	sample aliquot (ml)	number of samples per bottle	number of bottles per sample	hours sampled per bottle
quarterly, semi-annual, annual samples[1]	"storm"	4x 3.8L glass	120 every ΔV (note 2)	30	2 or 3[3]	varies as a function of ΔV
aircraft and ground deicing	time or flow[4]	4x 3.8L glass	120 every 20 min	24, 32, or other	1	6, 8, or other
Special purpose: semi-automatic	time	24 polyethy lene	1000	1	1	20 minutes to one hour[5]

1. Sampler takes grab in bottle 1, then completes composite in bottles 2-4
2. ΔV represents flow-weighted composite sample pacing, which is specific to each subbasin.
3. Two or three bottles per sample results in 2 or 3 identical composites that can be combined into a single sample, allowing runoff sampling over larger range of rainfall.
4. Deicing sampling will be flow-weighted if during a target storm event or time-composite if a baseflow, non-target storm, or dry-weather flow event.
5. Special purpose samples may be collected at discrete time intervals, usually 1 hour apart, then manually flow-weight composited if necessary.

6.5.2.2.grab sampling

Once enabled, the sampler should take the grab sample as quickly as possible. For sampling stations that typically have baseflow, standing water, or backwater (SDS3, SDS4, SDN3, SDN4, D, EY, and TY), the grab sample should be taken about 5 minutes after enabling. Delaying the grab in this manner prevents the sampler from taking a non-storm sample in the baseflow, backwater, or standing water. In pipes that are dry prior to the storm event, the grab sample should be composed of four 930-ml aliquots taken at time intervals of 2 to 5 minutes. Taking grab aliquots in this manner usually ensures a successful grab sample.

6.5.2.3.Flow-pacing

Flow pacing intervals will be chosen so that the sampler takes composite aliquots during a suitable period of the target storm discharge hydrograph. Because bottles 2-4 are essentially triplicates, they can be combined into a single sample of sufficient volume for analysis. In other words, with reasonably accurate estimation, flow-pacing intervals can be chosen so that samplers function over a wide range of anticipated storms from 0.20" up to approximately 0.6".

For example, to achieve sufficient sample volume of about 3.6 liters, the following computations are considered:

1. Minimum sample volume: 3.6L/3 bottles available = 1.2L/bottle
2. Minimum number of aliquots: 1.2L/bottle ÷120 ml/sample = 10 aliquots
3. Minimum flow pacing interval: if 0.20" rain results in about 25,000 gallons of runoff, then minimum pacing to achieve a sample representing the full duration of runoff corresponding to 0.20" is 25,000 gallons ÷10 aliquots = 2,500 gallons per aliquot.
4. Maximum runoff sampled: at a pacing of 2,500 gallons, the sampler's complete routine of 30 samples would sample up to 3X the target storm or about 0.6". This is very simplistic, but has worked very well in past experiences at STIA.

Samplers should be programmed to disable if more than 13 hours fall between sample aliquots, preventing sample collection from continuing into the next storm event. Time intervals between composite sample aliquots are not programmable, but are a function of the discharge hydrograph.

Flow pacing intervals vary for each subbasin and are a direct function of subbasin area, imperviousness, and hydrologic conditions. The flow-pacing interval must be selected to provide both sufficient total sample volume and sample duration over the hydrograph. Therefore, the total runoff volume must be estimated to select this interval. Typically, subbasins dominated by impervious surfaces require a fairly constant flow-pacing interval. Many of the airfield subbasins have grassed areas, often with drain inlets in these pervious areas (SDN3, SDN4, B, and D.) As a result, runoff volumes and flow-pacing intervals for a given storm depth vary seasonally as well as a function of antecedent conditions (soil saturation). Therefore, flow pacing intervals for certain outfalls must be adjusted downward for the drier, spring and summer months.

6.5.2.4.Semi-automatic compositing

Certain cases may require semi-automatic compositing. This procedure requires the collection of equal volume sample aliquots taken at equal time intervals. These aliquots are then combined manually in volumes proportional to the flow-rate at the time the sample was taken. In these cases, samples will be taken at equal time intervals of not more than 20 minutes and over a duration consistent with Section 5.3.2. Individual samples will then be taken to the laboratory or other suitable location for manual compositing. This method is recognized and accepted in the EPA NPDES Stormwater Sampling Guidance Document (USEPA, 1992). Plastic bottles will be employed for this compositing procedure using either automatic samplers or manual means of sample collection.

Table 5 Typical Flow Pacing

Outfall	Subbasin	Typical Flow Pacing Interval (gallons)
002	SDE4	20,000
003	SDS1	2,000
004	SDS2	2,000
005	SDS3	100,000
006	SDN1	2,500
007	SDN2	2,500
008	SDN3	1,500
009	SDS4	2,500
010	SDW3	2,000
011	SDN4	20,000
012	Eng Yard	1000
013	Taxi Yard	1000
014	subbasin B	2,000
015	subbasin D	2,000

Manual compositing will be proportional to the flow rate at the time the discrete sample was taken, or proportional to depth of flow according to the method of Tobiason, 1993. See Appendix A.

6.6. *Manual sampling*

Certain cases may require manual sample collection and manual flow-proportional compositing. This procedure is identical to Section 6.5.2.4 with the exception that the discrete samples will be collected manually. The Field Technician simply takes a fixed volume sample at constant time intervals of no more than 20 minutes, and records the flow rate or depth of flow. These discrete samples are then composited according to Appendix A. Manual grab samples will be collected in glass bottles.

6.7. *Deicing event monitoring*

As described in Section 4.5, the Port will monitor deicing events, both aircraft and ground related. The goal is to take a sample that estimates average glycol concentrations "during a precipitation event that coincides with a deicing/anti-icing event." The permit requires a composite sample for outfalls SDE4 (002), SDS3 (005), and SDN4 (011), and a grab sample at outfalls SDS1 (003), and SDN2 (007.)

Monitoring may take place during any type of precipitation event, including snow, sleet or hail, target rain storms, other rainstorms of undefined depth and antecedent conditions, or during baseflow or dry-weather flow conditions if dry-weather persists.

The type of deicing event monitored (aircraft or ground) depends directly upon the attendant atmospheric conditions. Therefore, monitoring will take place during these conditions, subject to the following exception. Airport security does not allow access to the Air Operations Area (AOA) during low-visibility conditions, or other emergency conditions likely during the inclement weather often associated with deicing. Therefore, during restricted access periods or other times where safety could be compromised, samples will not be taken at the following outfalls within the AOA: SDN2 (007), SDN3 (008), and SDN4 (011). Other outfalls will not be sampled if unsafe conditions exist outside the AOA.

The Port will analyze only total glycols (ethylene and propylene) in samples collected during deicing events. The permit requires no other tests. Samples will be either a 24-hour time composite sample, or when precipitation conditions allow, the Port will use a flow-weighted composite sample as described in Section 6.5. Time-composites ensure sufficient sample volume considering the uncertainties with precipitation forecasts and baseflow discharge estimates. Grab samples will be taken at SDS1 (003), and SDN2 (007), and when possible, composite samples to provide data comparable to past efforts. Previous data are from a variety of both grab and composite samples. According to the permit (S2.B.4, footnote b), grab "samples shall be collected in the first 60 minutes of the discharge event."

Time composite samples will be collected using automatic samplers using glass bottles. These time composites provide an estimate of average concentrations during the period sampled and are comprised of equal-volume sample aliquots taken at constant time intervals, usually every 15 to 20 minutes. The 24-hour time composite is thus a combination of up to 96 individual sample aliquots. During certain conditions, discharges at a particular monitoring point may be insufficient to collect individual aliquots at certain times. Even though equipment will be programmed to take samples over a 24-hour period, the actual discharge adequate for sampling may be less than 24 hours in duration. The field log, Figure 2, will record the type of sample and overall sampling periods.

6.8. Quality Assurance and Quality Control

The Port will strive to undertake the quality assurance (QA) and quality control (QC) procedures described below.

~~1.1.1.~~6.8.1. Containers, Sample Size, Preservation, and Holding Times

Generally, all stormwater samples will be collected in one-gallon glass bottles. All bottles and caps will be washed before sampling, using a commercial-grade, glass bottle-cleaning agent and thoroughly rinsed to remove surfactant residue. Bottles will then be rinsed with 10% nitric acid, followed by a final distilled or deionized water rinse. For safety and the best QA, the Port's analytical laboratory washes sample bottles.

Automatic stormwater sampling equipment will use only Teflon tubing for sample intake. An 18" to 24" section of flexible, medical grade silicone tubing is used in the non-contact peristaltic pump system. A 2" to 4" length of this same silicone tubing may be used as a flexible coupling to connect tubing segments at certain monitoring installations.

Grab and composite samples will be collected in one-gallon glass bottles when using automatic samplers. Sample preservation in the field is unnecessary due to the short holding times for fecal coliforms and BOD_5. The analytical laboratory will preserve and archive samples properly if necessary.

Holding times will be as specified in Appendix B of Ecology's Guidelines (WDOE, 1991). All samples will be retrieved and delivered to the laboratory for analysis in sufficient time to meet the shortest holding times applicable, typically 30-hours for fecal coliforms, and 48-hours for BOD_5.

~~1.1.2.~~6.8.2. Retrieving samples

Samples will be retrieved as soon as possible after sample completion to minimize and comply with required holding times. Sample bottles will be labeled and capped immediately. Samples will be placed in coolers with ice and maintained near 4°C. The Port will deliver the capped sample bottles directly to the analytical laboratory, or lab personnel may pick up the samples at STIA. Laboratory personnel will dispense aliquot volumes for analysis. This procedure prevents sample contamination in the field, speeds retrieval, and prevents analyte loss during dispensation. This procedure also allows the laboratory to archive extra sample volumes and promptly clean and return the empty 1-gallon sample bottles for the next use.

~~1.1.3.~~6.8.3. Sample Identification

Samples will be identified by outfall designation and a six-digit date code (mmddyy) designating the date the sample was collected. For example, "SDE4_010297 grab" indicates a grab sample taken from outfall SDE4 on January 2, 1997. In the case of composite samples collected into the next day, the identification shall be the date of the last composite sample aliquot. Other data including sample times, and grab or composite designation will be recorded on the chain of custody form. See Figure . In all cases, the sample time and date identity shall be that time and date that the last aliquot was taken. Sample identifiers are a primary key in the Port's ACCESS database.

6.8.4. Sample Custody

A chain-of-custody form will be completed for each set of samples delivered to or picked up by the commercial laboratory. See Section 6.9.3.

6.8.5. Analytical Procedures

Analytical methods shall comply with those specified in 40 CFR part 136 or in the 19th edition *of Standard Methods for the Examination of Water and Wastewater* (APHA, 1995) unless otherwise specified in the permit or approved in writing by the Department. Ethylene and propylene glycol analysis shall be according to the method approved by Ecology for Aquatic Research, Incorporated, on June 30, 1997.

6.8.6. Quality Control Procedures

6.8.6.1.Field QA Procedures

The Port will take the following field QC procedures to ensure consistency, reduce contamination, and ensure representative samples:

1. collect samples using automatic samplers,
2. collect samples in properly washed glass containers,
3. periodically clean and replace Teflon sampler tubing and strainers as necessary,
4. cool automatic samplers with ice when ambient temperatures require,
5. hold samples on ice in coolers during retrieval and delivery to laboratory, and
6. deliver samples to laboratory with proper chain of custody, and within recommended holding times.

6.8.6.2.Field QC Samples

The Port will take the QC samples listed below when sampling 5 or more outfalls. This policy results in QC samples being collected more frequently than the common 5% to 10% guideline.

1. Take one field (equipment) blank after a sampler completes it's routine for a storm event. A field blank will be collected using the automatic sampler to take a "sample" of de-ionized water from a clean container. The Port will have this sample analyzed for a partial or full suite of analytes. Field blank samples will be collected in the same bottle used for regular sampling.
2. Randomly duplicate a sample at one outfall during the storm event sampled. Because bottles 2-4 of the composite are triplicates, the Port will select one of these bottles for duplicate analysis at a particular outfall. When possible, program the sampler to take an extra grab sample as a QC duplicate sample.

6.8.6.3.Laboratory QC procedures

The Port's analytical laboratory will perform the following internal QC samples per their standard procedures:

- matrix spikes (to test for bias and interference),
- QC check standards (to test for accuracy),
- duplicate samples (to test for precision), and
- method blanks (to test for contamination).

Data for these laboratory QC samples will be recorded on each laboratory report and recorded in the Port's database.

6.8.7. Preventive Maintenance and Calibration

Preventive maintenance of flowmeters, automatic samplers, and analytical meters will be performed as specified by the manufacturer. Samplers and flowmeters will be calibrated according to the manufacturer's recommendations.

6.8.8. Data Assessment

Each sample and sampling routine will be compared to the representativeness criteria discussed in Section 5. Samples may be rejected and deemed "non-representative" if they do not meet each of these criteria. In the event samples do not meet the representativeness criteria, results will be deemed non-representative, and will *not* be reported on the DMRs. All stormwater data taken pursuant to the permit and this manual, including non-representative sample data will be reported in the Annual Stormwater Report.

Each data set collected for each event will be evaluated for values that appear atypical for the subbasin and STIA in general. The most recent Annual Stormwater Monitoring Report shows median concentrations and ranges for each analyte at each outfall. When results are higher than these values, appropriate actions will be taken, including re-analysis, blank corrections, etc.

6.9. *Record keeping*

The Port will keep the minimum records described below. The Port will retain all records for at least three years in accordance with Section 4.8 above.

~~1.1.1.~~6.9.1. Field Notebooks

The Field Technician will keep a handwritten field notebook. Information in this log will include: personnel present during the event, date, identification of samples collected, current and relevant antecedent weather conditions, and any other conditions or unusual circumstances. All field logs will be filed and retained by the Stormwater Monitoring Program Manager.

~~1.1.2.~~6.9.2. Sampling Event Log

The Field Technician will complete a one-page field log for every storm event sampled. Figure 2 shows the field log that will identify the storm date, rainfall data, and sampling event times for each applicable outfall. Sampler programming data will also be recorded in the spaces provided.

6.9.3. Chain-of-Custody form

The Field Technician will complete a chain-of-custody form for each storm event sampled. Figure 3 shows the chain of custody form which will accompany each set of samples. This form officially records changes in custody as samples are retrieved in the field and delivered to the analytical laboratory.

6.9.4. Analytical Data Reports

The Port will file and retain all analytical data reports for at least three years. Analytical data will be entered, stored, and retrieved in the Port's ACCESS database.

Storm Event ID/Date:		Rain Begin date:		Rain Begin time:		Total Rainfall Depth:	
48 hr Antecedent Rainfall (in.):		Rain End date:		Rain End time:			

updated 6/6/98

Setup Date	Outfall	monthly storm	Qtrly Storm	semi-ann storm	annual storm	monthly A/C deic	qtrly A/C deic	Runway Deic	Flow meter ID	Sampler ID	Enable date/time	Composite Sampling Begin	Composite Sampling End	Duration of Composite	Sample Rainfall Time	[illegible]	comments/observations
	SDE4 (002)								4150-1	3700-							
	SDS1 (003)								4150-11	3700-							
	SDS3 (005)								4230-1	3700-							
	SDS4 (009)								4150-2	3700-							
	SDN1 up(006)								4150-16	3700-							
	SDN2 (007)								4150-	3700-							
	SDN3 (008)								4150-	3700-							
	SDN4 (011)								3230-1	3700-							
	188B (014)								3230-	3700-							
	188D (015)								4150-	3700-							
	EY (012)								3230-	3700-							
	TY (013)								3230-	3700-							
	SDW3 (010)								3230-	3700-							
	SDS2 (004)								3230-	3700-							

Hydraulic Parameters

Outfall	Length (feet)	head (feet)	size (in)	[illegible] (gallons)	[illegible]	[illegible] (feet)**	Outfall	[illegible] (feet)	[illegible] (feet)	[illegible]	[illegible]	[illegible]
SDE4 (002)	25	20	48	15,000			SDN4 (011)			15" RCP	20,000 wet 2,500 dry	
SDS1 (003)	10	4	36	4,500		0.10	188B (014)				8,000	
SDS3 (005)	15	4	weir	33,000			188D (015)				3,000	
SDS4 (009)	20	8	36	18,000		current+0.1	EY (012)			8" RCP	1,000	
SDN1 (006)	17	11	36	2,500		0.08	TY (013)			12" cmp	800	
SDN2 (007)	12	8	24	1,500		0.10	SDW3 (0	14	7	30" RCP	5,000	
SDN3 (008)	23	8	48*	1,500		0.10	SDS2 (004)		5	12" cmp	3,000	

* Elliptical pipe: major dia = 48", minor = 36"

** to sample all of 0.20" rainfall, using runoff models used in DMRs. See QPACE.xls

Manning parameters:	n	S	d
EY	0.015	0.005	8"
TY	0.024	0.0083	12"
SDN4	0.012	0.18	15"
B	0.024	0.005	18"
SDS2	0.024	0.005	12"
SDW3	0.012	0.005	30"

Comments/Observations:

Figure 2 STIA Stormwater Monitoring Log

Port of Seattle Sea-Tac Airport Stormwater Program: Sample Chain of Custody Record

Laboratory: Aquatic Research Inc., 3927 Aurora Ave. N, Seattle, WA 98103 206-632-2715

Project: ___NPDES ___Spill ___Other Date:____________ Page ___ of ___
Contact: Scott Tobiason, 728-3171 Case File#______
Sampling Personnel:______________________

Turnaround Requirements:
___48 hour ___5 day ___2 week ___Standard

								Analyses Requested													Visual Observations***						
Item	Sample ID	[illegible]	Grab/Comp	Date Taken	Time*	[illegible]	Matrix	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Turbidity	BOD5	Total Recov Cu	Total Recov Pb	Total Recov Zn	Total Glycols	Susp Solids (0-5)	Turbidity (0-5)	Color (hue)	Sheen (0-5)	Odor (type)	Foam (0-5)	Other
1							w																				
2							w																				
3							w																				
4							w																				
5							w																				
6							w																				
7							w																				
8							w																				
9							w																				
10							w																				
11							w																				
12																											

* Time sample completed if composite

*** note presence and magnitude: 0 = absent, 5 = present to considerable degree

	Relinquished by:	Received by:	Relinquished by:	Received by:
[illegible]				
[illegible]				
[illegible]				
[illegible]				

Miscellaneous Notes:

Figure 3 STIA Chain of Custody Record

7. Data Reporting

7.1. Censored Data

Censored data are those values reported by the analytical lab that are below the method detection limits (MDL), or are greater than the highest value provided by the analytical procedure. The term "left censored" refers to values below the MDL, while "right" or "high" censored means values greater than the maximum analytical value. When reporting and analyzing censored data there are various simple methods and statistical procedures available. The Port will use a simple method when computing any mathematical results that combine censored data with non-censored data.

When a result is left censored, its true value will be assumed to be one-half of the MDL, or other value qualified with a "less than" symbol. For example, the true value of a lead result of "<0.001 mg/l" will be assumed to be 0.0005 mg/l when computing totals, averages, medians, coefficients of variation, etc.

When a result is right or "high" censored, its true value will be assumed to be the value reported. For example, the true value of a BOD_5 result of ">50 mg/l" will be assumed to be exactly 50 mg/l. These cases are rare and generally apply only to BOD5 results. Because the "strength" of the BOD_5 in a particular sample is unknown, the initial dilution used in the analytical procedure may be insufficient to prevent complete oxygen depletion in the sample within the 5-day incubation period. Hence, the true value is unknown. The 48-hour sample holding time generally prohibits re-analysis if the initial dilution proves insufficient.

If an aggregate parameter has each individual analyte result left censored, then the aggregate value will be reported and treated mathematically as the sum of the two left-censored results. For example, in using the NWTPH-Dx method the analytical laboratory reports results as individual diesel and motor oil ranges, each with a different MDL. However, the aggregate TPH value is reported on DMRs as the sum of these two values. If both values were reported by the analytical laboratory as left censored, i.e. "<0.05 mg/l" and "<0.11 mg/l", the sum reported on the DMR would be <0.16 mg/l. This convention also applies for Total Glycols, which is the aggregate of ethylene and propylene glycols (though each individual result is reported on the DMR.)

7.2. Annual Stormwater Monitoring Report

All stormwater data taken pursuant to permit condition S2.B, S3.E and this manual, including non-representative sample data, will be reported in the Annual Stormwater Report. This report will encompass data taken from July 1 in the prior year to June 30 in the current year. The Port will submit this report to Ecology by October 1 each year. The Port has already completed 4 successive Annual Reports (POS, 1995, 1996b, 1997, and 1998c)

7.3. Discharge Monitoring Reports (DMRs)

The Stormwater Monitoring Program Manager will complete DMRs and submit them to the Aviation Surface Water Program Manager. Laboratory reports for metals results shall accompany the DMRs. The Aviation Stormwater Program Manager will review the completed DMRs, obtain appropriate signatures, and submit them to Ecology by the 30th of the month following the particular reporting period. Section 4.7 lists the DMR reporting and submittal schedule.

The DMRs will report maximum and average (new requirement in 1998) analyte values for monitoring data only from storms and samples that meet the specific representativeness criteria (see Section 5.3). Because the DMRs require maximum and average parameter values, the data reported for a particular outfall might comprise more than one storm sample. The Port will indicate low or high censored results according to Section 7.1 above, appropriately qualified with the less-than ("<") or greater-than (">") symbols.

When outfalls are not sampled in a particular period, or a certain parameter was not analyzed, the Port will indicate such by stamping "NA" in the parameter column, and "0/90" in the frequency column of the quarterly DMR for example. These null values will indicate that the Port has no representative data in the reporting period, for a particular outfall or analyte that meet the criteria of Section 5. Doing so does not necessarily indicate that the Port failed to take a sample, but more than likely indicates those sampling attempts were unsuccessful. The Port will annotate the particular DMR page with a footnote explaining why required data is absent.

In a reporting period where no "storm" discharges occur (rainfall less than the target storm), the Port will indicate such by checking the "no discharge" box on the DMR page for the particular outfall. During the dry season, certain outfalls may not produce runoff, despite the presence of a "target storm." If the Port's monitoring data confirms this fact, then the "no discharge" box will be checked on the DMR.

7.3.1. Reporting glycol data on DMRs

The DMRs require glycol data reporting for 5 outfalls: SDE4, SDS3, SDN4, ,SDS1 and SDN2 on the quarterly DMRs. As stated in Section 4.5, to fulfill these requirements, the Port will only sample aircraft deicing events when they occur *within* the drainage area of the particular stormwater subbasin. Aircraft are not deiced within subbasins SDE4, SDS1, SDS3 nor SDN4. Only outfall SDN2 could be subject to direct aircraft deicing, and *only* if aircraft are deiced in the North Cargo area on a day with rainfall intense enough to cause the North Cargo Pump station to bypass peak flows from this IWS area to SDS outfall SDN2.

7.3.2. Acknowledging North Cargo Pump Station Bypasses on the DMR

When the North Cargo Pump station experiences a bypass to the SDN2 outfall, it will be indicated on the DMR by inserting "yes" in the "yes/no" box on the quarterly DMR, page 2, for outfall 007 (SDN2). Flow monitoring at this outfall is only required to the extent necessary to indicate bypasses. When affirming such a bypass, the Port will also add a footnote to the DMR that indicates if deicing activity took place within the area served by the pump station on the day the bypass occurred. If no deicing activity took place within the pump station service area on the day of the bypass, the Port will indicate this in a footnote. This latter indication is important because it shows that the Port was not required to sample the bypass for glycols according to condition S2.B.4. This condition applies only to aircraft deicing events as defined in Section 4.5.

References

Dunne et al., 1975. Recognition and Prediction of Runoff-Producing Zones in Humid Regions. T. Dunne, T.R. Moore, and C.H. Taylor. Hydrological Sciences Bulletin, Volume 20, No. 3, 1975

POS, 1995. Annual Stormwater Monitoring Summary Report: Water Quality Data of the Discharges from the Storm Drain System. Prepared for the Port of Seattle by Resource Planning Associates, Seattle, WA. August 30, 1995.

POS, 1996a. Procedure Manual for Stormwater Monitoring at Sea-Tac International Airport. Prepared for the Port of Seattle March 7, 1997. Reviewed and approved by the WA Department of Ecology on March 24, 1997 (WDOE, 1997)

POS, 1996b. Annual Stormwater Monitoring Report for Seattle-Tacoma International Airport for the Period July 1, 1995 through June 30, 1996. Prepared by Scott Tobiason, Port of Seattle, Seattle, WA. November 18, 1996.

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WDOE, 1991. Guidelines and Specifications for Preparing Quality Assurance Project Plans. Washington State Department of Ecology, Environmental Investigations and Laboratory Services Program, Manchester, WA. May 1991.

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Flow-rate proportional compositing

Figure 4 shows a spreadsheet programmed for manually forming a flow-weighted composite sample using discrete sample aliquots collected at constant time intervals. The method can be accomplished using either manually collected or automatically collected discrete samples, as long as flow rates are recorded at the time of collection. Discrete sample aliquots are then calculated so that each can be measured and dispensed into a compositing container, arriving at a desired volume. The spreadsheet automatically calculates the flow-proportional volume to pour-off as an aliquot from each discrete sample, and shows the total volume of the mixed composite. If desired, one can manipulate volumes to achieve the desired composite sample volume, while leaving enough of the discrete samples for individual analysis.

Depth-proportional compositing

In an evaluation of flow-weighted compositing methods, Tobiason, 1993, found that a depth-proportional composite was equivalent to the flow-rate proportional composite of the EPA guidance manual (USEPA, 1992). Using the approach and equations presented below, Tobiason derived the depth-proportional method based upon the Manning equation (Manning, 1895), for use in round pipes. The method can be applied to other situations where a stage-discharge relationship is known or estimated. The advantage of depth-proportional compositing is that it eliminates the uncertainty of estimating the slope and roughness when using the Manning equation.

Furthermore, multiple-parameter flow meters often lose Doppler-velocity signals, or fall out of range, registering only a stage, or depth signal. Without accurate velocities, direct estimates of flow rate are questionable. However, if stage is recorded accurately, it can be used to develop dimensionless ratios of flow rates at the particular times of interest, for example when discrete samples were collected. These ratios result from the equations below, and are identical to those used in the flow-rate proportional compositing method of the EPA guidance manual. This method is demonstrated in Figure 3.6 and the following equations:

For a round pipes::
r = pipe radius = d + h
h = depth of flow (less than full)
W = wetted perimeter
A = cross sectional area of flow stream
R = hydraulic radius, = A/W
S = slope of water surface, dimensionless
n = Manning roughness, dimensionless

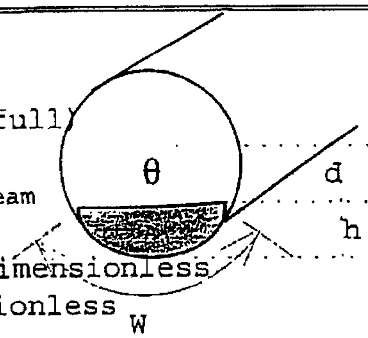

Figure 3 Geometry of Round Pipes and Manning Equation Parameters

Equation 1: Manning Equation (in metric form)

$$Q = \frac{AR^{2/3}S^{1/2}}{n} = kAR^{2/3}$$

$$\text{where} \quad k = \frac{S^{1/2}}{n}$$

Using Equation 1, the ratio of any two flow rates is:

$$\frac{Q_1}{Q_2} = \frac{A_1 R_1^{\ 2/3}}{A_2 R_2^{\ 2/3}}$$

Using the definition of the hydraulic radius, R = A/W, the equation reduces to

Equation 2

$$\frac{Q_1}{Q_2} = \left(\frac{A_1}{A_2}\right)^{5/3}\left(\frac{W_2}{W_1}\right)^{2/3}$$

By geometry, the shaded cross sectional area of the flow stream in Figure 3 is:

Equation 3

$$A = \tfrac{1}{2} r^2 (\theta - \sin\theta)$$

$$\text{where} \quad \theta = 2\cos^{-1}\left(\frac{d}{r}\right)$$

By geometry and using Equation 3, the wetted perimeter, W, in Figure 3 is:

Equation 4

$$W = 2r\cos^{-1}\left(\frac{d}{r}\right) = r\theta$$

Combining Equation 3 and Equation 4 into Equation 2 gives the ratio of any two flow rates as a direct function of the wetted angle, θ, for all depths up to a full pipe:

Equation 5

$$\frac{Q_1}{Q_2} = \frac{(\theta_1 - \sin\theta_1)^{5/3}}{(\theta_2 - \sin\theta_2)^{5/3}}\left(\frac{\theta_2}{\theta_1}\right)^{2/3}$$

With this relationship of Equation 5, the ratio of any two flow rates, i.e., Q_i/Q_{max}, is estimated in terms of the angles θ_1 and θ_2. These angles are readily computed using only the measurements of stage (depth of flow). Therefore, Equation 5 systematically relates any two flow rates using the Manning equation and the only independent variable, the depth of flow. This approach assumes that the roughness and slope are constant over all depths of flow, which is common practice using the Manning equation.

Though somewhat daunting to calculate manually, Equation 5 is easily programmed as a function in a spreadsheet program. Figure 4 shows the same example of a compositing spreadsheet as above, but using Equation 5, it requires one to simply input the stages or depths of flow recorded at the time of sampling.

Manual Flow-Proportional Composite Sample Worksheet (Tobiason, 1993)

Input Pipe Diameter, cm: 45

Discrete Sample Data		Flow-Rate Proportional Composite		
Bottle #	time	Q, LPS	QI/Qmax	aliquot vol, mL
1	20:30	4.06	0.01	7
2	20:45	7.98	0.03	14
3	21:00	11.05	0.04	20
4	23:15	17.68	0.06	32
5	23:30	21.18	0.08	38
6	23:45	15.16	0.05	27
7	0:00	17.68	0.06	32
8	0:15	103.30	0.37	186
9	0:30	127.08	0.46	228
10	0:45	122.89	0.44	221
11	1:00	197.99	0.71	356
12	1:15	235.18	0.84	422
13	1:30	133.96	0.48	241
14	1:45	121.62	0.44	218
15	2:00	213.87	0.77	384
16	2:15	278.34	1.00	500
	Qmax	278.34	TOTAL	2885
	Volmax	500		

Depth-Proportional Composite			
Flow Depth, cm	θ	QI/Qmax	aliquot vol, mL
2.5	0.67	0.01	6
3.5	0.79	0.02	12
4.1	0.86	0.03	17
5.1	0.96	0.06	28
5.5	1.00	0.06	32
4.7	0.92	0.05	23
5.2	0.97	0.05	29
12.1	1.50	0.34	170
13.4	1.58	0.42	210
13.2	1.57	0.41	204
16.9	1.79	0.68	339
18.6	1.89	0.82	411
13.6	1.60	0.43	217
13.3	1.58	0.41	207
17.7	1.84	0.74	372
20.5	1.99	1.00	500
θmax	1.99	TOTAL	2742
Volmax	500		

Instructions:

1. Input pipe daimeter, in centimeters
2. Enter sample times, flow rates "Q", and/or depths of flow recorded when each discrete sample was taken. This sheet uses metric, but any consistent units will work.
3. Enter desired maximum aliquot size, "Volmax", in ml. For example, setting Volmax =500 leaves 1/2 liter in a one liter discrete sample available for indivdual analysis.
4. Make sure composite volume, "TOTAL", = desired minimum sample volume, or increase Volmax
5. Measure out and mix composite sample using "aliquot vol" for each discrete sample.
6. See Tobiason, 1993 for equations nested in this worksheet.

Figure 4 Spreadsheet for Flow Rate and Depth-Proportional Compositing

References:

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