Appendix H to
2012 King County Long-term CSO Control Plan Amendment

Post Construction Monitoring Plan for King County CSO Controls

September 2012

FINAL

King County

Department of
Natural Resources and Parks
Wastewater Treatment Division

For comments or questions, contact:
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September 28, 2012

Karen Huber, Lead
King County CSO Program
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Re: Post-Construction Monitoring Plan for King County Combined Sewer Overflow (CSO) Controls - APPROVAL

Dear Ms. Huber:

Pursuant to condition S18.K.3.a of King County's NPDES permit, WA-02918-1, the required CSO Post-Construction Monitoring Plan (PCMP) was submitted to the Department of Ecology (Ecology) on June 30, 2010 for review and approval. Ecology reviewed the draft PCMP and provided comments on September 22, 2010. The County responded to Ecology's comments eighteen months later by providing a revised draft to Ecology on March 30, 2012. Ecology issued comments on the revised draft PCMP on July 30, 2012. The final PCMP document was received by Ecology on September 18, 2012. Ecology has reviewed the final PCMP (September 2012) for consistency with the permit requirements and is hereby **approved** for use as a general plan to conduct post-construction monitoring near the County's CSO outfalls. Enclosed please find an approved copy of the final PCMP for your records.

King County's NPDES permit condition S18.K.3.b requires the County to implement the PCMP after Ecology approval. Specifically, the County is required to submit a CSO PCMP Data Report no later than August 31, 2012. As this compliance date has passed, please provide the required PCMP data report as soon as possible.

Ecology reserves the right to require additional monitoring and other types of monitoring activities if the water and sediment quality standards are not being met.

If you have any questions concerning this approval, please contact Mark Henley at (425) 649-7103 or via e-mail at Mark.Henley@ecy.wa.gov.

Sincerely,

Kevin C. Fitzpatrick
Water Quality Section Manager

KCF:MH:bl
Enclosure: Post-Construction Monitoring Plan for King County Combined Sewer Overflow (CSO) Controls (dated September 2012)

cc: Central Files, King County, WA-02918-1, WQ 3.1

e -cc: Betsy Cooper, King County
Rob Grandinetti, EPA
Mark Henley, Municipal Unit Supervisor, Ecology
Alison Evans, Facility Manager, Ecology

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Summary

King County's post construction monitoring plan is designed to assess, document, and report on the effectiveness of its combined sewer overflow (CSO) control program in achieving performance requirements and complying with state water and sediment quality standards.

Post construction monitoring to be conducted at each CSO is summarized in the following table. All CSO locations will be monitored for onset, duration, and volume of the discharge. In addition, discharge locations that provide CSO treatment will be monitored for influent and effluent quality. Sampling of the wet-weather discharges will be done in coordination with sampling for NPDES permit compliance. In addition to this monitoring, King County will continue to collect precipitation data at an equivalent level to the existing network of rain gauges and will continue its ongoing ambient monitoring program.

Post Construction Compliance Monitoring Plan

Medium	Post Construction Monitoring to be Conducted
CSO discharge	Untreated CSOs controlled to one overflow per year or less: Overflow onset, duration, and volume using SCADA and portable meters Treated CSO discharges: Overflow onset, duration, and volume using SCADA Influent and effluent quality sampling; reasonable potential analysis to assess compliance with water quality standards
Sediment	Sites with adequate characterization and no existing SMS exceedances: No sediment monitoring Sites with existing SMS exceedances or inadequate sediment characterization: Project-specific pre-construction (if needed) and post-construction sediment monitoring used to determine if SMS still exceeded; a site specific cleanup plan if needed
Receiving water	Ongoing ambient monitoring programs and sampling specified in the NPDES permit

SCADA = supervisory control and data acquisition system.

Assumptions used to develop the plan are as follows:

- CSOs controlled to no more than one untreated event per year on average will request and be granted an average once per year exemption to the numeric mixing zone size criteria described in Section 173-201A-400 WAC and will be deemed to comply with receiving water quality standards. Monitoring for these sites focuses on characterizing the quantity and frequency of discharges.
- The effectiveness of the CSO control at treated CSO sites is to be assessed by monitoring their ability to provide the equivalent of primary treatment— at least 50 percent removal of the total suspended solids and discharges less than 0.3 mL/L/hr of settleable solids on an annual basis—and on other NPDES permit limits that apply to the effluent.

- King County will evaluate treated CSO compliance with state water quality standards by conducting a reasonable potential analysis based on the treated effluent quality data and existing ambient quality data.
- Data from previous studies and from ongoing monitoring programs are sufficient to characterize ambient water quality in receiving waters.
- At locations where SMS are currently met with an uncontrolled CSO, the activity of reducing the CSO discharge to achieve control will not degrade the existing sediment quality.
- All CSOs currently meeting SMS will be evaluated for the potential of new upstream sources discharging to the combined sewer system, or other factors adversely affecting sediment quality on a case-by-case basis.

Monitoring data and evaluation will be reported to the Washington State Department of Ecology through the monthly discharge monitoring reports, annual CSO reports, and CSO plan updates. The post construction monitoring plan will be updated periodically to reflect changing conditions and requirements.

1 Introduction

King County's wastewater collection and treatment system currently has 38 combined sewer overflow (CSO) locations and 4 CSO treatment plants. Their outfalls discharge to Lake Washington, Lake Union, Lake Washington Ship Canal, Duwamish River, Elliott Bay, and Puget Sound. The county is working toward controlling all its CSO locations by 2030 to meet the Washington State standard of no more than one untreated overflow on average per year at each location. These CSOs are regulated through the National Pollutant Discharge Elimination System (NPDES) permit for the West Point Treatment Plant.

In response to the Clean Water Act of 1972, the Municipality of Metropolitan Seattle (Metro) adopted the *Combined Sewer Overflow Control Program* in 1979. Since adoption of this first program, Metro and then later King County have modified plans to respond to evolving CSO regulations and wastewater system needs. The most recent CSO control plan was adopted in 1999 as part of the county's Regional Wastewater Services Plan (RWSP) and was updated in 2000 and 2008 as a part of the West Point plant's NPDES permit renewal.

This document describes a post construction compliance monitoring plan to measure the effectiveness of CSO controls and to provide information for use in demonstrating compliance with state water and sediment quality standards.

The following sections in this chapter provide background on the impetus for the plan, regulations that guide environmental protection and CSO control, and locations and control status of county CSOs.

A History of CSO Plans

1979—Metro adopted its first *Combined Sewer Overflow Control Program.*

1985 and 1986—The *Plan for Combined Sewer Overflow Control* and the *Supplemental Plan for Combined Sewer Overflow Control* were prepared as part of a system-wide planning effort

1988—The *1988 Combined Sewer Overflow Control Plan* was prepared in response to Ecology's 1987 definition of control as one untreated discharge per year.

1995—As part of the 1995 West Point NPDES permit renewal, King County prepared an update and amendment to the 1988 plan.

1999—A CSO control plan was adopted as part of the Regional Wastewater Services Plan (RWSP). The plan lists 21 control projects to bring all CSOs into control by 2030.

2000—The RWSP CSO control plan was updated as part of the West Point NPDES permit renewal. No changes to the RWSP CSO control plan were recommended.

2006—The first CSO control program review was completed.

2008—The RWSP CSO control plan was updated as part of the West Point NPDES permit renewal. No changes to the RWSP CSO control plan were recommended.

1.1 Background

The U.S. Environmental Protection Agency (EPA) requires CSO communities to conduct a post-construction monitoring program for their controlled CSOs to "verify compliance with water quality standards and protection of designated uses as well as to ascertain the effectiveness of CSO controls" (Section II.C.9 of the CSO Control Policy). In accordance with this requirement, Section 18.K of the West Point NPDES permit requires King County to implement a post construction compliance monitoring program and to prepare a plan that describes the program:

> The Permittee must implement a post construction compliance monitoring program adequate to verify compliance with water quality standards and protection of designated uses as well as ascertain the effectiveness of CSO controls. This water quality compliance monitoring program must include a plan that details the monitoring protocols to be followed, including

> the necessary effluent and ambient monitoring and, where appropriate, other monitoring protocols such as biological assessments, whole effluent toxicity testing, and sediment sampling. The plan must be reviewed and approved by Ecology….The plan should include a discussion of controlled outfalls that may be influenced by other County or City of Seattle uncontrolled outfalls that may adversely influence or interfere with the water quality assessment of controlled outfalls. The Permittee must provide adequate justification for not performing post construction monitoring for controlled CSO outfalls where water quality may be impacted by nearby outfalls.

The post construction monitoring plan described in this document groups CSO controls into two categories to evaluate their effectiveness. One category consists of the implementation of conveyance system improvements, including storage or Green Stormwater Infrastructure (GSI), with the objective of reducing the average number of overflows to no more than one untreated event per year on average as specified in WAC 173-245-020(22). Compliance will be based on a 20-year moving averaging period, including past years and the current year. It is assumed that for CSOs controlled to this standard the County will request and the State will grant the mixing zone exemption described in WAC 173-201A-400 (see "Regulations" below) and the CSO will be deemed to meet the surface water quality standards. Monitoring for these types of controls focuses on characterizing the quantity and duration of discharges, monitoring the condition of the GSI-managed area, as well as the confirmation that there are no exceedances of sediment management standards at the outfall due to the CSO. If the CSO appears to have contributed to existing SMS exceedances, then such contamination will be remediated.

The second type of control consists of a CSO treatment facility that is designed to provide the equivalent of primary treatment and disinfection. Monitoring for this type of control focuses on characterizing the quantity, duration, and quality of both the influent and treated effluent. The effectiveness of the CSO control is to be assessed from the ability to provide the equivalent of primary treatment: at least 50 percent removal of the total suspended solids (TSS) and discharges less than 0.3 mL/L/hr of settleable solids. In addition, the treated effluent must meet any limits defined in the NPDES permit that the reasonable potential analysis identified as being needed.

Monitoring activities designed to demonstrate compliance with water quality standards include effluent and sediment sampling. A reasonable potential calculation is proposed as the methodology to demonstrate compliance with surface water quality standards. Compliance with sediment quality standards will be demonstrated through sediment sampling combined with model predictions.

1.2 Regulations

In Washington State, the planning and design of the CSO controls are required to follow the requirements set out by the Washington State Department of Ecology (Ecology) in Chapter 173-245 WAC, submission of plans and reports for construction and operation of combined sewer overflow reduction facilities. These regulations include requirements for flow monitoring, hydraulic model development and verification, sampling of pollution levels, and sediment sampling if historical contamination may be present.

Once the Ecology-approved designs are constructed, WAC 173-201A-010 requires compliance with Chapter 173-201A WAC, water quality standards for surface waters of the State of

Washington; Chapter 173-204 WAC, sediment management standards; and applicable federal rules. These regulations are described below.

1.2.1 Regulations for Planning and Design of CSO Control Facilities

The plans and specifications developed during project design must conform to the guidance in the *Criteria for Sewage Works Design* (WAC 173-245-050), which states that "compliance with the state water quality standards is a requirement that must always be achieved" (C3-1.2.3). Analyses of how the design will meet applicable criteria are submitted to Ecology prior to project construction as part of a project-specific engineering report or facility plan. The NPDES permit sets conditions and permit limits to assure the goals and requirements are met. Following project completion, post construction monitoring assesses whether the CSO control is operating as designed and complies with state water quality standards.

Regulations Related to CSO Control

Clean Water Act (CWA)—Adopted in 1972 to eliminate the discharge of pollutants into the nation's waters and to achieve and maintain fishable and swimmable waters.

National Pollutant Discharge Elimination System (NPDES)—The Washington State Department of Ecology (Ecology) implements the CWA by issuing NPDES permits to wastewater agencies and industries that discharge effluent (including CSOs) to water bodies.

Water Quality Standards—To implement CWA, Ecology has developed biological, chemical, and physical criteria to assess a water body's health and to impose NPDES permit limits accordingly.

State CSO Control Regulations—Ecology requires agencies to develop plans for controlling CSOs at the earliest possible date so that an average of one untreated discharge per year occurs at each location.

Wet Weather Water Quality Act of 2000—The U.S. Environmental Protection Agency (EPA) requires agencies to implement Nine Minimum Controls and to develop long-term CSO control plans.

Sediment Quality Standards—Ecology developed chemical criteria to characterize healthy sediment quality and identified a threshold for sediment cleanup. King County has participated in sediment cleanup at some of its CSO locations.

Endangered Species Act (ESA)—Some species of fish that use local water bodies where CSOs occur have been listed as threatened under ESA.

1.2.2 Water Quality Regulations

Washington State surface water quality standards, Chapter 173-201A WAC, require meeting quantifiable standards as well as protecting the designated use of a water body. The standards include both numeric and narrative criteria (Appendix A).

Water quality standards must be met at the point of discharge or at the edge of a mixing zone. The standards include language that exempts one CSO discharge per year on average from the numeric water quality standards to align with the state CSO control standard. The exemption is implemented as a mixing zone of unlimited extent in WAC 173-201A-400 (mixing zones) which specifically applies to controlled CSO discharges:

> (11) Combined sewer overflows complying with the requirements of Chapter 173-245 WAC, may be allowed an average once per year exemption to the numeric size criteria in subsections (7) and (8) of this section and the overlap criteria in subsection (9) of this section, provided the discharge complies with subsection (4) of this section.

Referenced subsection (4) reads as follows:

> (4) No mixing zone shall be granted unless the supporting information clearly indicates the mixing zone would not have a reasonable potential to cause a loss of sensitive or important habitat, substantially interfere with the existing or characteristic uses of the water body, result

in damage to the ecosystem, or adversely affect public health as determined by the department.

Treated CSO discharge events, which may occur multiple times per year, are evaluated against water quality standards. The numeric size criteria exemption of a mixing zone is not applied to treated CSO discharge events, and water quality standards will be evaluated at the boundary of the mixing zone. The applicability of numeric standards to CSOs are as follows:

- The acute aquatic life numeric standards are applicable because of the intermittent and short duration (typically less than 48 hours) of CSOs.
- The chronic aquatic life standards, intended to be protective of four-day exposure durations (Ecology, 2008, Table VI-4), typically would not be applicable to shorter duration discharges.
- The human health criteria are based on lifetime exposure and are evaluated with the annual/maximum monthly effluent averages (Ecology, 2008, Table VII-1) and are not appropriate for CSO discharges.

Narrative criteria are designed to protect all existing and designated uses and are given in WAC 173-201A-260 (2) for fresh and marine waters (see Appendix A):

(a) Toxic, radioactive, or deleterious material concentrations must be below those which have the potential, either singularly or cumulatively, to adversely affect characteristic water uses, cause acute or chronic conditions to the most sensitive biota dependent upon those waters, or adversely affect public health (see WAC 173-201A-240, toxic substances, and 173-201A-250, radioactive substances).

(b) Aesthetic values must not be impaired by the presence of materials or their effects, excluding those of natural origin, which offend the senses of sight, smell, touch, or taste (see WAC 173-201A-230 for guidance on establishing lake nutrient standards to protect aesthetics).

The 1972 federal Clean Water Act requires states to prepare a list of water bodies that do not meet water quality standards for ensuring the water is healthy for such uses as fish and wildlife habitat and recreation in and on the water. Water bodies identified on the list must attain water quality standards within a reasonable period, either through a water cleanup plan based on total maximum daily loads (TMDLs) or other pollution control mechanisms. Water cleanup plans describe the type, amount, and sources of water pollution in a particular water body; analyze how much the pollution needs to be reduced or eliminated to meet water quality standards; and provide targets and strategies to control the pollution (Ecology, 2002).

Ecology compiles environmental data, including King County's, into a database named EIM. Violations of water quality standards identified through these data form the basis for the state's 303(d) list of impaired water bodies. The most recent list was published in 2008 and covers both fresh and marine waters. Subsequent to the 2008 listing, Ecology decided to publish assessments of marine waters and fresh waters in alternating two-year cycles, starting with a marine water assessment in 2010.

All of the receiving water bodies for county CSOs have listings for impairment because of fecal coliform bacteria levels. Water column samples also indicate impairment for dissolved oxygen (Duwamish Waterway), pH (Duwamish River), total phosphorus (Lake Washington and Lake

Union),[1] lead (Lake Washington Ship Canal and Lake Union), and aldrin (Lake Union). The Duwamish Waterway has listings for impairment from a wide variety of chemicals detected in sediment and tissue samples. In addition, there are a few sediment and tissue listings at discrete locations in Lake Washington and Puget Sound.

1.2.3 Sediment Quality Regulations

Regulation of contaminated sediments in the marine environment of Washington State typically falls under the authority of Ecology. In 1991, Ecology adopted the Sediment Management Standards (SMS; Chapter 173-204 WAC) for designating marine sediments that have acute or chronic adverse effects on aquatic organisms. Ecology has begun the process of creating a consistent set of standards for freshwater sediments (Ecology, 2011). Currently, state standards for freshwater sediment quality are determined on a case-by-case basis (WAC 173-204-315).

Three sets of standards were established under the SMS: sediment quality standards, sediment cleanup standards, and source control standards (Ecology, 2007):

- Sediment quality standards (SQS) correspond to a sediment quality that will result in no adverse effects, including acute or chronic adverse effects, on biological resources and no significant health risk to humans. The SQS includes chemical concentration criteria for 47 chemicals. If sediment chemical concentrations exceed SQS criteria, the sediments are designated as potentially having an adverse effect on biological resources and fail the SQS. Sediments failing the SQS may be reevaluated using biological tests described in WAC 173-204-315 to confirm or refute the original designation.
- If sediments exceed the SQS for any one of the 47 listed chemicals, they are subject to sediment cleanup standards set forth in WAC 173-204-520. Cleanup screening levels (CSLs) set the maximum degree of concentration needed to identify a cluster of potential concern, above which the cluster is defined as a cleanup site. Similarly, minimum cleanup levels (MCULs) establish the maximum degree of contamination to be allowed on a site after cleanup and are to be used in the evaluation of cleanup alternatives as specified in the SMS. MCULs are set at the same concentration as CSLs.
- Source control standards define the maximum level of sediment contamination allowed in sediments impacted by permitted ongoing discharges (WAC 173-204-420). Ecology has the ability to designate a zone (sediment impact zone or SIZ) in which contamination above the SQS standards is allowed provided that appropriate source control activities have occurred and the discharge is not expected to create a cleanup site (WAC 173-204-400/410).

1.3 Locations and Control Status of County CSOs

King County CSO outfalls and CSO treatment facilities are shown in Figure 1. Eighteen county CSO locations are reported as controlled to a frequency of, on average, less than one untreated event per year (Table 1). Four of the controlled locations receive treatment equivalent to primary and disinfection. The RWSP CSO control plan lists conveyance system improvements, storage facilities, and treatment facilities to bring the remaining CSOs into control.

[1] King County data indicate that total phosphorus levels do not exceed standards in Lake Washington and the Lake Washington Ship Canal.

The West Point Plant also provides some CSO treatment via a CSO-related bypass. The CSO flows receive primary treatment and then are mixed with secondary treated effluent before disinfection and discharge. The mixed effluent complies with secondary treatment standards.

As shown in Table 1, no King County outfalls that discharge treated CSO or will discharge treated CSO in the future are near (less than 500 feet) other CSOs. Other CSOs are near 15 untreated county CSOs, either currently controlled or not yet controlled to one overflow per year or less. It is assumed that once untreated CSOs are controlled, they meet state water quality standards with the application of the mixing zone exemption in WAC 173-201A-400, as described above under "Water Quality Regulations." As a result, adjacent discharges will not affect the ability of these CSOs to comply with the numeric water column quality standards.

Ongoing Reporting on Status of CSO Control Program

Monthly discharge monitoring report (DMR). Reports on onset, duration, volume, and frequency of discharge events; treated CSO quality; and rainfall.

Annual CSO control program report. Compiles and summarizes DMR information for each calendar year.

CSO control plan update. Submitted about every five years with renewal application for the West Point NPDES permit. Reports on progress and plans to control all CSOs to the state standard.

1.4 Goals of CSO Control Plan

King County's CSO Control plan is intended to fulfill the mandate encoded in King County Code 28.86.080. Of specific relevance to this PCMP are the CSO control policies 1 and 2:

> CSOCP-1: King County shall plan to control CSO discharges and to work with state and federal agencies to develop cost-effective regulations that protect water quality. King County shall meet the requirements of state and federal regulations and agreements.
>
> CSOCP-2: King County shall give the highest priority for control to CSO discharges that have the highest potential to impact human health, bathing beaches and/or species listed under ESA.

The Washington State requirements in WAC 173-245-015 state:

> All CSO sites shall achieve and at least maintain the greatest reasonable reduction, and neither cause violations of applicable water quality standards, nor restrictions to the characteristic uses of the receiving water, nor accumulation of deposits which: (a) Exceed sediment criteria or standards; or (b) have an adverse biological effect.

where the greatest reasonable reduction is defined in WAC 173-245-020 (22) as:

> "The greatest reasonable reduction" means control of each CSO in such a way that an average of one untreated discharge may occur per year.

The CSO control plan proposes controlling all of King County's CSOs to no more than one untreated discharge per year. The performance of CSO treatment facilities is proposed to meet Washington State requirements of the equivalent of primary treatment, defined by at least a fifty percent removal of the total suspended solids from the waste stream, and less than 0.3 ml/l/hr. of settleable solids in the discharge. Disinfection is proposed for treated discharges.

1.5 Purpose of this Post Construction Monitoring Plan

As outlined in EPA's CSO Control Policy, post construction compliance monitoring is intended to provide data that can be used to:

- Verify the effectiveness of CSO controls
- Demonstrate compliance with WQS, protection of designated uses and sensitive areas

The data gathered under this PCMP is intended to be used to determine if King County is achieving the goals of its CSO Control Plan. The data will first provide an assessment of system performance to determine if the CSO Control Plan has resulted in the system meeting the standard of an average of one or fewer untreated overflows per year and treated discharges receiving the equivalent of primary treatment and disinfection as outlined in WAC 173-245. Next, the data will assess if water quality standards are being met by the CSO discharges. The proposed monitoring reflects the guidance on how to conduct effective post construction compliance monitoring issued in the document "CSO Post Construction Compliance Monitoring Guidance" (EPA, 2011).

Figure 1. King County CSO Locations

Table 1. King County CSO Discharge Locations and Status

DSN No.[a]	Facility	Nearby CSO[b]	Receiving Water	Status
003	Ballard Siphon Regulator		Lake Washington Ship Canal via city Storm Drain	Not controlled
004	11th Avenue NW (also called East Ballard)		Lake Washington Ship Canal	Not controlled
006	Magnolia Overflow	City CSO 064 – 300 feet north	Elliott Bay/Puget Sound	Not controlled[d]
007	Canal Street Overflow	City CSO 174 – 500 feet west County CSO 008 – 500 feet west	Lake Washington Ship Canal	Controlled
008	3rd Ave W and Ewing Street	City CSO 174 – 200 feet north County CSO 007 – 500 feet east	Lake Washington Ship Canal	Not controlled
009	Dexter Avenue Regulator		Lake Union	Not controlled[c]
011	E Pine Street Pump Station Emergency Overflow	City CSO 028 – 350 feet south City CSO 027 – 100 feet west	Lake Washington	Controlled
012	Belvoir Pump Station Emergency Overflow	Shares outfall with County CSO 049 City CSO 018 – 250 feet south	Lake Washington	Controlled
013	Martin Luther King Way Trunkline Overflow	Shares outfall with County CSO 045 City CSO 047 – 125 feet north City CSO 176 – 200 feet south	Lake Washington via storm drain	Controlled
014	Montlake Overflow		Lake Washington Ship Canal	Not controlled
015	University Regulator		Lake Washington Ship Canal	Not controlled
018	Matthews Park Pump Station Emergency Overflows		Lake Washington	Controlled
027b	Elliot West CSO Treatment Facility	County CSO 027a 340 feet inshore	Elliott Bay	Controlled — CSO treatment facility
027a	Denny Way Regulator	County CSO 027b 340 feet offshore	Elliott Bay	Not controlled[c]
028	King Street Regulator		Elliott Bay	Not controlled
029	Kingdome Regulator (replaced Connecticut Street Regulator)		Elliott Bay via the Connecticut storm drain	Not controlled
030	Lander Street Regulator		East Waterway of Duwamish River	Not controlled
031	Hanford #1 Overflow (Bayview N, Bayview S, and Hanford at Rainier)	Shares outfall with county CSO 034 and city CSO 111	Duwamish River via Diagonal storm drain	Not controlled
032	Hanford #2 Regulator		East Waterway of Duwamish River	Not controlled
033	Rainier Avenue Pump Station Emergency Overflow	City CSO 039 – 50 feet NE City CSO 038 – 100 feet SE	Lake Washington	Controlled
034	East Duwamish Pump Station Emergency and Siphon Aftbay Overflows	Shares outfall with county CSO 031 City CSO 111 – 50 feet south	Duwamish River via the Diagonal storm drain	Controlled
035	West Duwamish Siphon Forebay Overflow		Duwamish River	Controlled
036	Chelan Avenue Regulator	City CSO 104 – 300 feet NE	West Waterway of Duwamish River	Not controlled
037	Harbor Avenue Regulator	City CSO 099 – 50 feet north	West Waterway of Duwamish River via a city storm drain	Not controlled[c]
038	Terminal 115 Overflow		Duwamish River via a city storm drain	Not controlled

DSN No.[a]	Facility	Nearby CSO[b]	Receiving Water	Status
039	Michigan Regulator (also called South Michigan Regulator)		Duwamish River	Not controlled
040	8th Avenue S Regulator and West Marginal Way Pump Station Emergency Overflow	Both facilities share the same outfall.	Duwamish River	Controlled
041	Brandon Street Regulator		Duwamish River	Not controlled
042	West Michigan Regulator (SW Michigan Street Regulator)		Duwamish River	Not controlled
043	East Marginal Pump Station		Duwamish River	Controlled
044	Norfolk Outfall and Henderson/MLK CSO Treatment Facility		Duwamish River	Controlled—CSO treatment facility
045	Henderson Pump Station	Shares outfall with county CSO 013 City CSO 047 – 125 feet north City CSO 176 – 200 feet south	Lake Washington via a storm drain	Controlled[c]
046	Carkeek CSO Treatment Facility Outfall		Puget Sound	Controlled—CSO treatment facility
048b	North Beach Pump Station Emergency Overflow (inlet structure)		Puget Sound	Not controlled[d]
048a	North Beach Pump Station Emergency Overflow (wet well)		Puget Sound	Not controlled[d]
049	30th Avenue NE Pump Station	Shares outfall with county CSO 012 City CSO 018 – 250 south	Lake Washington	Controlled
051	Alki CSO Treatment Facility Outfall		Puget Sound	Controlled — CSO treatment facility
052	53rd Avenue SW Pump Station Emergency Overflow		Puget Sound	Controlled
054	63rd Avenue SW Pump Station Emergency Overflow		Puget Sound	Controlled
055	SW Alaska Street Overflow		Puget Sound	Controlled
056	Murray Avenue Pump Station Emergency Overflow	City CSO 090 – 200 feet east	Puget Sound	Not controlled[d]
057	Barton Street Pump Station Emergency Overflow	City CSO 094 – 150 feet east	Puget Sound	Not controlled[d]

[a] DSN = discharge serial number, as set in the NPDES permit.
[b] Distances between outfalls are based on GIS data and may not be exact.
[c] Control project was completed; currently refining system operation and control strategies.
[d] Control project is in design.

2 Existing Data

As part of its CSO Control Program, Metro and then King County have conducted sampling to characterize ambient water quality conditions, untreated CSO quality, treated CSO quality, and sediment quality near CSO discharges. These data are included in Ecology's EIM database.

In the late 1980s, Metro began a sampling program to characterize CSOs to comply with the requirements of Chapter 173-245 WAC and to identify any high priority sites for early control. Overflow quality data were collected for five CSO sites each year, and sediment samples were collected at each site in the West Point service area.[2]

Later, sampling was expanded to assess compliance with state Sediment Management Standards. In parallel to this, the county conducted extensive monitoring and modeling for its 1999 *King County Combined Sewer Overflow Water Quality Assessment for the Duwamish River and Elliott Bay* (King County, 1999).

The following sections describe data from these and other CSO-related monitoring programs.

Findings and recommendations regarding CSO control—1958–2009 environmental studies

1958 *Metropolitan Seattle Wastewater and Drainage Study* recommended sewer separation and storage, as needed, to control CSOs as part of a larger schedule of projects.

1978 Areawide Section 208 Water Quality Plan recommended sewer separation and storage, as needed, to control overflows.

1979–1984 *Toxicant Pretreatment Planning Study* recommended that CSO control be part of a coordinated Elliott Bay Action Plan and that source control, including enhancement of Metro's pretreatment program, should be a priority.

1983 *Water Quality Assessment of the Duwamish Estuary* identified CSOs as a minor contributor to the larger pollution problem and CSO control as one part of the solution.

1988 *Elliott Bay Action Plan* recommended elimination of direct industrial discharges into the bay and implementation of stormwater source control to improve CSO quality; set Denny Way and Michigan Street as priorities for CSO control.

1988–1996 Metro Receiving Water Monitoring Program affirmed that CSOs were not a major part of larger wet-weather problems and that CSO control would not yield the largest benefit to water quality.

1988–1997 Metro/King County CSO Discharge and Sediment Quality Characterization affirmed the Denny Way CSO as a priority for control based on pollutant concentrations.

1999 *King County Combined Sewer Overflow Water Quality Assessment for the Duwamish River and Elliott Bay* recommended continuation of CSO control to meet state regulations and helped set control priorities.

1999 *Sediment Management Plan* recommended that sediment remediation at CSO sites proceed ahead of CSO control because most contamination was from historical inputs.

2009 *Comprehensive Sediment Quality Summary Report for CSO Discharge Locations.*

2.1 Untreated CSO Quality

Untreated (in-pipe) CSO quality data are usually collected at the regulator or pump station just upstream of the overflow location.

Overflow quality was first characterized in the late 1980s and early 1990s under the CSO sampling plan to meet the requirements of Chapter 173-245 WAC. The data have been supplemented over time through special studies and control project definitions. The untreated CSO quality data were compiled and summarized in the *Comprehensive Sediment Quality Summary Report for CSO Discharge Locations* (King County, 2009a).

These historical untreated CSO sampling data indicate that four chemicals—copper, silver, zinc, and ammonia—could approach or exceed acute marine water quality standards without additional source control or adequate removal in

[2] The service areas for the Carkeek and Alki Treatment Plants were not included in that original sampling plan because they were independent from the West Point system until 1994 (Carkeek) and 1998 (Alki).

treated CSO discharges. Other chemicals for which there are numeric water quality standards were either not detected or detected at sufficiently low concentrations that an exceedance of acute marine water quality standards was not probable.

The County has conducted two programs to assess how CSO discharges comply with the narrative criteria of the water quality standards. The County maintains a CSO information telephone line and directs the public to this phone number through signage at each CSO location and on the County's CSO web site. To date, no complaints have been received suggesting that a CSO discharge has violated narrative standards (adversely affected a characteristic water uses, or that a CSO discharge has offended aesthetic sensibilities). Additionally, eight uncontrolled CSO discharges were observed, photographed, and assessed for the presence of solid and floatable material under a floatables observation plan submitted to Ecology and EPA.

2.2 Treated CSO Quality

Sampling of treated CSOs is done in accordance with the West Point plant's NDPES permit and includes analysis for priority pollutants (metals and volatile organic, acid extractable, and base neutral compounds). Sampling results are submitted to Ecology with the monthly discharge monitoring reports (DMRs). Ecology maintains a searchable database of these data (Water Quality Permit Life Cycle System, http://www.ecy.wa.gov/programs/wq/permits/wplcs/index.html).

King County's CSO treatment plants provide a hypochlorite-based disinfection followed by dechlorination. Failure of a component of the disinfection system could result in an exceedance of water quality standards for fecal coliform bacteria, total residual chlorine, and/or pH. Limits for these compounds are included in the current NDPES permit (Ecology, 2009).

2.3 Ambient Water Quality

King County conducts ambient water quality monitoring in all water bodies where CSOs discharge. Samples are usually taken monthly and are typically analyzed for parameters such as nutrients, fecal indicator bacteria, dissolved oxygen, temperature, water clarity, turbidity, total suspended solids, pH (fresh water), salinity, and chlorophyll. The monitoring program has produced a comprehensive historical dataset that documents and assess trends in ambient water quality. Information and data can be found at http://green.kingcounty.gov/marine/ and http://www.kingcounty.gov/environment/waterandland/lakes.aspx.

In addition to routine monitoring programs, other monitoring efforts have looked at ambient water quality. In 1996–1997, for the 1999 *King County Combined Sewer Overflow Water Quality Assessment for the Duwamish River and Elliott Bay* (WQA), ambient water quality samples were collected from the Duwamish River and Elliott Bay during periods when CSOs were overflowing for analysis of metals and a number of organic compounds. In 1999–2001, samples were collected from the Central Basin of Puget Sound for analysis for a similar range of parameters, and between 1999 and 2008, quarterly samples were collected from Lake Washington and the Lake Washington Ship Canal. In all studies, metal compounds were detected at concentrations significantly below water quality standards, while most organic compounds were not detected. Organic compounds that were detected also were below water quality standards.

The WQA identified some risks to fish, wildlife, and humans in the estuary, but because CSOs were not found to be a significant source, the WQA predicted limited improvement if CSO discharges were eliminated from the estuary. Risk of infection from direct contact with viruses and *Giardia* in CSO discharges during and soon after CSO events were predicted to be reduced with removal of CSOs throughout the Duwamish River and along the Elliott Bay shoreline. In the immediate vicinity of CSOs, risks to sediment dwelling organisms from organic enrichment, and possibly from 1,4-dichlorobenzene and bis(2-ethylhexyl) phthalate, were predicted to be reduced by removal of CSOs. The WQA concluded that even if CSOs were eliminated from the Elliott Bay/Duwamish system, minimal to no improvement in water quality would be observed because most pollutants were shown to come from sources other than CSOs.

More information on these studies can be found in the WQA report (King County 1999) and in the *1999/2000 Water Quality Status Report for Marine Waters* (King County, 2001) and *2001 Water Quality Status Report for Marine Waters* (King County, 2002).

In the 2009 West Point NPDES permit renewal specific ambient sampling requirements for areas near West Point and CSO discharges were included. To satisfy these requirements KC will continue to perform existing, longstanding KC ambient monitoring programs described above as well as add 2 new monitoring stations to be more fully representative of CSO discharge areas.

2.4 Sediment Quality

Data on sediment quality around King County's CSO outfalls have been collected for a variety of purposes, including compliance with State Sediment Management Standards (SMS) and as a part of joint efforts such as Superfund projects in the Duwamish Waterway. Sediment quality data are available for most CSOs to help determine whether impacts have occurred and next steps are needed. Data for the other CSOs have not been collected because the sites were in fresh water for which there are no numeric sediment quality standards[3] or because the CSO basin was primarily residential and could be characterized by CSO data for similar residential basins. Existing data are included in the *Comprehensive Sediment Quality Summary Report for CSO Discharge Locations* (King County, 2009a). Table 2 provides a brief summary of the sediment samples that have been collected near CSO discharge locations.

For CSOs discharging into Puget Sound, current sediment quality data show either no exceedances of SQS or a single exceedance of a phthalate compound. For CSOs discharging into Elliott Bay and the Duwamish River, sediment quality data show multiple exceedances of SQS, often including PAHs, total PCBs, phthalate compounds, and some metals. CSOs discharging into Lake Washington and the Ship Canal have multiple exceedances of the freshwater sediment guidelines for metals, total PCBs, PAHs, phthalate compounds, and other organic compounds.

In addition, the county conducts ambient subtidal sediment monitoring in Elliott Bay, the Central Basin of Puget Sound, and three embayments: Quartermaster Harbor, Outer Salmon Bay, and Fauntleroy Cove. The latest sampling in 2007 found sediment in these areas to be of good quality with some evidence of minor impacts from human activities in a few locations (King County, 2009b).

[3] The SMS contains a narrative freshwater standard that can be evaluated on a case-by-case basis. There are currently no promulgated numeric standards for freshwater, or for the protection of human health but there are narrative standards.

King County sediment quality data, along with available QA/QC data, are included in the EIM database.

Table 2. Sediment Samples near CSO Discharge Locations and Status

DSN No.[a]	Facility	Receiving Water	Last date of sediment sample	Number of Stations	SQS Exceedances[b,c] (number)	Status
003	Ballard Siphon Regulator	Lake Washington Ship Canal via city Storm Drain	1989	1	total PCBs, bis(2-ethylhexyl) phthalate	expect area-wide cleanup; characterize following cleanup
004	11th Avenue NW (also called East Ballard)	Lake Washington Ship Canal	1989	1	total PCBs, bis(2-ethylhexyl) phthalate	expect area-wide cleanup; characterize following cleanup
006	Magnolia Overflow	Elliott Bay/Puget Sound	2011 (1996)	6 (6)	pending (previous: none)	Adequately characterized
007	Canal Street Overflow	Lake Washington Ship Canal	--	None		expect area-wide cleanup; characterize following cleanup
008	3rd Ave W and Ewing Street	Lake Washington Ship Canal	2011 (1989)	7 (1)	pending (previous: total PCBs, bis(2-ethylhexyl) phthalate; **total PAHs**)	expect area-wide cleanup; characterize following cleanup
009	Dexter Avenue Regulator	Lake Union	2001	1	DDE, **total PCBs**, bis(2-ethylhexyl) phthalate, **carbazole**, **chromium**, **copper**, **dibenzofuran**, **lead**, **mercury**, nickel, **tributyltin**, **total PAHs**	expect area-wide cleanup; characterize following cleanup
011	E Pine Street Pump Station Emergency Overflow	Lake Washington	2000	2	bis(2-ethylhexyl) phthalate (1), nickel (2)	Inadequate characterization; other contributing sources
012	Belvoir Pump Station Emergency Overflow	Lake Washington	--	None	--	Inadequate Characterization
013	Martin Luther King Way Trunkline Overflow	Lake Washington via storm drain	2000	3	total PCBs (2), bis(2-ethylhexyl) phthalate (3), dibenzofuran(1), dieldrin(1), nickel (2), silver(1), tributyltin(3), **total PAHs** (3), TPH-residual (1)	Inadequate characterization; other contributing sources
014	Montlake Overflow	Lake Washington Ship Canal	2011 (1996)	7 (1)	pending(previous: bis(2-ethylhexyl) phthalate)	Adequately characterized
015	University Regulator	Lake Washington Ship Canal	2011 (1996)	7 (1)	pending (previous: bis(2-ethylhexyl) phthalate)	Adequately characterized
018	Matthews Park Pump Station Emergency Overflows	Lake Washington	--	None	--	Inadequate Characterization
027b	Elliot West CSO Treatment Facility	Elliott Bay	2009	16	total PCBs (7); multiple PAHs (2); benzyl butyl phthalate (3); bis(2-ethylhexyl) phthalate (5); mercury (6)	Adequately characterized

DSN No.[a]	Facility	Receiving Water	Last date of sediment sample	Number of Stations	SQS Exceedances[b,c] (number)	Status
027a	Denny Way Regulator	Elliott Bay	2009	16	see Elliott West (027b)	Adequately characterized
028	King Street Regulator	Elliott Bay	1989	5	multiple PAHs, bis(2-ethylhexyl) phthalate; total PCBs, arsenic, mercury, silver, zinc	remediation planned
029	Kingdome Regulator (replaced Connecticut Street Regulator)	Elliott Bay via the Connecticut storm drain	1996	7	1,4-dichlorobenzene; multiple PAHs; benzyl butyl phthalate, bis(2-ethylhexyl) phthalate; total PCBs; copper	Port of Seattle dredged area in 2005; Inadequate characterization of current condition
030	Lander Street Regulator	East Waterway of Duwamish River				current area-wide cleanup; characterize following cleanup
031	Hanford #1 Overflow (Bayview N, Bayview S, and Hanford at Rainier)	Duwamish River via Diagonal storm drain	2009	23		current area-wide cleanup; early action sediment remediation completed; monitoring ongoing
032	Hanford #2 Regulator	East Waterway of Duwamish River				current area-wide cleanup; characterize following cleanup
033	Rainier Avenue Pump Station Emergency Overflow	Lake Washington	2000	2	total PCBs (1), bis(2-ethylhexyl) phthalate (1), nickel (1), silver (1), tributyltin(2)	Inadequate characterization; other contributing sources
034	East Duwamish Pump Station Emergency and Siphon Aftbay Overflows	Duwamish River				current area-wide cleanup; characterize following cleanup
035	West Duwamish Siphon Forebay Overflow	Duwamish River				current area-wide cleanup; characterize following cleanup
036	Chelan Avenue Regulator	West Waterway of Duwamish River	2011	6	pending	Adequate characterization; No Action Record of Decision
037	Harbor Avenue Regulator	West Waterway of Duwamish River via a city storm drain		None		Inadequate characterization; No Action Record of Decision
038	Terminal 115 Overflow	Duwamish River via a city storm drain		None		current area-wide cleanup; characterize following cleanup
039	Michigan Regulator (also called South Michigan Regulator)	Duwamish River				current area-wide cleanup; characterize following cleanup

DSN No.[a]	Facility	Receiving Water	Last date of sediment sample	Number of Stations	SQS Exceedances[b,c] (number)	Status
040	8th Avenue S Regulator and West Marginal Way Pump Station Emergency Overflow	Duwamish River				current area-wide cleanup; characterize following cleanup
041	Brandon Street Regulator	Duwamish River	2011	6	pending	current area-wide cleanup; characterize following cleanup
042	West Michigan Regulator (SW Michigan Street Regulator)	Duwamish River				current area-wide cleanup; characterize following cleanup
043	East Marginal Pump Station	Duwamish River				current area-wide cleanup; characterize following cleanup
044	Norfolk Outfall and Henderson/MLK CSO Treatment Facility	Duwamish River	2004	4		current area-wide cleanup; early action sediment remediation completed; monitoring completed
045	Henderson Pump Station	Lake Washington via a storm drain	2000	3	total PCBs (2), bis(2-ethylhexyl) phthalate (3), dibenzofuran(1), dieldrin(1), nickel (2), silver(1), tributyltin(3), **total PAHs** (3), TPH-residual (1)	Inadequate characterization; other contributing sources
046	Carkeek CSO Treatment Facility Outfall	Puget Sound	2000	6	None	Adequately characterized
048b	North Beach Pump Station Emergency Overflow (inlet structure)	Puget Sound	2011 (1996)	6 (6)	pending (previous: phenol (1))	Adequately characterized
048a	North Beach Pump Station Emergency Overflow (wet well)	Puget Sound	2011 (1996)	6 (6)	pending (previous: phenol (1))	Adequately characterized
049	30th Avenue NE Pump Station	Lake Washington	--	None	--	Inadequate Characterization
051	Alki CSO Treatment Facility Outfall	Puget Sound	2001	6	none	Adequately characterized
052	53rd Avenue SW Pump Station Emergency Overflow	Puget Sound	2011 (1996)	6 (6)	pending (previous: reference station exceeded Arochlor 1254, benzyl butyl)	Adequately characterized

DSN No.[a]	Facility	Receiving Water	Last date of sediment sample	Number of Stations	SQS Exceedances[b,c] (number)	Status
054	63rd Avenue SW Pump Station Emergency Overflow	Puget Sound	1997	6	None	Adequately characterized
055	SW Alaska Street Overflow	Puget Sound	1997	6	None	Adequately characterized
056	Murray Avenue Pump Station Emergency Overflow	Puget Sound	2011 (1997)	7 (6)	pending (previous: None)	Adequately characterized
057	Barton Street Pump Station Emergency Overflow	Puget Sound	2011 (1997)	6 (6)	pending (previous: benzyl butyl phthalate (2) **dimethyl phthalate** (1))	Adequately characterized

[a] DSN = discharge serial number, as set in the NPDES permit.
[b] Freshwater sediments compared to proposed criteria in November 2011 Draft Revisions Sedment Management Standards
[c] compounds in **bold** exceed Cleanup Screening Levels (CSL)

2.5 Rainfall

King County has a network of 12 rain gauges to measure rainfall across the service area. This network is supplemented by a network of 17 rain gauges operated and maintained by the City of Seattle. Data from the county's network of gauges are archived in the supervisory control and data acquisition (SCADA) system historian and summarized and reported to Ecology as part of the monthly DMRs when a CSO event occurs.

2.6 Discharge Onset, Duration, and Volume

The current program of monitoring CSO onset, volume, and duration has been in effect since the approval of the CSO control plan in 1988. The data are collected from flow meters or water surface gauges upstream of overflow weirs and input to SCADA. They are reported to Ecology as part of the monthly DMRs and are summarized in the annual CSO report. Previous CSO reports can be found at http://www.kingcounty.gov/environment/wastewater/CSO/Library/AnnualReports.aspx.

3 Post-Construction Monitoring

Post construction monitoring to be conducted at each CSO is summarized in Table 3 and described in the sections that follow.

All CSO locations will be monitored for onset, duration, and volume of the discharge. Discharge locations that provide CSO treatment will also be monitored for influent and effluent quality. Sampling of the wet-weather discharges will be done in coordination with sampling for NPDES permit compliance.

In addition to this monitoring, King County will continue to collect precipitation data at an equivalent level to the existing network of rain gauges and will continue its ongoing ambient monitoring program.

Table 3. Post Construction Compliance Monitoring Plan

Medium	Post Construction Monitoring to be Conducted
CSO discharge	Untreated CSOs controlled to one overflow per year or less: Overflow onset, duration, and volume using SCADA and portable meters Treated CSO discharges: Overflow onset, duration, and volume using SCADA Influent and effluent quality sampling; reasonable potential analysis to assess compliance with water quality standards
Sediment	Sites with no existing SMS exceedances and adequate characterization: No sediment monitoring Sites with existing SMS exceedances or no sediment quality data: Project-specific pre-construction (if needed) and post-construction sediment monitoring used to determine if SMS still exceeded; a site-specific cleanup plan, if needed
Receiving water	Ongoing ambient monitoring programs and sampling specified in the NPDES permit

SCADA = supervisory control and data acquisition system.

Assumptions used to develop the plan are as follows:

- CSOs controlled to no more than one untreated event per year on average will request and be granted the mixing zone exemption described in Section 173-201A-400 WAC and will be deemed to comply with receiving water quality standards. Monitoring for these sites focuses on characterizing the quantity and frequency of discharges.
- The effectiveness of the CSO control at treated CSO sties is to be assessed by monitoring their ability to provide the equivalent of primary treatment— at least 50 percent removal of the total suspended solids annually and discharges less than 0.3 mL/L/hr of settleable solids for each event—and on other NPDES permit limits that apply to the effluent.
- King County will evaluate treated CSO compliance with state water quality standards by conducting a reasonable potential analysis based on the treated effluent quality data and existing ambient quality data.

- Data from previous studies and from ongoing monitoring programs are sufficient to characterize ambient water quality in receiving waters.
- Implementing CSO control measures will not degrade the existing sediment quality. Presumably achieving CSO control will reduce the CSO discharge volume resulting in improved sediment quality.
- All CSOs currently meeting SMS will be evaluated for the potential of new upstream sources discharging to the combined sewer system, or other factors adversely affecting sediment quality on a case-by-case basis.

The post construction monitoring plan is described below in two major subsections that parallel EPA's CSO Post Construction Monitoring Guidance (EPA, 2011) according to the types of monitoring being conducted. Subsection 3.1 discusses monitoring to "verify the effectiveness of CSO controls." Subsection 3.2 discusses effluent and ambient monitoring to gather data to be used in assessing compliance with WQS. Each subsection will focus on the type of monitoring to be done to define what, where, and when monitoring will occur.

3.1 Monitoring to Verify the Effectiveness of CSO Controls

The CSO controls described in the County's CSO Control plan propose to limit untreated CSO discharges to one or fewer events per year on average. Section 3.1.1 describes the flow monitoring the County uses to determine the onset, duration, volume, and frequency of CSO events. Section 3.1.2 describes the effluent monitoring conducted at CSO treatment facilities to evaluate the effectiveness of the CSO treatment and ensure that the discharge is receiving the required level of treatment. Section 3.1.3 describes how post construction monitoring will be implemented for Green Infrastructure projects.

3.1.1 Discharge Frequency

Ecology has directed that the control standard of no more than one untreated event per year be assessed as a 20-year moving average of monitored event data. The standard will be met if there are no more than 20 untreated events in 20 years. Where 20 years of monitored data are not available, such as for a new control facility, the missing years are to be predicted using modeled data.

Metering is proposed at all CSO discharge locations to determine the onset, duration, and volume of each CSO event. Flow metering is implemented with permanent flow meters, portable flow meters, or weirs with level sensors depending upon the CSO. The following sections summarize how flow monitoring is conducted; additional details can be found in the CSO Discharge Flow Measurement Sample and Analysis Plan and Quality Assurance Project Plan included as Appendix B.

3.1.1.1 Methods for Measuring CSO Frequency

Direct monitoring of CSO frequency consists of recording physical data indicating that CSOs have occurred. Meters or sensors that measure CSO discharges as they occur directly monitor overflows at all CSO locations. Depending on the meter type, the data is telemetered directly to the County's SCADA system, telemetered in real time to a centralized data server, or manually downloaded by field personnel and transferred to the data server. Details of the instrumentation

can be found in the CSO Discharge Flow Measurement Sample and Analysis Plan and Quality Assurance Project Plan, the most recent plan is attached as Appendix B.

3.1.1.2 Which Outfalls to Monitor

King County currently monitors all of its CSO discharge locations with flow meters to provide estimates of overflow onset, duration, and volume. Real-time depth meters are installed upstream of overflow weirs at 32 CSO overflow points, allowing calculation and documentation of overflow onset, duration, and volume. Two locations are monitored by real-time, permanent flow meters connected to the County's SCADA system. An additional nine locations are monitored via continuously recording flow meters (velocity/depth) that are regularly downloaded. Some discharge points have multiple meters to record all potential overflow pathways.

Under this plan, overflow monitoring will continue at all CSO discharge locations. The locations and/or equipment associated with some monitoring sites may change to accommodate post construction configurations.

3.1.1.3 When and How Often to Monitor

Under this plan, overflow monitoring will be continuous at all CSO discharge locations.

3.1.1.4 Data Collection

At most locations the data will be telemetered and collected and archived as part of King County's control system. When telemetry is not feasible, data will be downloaded on a periodic basis. The data collected will allow an evaluation of whether a CSO has occurred, as well as a determination of the onset, duration, and volume of an overflow. Coincidental precipitation data will also be collected from the County's existing rain gauges (Section 2.5).

3.1.1.5 Data Evaluation

Ecology defines the minimum inter-event period (MIET) as 24 hours. A CSO event is considered to have ended only after at least 24 hours has elapsed since the last measured occurrence of an overflow. This elapsed time will be used in evaluating the overflow data and determining the number, duration, and event volumes of each overflow.

3.1.1.6 Estimating CSO Frequency Using Modeling

King County's fully dynamic, planning-level collection system model will be used for facilities that do not have a 20-year record of CSO overflow events. The model will predict how the new control facility would have performed under the previous 20 years of rainfall conditions. As post construction monitoring data become available, they will replace model results in the rolling 20-year average calculation. King County proposes that a commissioning period be established for each project, after which the monitoring data will be incorporated into the 20-year average. The duration of this commissioning period will be set on a case-by-case basis by Ecology. Allowing for such a period prevents initial startup issues from affecting the analysis of the level of control for the next 20 years.

Details of this collection system model are described in Appendix C of King County's 2008 CSO control plan update (King County, 2008).

3.1.2 Treatment Effectiveness

CSO treatment facilities must achieve a minimum level of treatment to comply with their discharge permit. This section describes the monitoring that will demonstrate if the minimum level of treatment has been achieved. Consistent with EPA's CSO Control Policy and Ecology's regulations for CSO Control Facilities, the CSO Control plan describes the minimum level of treatment as:

- Annual: Primary clarification equivalent to a 50% reduction in TSS and less than 0.3 mL/L/hr settleable solids. (Removal of floatables and settleable solids may be achieved by any combination of treatment technologies or methods that are shown to be equivalent to primary clarification); pH is within range of 6 to 9
- Disinfection of effluent, including removal of harmful disinfection chemical residuals, where necessary.

In addition to the prescribed minimum level of treatment, the treated discharge will be required to comply with Washington State water quality standards. Monitoring to verify compliance with water quality standards is described in Section 3.2.

Details of sampling to determine treatment effectiveness can be found in the Treated CSO Sample and Analysis Plan and Quality Assurance Project Plan, the most recent plan is attached as Appendix C.

3.1.2.1 Methods for Determining Treatment Effectiveness

Monitoring of the treated CSO effluent will be done in accordance with the current and future NPDES permits. Current requirements include collection of flow proportional composite samples for both influent and effluent TSS and settleable solids. Total residual chlorine is to be determined from the effluent chlorine analyzer or grab samples, and fecal coliforms is collected by grab samples from the effluent channel after disinfection.

3.1.2.2 Which Outfalls to Monitor

Effluent samples are currently collected at King County's four CSO treatment facilities at Alki, Henderson/MLK, Elliott West, and Carkeek. Additional treatment facilities are proposed in the current control plan for Hanford/Lander, King/Kingdome, Michigan, and Brandon.

3.1.2.3 When and How Often to Monitor

Each CSO event will be monitored, according to the sample collection requirements in the NPDES permit. Flow proportional composites are collected over the entire event duration within the sampling intervals mandated in the permit. Grab samples are also taken at specific time intervals after the discharge begins to the receiving water. These intervals are within the first three hours, within 4-8 hours, within 20-24 hours, and each following 24 hour period.

Table 4. Initiation of King County CSO Treatment and Effluent Quality Monitoring

DSN No.[a]	Facility	Flow/Frequency	Treatment Effectiveness	Effluent Quality
027b	Elliot West CSO Treatment Facility	ongoing	ongoing	ongoing
044	Norfolk Outfall and Henderson/MLK CSO Treatment Facility	ongoing	ongoing	ongoing
046	Carkeek CSO Treatment Facility Outfall	ongoing	ongoing	ongoing
051	Alki CSO Treatment Facility Outfall	ongoing	ongoing	ongoing
TBD	Michigan/Brandon CSO Treatment Facility	2022	2022	2022
TBD	Hanford/Lander/King/Kingdome CSO Treatment Facility	2031	2031	2031

[a] DSN = discharge serial number, as set in the NPDES permit.

3.1.2.4 Data Collection

The composite and grab samples will be transported to an accredited laboratory for analysis following the protocols required in the NPDES permit.

3.1.2.5 Data Evaluation

The total removal efficiency for TSS is to be calculated on a mass balance basis as the percent of solids captured at the CSO Treatment Facility and then permanently removed at the West Point Treatment Plant. The reported daily average(s) of TSS% removal efficiency at West Point WWTP, corresponding to the event, are to be used for calculating the total removal efficiency for the CSO Treatment Facility. Compliance with the % TSS removal is based on the yearly average as reported in the annual CSO report, although it is reported on a monthly basis. Likewise, the settleable solids discharge limit of 0.3 mL/L/hr is assessed on the annual average of the per-event flow proportional composite samples.

The disinfection effectiveness is evaluated from the average monthly value for fecal coliform in the effluent, calculated from the geometric mean for the day(s) in which a discharge(s) occurred. The average monthly value is not to exceed the level prescribed in the NPDES permit, which is either a technology based limit or a water quality based limit, depending on the CSO treatment facility.

Removal of the disinfectant is evaluated from the total residual chlorine concentration in the effluent. The average measurement over a calendar day is not to exceed the limit given for each CSO treatment facility in the NPDES permit. The total residual chlorine limit is a water-quality based value calculated by Ecology.

3.1.3 Green Stormwater Infrastructure

Green Stormwater Infrastructure (GSI) improvements that are implemented as part of the CSO Control Plan will include a detailed description of the GSI project as part of the plans and reports submitted to Ecology under the requirements in Chapter 173-245 WAC (see Section 1.2.1). This description will include the performance levels expected to be achieved with the

implementation of the GSI project and a description of any post-construction monitoring and modeling to be performed.

GSI projects will have scheduled routine maintenance of the facility. During these maintenance visits, the facility will be inspected for the parameters outlined in the City of Seattle's Green Stormwater Operations and Maintenance Manual (Seattle, 2009). The condition of the vegetation, mulch layer, hardscape and infrastructure components will be monitored through visual inspection and any defects will be corrected. Inspection and maintenance activities will be performed to Service Level A for the first two years of a project, and Service Level B for subsequent years. Projects may include underground infiltration structures, which will have initial and long-term monitoring. This monitoring may depend on the type of structure and location, and will be detailed in the description of the GSI project submitted to Ecology prior to construction.

The CSO Control plan envisions Green Infrastructure will be used as part of a larger CSO control effort. Consequentially, Green Infrastructure will be evaluated in terms of the larger CSO control approach because it is used in conjunction with other control methods. Principally, the net result of the Green Infrastructure projects plus any other CSO control measures will be evaluated on their ability meet the goals of the CSO Control Program (Section 1.4).

3.2 Monitoring to Assess Compliance with Water Quality Standards

As described in EPA's CSO Control Policy, this portion of the post construction water quality monitoring plan is intended to verify compliance with WQS and the protection of designated uses. This section and the relevant appendices detail the monitoring protocols to be followed, including the necessary effluent and ambient monitoring and sediment sampling.

The County will assess compliance with state surface water quality standards by conducting a reasonable potential analysis as described in the permit writer's manual (Ecology, 2010). The analysis will be based on the post construction monitoring of treated effluent quality data and on existing ambient quality data. This analysis is extremely protective of water quality standards. It uses the 95th percent confidence level of the 95th percentile concentration and then combines these concentrations with the 90th percentile concentration of ambient water quality samples and the calculated outfall dilution ratio to estimate a maximum concentration at the point of compliance. The point of compliance is either the discharge point or the boundary of an approved mixing zone. When the maximum reasonable potential concentrations are below state water quality standards, the analysis demonstrates that the treated CSO discharge has met receiving water quality standards. Where a reasonable potential to violate water quality standards at the edge of the mixing zone is predicted, the county will assess whether the maximum measured concentration, which may be less than the reasonable potential concentration, has the potential to violate water quality standards. Where the potential exists to exceed water quality standards, it is assumed that Ecology will set site-specific effluent limits and monitoring requirements to prevent violation.

The County will continue to maintain and advertise methods for providing comments, concerns, or complaints related to CSO discharges, such as the CSO Information Line, web pages, and email contact information. Concerns received will be used to assess compliance with the narrative portion of the state surface water quality standards.

3.2.1 Effluent Monitoring

Effluent monitoring is intended to characterize the parameters in the treated effluent that will be evaluated in the reasonable potential analysis. As described below and in Appendix C, effluent quality samples are typically collected during one overflow per year as flow proportional composites, or if more appropriate for a parameter, as a grab or continuous measurement. Details of sampling to characterize the treated CSO discharges can be found in the Treated CSO Sample and Analysis Plan and Quality Assurance Project Plan, the most recent plan is attached as Appendix C.

3.2.1.1 What will be Monitored

Monitoring of the treated CSO effluent will be done in accordance with the current and future NPDES permits. Current requirements include measurement of volume, duration, precipitation, BOD_5, TSS, TSS removal, settleable solids, total residual chlorine, fecal coliform, and pH for each discharge event. Measurement of effluent temperature, salinity, alkalinity, oil and grease, hardness, cyanide, total phenols, nutrients, EPA priority pollutants, and some Ecology priority toxic chemicals is required. The current monitoring requirements are detailed in Appendix C, including sampling parameters and methods. Monitoring of the influent to, or the recycle from, the CSO treatment facilities will be conducted to allow estimation of the removal rates of TSS and BOD_5.

King County will continue monitoring the West Point WWTP effluent, including CSO-related bypass durations and volumes and final effluent parameters, as required by current and future NPDES permits. Compliance with secondary permit limits will continue to be reported in monthly DMRs to Ecology.

3.2.1.2 Where Monitoring will be Performed

Samples will be collected from the effluent stream of King County's four CSO treatment facilities at Alki, Henderson/MLK, Elliott West, and Carkeek. Additional treatment facilities are proposed in the current control plan for Hanford/Lander, King/Kingdome, Michigan, and Brandon.

3.2.1.3 When Monitoring will occur

Monitoring will occur for one event per year, or as directed in the NPDES permit.

3.2.1.4 How Monitoring will be conducted

Monitoring of the treated CSO effluent will be done in accordance with the current and future NPDES permits. Current requirements include collection of most parameters in flow proportional composite samples, and grab samples or continuous analyzers for other parameters.

3.2.2 Ambient Water Quality Monitoring

King County conducts extensive monitoring of the ambient water quality in numerous water bodies throughout the County. A subset of this monitoring is relevant to characterizing water quality in locations potentially affected by the combined sewer system.

The County's ongoing ambient monitoring program does not analyze for trace metals or organic compounds, and such analyses are not proposed. King County has analyzed for these constituents multiple times. The most recent sampling occurred to comply with part of the 2009 West Point NDPES permit renewal, in which King County must conduct sampling and submit a receiving water characterization report to Ecology by June 30, 2013, that describes background conditions for use in future reasonable potential calculations. The requirement includes analysis for metals and some organics in the vicinity of each CSO treatment facility. Prior to this, the CSO Water Quality Assessment (King County, 1999) conducted extensive sampling, including wet weather events with CSO discharges. These and previous sampling events show that concentrations of ambient metal and organic compounds are low compared to the acute water quality standards applicable to CSO discharges. With the results of the current analysis, ambient conditions will be well characterized. King County anticipates that sampling for trace metals and organics will be conducted on a periodic basis to verify and document ambient conditions.

The following sections summarize the relevant portion of King County's ongoing ambient monitoring program for post construction monitoring. Additional details can be found in Appendix D, Receiving Water Characterization Study Sampling and Analysis Plan and Quality Assurance Project Plan, Appendix E, Major Lakes Sampling and Analysis Plan, and Appendix F, Freshwater Swimming Beach Monitoring Sampling and Analysis Plan.

3.2.2.1 What will be Monitored

Open water samples will be analyzed for the following parameters:

- Field measurements are taken for dissolved oxygen and temperature
- Fecal Coliforms
- Ammonia-Nitrogen
- Nitrite/Nitrate Nitrogen
- Ortho Phosphorus
- Total Suspended Solids

Marine intertidal (beach) samples will be analyzed for the following parameters:

- Field measurement for temperature
- Fecal Coliforms
- Ammonia-Nitrogen
- Nitrite/Nitrate Nitrogen
- Ortho Phosphorus

Swimming Beach (freshwater) samples will be analyzed for:

- Field measurement for temperature
- Fecal Coliforms

3.2.2.2 Where Ambient Monitoring will be Performed

Ambient monitoring will be conducted at the ambient monitoring stations described below in Table 5.

Table 5. PCMP Ambient Sampling Locations

Description	Locator	East Coordinate	North Coordinate	Type
Point Jefferson	KSBP01	1248062	275439	Open Water (marine)
Dolphin Point	LSNT01	1245197	198653	Open Water (marine)
Elliott Bay	LTED04	1264675	223909	Open Water (marine)
Duwamish River	LTXQ01	1278053	190313	Open Water (marine)
Ship Canal/above Locks	0512	1255339	246408	Open Water (freshwater)
Lake Union/depth profile station, near west shore	A522	1269458	234484	Open Water (freshwater)
Ship Canal / Montlake Bridge	0540	1277624	239584	Open Water (freshwater)
Lake Washington / mid-lake north off Sandpoint	0826	1295117	253655	Open Water (freshwater)
Lake Washington / S of I-90 Bridge	0890	1286489	213199	Open Water (freshwater)
Madrona Park	SD007SB	1282939	225430	Swimming Beach
Mathews Beach Park	0818SB	1285991	257467	Swimming Beach
Alki Beach	LSHV01	1253532	216852	Intertidal (Beach)
Carkeek Park	KSHZ03	1259784	263736	Intertidal (Beach)
Magnolia	KSYV02	1254488	234547	Intertidal (Beach)
Me-Kwa-Mooks Park (Barton CSO)	LSLT02	1251892	209683	Intertidal (Beach)
SAM Sculpture Park Beach (Elliott West)	LTBD27	1264297	228851	Intertidal (Beach)

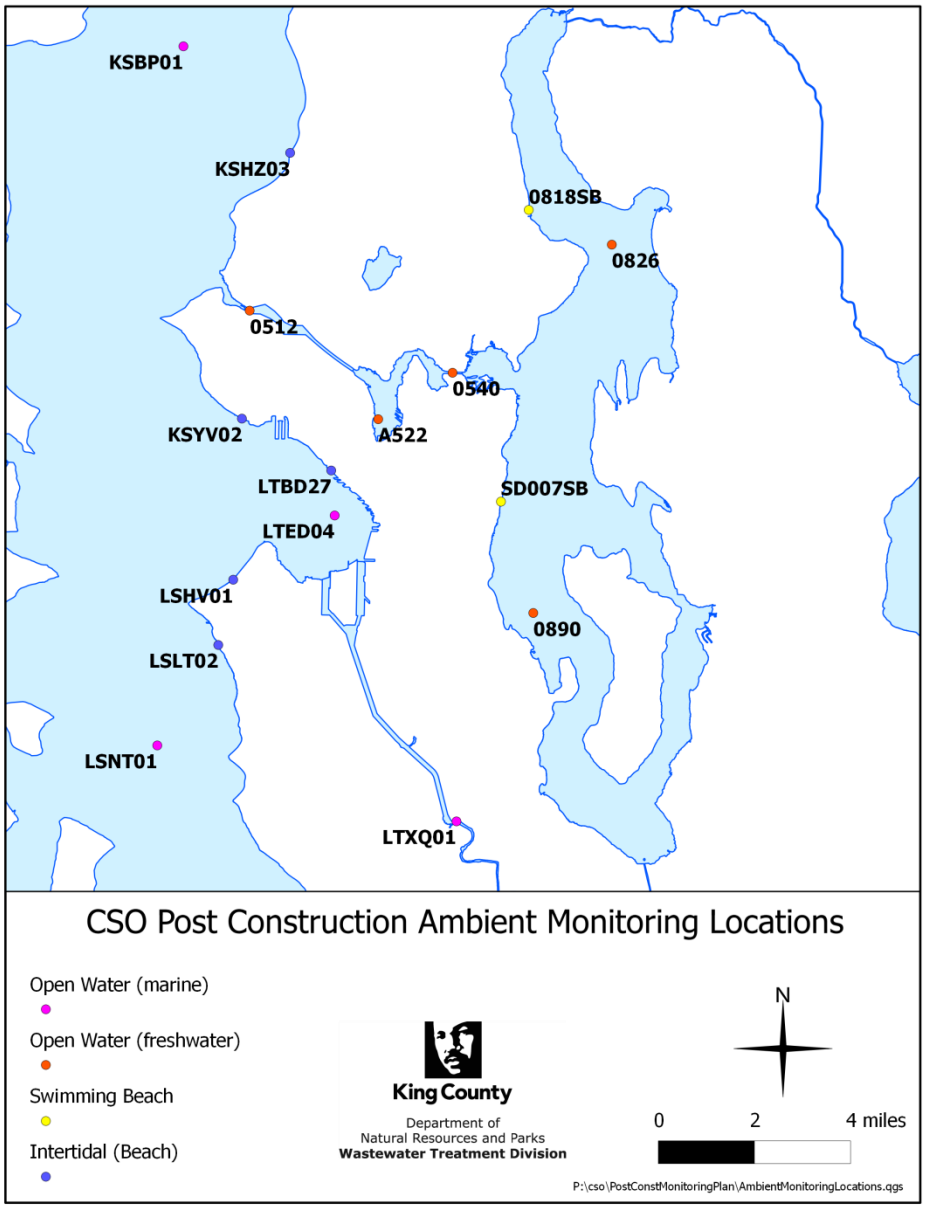

Figure 2. PCMP Ambient Monitoring Locations

3.2.2.3 When Ambient Monitoring will occur

Ambient monitoring at the open water and intertidal stations listed in Table 5 is conducted on a monthly schedule. Sampling may be delayed or cancelled due to weather conditions or equipment problems.

The swimming beach stations in Table 5 (Madrona Park, Mathews Beach Park) are sampled on a weekly basis from mid-May through mid-September by collecting a single grab sample. Time of day of sampling is determined by field and lab requirements. If the bacterial results from the initial sampling at a beach is above the criteria for closing a beach (geometric mean >200

cfu/100ml or single sample >1000 cfu/100ml), an additional sample will be immediately collected from the same location using the same sampling protocols. The rationale for immediate re-sampling is based on lack of statistical sampling power with a single grab and the possibility of collecting a false high count from a small localized source not representative of the overall bacterial water quality or human health concern.

3.2.2.4 How Ambient Monitoring will be conducted

Electronic in situ data are collected at the open water stations using a CTD (conductivity, temperature, depth) sensor array or Hydrolab® instrument deployed from the County's research vessels R/V Liberty or R/V Chinook, with the exception of the Duwamish River station (LTXQ01). Samples from the Duwamish River station are collected using a modified van Dorn-style sampling bottle that is lowered from the bridge mid-channel.

Discrete water samples are collected from between one and seven depths at each offshore station, depending on the total station depth. Laboratory analytes for discrete samples include fecal coliform, suspended solids, and nutrients (ammonia, nitrite/nitrate nitrogen, orthophosphate). Bacteria samples are collected from the surface sampling depth, with the exception of Duwamish River samples. Bacteria samples are collected from two depths at each Duwamish River station. All other laboratory parameters are analyzed on samples collected from every depth.

Intertidal (marine beach) water samples are collected as grab samples by wading into the water to a depth of approximately one meter and collecting a single sample from a depth of approximately one-half meter.

Samples at swimming beach locations are collected as grab samples within one foot of the surface of the water where the swimming area is three to six feet deep. Samples are collected using the dip method.

Additional details are provided in the respective SAP/QAPP attached in the Appendices.

3.2.3 Sediment Monitoring

King County has collected sediment quality data at the majority of its CSO outfall discharge locations, both as part of its NPDES sediment monitoring program and for special environmental studies. Section 2.4 provides a brief overview of the data; results were discussed and provided in King County's comprehensive sediment quality report (King County 2009).

The County's Sediment Management Plan (King County 1999) develops remedial strategies for correcting short- and long-term hazards associated with contaminated sediments near King County CSO sites. Sediment quality data is being collected at 10 CSO discharge locations for the current update to the SMP. This data will be used to calibrate and validate a near-field sediment model developed by the County primarily to evaluate recontamination potential for CSOs, following control and sediment remediation projects. Analysis of the model output will provide one line of evidence to characterize the sediment quality in areas around other County CSOs.

Many of the County's CSOs are situated in areas that will likely be the subject of an area-wide sediment remediation project in the future. The County expects to participate in area-wide remediation projects that encompass the Lower Duwamish Waterway, East Waterway, Ship Canal and Lake Union. Following completion of the area-wide remediation, the County will

assess if the sediments in the vicinity of its CSO discharges have been adequately characterized, or if additional monitoring or modeling is required.

Post construction sediment monitoring comprises a combination of modeling and sediment quality samples that provide a site characterization. King County, in consultation with Ecology, will determine what comprises an adequate site characterization on a site specific basis. Based on the site characterization, certain CSO discharge locations may exceed Sediment Management Standards (SMS). For these locations, a site-specific sediment cleanup plan will be developed. Cleanup plans will contain actions required to meet the Sediment Management Standards (SMS) as well as a sampling program to ensure the outcome has been achieved and recontamination is not occurring.

3.2.3.1 What will be Monitored

Monitoring of sediments near CSO discharges will be done according to the priorities and needs identified by King County's Sediment Management Program and through consultation with Ecology and EPA. The sediment quality samples at each CSO location will typically involve sampling surficial sediments at three to seven sites (depending on site-specific conditions) for metals and priority pollutants, using the most current Puget Sound Estuarine Program (PSEP) protocols. The Sampling and Analysis Plan (SAP) included in Appendix G was developed for sampling sediments around 10 CSO locations for the current SMP update. King County anticipates that the SAPs developed to conduct additional site-assessments around its CSO discharges would be similar to this document in terms of the sampling methodology, analytical parameters and detection limits, data analysis, and QA/QC controls. Individual SAPs will vary by sampling objectives and sample design based on site-specific issues.

Chemical analysis for metal and priority pollutants in surficial sediments is the only type of sediment quality monitoring proposed to characterize sediments near CSO discharges. Initial sampling results, site specific information, and consultation with Ecology and EPA may suggest that other types of monitoring be conducted on a case by case basis. A sampling and analysis plan will be developed prior to implementing any other types of monitoring.

3.2.3.2 Where Sediment Monitoring will be Performed

Sediment quality will be characterized at all CSO discharge locations through a combination of monitoring and modeling. Beyond the existing data, additional sediment quality sampling or modeling is anticipated to characterize specific CSO locations depending upon the CSO control status, existing sediment characterization, and the status of area-wide cleanup projects. King County, in consultation with Ecology, will assess the sediment data and modeling results to ensure the sediment quality is adequately characterized.

The anticipated sampling is discussed below.

No further sediment monitoring is planned at sites that have previously been characterized as not having SMS exceedances and where source conditions have not changed. It is assumed that if there were no exceedances at an uncontrolled CSO, there would be no exceedances after the site is controlled. Thus no additional sediment sampling is proposed at:

- Alki CSO (DSN 051)
- Carkeek CSO (DSN 046)
- 63rd Avenue (DSN 054)
- SW Alaska (DSN 055)

Additionally, no additional sediment sampling is proposed at the Norfolk Outfall and Henderson/MLK CSO Treatment Facility (one location). Sediment remediation was completed here in 1999, and the post-cleanup sediment monitoring did not indicate sediment recontamination from the CSO discharges. Additional sediment concerns from other contaminant sources at this location will be addressed through the current Lower Duwamish Waterway sediment clean-up.

Sediment sampling being conducted for the current SMP update is expected to provide sufficient data to characterize the following CSO discharge locations:

- Magnolia (DSN 006)
- 3rd Ave. W. (DSN 008)
- Montlake (DSN 014)
- University (DSN 015)
- Chelan Avenue (DSN 036)
- Brandon Street (DSN 041)
- North Beach (DSN 048a, 048b)
- 53rd Ave (DSN 052)
- Murray (DSN 056)
- Barton (DSN 057)

If this data and modeling results do not indicate SMS exceedances, no future sediment monitoring will occur at these sites. If SMS exceedances exist, a site-specific cleanup-plan will be developed. If site-specific cleanup plans are needed for 3rd Ave. W. or Brandon Street, they will be developed following completion or in coordination with the relevant area-wide cleanup project.

The SMP update process will use existing samples, near-field modeling, and additional sediment verification samples to evaluate sediment quality at the following controlled CSOs:

- East Pine (DSN 011)
- shared outfall: Belvoir (DSN 012) and 30th Ave NE Pump Station (DSN 049)
- shared outfall: Martin Luther King Way Trunkline Overflow (DSN 013) and Henderson Pump Station (DSN 045)
- Mathews Park Pump Station Emergency Overflow (DSN 018)
- Rainier Ave Pump Station Emergency Overflow (DSN 033)

If the data and modeling support an adequate characterization, a site-specific cleanup plan will be developed if SMS exceedances exist. At locations with other contributing sources (Table 2),

King County will develop the cleanup plan in partnership with the other entities that have contributed to the contamination. No additional sampling for post construction monitoring will be proposed if the sediments meet SMS standards and there is adequate characterization.

Sediment characterization is ongoing and an interim cleanup plan has been developed for:

- Elliot West CSO Treatment Facility (DSN 027b)
- Denny Way Regulator (DSN 027a)

Sediment quality samples will be collected for the remaining locations following completion of the respective CSO control project or of the area-wide cleanup project unless adequate recent data exists. These CSO locations are:

- Ballard Siphon Regulator (DSN 003)
- 11th Avenue NW (DSN 004)
- Canal Street Overflow (DSN 007)
- Dexter Avenue Regulator (DSN 009)
- King Street Regulator (DSN 028)
- Kingdome Regulator (replaced Connecticut Street Regulator)
- Lander Street Regulator (DSN 030)
- Hanford #1 Overflow (DSN 031)
- Hanford #2 Regulator (DSN 032)
- East Duwamish Pump Station Overflows (DSN 034)
- West Duwamish Siphon Forebay Overflow (DSN 035)
- Harbor Avenue Regulator (DSN 037)
- Terminal 115 Overflow (DSN 038)
- Michigan Regulator (DSN 039)
- 8th Avenue S Overflow (DSN 040)
- West Michigan Regulator (DSN 042)
- East Marginal Pump Station (DSN 043)

3.2.3.3 When Sediment Monitoring will occur

When sediment monitoring is proposed to occur is described below and summarized in Figure 3 and Table 6. The County expects to participate in area-wide sediment remediation projects that incorporate sediments off CSO discharges. Following completion of the area-wide remediation, the County will assess if the sediments in the vicinity of its CSO discharges have been adequately characterized, or if additional monitoring or modeling is required.

Any in-water work associated with CSO control projects will involve collection of pre-construction and post-construction sediment samples. These samples will serve to document any change in sediment quality from construction activities as well as to characterize the sediment quality.

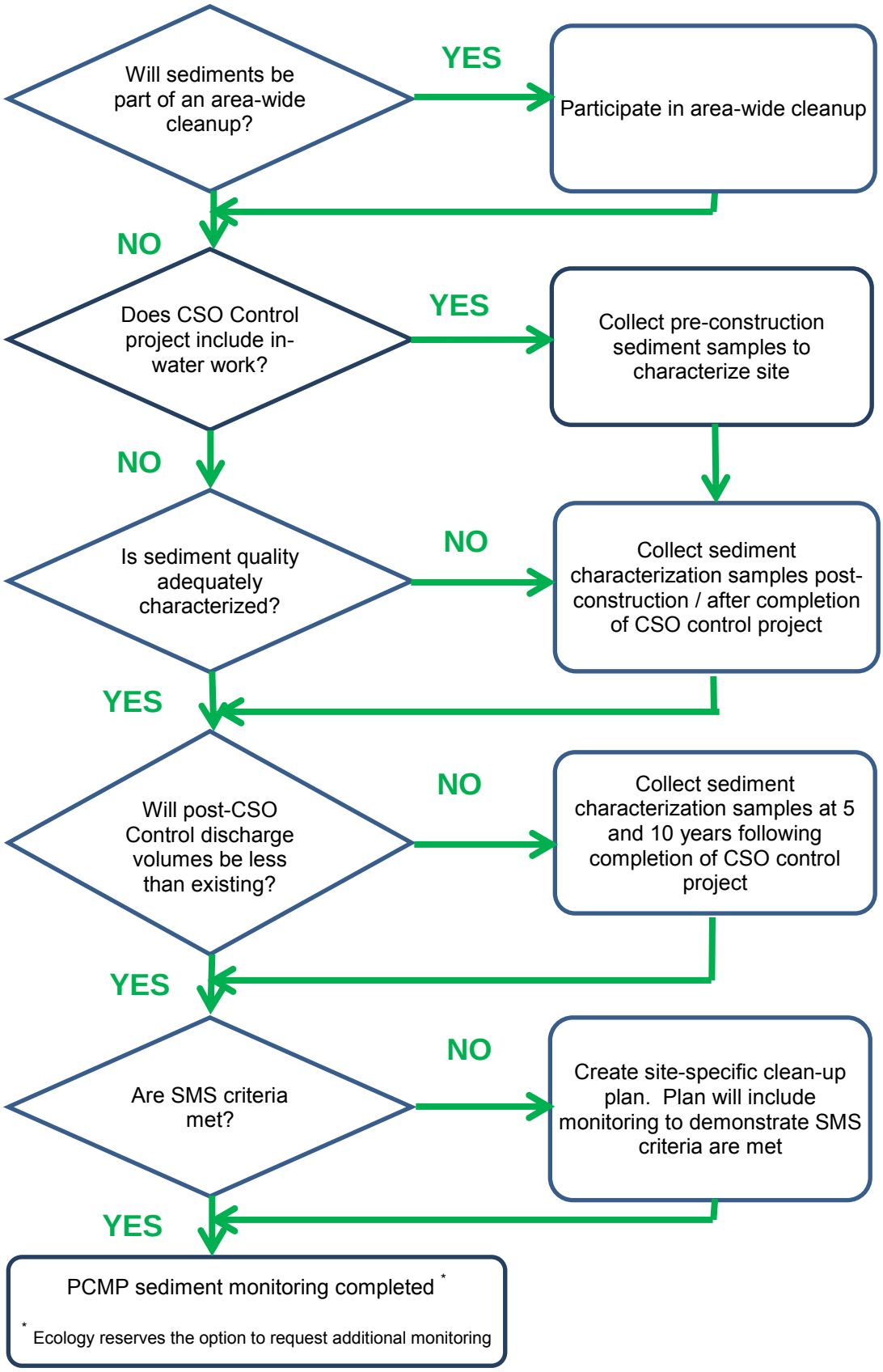

Figure 3. PCMP Sediment monitoring flowchart

For CSO control projects that will reduce the CSO discharge volume, one set of sediment quality samples will be collected to characterize the sediment quality. Sediment quality samples were collected in 2011 for 10 CSO locations (identified in Table 2). If existing samples provide adequate characterization and have no exceedances of SMS standards, no additional samples will be collected. Otherwise, one set of sediment quality samples will be collected following the completion of each CSO control project. If these samples indicate exceedances of SMS standards, a site-specific cleanup plan will be developed. The additional monitoring required as part of the site-specific cleanup plan will be described and documented in that plan. Sediment monitoring associated with any cleanup plan will be designed to demonstrate compliance with SMS.

CSO control projects that create or relocate a discharge location, or increase the volume of CSO discharge (such as combining flows to a CSO treatment facility), sediment quality sampling will happen three times. Initial sampling will occur prior to discharge to provide a pre-discharge characterization of the sediment quality. Sediment monitoring will be repeated at 5 and 10 years after completion of the CSO control project to ensure SMS standards are met. Should a trend indicating natural recovery not be observed at the 5-year sampling, or SMS standards not be met at the 10 year sampling, a site-specific cleanup plan will be developed.

Sediment remediation and monitoring may be performed prior to the completion of CSO control projects at locations where sediment recontamination modeling indicates that recontamination will not occur under existing conditions. Otherwise, sediment remediation will be performed after the CSO control project is completed.

At all CSO discharge locations, Ecology reserves the option to require additional sediment monitoring if evidence suggests there are new sources within the combined sewer basin, CSO discharge conditions have changed, or to determine continued compliance with the SMS.

Table 6. Sediment characterization schedule

DSN No.[a]	Facility	CSO Control Project Complete	Area-Wide Cleanup Anticipated	Year of sediment characterization
003	Ballard Siphon Regulator	2013	Yes	TBD[b]
004	11th Avenue NW (also called East Ballard)	2030	Yes	TBD[b]
006	Magnolia Overflow	2015	No	2011
007	Canal Street Overflow	Controlled	Yes	TBD[b]
008	3rd Ave W and Ewing Street	2025	Yes	TBD[b]
009	Dexter Avenue Regulator	[c]	Yes	TBD[b]
011	E Pine Street Pump Station Emergency Overflow	Controlled	No	2012
012	Belvoir Pump Station Emergency Overflow	Controlled	No	2012
013	Martin Luther King Way Trunkline Overflow	Controlled	No	2012
014	Montlake Overflow	2027	No	2011
015	University Regulator	2027	No	2011
018	Matthews Park Pump Station Emergency Overflows	Controlled	No	2012
027b	Elliot West CSO Treatment Facility	Controlled	No	ongoing
027a	Denny Way Regulator	[c]	No	ongoing

DSN No.[a]	Facility	CSO Control Project Complete	Area-Wide Cleanup Anticipated	Year of sediment characterization
028	King Street Regulator	2030	No	2031
029	Kingdome Regulator (replaced Connecticut Street Regulator)	2030	No	2031
030	Lander Street Regulator	2030	Yes	2031
031	Hanford #1 Overflow (Bayview N, Bayview S, and Hanford at Rainier)	2018	Yes	ongoing
032	Hanford #2 Regulator	2030	Yes	2031
033	Rainier Avenue Pump Station Emergency Overflow	Controlled	No	2012
034	East Duwamish Pump Station Emergency and Siphon Aftbay Overflows	Controlled	Yes	TBD[b]
035	West Duwamish Siphon Forebay Overflow	Controlled	Yes	TBD[b]
036	Chelan Avenue Regulator	2024	No	2011
037	Harbor Avenue Regulator	[c]	Existing	2012
038	Terminal 115 Overflow	2024	Yes	TBD[b]
039	Michigan Regulator (also called South Michigan Regulator)	2021	Yes	2022
040	8th Avenue S Regulator and West Marginal Way Pump Station Emergency Overflow	Controlled	Yes	TBD[b]
041	Brandon Street Regulator	2021	Yes	2022
042	West Michigan Regulator (SW Michigan Street Regulator)	2024	Yes	TBD[b]
043	East Marginal Pump Station	Controlled	Yes	TBD[b]
044	Norfolk Outfall and Henderson/MLK CSO Treatment Facility	Controlled	Yes	completed
045	Henderson Pump Station	Controlled	Yes	2012
046	Carkeek CSO Treatment Facility Outfall	Controlled	Yes	completed
048b	North Beach Pump Station Emergency Overflow (inlet structure)	2015	Yes	2011
048a	North Beach Pump Station Emergency Overflow (wet well)	2015	Yes	2011
049	30th Avenue NE Pump Station	Controlled	Yes	2012
051	Alki CSO Treatment Facility Outfall	Controlled	Yes	completed
052	53rd Avenue SW Pump Station Emergency Overflow	Controlled	Yes	2011
054	63rd Avenue SW Pump Station Emergency Overflow	Controlled	Yes	completed
055	SW Alaska Street Overflow	Controlled	Yes	completed
056	Murray Avenue Pump Station Emergency Overflow	2016	Yes	2011
057	Barton Street Pump Station Emergency Overflow	2015	Yes	2011
TBD	Michigan/Brandon CSO Treatment Facility	2021	Yes	2021, 2026, 2031
TBD	Hanford/Lander/King/Kingdome CSO Treatment Facility	2030	Yes	2030, 2035, 2040

[a] DSN = discharge serial number, as set in the NPDES permit.
[b] TBD = To Be Determined, depending on schedule of area-wide cleanup.
[c] Control project was completed; currently refining system operation and control strategies.

3.2.3.4 How Sediment Monitoring will be conducted

Prior to sampling at a site, King County will develop a Sampling and Analysis Plan (SAP) for that site. Each SAP will be prepared according to the guidance provided in the Sediment Source Control Standards User Manual, Appendix B: Sediment Sampling and Analysis Plan (Ecology, 2008). The purpose of the plans is to determine whether the sediment at a site exceeds the SMS and, if so, to delineate the exceedances. A SAP from the current CSO sediment sampling is included in Appendix G to illustrate the methods and sampling details typically employed.

3.3 Quality Control and Data Management

Activities under the plan will be implemented with appropriate quality control standards. The county has standard operating procedures (SOPs) in place for CSO outfall flow monitoring and for water and sediment quality sampling. In general, quality control procedures are as follows:

- A dedicated CSO crew manages CSO flow monitoring by following SOPs for maintenance, equipment replacement, data downloads, and associated field activities. A data analyst reviews the flow data for validity and representativeness.
- Trained staff at the county's certified environmental laboratory performs ambient water and sediment quality sampling. Standard sampling procedures and documentation, including use of chain-of-custody forms and appropriate sample preservation techniques, are a required part of the program.
- Environmental laboratory staff analyze water quality samples, following standard and required methods, protocols, and documentation.
- Rainfall data are recorded and archived by the county's SCADA system. Rain gauge calibration and maintenance are performed every three months, as scheduled and tracked by the county's computerized maintenance management system.

Data on controlled untreated and treated CSO discharges are currently being collected as part of the county's ongoing monitoring program; the post construction monitoring data will be integrated into existing data validation, archival, retrieval, and management tools.

Details on King County's quality control and data management procedures and protocols can be found in the NPDES permit sampling requirements and the sampling and analysis plans included in the Appendices.

4 Data Evaluation and Progress Reporting

King County will evaluate the post construction monitoring data to assess CSO control effectiveness and compliance with water quality standards and will report progress in the annual CSO report. Each CSO control plan update submitted with the West Point NPDES permit renewal application will consolidate the information relevant to each project; document the performance of the fully implemented CSO control measures, both by individual CSOs and systemwide; and provide further assessment of long-term trends.

If a CSO control project has been completed, but has not met performance goals, supplemental compliance plans will be developed as described in 2011 CSO Control Program Review Summary of Technical Memorandum, Section 9.0. On-going monitoring meeting PCMP needs will continue, and any special studies identified to support the review of project effectiveness will be implemented. The schedule for data review, conclusions and reporting will be defined in the supplemental compliance plan.

4.1 Discharge Frequency

Ecology has directed that the control standard of no more than one untreated event per year be assessed as a 20-year moving average of monitored event data. Where 20 years of monitored data are not available, such as for a new control facility, the missing years are to be predicted using modeled data. The model will predict how the new control facility would have performed under the previous 20 years of rainfall conditions. As post construction monitoring data become available, they will replace model results in the rolling 20-year average calculation. King County proposes that a commissioning period be established for each project, after which the monitoring data will be incorporated into the 20-year average. Allowing for such a period would prevent initial startup issues from affecting the analysis of the level of control for the next 20 years.

The modeled data will come from King County's fully dynamic, planning-level collection system model that has been continually refined since its development in the late 1980s. Details of this collection system model are described in Appendix C of King County's 2008 CSO control plan update (King County, 2008). The county will use this model to simulate up to 20 years of overflow events to fill in any missing years of data, using the following steps:

1. Use the model as calibrated and configured during a CSO control project's design phase to run a continuous simulation of CSO discharges for a representative 20-year period.
2. Replace successive years of the model run with monitored post construction CSO discharges, as actual overflow data becomes available.
3. Used this combination of model results and monitored data each year to assess compliance with the control standard.
4. If the modeled average annual overflow frequency is one or less under the mixing zone rules, the CSO will be deemed to be in compliance with Washington State surface water quality standards, Section 173-201A, if an unlimited mixing zone is approved once per year on average.

4.2 Compliance with Surface Water Quality Standards

The county will assess compliance with state surface water quality standards by conducting a reasonable potential analysis as described in the permit writer's manual (Ecology, 2010). The analysis will be based on the post construction monitoring of treated effluent quality data and on existing ambient quality data. This analysis is extremely protective of water quality standards. It uses the 95th percent confidence level of the 95th percentile concentration and then combines these concentrations with the 90th percentile concentration of ambient water quality samples and the calculated outfall dilution ratio to estimate a maximum concentration at the point of compliance. The point of compliance is either the discharge point or the boundary of an approved mixing zone. When the maximum reasonable potential concentrations are below state water quality standards, the analysis demonstrates that the treated CSO discharge has met receiving water quality standards. Where a reasonable potential to violate water quality standards at the edge of the mixing zone is predicted, the county will assess whether the maximum measured concentration, which may be less than the reasonable potential concentration, has the potential to violate water quality standards. Where the potential exists to exceed water quality standards, it is assumed that Ecology will set effluent limits and monitoring requirements to prevent violation.

As part of the 2009 West Point NDPES permit renewal, King County must submit a receiving water characterization report to Ecology by June 30, 2013, that describes background conditions for use in future reasonable potential calculations. The requirement includes analysis for metals and some organics in the vicinity of each CSO treatment facility. With the results of this analysis combined with sampling King County has conducted in marine and fresh waters, ambient conditions will be well characterized and no additional receiving water sampling, other than ongoing ambient monitoring programs, is proposed under this post construction monitoring plan.

The discharge from CSOs controlled to no more than one untreated event per year will be assumed to comply with the numeric surface water quality standards with the application of the mixing zone exemption in WAC 173-201A-400. A reasonable potential analysis will not be conducted for these discharges.

The County will continue to assess compliance with the narrative portion of the state surface water quality standards by monitoring and responding to complaints received about CSO discharges. Existing uncontrolled CSO discharges do not appear to adversely affect existing or designated uses, and implementation of the CSO control plan should only reduce the impact of CSO discharges.

4.3 Compliance with Sediment Management Standards

Sediment chemistry data will be evaluated by comparison with SMS sediment chemical criteria from Tables I and III of Chapter 173-204 WAC. Sediment data for some organic compounds are generally normalized to organic carbon content for comparison to SMS criteria. Normalization to organic carbon can produce biased results, however, when the organic carbon content of the sample is very low (Ecology, 1992). When the organic carbon content of a sample is near 0.1 or 0.2 percent (1,000 to 2,000 mg/kg dry weight), even background concentrations of certain organic compounds can exceed sediment quality criteria.

If the organic carbon content at any particular station is below 0.5 percent dry weight, then dry weight-normalized results for non-ionizable organic compounds will be compared to Lowest

Apparent Effects Threshold (LAET) or Second Lowest Apparent Effects Threshold (2LAET) criteria (EPA, 1988), rather than SMS criteria. The LAET and 2LAET are considered equivalent to the SQS and CSL, respectively.

The chemistry data will be submitted to Ecology in EIM format (latest version), and exceedances of SMS will be summarized in the annual CSO report.

If the sediment sampling confirms exceedances of the SMS, a project-specific sediment cleanup plan will be developed for approval by Ecology. The plan will identify remediation measures and the subsequent sediment monitoring program. It may also include sediment recontamination modeling to assess the potential for recovery or recontamination. The extent and frequency of the subsequent sediment monitoring will depend on the type and extent of existing contamination and the expected recovery or recontamination rate. Sediment monitoring associated with any cleanup plan will be designed to demonstrate compliance with SMS.

4.4 Influence of Other CSOs

In S.18.K.3 of the West Point NDPES permit, Ecology requested that the post construction monitoring plan address the following:

> …a discussion of controlled outfalls that may be influenced by other County or City of Seattle uncontrolled outfalls that may adversely influence or interfere with the water quality assessment of controlled outfalls. The Permittee must provide adequate justification for not performing post construction monitoring for controlled CSO outfalls where water quality may be impacted by nearby outfalls.

For untreated CSOs controlled to an average of one or fewer events per year, it is assumed that surface water quality standards will have been met by requesting and being granted the once per year unlimited mixing zone. The presence of nearby uncontrolled CSOs will not influence the ability to achieve water quality standards under this scenario. As a result, no additional monitoring other than the post construction monitoring described previously, is proposed to evaluate the influence of nearby CSOs on the control status of King County CSOs.

CSOs that treat and discharge could be impacted by nearby uncontrolled CSOs affecting the ambient water quality conditions. The Elliott West discharge (DSN 027b) is located 340 feet offshore of the Denny CSO (DSN 027a), which is not fully controlled (see Table 1). However, the Elliott West discharge terminates at a depth of 60 feet and primarily mixes with ambient water at depth as it rises to the surface. The Denny CSO discharges at a depth of 20 feet and will reach the surface before it could reach the mixing zone for the Elliott West discharge. As a result, it is unlikely that the Denny CSO would affect compliance with water quality standards at Elliott West. No other treated CSO discharges have a nearby CSO discharge. King County believes that the ambient water quality sampling conducted during its ongoing program and the wet-weather sampling that occurred during the 1999 Duwamish/Elliott Bay WQA are sufficiently comprehensive to include the effects of other discharges, particularly since the reasonable potential analysis uses the 90th percentile ambient concentration (King County, 1999). The WQA includes samples taken during periods of CSO overflow events.

Sediment quality near CSOs can be affected by sediment deposition from historical activities and other sources. Cleanup plans developed to address area-wide sediment quality exceedances will address sediment deposition from all nearby outfalls. In many cases, there is wide spread

sediment contamination and cleanup activities are expected to be integrated with an area-wide cleanup.

5 References

Ecology. 1988. *Sediment Quality Values. Refinement: 1988 Update and Evaluation of Puget Sound AET.* Prepared for the U.S. Environmental Protection Agency, Region 10, by PTI Environmental Services. Seattle, WA.

Ecology. 1992. Technical Information Memorandum, Organic Carbon Normalization of Sediment Data. Prepared by Teresa Michelsen for the Washington State Department of Ecology, Sediment Management Unit. Olympia, WA.

Ecology. 2002. *Water Cleanup Plans – Total Daily Maximum Loads.* Publication Number 02-10-038. http://www.ecy.wa.gov/pubs/0210038.pdf.

Ecology. 2007. *Agreed Order DE 5068, Exhibit D: Sediment Management Standards Interim Action Work Plan: Denny Way Combined Sewer Overflow Site Seattle, Washington.* http://www.ecy.wa.gov/programs/tcp/sites/denny_way/dw_hp.htm.

Ecology. 2008. *Criteria for Sewage Works Design* (Orange Book). Publication Number 98-37. http://www.ecy.wa.gov/biblio/9837.html.

Ecology. 2011. *Development of Benthic SQVs for Freshwater Sediments in Washington, Oregon, and Idaho.* Publication Number 11-09-054. Prepared by Avocet Consulting.

EPA. 2011. *CSO Post Construction Compliance Monitoring Guidance*. Publication Number EPA-833-K-11-001, April 2011.

Ecology. 2009. *National Pollutant Discharge Elimination System Waste Discharge Permit No. WA-002918-1* (West Point Wastewater Treatment Plant), http://www.ecy.wa.gov/programs/wq/permits/permit_pdfs/west_point/2009/WestPointWWTP_Permit.pdf.

Ecology. 2010. *Water Quality Program Permit Writer's Manual.* Publication Number 92-109. originally issued June 1989, revised November 2010. http://www.ecy.wa.gov/biblio/92109.html.

Ecology, 2011. *Draft Revisions Sediment Management Standards (SMS) (Part V and Definitions)*. Discussion Materials Prepared for the Sediment Cleanup Advisory Committee. November 2011. http://www.ecy.wa.gov/programs/tcp/regs/2011-SMS/adv-comm/mtg-111209/SMS_Revisions_Advisory_Group_Preliminary%20Draft_Nov_2011.pdf

King County. 1999. *King County Combined Sewer Overflow Water Quality Assessment for the Duwamish River and Elliott Bay*. King County Department of Natural Resources and Parks, Wastewater Treatment Division. Seattle, WA. http://www.kingcounty.gov/environment/wastewater/CSO/Library/WaterQuality.aspx.

King County, 2001. *1999/2000 Water Quality Status Report for Marine Waters*. King County Department of Natural Resources and Parks, Water and Land Division. Seattle, WA. http://green.kingcounty.gov/marine/Reports.aspx.

King County. 2002. *2001 Water Quality Status Report for Marine Waters.* King County Department of Natural Resources and Parks, Water and Land Division. Seattle, WA. http://green.kingcounty.gov/marine/Reports.aspx.

King County. 2008. *Combined Sewer Overflow Program, 2008 CSO Control Plan Update.* King County Department of Natural Resources and Parks, Wastewater Treatment Division. Seattle, WA. http://www.kingcounty.gov/environment/wastewater/CSO/Library.aspx.

King County. 2009a. *Comprehensive Sediment Quality Summary Report for CSO Discharge Locations*. King County Department of Natural Resources and Parks, Wastewater Treatment Division. Seattle, WA. http://www.kingcounty.gov/environment/wastewater/CSO/Library/PlanUpdates.aspx.

King County. 2009b. *Regional Wastewater Services Plan, 2008 Annual Report.* King County Department of Natural Resources and Parks, Wastewater Treatment Division. Seattle, WA. http://www.kingcounty.gov/environment/wtd/Construction/planning/rwsp/Library/AnnualReport.aspx.

King County, 2009c. *King County Surface Water Design Manual.* King County Department of Natural Resources and Parks. Seattle, WA. http://www.kingcounty.gov/environment/waterandland/stormwater/documents/surface-water-design-manual.aspx

Seattle Public Utilities, 2009. *Green Stormwater Operations and Maintenance Manual*, Seattle, WA.

Post Construction Monitoring Plan for King County CSO Controls

March 2012

Appendices

Appendix A. Water Quality Standards

Appendix B. Flow Measurement Sampling and Analysis Plan and Quality Assurance Project Plan

Appendix C. Treated CSO Sampling and Analysis Plan and Quality Assurance Project Plan

Appendix D. Receiving Water Characterization Study Sampling and Analysis Plan and Quality Assurance Project Plan

Appendix E. Freshwater Lakes Sampling and Analysis Plan and Quality Assurance Project Plan

Appendix F. Beaches Sampling and Analysis Plan and Quality Assurance Project Plan

Appendix G. Marine Water Column and Nearshore Sampling and Analysis Plan and Quality Assurance Project Plan

Appendix H. Sediment Sampling and Analysis Plan and Quality Assurance Project Plan

Appendix A. Water Quality Standards

Numeric Standards

Table 240(3). Toxics Substances Criteria

	Freshwater		Marine Water	
Substance	Acute	Chronic	Acute	Chronic
Aldrin/Dieldrin e	2.5a	0.0019b	0.71a	0.0019b
Ammonia	f,c	g,d	0.233h,c	0.035h,d
(un-ionized NH3) hh				
Arsenic dd	360.0c	190.0d	69.0c,ll	36.0d,cc,ll
Cadmium dd	i,c	j,d	42.0c	9.3d
Chlordane	2.4a	0.0043b	0.09a	0.004b
Chloride (Dissolved) k	860.0h,c	230.0h,d	-	-
Chlorine (Total Residual)	19.0c	11.0d	13.0c	7.5d
Chlorpyrifos	0.083c	0.041d	0.011c	0.0056d
Chromium (Hex) dd	15.0c,l,ii	10.0d,jj	1,100.0c,l,ll	50.0d,ll
Chromium (Tri) gg	m,c	n,d	-	-
Copper dd	o,c	p,d	4.8c,ll	3.1d,ll
Cyanide ee	22.0c	5.2d	1.0c,mm	d,mm
DDT (and metabolites)	1.1a	0.001b	0.13a	0.001b
Dieldrin/Aldrin e	2.5a	0.0019b	0.71a	0.0019b
Endosulfan	0.22a	0.056b	0.034a	0.0087b
Endrin	0.18a	0.0023b	0.037a	0.0023b
Heptachlor	0.52a	0.0038b	0.053a	0.0036b
Hexachlorocyclohexane (Lindane)	2.0a	0.08b	0.16a	-
Lead dd	q,c	r,d	210.0c,ll	8.1d,ll
Mercury s	2.1c,kk,dd	0.012d,ff	1.8c,ll,dd	0.025d,ff
Nickel dd	t,c	u,d	74.0c,ll	8.2d,ll
Parathion	0.065c	0.013d	-	-
Pentachlorophenol (PCP)	w,c	v,d	13.0c	7.9d
Polychlorinated				

Biphenyls (PCBs)	2.0b	0.014b	10.0b	0.030b
Selenium	20.0c,ff	5.0d,ff	290c,ll,dd	71.0d, x,ll,dd
Silver dd	y,a	-	1.9a,ll	-
Toxaphene	0.73c,z	0.0002d	0.21c,z	0.0002d
Zinc dd	aa,c	bb,d	90.0c,ll	81.0d,ll

Notes to Table 240(3):

a. An instantaneous concentration not to be exceeded at any time.

b. A 24-hour average not to be exceeded.

c. A 1-hour average concentration not to be exceeded more than once every three years on the average.

d. A 4-day average concentration not to be exceeded more than once every three years on the average.

e. Aldrin is metabolically converted to Dieldrin. Therefore, the sum of the Aldrin and Dieldrin concentrations are compared with the Dieldrin criteria.

f. Shall not exceed the numerical value in total ammonia nitrogen (mg N/L) given by:

For salmonids present:	0.275	+	39.0
	$1 + 10^{7.204-pH}$		$1 + 10^{pH-7.204}$
For salmonids absent:	0.411	+	58.4
	$1 + 10^{7.204-pH}$		$1 + 10^{pH-7.204}$

g. Shall not exceed the numerical concentration calculated as follows:

Unionized ammonia concentration for waters where salmonid habitat is an existing or designated use:

$$0.80 \div (FT)(FPH)(RATIO)$$

where: RATIO = 13.5; $7.7 \le pH \le 9$

RATIO =

$(20.25 \times 10^{(7.7-pH)}) \div (1 + 10^{(7.4-pH)})$; $6.5 \le pH \le 7.7$

FT = 1.4; $15 \le T \le 30$

FT = $10^{[0.03(20-T)]}$; $0 \le T \le 15$

FPH = 1; $8 \le pH \le 9$

FPH = $(1 + 10^{(7.4-pH)}) \div 1.25$; $6.5 \le pH \le 8.0$

Total ammonia concentrations for waters where salmonid habitat is not an existing or designated use and other fish early life stages are absent:

$$\text{Chronic Criterion} = \left(\frac{0.0577}{1+10^{7.688-pH}} + \frac{2.487}{1+10^{pH-7.688}} \right) \times (1.45 \times 10^{0.028(25-A)})$$

where: A = the greater of either T (temperature in degrees Celsius) or 7.

Applied as a thirty-day average concentration of total ammonia nitrogen (in mg N/L) not to be exceeded more than once every three years on average. The highest four-day average within the thirty-day period should not exceed 2.5 times the chronic criterion.

Total ammonia concentration for waters where salmonid habitat is not an existing or designated use and other fish early life stages are present:

$$\text{Chronic Criterion} = \left(\frac{0.0577}{1+10^{7.688-pH}} + \frac{2.487}{1+10^{pH-7.688}} \right) \times B$$

where: B = the lower of either 2.85, or $1.45 \times 10^{0.028 \times (25-T)}$. T = temperature in degrees Celsius.

Applied as a thirty-day average concentration of total ammonia nitrogen (in mg N/L) not to be exceeded more than once every three years on the average. The highest four-day average within the thirty-day period should not exceed 2.5 times the chronic criterion.

h. Measured in milligrams per liter rather than micrograms per liter.

i. ≤ (0.944)(e(1.128[ln(hardness)]-3.828)) at hardness = 100. Conversion factor (CF) of 0.944 is hardness dependent. CF is calculated for other hardnesses as follows: CF = 1.136672 - [(ln hardness)(0.041838)].

j. ≤ (0.909)(e(0.7852[ln(hardness)]-3.490)) at hardness = 100. Conversions factor (CF) of 0.909 is hardness dependent. CF is calculated for other hardnesses as follows: CF = 1.101672 - [(ln hardness)(0.041838)].

k. Criterion based on dissolved chloride in association with sodium. This criterion probably will not be adequately protective when the chloride is associated with potassium, calcium, or magnesium, rather than sodium.

l. Salinity dependent effects. At low salinity the 1-hour average may not be sufficiently protective.

m. $\leq (0.316)e^{(0.8190[\ln(hardness)] + 3.688)}$

n. $\leq (0.860)e^{(0.8190[\ln(hardness)] + 1.561)}$

o. $\leq (0.960)(e^{(0.9422[\ln(hardness)] - 1.464)})$

p. $\leq (0.960)(e^{(0.8545[\ln(hardness)] - 1.465)})$

q. $\leq (0.791)(e^{(1.273[\ln(hardness)] - 1.460)})$ at hardness = 100. Conversion factor (CF) of 0.791 is hardness dependent. CF is calculated for other hardnesses as follows: CF = 1.46203 - [(ln hardness)(0.145712)].

r. $\leq (0.791)(e^{(1.273[\ln(hardness)] - 4.705)})$ at hardness = 100. Conversion factor (CF) of 0.791 is hardness dependent. CF is calculated for other hardnesses as follows: CF = 1.46203 - [(ln hardness)(0.145712)].

s. If the four-day average chronic concentration is exceeded more than once in a three-year period, the edible portion of the consumed species should be analyzed. Said edible tissue concentrations shall not be allowed to exceed 1.0 mg/kg of methylmercury.

t. $\leq (0.998)(e^{(0.8460[\ln(hardness)] + 3.3612)})$

u. $\leq (0.997)(e^{(0.8460[\ln(hardness)] + 1.1645)})$

v. $\leq e^{[1.005(pH) - 5.290]}$

w. $\leq e^{[1.005(pH) - 4.830]}$

x. The status of the fish community should be monitored whenever the concentration of selenium exceeds 5.0 ug/ l in salt water.

y. $\leq (0.85)(e^{(1.72[\ln(hardness)] - 6.52)})$

z. Channel Catfish may be more acutely sensitive.

aa. $\leq (0.978)(e^{(0.8473[\ln(hardness)] + 0.8604)})$

bb. $\leq (0.986)(e^{(0.8473[\ln(hardness)] + 0.7614)})$

cc. Nonlethal effects (growth, C-14 uptake, and chlorophyll production) to diatoms (*Thalassiosira aestivalis* and *Skeletonema costatum*) which are common to Washington's waters have been noted at levels below the established criteria. The importance of these effects to the diatom populations and the aquatic system is sufficiently in question to persuade the state to adopt the USEPA National Criteria value (36 µg/L) as the state threshold criteria, however, wherever practical the ambient concentrations should not be allowed to exceed a chronic marine concentration of 21 µg/L.

dd. These ambient criteria in the table are for the dissolved fraction. The cyanide criteria are based on the weak acid dissociable method. The metals criteria may not be used to calculate total recoverable effluent limits unless the seasonal partitioning of the dissolved to total metals in the ambient water are known. When this information is absent, these metals criteria shall be applied as total recoverable values, determined by back-calculation, using the conversion factors incorporated in the criterion equations. Metals criteria may be adjusted on a site-specific basis when data are made available to the department clearly demonstrating the effective use of the water effects ratio approach established by USEPA, as generally guided by the procedures in USEPA Water Quality Standards Handbook, December 1983, as supplemented or replaced by USEPA or ecology. Information which is used to develop effluent limits based on applying metals partitioning studies or the water effects ratio approach shall be identified in the permit fact sheet developed pursuant to WAC 173-220-060 or 173-226-110, as appropriate, and shall be made available for the public comment period required pursuant to WAC 173-220-050 or 173-226-130(3), as appropriate. Ecology has developed supplemental guidance for conducting water effect ratio studies.

ee. The criteria for cyanide is based on the weak acid dissociable method in the 17th Ed. Standard Methods for the Examination of Water and Wastewater, 4500-CN I, and as revised (see footnote dd, above).

ff. These criteria are based on the total-recoverable fraction of the metal.

gg. Where methods to measure trivalent chromium are unavailable, these criteria are to be represented by total-recoverable chromium.

hh. The listed fresh water criteria are based on unionized or total ammonia concentrations, while those for marine water are based on total ammonia concentrations. Tables for the conversion of total ammonia to un-ionized ammonia for freshwater can be found in the USEPA's Quality Criteria for Water, 1986. Criteria concentrations based on total ammonia for marine water can be found in USEPA Ambient Water Quality Criteria for Ammonia (Saltwater)-1989, EPA440/5-88-004, April 1989.

ii. The conversion factor used to calculate the dissolved metal concentration was 0.982.

jj. The conversion factor used to calculate the dissolved metal concentration was 0.962.

kk. The conversion factor used to calculate the dissolved metal concentration was 0.85.

ll. Marine conversion factors (CF) which were used for calculating dissolved metals concentrations are given below. Conversion factors are applicable to both acute and chronic criteria for all metals except mercury. The CF for mercury was applied to the acute criterion only and is not applicable to the chronic criterion. Conversion factors are already incorporated into the criteria in the table. Dissolved criterion = criterion x CF

	Metal	CF	
	Arsenic	1.000	
	Cadmium	0.994	

	Chromium (VI)	0.993	
	Copper	0.83	
	Lead	0.951	
	Mercury	0.85	
	Nickel	0.990	
	Selenium	0.998	
	Silver	0.85	
	Zinc	0.946	

mm. The cyanide criteria are: 2.8µg/l chronic and 9.1µg/l acute and are applicable only to waters which are east of a line from Point Roberts to Lawrence Point, to Green Point to Deception Pass; and south from Deception Pass and of a line from Partridge Point to Point Wilson. The chronic criterion applicable to the remainder of the marine waters is l µg/L.

(4) USEPA Quality Criteria for Water, 1986, as revised, shall be used in the use and interpretation of the values listed in subsection (3) of this section.

(5) Concentrations of toxic, and other substances with toxic propensities not listed in subsection (3) of this section shall be determined in consideration of USEPA Quality Criteria for Water, 1986, and as revised, and other relevant information as appropriate. Human health-based water quality criteria used by the state are contained in 40 CFR 131.36 (known as the National Toxics Rule).

(6) Risk-based criteria for carcinogenic substances shall be selected such that the upper-bound excess cancer risk is less than or equal to one in one million.

Narrative Standards

The designated uses of water bodies that King County CSOs discharge into are given in the following two tables. Note that the Duwamish River is listed as freshwater for designating beneficial uses but the marine numeric criteria apply from the mouth to at least river mile 5 due to the presence of saline water.

Designated Uses for the Freshwater Bodies Where King County CSOs Discharge

Water body	Aquatic Life Uses						Recreation Uses			Water Supply Uses				Misc. Uses				
	Char Spawning/Rearing	Core Summer Habitat	Spawning/Rearing	Rearing/Migration Only	Redband Trout	Warm Water Species	Ex Primary Contact	Primary Contact	Secondary Contact	Domestic Water	Industrial Water	Agricultural Water	Stock Water	Wildlife Habitat	Harvesting	Commerce/Navigation	Boating	Aesthetics
Duwamish River from mouth south of a line bearing 254° true from the NW corner of berth 3, terminal No. 37 to the Black River (river mile 11.0)				x					x		x	x	x	x	x	x	x	x
Lake Washington Ship Canal from Government Locks (river mile 1.0) to Lake Washington (river mile 8.6)	x						x			x	x	x	x	x	x	x	x	x
Lake Washington		x	x				x			x	x	x	x	x	x	x	x	x

Designated Uses for the Marine Water Bodies Where King County CSOs Discharge

Water Body	Aquatic Life Uses					Recreation Uses		Misc. Uses				
	Extraordinary	Excellent	Good	Fair	Shellfish Harvest	Primary Contact	Secondary Contact	Wildlife Habitat	Harvesting	Commerce/Navigation	Boating	Aesthetics
Elliott Bay east of a line between Pier 91 and Duwamish Head		x			x	x		x	x	x	x	x
Puget Sound through Admiralty Inlet and South Puget Sound, south and west to longitude 122°52'30"W (Brisco Point) and longitude 122°51'W (northern tip of Hartstene Island).	x				x	x		x	x	x	x	x

Appendix B. Flow Measurement Sampling and Analysis Plan and Quality Assurance Project Plan

The current version of the CSO Flow Monitoring Sampling and Analysis Plan and Quality Assurance Project Plan (SAP/QAPP) is attached electronically to this document.

Combined Sewer Overflow Flow Monitoring Sampling and Analysis Plan

March 2012

King County

Department of
Natural Resources and Parks
Wastewater Treatment Division

Alternate Formats Available

206-296-7380 TTY Relay: 711

Combined Sewer Overflow Flow Monitoring
Sampling and Analysis Plan

King County

Department of
Natural Resources and Parks
Wastewater Treatment Division

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1.0. INTRODUCTION

This sampling and analysis plan and quality assurance project plan (SAP/QAPP) presents project information along with sampling and analytical methodologies that are employed to measure the discharge flow rates at King County's Combined Sewer Overflows (CSO). This work is being performed to fulfill one requirement of the County's National Pollutant Discharge Elimination System (NPDES) permit for the West Point treatment plant. The SAP includes a description of the project, monitoring history, sampling design, sampling and analytical methodologies, and reporting requirements

1.1 Program Background

Seattle's combined sewer system dates from the 1890s. Sanitary engineers of that period were trained to deal with all aspects of streets and with sewage, drainage and water supply. Combined sewers were the inevitable result. Since the streets were then visibly coated with manure, it seemed logical that they should also drain into the same single pipe network that carried human wastes.

Combined sewers moved the problems of sanitary wastes, horse manure and rainwater away from the immediate vicinity of houses and streets out into an appropriate body of water, where dilution was assumed to (and initially did) take care of it. Overflows of the combined sewers (storm water combined with raw sewage) were designed to occur in these systems because pipes large enough to store or carry all the rainwater to its ultimate destination were too expensive to put in and because treatment of these combined wastes was not an issue--just getting them to the nearest lake or bay was considered an improvement.

Since the early 1950s the construction of separate systems for sanitary sewage (which is now treated before disposal) and storm water (which is discharged directly to the nearest water body) has been the standard environmental and engineering practice for drainage and wastewater utilities locally as well as nationwide. The City of Seattle is the only jurisdiction with combined sewers in the King County Wastewater Treatment Division service area.

Metro was formed in 1958 to provide a regional wastewater treatment system for the entire metropolitan Seattle area and in 1994 King County assumed authority of Metro and its legal obligation to treat wastewater. Shortly after Metro was formed, construction began on the county's two existing regional treatment plants, West Point in Seattle's Magnolia neighborhood and South Treatment Plant in Renton, which were officially up and running by 1966.

In July 1986, the Metro Council adopted a plan to upgrade its Puget Sound plants to secondary treatment. Under the plan, Metro would upgrade its West Point plant to secondary and convert its Alki and Carkeek plants to treat combined sewer overflows only. The Renton plant has provided secondary treatment since it opened in 1965. In addition, Metro adopted a program to control combined sewer overflows further and achieve a 75 percent reduction in overflows during a 20-year-period to fulfill new state Ecology Department requirements.

In 1972 the National Pollution Discharge Elimination System (NPDES) was created in Section 402 of the Clean Water Act. "NPDES prohibits [discharges] of pollutants from any point source into the nation's waters except as allowed under an NPDES permit." The program gives the EPA

the authority to regulate discharges into the nation's waters by setting limits on the effluent that can be introduced into a body of water from an operating and permitted facility.

Washington State established Combined Sewer Overflow (CSO) control standards (RCW 90.48.480, WAC 173-245) in 1987, ahead of EPA adopting their CSO control policy in 1994. In 1988, King County adopted a new CSO control program to meet the new standard of one untreated CSO discharge per CSO site per year, on a long-term average.

1.2 Scope of Work

This flow measurement involves collection and analysis of Combined Sewer Overflow (CSO) discharge rates from all of King County's CSO discharge locations during all discharge events. The goal is to produce data of known quality that can be used to determine the onset, duration, and volume of discharges from King County's CSO facilities and associated outfalls.

The planned scope of work described in this SAP is designed to meet requirements of King County's NPDES West Point Permit #WA-002918-1, issued by Ecology, effective July 1, 2009. The permit states, in part (Section S2.C), the Permittee must:

1. Select and use appropriate flow measurement, field measurement, and continuous monitoring devices and methods consistent with accepted scientific practices.
2. Install, calibrate, and maintain these devices to ensure the accuracy of the measurements is consistent with the accepted industry standard and the manufacturer's recommendation for that type of device.
3. Use field measurement devices as directed by the manufacturer and do not use reagents beyond their expiration dates.
4. Calibrate these devices at the frequency recommended by the manufacturer.
5. Calibrate flow monitoring devices at a minimum frequency of at least one calibration per year.
6. Maintain calibration records for at least three years.

1.3 Schedule

Monitoring data must be summarized monthly and reported to Ecology on a discharge monitoring report (DMR) form that is postmarked or received by Ecology no later than the 20th day of the month following the completed monitoring period, unless otherwise specified in the NPDES permit.

1.4 Project Staff

The following staff are responsible for project execution:

Dan Grenet, West Section Plant Manager	(206) 263-3825
Karl Zimmer, West Section Offsite Supervisor	(206) 263-3955
John Cameron, South Treatment Plant Offsite Supervisor	(206) 684-2403
Abraham Araya, Flow Monitoring Data Analyst	(206) 684-1118

Betsy Cooper, WTD Project Manager	(206) 263-3728

2.0. PROGRAM DESIGN

The goal of King County's CSO Discharge Flow Rate Monitoring is to characterize the discharge rates from the collection system. The resulting data will allow King County to meet the monitoring requirement of the County's NPDES permit and to characterize the effectiveness of CSO controls for the CSO Control Plan.

2.1 Data Quality Objectives

The data quality objectives (DQOs) are to collect data of known and sufficient quality to meet the program goals. Validation of project data will assess whether the data collected are of sufficient quality to meet the program goals. The data quality issues of precision, accuracy, bias, representativeness, completeness, comparability, and sensitivity are described in the following sections, along with data validation.

2.1.1 Precision, Accuracy, and Bias

Precision is the agreement of a set of results among themselves and is a measure of the ability to reproduce a result. Accuracy is an estimate of the difference between the true value and the measured value. The accuracy of a result is affected by both systematic and random errors. Bias is a measure of the difference, due to a systematic factor, between an analytical result and the true value of an analyte. Precision, accuracy, and bias for flow measurement is typically determined by calibration of the flow meter by a standardized procedure.

2.1.2 Representativeness

Representativeness expresses the degree to which sample data accurately and precisely represent a characteristic of a population, parameter variations at the sampling point, or an environmental condition. Conditions required to insure representative flow measurements depend on the specific instrumentation, but may require the instrumentation to be installed in a specific configuration. Flow meters will be installed according to their manufacturer's recommendations.

2.1.3 Completeness

Completeness is defined as the total number of samples analyzed for which acceptable analytical data are generated, compared to the total number of samples submitted for analysis. Sampling with adherence to standardized sampling and testing protocols will aid in providing a complete set of data for this survey. The goal for completeness is 100%. If 100% completeness is not achieved, the project team will evaluate if modifications to the instrumentation or facility need to be made to meet this goal in future events. Additionally, the program team will evaluate whether the DQOs can still be achieved using simulated flow rates from King County's collection system model or from calculated flow rates based on other data sensors.

2.1.4 Comparability

Comparability is a qualitative parameter expressing the confidence with which one data set can be compared with another. This goal is achieved through using standard techniques to collect

and analyze representative samples, along with standardized data validation and reporting procedures. By following the guidance of this SAP, the goal of comparability between this and future events will be achieved.

2.1.5 Sensitivity

Sensitivity is a measure of the capability of analytical methods to meet the program goal. The flow measurement techniques presented in Section 4.0 are sensitive enough to allow reporting of discharge flows and assessment of the performance of CSO controls.

2.2 Sampling Strategy

The sampling strategy for the CSO Discharge Flow Rate Monitoring was designed to allow continuous flow rate monitoring at all CSO discharge locations. The physical configuration of each CSO discharge locations determines the type of flow measurement instrumentation installed.

Electromagnetic flow meters are typically found at more recent CSO treatment facilities. Operation is based on Faraday's law, which states that a voltage is generated in any conductive liquid as the liquid moves through a magnetic field. This voltage is sensed by electrodes embedded in the sensor, and is transmitted to the meter. The voltage is proportional to the velocity of the conductive liquid (conductor).

Weirs are used at some CSO treatment facilities and many CSO overflow locations to determine flow rates. A weir is a calibrated obstruction or dam built across an open channel over which the liquid flows, often through a specially shaped opening or notch. The flow rate is calculated by measuring the liquid level upstream of the weir and applying an equation specific to the geometry of the weir.

Area-Velocity flow meters are installed in locations where electromagnetic flow meters or weirs are not available. These instruments measure water depth and flow velocity using the Doppler shift principle. Depending on the type of meter, water depth is measured with a pressure transducer mounted on the bottom of the pipe or from an ultrasonic probe mounted at the top of the pipe. Velocity is measured by ultrasonic or radio waves of known frequency and duration that are emitted from a transmitter located either on the channel invert or on the outside of the conduit in the 3 or 9 o'clock position. Suspended particles and air bubbles in the flow reflect the emitted waves. The sensor receives and detects the deflected frequencies, and processes them to determine the average velocity. This is combined with the water depth and channel geometry to calculate the total flow rate.

2.2.1 Monitoring Station Locations and Identification

Forty-six monitoring locations will be used to determine the overflows from King County's 42 CSO discharge locations shown in Figure 1. Flow rates will be identified using the sample location or locator name and the date and time of measurement. Locator names are given in Table 1.

Figure 1. King County CSO Locations

Table 1. King County CSO Discharge Locations and Instrument Types

DSN No.[a]	Facility	Locator/Data Location	Notes
003	Ballard Siphon Regulator	BALL815FYF815431	
004	11th Avenue NW (also called East Ballard)	11aveNWCSO[b]	
006	Magnolia Overflow	Magnolia[b]	
007	Canal Street Overflow	LCTR818FYF818431	
008	3rd Ave W and Ewing Street	WPTP600LB603108A WPTP600LB603104A	
009	Dexter Avenue Regulator	DEXT817FYF817431	
011	E Pine Street Pump Station Emergency Overflow	PINE783FYF783065	
012	Belvoir Pump Station Emergency Overflow	BELV785FYF785065	
013	Martin Luther King Way Trunkline Overflow	MLKI774FI774784	not expected to overflow sensor not reliable
014	Montlake Overflow	MONT820FYF820431	
015	University Regulator	UNIV819FYF819431	
018	Matthews Park Pump Station Emergency Overflows	MATT786FYF786065[e] MATT786LB786104M MATT786LB786109 MATT786LB786106 KENM788LB788462	 Lake line Lvl bypass level Wet Well level Logboom
027b	Elliot West CSO Treatment Facility	ECSO792FB792003 ECSO792FYF792065[e]	
027a	Denny Way Regulator	DENL800FYF800431 DENU813FYF813431 INTE780FYF780065	
028	King Street Regulator	KING801FYF801431	
029	Kingdome Regulator (replaced Connecticut Street Regulator)	levels CONN802LB802001 CONN802LB802003 KDOM830FYF830431[e]	
030	Lander Street Regulator	LAN2821FYF821431	
031	Hanford #1 Overflow (Bayview N, Bayview S, and Hanford at Rainier)	HECSODRY[c] HECSOWET[c] HFORDSO2[d] HFORDSO4[c]	
032	Hanford #2 Regulator	HANF803FYF803431	
033	Rainier Avenue Pump Station Emergency Overflow	RAIN770FYF770065	
034	East Duwamish Pump Station Emergency and Siphon Aftbay Overflows	DWMSHOUT[c]	
035	West Duwamish Siphon Forebay Overflow	DWMSHIN[c]	
036	Chelan Avenue Regulator	CHEL806FYF806431	
037	Harbor Avenue Regulator	HARB805FYF805431	
038	Terminal 115 Overflow	Terminal115[b]	
039	Michigan Regulator (also called South Michigan Regulator)	MICH810FYF810431	

DSN No.[a]	Facility	Locator/Data Location	Notes
040	8th Avenue S Regulator and West Marginal Way Pump Station Emergency Overflow	8TH808FYF808431 WMAR772FYF772065	Both facilities share the same outfall.
041	Brandon Street Regulator	BRAN809FYF809431	
042	West Michigan Regulator (SW Michigan Street Regulator)	WMIC807FYF807431	
043	East Marginal Pump Station	EMAR773FYF773065	
044	Norfolk Outfall and Henderson/MLK CSO Treatment Facility	NORF811FYF811431A	
045	Henderson Pump Station	level: HEND774LB774271A HEND774LB774271B HEND774FYF774065[e]	
046	Carkeek CSO Treatment Facility Outfall	CARK520FB510291	
048b	North Beach Pump Station Emergency Overflow (inlet structure)	NBCH[b]	
048a	North Beach Pump Station Emergency Overflow (wet well)	level: NBEA540LB540106 NBEA540FYF540431[e]	
049	30th Avenue NE Pump Station	30TH784FYF784065	
051	Alki CSO Treatment Facility Outfall	ALKI400FB400111 ALKI400FB400112 ALKI400LB400631 ALKI400LB400632 ALKI400LB400633 ALKI400LB400634 ALKI400LB400635 ALKI400LB400636 ALKI400FYF400065[e]	Correction for stored volume and raw sludge pumped.
052	53rd Avenue SW Pump Station Emergency Overflow	53RD480LB480106A 53RD480LB480106B 53RD480FYF480065[e]	
054	63rd Avenue SW Pump Station Emergency Overflow	63RD483LB483106 63RD483FYF483065[e]	
055	SW Alaska Street Overflow	BeachCSO[b]	
056	Murray Avenue Pump Station Emergency Overflow	level: MURR484LB484106A MURR484LB484106B MURR484FYF484065[e] MURRAYPS[d]	
057	Barton Street Pump Station Emergency Overflow	level: BART485LB485106 BART485FYF485065[e]	

[a] DSN = discharge serial number, as set in the NPDES permit.
[b].found at \\wtd-flowdata\FlowMonitoring\FlowData_Review\MMI_Data\ZZ CSO Appended Site Data\
[c].found at \\wtd-flowdata\PORTABLE\ZZZ_Backup_Profile_Telog
[d].found at http://fsdata.hatch.com
[e] overflow volumes are currently calculated manually

- Matthews Park Pump Station Emergency Overflows: Total overflow is the calculated flow from seven overflow orifices located along the Lake Line between Matthews Park Pump Station and Kenmore. The overflow volume from the orifices is calculated by spreadsheet based on the measured levels at the pump station wet well and at Kenmore.
- Elliott West CSO Treatment Facility overflow is dependent upon gate position diverting flow to the outfall instead of back to the collection system.
- Alki CSO Treatment Facility discharge is the sum of the two influent flow meters less the storage within the Treatment Facility, as determined by the level sensors.
- Murray CSO has two possible overflow points, one is measured with a ultrasonic meter.

2.2.2 Sample Acquisition and Analytical Parameters

Where possible, monitoring data is reported to King County's SCADA system and subsequently archived in a process historian. Where this is not possible, data is telemetered to King County's flow database or is downloaded by King County personnel and entered in to the flow database.

Depending on the type of instrumentation, the recorded parameter(s) may include: total flow, water surface elevation, and/or flow velocity.

3.0. MONITORING PROCEDURES

This section describes the monitoring procedures that will be followed over the course of all events to meet the survey DQOs: representativeness, comparability, and completeness.

3.1 Instrumentation Placement

Flow monitoring equipment is generally designed and installed as a permanent component of the CSO facility. When instrumentation is replaced or upgraded, instrumentation will be selected to ensure that placement meets the manufacturer's requirements for appropriate placement. Placement of area-velocity flow meters will follow manufacturer's guidelines and the King County's Flow Montoring Standard Operating Proceedures (SOP).

The overflow configuration and instrumentation type is summarized in **Table 2**.

Table 2. King County CSO Discharge Weirs, Gates, and Senor types

DSN No.[a]	Facility	Weir Length	Crest Shape	Gate (w x h)	Sensor
003	Ballard Siphon Regulator	38.5 ft inside rectangle, 36.8 ft effective	9" + 3" bevel	72" x 48"	bubbler
004	11th Avenue NW (also called East Ballard)	29.1 ft	3" + variable upstream bevel	--	ultrasonic depth sensor
006	Magnolia Overflow	3.625 ft	¼" plate	43.5"	ultrasonic depth sensor
007	Canal Street Overflow	4 ft	6" + 10" downstream bevel	120" x 60" (manual)	bubbler
008	3rd Ave W and Ewing Street	30.0 ft	width varies, radiused edges	--	bubbler
009	Dexter Avenue Regulator	30.0 ft	width varies	84" x 60"	bubbler
011	E Pine Street Pump Station Emergency Overflow	6 ft	6" flat	--	bubbler
012	Belvoir Pump Station Emergency Overflow	2 – 6 ft (12 ft total) flap gates	12" flat	--	bubbler
013	Martin Luther King Way Trunkline Overflow	3.5 ft	12" flat + 10 ft shelf	--	bubbler
014	Montlake Overflow	24 ft	6" + 6" bevel on downstream	60" x 60"	bubbler
015	University Regulator	70 ft inside rectangle 66.6 ft effective	varies. typ 12" including downstream bevel	60" x 58"	bubbler
018	Matthews Park Pump Station Emergency Overflows	orifices			bubbler
027b	Elliot West CSO Treatment Facility	--		--	EMF meter

DSN No.[a]	Facility	Weir Length	Crest Shape	Gate (w x h)	Sensor
027a	Denny Way Regulator:				
	Denny Local	4 ft		24” x 48”	bubbler
	Denny Lake Union	15.3 ft		48” x 60”	bubbler
	Interbay Pump Station	8 ft circular		--	bubbler
028	King Street Regulator	10 ft	4” upstream bevel + 4” crest with 2” radius on downstream edge	60” x 36”	bubbler
029	Kingdome Regulator (replaced Connecticut Street Regulator)	79 ft	½” plate	--	bubbler
030	Lander Street Regulator	49.33 ft	¼” plate	24” x 48”	bubbler
031	Hanford #1 Overflow	129.75 ft	1” + 9” upstream + 2” downstream bevels	--	bubbler (not functional)
	Bayview N	18 ft	12” flat, width varies	--	Ultrasonic / pressure depth meters
	Bayview S	18 ft	6” flat	--	
	Hanford at Rainier	18 ft		--	
032	Hanford #2 Regulator	--		144” x 96”	bubbler
033	Rainier Avenue Pump Station Emergency Overflow	39.4 ft horseshoe	flat, width varies	--	bubbler
034	East Duwamish Pump Station Emergency and Siphon Aftbay Overflows	5.0 ft	8” flat with flap gate	--	Ultrasonic / pressure depth meter
035	West Duwamish Siphon Forebay Overflow	5.0 ft	8” flat with flap gate	--	Ultrasonic / pressure depth meter
036	Chelan Avenue Regulator	4.5 ft	12” flat	54” x 54”	bubbler
037	Harbor Avenue Regulator	7 ft		54” x 54”	bubbler
038	Terminal 115 Overflow	--		--	Area-Velocity meter
039	Michigan Regulator (also called South Michigan Regulator)	10 ft		96” x 60”	bubbler
040	8th Avenue S Regulator and West Marginal Way Pump Station Emergency Overflow	3.0 ft	12” flat	36” x 36”	bubbler
041	Brandon Street Regulator	4.8 ft		48” x48”	bubbler
042	West Michigan Regulator (SW Michigan Street Regulator)	4.8 ft		24” circular	bubbler
043	East Marginal Pump Station	3 ft circular		--	bubbler
044	Norfolk Outfall and Henderson/MLK CSO Treatment Facility	2 – 7 ft (14 ft total)	6” + 18” downstream bevel	54” x 48”	bubbler
045	Henderson Pump Station	2 - 6 ft (12 ft total)	12” flat with flap gate	--	bubbler
046	Carkeek CSO Treatment Facility Outfall	V-notch		--	bubbler
048b	North Beach Pump Station Emergency Overflow (inlet structure)	4.8 ft	radius both sides	--	Ultrasonic / pressure depth meter

DSN No.[a]	Facility	Weir Length	Crest Shape	Gate (w x h)	Sensor
048a	North Beach Pump Station Emergency Overflow (wet well)	9 ft	2" + 4" downstream bevel	--	bubbler
049	30th Avenue NE Pump Station	6 ft		--	bubbler
051	Alki CSO Treatment Facility Outfall	--		--	EMF meter
052	53rd Avenue SW Pump Station Emergency Overflow	2.5 ft		--	bubbler
054	63rd Avenue SW Pump Station Emergency Overflow	114.29 ft	¼" plate	--	bubbler
055	SW Alaska Street Overflow	30 ft	¼" plate	--	Ultrasonic / pressure depth meter
056	Murray Avenue Pump Station Emergency Overflow	72 ft	¼" plate	--	bubbler + Area-Velocity meter
057	Barton Street Pump Station Emergency Overflow	33 ft	2" + 4" downstream bevel	--	bubbler

[a] DSN = discharge serial number, as set in the NPDES permit.
[b].EMF meter = Electro-Magnetic Flow meter

3.2 Measurement Acquisition and Storage

Where possible, monitoring data is reported to King County's SCADA system and subsequently archived in a process historian. Where this is not possible, data is telemetered to King County's flow database or is downloaded by King County personnel and entered in to the flow database.

3.3 Sample Documentation

Sampling information and sample metadata are limited to:

1. station name/locator
2. date and time of measurement

These data are stored with the data in the County's SCADA system or in King County's flow database.

4.0. MEASURMENT METHODS AND DETECTION LIMITS

Measurement and calculation methods to determine flow rate is presented in this section, along with instrument-specific detection limits.

4.1 Electromagnetic Flow Meters

Electromagnetic flow meters are characterized by high linearity and wide measuring spans (over 1:100 at errors of less than 1% of the measured value). The accuracy can vary by manufacturer and model, details may be found in the Facility Operations Manual or in King County's Maintenance database (MainSaver).

4.2 Weirs and Gates

A weir is defined as an overflow structure built according to specific design standards across an open channel to measure the flow of water. Equations can be derived for weirs of specific geometry which relate static head to water flow. Weirs are classified into two general categories, broad crested and sharp crested.

Gates block the discharge opening until they are raised, allowing flow to exit underneath the gate. The gate position can be regulated and equations can be derived to relate the water flow to the gate position and static head.

Computer code integrated into King County's SCADA system calculates overflow discharges from weir and gate structures. The method uses two equations for calculating flow: one for conditions when the tailwater is free flowing or partially submerged, and the other for conditions when the gate is totally submerged by tailwater. Additional information of the algorithms is contained in CATAD Software Conversion (Metro, 1988).

The primary measurement variable for flows through weirs and gates is the upstream water surface elevation. Most locations measure water level surface with an air bubbler, although ultrasonic depth sensors or pressure depth sensors are used in specific locations. An air bubbler system uses a tube with an opening below the surface of the liquid level. A fixed flow of air is passed through the tube. Pressure in the tube is proportional to the depth (and density) of the liquid over the outlet of the tube. Air bubbler systems contain no moving parts, making them suitable for measuring the level of sewage. The only part of the sensor that contacts the liquid is a bubble tube. These instruments are expected to be accurate to 0.1 ft.

4.3 Area-Velocity Meters

Area-Velocity flow meters measure flow depth and velocity, and convert these measurements into a total flow rate. Flow depth may be measured with an ultrasonic level sensor or a pressure depth sensor, or both. Velocity may be measured from the Doppler shift of an ultrasonic signal or from time-of-flight measurements of an ultrasonic signal, or from a radar measurement. Comparisons in laboratory evaluations suggest these meters are accurate to +/- 10%, but site specific conditions can reduce this performance.

5.0. QUALITY ASSURANCE/QUALITY CONTROL

This section presents laboratory quality assurance/quality control (QA/QC) measures that will be employed to ensure data are of sufficient quality to meet the project DQOs.

5.1 Electromagnetic

Electromagnetic flow meters (EMF) operate without any mechanically moving parts and so basically never wear out. Many EMFs in service have been doing their job quietly and unnoticed for decades without requiring maintenance or recalibration. Maintenance therefore relates primarily to controls for signs of damage due to external influence, to deposits and the effect of abrasion in the measuring tube, and the usual failure modes. Each flow meter and its head unit are inspected yearly to ensure that the programming is intact and matches the original calibration data.

5.2 Weirs and Gates

Flow over weirs or through gates is calculated from the upstream, and sometimes downstream, water surface elevation. Water surface elevations are measured from bubbler systems, pressure transducers, or ultrasonic depth probes. O&M staff verify the operation of all level detectors against expected levels during visits to each facility, typically monthly.

Bubblers systems are maintained continuously by O&M staff. Bubbler systems are purged at least monthly by Operations, sometimes more frequently. Purging uses high-pressure air to dislodge any solids that may clog the bubble tube. Some bubblers have automatic system purges that occur every 24 hours.

Bubbler system depth/pressure transmitters are checked / tested / calibrated on at least a yearly basis by Instrumentation staff. This is done by removing the transmitter from active service, verifying an accurate zero, span check, and point calibration. The pressure sensor zero-point is checked to atmospheric pressure. Air bubbler accuracy is generally reported by manufacturers as +/- 0.02 ft or +/- 0.05% of full scale.

On at least an annual basis, the setup and programming parameters of pressure transducers are verified by O&M staff. A visual inspection is made to ensure the sensor is not covered with debris.

On at least an annual basis, the setup and programming parameters of the ultrasonic level detectors are verified by O&M staff. The units sensing heads are permanently installed and have fixed elevations as called out on the record drawings.

5.3 Area-Velocity Meters

Installation of area-velocity flow meters is accompanied by a field verification process to independently verify the accuracy of the flow meters and generate depth-velocity relationships and variables that would be used in flow calculations. The field verification process is outlined in the Flow Monitoring SOP (King County, 2011), and requires field crews to descend into the manhole to take the manual measurements. The process of field verification includes manually measuring depth, velocity, and flow quantity at the monitoring site and comparing these readings with real time readings from the meter. Meters installed to measure CSO overflows may be located in normally dry pipes, in which case field verification consists of verifying depth. The field verification process is repeated at least annually.

The raw data collected from flow meters is reviewed and edited as necessary by a Data Analyst. The detailed review and editing procedure is described in the Flow Monitoring SOP (King County, 2011). The Data Analyst reviews the data to identify erroneous data, including depth and/or velocity "pops" and "drop outs", depth and velocity not showing matching diurnal patterns during normal open channel flow, and shift in depth indicating a backwater condition but not accompanied by drop in velocity. Based on review and analysis of field confirmations, field crew observations during site visits, and historical trend and data consistency with site hydraulics, some of the invalid data may be reconstituted or flagged. Flagging is a term applied to removing the invalid data from being used in flow calculations. Reconstituted refers to the process of generating depth-velocity relationships using good quality and valid data to reconstruct poor/erroneous velocity (and in some cases depth) data. Reconstituted data are used in flow quantity calculations.

6.0. DATA VALIDATION, REPORTING AND RECORD KEEPING

This section provides information on how monitoring data will be reported and interpreted and how project records will be maintained.

6.1 Data Validation

Data validation is critical for evaluating how well analytical data meet project DQOs. Data validation is performed by a Data Analyst prior to overflow data being reported to Ecology. This validation consists of reviewing time series plots of rainfall, upstream water depth, in-pipe flow rates, pump speeds and rates (if applicable), and overflow rates. Erroneous or invalid data will be flagged and noted as such when reported to Ecology.

6.2 Reporting

All overflow data will be reported to Ecology on King County's monthly DMR report. CSO locations that did not have an overflow in the previous month will be reported as "NO DISCHARGE" or with a zero.

All data and supporting information will be available for review upon request. Analytical data reports may be requested, either in hard copy or electronic formats, in Microsoft Excel spreadsheets. Data validation logs will be available, either hard copy or electronically. All other project information will be available for review in hard copy only.

6.3 Record Keeping

All hard-copy field sampling records, raw data, and summaries will be archived according to Ecology requirements for a minimum of 3 years from the date samples were collected.

7.0. REFERENCES

King County, 2011. *Standard Operating Proceedures – Flow Monitoring*. October 18, 2011. Seattle, WA.

Municipality of Metropolitan Seattle, 1988. *CATAD Software Conversion.* Publication 184, August 1988. Seattle, Washington

U.S. Department of the Interior, Bureau of Reclamation, 2001. *Water Measurement Manual*. http://www.usbr.gov/pmts/hydraulics_lab/pubs/wmm/

Appendix C. Treated CSO Sampling and Analysis Plan and Quality Assurance Project Plan

The current version of the Treated CSO Sampling and Analysis Plan and Quality Assurance Project Plan (SAP/QAPP) is attached electronically to this document.

Combined Sewer Overflow Effluent Quality Sampling and Analysis Plan

March 2012

King County

Department of
Natural Resources and Parks
Wastewater Treatment Division

Alternate Formats Available

206-296-7380 TTY Relay: 711

Combined Sewer Overflow Effluent Quality
Sampling and Analysis Plan

King County

Department of
Natural Resources and Parks
Wastewater Treatment Division

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1.0. INTRODUCTION

This sampling and analysis plan and quality assurance project plan (SAP/QAPP) presents project information along with sampling and analytical methodologies that are employed to measure the effluent quality at King County's Combined Sewer Overflows (CSO) treatment facilities. Effluent quality includes chemical and conventional parameters. This work is being performed to fulfill one requirement of the County's National Pollutant Discharge Elimination System (NPDES) permit for the West Point treatment plant. The SAP includes a description of the project, monitoring history, sampling design, sampling and analytical methodologies, and reporting requirements.

1.1 Project Background

Seattle's combined sewer system dates from the 1890s. Sanitary engineers of that period were trained to deal with all aspects of streets and with sewage, drainage and water supply. Combined sewers were the inevitable result. Since the streets were then visibly coated with manure, it seemed logical that they should also drain into the same single pipe network that carried human wastes.

Combined sewers moved the problems of sanitary wastes, horse manure and rainwater away from the immediate vicinity of houses and streets out into an appropriate body of water, where dilution was assumed to (and initially did) take care of it. Overflows of the combined sewers (storm water combined with raw sewage) were designed to occur in these systems because pipes large enough to store or carry all the rainwater to its ultimate destination were too expensive to put in and because treatment of these combined wastes was not an issue--just getting them to the nearest lake or bay was considered an improvement.

Since the early 1950s the construction of separate systems for sanitary sewage (which is now treated before disposal) and storm water (which is discharged directly to the nearest water body) has been the standard environmental and engineering practice for drainage and wastewater utilities locally as well as nationwide. The City of Seattle is the only jurisdiction with combined sewers in the King County Wastewater Treatment Division service area.

Metro was formed in 1958 to provide a regional wastewater treatment system for the entire metropolitan Seattle area and in 1994 King County assumed authority of Metro and its legal obligation to treat wastewater. Shortly after Metro was formed, construction began on the county's two existing regional treatment plants, West Point in Seattle's Magnolia neighborhood and South Treatment Plant in Renton, which were officially up and running by 1966.

In July 1986, the Metro Council adopted a plan to upgrade its Puget Sound plants to secondary treatment. Under the plan, Metro would upgrade its West Point plant to secondary and convert its Alki and Carkeek plants to treat combined sewer overflows only. The Renton plant has provided secondary treatment since it opened in 1965. In addition, Metro adopted a program to control combined sewer overflows further and achieve a 75 percent reduction in overflows during a 20-year-period to fulfill new state Ecology Department requirements.

In 1972 the National Pollution Discharge Elimination System (NPDES) was created in Section 402 of the Clean Water Act. "NPDES prohibits [discharges] of pollutants from any point source into the nation's waters except as allowed under an NPDES permit." The program gives the EPA

the authority to regulate discharges into the nation's waters by setting limits on the effluent that can be introduced into a body of water from an operating and permitted facility.

Washington State established Combined Sewer Overflow (CSO) control standards (RCW 90.48.480, WAC 173-245) in 1987, ahead of EPA adopting their CSO control policy in 1994. In 1988, King County adopted a new CSO control program to meet the new standard of one untreated CSO discharge per CSO site per year. The County's CSO plan and Ecology's requirements included data collection to characterize the CSO discharges and estimate historical impacts. Beginning in 1988, Metro conducted discharge sampling of five CSO sites annually through 1992 to meet requirements of WAC 173-245-040 (2) (a) (i) and condition S11.Cl of the West Point Treatment Plant's National Pollutant Discharge Elimination System (NPDES) permit. Sampling included trace organics analysis, metals and conventionals analyses.

In order to comply with WAC 173-245-040(2) and the West Point Treatment Plant NPDES permit requirements, a CSO reduction plan must include a characterization of CSO discharges based on flow monitoring and sampling of CSOs. As described in the 1988 CSO Plan, Metro was to sample overflows from five sites per year and sediment off of nine outfalls in an effort to characterize CSO discharges and the affected offshore sediments. Sampling was determined to be complete in 1995.

1.2 Scope of Work

This effluent quality sampling involves collection and analysis of effluent water samples from King County's Combined Sewer Overflow (CSO) treatment facilities. The goal is to produce data of known quality that can be used to characterize the specified chemical concentrations and parameters in the effluent discharge from King County's CSO treatment facilities and associated outfalls.

Samples will be analyzed for conventional water quality parameters, metals, volatile organics, and Base/Neutral and Acid (BNA) organic compounds.

The planned scope of work described in this SAP is designed to meet requirements of King County's NPDES West Point Permit #WA-002918-1, issued by Ecology, effective July 1, 2009. The permit states, in part (Section S2.B):

> Samples and measurements taken to meet the requirements of this permit must represent the volume and nature of the monitored parameters. The Permittee must conduct representative sampling of any unusual discharge or discharge condition, including bypasses, upsets, unit process failures, and maintenance-related conditions that may affect effluent quality.

1.3 Schedule

Sampling data must be reported to Ecology on a discharge monitoring report (DMR) form that is postmarked or received by Ecology no later than the 20th day of the month following the completed monitoring period, unless otherwise specified in the NPDES permit.

Priority pollutant analysis data must be reported to Ecology no later than 60 days following the monitoring event.

1.4 Project Staff

The following staff are responsible for project execution:

Dan Grenet, West Section Plant Manager	(206) 263-3825
Karl Zimmer, West Offsite Supervisor	(206) 263-3955
John Cameron, East Offsite Supervisor	(206) 684-2403
Fritz Grothkopp, Laboratory Project Manager	(206) 684-2327
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2.0. PROGRAM DESIGN

The goal of King County's effluent quality monitoring is to collect samples that represent the nature of the monitored parameters. Resulting data will allow King County to meet the monitoring requirement of the County's NPDES permit and to characterize the effectiveness of CSO controls for the CSO Control Plan.

2.1 Data Quality Objectives

The data quality objectives (DQOs) are to collect data of known and sufficient quality to meet the program goals. Validation of project data will assess whether the data collected are of sufficient quality to meet the program goals. The data quality issues of precision, accuracy, bias, representativeness, completeness, comparability, and sensitivity are described in the following sections, along with data validation.

2.1.1 Precision, Accuracy, and Bias

Precision is the agreement of a set of results among themselves and is a measure of the ability to reproduce a result. Accuracy is an estimate of the difference between the true value and the measured value. The accuracy of a result is affected by both systematic and random errors. Bias is a measure of the difference, due to a systematic factor, between an analytical result and the true value of an analyte. Precision, accuracy, and bias for analytical chemistry may be measured by one or more of the following quality control (QC) procedures:

- analysis of various laboratory QC samples such as blanks, surrogates, and replicates; and
- collection and analysis of field replicate samples.

2.1.2 Representativeness

Representativeness expresses the degree to which sample data accurately and precisely represent a characteristic of a population, parameter variations at the sampling point, or an environmental condition. Water samples will be collected from locations within the effluent discharge structure to represent CSO effluent. Flow proportional composite samples will be collected via an automatically triggered auto sampler. The auto samplers will be set to collect a series of individual samples collected over a flow period, and combined into a single container and analyzed as one sample.

2.1.3 Completeness

Completeness is defined as the total number of samples analyzed for which acceptable analytical data are generated, compared to the total number of samples submitted for analysis. Sampling with adherence to standardized sampling and testing protocols will aid in providing a complete set of data for this survey. The goal for completeness is 100%. If 100% completeness is not achieved, the project team will collect additional samples from a subsequent event. If 100% completeness is not achieved for a parameter that is required on a per event frequency, the project team will evaluate if modifications to the instrumentation or facility need to be made to meet this goal in future events.

2.1.4 Comparability

Comparability is a qualitative parameter expressing the confidence with which one data set can be compared with another. This goal is achieved through using standard techniques to collect and analyze representative samples, along with standardized data validation and reporting procedures. By following the guidance of this SAP, the goal of comparability between this and future sampling events will be achieved. Historical CSO data may be compared with data generated from this program to enhance data analysis efforts. Previous sampling efforts have analyzed CSO effluents by similar methods.

2.1.5 Sensitivity

Sensitivity is a measure of the capability of analytical methods to meet the survey goal. The analytical method detection limits presented in Section 4.0 are sensitive enough the analytes at the minimum concentrations required by Ecology.

2.1.6 Data Validation

All chemical analysis and associated conventional water quality data will be validated against requirements of the reference methods as well as the requirements of this SAP.

2.2 Sampling and Analytical Strategy

The CSO effluent quality sampling strategy has been designed to meet the requirements of the NPDES permit and to obtain samples that are representative in nature of the CSO effluent. Thus, the sampling strategy divides sample collection into two activities. Samples intended to characterize the treatment performance and compliance with final effluent permit limits will be collected for each CSO event. Samples for final effluent characterization (often referred to as priority pollutant sampling) will be collected for one event each year, or as specified in the NPDES permit. Samples will be collected from the effluent channel during periods the CSO facility is discharging.

2.2.1 Sampling Station Locations and Sample Identification

The four sampling station locations are: Alki CSO Treatment Facility, Carkeek CSO Treatment Facility, Elliott West CSO Treatment Facility, and MLK/Henderson CSO Treatment Facility, as shown in Figure 1. Samples are collected from different locations within these facilities. Sampling locations and locator tags are summarized in Table 1. Samples will be identified using the sample location or locator name and the date of collection.

Figure 1. King County CSO Treatment Plant/Facility Locations

Table 1. King County CSO Discharge Sampling Locations

DSN No.[a]	Facility	Sample Type	Locator	Sampling Location
027b	Elliot West CSO Treatment Facility	Effluent Characterization	A4004	ELLIOTT WEST CSO TREATMENT PLANT TRANSITION STRUCTURE; SOUTH-END SIDE OF DENNY WY REGULATOR BLDG. 3165 ALASKAN WAY IN MYRTLE EDWARDS PARK
027b		Main pump return flow composite	SAM792,501 Elliott West Main Return	automatic sampler on ground level, north wall
027b		Main pump return flow grab		pump discharge channel on mezzanine level
027b		Dewatering pump return flow composite	SAM792,502 Elliott West Dewatering	dewatering pump discharge pipe on pump level
027b		Dewatering pump return flow grab		dewatering pump discharge pipe on pump level
027b		Effluent composite	SAM800,214	in Denny Way Regulator Station: automatic sampler in chemical room
027b		Effluent grab		in Denny Way Regulator Station: final effluent line sampling port in chemical room
027b		Fecal coliform grab		in Denny Way Regulator Station: final effluent line sampling port in chemical room
044	Norfolk Outfall and Henderson/MLK CSO Treatment Facility		HEND/MLK OUTLET CSO	HENDERSON/ML KING OUTLET REGULATOR CSO TREATMENT PLANT STRUCTURE; S NORFOLK ST APPROX 300 FEET WEST OF MARTIN LUTHER KING JR WAY
044		Influent composite		Inlet Regulator Building, Flow Control Room
044		Effluent composite		Outlet Regulator Building, Equipment Room
044		Alternate Effluent composite		Outlet Regulator Building, Equipment Room
046	Carkeek CSO Treatment Facility Outfall		A1001	at V-notch weir of Chlorine contact channel
046		Influent composite	CPTP_INFLUENT	Collect from wet well overflow; sampler in Pump room of Pump Station building
046		Influent grab	CPTP_INFLUENT	Collect from wet well overflow
046		Effluent composite	CPTP_EFFLUENT	Collected from V-notch weir; sampler in Operations Building, Chemical Feed Room
046		Effluent grab	CPTP_EFFLUENT	Collect from V-notch weir at Chlorine contact channel
051	Alki CSO Treatment Facility Outfall		A4002	located at Chlorine Contact channel weir
051		Influent composite		see Figure 2
051		Influent grab		see Figure 2
051		Effluent composite		see Figure 2
051		Effluent grab		see Figure 2

[a] DSN = discharge serial number, as set in the NPDES permit.

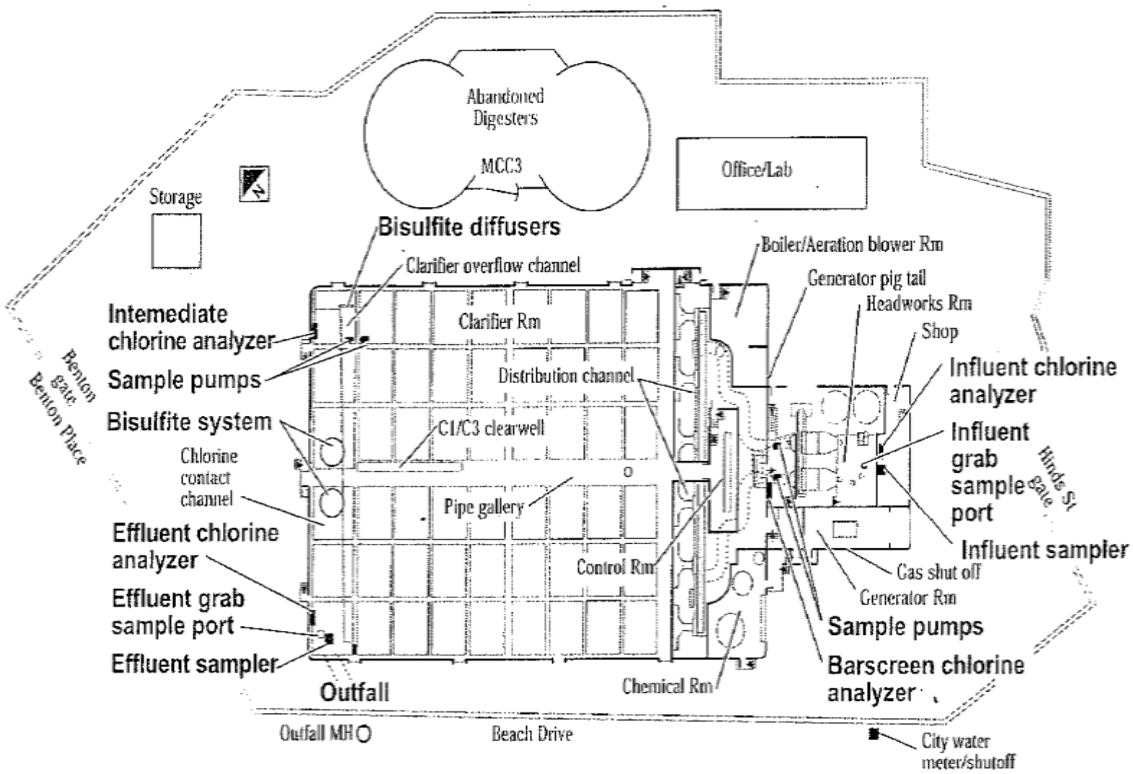


Figure 2. Alki CSO Treatment Facility Sampling Locations

2.2.2 Sample Acquisition and Analytical Parameters

Samples intended to characterize the treatment performance and compliance with final effluent permit limits ("per event" samples) will be collected for each CSO event. Samples for final effluent characterization ("effluent characterization" samples, often referred to as priority pollutant sampling) will be collected for one event each year, or as specified in the NPDES permit.

2.2.2.1 Per Event Samples

Sampling will be conducted by King County Offsite, South Plant Process Lab Specialists and Environmental Laboratory (KCEL) personnel. Sampling techniques are discussed in Section 3.

King County personnel involved in sample collection participate in an annual training program prior to the beginning of the wet season. Operations staff, and laboratory staff from all three labs participate in these training sessions. Training is held on location at the CSO facilities and at the laboratories. Training entails reviewing the SOP for sampling technique, sample locations, NPDES permit requirements for monitoring, holding times etc. Protocols for special situations

are reviewed, including sampling for short events – where two additional sampling locations are required when event is so short that the event is over before staff respond.

King County offsite personnel or process lab staff will collect flow proportional composite samples from the influent and effluent streams from each CSO event. The influent samples will be analyzed for BOD_5 and TSS, and the effluent samples will be analyzed for BOD_5, TSS, and settleable solids (Table 2). pH and chlorine residual is recorded from inline instrumentation. Grab samples will be collected at specific time intervals after the discharge begins to the receiving water as follows:

1. 1 sample within first 3 hours
2. 1 sample within 4-8 hours
3. 1 sample after 20-24 hours
4. If the discharges extends beyond 24 hours, at a minimum 1 sample will be taken each day until the discharge ends.

Grab samples will be analyzed for fecal coliforms. Samples will also be analyzed for pH and residual chlorine if online instrumentation is not available. These analyses will be conducted by King County West Point Laboratory or King County South Plant Laboratory.

Table 2. Per Event Analyte List

Analyte & CAS No. ***(if available)***	
Conventional Pollutants	
Influent Biochemical Oxygen Demand	Effluent Biochemical Oxygen Demand
Influent Total Suspended Solids	Effluent Total Suspended Solids
	Effluent settleable solids
	Effluent fecal coliforms
	Effluent residual chlorine
	Effluent pH

2.2.2.2 Effluent Characterization Samples

Effluent characterization samples are typically collected for one event each year (or as specified in the NPDES permit). King County Environmental Laboratory personnel will collect flow proportional composite samples which will be analyzed for conventional parameters, metals, volatile organics, base/neutral and acid (BNA) organics as shown in Table 3. All analyses will be conducted by the King County Environmental Laboratory.

Table 3. Effluent Characterization Analyte List

Analyte & CAS No. ***(if available)***

Analyte & CAS No. ***(if available)***		
Conventional Pollutants, HEM, Cyanide & Total Phenols		
Dissolved oxygen	Total Ammonia (as N)	Oil and Grease (HEM)
Temperature	Nitrate-Nitrite (as N)	Total dissolved solids
Phenols, Total	Total Kjeldahl Nitrogen (as N)	Cyanide, Weak Acid Dissociable (7440-66-6)
Total Alkalinity	Ortho-Phosphorus (PO_4 as P)	Total Hardness
Salinity	Phosphorus, Total (as P)	
Metals		
Antimony, Total (7440-36-0)	Copper, Total (7440-50-8)	Selenium, Total (7782-49-2)
Arsenic, Total (7440-38-2)	Lead, Total (7439-92-1)	Silver, Total (7440-22-4)
Beryllium, Total (7440-41-7)	Mercury, Total (7439-97-6)	Thallium, Total (7440-28-0)
Cadmium, Total (7440-43-9)	Nickel, Total (7440-02-0)	Zinc, Total (7440-66-6)
Chromium,Total (7440-47-3)		
Volatile Compounds[b]		
Acetone (67-64-1)[a]	1,2-Dichlorobenzene (95-50-1)	4-Methyl-2-Pentanone (108-10-1)[a]
Acrolein (107-02-8)	1,3-Dichlorobenzene (541-73-1)	Methyl-t-butyl ether (1634-04-4)[a]
Acrylonitrile (107-13-1)	1,4-Dichlorobenzene (106-46-7)	Methylene chloride (75-09-2)
Benzene (71-43-2)	Dichlorobromomethane (75-27-4)	Styrene (100-42-5)[a]
Bromoform (75-25-2)	1,1-Dichloroethane (75-34-3)	1,1,2,2-Tetrachloroethane (79-34-5)
2-Butanone (78-93-3)[a]	1,2-Dichloroethane (107-06-2)	Tetrachloroethylene (127-18-4)
Carbon Disulfide (75-15-0)[a]	1,1-Dichloroethylene (75-35-4)	Toluene (108-88-3)
Carbon tetrachloride (108-90-7)	1,2-Dichloropropane (78-87-5)	1,2-Trans-Dichloroethylene (156-60-5) (Ethylene dichloride)
Chlorobenzene (108-90-7)	1,3-dichloropropylene (mixed isomers) (542-75-6)	1,1,1-Trichloroethane (71-55-6)
Chloroethane (75-00-3)	1,2-Dimethylbenzene(Ortho-xylene) (95-47-6)[a]	1,1,2-Trichloroethane (79-00-5)
2-Chloroethylvinyl Ether (110-75-8)	1,3-,1,4-Dimethylbenzene(Meta-,Para-Xylene) (108-38-3, 106-42-3)[a]	Trichloroethylene (79-01-6)

Analyte & CAS No. ***(if available)***		
Chloroform (67-66-3)	Ethylbenzene (100-41-4)	Trichlorofluoromethane (75-69-4)[a]
Dibromochloromethane (124-48-1)	2-Hexanone (591-78-6)[a]	Vinyl acetate (108-05-4)[a]
1,2-Dibromoethane (106-93-4)[a]	Methyl bromide (74-83-9) (Bromomethane)	Vinyl chloride (75-01-4)
	Methyl chloride (74-87-3) (Chloromethane)	Total Xylenes (1330-20-7)[a]
Acid Compounds		
Benzoic Acid (65-85-0)[a]	2,4-Dimethylphenol (105-67-9)	2-Nitrophenol (88-75-5)
Benzyl Alcohol (100-51-6)[a]	4,6-dinitro-o-cresol (534-52-1) (2-methyl-4,6,-dinitrophenol)	4-Nitrophenol (100-02-7)
4-chloro-3-methylphenol (59-50-7) (Parachlorometa cresol)	2,4 Dinitrophenol (51-28-5)	Pentachlorophenol (87-86-5)
2-Chlorophenol (95-57-8)	2-Methylphenol (95-48-7)[a]	Phenol (108-95-2)
2,4-Dichlorophenol (120-83-2)	3-,4-Methylphenol (108-39-4,106-44-5)[a]	2,4,6-Trichlorophenol (88-06-2)
Base/Neutral Compounds		
Acenaphthene (83-32-9)	Chrysene (218-01-9)	Hexachlorobutadiene (87-68-3)
Acenaphtylene (208-96-8)	n-Decane (124-18-5)[a]	Hexachlorocyclopentadiene (77-47-4)
Anthracene (120-12-7)	Dibenzo (a,j)acridine (224-42-0)	Hexachloroethane (67-72-1)
Benzidine (92-87-5)	Dibenzo (a,h)acridine (226-36-8)	Indeno(*1,2,3-cd*)Pyrene (193-39-5)
Benzyl butyl phthalate (85-68-7)	Dibenzo(a-*h*)anthracene (53-70-3) (1,2,5,6-dibenzanthracene)	Isophorone (78-59-1)
Benzo(*a*)anthracene (56-55-3)	Dibenzo(a,e)pyrene (192-65-4)	3-Methyl cholanthrene (56-49-5)
Benzo[b]fluoranthene (3,4-benzofluoranthene) (205-99-2) reported as combined Benzo[b,j,k]fluoranthene	Dibenzo(a,h)pyrene (189-64-0)	2-Methylnaphthalene (91-57-6)[a]
Benzo[j]fluoranthene (205-82-3) reported as combined Benzo[b,j,k]fluoranthene	Dibenzofuran (132-64-9)[a]	Naphthalene (91-20-3)
Benzo[k]fluoranthene (11,12-benzofluoranthene) (207-08-9) reported as combined Benzo[b,j,k]fluoranthene	3,3'-Dichlorobenzidine (91-94-1)	Nitrobenzene (98-95-3)

Analyte & CAS No. ***(if available)***		
Benzo(r,s,t)pentaphene (189-55-9)	Diethyl phthalate (84-66-2)	N-Nitrosodibutylamine (924-16-3)[a]
Benzo(*a*)pyrene (50-32-8)	Dimethyl phthalate (131-11-3)	N-Nitrosodiethylamine (55-18-5)[a]
Benzo(*ghi*)Perylene (191-24-2)	Di-n-butyl phthalate (84-74-2)	N-Nitrosodimethylamine (62-75-9)
Bis(*2-chloroethoxy)*methane (111-91-1)	2,4-dinitrotoluene (121-14-2)	N-Nitrosodi-n-propylamine (621-64-7)
Bis(*2-chloroethyl*)ether (111-44-4)	2,6-dinitrotoluene (606-20-2)	N-Nitrosodiphenylamine (86-30-6)
Bis(*2-chloroisopropyl*)ether (108-60-1)	Di-n-octyl phthalate (117-84-0)	n-Octadecane (593-45-3)[a]
Bis(*2-ethylhexyl*)phthalate (117-81-7)	1,2-Diphenylhydrazine (*as Azobenzene*) (122-66-7)	Perylene (198-55-0)
4-Bromophenyl phenyl ether (101-55-3)	Fluoranthene (206-44-0)	Phenanthrene (85-01-8)
Carbazole (86-74-8)[a]	Fluorene (86-73-7)	Pyrene (129-00-0)
2-Chloronaphthalene (91-58-7)	Hexachlorobenzene (118-74-1)	1,2,4-Trichlorobenzene (120-82-1)
4-Chlorophenyl phenyl ether (7005-72-3)		

[a] Analysis is not required under current NPDES permit

[b] NPDES permit lists 3,3'-Dichlorobenzidine (91-94-1) under both Volatile Organics and Base/Neutral Compounds. Included here under Base/Neutral Compounds

3.0. SAMPLING PROCEDURES

This section describes the sampling procedures that will be followed over the course of all sampling events to meet the program's DQOs: representativeness, comparability, and completeness. Separate procedures are used for the two types of sampling activities. Samples intended to characterize the treatment performance and compliance with final effluent permit limits ("per event" samples) will be collected for each CSO event. Samples for final effluent characterization (often referred to as priority pollutant sampling) will be collected for one event each year, or as specified in the NPDES permit. Equipment and sample preparation will generally follow PSAMP (1997) protocols.

3.1 Sampler Decontamination and Sample Collection

3.1.1 Per Event Samples

Samples collected during each CSO event (see Table 2 for parameters) use an automated sampler system installed at each CSO treatment facility. When the CSO treatment facility is not in operation, sampler lines are flushed with C2 water. Once the facility commences operation, sampler pumps provide influent/effluent to the online analyzers (residual chlorine, pH) and to the autosampler. Additional details on the sampling configuration are contained in each facility's Operations and Maintenance manual.

The autosampler will continue to collect samples as long as the CSO facility is discharging. The composite sample is collected in a sampler jug located in a refrigerated unit within the autosampler. At a prescribed time, typically 7am, the sampler jug is removed from the refrigerator and gently shaken. A pre-cleaned 2L sampling bottle (HDPE) is filled from the sampler jug and labeled. The sampler jug is emptied, rinsed (tap water), capped, and put back into the refrigerator.

Grab samples will be taken at pre-specified times during the period the CSO facility is discharging. A pre-cleaned 2L sampling bottle or sterile glass bottle for coliforms is filled from the sampling location and labeled. Sample bottles are prepared and supplied to the CSO facilities by either the Process Labs or King County Environmental Labs.

3.1.2 Effluent Characterization Samples

Samples collected for priority pollutant analysis (see Table 3 for parameters) are collected with flow-paced autosamplers. Auto samplers will be fitted with new and pre-cleaned silicon tubing in the peristaltic pump for each sampling event. Teflon tubing and stainless steel (SS) fittings shall be used for all other tubing runs. Teflon tubing and autosampler containers shall be cleaned with: 1) alconox or other suitable laboratory detergent, 2) a H2SO4 rinse and 3) a DI water rinse. All SS fittings and connectors are cleaned in the same manner except they are not subjected to the acid rinse step. Composite autosampler bottles and autosampler tubing will be cleaned prior to each sampling event according to laboratory standard operating procedures (SOP # 02-02-014-001) for collecting samples for low-level analysis using autosamplers.

3.2 Sample Delivery and Storage

Sampler bottles for parameters collected for each CSO event are kept in refrigerators until transport to the laboratory. Samples are delivered to the laboratory within 2 hours. Additional sample preservation, if required, will be performed upon receipt of the samples at the King County West Point Laboratory or South Plant Laboratory. Samples will be split from the 2L container into the appropriate analytical containers and preserved according to method specifications at the laboratory.

Sampler bottles for priority pollutant analysis are packed in ice and transported to the King County Environmental Laboratory. Additional sample preservation, if required, will be performed upon receipt of the samples at the laboratory. Samples will be split from the sampler bottles into the appropriate analytical containers and preserved according to method specifications at the laboratory.

Table 4 shows sample handling and storage requirements.

Table 4. Sample Container, Preservation, Storage, and Hold Time Requirements

Analyte	Analysis Lab	Container	Preservation	Storage	Hold Time
BOD	Process Lab	300 ml HDPE or Glass	None	Refrigerate at 4°C	24 Hours
Total Suspended Solids	Process Lab	1-L clear HDPE	None	refrigerate at 4°C	7 days
Settleable Solids	Process Lab	300 ml HDPE or Glass	None	Refrigerate at 4°C	24 Hours
Total Residual Chlorine	Process Lab	10 mL HDPE or Glass	None	Analyze immediately	0.25 hours
Fecal Coliform	Process Lab	500 mL HDPE or Glass with Sodium Thiosulfate	Sodium Thiosulfate add before sterilization	Refrigerate at 4°C	8 hours
pH	Process Lab	100 mL HDPE or Glass	None	Analyze immediately	0.25 hours
Temperature	KCEL	100 mL HDPE or Glass	None	Analyze immediately	0.25 hours
Volatile Organics (VOA)	KCEL	2 X 40ml glass vials	None	refrigerate at 4°C	7 days
Base/Neutral and Acid Organics (BNA)	KCEL	2 x 1L amber glass	None	refrigerate at 4°C	7/40[2]
Metals (Total)	KCEL	500 mL Acid washed HDPE	HNO_3 to pH<2	n/a	180 days
Mercury	KCEL	500 mL Acid washed Teflon bottle	HCL to pH<2	n/a	90 days

Analyte	Analysis Lab	Container	Preservation	Storage	Hold Time
Ammonia N, nitrate-nitrite	KCEL	250mL CWM HDPE	Freeze filtered aliquot[1]	Freeze at -20°C	14 days
Total Phosphorus	KCEL	- (from same 250mL container above)	Freeze sample[3]	Freeze at -20°C	28 days
Ortho-Phosphate	KCEL	60mL CWM HDPE	Freeze filtered aliquot[5]	Freeze at -20°C	14 days
Total Kjeldahl Nitrogen	KCEL	250mL CWM HDPE	H_2SO_4 to pH < 2	Cool to ≤ 6ºC	28 days
Total Alkalinity	KCEL	500mL clear HDPE	None	Cool to ≤ 6ºC	14 days
Winkler Dissolved Oxygen	KCEL	300mL Glass Wheaton with glass stopper	$MnSO_4$ / AIA[4,6]	Ambient temperature	8 hours
Total Dissolved Solids	KCEL	500mL CWM HDPE	None	Cool to ≤ 6ºC	7 days
Cyanide, Weak Acid Dissociable	KCEL	500 mL AWM HDPE	NaOH to pH>12[4]	Cool to ≤ 6ºC	14 days
Salinity	KCEL	125 mL CNM HDPE	None	Cool to ≤ 6ºC	28 days
Phenolics	KCEL	1L AWM Glass	H2SO4 to pH<2[4]	Cool to ≤ 6ºC	28 days
Oil and Grease (HEM)	KCEL	1L AWM Glass	H_2SO_4 to pH<2[4]	Cool to ≤ 6ºC	28 days

[1] Within 1 day of collection, samples must be filtered (.45 µm) prior to preservation.
[2] 7 days from sampling to extraction, 40 days from extraction to analysis
[3] Samples must be frozen or preserved with H2SO4 within 2 days of collection
[4] Sample must be preserved with 15 minutes of collection.
[5] Sample must be field filtered within 15 minutes of collection
[6] Sample must have zero headspace; avoid direct sunlight.

3.3 Chain of Custody

Chain of custody (COC) will commence at the time that each sampler is collected from the autosampler jug (composite) or the sampling location (grab). The autosamplers are located within a secured facility. Thus, all samples (carboys) will be under direct possession and control of King County staff. For chain of custody purposes, treatment facilities, autosamplers, and field vehicles will be considered "controlled areas." All sample information will be recorded on a COC form (see Appendix A for forms). This form will be completed in the field and will accompany all samples during transport and delivery to the laboratory. Upon arrival at the King County West Point or South Plant Laboratory, the samples will be relinquished to the sample login person. The date and time of sample delivery will be recorded and both parties will then

sign off in the appropriate sections on the COC form at this time. Once completed, original COC forms will be kept on file at the West Point Laboratory.

Samples collected for analysis at the King County Environmental Laboratory (priority pollutant samples) will have all sample information recorded on a COC form (Figure 9). This form will be completed in the field and will accompany all samples during transport and delivery to the laboratory. Upon arrival at the King County Environmental Laboratory, the samples will be split in the appropriate containers then relinquished to the sample login person. The date and time of sample delivery will be recorded and both parties will then sign off in the appropriate sections on the COC form at this time. Once completed, original COC forms will be archived in the project file.

3.4 Sample Documentation

Sampling information and sample metadata will be documented using the methods noted below.

- Pre-printed container labels will identify each container with a unique sample number, station and site names, and analyses required.
- Labels will be completed with the type of sample (composite/grab), collection date and time, and the initials of the sampling personnel.
- COC documentation will consist of the Lab's standard COC form, which is used to track release and receipt of each sample from collection to arrival at the lab.

4.0. ANALYTICAL METHODS AND DETECTION LIMITS

Analytical methods for organics, metals, and conventional analyses are presented in this section, along with analyte-specific detection limits. For the organics, metals and selected conventional analytes, the terms MDL and RDL, used in the following subsections, refer to method detection limit and reporting detection limit, respectively. The MDL is defined as the *minimum concentration of a chemical constituent that can be reliably determined with 99% confidence to be greater than zero* (40 CFR Part 136.2), while the RDL is defined as *the minimum concentration of a chemical constituent that can be reliably quantified* (also known as the practical quantitation limit) *within specified limits of precision and accuracy during routine laboratory operating conditions* (50 FR 46906, November 13, 1985).

4.1 Conventionals

All conventional analyses will follow Standard Methods (SM) protocols (American Public Health Association [APHA] 1998). Table 5 presents the analytical methods, detection limits and units for conventional analyses.

All of the online instrumention for flow, chlorine residual and pH are checked for accuracy as part of a preventative maintenance program and re checked for calibration by Operations and Lab staff during a CSO event. Calibration and repair records are kept in the preventive maintenance database (Mainsaver).

Table 5. Conventionals Analytical Methods and Detection Limits in mg/L

Conventional Pollutants	Analysis Lab	Method	SOP	MDL	RDL
BOD_5	Process Lab	SM5210-B	Process Lab BOD		2 mg/L
TSS	Process Lab	SM2540-D	Process Lab TSS	0.5 mg/L	1.0 mg/L
Settleable Solids	Process Lab	SM2540-F	Process Lab Settleable Solids	0.5 mg/L	0.1 mg/L
Total Residual Chlorine	Process Lab	SM4500-Cl G	Process Lab Residual Chlorine		0.05 mg/L
Fecal Coliform	Process Lab	SM9221E	Process Lab Fecal Coliform		0 CFU/100mL
pH	Process Lab	SM4500-H* B	Process Lab pH		N/A
Temperature	KCEL	Analog probe			0.2°C
Dissolved Oxygen	KCEL	SM4500-OC/OG	325	0.1 mg/L	0.5 mg/L
Total Dissolved Solids	KCEL	SM2540-C	308	10 mg/L	20 mg/L
Total Alkalinity	KCEL	SM2320-B	319	1 mg/L as CaCO3	5 mg/L as CaCO3

Total Hardness	KCEL	SM2340-B	614	0.33 mg/L as $CaCO_3$	0.33 mg/L as CaCO3
Total ammonia (as N)	KCEL	SM4500-NH3-GH	330	0.01 mg/L	0.02 mg/L
Total Kjeldahl Nitrogen (as N)	KCEL	EPA 351.2	347	0.1 mg/L	0.2 mg/L
Nitrate-Nitrite Nitrogen (as N)	KCEL	SM4500-NO3-E/F/H	330	0.02 mg/L	0.04 mg/L
Total Phosphorus (as P)	KCEL	SM4500-P-B,F	331	0.005 mg/L	0.01 mg/L
Ortho-Phosphate (PO_4 as P)	KCEL	SM4500-P-F	330	0.002 mg/L	0.005 mg/L
Salinity	KCEL	SM2520-B	316	2 PSS	3 PSS
Oil and Grease	KCEL	1664B	749	1.4 mg/L	5 mg/L
Cyanide, Weak Acid Dissociable	KCEL	SM4500-CN-I,E	321	0.005 mg/L	0.01 mg/L
Total Phenolic Compounds	KCEL	EPA 420.1	subcontracted	0.05 mg/L	0.05 mg/L

Table 6 describes the minimum QC required for the conventionals analysis.

Table 6. Conventionals QA/QC Frequency and Acceptance Criteria

Frequency	**Method Blank** 1 per batch[1]	**Lab Duplicate (RPD)** 1 per batch[1]	**Spike Blank (% Recovery)** 1 per batch[1]	**Matrix Spike (% Recovery)** 1 per batch[1]	**LCS (% Recovery)** 1 per batch[1]
BOD_5 [f]	<0.2 mg/L	N/A	80-120%	N/A	N/A
Dissolved Oxygen	N/A	N/A	N/A	N/A	N/A
TSS	<MDL	25%	N/A	N/A	80-120%
Settleable Solids	<MDL	25%	N/A	N/A	N/A
Total Dissolved Solids	<MDL	25%	N/A	N/A	80-120%
Total Alkalinity	<MDL	10%	N/A	N/A	85-115%
Total Hardness	N/A	N/A	N/A	N/A	N/A
Total Residual Chlorine					
Fecal Coliform	<MDL	20%	80-120%	75-125%	85-115%
pH	N/A	N/A	N/A	N/A	+/- 2%
Temperature [b]	<MDL	20%	80-120%	75-125%	85-115%
Total ammonia	<MDL	20%	80-120%	75-125%	85-115%
Total Kjeldahl Nitrogen	<MDL	20%	80-120%	70-130%	80-120%
Nitrate-Nitrite Nitrogen	<MDL	20%	80-120%	75-125%	85-115%
Total Phosphorus	<MDL	20%	80-120%	75-125%	85-115%

Frequency	**Method Blank** 1 per batch[1]	**Lab Duplicate (RPD)** 1 per batch[1]	**Spike Blank (% Recovery)** 1 per batch[1]	**Matrix Spike (% Recovery)** 1 per batch[1]	**LCS (% Recovery)** 1 per batch[1]
Ortho-Phosphorus (PO_4)	<MDL	20%	80-120%	75-125%	85-115%
Salinity	NA	+/- 0.05 PSS	N/A	NA	99.811 - 100.189%
Oil and Grease	<MDL	SBD, 18%	78-114%	78-114%	NA
Cyanide, Weak Acid Dissociable	<MDL	25%	80-120%	70-130%	73-127%
Total Phenolic Compounds	<MDL	20%	N/A	75-125%	75-125%

[1] batch = 20 samples or less prepared as a set
< MDL = less than the Method Detection Limit.
RPD = Relative Percent Difference
LCS = Lab Control Sample
N/A = Not Applicable

Quality control samples analyzed in association with conventional analyses will include method blanks, laboratory duplicates, and matrix spikes. Conventional QC samples will be analyzed at the frequency of one per QC batch. In general, this frequency is 1 in 20 samples or 1 per batch whichever is more frequent.

- A **method blank** is an aliquot of a clean reference matrix (deionized, distilled water for water samples) that is processed through the entire analytical procedure. Analysis of method blanks is used to evaluate the levels of contamination that might be associated with the processing and analysis of samples in the laboratory and introduce bias into the sample result. Method blank results for all target analytes should be "less than the MDL" for all conventional analyses.
- A **spike blank** is an aliquot of the same matrix used for the method blank (reagent water), to which a known concentration of target analyte(s) has been added. The spiked aliquot is processed through the entire analytical procedure. Analysis of the spike blank is used as an indicator of method accuracy. Spike blanks are not addressed in the National Functional Guidelines, however, King County has empirically-derived control limits for spike blank analytes for conventional, metal, and organic analyses, which are shown on the attached QC reports. Spike blank results should be within these control limits.
- A **laboratory duplicate** is a second aliquot of sample matrix that is processed through the entire analytical procedure along with the original sample in the same quality control batch. For conventional analyses, the laboratory duplicate aliquots are all analyzed on matrix taken from a single sample container. Laboratory duplicate results are used to assess the precision of the analytical method and the relative percent difference of the results should be within method-specified or performance-based quality control limits.
- A **matrix spike** is a known concentration of one or more target analytes, which is introduced into a second aliquot of one analytical sample. The spiked sample is processed through the entire analytical procedure. Analysis of the matrix spike is used as an indicator of sample matrix effect on the recovery of target analytes and, thus, potential

bias introduced into the sample results. Quality control limits are based on the percent recovery of the spiked compounds and are either method-specific or performance-based.

- A **matrix spike duplicate** is another aliquot of a sample, processed concurrently and in an identical manner with the matrix spike. Comparison of the results for the matrix spike and matrix spike duplicate is used to evaluate analytical method precision. It can also be an indicator of sample homogeneity.

4.2 Metals

Metals samples will be preserved with ultrapure HNO_3 to a pH less than 2. All metals with the exception of mercury will be analyzed by ICP-MS following KCEL SOP 624. Mercury will be analyzed by CVAF following KCEL SOP 606. The following detection limits are required (Table 7).

Table 7. Trace Metals Target Analytes and Detection Limits (µg/L)

Analyte	Method	MDL	RDL
Antimony, Total	200.8	0.3	1.0
Arsenic, Total	200.8	0.1	0.5
Beryllium, Total	200.8	0.1	0.5
Cadmium, Total	200.8	0.05	0.25
Chromium, Total	200.8	0.2	1.0
Copper, Total	200.8	0.4	2.0
Lead, Total	200.8	0.1	0.5
Mercury, Total	1631E	0.0002	0.0005
Nickel, Total	200.8	0.1	0.5
Selenium, Total	200.8	0.5	1.0
Silver, Total	200.8	0.04	0.2
Thallium, Total	200.8	0.04	0.2
Zinc, Total	200.8	0.5	2.5

Quality control samples shall be within the following limits, although matrix spikes and laboratory duplicates will only be conducted if sufficient sample material is available. Trace Metals QC samples will be analyzed at the frequency of one per QC batch. In general, this frequency is 1 in 20 samples or 1 per batch whichever is more frequent. Mercury by CVAF requires the analysis of an MS/MSD with a frequency of 1 per 10 or fewer samples.

- A **method blank** is an aliquot of a clean reference matrix (deionized, distilled water for water samples) that is processed through the entire analytical procedure. Analysis of method blanks is used to evaluate the levels of contamination that might be associated with the processing and analysis of samples in the laboratory and introduce bias into the sample result. Method blank results for all target analytes should be “less than the MDL” for all metals analyses.
- A **spike blank** is an aliquot of clean reference matrix used for the method blank, such as reagent water, to which a known concentration of target analyte(s) has been added. The

spiked aliquot is processed through the entire analytical procedure. Analysis of the spike blank is used as an indicator of method accuracy.

- A **laboratory duplicate** is a second aliquot of sample matrix that is processed through the entire analytical procedure along with the original sample in the same quality control batch. For conventional analyses, the laboratory duplicate aliquots are all analyzed on matrix taken from a single sample container. Laboratory duplicate results are used to assess the precision of the analytical method and the relative percent difference of the results should be within method-specified or performance-based quality control limits.
- A **matrix spike** is a known concentration of one or more target analytes, which is introduced into a second aliquot of one analytical sample. The spiked sample is processed through the entire analytical procedure. Analysis of the matrix spike is used as an indicator of sample matrix effect on the recovery of target analytes and, thus, potential bias introduced into the sample results. Quality control limits are based on the percent recovery of the spiked compounds and are either method-specific or performance-based.
- A **matrix spike duplicate** is another aliquot of a sample, processed concurrently and in an identical manner with the matrix spike. Comparison of the results for the matrix spike and matrix spike duplicate is used to evaluate analytical method precision. It can also be an indicator of sample homogeneity

Table 8. Trace Metals QA/QC Frequency and Acceptance Criteria

	Method Blank 1 per batch*	**Lab Duplicate (RPD)** 1 per batch*	**Spike Blank (% Recovery)** 1 per batch*	**Matrix Spike / Matrix Spike Duplicate (% Recovery)** 1 per batch*	**SRM (% Recovery)** 1 per batch* **(if available)**
Total & Dissolved Metals by ICP-MS	< MDL	RPD ≤ 20%	85 – 115%	75% - 125% MS recovery only	NA
Total Mercury / CVAF	< MDL[2]	NA	77-123%	71-125% RPD ≤ 24%	NA

* = 1 per batch of 20 samples or less, except in the case of mercury by CVAF
[2] = Method 1631E requires 3 method blanks per batch of 20 samples or less.
[3] = Method 1631E requires one MS/MSD per batch of 10 samples or less.
< MDL = less than the Method Detection Limit.
RPD = Relative Percent Difference
NA = Not Applicable

4.3 Volatile Organic Compounds

Volatile organics will be analyzed as detailed in KCEL SOP 07-03-002-003 which is based upon EPA method 624 and SW-846 method 8260B. Samples may be stored for up to 7 days at 4°C

for most compounds. Acrolein and Acrylonitrile must be analyzed within 3 days of flagged with an H.

Method detection limits and reporting limits are as shown.

Table 9. Method 624 VOA Target Compounds and Reporting Limits in µg/L.

Volatile Compounds	MDL[1] (µg/L)	RDL[1] (µg/L)
1,1,1-Trichloroethane	1	2
1,1,2,2-Tetrachloroethane	1	2
1,1,2-Trichloroethane	1	2
1,1,2-Trichloroethylene	1	2
1,1-Dichloroethane	1	2
1,1-Dichloroethylene	1	2
1,2-Dibromoethane	1	2
1,2-Dichlorobenzene	1	2
1,2-Dichloroethane	1	2
1,2-Dichloropropane	1	2
1,3-Dichlorobenzene	1	2
1,4-Dichlorobenzene	1	2
2-Butanone (MEK)	5	10
2-Chloroethylvinyl ether	1	2
2-Hexanone	5	10
4-Methyl-2-Pentanone (MIBK)	5	10
Acetone	2.5	10
Acrolein	5	10
Acrylonitrile	1	2
Benzene	1	2
Bromodichloromethane	1	2
Bromoform	1	2
Bromomethane	5	10
Carbon Disulfide	1	2
Carbon Tetrachloride	1	2
Chlorobenzene	1	2
Chlorodibromomethane	1	2
Chloroethane	1	2
Chloroform	1	2
Chloromethane	1	2
Cis-1,3-Dichloropropene	1	2
Ethylbenzene	1	2
M/P Xylenes	1	2
Methylene Chloride	5	10
Methyl-t-butyl Ether (MTBE)	1	2

Volatile Compounds	**MDL[1] (µg/L)**	**RDL[1] (µg/L)**
O-Xylene	1	2
Styrene	1	2
Tetrachloroethylene	1	2
Toluene	1	2
Total Xylenes	1	2
Trans-1,2-Dichloroethylene	1	2
Trans-1,3-Dichloropropene	1	2
Trichlorofluoromethane	1	2
Vinyl Acetate	5	10
Vinyl Chloride	1	2

[1] NOTE: The MDL/RDL limits are based upon a 5 ml sample purge volume.

The following QC samples will be evaluated:

- A **method blank** is an aliquot of a clean reference matrix (RO water) that is processed through the entire analytical procedure. Analysis of method blanks is used to evaluate the levels of contamination that might be associated with the processing and analysis of samples in the laboratory and introduce bias into the sample result. Method blank results for all target analytes should be "less than the MDL" for all organics analyses.
- A **spike blank** is an aliquot of clean reference matrix used for the method blank, such as reagent water, to which a known concentration of target analyte(s) has been added. The spiked aliquot is processed through the entire analytical procedure. Analysis of the spike blank is used as an indicator of method accuracy.
- A **matrix spike** is a known concentration of one or more target analytes, which is introduced into a second aliquot of one analytical sample. The spiked sample is processed through the entire analytical procedure. Analysis of the matrix spike is used as an indicator of sample matrix effect on the recovery of target analytes and, thus, potential bias introduced into the sample results. Quality control limits are based on the percent recovery of the spiked compounds and are either method-specific or performance-based.
- A **matrix spike duplicate** is another aliquot of a sample, processed concurrently and in an identical manner with the matrix spike. Comparison of the results for the matrix spike and matrix spike duplicate is used to evaluate analytical method precision. It can also be an indicator of sample homogeneity. If there is not sufficient sample for a matrix spike duplicate, a spiked blank duplicate will be prepared to measure precision.
- **Surrogates** are compounds that are compounds that are chemically similar to the target analytes. They are added to all samples. Their recoveries indicate extraction/purge efficiency on a per sample basis.

Acceptance criteria for volatile organic analysis are as shown in Table 10 below.

Table 10. VOA QA/QC Frequency and Acceptance Criteria

Parameter	**Method Blank** (1 per batch[1])	**Spike Blank (% Recovery)** (1 per batch[1])	**Matrix Spike / Matrix Spike Duplicate (% Recovery)** (1 per batch[1])	**Matrix Spike or Spike Blank Duplicate** (RPD[2])
1,1,1-Trichloroethane	<MDL	72-120	73-126	40
1,1,2,2-Tetrachloroethane	<MDL	76-126	31-164	40
1,1,2-Trichloroethane	<MDL	80-117	79-121	40
1,1,2-Trichloroethylene	<MDL	79-119	55-153	40
1,1-Dichloroethane	<MDL	71-126	71-131	40
1,1-Dichloroethylene	<MDL	68-123	59-139	40
1,2-Dibromoethane	<MDL	76-123	76-123	40
1,2-Dichlorobenzene	<MDL	86-116	71-129	40
1,2-Dichloroethane	<MDL	73-128	69-132	40
1,2-Dichloropropane	<MDL	72-117	70-124	40
1,3-Dichlorobenzene	<MDL	86-119	70-130	40
1,4-Dichlorobenzene	<MDL	87-118	68-132	40
2-Butanone (MEK)	<MDL	47-146	41-176	40
2-Chloroethylvinyl ether	<MDL	1-200	1-200	40
2-Hexanone	<MDL	55-139	23-176	40
4-Methyl-2-Pentanone (MIBK)	<MDL	49-132	46-147	40
Acetone	<MDL	37-179	31-191	40
Acrolein	<MDL	36-142	1-135	40
Acrylonitrile	<MDL	55-134	26-159	40
Benzene	<MDL	69-126	74-130	40
Bromodichloromethane	<MDL	73-114	72-119	40
Bromoform	<MDL	59-115	45-129	40
Bromomethane	<MDL	15-140	15-138	40
Carbon Disulfide	<MDL	33-142	54-126	40
Carbon Tetrachloride	<MDL	50-132	54-137	40
Chlorobenzene	<MDL	87-116	80-120	40
Chlorodibromomethane	<MDL	75-114	68-121	40
Chloroethane	<MDL	30-152	63-138	40
Chloroform	<MDL	74-123	71-130	40
Chloromethane	<MDL	1-173	18-159	40
Cis-1,3-Dichloropropene	<MDL	65-118	54-122	40
Ethylbenzene	<MDL	89-125	86-128	40
M/P Xylenes	<MDL	89-125	88-134	40
Methylene Chloride	<MDL	61-133	32-157	40
Methyl-t-butyl Ether (MTBE)	<MDL	60-131	61-140	40
O-Xylene	<MDL	89-125	83-134	40
Styrene	<MDL	86-121	70-131	40
Tetrachloroethylene	<MDL	51-139	24-187	40

Parameter	**Method Blank** (1 per batch[1])	**Spike Blank (% Recovery)** (1 per batch[1])	**Matrix Spike / Matrix Spike Duplicate (% Recovery)** (1 per batch[1])	**Matrix Spike or Spike Blank Duplicate** (RPD[2])
Toluene	<MDL	77-128	70-134	40
Trans-1,2-Dichloroethylene	<MDL	62-122	58-133	40
Trans-1,3-Dichloropropene	<MDL	66-118	58-120	40
Trichlorofluoromethane	<MDL	32-165	47-159	40
Vinyl Acetate	<MDL	30-141	15-142	40
Vinyl Chloride	<MDL	11-169	18-180	40

[1] Extraction batch = 20 samples or less prepared within a 12 hour shift
[2] RPD = Relative Percent Difference

Table 11. VOA Surrogate QA/QC Frequency and Acceptance Criteria

VOA Surrogates	**% Recovery**
D4-1,2-Dichloroethane	82-125
D8-Toluene	90-114
4-Bromofluorobenzene	87-118

Note: All limits are subject to change as control limits are control charted and updated annually.

4.4 Base/Neutral and Acid Compounds

Base/Neutral and Acid (BNA) compounds will be prepared by liquid-liquid extraction as detailed in KCEL SOP 701 which is based upon EPA method 3520C. Briefly, samples may be stored for up to 7 days at 40C. Samples are extracted over 2 days. The first day the sample is left at neutral pH. The second day the pH is adjusted with H_2SO_4 to approximately 2. Samples are extracted with methylene chloride for 36 to 48 hours. Sample extracts will be concentrated using a Kuderna Danish apparatus to a volume of 0.5 to 1 mL. Additional cleanup may be performed to ensure adequate instrument performance. Analysis will be performed as detailed in KCEL SOP #731.

Following extraction and concentration, samples will be analyzed for the following list of compounds. Method detection limits and reporting limits goals are as shown below and are based upon a 1000 ml to 1 ml concentration factor. If samples are concentrated more than 1000 ml to 1 ml the MDL/RDLs will decrease and if the extracts are diluted due interference or there is <1000 ml of sample the MDL/RDLs will be higher.

Table 12. Method 3520C/625 BNA Target Compounds and Reporting Limits in µg/L.

Acid Compounds	MDL	RDL
2-Methylphenol (95-48-7)	0.5	1
2-Chlorophenol (95-57-8)	1	2
2,4-Dichlorophenol (120-83-2)	0.5	1
2,4-Dimethylphenol (105-67-9)	0.5	1

4,6-dinitro-o-cresol (534-52-1) (2-methyl-4,6,-dinitrophenol)	1	2
2,4 dinitrophenol (51-28-5)	1	2
2-Nitrophenol (88-75-5)	0.5	1
4-nitrophenol (100-02-7)	0.5	1
3- 4-Methylphenol (106-44-5/108-39-4)	0.5	1
Parachlorometa cresol (59-50-7) (4-chloro-3-methylphenol)	1	2
Pentachlorophenol (87-86-5)	0.5	1
Phenol (108-95-2)	2	3
2,4,6-Trichlorophenol (88-06-2)	2	4
Benzoic Acid	2	3
Benzyl Alcohol	0.5	1
Base/Neutral Compounds		
2-Methylnaphthalene (91-57-6)	0.8	1.5
Acenaphthene (83-32-9)	0.2	0.4
Acenaphtylene (208-96-8)	0.3	0.5
Anthracene (120-12-7)	0.3	0.5
Benzidine (92-87-5)	12	24
Benzyl butyl phthalate (85-68-7)	0.3	0.5
Benzo(*a*)anthracene (56-55-3)	0.3	0.5
Benzo(b,j,k)fluoranthene (205-99-2, 205-82-3, 207-8-9))	0.5	1
Benzo(r,s,t)pentaphene (189-55-9)	2.5	10
Benzo(*a*)pyrene (50-32-8)	0.5	1
Benzo(*ghi*)Perylene (191-24-2)	0.5	1
Bis(*2-chloroethoxy)*methane (111-91-1)	5.3	21.2
Bis(*2-chloroethyl*)ether (111-44-4)	0.3	1
Bis(*2-chloroisopropyl*)ether (108-60-1)	0.3	0.6
Bis(*2-ethylhexyl*)phthalate (117-81-7)	0.1	0.5
4-Bromophenyl phenyl ether (101-55-3)	0.2	0.4
2-Chloronaphthalene (91-58-7)	0.3	0.5
4-Chlorophenyl phenyl ether (7005-72-3)	0.3	0.5
Chrysene (218-01-9)	0.3	0.6
Dibenzo (a,j)acridine (224-42-0)	2.5	10.0
Dibenzo (a,h)acridine (226-36-8)	2.5	10.0
Dibenzo(a-,*h*)anthracene (53-70-3) (1,2,5,6-dibenzanthracene)	0.8	1.6
Dibenzo(a,e)pyrene (192-65-4)	2.5	10.0
Dibenzo(a,h)pyrene (189-64-0)	2.5	10.0
3,3'-Dichlorobenzidine (91-94-1)	0.5	1.0
Diethyl phthalate (84-66-2)	1.9	7.6
Dimethyl phthalate (131-11-3)	0.2	0.3
Di-n-butyl phthalate (84-74-2)	0.5	1
2,4-dinitrotoluene (121-14-2)	0.2	0.4
2,6-dinitrotoluene (606-20-2)	0.2	0.4
Di-n-octyl phthalate (117-84-0)	0.3	0.6
1,2-Diphenylhydrazine (*as Azobenzene*) (122-66-7)	5.0	20
Fluoranthene (206-44-0)	0.3	0.6
Fluorene (86-73-7)	0.3	0.6
Hexachlorobenzene (118-74-1)	0.3	0.6

Hexachlorobutadiene (87-68-3)	0.5	1
Hexachlorocyclopentadiene (77-47-4)	0.5	1
Hexachloroethane (67-72-1)	0.5	1
Indeno(*1,2,3-cd*)Pyrene (193-39-5)	0.5	1
Isophorone (78-59-1)	0.5	1
3-Methyl cholanthrene (56-49-5)	2.0	8.0
Naphthalene (91-20-3)	0.3	0.6
Nitrobenzene (98-95-3)	0.5	1
N-Nitrosodibutylamine (924-16-3)	10	40
N-Nitrosodiethylamine (55-18-5)	10	40
N-Nitrosodimethylamine (62-75-9)	2	3
N-Nitrosodi-n-propylamine (621-64-7)	0.5	1
N-Nitrosodiphenylamine (86-30-6)	0.5	1
Perylene (198-55-0)	1.9	7.6
Phenanthrene (85-01-8)	0.3	0.5
Pyrene (129-00-0)	0.3	0.6
1,2,4-Trichlorobenzene (120-82-1)	0.3	0.5
Carbazole (86-74-8)	0.5	1
Dibenzofuran (132-64-9)	0.5	1
n-Decane (124-18-5)	0.3	0.6
n-Octadecane (593-45-3)	0.3	0.6

[a] These compounds are reported, but are not required under the current NPDES permit

The following QC samples will be evaluated:

- A **method blank** is an aliquot of a clean reference matrix (RO water) that is processed through the entire analytical procedure. Analysis of method blanks is used to evaluate the levels of contamination that might be associated with the processing and analysis of samples in the laboratory and introduce bias into the sample result. Method blank results for all target analytes should be "less than the MDL" for all organics analyses.
- A **spike blank** is an aliquot of clean reference matrix used for the method blank, such as reagent water, to which a known concentration of target analyte(s) has been added. The spiked aliquot is processed through the entire analytical procedure. Analysis of the spike blank is used as an indicator of method accuracy.
- A **matrix spike** is a known concentration of one or more target analytes, which is introduced into a second aliquot of one analytical sample. The spiked sample is processed through the entire analytical procedure. Analysis of the matrix spike is used as an indicator of sample matrix effect on the recovery of target analytes and, thus, potential bias introduced into the sample results. Quality control limits are based on the percent recovery of the spiked compounds and are either method-specific or performance-based.
- A **matrix spike duplicate** is another aliquot of a sample, processed concurrently and in an identical manner with the matrix spike. Comparison of the results for the matrix spike and matrix spike duplicate is used to evaluate analytical method precision. It can also be an indicator of sample homogeneity. If there is not sufficient sample for a matrix spike duplicate, a spiked blank duplicate will be prepared to measure precision.
- **Surrogates** are compounds that are compounds that are chemically similar to the target analytes. They are added to all samples. Their recoveries indicate extraction/purge efficiency on a per sample basis.

Acceptance criteria for BNA analysis are as shown in Table 13 below.

Table 13. BNA QA/QC Frequency and Acceptance Criteria

Parameter	**Method Blank** (1 per batch[1])	**Spike Blank (% Recovery)** (1 per batch[1])	**Matrix Spike / Matrix Spike Duplicate (% Recovery)** (1 per batch[1])	**Matrix Spike or Spike Blank Duplicate** (RPD[2])
1,2,4-Trichlorobenzene	<MDL	22-96	41-97	40
1,2-Diphenylhydrazine	<MDL	37-133	70-130	40
2,4,6-Trichlorophenol	<MDL	50-99	59-119	40
2,4-Dichlorophenol	<MDL	34-110	32-132	40
2,4-Dimethylphenol	<MDL	10-82	5-120	40
2,4-Dinitrophenol	<MDL	37-117	53-124	40
2,4-Dinitrotoluene	<MDL	49-127	38-110	40
2,6-Dinitrotoluene	<MDL	63-114	54-117	40
2-Chloronaphthalene	<MDL	48-100	43-115	40
2-Chlorophenol	<MDL	49-104	24-117	40
2-Methylnaphthalene	<MDL	47-98	40-121	40
2-Methylphenol	<MDL	24-119	10-120	40
2-Nitrophenol	<MDL	51-97	45-111	40
3,3'-Dichlorobenzidine	<MDL	10-119	1-116	40
3-,4-Methylphenol	<MDL	24-119	10-120	40
3-Methylcholanthrene	<MDL	32-130	22-125	40
4,6-Dinitro-O-Cresol	<MDL	57-114	35-132	40
4-Bromophenyl Phenyl Ether	<MDL	64-126	51-137	40
4-Chloro-3-Methylphenol	<MDL	29-106	33-150	40
4-Chlorophenyl Phenyl Ether	<MDL	51-124	48-125	40
4-Nitrophenol	<MDL	23-150	22-150	40
Acenaphthene	<MDL	65-103	47-105	40
Acenaphthylene	<MDL	63-114	46-122	40
Anthracene	<MDL	59-122	32-140	40
Benzidine	<MDL	1-102	1-50	40
Benzo(a)anthracene	<MDL	67-130	50-120	40
Benzo(a)pyrene	<MDL	55-132	45-121	40
Benzo(b,j,k)fluoranthene	<MDL	49-139	42-123	40
Benzo(g,h,i)perylene	<MDL	32-130	22-125	40
Benzo(r,s,t)pentaphene	<MDL	32-130	22-125	40
Benzoic Acid	<MDL	10-149	15-150	40
Benzyl Alcohol	<MDL	20-125	11-100	40
Benzyl Butyl Phthalate	<MDL	49-145	39-151	40
Bis(2-Chloroethoxy)Methane	<MDL	38-113	25-139	40
Bis(2-Chloroethyl)Ether	<MDL	30-92	31-103	40
Bis(2-Chloroisopropyl)Ether	<MDL	24-130	25-135	40
Bis(2-Ethylhexyl)Phthalate	<MDL	48-128	11-188	40
Carbazole	<MDL	63-118	30-130	40
Chrysene	<MDL	58-114	42-115	40
Dibenzo(a,e)pyrene	<MDL	32-130	22-125	40

Parameter	**Method Blank** (1 per batch[1])	**Spike Blank (% Recovery)** (1 per batch[1])	**Matrix Spike / Matrix Spike Duplicate (% Recovery)** (1 per batch[1])	**Matrix Spike or Spike Blank Duplicate** (RPD[2])
Dibenzo(a,h)acridine	<MDL	32-130	22-125	40
Dibenzo(a,h)anthracene	<MDL	47-134	31-121	40
Dibenzo(a,h)pyrene	<MDL	32-130	22-125	40
Dibenzo(a,j)acridine	<MDL	32-130	22-125	40
Dibenzofuran	<MDL	45-115	19-129	40
Diethyl Phthalate	<MDL	26-141	33-140	40
Dimethyl Phthalate	<MDL	59-124	34-134	40
Di-N-Butyl Phthalate	<MDL	64-127	44-134	40
Di-N-Octyl Phthalate	<MDL	51-126	48-125	40
Fluoranthene	<MDL	57-123	49-123	40
Fluorene	<MDL	43-127	44-137	40
Hexachlorobenzene	<MDL	45-113	30-118	40
Hexachlorobutadiene	<MDL	25-109	26-111	40
Hexachlorocyclopentadiene	<MDL	1-52	1-74	40
Hexachloroethane	<MDL	20-89	40-104	40
Indeno(1,2,3-Cd)Pyrene	<MDL	53-122	39-122	40
Isophorone	<MDL	1-142	10-175	40
Naphthalene	<MDL	32-93	37-95	40
n-Decane	<MDL	31-101	20-140	40
Nitrobenzene	<MDL	43-109	47-114	40
N-Nitrosodimethylamine	<MDL	12-132	23-123	40
N-Nitrosodi-N-Propylamine	<MDL	30-138	27-136	40
N-Nitrosodiphenylamine	<MDL	52-127	35-147	40
n-Octadecane	<MDL	69-117	47-131	40
Pentachlorophenol	<MDL	10-137	44-145	40
Perylene	<MDL	32-130	22-125	40
Phenanthrene	<MDL	57-114	62-116	40
Phenol	<MDL	48-105	26-127	40
Pyrene	<MDL	51-139	37-147	40

[1] Extraction batch = 20 samples or less prepared within a 12 hour shift
[2] RPD = Relative Percent Difference

Table 14. BNA Surrogate QA/QC Frequency and Acceptance Criteria

BNA Surrogates	**% Recovery Limits**
2-Fluorophenol	34-116
d5-Phenol	41-128
d5-Nitrobenzene	48-116
d4-2-Chlorophenol	42-113
2-Fluorobiphenyl	30-128
2,4,6-Tribromophenol	35-149
d14-Terphenyl	51-133

Note: All limits are subject to change as control limits are control charted and updated annually.

5.0. DATA VALIDATION, REPORTING AND RECORD KEEPING

Data will receive standard King County validation but full documentation will be maintained in the file should more detailed, external, review be necessary.

5.1 Data Validation

Data validation is critical for evaluating how well analytical data meet project DQOs. Data validation is performed, at some level, during several steps in the process of sample analysis. All data will be validated against reference method requirements and the QC requirements provided in this SAP.

5.2 Reporting

All data will be reported to Ecology using King County's DMR forms. Sample data will be reported on the DMR form for that month, except for priority pollutant data which will be reported within 60 days of the sampling event. All data and supporting information will be available for review upon request. Analytical data reports may be requested, either in hard copy or electronic formats, in Microsoft Excel spreadsheets. Data validation memoranda will be available, either hard copy or electronically, in Microsoft Word format.

5.3 Record Keeping

All hard-copy field sampling records, custody documents, raw lab data, and laboratory summaries and narratives will be archived according to Ecology requirements for a minimum of three years from the date samples were collected. Conventional, Trace Metals and Trace Organics analytical data produced by the King County Environmental Laboratory will be maintained on its LIMS database in perpetuity.

6.0. REFERENCES

APHA 1998. Standard Methods for the Examination of Water and Wastewater, 20th Edition. American Public Health Association. Washington, D.C.

King County Environmental Laboratory, 2003. Standard Operating Procedure for Hexane Extractable Material Analysis (Liquids) by Solid Phase Extraction, SOP #749. Seattle, Washington.

King County Environmental Laboratory, 2003. Standard Operating Procedure for Instrumental Analysis of Environmental Samples for Mercury Using Automated Cold Vapor Atomic Fluorescence Spectrometry, SOP #606. Seattle, Washington.

King County Environmental Laboratory, 2003. Standard Operating Procedure for Analysis of Semivolatile Compounds by GC/MS. SOP # 731 (07-03-001-004). Seattle, Washington.

King County Environmental Laboratory, 2005. Standard Operating Procedure for Continuous Liquid/Liquid Extraction Proceedure. SOP # 701 (07-01-001-002). Seattle, Washington.

King County Environmental Laboratory, 2005. Standard Operating Procedure for Cyanide – Total, Weak Acid Dissociable and Amenable to Chlorination, SOP #321. Seattle, Washington.

King County Environmental Laboratory, 2006. Standard Operating Procedure for ICPMS Analysis of Ambient Water Samples by the Thermo X Series II CCT, SOP #624. Seattle, Washington.

King County Environmental Laboratory, 2007. Standard Operating Procedure for Ammonia-Nitrogen, Nitrate-Nitrogen, Nitrite-Nitrogen, ortho-Phosphate and Silica in Liquid Matrices, SOP #330. Seattle, Washington.

King County Environmental Laboratory, 2007. Standard Operating Procedure for Total Phosphorus, Total Dissolved Phosphorus, Total Nitrogen and Total Dissolved Nitrogen in Liquid Matricies, SOP #331. Seattle, Washington.

King County Environmental Laboratory, 2008. Standard Operating Procedure for Total Kjeldahl Nitrogen (TKN) in Liquids, SOP #347. Seattle, Washington.

King County Environmental Laboratory, 2008. Standard Operating Procedure for Total Dissolved Solids, SOP #308. Seattle, Washington.

King County Environmental Laboratory, 2009. Standard Operating Procedure for Preparation of Water Samples for Analysis of Total and Dissolved Metals by Inductively Coupled Plasma – Mass Spectrometer (ICP-MS), SOP #614. Seattle, Washington.

King County Environmental Laboratory, 2010. Standard Operating Procedure for Oxygen, Dissolved – Winkler Titration, Azide Modification, SOP #325. Seattle, Washington.

King County Environmental Laboratory, 2010. Standard Operating Procedure for Alkalinity, SOP #319. Seattle, Washington.

King County Environmental Laboratory, 2011. Standard Operating Procedure for Salinity, SOP #316. Seattle, Washington.

PSAMP 1997. Recommended Guidelines for Sampling Marine Sediment, Water Column, and Tissue in Puget Sound. Prepared for the Puget Sound Estuary Program (U.S. Environmental Protection Agency Region 10) by the King County Environmental Laboratory. Seattle, Washington. Available at: http://www.psparchives.com/publications/our_work/science/protocals_guidelines/field.pdf

PSAMP 1997. Recommended Guidelines for Measuring Organic Compounds in Puget Sound Water, Sediment, and Tissue Samples. Prepared for the Puget Sound Estuary Program (U.S. Environmental Protection Agency Region 10) by the King County Environmental Laboratory. Seattle, Washington. Available at: http://www.psparchives.com/publications/our_work/science/protocol_guidelines/organics.pdf

PSAMP 1997. Recommended Guidelines for Measuring Metals in Puget Sound Marine Water, Sediment, and Tissue Samples. Prepared for the Puget Sound Estuary Program (U.S. Environmental Protection Agency Region 10) by the King County Environmental Laboratory. Seattle, Washington. Available at: http://www.psparchives.com/publications/our_work/science/protocals_guidelines/metals.pdf

PSAMP 1997. Recommended Quality Assurance and Quality Control Guidelines for the Collection of Environmental Data in Puget Sound. Prepared for the Puget Sound Estuary Program (U.S. Environmental Protection Agency Region 10) by the King County Environmental Laboratory. Seattle, Washington. Available at: http://www.psparchives.com/publications/our_work/science/protocals_guidelines/qaqc.pdf

7.0. APPENDIX A – FIELD SHEETS

The following chain of custody or field sheets are samples of the forms used to document and record information on collected samples.

Alki CSO Event - Field Sheet

Bring this form to the lab with each sample delivery. For each event keep a copy of this information with the Alki Plant log book.

Date / Time Filling Started		Bisulfite tank level Start		Hypo 4% Start_____	Stop_____
Date / Time Discharge Started		Bisulfite tank level End		12% Start_____	Stop_____
Date / Time Discharge Ended					

Meter/Analyzer calibration checks	Barscreen Cl2 analyzer reading		Hach Cl2 meter reading
At the beginning of the CSO event check the calibration of the pH and	Before bisulfite Cl2 meter reading		Hach Cl2 meter reading
chlorine meters using the Hach kits. If the results are within 20% of the	Final Cl2 analyzer reading		Hach Cl2 meter reading
analyzer readings only record the meter readings.			

Sampling Notes

Start time: Influent grab sample time starts when the plant starts filling. Effluent grab sample time starts when the plant starts discharging.
A "grab" sample is an individual sample collected over a fifteen or less minute period.
A "composite" sample is a series of individual samples collected over a flow period (no longer than 24 hours) **7am to 7am** and analyzed as one sample.
Composites must be collected over the entire event. Composites are collected from the samplers if they are operating.
An "event" ends when 24 hours has elapsed since the last measured discharge to Puget Sound.
Containers: Coliform grab samples must be collected in a sterile, (typically glass) bottle. The black striped tape on the bottle top confirms sterilization .
Other samples may be collected in plastic containers.
Transportation: Fecal coliforms must be analyzed within 8 hours and BOD tests on composites must be analyzed within 24 hours of collection.
Additional sampling: There is an annual requirement to collect samples for the KC Lab. Please collect these grabs if bottles are in the Alki lab.

Sample description			Container	Sample Date/Time	pH analyzer reading	Barscreen Cl2 analyzer reading	Before bisulfite Cl2 analyzer reading	Final Cl2 analyzer reading		Time sample transported to lab
Immediate	Influent	Grab	plastic							
	Effluent	Grab	plastic							
0 - 3 hours	Effluent	Grab	glass							
4 - 8 hours	Effluent	Grab	glass							
20 - 24 hours	Effluent	Grab	glass							
(1st day)	Effluent	Comp	plastic							
	Influent	Comp	plastic							
48 hours	Effluent	Grab	glass							
(2nd day)	Effluent	Comp	plastic							
	Influent	Comp	plastic							
72 hours	Effluent	Grab	glass							
(3rd day)	Effluent	Comp	plastic							
	Influent	Comp	plastic							
96 hours	Effluent	Grab	glass							
(4th day)	Effluent	Comp	plastic							
	Influent	Comp	plastic							

Figure 3. Sample Chain of Custody form for Alki CSO Treatment Facility

ELLIOTT WEST CSO TREATMENT FACILITY
Returned Flow Sample Chain of Custody Form
(To be delivered before 9 am to WP Lab. Need at least 2-liters)

EW Dewatering Composite Sample		EW Dewatering Grab Sample	
OPERATIONS			
Sample ID:	EW_DewatPump-: 2011-45	Sample ID:	EW_DewatPump-
Composite Start/Stop (Date-Time)	Start Time: 5-02-11 Stop Time:	Date-Time of Grab	Date-Time: Initials:
Composite Pickup	Date & Time: 5-03-11 0700 Initials:	Grab Pickup	Date & Time: Initials:
Composite Drop-off	Date & Time: 5-03-11 0815 Initials:	Grab Drop-off	Date & Time: Initials:
LAB			
Composite Received	Date & Time: Initials:	Grab Received	Date & Time: Initials:

EW Main Pump Composite Sample		EW Main Pump Grab Sample	
OPERATIONS			
Sample ID:	EW_MainPump-	Sample ID:	EW_MainPump-
Composite Start/Stop	Start Time: Stop Time:	Date-Time of Grab	Date & Time: Initials:
Composite Pickup	Date & Time: Initials:	Grab Pickup	Date & Time: Initials:
Composite Drop-off	Date & Time: Initials:	Grab Drop-off	Date & Time: Initials:
LAB			
Composite Received	Date & Time: Initials:	Grab Received	Date & Time: Initials:

Comments (Equipment failures: Chemical Pumps, Samplers etc., and Corrective Actions Taken)

Figure 4. Sample Chain of Custody form for Elliott West CSO Treatment Facility

ELLIOTT WEST CSO TREATMENT FACILITY
Effluent Sample Chain of Custody Form
(Sampler Located in Denny Regulator)
(Pick up by 0700 hours and Drop-off by 0900 hours at WP Lab. Need at least 2-liters)

EW Effluent Composite Sample	EW Effluent Grab Sample

OPERATIONS

Sample ID	EW_Effluent-2010-	Sample ID	EW_Effluent-2010-
Composite Start/Stop (Date-Time)	Start: Stop:	Date-Time of Grab	Date & Time: Initials:
Composite Pickup	Date & Time: Initials:	Grab Pickup	Date & Time: Initials:
Composite Drop-off	Date & Time: Initials:	Grab Drop-off	Date & Time: Initials:

LAB

Composite Received	Date & Time: Initials:	Grab Received	Date & Time: Initials:

Fecal Grab Samples (Collected at Denny Regulator Station)
(Call MCC & Deliver it to WP Lab ASAP after collecting the sample)

For the samples below, collect in sterile 125 ml bottles provided by WP lab. Sample Analysis needs to begin within 8 hours from the time a sample is collected.

Fecal Sample	Sample ID	Collection: Date, Time & Initials	pH	Pre-DeCl$_2$ Residual (Hach/Analyzer)	Effluent Cl$_2$ Residual (Hach/Analyzer)	Drop-off: Date, Time & Initials	Received: Date, Time & Initials
0-3 hr	EW_Fecal_2010-02	3-9-11 1130 V.O.	6.59	0.00 / 0.18	0.00 / 0.02	3-10-11 0340 V.O.	
4-8 hr	EW_Fecal_2010-04	3-10-11 0235 V.O	6.61	1.06 / .62	0.00 / 0.00	3-10-11 0340 V.O.	
20-24 hr	EW_Fecal_2010-						
48 hr	EW_Fecal_2010-						
72 hr	EW_Fecal_2010-						
96 hr	EW_Fecal_2010-						

Comments (Equipment failures; Sample pumps, Chemical Pumps, Samplers etc., and Corrective Actions Taken)

ALL STILLING WELLS WERE NOT WORKING WELL. HAD TO BACKFLUSH A LOT TO GET THEM SAMPLING.

V.O.

Figure 5. Sample Chain of Custody form for fecal grab samples at Elliott West

Influent Composite Sample

Influent Grab Sample

(To be delivered daily by 9 am to WP Lab)

Need at least 2 liters

Sample ID (composite):	CPTP_INFLUENT_20__-	Sample ID (grab):	CPTP_INFLUENT_20__-
Sample Pick Up Date & Time		Sample Pick Up Date & Time	
Sample Drop-off Date, Time & Initials		Sample Drop-off Date, Time & Initials	
Crewmember Initials		Crewmember Initials	
Received Date and Time & Initials (Lab)		Received Date and Time & Initials (Lab)	

There may be more than one composite sample, if sampler carboy fills up. (high flows)

Shake carboy and transfer 2-l portion to bottle, mark time and date location and initials on all bottles.

Effluent Composite Sample

Effluent Grab Sample

(To be delivered daily by 9 am to WP Lab)

Need at least 2 liters

Sample ID (Composite)	CPTP_EFFLUENT_20__-	Sample ID (Grab)	CPTP_EFFLUENT_20__-
Sample Pick Up Date & Time		Sample Pick Up Date & Time	
Sample Drop-off Date, Time & Initials		Sample Drop-off Date, Time & Initials	
Crewmember Initials		Crewmember Initials	
Received Date and Time & Initials (Lab)		Received Date and Time & Initials (Lab)	

Shake carboy and transfer 2 liters portion to bottle, mark time, date, location and initials on all bottles.

Fecal Samples

(To be delivered to WP Lab ASAP after collecting the sample)

For the samples below, collect in sterile 125 ml bottles provided by WP lab & drop off at WP lab ASAP. Contact MCC right after collecting fecal grabs to coordinate lab analysis.

Within 0-3 hours of discharge	Sample collected @:	Chlorine Residual:	pH:
Within 4 - 8 hrs of discharge	Sample collected @:	Chlorine Residual:	pH:
Within 20 - 24 hrs of discharge	Sample collected @:	Chlorine Residual:	pH:
Next and every 24th hour of discharge	Sample collected @:	Chlorine Residual:	pH:

Comment (Equipment Failures: Chemical Pumps, Samplers etc and corrective action taken)

Figure 6. Sample Chain of Custody form for Carkeek CSO Treatment Facility

Login: P54133 **Henderson CSO Plnt Disc** **Personnel: _____**

Project: 421185

CHAIN OF CUSTODY

Relinquished by	***Date***	***Time***
Received by	***Date***	***Time***
Sample Numbers		***[All]***

Sample Number	**P54133-1**	**P54133-2**	**P54133-3**
QC Link			
Locator	**HEND/MLK OUTLET CSO**	**HEND/MLK OUTLET CSO**	**HEND/MLK OUTLET CSO**
Short Loc Desc	MLK OUTLET	MLK OUTLET	MLK OUTLET
Locator Desc	HENDERSON/ML KING OUTLET REGULATOR CSO TREATM	HENDERSON/ML KING OUTLET REGULATOR CSO TREATM	HENDERSON/ML KING OUTLET REGULATOR CSO TREATM
Site	FACILITIES	FACILITIES	FACILITIES
Comments	Comp	Grab	Grab
Start Date/Time			
End Date/Time			
Time Span			
Sample Depth			
DIS VOL		**********	**********
PERSONNEL			
SAMP INFO			
SAMPLE CODE			
SAMPLE UNIT			
Dept, Matrix, Prod	6 LG BA-ICPMS 6 LG HG-CVAF-UL 6 LG PP ICPMS 7 LG BNA-INT-SUR 7 LG VOA-SUR	3 LG CN-WD 3 LG PHENOLICS 3 LG SAL 3 LG WDO 7 LG HEM	3 LG CN-WD 3 LG PHENOLICS 7 LG HEM

(1 / 2)

Figure 7. Sample Chain of Custody form for Henderson/MLK CSO Treatment Facility

MLK CSO Field Sheet

Bring this form to the lab with each sample delivery. For each event keep a copy of this information with the plant log book.

Date / Time Filling Started		Bisulfite tank level Start	
Date / Time Discharge Started		Bisulfite tank level End	
Date / Time Discharge Ended		Hypo #1 tank level Start	
		Hypo#1 tank level End	
1. Verify chlorine residual before bisulfite addition		Hypo #2tank level Start	
Take a grab sample from the hatch upstream of the screen.		Hypo#2 tank level End	

2. Check the calibration of the final ULR Cl2 analyzer using the Hach DR2400.

If the results are within 20% of the analyzer reading only record the analyzer readings.

Take a grab sample from the hatch in the floor after the screens.	Analyzer reading	
	DR2400 reading	

Sample description			Container	Sample Date/Time	Portable pH meter reading	Cl2 analyzer reading	Time sample transported to lab
Immediate	Influent	Grab	plastic				
	Effluent	Grab	plastic				
0 - 3 hours	Effluent	Grab	glass				
4 - 8 hours	Effluent	Grab	glass				
20 - 24 hours	Effluent	Grab	glass				
(1st day)	Effluent	Comp	plastic				
	Influent	Comp	plastic				
48 hours	Effluent	Grab	glass				
(2nd day)	Effluent	Comp	plastic				
	Influent	Comp	plastic				
72 hours	Effluent	Grab	glass				
(3rd day)	Effluent	Comp	plastic				
	Influent	Comp	plastic				
96 hours	Effluent	Grab	glass				
(4th day)	Effluent	Comp	plastic				
	Influent	Comp	plastic				

Sampling Notes

Lab responds to the first discharge a MLK Outlet.

Start time: Influent grab sample time starts when the plant starts filling.

Effluent grab sample time starts when the plant starts discharging.

A "grab" sample is an individual sample collected over a fifteen or less minute period.

There is a grab sample hatch before the screen in the flow control room. (Cl2, pH)

There is another grab sample hatch after the screen in the flow control room. (Cl2, pH, coliforms)

A "composite" sample is a series of individual samples collected over a flow period and analyzed as one sample.

A composite sample is no longer than 24 hours. Composites collected at 7 am daily.

Composites must be collected over the entire event. Composites are collected from the samplers if they are operating.

The influent composite sampler is in the inlet structure.

The effluent composite sampler is in the equipment room of the outlet structure.

An "event" ends when 24 hours has elapsed since the last measured discharge to Puget Sound.

Containers: Coliform grab samples must be collected in a sterile, (typically glass) bottle.

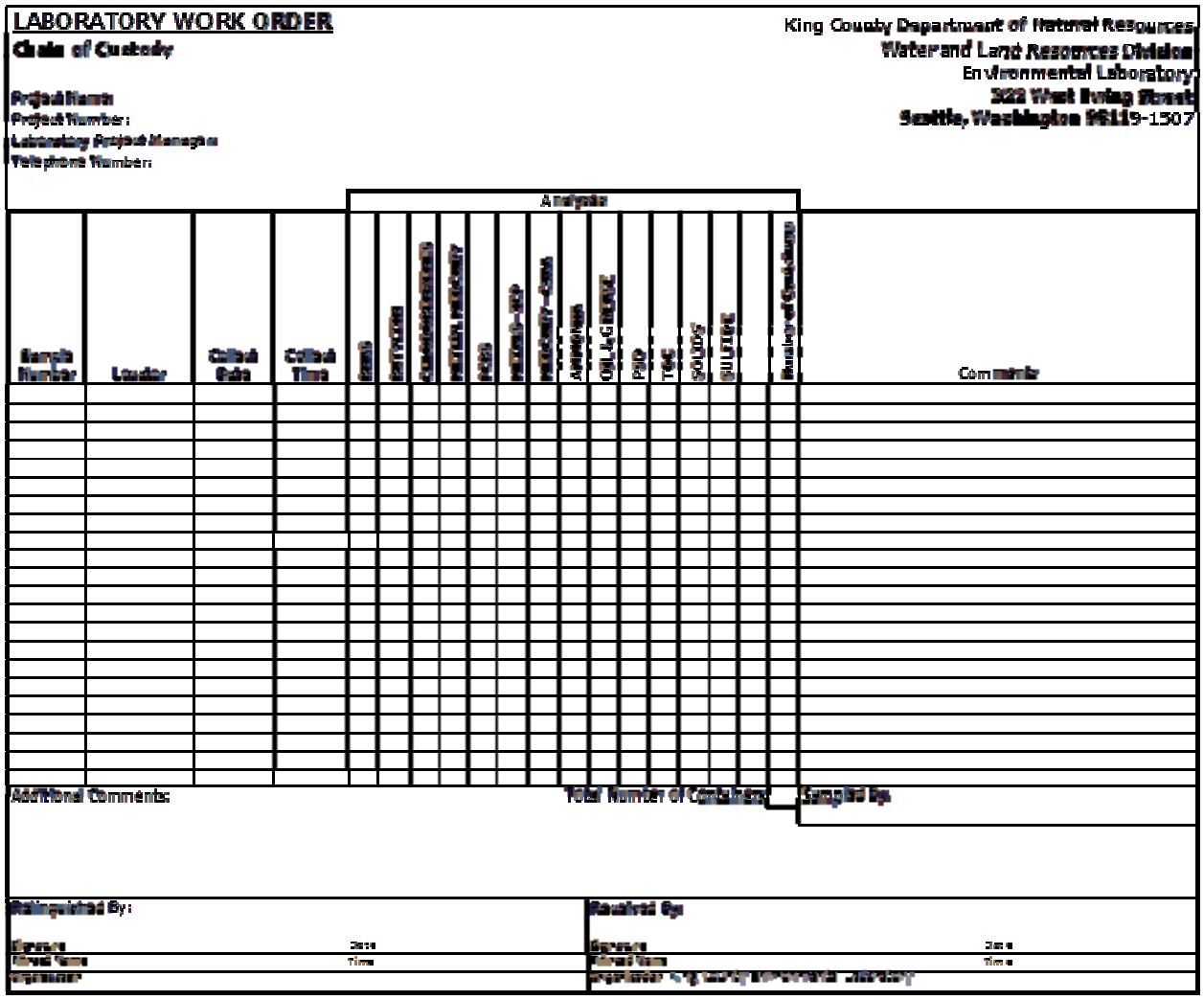
The black striped tape on the bottle top confirms sterilization.

Transportation: Fecal coliforms must be analyzed within 8 hours of collection.

BOD tests on composites must be analyzed witin 24 hours of collection.

Additional sampling: There is an annual requirement to collect samples for the KC Lab.

Figure 8. Sample Chain of Custody form for Henderson/MLK CSO Treatment Facility



LABORATORY WORK ORDER

Chain of Custody

King County Department of Natural Resources
Water and Land Resources Division
Environmental Laboratory
322 West Ewing Street
Seattle, Washington 98119-1507

Project Name
Project Number:
Laboratory Project Manager
Telephone Number:

Sample Number	Loader	Collect Date	Collect Time	Analysis															Comments
												OIL & GREASE				SOLIDS	SULFIDE		
													PSD		TSS				
											Ammonia								
										Metals, Inductively Coupled Plasma-Mass									
									Metals-ICP										
								PCB											
							Metals, Inductively												
						Carbonaceous													
					Carbon														
				Chlorides															
				Sulfate															

Additional Comments:

Total Number of Containers

Sampled By

Relinquished By:

Signature Date
Printed Name Time
Organization

Received By

Signature Date
Printed Name Time
Organization: King County Environmental Laboratory

Figure 9. King County Environmental Laboratory Field Sheet Form

Appendix D. Receiving Water Characterization Study Sampling and Analysis Plan and Quality Assurance Project Plan

The current version of the Receiving Water Characterization Study Sampling and Analysis Plan and Quality Assurance Project Plan (SAP/QAPP) is attached electronically to this document. This SAP/QAPP reflects the protocols and methods used in King County's ambient monitoring program for marine waters, and would apply to the Open Water (marine) stations listed in Table 4 (KSBP01, LSNT01, LTED04, LTXQ01).

South and West Point Wastewater Treatment Plants Alki, Carkeek, Elliott West, and MLK/Henderson Storage and CSO Treatment Plants

---

Receiving Water Characterization Study

King County NPDES Monitoring Program

Final Sampling and Analysis Plan and Quality Assurance Project Plan

---

Prepared for the

King County Department of Natural Resources and Parks
Wastewater Treatment Division

and the

Washington State Department of Ecology

by the

King County Department of Natural Resources
Marine and Sediment Assessment Group

December 2010

King County

South and West Point Wastewater Treatment Plants
Alki, Carkeek, Elliott West, and MLK/Henderson Storage and CSO Treatment Plants

---

Receiving Water Characterization Study

King County NPDES Monitoring Program

Final Sampling and Analysis Plan and Quality Assurance Project Plan

---

Prepared by

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December 2010

King County

APPROVALS

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Katherine Bourbonais King County Environmental Laboratory Laboratory Project Manager	Date
Colin Elliott King County Environmental Laboratory QA/QC Officer	Date

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1 INTRODUCTION

This sampling and analysis plan and quality assurance project plan (SAP/QAPP) presents project information, along with sampling and analytical methodologies and quality assurance procedures that will be employed to conduct a receiving water characterization study in Puget Sound, Elliott Bay, and the Duwamish River. King County is conducting this study to fulfill one requirement of its National Pollutant Discharge Elimination System (NPDES) permits for the South Wastewater Treatment Plant (WA-002958-1) and the West Point Wastewater Treatment Plant and Alki, Carkeek, Elliott West, and MLK/Henderson CSO Storage and Treatment Plants (WA-002918-1), issued by the Washington State Department of Ecology (Ecology).

King County's NPDES permits for the South and West Point Wastewater Treatment Plants (including CSO facilities) require that " . . . *the Permittee must provide data via ambient monitoring stations or collect receiving water information via field sampling necessary to determine if the effluent has a reasonable potential to cause a violation of the water quality standards. If reasonable potential exists, Ecology will use this information to calculate effluent limits. Field sampling will be required where ambient monitoring station data does not exist."* (Ecology 2009a,b). King County will fulfill these permit requirements through a combination of existing ambient water quality data and new field sampling.

This SAP/QAPP includes a description of the project, the County's ambient water quality monitoring history, a description of the existing data that will be submitted to Ecology, the sampling design for acquiring new environmental data, sampling and analytical methodologies, quality assurance procedures, and reporting requirements. The SAP/QAPP has been prepared in accordance with *Guidelines for Preparing Quality Assurance Project Plans for Environmental Studies* (Ecology 2004).

2 PROJECT DESCRIPTION

King County's Receiving Water Characterization Study will provide Ecology with ambient water quality data and new sampling and analytical data needed to evaluate whether effluent from the South and West Point treatment plants and the Alki, Carkeek, Elliott West, and MLK/Henderson CSO storage and treatment plants have a reasonable potential to cause a violation of water quality standards.

The receiving water characterizations for the South treatment plant and the West Point treatment plant and CSO facilities have different timelines in their respective permits (e.g., September 2011 and June 2010, respectively, for submittal of project quality assurance project plans). Section S11.5 of the South Treatment Plant permit also requires that sampling should occur " . . . *as close as possible to the critical period*." For the South treatment plant, the critical periods are July (chronic water quality criteria) and December (acute water quality criteria). Section S12.E of the West Point Treatment Plant permit requires that sampling should occur " . . . *during a spring tide*." Due to the sampling and analytical requirements for assessment of trace metals, the County will undertake these characterizations concurrently.

King County's Marine and Sediment Assessment Group monitors water quality in Puget Sound, Elliott Bay, and the Duwamish River both proximal to its wastewater treatment plant outfalls and CSO storage and treatment plant outfalls as well as at ambient locations outside the zone of influence of the effluent from these facilities. These stations have been sampled for numerous years and a large body of water quality data exists for these monitoring locations. The County's routine ambient monitoring program samples these stations on a monthly basis, collecting data both through *in situ* field measurements and laboratory analysis of collected samples. Data from the County's existing water quality monitoring program will be submitted to Ecology to fulfill part of the receiving water quality characterization study data requirements.

2.1 Existing Water Quality Monitoring

Water column monitoring at outfall and ambient sites is an important component of the County's overall water quality monitoring program and is structured to detect natural seasonal changes in the water column as well as to identify changes from anthropogenic inputs. Two of the County's Puget Sound water quality stations have been monitored continuously since 1988. General water quality parameters, including temperature, salinity, dissolved oxygen, phytopigments, nutrients, total suspended solids, and fecal bacteria are monitored on a monthly basis.

King County measures *in situ* water quality parameters at offshore monitoring stations using a SeaBird Electronics SBE 25 SEALOGGER conductivity-temperature-depth (CTD) profiler. Parameters measured by the CTD include temperature, conductivity, transmissivity, dissolved oxygen, photosynthetically active radiation (PAR), and fluorescence (an indicator of chlorophyll-*a* abundance). Salinity and density are calculated parameters, using temperature and conductivity measurements. The CTD collects a continuous water column profile on both the downcast and upcast of the instrument. Multiple 5-liter Niskin bottles are mounted onto the rosette containing the CTD profiler for collecting discrete water samples on the upcast at predetermined depths for laboratory analysis of nutrients, total suspended solids, phytopigments, and bacteria.

Figure 1 shows the location of the West Point and South treatment plant outfalls and the Carkeek, Alki, Elliott West, and MLK/Henderson storage and CSO treatment plant outfalls. The figure also shows four of King County's existing ambient monitoring stations, which will be used as the stations for the NPDES receiving water characterization study. Station KSBP01 will be the monitoring station for the West Point and Carkeek outfalls, Station LSNT01 will be the monitoring station for the South and Alki outfalls, Station LTED04 will be the monitoring station for the Elliott West outfall, and Station LTXQ01 will be the monitoring station for the MLK/Henderson outfall.

2.1.1 Station KSBP01

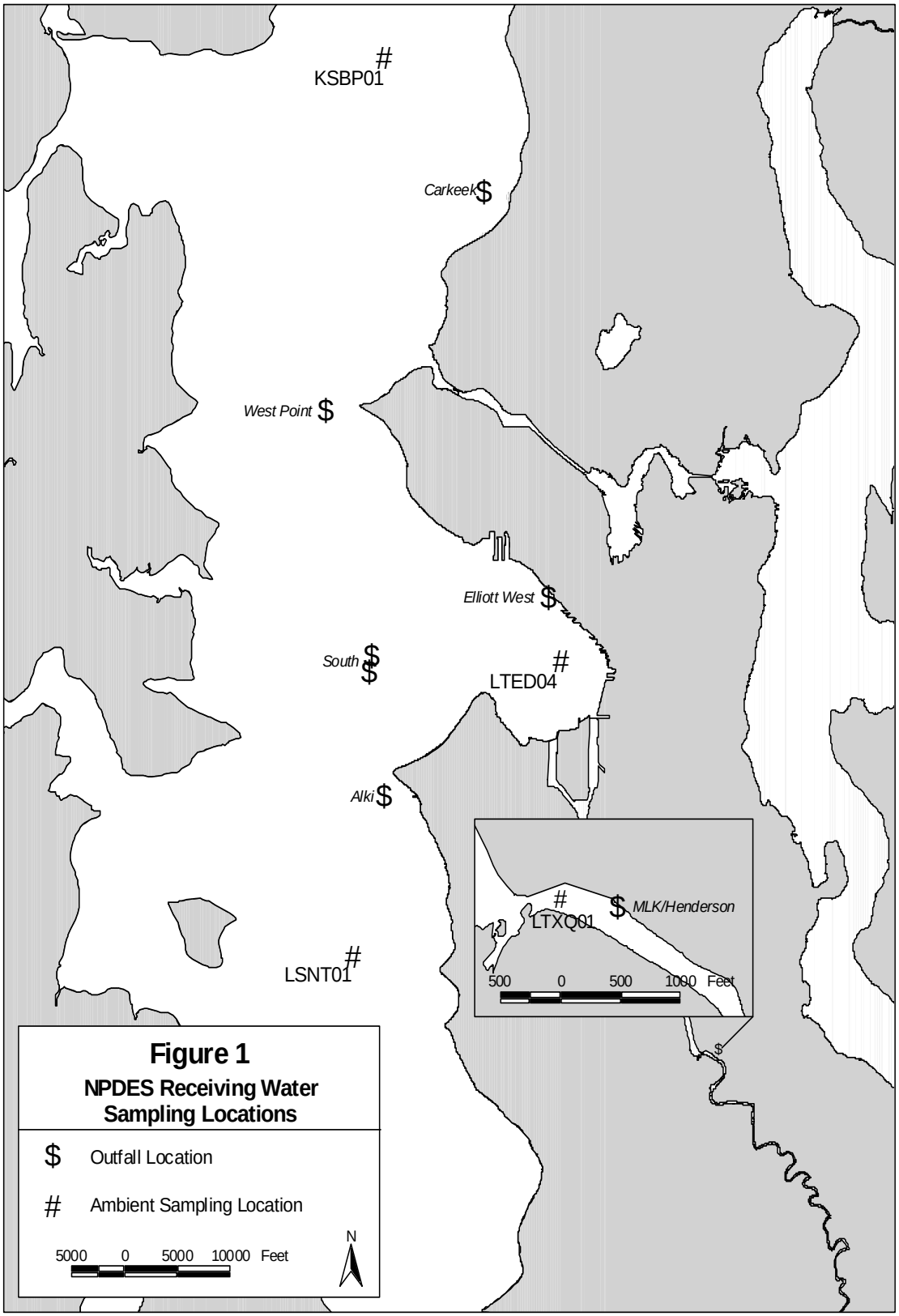
Station KSBP01 is located in the North Central Puget Sound Basin, approximately two miles from the Carkeek outfall and six miles from the West Point outfall (see Figure 1). The monitoring history for this station goes back to 1966 and, for certain parameters, it has been monitored continuously since 1988. King County currently samples this station on a monthly basis for *in situ* field measurement of temperature, dissolved oxygen, salinity, density, and transmissivity and laboratory analysis of fecal coliform and enterococcus bacteria, nutrients (ammonia, nitrate + nitrite nitrogen, silica, and total phosphorus), chlorophyll-*a* and pheophytin, and total suspended solids. Nutrient and total suspended solids samples are collected from seven depths at this station – 1, 15, 25, 35, 55, 100, and 200 meters. Chlorophyll-*a* and pheophytin samples are collected from four depths – 1, 15, 25, and 35 meters. Bacteria samples are collected from a single depth – 1 meter.

Station KSBP01 will continue to be sampled monthly as part of King County's routine ambient monitoring program. King County will submit to Ecology two years' worth of monthly data from this station for total suspended solids, dissolved oxygen, temperature, fecal coliform bacteria, and salinity (as well as future routine monitoring data, if needed) to meet the requirements of Sections S12.G and S18.I.7 of the West Point permit.

2.1.2 Station LSNT01

Station LSNT01 is located in the South Central Puget Sound Basin, approximately three miles from the Alki outfall and five miles from the South outfall (see Figure 1). This station has been monitored continuously since 1988. King County currently samples this station on a monthly basis for *in situ* field measurement of temperature, dissolved oxygen, salinity, density, and transmissivity and laboratory analysis of fecal coliform and enterococcus bacteria, nutrients (ammonia, nitrate + nitrite nitrogen, silica, and total phosphorus), chlorophyll-*a* and pheophytin, and total suspended solids. Nutrient and total suspended solids samples are collected from seven depths at this station – 1, 15, 25, 35, 55, 100, and 180 meters. Chlorophyll-*a* and pheophytin samples are collected from four depths – 1, 15, 25, and 35 meters. Bacteria samples are collected from a single depth – 1 meter.

Station LSNT01 will continue to be sampled monthly as part of King County's routine ambient monitoring program. The County will submit to Ecology two years' worth of monthly data from this station for total suspended solids, dissolved oxygen, temperature, fecal coliform bacteria, and salinity (as well as future routine monitoring data, if needed) to meet the requirements of Section S11.7 of the South Treatment Plant permit and Section S18.I.7 of the West Point permit.


KSBP01
Carkeek
West Point
Elliott West
South
LTED04
Alki
MLK/Henderson
LTXQ01
500 0 500 1000 Feet
LSNT01
Figure 1
NPDES Receiving Water Sampling Locations
Outfall Location
Ambient Sampling Location
5000 0 5000 10000 Feet
N

2.1.3 Station LTED04

Station LTED04 is located in Elliott Bay, approximately one mile from the Elliott West outfall (see Figure 1). This station has been monitored continuously since 1997. King County currently samples this station on a monthly basis for *in situ* field measurement of temperature, dissolved oxygen, salinity, density, and transmissivity and laboratory analysis of fecal coliform and enterococcus bacteria, nutrients (ammonia, nitrate + nitrite nitrogen, silica, and total phosphorus), chlorophyll-*a* and pheophytin, and total suspended solids. Nutrient and total suspended solids samples are collected from six depths at this station – 1, 15, 25, 35, 55, and 75 meters. Chlorophyll-a and pheophytin samples are collected from four depths – 1, 15, 25, and 25 meters. Bacteria samples are collected from a single depth – 1 meter.

King County partnered with the Seattle Aquarium in November 2007 to deploy its first high-frequency, real-time, marine water quality data collection system to assess the nearshore environment in Elliott Bay. Automated, high-frequency, water quality data collection systems allow continuous measurements of physical, chemical, and biological water quality parameters as well as meteorological parameters. The data generated by these systems allow users to characterize temporal and spatial variability for multiple parameters over numerous scales (e.g., daily, seasonal, annual, inter-annual). This moored system is comprised of two YSI 6600 EDS sonde/sensor arrays that are deployed from the Aquarium's pump house at the end of Pier 59. A weighted-pulley system allows the two arrays to be deployed at fixed depths – approximately one meter and ten meters below the surface. Parameters measured include temperature, conductivity (salinity), pressure (depth), dissolved oxygen, turbidity, pH, and fluorescence (chlorophyll). Data are collected and uploaded every 15 minutes to a web interface. Data from this monitoring system may be viewed at http://green.kingcounty.gov/marine-buoy/.

Station LTED04 will continue to be sampled monthly as part of King County's routine ambient monitoring program. The County will submit to Ecology two years' worth of monthly data from this station for total suspended solids, dissolved oxygen, temperature, fecal coliform bacteria, and salinity (as well as future routine monitoring data, if needed) to meet the requirements of Section S18.I.7 of the West Point permit. One year of high-resolution pH, dissolved oxygen, temperature, and salinity data from the County's marine mooring in Elliott Bay will also be submitted to assess temporal variations of these parameters on a finer scale.

2.1.4 Station LTXQ01

Station LTXQ01 is located in the Duwamish River, approximately 600 feet downstream of the MLK/Henderson outfall (see Figure 1). King County currently samples this station on a monthly basis for field measurement of temperature and dissolved oxygen and laboratory analysis of fecal coliform and enterococcus bacteria, nutrients (ammonia, nitrate + nitrite nitrogen, and total phosphorus), salinity, hardness, and total suspended solids. Samples are collected mid-channel from the river, using a modified, van Dorn-style sampling bottle that is lowered from a bridge. Data have been collected at this station since May 2009.

Station LTXQ01 will continue to be sampled monthly as part of King County's routine ambient monitoring program. The County will submit to Ecology two years' worth of monthly data from this station for total suspended solids, dissolved oxygen, temperature, fecal coliform bacteria, and salinity (as well as future routine monitoring data, if needed) to meet the requirements of Section S18.I.7 of the West Point permit.

2.2 New Water Quality Monitoring

The County's NPDES permits also require submittal of data for certain water quality parameters that have not been measured previously on a regular basis or have not been measured recently. These include trace metals and pH for all sampling locations and weak acid dissociable cyanide and alkalinity for the sampling location that will serve the South treatment plant outfall.

King County will collect a total of 12 samples from all four monitoring stations for analysis of total and dissolved metals to meet the requirements of Sections S12.H and S18.I.8 of the West Point permit and Section S11.7 of the South Treatment Plant permit. The four sampling events will be timed to occur during a spring tide in December 2010, July 2011, December 2011, and July 2012. This timing will meet the requirements of both the West Point and South Treatment Plant permits. King County previously collected monthly metals data at Stations KSBP01 and LSNT01 for 15 months during 1999 and 2000. These previous data, along with the new trace metals data collected over an 18-month period, will allow an assessment of any spatial or temporal variations in trace metals' concentrations. New sampling at Station LSNT01 will also include weak acid dissociable cyanide and alkalinity as required in the South treatment plant permit. Given the periodic excursion of the Duwamish River salt wedge into the area in which Station LTX01 is located, synoptic hardness and salinity data will also be collected along with trace metals, to allow comparison of metals' data with appropriate water quality criteria. At the three offshore stations, pH will be measured *in situ* during each sampling event in a continuous surface to bottom profile. At Station LTXQ01, pH will be measured in the field each time samples are collected for analysis of trace metals.

3 PROJECT ORGANIZATION AND SCHEDULE

3.1 Project Organization

The tasks involved in conducting the NPDES Receiving Water Characterization Study and the personnel responsible for those tasks are shown below.

- **Scott Mickelson** King County Marine and Sediment Assessment Group – (206) 296-8247 scott.mickelson@kingcounty.gov Project management, study design, preparation of draft SAP/QAPP, approval of final SAP/QAPP, data validation, data analysis, and preparation of final study report.
- **Betsy Cooper** King County Wastewater Treatment Division – (206) 263-3728 betsy.cooper@kingcounty.gov Internal review of study design and draft SAP/QAPP, approval of final SAP/QAPP, and internal review of final study report.
- **Mark Henley** Department of Ecology Water Quality Program – (425) 649-7103 mahe461@ecy.wa.gov Review and approval of SAP/QAPP, review of final report and resulting data.
- **Jean Power** King County Environmental Laboratory – (206) 684-2384 jean.power@kingcounty.gov Coordination of field activities for all routine sampling events and semiannual sampling events.
- **Katherine Bourbonais** King County Environmental Laboratory – (206) 684-2382 katherine.bourbonais@kingcounty.gov Coordination of all King County Environmental Laboratory activities, data verification, and internal data reporting.
- **Colin Elliott** King County Environmental Laboratory – (206) 684-2343 colin.elliott@kingcounty.gov Internal review of draft SAP/QAPP, data verification, coordination of King County Environmental Laboratory QA/QC programs.

3.2 Project Schedule

The receiving water characterization studies for the South treatment plant and the West Point treatment plan and CSO facilities have different timelines in their respective permits. Due to the sampling and analytical requirements for trace metals, the decision was made to conduct the studies concurrently, using the earlier West Point permit timeline to create the project schedule. The following schedule for preparing draft and final SAP/QAPP documents will allow the first round of sampling to occur in July 2011:

- June 30, 2010 – Submittal of draft SAP/QAPP by King County to Department of Ecology for review and comment. This project deadline meets the reporting schedule outlined in Sections S12.A and S18.I.1 of the West Point permit
- December 16, 2010 – Submittal of comments on draft SAP/QAPP by Department of Ecology to King County for incorporation into final document.
- December 17, 2010 – Submittal of final SAP/QAPP to Department of Ecology for letter of approval.

Upon approval of the project SAP/QAPP, the following schedule will commence for the four rounds of trace metals, pH, cyanide, alkalinity, and hardness sampling:

- July 2011 (Spring Tide) – The first sampling event will be conducted during a spring tide in the month of July to meet the timing requirements of both the West Point treatment plant (spring tide) and South treatment plant (critical period) NPDES permits. Samples will be collected for analysis of trace metals at all four monitoring stations. The monitoring station proximal to the South Treatment Plant will be sampled for analysis of weak acid dissociable cyanide and alkalinity in addition to trace metals. The monitoring station proximal to the MLK/Henderson Storage and CSO Treatment Plant will be sampled for analysis of hardness in addition to trace metals. Field measurement of pH will occur at all four stations.
- December 2011 (Spring Tide) – Second sampling event for trace metals, cyanide, alkalinity, and hardness.
- July 2012 (Spring Tide) – Third sampling event for trace metals, cyanide, alkalinity, and hardness.
- December 2012 (Spring Tide) – Fourth sampling event for trace metals, cyanide, alkalinity, and hardness.

In addition to new sampling, King County will also submit to Ecology existing data from its routine monthly water column monitoring program according to the following schedule:

- June 2013 – Submittal of two years' data from four monitoring stations, to include the following parameters; total suspended solids, dissolved oxygen, temperature, fecal coliform bacteria, and salinity.
- June 2013 – Submittal of one year of high-resolution data for King County's moored water quality monitoring station in Elliott Bay for the following parameters; dissolved oxygen, temperature, salinity, and pH.
- June 2013 – Submittal of 12 months of pH data from four monitoring stations, which will have had sampling begun in January 2011.

Upon completion of all sampling and analysis, King County will prepare a final study report and data submission. The data submission will include both data collected under this SAP/QAPP, as well as trace metals data collected during a prior sampling program conducted in 1999 and 2000.

- June 30, 2013 – Submittal of study report to the Department of Ecology and submittal of study data in electronic format to the Environmental Information Management (EIM) System.

4 DATA QUALITY OBJECTIVES

The data quality objectives of the NPDES receiving water characterization study are to provide sufficient data of known quality to Ecology for use in their "Reasonable Potential" analysis. This section discusses both the quantity and quality of data to be collected during this study.

4.1 Data Quantity

The quantity of data to be collected is prescribed in the NPDES permits for both the South and West Point treatment plants (Ecology 2009 a,b). A minimum of 10 receiving water samples at each sampling location must be collected to meet the requirements of both permits. The submission of two years'worth of existing data from the County's monthly ambient sampling program, as discussed in Section 2, coupled with the collection of 12 new samples at each sampling location for additional trace metals and conventionals analyses will meet the requirements of the NPDES permits and provide a sufficient quantity of data for Ecology to perform their analysis.

4.2 Data Quality

Validation of project study data will assess whether the data collected are of sufficient quality to meet the study goals. The data quality issues of precision, accuracy, bias, representativeness, completeness, and comparability are described in the following sections.

4.2.1 Precision, Accuracy, and Bias

Precision is the agreement of a set of results among themselves and is a measure of the ability to reproduce a result. Accuracy is an estimate of the difference between the true value and the determined mean value. The accuracy of a result is affected by both systematic and random errors. Bias is a measure of the difference, due to a systematic factor, between an analytical result and the true value of an analyte. Precision, accuracy, and bias for chemistry analyses may be measured by one or more of the following quality assurance/quality control (QA/QC) procedures:

- collection and analysis of field replicate samples and various field blanks such as atmosphere, bottle, filtration, and equipment blanks; and
- analysis of various laboratory QC samples such as method blanks, matrix spikes, certified reference materials, and laboratory replicates.

4.2.2 Representativeness

Representativeness expresses the degree to which sample data accurately and precisely represent a characteristic of a population, parameter variations at the sampling point, or an environmental condition. Water samples for trace metals and conventional analyses will be collected from stations with predetermined coordinates and sampling depths to represent specific site locations. The collection of electronic *in situ* water column data will also be performed at stations with predetermined coordinates.

4.2.3 Completeness

Completeness is defined as the total number of samples analyzed for which acceptable analytical data are generated, compared to the total number of samples submitted for analysis. Sampling at

stations with known position coordinates in favorable conditions, along with adherence to standardized sampling and testing protocols will aid in providing a complete set of data for this project. The goal for completeness is 100%. If 100% completeness is not achieved, the project team will evaluate if the data quality objectives can still be met or if additional samples may need to be collected and analyzed.

4.2.4 Comparability

Comparability is a qualitative parameter expressing the confidence with which one data set can be compared with another. This goal is achieved through using standard techniques to collect and analyze representative samples, along with standardized analytical procedures. By following the guidance of this SAP/QAPP, the goal of comparability will be achieved. Historical water quality data from King County's previous trace metals' sampling program will be compared with data generated from this study to enhance the data set. Previous data may be used since comparable sampling and analytical techniques have been employed and water samples were collected from the same locations and depths.

5 STUDY DESIGN FOR NEW MONITORING

The goal of the receiving water characterization study is to collect new water column data for trace metals, pH, cyanide, and alkalinity that will provide Ecology information necessary to perform their "Reasonable Potential" analysis. Both the South and West Point treatment plant permits stipulate that a minimum of 10 receiving water samples will be collected for analysis of trace metals and pH, with the additional analyses of cyanide and alkalinity required under the South treatment plant permit.

The following study design meets the requirements of both permits and, coupled with previous trace metals data collected in Puget Sound, will provide a robust data set that will meet the study goal by allowing spatial and temporal evaluations of trace metals concentrations in receiving water. The previous trace metals data were collected over 15 months in 1999 and 2000 from eight stations in Puget Sound, two of which will be revisited during this receiving water characterization study, sampling the same depths as the previous study.

The four stations shown in Figure 1 will each be sampled four times, with three samples collected from each station during each sampling event. The four sampling events will occur over an 18 month period from December 2010 to July 2012. Each sampling event will be scheduled to meet the timing requirements of both NPDES permits – sampling during the critical period (July and December) for the South treatment plant permit and during a spring tide for the West Point treatment permit.

5.1 Station KSBP01

A total of 12 samples will be collected from this station for analysis of total and dissolved arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc. Samples will be collected from three depths – 5, 50, and 200 meters – during each of four sampling events. The four sampling events will be timed to occur during a spring tide in December 2010, July 2011, December 2011, and July 2012. King County previously collected monthly metals data from the same three depths at Station KSBP01 for 15 months during 1999 and 2000. *In situ* measurement of pH will occur in a full water-column profile during each sampling event.

5.2 Station LSNT01

A total of 12 samples will be collected from this station for analysis of total and dissolved antimony, arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc. Synoptic samples will be collected for analysis of alkalinity and cyanide complete the requirements of Section S11.7 of the South Treatment Plant permit. Samples will be collected from three depths – 5, 50, and 160 meters – during each of the four sampling events occurring in December 2010, July 2011, December 2011, and July 2012. King County also previously collected monthly metals data from the same three depths at Station LSNT01 for 15 months during 1999 and 2000. *In situ* measurement of pH will occur in a full water-column profile during each sampling event.

5.3 Station LTED04

A total of 12 samples from this station will be collected for analysis of total and dissolved arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc. Samples will be collected from three depths – 5, 50, and 75 meters – during each of the four sampling events

occurring in December 2010, July 2011, December 2011, and July 2012. *In situ* measurement of pH will occur in a full water-column profile during each sampling event.

5.4 Station LTXQ01

A total of 12 samples will be collected from this station for analysis of total and dissolved arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc to meet the requirements of Section S18.I.8 of the West Point permit. Due to both the shallow depth of the river at this station and the resulting sampling method that will be used, samples can only be collected from a single depth – slightly below the surface. To facilitate efficient analytical batching of samples, this station will be sampled on the same schedule as the three marine stations; December 2010, July 2011, December 2011, and July 2012. This will provide two sampling events in both wet and dry seasons. To assess environmental variability, one sample will be collected on each of three successive days during each sampling event, resulting in a total of 12 samples. Given the periodic excursion of the salt wedge into this area, synoptic hardness and salinity data will also be collected, to allow comparison of metals' data with appropriate water quality criteria. Field measurement of pH will be collected synoptically with each sample collected for trace metals analysis.

6 SAMPLING PROCEDURES AND FIELD MEASUREMENTS

The representativeness of a data set may be enhanced by following a standard set of protocols and procedures for collecting samples and gathering field data. This section describes field methodologies and protocols for collection of representative water-column samples, as well as the electronic collection of *in situ* field data. Included in this description are the procedures that have been used to collect ongoing ambient water quality data that will be submitted to Ecology as well as the procedures for collecting new data for trace metals, cyanide, alkalinity, and pH.

Three applicable King County Environmental Laboratory Standard Operating Procedures (SOP) have been included as appendices to this SAP/QAPP. *Standard Operating Procedure for the SBE25 SeaLogger CTD (SOP #220v3)* has been included as Appendix A. *Standard Operating Procedure for Clean Sampling for Ultra Low Trace Metals using Modified Niskin Bottles (SOP #221v2)* has been included as Appendix B. *Standard Operating Procedure for Clean Surface Water Sampling for Ultra Low Trace Metals and Organics (SOP #222v2)* has been included as Appendix C.

6.1 Sampling Procedures for Existing Data Submission

This section describes the sampling methodologies that King County employs during routine collection of water column samples for its ambient marine monitoring program. Included in the routine monitoring program are the collection of samples for laboratory analysis of total suspended solids and fecal coliform bacteria and *in situ* measurement of dissolved oxygen, salinity, and temperature – the parameters for which King County will be submitting existing data to Ecology.

6.1.1 In Situ Measurement and Sample Collection Using a CTD

Water quality constituents that are measured *in situ* at the three offshore marine stations – KSBP01, LSNT01, and LTED04 – employ a conductivity/temperature/depth (CTD) instrument that is deployed from King County's research vessel *Liberty*.

The SBE 25 SEALOGGER® CTD, manufactured by SeaBird Electronics of Bellevue, Washington, is a profiling system for lake, coastal, estuarine, and deep water work. In addition to measuring conductivity, temperature, and depth, the instrument also measures dissolved oxygen, chlorophyll, light intensity (photosynthetically active radiation), and turbidity (optical backscatterance). Direct measurements are also used to calculate the parameters of salinity and density.

The CTD is deployed from the *Liberty* by hydraulic winch. The instrument is allowed to equilibrate to surface conditions for approximately five minutes before data recording begins. The CTD is lowered at a specified descent rate from the surface to approximately five meters above the sea floor (downcast). Data are recorded both on the down cast and during the instrument's return to the surface (upcast). Data are recorded to a datalogger at a frequency of eight hertz or eight recordings per second.

Upon retrieval of the instrument, data are uploaded to a laptop computer from the datalogger prior to the next cast. System software converts parameter data into surface-to-depth plots which are field-reviewed for quality control.

The thermometer, conductivity probe, turbidity probe, light intensity probes, and fluorometer are calibrated, as recommended, on an annual basis by the instrument manufacturer/distributor. The dissolved oxygen probe is calibrated by comparing samples collected and analyzed in the laboratory using Winkler titration methodology. System maintenance and calibration information are kept in instrument logbooks along with cruise-specific notes.

Samples for analysis of total suspended solids and fecal coliform bacteria are collected using Niskin sample bottles deployed on the CTD "rosette." Predetermined sampling depths are programmed into the CTD and the instrument deployed as described in the previous paragraphs. Analytical samples are collected on the upcast of the CTD. Upon retrieval of the CTD, sample aliquots are transferred from the Niskin bottles into sample containers. Total suspended solids samples are collected in 1-liter HPDE bottles and fecal coliform samples are collected in sterile 500-ml polypropylene bottles. Samples are stored in ice-filled coolers until delivery to the laboratory. Field QC samples include collection of replicate samples at the rate of one per 20 analytical samples collected.

6.1.2 Collection of Samples Using Hand-Held Sampling Bottles and Meters

Due to logistics at sampling station LTXQ01, samples at this location are collected from a bridge over the Duwamish River. Samples are collected from center channel, using a modified, van Dorn-style sampling device deployed on a sampling line from the bridge. Once the sampling device has entered the river, a sharp “tug” on the rope closes the device, capturing a discrete water sample from just below the surface. Upon retrieval of the sampling device, sample aliquots are collected for analysis of bacteria, total suspended solids, nutrients, salinity, and hardness. Another aliquot of sample is place into a measurement cup, in which field measurements of dissolved oxygen and temperature are collected as soon as possible after sample collection. Field measurement of dissolved oxygen and temperature employs a hand-held, YSI multi-probe field meter.

6.2 Sampling Procedures for Acquisition of New Data

This section describes the collection of samples for analysis of trace metals, hardness, alkalinity, cyanide, and salinity, and the field measurement of pH.

6.2.1 Station Positioning

A precise method of offshore station positioning is important for studies in which sampling stations are revisited multiple times. The receiving water characterization study will not only assess spatial differences in water column characteristics over the study area but temporal changes at each particular location as well. In order to assess both spatial differences and temporal changes in water column characteristics, the station must be revisited as precisely as possible. Reliable station positioning is crucial to be able to revisit established stations. Inaccuracies in station positioning when conducting water-column sampling in deep water can result from the action of currents and wind on the sampling vessel as well as current forces and viscous drag on the CTD and deployment line.

Station positioning for this study will be accomplished using a Furuno® Differential Global Positioning System (DGPS). Prior to the study, prescribed station coordinates (Lat/Lon coordinate system) will be loaded into the shipboard DGPS. During the sampling event, the shipboard navigational system will utilize the differential data transmissions from regional Coast

Guard base stations to automatically correct its GPS satellite data. Previous DGPS usage indicates that an average precision of one to two meters can usually be attained.

6.2.2 Trace Metals at Offshore Stations

Prior to each sampling event, all sampling equipment and containers will be cleaned according to King County Environmental Laboratory SOP #630v1 (King County 2006). The sampling procedures will utilize the "clean hands/dirty hands" technique outlined in EPA Method 1669 (EPA 1995). Before arriving at the initial sampling site, sampling personnel will be designated "clean hands," "dirty hands," and "crane operator." "Clean hands" will handle all operations involving contact with the sample container and transfer of the sample from the sampling device to the sample container. "Dirty hands" is responsible for preparation of the sampling device and for all other activities that do not involve direct contact with the sample. "Crane operator" is responsible for setup and operation of the clean winch system along with backup "dirty hands" responsibilities.

All equipment will be non-metallic and sampling personnel will always wear non-powdered PVC gloves. Prior to the sampling event, a pre-deployment equipment blank will be collected and all sampling equipment will be double-bagged in zippered, plastic bags. Samples will be collected using Niskin-X bottles attached to a synthetic hydroline. A specialized, non-contaminating winch system mounted on the rear deck of the *Liberty* controls the hydroline. The skipper maneuvers the vessel in a manner that allows the hydroline to remain upwind and upcurrent of engine exhaust. The Niskin-X bottles are attached to the hydroline and lowered to the specified sampling depth. A "messenger" is released down the hydroline to trip the bottles. The Niskin-X bottles are then brought up and samples dispensed into sample containers immediately upon coming out of the water and while still attached to the hydroline. Sample containers are then double-bagged and stored in ice-filled coolers until delivery to the King County Environmental Laboratory.

6.2.3 Alkalinity and Cyanide Sample Collection at Station LSNT01

Samples for the analysis of alkalinity and weak acid dissociable cyanide will be collected concurrently with the trace metals samples at Station LSNT01. Samples for both conventionals' parameters will be collected from the same three depths as the trace metals samples. Sample aliquots for alkalinity analysis will be placed into 500-ml, clear, high-density polyethylene (HDPE) bottles. Sample aliquots for cyanide will be placed into 500-ml, amber, HDPE bottles. Samples for analysis of cyanide will be preserved in the field by adding sodium hydroxide (NaOH) tablets to the sample bottle and measuring the pH with litmus paper until a pH of greater than 12 has been attained. Cyanide sample preservation will occur within 15 minutes of sample collection. All sample containers will be kept in ice-filled coolers until receipt at the King County Environmental Laboratory.

6.2.4 Field Measurement of pH at Offshore Stations

Field measurement of pH will be added to the suite of analytes measured by the CTD, starting in January 2011, and measured for a period of 12 months. Measurement of pH will occur continuously from the surface to deepest depth measured at each station, both on the downcast and upcast of the CTD. Measurements will be averaged over 0.5-m increments for reporting purposes. The sensor used to measure pH will be a SeaBird SBE 18 pressure-balanced, glass-electrode, silver/silver chloride reference pH probe.

6.2.5 Sample Collection at Station LTXQ01

Sample collection for trace metals at Station LTXQ01 will also be accomplished following EPA Method 1669. Samples will be collected at this station by lowering a single-use Teflon bailer attached to a clean rope from a bridge above the river. Two sampling staff, designated "clean hands" and "dirty hands" will accomplish all sampling. "Dirty hands" will unpack and deploy the Teflon bailer and retrieve the sample. "Clean hands" will be responsible for filling all sample containers. Samples collected in this method will include total and dissolve trace metals and hardness. An additional aliquot of water will be collected using a modified van Doren-style bottle. The salinity container will be filled from this aliquot as well as field measurement of pH. Field measurement of pH will be performed during each sampling event at this site through the use of a portable single-parameter probe or a multi-parameter such as a Hydrolab®. The single-parameter instrument is a combination electrode with a potentiometric meter and temperature probe, which automatically compensates for temperature. A two-point calibration of the meter will be performed prior to measurement. The buffers used for the two-point calibration will bracket the expected sample values.

6.3 Sample Containers, Storage Conditions, and Holding Times

Table 6-1 summarizes the sample containers, sampling holding conditions, and method-specific holding times for samples that will be collected during the new data acquisition effort.

Table 6-1 Sample Containers, Storage Conditions, and Holding Times

Analyte	Container	Storage/Preservation	Holding Time
Alkalinity	500-ml CWM HDPE	Refrigerate at 4°C	14 days
Cyanide, weak acid dissociable	500-ml AWM HDPE	Refrigerate at 4°C, NaOH to pH > 12 within 15 minutes	14 days
Salinity	125-ml CNM HPDE	Refrigerate at 4°C	28 days
Hardness	500-ml CNM HPDE	Room temperature, HNO_3 to pH < 2	6 months
Mercury	500-ml Teflon (hot acid-washed)	Room temperature, HCl to pH < 2	90 days
ICP-MS Metals	500-ml CNM HPDE (acid-washed)	Room temperature, HNO_3 to pH < 2	6 months

HDPE – high-density polyethylene
AWM – amber wide mouth
CNM – clear narrow mouth
CWM – clear wide mouth

7 LABORATORY ANALYTICAL METHODS

The completeness and comparability of a data set may be enhanced by following a standard set of protocols for analyzing samples. This section describes both the laboratory analytical methods currently in use for data that will be part of the existing data submission as well as those methods that will be used during the acquisition of new data. All laboratory analyses referenced in this section have been performed, or will be performed, by the King County Environmental Laboratory.

Included in the description of the analytical methodologies are the respective detection limits for each analysis. The terms MDL and RDL, used in the following subsections, refer to *method detection limit* and *reporting detection limit*, respectively. The MDL is defined as *the minimum concentration of a chemical constituent that can be detected*, while the RDL is defined as *the minimum concentration of a chemical constituent that can be reliably quantified*.

7.1 Summary of Methods for Existing Data Submission

The existing data submission will include three parameters for which laboratory analysis is performed – total suspended solids, fecal coliform bacteria, and salinity. Salinity is generally measured *in situ*, however, at Station LTXQ01 (Duwamish River), samples are collected and analyzed in the laboratory due to field logistics.

7.1.1 Total Suspended Solids

Total suspended solids analysis is performed according to Standard Method (SM) 2540D (APHA 1998), following King County Environmental Laboratory Standard Operating Procedure (SOP) #309v3 (King County 2008). The MDL and RDL for this analysis are 0.5 and 10 mg/L, respectively. For the determination of total suspended solids, a measured volume of a well-mixed water sample is filtered through a 934AH glass fiber filter. The residue retained on the glass fiber filter is dried to a constant weight at 103 to 105°C. The resulting net weight represents the total suspended solids.

7.1.2 Fecal Coliform Bacteria

Fecal coliform analysis is performed according the SM9222D (APHA 1998), following King County Environmental Laboratory SOP #506v1 (King County 2005a) . The MDL for this analysis is 1 colony forming unit per 100 milliliters (CFU/100 ml). Appropriate dilutions, if necessary, are prepared using APHA buffered water as the diluent. The sample and its dilutions are filtered through a sterile 0.45 μm nitrocellulose membrane. The membrane is then applied to an mFC agar plate. After incubation at 44.5 ± 0.2^{o}C for 24 ± 2 hours, all colonies with a characteristic blue color are counted. The number of colonies per 100 mL of sample is calculated based on the colonies counted and the dilutions used per plate.

7.1.3 Salinity

Salinity analysis is performed according to SM 2520B (APHA 1998), following King County Environmental Laboratory SOP #316v3 (King County 2002). The MDL and RDL for this analysis is 2.0 and 3.0 PSS (Practical Salinity Scale), respectively. Salinity is determined by measuring the conductance of an electrical current through the sample kept at constant temperature of 25 °C (set at 2°C above mean ambient room temperature) and comparing the

measurement to the conductivity of a standard sea water or reference potassium chloride (KCl) solution. The relative measurement can be displayed as conductivity ratio or Practical Salinity. The control and measurement conversion is performed by a microprocessor from the instrument to calculate salinity corrected for the bath temperature to give the equivalent salinity relative to standard sea water at 15°C.

7.2 Summary of Methods for Acquisition of New Data

The acquisition of new data will include the collection of samples for analysis of both conventional and trace metal parameters. Trace metals samples will be collected from all four stations and the additional conventional samples will be collected from the station representing the South treatment plant.

7.2.1 Conventionals

Conventional analyses will include alkalinity and cyanide, which will be performed on the 12 samples collected from Station LSNT01, the station associated with the South Wastewater Treatment Plant outfall.

7.2.1.1 Alkalinity

As of the date this SAP/QAPP is being submitted to Ecology for review, the King County Environmental Laboratory does not have an in-house method for the analysis of alkalinity in seawater. Laboratory staff are investigating both the development of an in-house method or the possibility of contracting this analysis to an outside laboratory. Staff at Ecology will be kept apprised of the progress throughout the SAP/QAPP approval process.

7.2.1.2 Cyanide

Cyanide analysis will be performed according to SM 4500CN- I,E (APHA 1998), following King County Environmental Laboratory SOP #321v5 (King County 2005b). The MDL and RDL for this analysis are 0.005 and 0.010 mg/L, respectively.

This method is for determination of weak acid dissociable cyanide. The cyanide, as hydrogen cyanide (HCN) is released from cyanide complexes by means of a reflux-distillation using a weak acid (pH ~ 4.5) in the presence of a zinc acetate buffer. Simple and weak metal-cyano-complexes are recovered, while stronger complexes are not. The HCN is absorbed in a scrubber containing a sodium hydroxide solution. The cyanide in the scrubbing solution is determined colorimetrically. In the colorimetric measurement, the cyanide is converted to cyanogen chloride (CNCl) by the reaction with chloramine-T at a pH less than 8 without hydrolyzing to the cyanate. After the reaction is complete, color is formed by the addition of pyridine-barbituric acid reagent and the absorbance is read at 570nm using a standard 6 mm flow cell.

7.2.2 Trace Metals

Analysis of trace metals will be performed on 48 samples, collected from Stations KSBP01, LSNT01, LTED04, and LTXQ01. The samples collected from Stations KSBP01, LTED04, and LTXQ01 will be analyzed for arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc. The samples collected from Station LSNT01 will be analyzed for those nine metals plus antimony. The 12 samples collected from Station LTXQ01, located in the Duwamish River, will also be analyzed for hardness.

7.2.2.1 Total and Dissolved Mercury

Total and dissolved mercury analysis will be performed according to EPA Method 1631E (EPA 2002), following King County Environmental Laboratory SOP #605v0 and #606v0 (King County 2003a,b). The MDL and RDL for this analysis are 0.2 and 0.5 nanograms per liter (ng/L), respectively.

- Mercury (Hg) Sample Preparation – A representative aliquot of sample is digested at room temperature for 12 hours with bromine monochloride in order to convert the organic and complex forms of mercury to the mercuric ion.

- Mercury Analysis – The sample is reduced with tin (stannous) chloride ($SnCl_2$) to convert Hg(II) to volatile Hg(0). The Hg(0) is separated from solution by purging the sample with nitrogen and driving the Hg(0) onto a gold trap. The trapped mercury is thermally desorbed from the gold trap into an inert gas stream that carries the released Hg(0) into the cell of a cold-vapor atomic fluorescence spectrometer (CVAFS) for detection. The sample is analyzed by purge and trap dual amalgamation Automated Cold Vapor Atomic Fluorescence Spectrometry using a Tekran 2600 flow-injection mercury analyzer equipped with a Model 2620 auto-sampler

7.2.2.2 Total and Dissolved Metals by ICP-MS

Analysis of total and dissolved metals will be performed according to EPA Method 1640 modified (EPA 1997), following King County Environmental Laboratory SOP #643v1 (King County 2010). The MDL and RDL for this study's target metals are shown Table 7-1.

Table 7-1 Trace Metals Detection Limits

Metal	MDL (µg/L)	RDL (µg/L)
Antimony	0.3	1.0
Arsenic	0.1	0.5
Cadmium	0.05	0.25
Chromium	0.2	1.0
Copper	0.4	2.0
Lead	0.1	0.5
Nickel	0.1	0.5
Silver	0.04	0.2
Zinc	0.5	2.5

- Metals Sample Preparation – Marine water samples for total metals analysis are preserved to a pH of <2 by acidification with ultrapure nitric acid. Dissolved metals samples are also preserved to a pH of <2 by the same method after being filtered through a 0.45 µm capsule filter within 15 minutes of sample collection. Due to the inherent matrix interference of seawater on trace metals' analysis, both the total recoverable and dissolved samples will undergo reductive precipitation and preconcentration steps prior to analysis, according to American Society for Testing and Materials (ASTM) Method D6800 (ASTM 2002).

- Metals Analysis – Samples will be analyzed by Inductively Coupled Plasma – Mass Spectrometry (ICP-MS) according to EPA Method 200.8r5.4 (EPA 1994a). Aqueous samples are nebulized into a spray chamber where a stream of argon carries the sample

aerosol through a quartz torch and injects it into a plasma, where the sample is decomposed and desolvated. The ions produced are entrained in the plasma gas and by means of a water cooled, differentially pumped interface, introduced into a high-vacuum chamber that houses a quadrupole mass spectrometer. The ions are sorted according to their mass-to-charge ratio and measured with a detector.

7.2.2.3 Hardness by ICP

Analysis of hardness will be performed according to SM 2340B (APHA 1998), which is a calculation based upon separately determined calcium and magnesium concentrations. Calcium and magnesium will be analyzed according to EPA Method 200.7r4.4 (EPA 1994b), following King County Environmental Laboratory SOP #612v4 (King County 2007). This method involves the simultaneous determination of multiple elements by inductively coupled plasma atomic emission spectroscopy (ICP).

8 PROJECT QUALITY CONTROL

This section presents field and laboratory quality control (QC) measures that will be employed to ensure data are of sufficient quality to meet the project DQOs.

8.1 Field Quality Control

Field QC samples are collected to assess any bias that may be introduced to an environmental sample through sampling and sample handling techniques, as well as environmental variability at a sampling location. Field QC samples will include atmosphere blanks, bottle blanks, field filtration blanks, field blanks, Niskin blanks, and field replicates.

8.1.1 Atmosphere Blank

An atmosphere blank is a sample of reagent water in a laboratory-supplied container, which is left uncapped during sampling for the same amount of time that the environmental sample is exposed to the atmosphere. Analysis of atmosphere blanks is used to measure possible contamination imparted to samples from airborne sources. Atmosphere blanks are analyzed for trace metals and will be collected at the rate of one per sampling location during each sampling event.

8.1.2 Bottle Blank

A bottle blank is a sample container taken from the same set used for a sampling event. The sample container is filled in the laboratory with reagent water and sent into the field with the other sample containers. Analysis of bottle blanks is used to measure and document any sample contamination that may be imparted to the samples from the sampling containers themselves. Bottle blanks are analyzed for trace metals and will be collected at the rate of one per sampling event.

8.1.3 Field Blank

A field blank is a sample of reagent water supplied by the laboratory, which is transported to the field and treated as a sample in all respects – including contact with a sampling device and/or field filtration processes. Analysis of field blanks is used to measure and document any sample contamination resulting from sample handling, transport, exposure to the atmosphere or contact the sampling device(s) at the sampling location. Field blanks will be analyzed for trace metals and will be collected at the rate of one per sampling event.

8.1.4 Niskin Blank

A Niskin blank is a sample of reagent water that has been used to rinse one of the Niskin bottles in the laboratory after prescribed decontamination. Analysis of the Niskin blank is used to measure and document the possible contamination of an environmental sample by the sampling equipment and to document the effectiveness of the decontamination procedure in the laboratory. An acceptable Niskin blank should be achieved before the sampling devices are deployed. Niskin blanks will be analyzed for trace metals and will be collected at the rate of one per sampling event.

8.1.5 Field Replicate

A field replicate sample consists of a second sample collected at a sampling location using the exact collection methodology that was used to obtain the first sample. The field replicate is collected at the same sampling location and as soon after the original sample as possible. The field replicate sample is generally analyzed for all the analytes for which the sample was analyzed. Analysis of the field replicate sample is used to measure and document the precision of field sampling methodologies and the environmental variability at the sample site. Field replicates will be collected at the rate of two per sampling event and will be analyzed for trace metals, alkalinity, cyanide, hardness, and salinity.

8.2 Laboratory Quality Control

Laboratory QC will include the analysis of several types of QC samples that measure accuracy, precision, and bias. Laboratory QC samples will be analyzed at the rate of one per analytical batch or every 20 samples, whichever is less. Measurement of cyanide will include analysis of method blanks, spike blanks, matrix spikes, laboratory control samples, and laboratory duplicates. Measurement of alkalinity and salinity will include analysis of laboratory control samples and laboratory duplicates. Measurement of trace metals will include analysis of method blanks, spike blanks, matrix spikes, matrix spike duplicates, and laboratory duplicates. A short description of these types of laboratory QC samples is provided in the following sections.

8.2.1 Method Blank

A method blank is an aliquot of reagent water that is processed through the entire analytical procedure. Analysis of the method blank is used to evaluate the levels of contamination that might be associated with the processing and analysis of samples and any introduced bias to sample results. All method blank results should be less than the method detection limit.

8.2.2 Spike Blank

A spike blank is a second aliquot of reagent water, to which a known concentration of target analyte(s) has been added. The spiked aliquot is processed through the entire analytical procedure. Analysis of the spike blank is used as an indicator of method accuracy. The King County Environmental Laboratory has empirically-derived control limits for the percent recovery of spike blank analytes. Spike blank results should be within these control limits.

8.2.3 Matrix Spike

A matrix spike is a second aliquot of an analytical sample fortified with a known concentration of target analyte(s). The spiked sample is processed through the entire analytical procedure. Analysis of the matrix spike is used as an indicator of sample matrix effect on the recovery of target analyte(s) and any introduced bias, as a result. Both method-specified and empirically-derived control limits for the percent recovery of matrix spike analytes are used, depending on the analysis. Matrix spike results should be within these control limits.

8.2.4 Matrix Spike Duplicate

A matrix spike duplicate is a third sample aliquot fortified with a known concentration of a target analyte(s). The spiked sample is processed through the entire analytical procedure. Analysis of the matrix spike duplicate is used as an additional indicator of sample matrix effect on the recovery of target analyte(s) as well as an indicator of method precision. The relative percent

difference (RPD) between matrix spike and matrix spike duplicate results uses both method-specified and empirically-derived control limits, depending on the analysis. Both the matrix spike duplicate recovery and RPD between matrix spike and matrix spike duplicate results should be within these control limits.

8.2.5 Laboratory Control Sample

A laboratory control sample is a sample of known analyte concentration(s) that is prepared in the lab from a separate source of analyte(s) relative to the calibration standards. Since the laboratory control sample analysis should follow the entire analytical process, it should be stored and prepared following the same procedures as a field sample. Analysis of a laboratory control sample is used as an indicator of method accuracy and long-term analytical precision. Both method-specified and empirically-derived control limits for the percent recovery of laboratory control samples are used, depending on the analysis. Laboratory control sample results should be within these control limits.

8.2.6 Laboratory Duplicate

A laboratory duplicate is a second aliquot of an analytical sample, processed concurrently and in an identical manner with the original sample. Analysis of the laboratory duplicate is used as an indicator of method precision and laboratory subsampling procedures. The laboratory duplicate can also be used to provide information regarding the homogeneity of the sample matrix. The relative percent difference (RPD) between sample and laboratory duplicate results uses both method-specified and empirically-derived control limits, depending on the analysis. Laboratory duplicate results should be within these control limits.

8.2.7 Laboratory QC Sample Control Limits

Tables 8-1 and 8-2 provide the types of laboratory QC samples that will be analyzed for each type of analysis, along with the respective control limits.

Table 8-1 Conventionals QC Samples and Control Limits

Analysis	Method Blank Result	Spike Blank Recovery	Matrix Spike Recovery	LCS Recovery	Lab Dup. RPD
Alkalinity	--	--	--	(reserved)	(reserved)
Cyanide	<MDL	80 – 120%	70 – 130%	73 – 127%	25%
Salinity	--	--	--	99.8 – 100.2%	0.05%

Table 8-2 Trace Metals QC Samples and Control Limits

Analysis	Method Blank Result	Spike Blank Recovery	Matrix Spike Recovery	MS/MSD RPD	Lab Dup. RPD
Mercury	<MDL	77 – 123%	71 – 125%	24%	--
Antimony	<MDL	85 – 115%	75 – 125%	20%	--
Arsenic	<MDL	58 – 110%	58 – 110%	20%	--
Cadmium	<MDL	64 – 105%	64 – 105%	20%	--
Chromium	<MDL	85 – 115%	75 – 125%	20%	--
Copper	<MDL	77 – 109%	75 – 125%	20%	--
Lead	<MDL	62 – 129%	62 – 129%	20%	--
Nickel	<MDL	26 – 147%	26 – 147%	20%	--
Silver	<MDL	30 – 151%	30 – 151%	20%	--
Zinc	<MDL	75 – 95%	75 – 125%	20%	--
Hardness by ICP	<MDL	85 – 115%	75 – 125%	--	20%

9 DATA VERIFICATION AND VALIDATION

Data verification and validation are critical in the evaluation of how well analytical and field data meet project DQOs. Data verification is performed, at some level, during several steps in the process of sample collection and analysis.

All laboratory analytical data and field measurements are entered into King County's Laboratory Information Management System (LIMS). Field data, such as *in situ* data measurements or recorded environmental observations, are peer reviewed prior to entry into LIMS. Laboratory analytical data are reviewed, first by the primary analyst and then by a senior peer reviewer, prior to entry of the data into LIMS. Analytical data are reviewed for completeness and QC sample data are viewed for compliance with project and method QA/QC requirements. If there are any QC failures at this point, corrective action may be taken or qualifier flags applied to the data.

The laboratory project manager (LPM) for the receiving water characterization study will provide the next data review step, at a "per-sampling-event" level. The LPM will verify the completeness of the data set and report any QA/QC failures or anomalies. Upon completion of all sampling and analysis, the project manager (study lead) will provide a final data validation process of all data to ensure that they meet the project DQOs. Data then will be reported in a variety of formats.

All laboratory analytical data and *in situ* field measurements are maintained *in perpetuity* on LIMS. Laboratory analytical data may be stored with data qualifier flags indicating QC failures. The flag "B" is used to indicate possible laboratory contamination of a sample and is applied when the parameter of interest is also detected in the laboratory method blank. Sample results that are less than five times the concentration detected in the method blank will be qualified with a "B" flag. The flag "J" is used to indicate that the sample result is an estimate (with unknown bias) due to one or more QC failures. A "JL" flag indicates possible high-biased data and a "JG" flag indicates possible low-biased data. A "JK" flag indicates unknown bias. The flag "H" is used to indicate an analytical holding time exceedence. The "SH" flag indicates that one or more sampling criteria/conditions were not met. Handling conditions may include an improper sample container or improper preservation of the sample.

Collection of CTD data at a rate of eight readings per second generates a very large data set for each sampling event and precludes inclusion of these data on LIMS. Some CTD data that have been averaged at discrete depths will be maintained on LIMS, however, the major portion of these data will be maintained in a separate web-accessible database.

Hard copy field notes, field instrument calibration records, raw analytical data, and any other hard copy project information will be stored according to standard King County Environmental Laboratory practices for a period of ten years.

10 DATA REPORTING

A final study report will be prepared and submitted to Ecology no later than June 30, 2013. The report will include the following elements:

- A study narrative. The narrative will include:
    1. A summary of sampling and analytical methodologies.
    2. Maps of sampling locations.
    3. An assessment of overall data quality.
    4. Summary tables of both existing data and new data generated during the study.
- Appendices that will provide complete hard-copy data reports for both existing data and new generated during the study.
- Appendices of data validation memoranda. Project data will be validated following guidance provided in *USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review* (EPA 2004).

All data will also be submitted at that time in electronic format, which will be compatible with Ecology's EIM database.

11 REFERENCES

APHA 1998. *Standard Methods for the Examination of Water and Wastewater, 20th Edition.* American Public Health Association. Washington, D.C.

ASTM 2002. *Standard Practice for Preparation of Water Samples Using Reductive Precipitation Technique for ICP-MS Analysis of Trace Metals (Method D6800)*. American Society of Testing and Materials. West Conshohocken, PA.

Ecology 2004. *Guidelines for Preparing Quality Assurance Project Plans for Environmental Studies*. Publication No. 04-03-030. Washington State Department of Ecology. Olympia, WA.

Ecology 2009a. *National Pollutant Discharge Elimination System Waste Discharge permit No. WA-002958-1*. Washington State Department of Ecology. Olympia, WA.

Ecology 2009b. *National Pollutant Discharge Elimination System Waste Discharge permit No. WA-002918-1*. Washington State Department of Ecology. Olympia, WA.

EPA 1994a. *Method 200.8 – Determination of Trace Elements in Waters and Wastes by Inductively Coupled Plasma – Mass Spectrometry (Revision 5.4 EMMC Version).* United States Environmental Protection Agency Office of Research and Development. Cincinnati, OH.

EPA 1994b. *Method 200.7 – Inductively Coupled Plasma – Atomic Emission Spectrometric Method for Trace Element Analysis of Water and Wastes (Revision 4.4).* United States Environmental Protection Agency Office of Water. Washington, DC.

EPA 1995. *Method 1669: Sampling Ambient Water for Trace Metals at EPA Water Quality Criteria Levels* EPA-R-95-034 (April 1995 Draft). United States Environmental Protection Agency Office of Water. Washington, DC.

EPA 1997. *Method 1640: Determination of Trace Elements in Water by Preconcentration and Inductively Coupled Plasma – Mass Spectrometry*. United States Environmental Protection Agency Office of Water. Washington, DC.

EPA 2000. *EPA Method 6010C from Test Methods for Evaluating Solid Waste*. *Laboratory Manual – Physical/Chemical Methods, SW-846, 3rd Edition, Update IIB.* United States Environmental Protection Agency, Office of Solid Waste and Emergency Response. Washington, D.C.

EPA 2002. *Method 1631, Revision E: Mercury in Water by Oxidation, Purge and Trap, and Cold Vapor Atomic Fluorescence Spectrometry*. United States Environmental Projection Agency Office of Water. Washington, DC.

EPA 2004. *USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review*. OSWER 9240.1-45, EPA 540-R-00-004. United States Environmental Protection Agency. Washington, D.C.

King County 2002. *Standard Operating Procedure for Salinity (SOP #316v3).* King County Environmental Laboratory. Seattle, WA.

King County 2003a. *Standard Operating Procedure for Preparation of Aqueous Samples for Analysis of Total and Dissolved Mercury by Automated Cold Vapor Atomic Fluorescence Spectrometry (SOP #605v0).* King County Environmental Laboratory. Seattle, WA

King County 2003b. *Standard Operating Procedure for Instrumental Analysis of Environmental Samples for Mercury Using Automated Cold Vapor Atomic Fluorescence Spectrometry (SOP #606v0).* King County Environmental Laboratory. Seattle, WA.

King County 2005a. *Standard Operating Procedure Fecal Coliforms in Environmental Water by Membrane Filtration (SOP #506v1).* King County Environmental Laboratory. Seattle, WA.
King County 2005b. *Standard Operating Procedure for Cyanide – Total, Weak Acid Dissociable, and Amenable to Chlorination (SOP #321v5).* King County Environmental Laboratory. Seattle, WA.

King County 2006. *Standard Operating Procedure for Trace Metals Section Labware and Equipment Cleaning Procedures (SOP #630v1).* King County Environmental Laboratory. Seattle, WA.

King County 2007. *Standard Operating Procedure for ICP Analysis of Waters, Sediments and Tissues for Trace Metals (SOP #612v4).* King County Environmental Laboratory. Seattle, WA.

King County 2008. *Standard Operating Procedure for Suspended Solids - Total, 0.45 μm, and Volatile (SOP #309v3).* King County Environmental Laboratory. Seattle, WA.

King County 2010. *Standard Operating Procedure for Determination of Trace Elements in Water by Preconcentration and Inductively Coupled Plasma – Mass Spectrometry (Draft SOP #643v1).* King County Environmental Laboratory. Seattle, WA.

APPENDIX A

Standard Operating Procedure for the SBE25 SeaLogger CTD

King County Environmental Laboratory SOP #220v3

STANDARD OPERATING PROCEDURE

for

SBE 25 SEALOGGER CTD

SOP # 220v3

Date of Implementation: February 28, 2005

Supersedes SOP: 02-02-011-002

Approved by:

Author: _____ Date: _____

Supervisor: _____ Date: _____

QA Officer: _____ Date: _____

King County Environmental Laboratory
322 W. Ewing Street
Seattle WA 98119-1507

Date approved: 11/22/2006
Revision number: 3
File name: Receiving Water QAPP - Appendix A (2).doc
SOP #: 220v3

1.0 SCOPE AND APPLICATION

This Standard Operating Procedure (SOP) describes the use of the Seabird SBE 25 CTD and LI-COR LI-1400 DataLogger, including maintenance, calibration, routine use, sample collection, quality control, instrument programming, data upload, reporting and review. This SOP applies to attended field operations. Two CTD configurations are possible; one using the CTD independently and the second incorporating the AFM (Auto-Fire Module) to simultaneously collect water quality samples. The CTD instrument and calibration is optimized for marine work but can be utilized in fresh water for physical water sample collection. Fresh water analysis using CTD sensors is not recommended for two reasons: (1) the conductivity probe is calibrated for high salinity water bodies and does not have the dynamic range to accurately measure fresh water conductivity levels and (2) the instrument is designed to move quickly through the water column which is not conducive for accurately measuring extreme thermoclines that often occur in fresh water bodies such as Lake Washington.

2.0 ASSOCIATED DOCUMENTS AND SOPS

2.1 KCEL Sampling Methods for Marine Water Column: 02-02-002-003
2.2 KCEL Sampling Methods for Water Column of Lakes: 02-02-003-001
2.3 KCEL C-14 Study Nutrient and Chlorophyll Sampling: 02-02-010-001
2.4 KCEL CTD File Handling Protocol (see appendix at the end of this SOP)
2.5 KCEL Oxygen, Dissolved -- Winkler Titration, Azide Modification : 03-03-007-002

3.0 METHOD SUMMARY

The *SBE 25 SEALOGGER CTD* (referred to as CTD) is a profiling system for lake, coastal, estuarine, and deep water work. In addition to monitoring conductivity, temperature, pressure, derived salinity, density, dissolved oxygen, chlorophyll, light intensity (PAR)and light transmission, the CTD also utilizes a carousel (rosette) of sample bottles capable of collecting up to 12-five liter samples. Additional sensors can be added to analyze more or different parameters. Individual probes for the parameters to be monitored are calibrated annually at the factory or, in the case of dissolved oxygen and light transmission, monthly based on laboratory Winkler dissolved oxygen results and transmissometer calibration. The LI-1400 DataLogger is a simple data collection instrument with a remote radiation sensor attached. For both instruments, data is collected electronically and uploaded to a PC. Sample data are downloaded to LIMS. Daily logbooks are kept, along with calibration and system maintenance records.

4.0 DEFINITIONS

4.1 Conductivity, Temperature, Depth Profiler (CTD): An instrument capable of profiling conductivity, temperature, and depth (pressure) throughout a water column.
4.2 Auto-Fire Module (AFM): The AFM allows Carousel operation without a conducting sea-cable by firing bottles at user programmed time intervals, or when used with SBE 25 CTDs, the AFM monitors CTD pressure data and fires bottles at user-programmed depths. The AFM also records bottle number, firing confirmation, and 5 scans of CTD data for each bottle fired.
4.3 Fluorometer: Optical instrument used for the detection of chlorophyll and other pigments that fluoresce in the selected wavelength range.
4.4 Light Intensity (see PAR): Measurement of solar energy in units of $\mu mol\ s^{-1}\ m^{-2}$.
4.5 PAR: Photosynthetically Active Radiation
4.6 Dissolved Oxygen (DO): The concentration of oxygen dissolved in water, expressed in mg/l or as percent saturation, where saturation is the maximum amount of oxygen that can theoretically be dissolved in water at a given altitude and temperature.
4.7 Temperature/Conductivity (TC) Duct: Plastic duct though which an exact amount of water is pumped at a constant rate in order to produce a consistent time delay between the temperature and conductivity sensors. This time delay can then be corrected when calculating water column parameters.
4.8 Bottle Data: The .afm file stores the exact time each bottle is tripped. Using the Seabird Data Processing Software, CTD data can be related and compared directly to the physical water collected.

4.9 RO Water: Reverse osmosis water (de-ionized water).
4.10 Nickel-Cadmium (Nicad) Battery: 12 volts at maximum charge; CTD shuts down at 7.4 volts. Alkaline Battery: 13.5 volts fresh.
4.11 Transmissometer: An instrument used in the measurement of light transmission though water in units of % transmission.
4.12 Density is calculated from in situ measurements of pressure, temperature, and conductivity using the equation of state for sea water. The units are defined as kg/m^3. (description and units)
4.13 Chlorophyll: The WETStar miniature fluorometer allows the user to measure relative chlorophyll by directly measuring the amount of fluorescence emission from a given sample of water. Specifically, it measures the fluorescence of chlorophyll-containing phytoplankton, which absorb light of wavelengths between 400 and 520 nm and emit light between 670 and 730 nm. The instrument is calibrated at the factory on an annual basis.

5.0 SAFETY AND HAZARDOUS MATERIALS MANAGEMENT

All sampling personnel will follow standard safety procedures while on board the sampling vessel. The vessel skipper has ultimate responsibility for safety while the vessel is underway. During deployment and retrieval of the CTD, the boom operator takes responsibility for safety on the back deck of the vessel. Sampling personnel are required to wear steel-toed footwear during deployment and retrieval of the CTD.

No hazardous materials are associated with this method of sample collection and *in-situ* analysis except for **Alkali-Iodide-Azide (AIA)-** AIA is a poisonous and caustic liquid reagent used for Winkler dissolved oxygen fixation. Contact with skin must be avoided. AIA must be stored in a well ventilated, dry, and cool area. Working reagents will be stored in a re-pipet dispenser. Always wear gloves and safety glasses when working with AIA.

6.0 SAMPLE CONTAINERS, PRESERVATION AND STORAGE

See appropriate method SOPs if water quality samples are to be collected and analyzed.

7.0 APPARATUS, EQUIPMENT, AND CONSUMABLES

7.1 Seabird SBE 25 Sealogger CTD
7.2 Seabird SBE 32 Carousel Water Sampler
7.3 Seabird Auto-Fire Module
7.4 Seabird SBE 29 Pressure Sensor
7.5 Seabird SBE 3 Temperature Sensor
7.6 Seabird SBE 4 Conductivity Sensor
7.7 Seabird SBE 5T Pump
7.8 Seabird SBE 43 Dissolved Oxygen Sensor
7.9 WETlabs WETStar Chlorophyll Fluorometer
7.10 WETlabs Seastar Transmissometer
7.11 LI-COR Light Intensity (PAR), LI-193-SA
7.12 LI-COR Surface Light Intensity (PAR), LI-190-SA-50
7.13 LI-COR LI-1400 Data Logger
7.14 Laptop computer with Microsoft Windows
7.15 Seabird SeaTermAF, Seasave-Win32, and SBE Data Processing-Win32 software
7.16 Replacement Ni-Cad Battery (PN 80256)
7.17 Deck crane with meter wheel
7.18 100 ml syringe with tube

8.0 PROCEDURE

8.1 CTD with AFM and Rosette

8.1.1 Prior to the first cast of the Day

Disconnect the dummy plug on the AFM bulkhead connector and insert the 10 meter four pin data I/O cable (801616). Connect the opposite end of the I/O cable to the 9 pin serial port on the PC. In Windows, open SeaTermAF Click on the Connect CTD Button. An S> prompt should appear. Note the connection is using a baud rate of 4800.Type st and press Enter. This will prompt you for the correct time. Type in the time using the following format; e.g. 134325 is 1:34:25 pm. Press Enter and type the date; e.g. 091006 is September 10, 2006. Press Enter. Click on the Status button. The important things to look for are the vmain (the nicad battery stops working below 7.4 volts), the vlith (this should be >5 and can be replaced only by the factory), the minimum frequency for pump turn on (3500 for salt water, 2000 for fresh water), and the correct time and date. If the main battery voltage is low, replace with either a freshly charged nicad battery or new alkaline batteries (use cc if changing battery types). If the minimum frequency for pump turn on is incorrect, use the cc command to adjust to the correct setting. The date and time should be calibrated between the AFM, CTD, and Li-Cor based on the atomic clock in the calibration room. Each of the instruments should be within one second. Switch to the AFM by clicking on the Connect AFM button. Type st as above to correct the AFM time.

8.1.2 Programming CTD

In Sea-TermAF, click on the Connect CTD button. If the minimum frequency to turn pump on is incorrect, adjust it according to 8.1.1. At the S> prompt, type il to initialize logging. Click on the Init Log button. This changes the ncast to 0 and prepares the instrument for the upcoming cast. Wait for about 5 seconds until a message box confirms the CTD is ready to go. . .

8.1.3 Programming AFM

Click on Connect AFM and the A> prompt should appear. Click on the Configure Menu and then AFM with SBE 25. Make sure the current CTD instrument configuration (.con) file is being used. Monthly, a new configuration file is created following calibration. Real time baud rate is always 4800 and radio button is either on **Close on upcast** or **Close on elapsed time, record CTD Data**. Use the latter setting only for very shallow stations that require multiple bottles tripped at the same depth.

8.1.3.1 Close on Upcast

8.1.3.1.1 Option one is to close the first bottle at the bottom of the cast after it has been sitting stationary for one minute. Check the **Bottom bottle closure enabled** box, set **Pressure to Enable Upcast** to 0.5xdepth. Pressure Change to Enable upcast is 2, Stationary time on Bottom is 1 minute and Bottom Pressure Window is 3. Click on the Bottle Closure Pressures/Times tab and select the Number of Bottles to Close and type the closure pressures.

8.1.3.1.2 Option two is to close the bottom bottle with no wait at the end of the downcast. Uncheck the Bottom bottle closure enabled box, set Pressure to Enable Upcast to (0.5 x depth). Pressure Change to Enable upcast is 2. Click on the Bottle Closure Pressures/Times tab and select the Number of Bottles to Close and type the closure pressures.

8.1.3.2 Close on Elapsed Time

Set the Number of bottles using the drop down box, then Bottle Closure Times to allow for time to deploy the CTD and become stationary for each bottle/depth. For very shallow sampling, allow for 3 minutes of CTD equilibration and one minute of casting prior to the first sample. Samples only need to be separated by 0.1 minutes if conducting freps or multiple bottles at one depth. Note that if you use this method, the elapsed time begins when you click the Arm button!

Click on the OK button. Click on the Program Button. Be patient-this takes about 20 seconds to complete. Click on the Arm Button.

8.1.4 Deployment

Cock all bottles on the carousel, tighten all air valves and close each Niskin's spigot. Communicate with the vessel's skipper to determine if deployment is OK. Detach the computer cable from the AFM and attach the dummy plug. Make sure the connection is good and that all air has been "burped out". See section 13 for info on rinsing the TC Duct. Tighten the plastic fitting. Remove the rinsing syringe and slowly slide the CTD on/off switch to the on position. Using the deck crane and a swivel shackle, lift the unit out of the vessel and place in the water so the top of the CTD package is slightly under water.. Adjust the meter wheel. Make sure the elapsed time between switching the unit on and placing it in the water is less than two minutes. After a total of five minutes from the time the switch was

turned on, begin the descent at 0.5 meters per second for the first 20 meters and then 1.5 meters per second below that. (slower rates will produce better data). If necessary, Stop the descent at the proper depth and wait for the period indicated in the Time to Hold Stationary at Bottom setting, otherwise instantly begin the upcast after the proper depth has been achieved. On the upcast, ascend at 1.5 meters per second until the top 20 meters where you slow down to less than 0.5 m/s. .Once the CTD is in sight, inform the skipper and place the CTD on the deck. Immediately turn the on/off switch to off and rinse the TC duct, temperature probe, conductivity cell, DO probe, fluorometer and transmissometer with 10-100 mL of RO water.

8.1.5 Filling Sample Bottles

Following the CTD retrieval, water collected in each Niskin bottle is to be transferred to individual sample bottles as soon as possible. The order of bottle filling should be described in each Sampling and Analysis Plan or Sampling Procedure SOP. Prior to the next cast, the bottles must be cocked and the air vents and spouts closed.

8.1.6 Data Upload

Remove the dummy plug on the AFM bulkhead connector and connect the 10-meter four-pin data I/O cable with the blue label. In the SeaTermAF software, click on the Connect CTD button. Click on the status button to verify there is only one cast. If it is greater than 1, note that value minus one for the cast number and record this in the log book. Click on the Upload button. Note the ncasts value. It should be 1. If not, use that value minus one for the cast number. Type in the cast number (usually 0) and press OK. A header prompt will occur and the following information must be entered:
Ship:
Project:
Station:
Operator:
Comments: - leave this field blank under all circumstances.
Click on OK and a Save As box will display. Enter the cast ID and select the proper directory for the file. Click Save and the file will download. Following the hex file download, click on the Connect AFM button. Click on OK. Click on the Upload button and fill in the header information (again). Click on OK and a Save As box will display. Enter the cast ID (same as hex file name) and select the proper directory for the file. Click Save and the file will download.

8.1.7 Data Evaluation

After each cast, two evaluations are to be completed; a display of the sensors to evaluate data quality and sample bottle depth data should be checked before moving on to a new cast site.

8.1.7.1 Reviewing the Cast Profile

Open the program entitled “Seasave-Win32”. Click on Screen Display and Edit Selected Display Window. Click on Select Display (.DSO) File and select the proper file (salt.dso or fresh.dso). Click on OK.

Click on Modify Display Parameters and enter the proper maximum depth and modify any other parameters that may be appropriate. Click on OK but don’t save the settings since they will remain the same until you close the program.

Click on Archived Data and No Wait. Click on Archived Data and Start. Select the appropriate data (.dat) and instrument configuration (.con) files. Click on the green Start Display button. The cast should be displayed and the operator can evaluate the data quality based on the results. This evaluation is based on experience and an understanding of historical data. The operator should look for signs of instrument anomalies such as spikes, drifts, unexpected noise and significant differences between the downcast and upcast. Also, operators should be familiar with the symptoms of a plugged air vent, hitting the bottom and plugging the TC duct and when a hose becomes detached, stopping the controlled flow of water past the sensors. If any of these problems should be identified, the cast should be discarded and done over.

8.1.7.2 Sample Bottle Depth Data Processing

After the upload, please follow these steps to determine if the Niskins tripped at the proper depth:

On the desktop in Windows, open SBE Data Processing-Win32. Under Run, open Data Conversion. Open the Program setup file DatCnv.psa Select the proper configuration file. Select the input file (the cast that was just previously uploaded with the .hex extension). The output directory should be the

same as the input directory. Output file should be the same as the input files, but without an extension. Click on Start Process. Following processing, click Cancel.

Open Bottle Summary. Open the Program setup file BottleSum.psa.
Select the input file (the .ros file that was created during Data Conversion). Make sure the output directory is the same as the input directory. Name append should be blank. The Output file should be the same as the input files, but with a .btl extension. Click on Start Process and once the program has completed, click on Exit. Close SBE Data Processing.

Open Microsoft Excel and open the appropriate .btl file that was just created. Click Next. Select Space Delimiters (Tab is already selected). Click on finish, then scroll down and look at cell F49, F53, F57, F61, F65, F69, F73, etc to compare the actual sampled depth to the target depth. See section 9.6 for acceptance criteria. Corrective action would include qualifying data in LIMS and filling out a Data Anomaly Form. The DAF is electronically entered into LIMS.

8.1.8 Data Reduction
See section 10.1

8.2 CTD without AFM

8.2.1 Prior to the first cast of the Day
Remove the dummy plug on the AFM bulkhead connector and connect the 10 meter four pin data I/O cable (801616). Connect the opposite end of the I/O cable to the 9 pin serial port on the PC. In Windows, open Open TermAF Click on the Connect CTD Button. An S> prompt should appear. Note the connection is using a baud rate of 4800. Type st and press Enter. This will prompt you for the correct time. Type in the time using the following format; e.g. 134325 is 1:34:25 pm. Press Enter and type the date; e.g. 091006 is September 10, 2006. Press Enter. Click on the Status button. The important things to look for are the vmain (the nicad battery stops working below 7.4 volts), the vlith (this should be >5 and can be replaced only by the factory), the minimum frequency for pump turn on (3500 for salt water, 2000 for fresh water), and the correct time and date. If the main battery voltage is low, replace with either a freshly charged nicad battery or new alkaline batteries (use cc if changing battery types). If the minimum frequency for pump turn on is incorrect, use the cc command to adjust to the correct setting).

8.2.2 Programming CTD
In TermAF, click on the Connect CTD button. If the minimum frequency to turn pump on is incorrect, adjust it according to 8.2.1. At the S> prompt, type il to initialize logging. Click on the Init Log button. This changes the ncast to 0 and prepares the instrument for the upcoming cast. Wait for about 5 seconds until a message box confirms the CTD is ready to go. . .

8.2.3 Deployment
Communicate with the vessel's skipper to determine if deployment is OK. Detach the computer cable from the CTD and attach the dummy plug. Make sure the connection is good and that all air has been "burped out". Tighten the plastic fitting. Remove the rinsing syringe and slowly slide the CTD on/off switch to the on position. Using the deck crane and a swivel shackle, lift the unit out of the vessel and place in the water so the top of the CTD package is slightly under water.. Adjust the meter wheel. Make sure the elapsed time between switching the unit on and placing it in the water is less than two minutes. After a total of five minutes from the time the switch was turned on, begin the descent at 0.5 meters per second for the first 20 meters and then 1.5 meters per second below that. (slower rates will produce better data). If necessary, Stop the descent at the proper depth and wait for the period indicated in the Time to Hold Stationary at Bottom setting, otherwise instantly begin the upcast after the proper depth has been achieved. On the upcast, ascend at 1.5 meters per second until the top 20 meters where you slow down to less than 0.5 m/s. .Once the CTD is in sight, inform the skipper and place the CTD on the deck. Immediately turn the on/off switch to off and rinse the TC duct, temperature probe, conductivity cell, DO probe, fluorometer and transmissometer with RO water.

8.2.4 Data Upload
Remove the dummy plug on the CTD bulkhead connector and connect the 10-meter four-pin data I/O cable with the blue label. In the SeaTermAF software, click on the Connect CTD button. Click on the status button to verify there is only one cast. If it is greater than 1, note that value minus one for the

cast number and record this in the log book. Click on the Upload button. Note the ncasts value. It should be 1. If not, use that value minus one for the cast number. Type in the cast number (usually 0) and press OK. A header prompt will occur and the following information must be entered:
Ship:
Project:
Station:
Operator:
Comments: - leave this field blank under all circumstances.
Click on OK and a Save As box will display. Enter the cast ID and select the proper directory for the file. Click Save and the file will download.

8.2.5 Reviewing the Cast Profile

Open the program entitled "Seasave-Win32". Click on Screen Display and Edit Selected Display Window. Click on Select Display (.DSO) File and select the proper file (salt.dso or fresh.dso). Click on OK.
Click on Modify Display Parameters and enter the proper maximum depth and modify any other parameters that may be appropriate. Click on OK but don't save the settings since they will remain the same until you close the program.
Click on Archived Data and No Wait. Click on Archived Data and Start. Select the appropriate data (.dat) and instrument configuration (.con) files. Click on the green Start Display button. The cast should be displayed and the operator can evaluate the data quality based on the results. This evaluation is based on experience and an understanding of historical data. The operator should look for signs of instrument anomalies such as spikes, drifts, unexpected noise and significant differences between the downcast and upcast. Also, operators should be familiar with the symptoms of a plugged air vent, hitting the bottom and plugging the TC duct and when a hose becomes betached, stopping the controlled flow of water past the sensors. If any of these problems should be identified, the cast should be discarded and done over..

8.2.6 Data Reduction

See section 10.1

8.3DataLogger (Surface Light Intensity)

8.3.1Preparation for Deployment: Programming the LI-1400

Connect the sensor to the BNC setting I1. Press the On/Off button. Press the Fct button. Arrow to the right until Clear Memory appears. Press Enter. Arrow down until the display reads !Clear Mem ?NO!. Arrow right and the NO will change to YES. Press Enter and the memory will clear.
Press the Setup button and the arrow right button until SETUP LOGGING is on the screen. Press Enter. Arrow down until the cursor is on LR1. Press Enter. Type in the start time in military time and press Enter. Arrow down and type the Stop Time. Press Enter. Arrow down and type in the Smpl Per= and arrow to the right or left to choose different sampling times. Currently we are using 1 second. Arrow down to Log Per= and arrow to the right or left to choose different logging times. We are currently using 30 seconds. Press Esc. Arrow up until the cursor is under Logging=Off. Press the right arrow button for Logging=On. Monitor the new data by pressing the View button and arrowing to the right or left to choose VIEW NEW DATA. Press Enter and current Light Intensity data will appear on the screen. If sampling for more than 15 minutes, the display will turn off automatically, but logging will continue until the sampling period is over. The instrument uses an AC adapter and four alkaline "AA" batteries with a life of approximately 50 hours for backup.

8.3.2 Licor Data Upload

The LI-1400 utilizes a Microsoft Windows software package. Connect the LI-1400's RS-232 port to the PC's COM1 port using a 9 pin serial cable. Open the LI-1400 software package. Open the Liberty.I14 file and click on Remote, Connect. Select Channels I1, click on Remote, then Receive data. Select the 'all' button and click on OK. Type file name (using the following format: YYMMDDpar.txt, where YY is year, MM is month and DD is date) and press Enter. At this point, the logged data will upload to the PC. When it is finished, close the LI-1400 software and open the text file with Microsoft Excel.

9.0 QA/QC REQUIREMENTS

9.1 Calibration

Calibration of the Thermometer, Conductivity, and Dissolved Oxygen sensors will be calibrated at Seabird on an annual basis. The SBE-43 Dissolved Oxygen sensor is post-calibrated using comparisons to Winkler DO samples. The C-Star Transmissometer is also post-calibrated in the lab.. This is done post-cruise for two reasons. One is to determine if the instrument has drifted since the last calibration and secondly, there is no other way to determine if the results are within a reasonable range since there are no conventional chemistry tests or field tests that can be done for evaluation. There are no standards to do a "check", so post-cruise calibrations are the most efficient and sensible method. The PAR sensors are sent to Li-Cor on a bi-annual basis while the C-Star Transmissometer and the Wetstar Fluorometer are sent to Wetlabs annually. The depth sensor is maintained and calibrated by Seabird every 5 years based on their recommendation.

9.1.1 SBE 43 Post-Cruise Calibration for Dissolved Oxygen

9.1.1.1 Initial DO evaluation: Using the method in section 8.1.7.2, process CTD bottle data using the LIMS datcnv.psa file and the previous month's configuration file to calculate the pre-cal CTD dissolved oxygen values. Note these values on a copy of the Conventional Chemistry Unit's Winkler analysis form for the associated samples. This will give the operator a general idea of how much the instrument has drifted since the last calibration and the general quality of the data. There are no acceptance windows, but if the differences between the Winklers and the CTD DO are greater than 1 mg/L, the instrument should be sent in for repair.

9.1.1.2 Seabird 64-2 Regression: Reprocess the CTD bottle data using datcnv cal 43.psa and the previous month's configuration file to obtain the following data: Pressure (db), Temperature (deg. C), Salinity (PSS), Oxygen Saturation (ml/l) and SBE 43 Output Voltage. Enter these values into the SBE43 DO Calibration Template (taken from Seabird's Application Note 64-2 Regression), along with the Conventional Chemistry Unit's Winkler values to calculate new SOC and Voffset values. Do not use the FREP samples in the SOC and BOC calculation. These samples will be used to evaluate the quality of the Winkler vs. CTD data.

9.1.1.3 Updating the configuration file: Enter the new SOC and Voffset values into a new configuration file with appropriate nomenclature. This configuration file is now ready to be used to reprocess the new LIMS Bottle data and the CTD database data.

9.1.1.4 Compare the final calculated Bottle Data DO values to the Winkler values for a final quality evaluation. Control windows have not been set for qualification.

9.1.2 C-Star Post-Cruise Calibration for Light Transmission

Using the C-Star Calibration Sheet, calibrate the C-Star by monitoring voltages with no blockage followed by complete blockage. This is done by first cleaning the lenses with RO water and alcohol using Kim Wipes. Disconnect the AFM-CTD cable and insert the 10 meter four pin data I/O cable (801616). Connect the opposite end of the I/O cable to the 9 pin serial port on the PC. Open TermAF, click on the Connect CTD button. Change the minimum frequency to turn pump on to 3500 using the method in 8.2.1. Following this, at the S> prompt type il to initialize logging. Click on the Init Log button. This changes the ncast to 0 and prepares the instrument for the upcoming cast. Wait for about 5 seconds until a message box confirms the CTD is ready to go. Open Seasave-Win32. Open the C-StarTransmissometer Seasave Configuration. Click on RealTimeData and Start Acquisition. Select the previous month's configuration file and uncheck Store on Disk. Make sure the COMM port configuration settings are COM1 and baud rate of 4800. Click on Start Acquire and begin monitoring the voltages. After approximately 200 scans or when the Light Transmission values become stable begin reporting the following: Scan #, CTD Temp, Volt 1, and Light %. Completely block the light pathway and record the values as "Blocked" on the calibration sheet. Compute the M and B values and enter them into the new CTD configuration file.

9.2 Replicate Measurements

Replicate sensor readings will be reported to LIMS once per cruise. . Both the original and replicate samples are true samples and loaded to LIMS. In order to calculate RPD values, QC replicate samples

are created in LIMS using the FREP locator and linked back to the original sample. See the table below for acceptable limits.

Parameter	DO, Field	Sal, Field	Samp Depth	Sample Temp	Light Transmission, Field
Acceptance Limits	20 % RPD	0.3 PSS	1 or 4 meters	0.3 deg C	20 % RPD

9.3 Split Samples and Field Replicates
For marine projects, Salinity and Dissolved Oxygen measurements will be analyzed synoptically using water samples in the Conventionals Unit. The frequency will be a minimum of 1 per cast to facilitate the dissolved oxygen post-cruise calibration. The acceptance range for field dissolved oxygen versus Winkler DO is 20% RPD. For salinity, the acceptance range is 0.3 PSS. Field replicates are analyzed at a minimum frequency of 1 per 20 samples or once per day, whichever is more frequent.

9.4 Method Blanks
Method Blanks are not appropriate for CTD analysis.

9.5 Continuing Calibration Verification
CCV's are not appropriate for CTD analysis.

9.6 Depth Comparison
Following the Bottle Summary calculations, each bottle trip will be compared with the intended sample depths. For samples less than 100 meters, the intended depth and the CTD depth should be within 1 meter. For depths greater than 100 meters, the difference should be no greater than 4 meters.

10.0 DATA REDUCTION, REPORTING, REVIEW AND DOCUMENTATION

10.1 LIMS

10.1.1 Data Entry to LIMS
After all post-calibration work and creation of a workgroup with the appropriate sample numbers and products, follow the steps in 8.1.7.2 to create the necessary .btl files required to extract the LIMS data. Open Excel, Click on EnvLab then ESS Data Entry. Click on the CTD Data option button then Open Data. Find the .btl file, select it and click OK. The macro will run and a pop-up window will ask you to Enter Sample Numbers, Surface PAR data, and then press Load to LIMS button. Click on OK. Complete these tasks and other necessary editing. Click on the Post to LIMS button. It will then ask you if you are ready to post and say Yes. The data will automatically be transferred to LIMS. Note that the values for all LIMS parameters, including sample depth, will be averaged for three seconds during the bottle trip period. Field replicates will then need to be created in Workstat and those data will be entered into LIMS electronically.

10.1.2 LIMS Data Review
Seedpak3 reports are to be reviewed against the *.xls rossum files for accuracy. Following this, the data is approved and moved to EDS. Once all the laboratory analyses have been completed, an EDS report is created to compare the CTD data versus the laboratory data.

10.1.3 Documentation and Data Reporting
Seedpak3 reports, *.txt transfer files, *.xls rossum files, post-cruise calibration records and lab data comparisons are to be filed as a hard copy report. All electronic files are stored and backed up on a daily basis. Instrument calibration records done by the manufacturer, including sensor serial numbers and inclusive dates, are stored in a logbook and updated when applicable.

10.1.4 LIMS Table

Product	Parameter	Listtype	Units	MDL	RDL	Sigfig MDL	Sigfig RDL
SAMP DEPTH	Sample Depth	ESS-CTD	m	n/a	n/a	2	3
SAMP TEMP	Sample Temperature, Field	ESS-CTD	Deg. C	n/a	n/a	*	*
DO, FIELD	Dissolved Oxygen, Field	ESS-CTD	mg/L	0.5	1.0	2	3

SAL, FIELD	Salinity, Field	ESS-CTD	PSS	n/a	n/a	5	5
DENSITY, FIELD	Density, Field	ESS-CTD	kg/m^3	n/a	n/a	7	7
CHLA, FIELD	Chlorophyll	ESS-CTD	ug/L	0.06	0.12	2	3
LIGHT TRANSMISSION	Light Transmission	ESS-CTD	% light	0.01	0.01	2	3
PAR, FIELD	Light Intensity (PAR), Field	ESS-CTD	$umol/sm^2$	n/a	n/a	*	n/a
PAR, SURF, FIELD	Surface Light Intensity (PAR), Field	ESS-FM	$umol/sm^2$	n/a	n/a	*	*

*= Round to 0.1

10.2 Full Cast File Handling

Follow the instructions in the CTD File Handling Protocol (2.5). Completed data files are reviewed, qualified and loaded to the CTD database.

11.0 STANDARDS AND REAGENTS

11.1 Triton X100 cleansing solution: Add 10 ml of solution to 1 liter of RO water. Prepare fresh monthly. Use this reagent very sparingly and rinse extremely thoroughly with RO water following the use. It can foul the dissolved oxygen membrane.

11.2 RO Water: Reverse-osmosis water produced at the laboratory and retrieved from an RO water tap. This reagent can be disposed of down the drain or overboard. ASTM Type I or equivalent. It is stored in a 2 liter HDPE bottle and replaced monthly.

11.3 **Alkali-Iodide-Azide (AIA)-** AIA is a poisonous and caustic reagent used for Winkler dissolved oxygen fixation. Contact with skin must be avoided. AIA must stored in a well ventilated, dry, and cool area. Working reagents will be stored in a re-pipet dispenser. Always wear gloves and goggles when working with AIA. AIA is purchased by the Conventional Chemistry Unit and dispensed by a small re-pipet dispenser on the Liberty.

11.4 **Manganous Sulfate (MnS04). A reagent used for Winkler dissolved oxygen fixation. Avoid contact with skin. Store in a well ventilated, dry and cool area in a re-pipet dispenser. Always wear gloves and safety glasses when working with MnSO4. MnSO4 is purchased by the Conventional Chemistry Unit and dispensed by a small re-pipet dispenser on the Liberty.**

12.0 CONTAMINATION

Oil and grease can coat sensors and hoses and can destroy the on-line pump. Airborne contaminants can affect conductivity results if allowed to enter and dry in cell. Any material capable of fluorescing at or near 676 nm can affect the chlorophyll analysis. In addition, high turbidity may create a high bias with respect to chlorophyll values. Particles caught in the inverted ‘Y’ fitting can stop air from exiting, thus not allowing the pump to prime or causing poor readings throughout the instrument. Dirty transmissometer lenses can reduce light transmission values.

13.0 PREVENTATIVE MAINTENANCE

The TC duct, temperature probe, conductivity cell, DO probe, and fluorometer must be rinsed with RO water prior to and immediately following each cast. Rinse with a full 60cc syringe and a connecting tube (7/16” Tygon) on the end of the TC duct. All other parts of the CTD and carousel must be rinsed thoroughly with fresh water following each cruise. Store the CTD with the conductivity cell full of RO water between cruises. Use a 1% TritonX soution to clean the sensors if oil or grease has been encountered. Rinse thoroughly with RO water following the Triton cleaning. Use a dilute sodium hypochlorite solution (1% bleach) to kill biological growth if absolutely necessary. Rinse immediately with RO water (5 minutes minimum) following the bleach cleaning.

For storage, The DO cell should remain free of water, but the high humidity from the RO water in the conductivity cell will keep the DO sensor fresh.

The DO sensor membrane should be replaced at least every year by Seabird. Clean the transmissometer lenses with alcohol, RO water and Kim Wipes before and after each cruise.

Maintenance must be recorded in the maintenance logbook.

14.0 TRAINING

New analysts must successfully perform maintenance, field measurements and data reduction/review under the direct supervision of an experienced analyst following review of this document.

15.0 REFERENCES

SBE 25 Sealogger CTD Operating Manual
CTD Data Acquisition software: Seasoft
Model LI-1400 Datalogger Instruction Manual
Li-Cor Surface PAR Data Acquisition software: LI-1400.

16.0 APPENDIX

King County Environmental Lab CTD File Handling Protocol

Datcnv
- Process scans until end of file
- Scans to skip over = 1100
- Use ascii output
- Convert Data from Upcast and Downcast
- Create converted (.CNV) file only
- Output Variables (in this order) = scan count, pressure (strain gauge db), depth (salt water,meters), temperature ITS-90, conductivity (S/m), oxygen voltage (SBE 43), PAR/irradiance biospheric Licor, Fluroescence (wetlab wetstar mg/m3), Beam Transmission (Chelsea/Seatech/Wetlab).
- Do not output water bottle data, this will be done by the environmental laboratory and stored on LIMS for later retrieval.
- Creates a file with the same name and a .cnv file extension.

Alignctd
Advance Values
- Primary Conductivity alignment = 0.11 seconds
- Oxygen alignment = 2.0 seconds
- Fluorescence alignment = 4.0 seconds
- Everything else = 0
- Overwrite .cnv file

Cell Thermal Mass
- Alpha = 0.04
- 1/beta = 8.0
- Corrects for cell thermal mass
- Overwrite .cnv file

Derive
- Variables to be Derived = salinity, oxygen mg/L, potential temperature, density kg/m3, sigma-theta, descent rate.
- Variable Coefficients (oxygen, descent rate) = 2 seconds (for both coefficients)
- Overwrite .cnv file

Binavg
- Arrange into depth bins, no interpolation
- Bins are 0.5 meters in size
- Include number of scans per bin in output file
- Exclude bad scans (marked with Loopedit)
- Skip 0 scans
- Process upcast and downcast
- Don’t include surface bin
- Overwrite new .cnv file

APPENDIX B

Standard Operating Procedure for Clean Sampling for Ultra Low Trace Metals using Modified Niskin Bottles

King County Environmental Laboratory SOP #221v2

STANDARD OPERATING PROCEDURE

for

Clean Sampling for Ultra Low Trace Metals using Modified Niskin Bottles

SOP #221v2

Implemented: December, 2004

Supersedes SOP: #02-02-12-001

Approved by:

Author: _____ **Date:** _____

Supervisor: _____ **Date:** _____

QA Officer: _____ **Date:** _____

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1. Scope and Application

This standard operating procedure (SOP) applies specifically to the collection of marine and fresh water samples for analysis of ultra low trace metals in the range of ng/L (parts per trillion). The purpose of this SOP is to describe the method of collecting ultra low

level metals at depths up to 250 meters. This method is not intended for the collection of samples found at industrial facilities or in areas of known high metals concentrations. Sampling at depths less than 20 meters may be done more efficiently using the peristaltic pumping procedure, SOP #02-02-005-002 or by collection of surface grabs, SOP #02-02-013-001. For further information regarding historical trace metals collection methods, contamination sources and control, or other ultra-trace metals issues, refer to section 15: References.

2. Associated Documents and SOPs

2.1 Reductive Precipitation Preparation of Seawater Samples (06-03-006-000)
2.2 Equipment Cleaning For Clean Sampling of Ultra Trace Metals Utilizing the Niskin-X (06-05-005-000)
2.3 Clean Sampling for Ultra Low Trace Metals by Peristaltic Pump (SOP #02-02-005-002)
2.4 Sampling Methods for Marine Water Column (02-02-003)
2.5 Trace Metal Unit's Labware and Equipment Cleaning Procedures (SOP #06-05-002-000.

3. Method Summary

Prior to the sampling event, all sampling equipment and containers are cleaned according to the SOP titled "Equipment Cleaning for Clean Sampling of Ultra Trace Metals using the Niskin-X (SOP#06-05-005-000). The sampling procedure will utilize the "clean hands/dirty hands" technique. Prior to arrival at the sampling site, members of the sampling team will be designated as "clean hands", "dirty hands", and "crane operator". "Clean hands" handles all operations involving contact with the sample bottle and transfer of the sample from the sample collection device to the sample bottle. "Dirty hands" is responsible for preparation of the sampling device (except the sample container itself) and for all other activities that do not involve direct contact with the sample. "Crane operator" is responsible for setup and operation of the clean winch system, along with backup dirty-hands responsibilities.

All equipment is non-metallic and sampling staff will always wear non-powder, PVC gloves. Prior to leaving the laboratory, a pre-deployment equipment blank is collected from one Niskin. All sample containers are double-bagged, Niskin bottles are single-bagged and they are all placed on the research vessel.

Samples are collected using Niskin-X bottles attached to a synthetic hydroline. A specialized winch system mounted on the rear deck of the vessel controls the hydroline. The skipper maneuvers the vessel in a manner that allows the hydroline to remain upwind and upcurrent. The Niskin-X bottles are attached to the hydroline and lowered to the correct depth. A teflon-coated messenger is sent down the hydroline to trip the bottles. The Niskin-X bottles are then brought up and placed in a special plastic rack, where the samples are dispensed into sample containers. Finally, sample containers are double-bagged and placed on ice for transport to the laboratory.

4. Definitions

4.1 **Ambient Water:** Waters in the natural environment (e.g., rivers, lakes, streams, Puget Sound).

4.2 **Apparatus:** The sample containers, sampling devices, instrumentation, and all other materials and devices used in sample collection. (See 7.5). All original o-rings are replaces with Viton o-rings.

4.3 **Clean Winch System:** This is a custom built system for low level metals sampling. It consists of a plastic box that contains an enclosed hydraulic motor that runs a Teflon drum. The drum contains 1000 feet of synthetic hydroline and utilizes an electronic line-measuring device. The system is bolted to the deck and can be removed for cleaning.

4.4 **Niskin-X Bottle: (Sample Collection Device):** A specialized sampling bottle designed to collect water samples for low-level metals at discrete depths. These bottles have been modified using Teflon coating on the inside of the bottle and plastic/silicon coating over exposed metal on the outside.

4.5 **Sample Container:** HDPE or Teflon Bottles used to collect the sample from the Niskin-X for transport and storage at the lab.

4.6 **Ultra Low Trace Metals Samples:** Samples that will be analyzed for metals in the ng/L (parts per trillion) range. These include the following LIMS products: HG-CVAF-UL, HG-CVAF-UL, DISS and all ICPMS products using the Reductive Precipitation preparation methodology.

4.7 **Atmosphere blank:** A sample of analyte-free water in a lab-supplied container which is left uncapped during sampling. The analysis of the atmosphere blank is used measure possible contamination from airborne sources.

4.8 **Carboy Blank:** Reagent water that is used for the Field Blank is sampled to evaluate contamination by the reagent water from the carboy. This sample is collected from the carboy just prior to the Field Blank.

4.9 **Pre-deployment Equipment Blank:** A sample of analyte-free water that has been processed through the sampling equipment **in the laboratory** after prescribed decontamination. The collection of the equipment blank should follow the same techniques used to collect field samples (i.e. Clean Hands / Dirty Hands). The equipment blank may be analyzed for any or all of the analytes for which the samples are being analyzed. Analysis of the equipment blank is used to measure and document the possible contamination by sampling equipment and the effectiveness of decontamination. An acceptable equipment blank should be achieved before sampling devices are used for sample collection.

4.10 **Field Blank**: A field blank is a sample of analyte-free water that is supplied by the laboratory, shipped to the field, and treated as a sample in all respects including contact with the sampling device following field decontamination. The field blank may be analyzed for any or all of the analytes for which the samples are being analyzed. Analysis of the field blank is used to measure and

document any sample contamination resulting from transport, exposure to the atmosphere or contact with the sampling device at the sampling location.

4.11 **Reagent Water:** Reverse-Osmosis water collected from the Trace Metals Clean Room and demonstrated to be free from (or as low as possible) the metals of interest and potentially interfering substances. This water is equivalent to ASTM Type I water (ASTM D 1193).

4.12 **Field Replicate:** A field replicate sample consists of a second sample collected at a sampling location using the exact collection methodology as was used to obtain the first sample and as soon after the original sample as possible. The field replicate sample is generally analyzed for all the analytes for which the sample was analyzed. Analysis of the field replicate sample is used to measure and document the precision of field sampling methodologies and the homogeneity of the sample site.

5. Safety and Hazardous Materials Management

All sampling personnel will follow standard safety procedures while on board the sampling vessel. The vessel skipper has ultimate responsibility for safety while the vessel is underway. During operation of the sampling device, the crane operator has ultimate responsibility for safety on the back deck of the vessel. Sampling personnel are required to wear steel-toed footwear and hard hats during operation of the sampling device. Recommended equipment includes foul-weather gear and eye protection.

6. Sample Containers, Preservation, and Storage

6.1 One set of double polypropylene-bagged, acid washed and pre-labeled HDPE 500 ml bottles with lids for ICPMS using reductive precipitation preparation technique..

6.2 One set of double polypropylene-bagged (bags pre-labeled), acid washed Teflon 500 ml bottles with lids (HG-CVAF-UL or HG-CVAF-UL, DISS).

6.3 Store double-bagged sample bottles on ice for delivery to the lab. Once samples have been logged in at the lab, Trace Metals staff preserve (filter and preserve dissolved fraction) the samples in a “clean laboratory”.

7. Apparatus, Equipment, and Consumables

7.1 Carboy, 50 liter, pre-cleaned polyethylene, filled with reagent water for field blanks.

7.2 PVC non-powder gloves (VWR Catalog #32916-53x)

7.3 Non-metallic ice chest with ice and plastic barrier.

7.4 Field Sheets
7.5 Niskin-X Bottles (General Oceanics Model 101005X; modified with Viton O-rings (fluoroelastomer 75 durometer Gardico Large; AS568-336, Medium; AS568-312, Small; AS568-012), and shrink-wrap covers on metal fittings. (See 12.2.1 for retrofit procedure).
7.6 Nylon coated weight; Pre-cleaned and bagged.
7.7 Polypropylene bags, 18"x42"x3.0 mil; John T. Vlasick
7.8 Visquene, clean, colorless
7.9 Specialized winch system with synthetic hydroline (single braid, 12 strand ¼" Spectra)
7.10 Teflon coated messengers, pre-cleaned and bagged.
7.11 Custom Niskin bottle rack with plastic interior.

8. Procedure

8.1 **In Lab Preparation**

8.1.1 Cleaning Equipment: The Environmental Services Unit is responsible for arranging to have all sampling apparatus cleaned. Trace Metals Lab Assistants can provide cleaning services. See Section 15: References and (Section 2.3) Equipment Cleaning For Clean Sampling of Ultra Trace Metals Utilizing the Niskin-X (06-05-005-000) The Environmental Services Unit is responsible for the proper deployment and maintenance of the sampling equipment including Niskin-X bottles, O-rings, etc.

8.1.2 Clean sample containers and Niskin-X bottles (packaged into plastic bags) are placed into plastic boxes. Sample coolers are filled with ice, which is covered with a plastic barrier. All sampling apparatus is transported to the vessel the morning of the sampling event. All sample containers, sampling collection devices, and other "clean" materials are stored in the cabin until the individual pieces are needed. The Clean Winch System is bolted to the deck of the vessel and covered with plastic prior to leaving the laboratory. All sampling apparatus is organized to enhance efficiency and cleanliness once on the sampling site.

8.2 **On-Site Procedures**

8.2.1 Roles of Sampling Team: Dirty Hands, Clean Hands

8.2.1.1 Summary of Skipper's Responsibilities:

- Ultimate responsibility for the vessel and the safety of the crew.
- Maneuvers the vessel in a manner which reduces self-contamination.
- Communicates with the Dirty Hands and Clean Hands.

8.2.1.2 Summary of Crane Operator's Responsibilities:

- Responsible for safety and overseeing activities on the back deck.
- Operates Crane.

- Communicates with all back deck staff and skipper.
- Never touches cleaned plastic or Teflon-coated equipment.
- Data entry to the field sheets.

8.2.1.3 Summary of Clean Hand's Responsibilities:

- Opens inner sealed bags
- Fills all lab sample containers
- Prepares atmosphere, field, and carboy blanks

8.2.1.4 Summary of Dirty Hand's responsibilities:

- Opens outer sealed bags.
- Operates Niskin stopcock during filling of the sample container.
- Never comes in contact with lab sample containers.
- Attaches Niskin bottles to Hydroline.
- Cocks Niskin bottles.
- Responsible for weight, synthetic line, and deployment of messengers.

8.2.2 Station Positioning: In order to assess temporal changes in water column characteristics, the station must be revisited as precisely as possible. Station positioning for sampling will be accomplished using a Trimble Differential Global Positioning System (DGPS). Prior to the study, prescribed station coordinates (State Plane NAD83 coordinate system) are loaded into the shipboard DGPS. During the sampling event, the shipboard navigational system will utilize the differential data transmissions from regional Coast Guard base stations to automatically correct its GPS satellite data. The GPS antenna is boom-mounted above the sampler descent line to achieve a more accurate coordinate fix above the sampling point. Previous DGPS usage indicates that an average precision of one to two meters can usually be attained. Water column samples will be collected only when the DGPS coordinates are within 100 ft of the station target coordinates (King County, Jan 2003). In order to minimize contamination, the skipper will maneuver the vessel so that the Niskin-X bottles are deployed upwind and upcurrent from the exhaust of the engines, while at the same time remaining within the 100 ft window.

8.2.3 Niskin-X Deployment

After arriving on station:

8.2.3.1 Skipper maneuvers the vessel so that the sampling will occur upwind and upcurrent.

8.2.3.2 Dirty Hands and crane operator don PVC gloves. Hint; using multiple gloves and removing dirty ones can increase efficiency.

8.2.3.3 Dirty Hands covers the safety rail with plastic.

8.2.3.4 Crane Operator sets up the clean winch system and Skipper provides hydraulic power.

8.2.3.5 Crane Operator orients the boom to the starboard side of the *Liberty* and attaches a nylon block to the crane.
8.2.3.6 Dirty Hands opens the plastic bag containing the nylon coated weight and attaches the weight to the synthetic hydroline.
8.2.3.7 Dirty Hands lifts the synthetic hydroline and places it through the nylon block.
8.2.3.8 Crane Operator operates the winch so the nylon coated weight is moved over the side of the *Liberty* and under the surface of the water.
8.2.3.9 Dirty Hands changes gloves.
8.2.3.10 Dirty Hands opens the box containing the Niskin-X bottles and removes the first (greatest depth) bottle.
8.2.3.11 Dirty Hands unzips the outer plastic bag, removes the Niskin-X bottle and attaches it to the hydroline. The first Niskin-X bottle should be attached just above the nylon weight.
8.2.3.12 Dirty Hands cocks the Niskin-X.
8.2.3.13 Crane Operator zeros the line metering device and lowers the hydroline until the correct length of line for attaching the second bottle is displayed on the line metering device.
8.2.3.14 Dirty Hands opens the box containing the Niskin-X bottles and removes the second bottle.
8.2.3.15 Dirty Hands opens the outer plastic bag and pulls out the second Niskin-X bottle and attaches it to the hydroline.
8.2.3.16 Dirty Hands cocks the bottle.
8.2.3.17 Dirty Hands removes a cleaned and bagged Teflon coated messenger from the box and unzips the bag. This messenger will be used to trip the bottom bottle.
8.2.3.18 Dirty Hands clips it to the synthetic hydroline and attaches the release strap to the Niskin bottle.
8.2.3.19 If necessary, Crane Operator lowers the hydroline until the correct length of line for attaching the third bottle is displayed on the line metering device and the procedure is repeated.
8.2.3.20 Once the bottles are at the correct depth, Dirty Hands sends a Teflon coated messenger down the hydroline to trip the bottles.
8.2.3.21 The trip time is noted on the fieldsheet.
8.2.3.22 The serial numbers of each Niskin-X must be added to the appropriate sample on the fieldsheet.

8.2.4 Sample Collection from Niskin Bottles

8.2.4.1 Dirty hands changes gloves and clean hands dons gloves.
8.2.4.2 After all bottles have tripped, Crane Operator operates the winch system and brings the top bottle above the surface of the water and adjacent to the side of the *Liberty*.

8.2.4.3 The Niskin bottles are removed from the hydroline and placed in the sample rack.

8.2.4.4 The Crane Operator, with the help of Dirty Hands, brings the weight onto the *Liberty* and stows it in a plastic bag. Dirty Hands prepares the sampling apparatus for transport to the next station.

8.2.4.5 At this point, Liberty may get underway during container filling to minimize contamination.

8.2.4.6 Clean Hands opens the air vent at the top and the outlet nipple at the bottom of the Niskin-X bottle to begin draining sample water. Approximately 100 ml of sample water should be drained out and discarded.

8.2.4.7 While this is happening, dirty hands removes the first sample container from the bottle kit and unzips the outer plastic bag.

8.2.4.8 Clean hands reaches into the outer bag, opens the inner bag, and removes the container.

8.2.4.9 Clean Hands takes the sample bottle to the Niskin-X, removes the cap, and immediately begins rinsing the container. Following three rinses of the sample container and cap, the container is filled and capped. During this process, atmospheric exposure should be kept to a minimum.

8.2.4.10 Once the sample container is filled, clean hands replaces the cap on the sample container, places it back into the inner bag, closes the bag, and puts it in the outer bag. Dirty hands closes the outer bag and places it into the cooler filled with ice. All sample bottles for this depth are filled using the same method.

8.2.4.11 Dirty hands places the bottle/bag back into the original box.

8.2.4.12 Clean hands and Dirty Hands will again change gloves.

8.2.4.13 The process is repeated until all sample bottles are filled.

8.3 Sample Login Procedures

Samples are to be delivered to Trace Metals for filtration and preservation. The samples should be logged in according to Chain of Custody or standard procedures, depending upon project requirements. After login, subcontracted samples must either be sent to the subcontract lab immediately following the cruise, or placed in a cooler at 4 degrees C and sent out the following morning. Mercury samples must be filtered and preserved within 48 hours of collection (EPA method 1631).

9. QA/QC Requirements

The QC practices defined in this section are subject to change for specific projects. Project-specific QC requirements that differ from this SOP should be defined in a Sampling and Analysis Plan prepared for each project.

9.1 **Initial Validation**

Initial method validation was conducted by comparing the metals results of 10 samples collected using the Niskin-X bottles with samples collected simultaneously at the same depth using the pumping system (SOP # 02-02-005-002). The results of this comparison verified that the methods were comparable. Changes to this procedure, which might bias the results, must be validated by repeating the simultaneous collection of 10 samples with the pumping system and the modified version of this method.

9.2 **Continuing Quality Control**

To ensure continuing quality control, the following QA/QC protocols will be followed, using Clean Hands/Dirty Hands methodology throughout. "Clean hands" will prepare the atmosphere, carboy, and field blanks.

9.2.1 **Field Replicates:** A minimum of two field replicates will be collected per sampling event. If more than 20 field samples are collected, a minimum frequency of 10% is required. (See 4.12). Replicates are collected using a separate Niskin mounted as close as possible to the original on the hydrowire.

9.2.2 **Atmosphere Blanks:** Two atmosphere blanks will be collected per sampling event. These samples will be collected at the first station of the cruise, prior to collecting ambient samples, and at the last station, following collection of the ambient samples. The collection is done by opening the cap (of the previously filled Atmosphere Blank) for the equivalent time and at the same physical space that a sample container would be filled. (See 4.7).

9.2.3 **Field Blanks:** A minimum of two field blanks will be collected per sampling event. If more than 20 field samples are collected, a minimum frequency of 10% is required. These blanks will be collected at the first and last stations of each cruise. (See 4.10). The field blank is typically prepared by filling a previously-rinsed Niskin-X with reagent water via a tube from the carboy. After filling the Niskin-X, the field blank is collected like a field sample.

9.2.4 **Carboy Blanks:** A minimum of two carboy blanks will be collected per sampling event. If more than 20 field samples are collected, a minimum frequency of 10% is required. These are collected by simply pouring the carboy water into the carboy blank sampling bottles, immediately after the collection of the field blank. (See 4.8).

9.2.5 **Pre-deployment Blank:** See SOP #06-05-004-000. This is done by the Trace Metals Staff prior to cruise.

Each set of blanks and replicates are all collected at the same site. If multiple sets are required, they are typically collected at the first and last stations of the day.

9.3 **Acceptance Limits**

The results of each blank analysis should be less than the MDL. If results of a particular blank are above the MDL, the data will be evaluated against results of other field and method blanks, and measured concentrations in the field samples. The samples and blanks may be re-analyzed if the source of the contamination is identified as a laboratory contaminant. The Relative Percent Different (RPD) of each set of field replicates will be calculated. The acceptance limits will be project-specific. It is understood that the carboy reagent water will become contaminated with mercury from the atmosphere during the sampling event. It is therefore expected that the field blanks and carboy blanks will be greater than the method detection limit. An acceptable field blank for mercury should not contain significantly greater levels of mercury than the carboy blank.

10. Data Reduction, Reporting, Review and Documentation

Field sheet data for each sample will include:

- client locator – a unique sample identifier;
- sample depth – may be entered prior to sampling event
- time and date of sample collection
- field observations that could affect the quality of the samples and blanks
- precipitation-none, light, medium, or heavy
- serial numbers of Niskin-X bottles associated with each sample

These field sheet data will be entered into LIMS for each sample.

11. Standards and Reagents

This section is not applicable to this specific field sampling method.

12. Contamination

12.1 Background and Suggestions

12.1.1 EPA method 1669 states that the greatest challenge faced in trace metals determination, including the sampling portion, is preventing the samples from becoming contaminated. Routes of contamination include metal-containing sampling equipment, containers, reagent water, improperly cleaned and stored equipment, atmospheric inputs such as engine exhaust, and even human contact. The goal will be to eliminate contamination by ensuring that any object that contacts the sample is nonmetallic and free from potential metal contamination. Observe the following during the sample collection process:

12.1.2 Minimize atmospheric exposure. Airborne particulate matter such as dust, dirt, exhaust, smoke, nearby corroded metallic material, and human breath (Hg cavity fillings) can contaminate samples.

12.1.3 Wear clean, non-powdered gloves at all times. When gloves touch any potential contaminant, change them immediately.

12.1.4 Use metal-free sampling equipment and containers. Materials such as FEP, PTFE, polyethylene, polycarbonate, polysulfone, polypropylene, and ultrapure quartz are free of contaminates when properly cleaned. FEP and PTFE must be used if for mercury determination.

12.1.5 Mark and record serial numbers on all equipment.

12.1.6 Pre-clean all sampling equipment using a verified cleaning procedure. Avoid carryover by rinsing equipment between sampling and by completely avoiding highly contaminated sampling sites. Alternative sampling methods may be used in these areas.

12.1.7 Sampling vessel should be positioned downwind and downstream from the sampling point during collection.

12.2 Decontamination Procedure

12.2.1 Niskin-X Bottle Retrofit

8.2.1.1 The following steps were taken to reduce metal exposure and potential contamination from the standard Niskin-X sampling bottles.

8.2.2.1 All brass crimps were replaced with stainless steel crimps and covered with plastic shrink tubing.

8.2.3.1 The brass clips that keep the bottles cocked were replaced with nylon clips.

8.2.4.1 All rubber o-rings were replaced with Viton o-rings.

8.2.5.1 Silicon adhesive was used to cover all exposed screw heads and other exposed metal. Note: The stainless steel bolts and wingnuts that attach the Niskin-X to the hydroline cannot be replaced or coated.

12.2.2 Pre-Cruise Cleaning Procedure

The Trace Metals Unit is responsible for cleaning all sample containers and sample collection devices. The Environmental Services Unit is responsible for the proper deployment and maintenance of the sampling equipment. Niskin-X bottles will be thoroughly rinsed with ambient water prior to sampling. The number of Niskin-X bottles to be cleaned is dependent on the sampling plan. There should be N + 2 Niskin-X bottles cleaned, where N is the maximum number of depths at any one station. This will provide enough bottles for each depth, plus a field replicate and a spare.

12.2.3 **Intra-Cruise Cleaning Procedure**

Sampling equipment is reused and therefore cleaned between stations with copious quantities of in-situ ambient water. This process is done in the process of deployment by lowering the bottles, in an open position, to their respective sampling depths.

13. Preventative Maintenance

The ultra low-level metals winch, along with all other sampling apparatus, must be kept covered to avoid possible contamination during storage. Niskin-X bottles must be regularly maintained so they will be in good operating condition at all times. If contamination has been suspected, the Trace Metals laboratory will clean the Niskin-X bottles. All broken or worn parts will be replaced upon completion of the previous cruise.

14. Training Outline

The skipper and crane operator must be fully trained and experienced using this method. They must also be briefed on all of the details of the cruise. Clean Hands and Dirty Hands must go through a training process specific to this sampling method and be supervised by an experienced lead. This training process will include use of all sampling equipment and a summary of issues associated with clean sampling and ultra trace metals analysis. This includes familiarization with the SOP and references 1, 3, 4, 5, and 6. Results from field QC samples will be used to determine the effectiveness of this training.

15. References

Method 1669: Sampling Ambient Water for Determination of Trace Metals at EPA Water Quality Criteria Levels. Draft 1994. USEPA.

Method 1640: Determination of Trace Elements in Ambient Waters by On-Line Chelation Preconcentration and Inductively Coupled Plasma-Mass Spectrometry. Draft 1996. USEPA.

Stewart, R. E. (1997) Collection of Freshwaters and Wastewaters for the Determination of Trace Elements. *Virginia Department of Environmental Quality SOP*.

Hunter, Craig N. et. al. (1996) A Rosette System for the Collection of Trace Metal Clean Seawater. *Limnol. Oceanogr.*, **41(6)**, 1367-1372.

Bewers, J.M. and H.L. Windom (1982) Comparison of Sampling Devices for Trace Metal Determinations in Seawater. *Marine Chemistry*, **11**, 71-86.

Nolting, R. F. and J. T. M. de Jong (1994) Sampling and Analytical Methods for the Determination of Trace Metals in Surface Seawater. *Intern. J. Environ. Anal. Chem.*, **57**, 189-196.

In Field Sampling Protocol-Dip Method from Rubber Inflatable Boat. UCSC. Date and author unknown.

Ultra Low Level Metals Sampling at Depth Validation Document. King County Environmental Laboratory, 1999.

Method 1631: Mercury in water by Oxidation, Purge and Trap, and CVAFS. Revision C, March 2001. USEPA.

APPENDIX C

Standard Operating Procedure for Clean Surface Water Sampling for Ultra Low Trace Metals and Organics

King County Environmental Laboratory SOP #222v2

STANDARD OPERATING PROCEDURE

for

Clean Surface Water Sampling for Ultra Low Trace Metals and Organics

SOP #: 222v2

Implemented: January 2008

Supersedes SOP #: 02-02-13-001

Approved by:

Author: _____ Date: _____

Supervisor: _____ Date: _____

QA Officer: _____ Date: _____

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1. SCOPE AND APPLICATION

This standard operating procedure (SOP) applies to the collection by grab sampling of surface water samples for the analysis of ultra low level metals in the range of ng/L (parts per trillion) using the "clean hands/dirty hands" grab methodology. It also covers non-ultra low trace metals and trace organics sampling. The purpose of this SOP is to describe the method of collecting surface grab samples including, but not limited to, streams, lakes, inter-tidal, offshore, and other surface waters. The "clean hands/dirty hands" portion of this method is not intended for the collection of samples found at industrial facilities or in areas of known high metals or organics concentrations. For further information regarding historical trace metals collection methods, contamination sources and control, or other ultra low trace metals issues, refer to section 15. REFERENCES.

2. ASSOCIATED DOCUMENTS AND SOPS

- Labware and Equipment Cleaning Procedures (SOP # 630vl)
- Clean Sampling for Ultra Trace Metals by Peristaltic Pump (SOP #215v2)
- Clean Sampling for Ultra Trace Metals using Modified Niskin Bottles (SOP #221v2)
- Clean Sampling for Trace Metals and Trace Organics using Modified Automated Samplers (SOP #223v2)
- Sampling Methods for Stream and River Water (SOP # 214v3)
- Lakes Water Column Sampling (SOP #213v2)

3. METHOD SUMMARY

When analyzing for the dissolvable trace metals constituents (except mercury) in surface water, it is necessary to filter samples within 15 minutes of collection. This constraint requires that all metals samples be filtered while in the field. Field filtration is not required when collecting trace organics samples. Samples for dissolved mercury by CVAF are filtered in the lab.

Metals sampling of surface water can be either for ultra low level analysis where special clean-handling techniques are required, or for routine (non-ultra) low level analysis using the more standard sampling methodologies (see SOP # 214v3).

3.1. Ultra Low Trace Metals

Prior to the sampling event, all sampling containers are cleaned according to Trace Metals SOP # 630vl. The sampling procedure for Trace Metals samples will utilize the "clean hands/dirty hands" technique. Prior to arrival at the sampling site, members of the sampling team will be designated as "clean hands" and "dirty hands". "Clean hands" handles all operations involving contact with the sample bottle. "Dirty hands" is responsible for all other activities that do not involve direct contact with the sample. All equipment is non-metallic and sampling staff will always wear extra long, non-powder, PVC gloves. Prior to leaving the laboratory, bottles are filled for atmosphere blanks and sample containers are double-bagged with plastic zip-lock type bags. Samples are collected using the dip method (Sections 8.2.2. and 3.2.3). Samples containers are then double-bagged and placed on ice for transport to the laboratory.

3.2. Non-Ultra Low Trace Metals

Samples are collected using the dip method using PVC gloves. Samples are not bagged, but are placed in a cooler with ice for transport to the laboratory (see SOP # 214v3).

3.3. Trace Organics

Samples are collected using the dip method. Special mid-size mouth, one-liter glass bottles will be used for non-volatile parameters. Care must be taken to minimize atmospheric contamination. The preference is for sampling staff to not use gloves, but if staff is more comfortable wearing gloves, purple Nitrile surgical gloves are acceptable. Samples are placed in a cooler with ice for transport to the laboratory.

4. DEFINITIONS

- **Ambient Water** - Waters in the natural environment (e.g., rivers, lakes, streams, Puget Sound).
- **Sample Container** - Bottles used to collect the sample for transport and storage to the Lab.
- **Ultra Low Trace Metals Samples** - Samples that will be analyzed for metals in the ng/L (parts per trillion) range. These include the following LIMS products: HG-CVAF-UL, HG-CVAF-UL, DISS and all ICPMS-UL products.
- **Atmosphere Blank** - a sample of analyte-free water in a lab-supplied container which is left uncapped during sampling. The analysis of the atmosphere blank is used measure possible contamination from airborne sources.
- **Reagent Water** - Reverse-Osmosis water collected from the Trace Metals Clean Room and demonstrated to be free (or as low as possible) from the analytical parameters of interest and potentially interfering substances. This water is equivalent to ASTM Type I water (ASTM D 1193). (Note: this water is not considered sterile.)
- **Field Replicate Sample** - A field replicate sample consists of a second sample collected right after the first sample at the same sampling location using identical collection methodology. Both the field replicate and the first sample are generally analyzed for identical parameters. The purpose of the field replicate sample is to measure and document the precision of field sampling methodologies and the homogeneity of the sample site.
- **Field Filtration Blank** - a sample of analyte-free water in a lab-supplied container which is filtered in the field using the same equipment and process used for filtration of field samples.

5. SAFETY AND HAZARDOUS MATERIALS MANAGEMENT

Grab sampling often appears docile, but there are many dangers that must be taken into account. Some of these dangers include the following:

- rolling beach logs and other debris
- wave action
- unstable surface

- Potentially toxic water
- winter cold issues
- broken glass, including sample containers
- fast currents, floods

All sampling personnel will follow standard safety procedures while on a sampling run. Recommended equipment includes foul weather gear, appropriate safety gloves, and eye protection. Personnel can choose to wear personal flotation devices.

6. SAMPLE CONTAINERS, PRESERVATION, AND STORAGE

- Double polypropylene-bagged, acid washed and pre-labeled HDPE 500 ml bottles with lids for ICPMS UL Trace Metals analysis.
- Double polypropylene-bagged (bags pre-labeled), acid washed Teflon ™ (FEP) 500 ml bottles with lids for CVAF-analyzed Hg samples.
- One set of glass, 1 liter medium-mouth bottles for Trace Organics analysis.
- One set of glass VOA bottles.

7. APPARATUS, EQUIPMENT, AND CONSUMABLES

- PVC non-powder gloves (Extra Long) (VWR Catalog #32916-53x).
- Purple Nitrile Gloves (VWR #40101-34x).
- Clean non-metallic ice chest with ice.
- Field sheets.
- Reagent Water (collected from Trace Metals Clean room by “Clean Hands” personnel in Trace Metals sample containers). Two sets are required if both an atmosphere blank and field filter blank are to be collected.
- Reagent Water (collected in Trace Organics bottles) for atmosphere blanks.
- Peristaltic pump with tubing and battery power supplied.
- Cleaned Nalgene 500 ml filtration apparatuses with 0.45 micron filters for dissolved metals sampling. A separate unit is required for each sample.

8. PROCEDURES

8.1. In-Lab Preparation

8.1.1. Pre-Event Cleaning Procedure

The Environmental Services Unit (ESS) is responsible for either cleaning or arranging to have all sampling apparatus cleaned. Trace Metals Lab scientists provide cleaned filtering apparatus for dissolved metals and acid-washed sample bottles. ESS is responsible for the proper deployment and maintenance of the rest of the sampling equipment.

8.1.2. Final Preparation

Clean sample containers are placed into boxes. Trace Metals sample containers are packaged into double plastic bags. Trace Organics sample containers should be kept separate from the

plastic bags. Sample coolers are filled with plastic bags containing ice. All sampling apparatus are transported to a vehicle the morning of the sampling event. It is organized to enhance efficiency and cleanliness once on the sampling site.

8.1.3. Atmosphere and Filter Blanks

A sample container for each appropriate parameter is filled with reagent water at the Lab and transported into the field with the other sample containers. Separate bottles, each filled with reagent water, must be prepared if both an atmosphere and field filter blank are to be collected.

8.2. On-Site Procedures

8.2.1. Roles of the Ultra Low Trace Metals Sampling Team: 'Clean Hands/Dirty Hands'

8.2.1.1. Summary of Clean Hand's Responsibilities

- Opens inner sealed bags.
- Fills all lab sample containers.
- Filters dissolved samples and prepares field blanks.

8.2.1.2. Summary of Dirty Hand's Responsibilities

- Opens outer sealed bags.
- Never comes in contact with lab sample containers.
- Enters data on the field sheets.
- Sets up the filtration apparatus and pump

8.2.2. Field Filter Blanks

After the sampling personnel have reached the first sampling location of the day, but before taking the first sample, the filtering equipment is tested for contamination.

1. Dirty Hands sets up the peristaltic pump and attaches the battery.
2. Wearing clean PVC gloves, Dirty Hands opens the outer bag of the double bagged pre-cleaned filter apparatus.
3. Clean Hands opens the inner bag and removes the filter apparatus.
4. Dirty Hands attaches the suction side of the pump tubing to the filter suction port.
5. Dirty Hands opens the outer bag containing the filter blank bottle filled with reagent water.
6. Wearing clean PVC gloves, Clean Hands opens the inner bag and extracts the filter blank bottle.
7. Clean Hands opens the filter lid and blank bottle lid and pours the contents of the blank bottle into the filter apparatus and closes the lid.
8. Dirty Hands turns on the peristaltic pump. When the blank water has filtered, Dirty Hands turns off the pump and removes the tubing from the port.
9. Clean Hands removes the label from the original field filter blank bottle and attaches it to the bottom of the filtering apparatus which holds the filtrate.

10. Clean Hands unscrews the filter top from the filtrate bottom and caps the filtrate bottle. Clean Hands puts the filtrate bottle into the inner bag and closes the bag.
11. Dirty Hands closes the outer bag and stores the double-bagged field filter sample on ice in the same cooler that the samples will be stored in.

8.2.3. Atmosphere Blank Collection

8.2.3.1. Ultra Low Trace Metals

The atmosphere blank will have been prepared in the Lab using the procedure described in Section '8.1.3. Atmosphere Blanks'. Once on-site and just before sample collection begins:

1. Dirty Hands opens the outer bag of the double bagged atmosphere blank bottle.
2. Clean Hands opens the inner bag, pulls the bottle out and removes the cap.
3. The bottle remains open for the same length of time that the samples are typically exposed to the atmosphere.
4. Clean Hands replaces the cap, puts the bottle back into the inner bag and re-seals.
5. Dirty Hands closes the outer bag and places it into the cooler filled with ice.

8.2.3.2. Non-Ultra Low Trace Metals and Trace Organics

This is not a Clean Hands/Dirty Hands operation. The atmosphere blank bottle will have been previously filled with reagent water in the Trace Organics laboratory. Once on-site and just before sample collection begins:

1. The sampler removes the cap of the atmosphere blank.
2. The bottle remains open for the same length of time that the samples are typically exposed to the atmosphere.
3. The sampler replaces the cap and puts the bottle into the cooler filled with ice.

8.2.4. Clean Sample Collection: Ultra Low Trace Metals using the Grab Technique

Sample collection can start after the field filter blank has been collected and the atmosphere blank cap has been removed, initiating blank sample exposure to the atmosphere (refer to sections 8.2.2. and 8.2.3.).

Dissolved metals samples are collected in a 500 ml bottle and then filtered into and stored in the bottom portion of the filtering apparatus. Note that dissolved metals samples (except ultra low level mercury) must be filtered within 15 minutes of sample collection. Dissolved Mercury samples are typically filtered in the lab but a portion of the ICP or ICPMS filtrate can also be used if split in the field into a 500 ml FEP bottle. Total ICP and ICPMS metals samples are collected in a second 500 ml bottle, while mercury samples are collected in a separate 500ml FEP bottle. Total metals and mercury samples do not require field filtration.

Each trace metals bottle is rinsed prior to sample collection. The rinsing procedure consists of removing the cap, partially filling the bottle with ambient water, replacing the cap, inverting

three times, then pouring out the water. This is repeated three times for complete rinsing. When collecting, do not fill bottles above shoulder. This headspace is used for mixing and adding preservative.

1. Prior to entering the water, the team determines the direction of current and effects of wave action, and if it is safe to enter.
2. The team enters the water down-current from the collection site and wades in a manner to avoid disturbing the water with sediment disruption.
3. Wearing clean PVC gloves, Dirty Hands removes the first sample packet from the bottle kit and unzips the outer plastic bag.
4. Wearing clean PVC gloves, Clean Hands opens the inner bag, and removes the sample container.
5. Facing upstream, Clean Hands removes the cap, tips the sample container downward at a 45 degree angle and plunges the container in so that the mouth is approximately 5 inches below the surface. In the same motion, the sample container is then turned upward so it begins filling with ambient water. The container must remain below the surface until it is full.
6. Once the sample container is filled, Clean Hands lifts the sample container out of the water and immediately replaces the cap.
7. Clean Hands then places the sample container back into the inner bag, and reseals it.
8. Dirty Hands closes the outer bag, then both return to the van.
9. If dissolved metals are required, Dirty Hands sets up the peristaltic pump and attaches the battery.
10. Wearing clean PVC gloves, Dirty Hands opens the outer bag of the double bagged pre-cleaned filter apparatus.
11. Clean Hands opens the inner bag and removes the filter apparatus.
12. Dirty Hands attaches the suction side of the pump tubing to the filter suction port.
13. Dirty Hands opens the outer bag containing the sample container.
14. Wearing clean PVC gloves, Clean Hands opens the inner bag and extracts the sample container.
15. Clean Hands opens the filter lid and sample container lid and pours the container's contents into the filter apparatus, then closes the filter lid.
16. Dirty Hands turns on the peristaltic pump. After filtration, Dirty Hands turns off the pump and removes the tubing from the port.
17. Clean Hands removes the label from the original sample container and attaches it to the bottom of the filtering apparatus which holds the filtrate.
18. Clean Hands unscrews the filter top from the filtrate bottom and caps the filtrate bottle. Clean Hands puts the filtrate bottle into the inner bag and closes the bag.
19. Dirty Hands closes the outer bag and stores the double-bagged filtrate bottle on ice in the appropriate sample cooler.

This process is repeated until all metals sample containers for this site are filled. Clean Hands must try to avoid collecting any debris, including sticks, seaweed, leaves, feathers, etc. During this process, atmospheric exposure should be kept to a minimum. Touching anything besides the

sampling bottles is strictly prohibited. If this happens, new gloves should be donned. New gloves are also donned by both Clean Hands and Dirty Hands between sample sites.

8.2.5. Standard Sample Collection: Non-Ultra Low Trace Metals and Trace Organics using the Grab Technique

Sample collection can start after the field filter blank has been collected and the atmosphere blank cap has been removed, initiating blank sample exposure to the atmosphere (refer to sections 8.2.2. and 8.2.3.).

1. Prior to entering the water, the team determines the direction of current and effects of wave action.
2. The team enters the water down-current from the collection site and wades in a manner to avoid disturbing the water with sediment disruption.
3. The sampler opens the sample container, tips it downward at a 45 degree angle and plunges the container in so that the mouth is approximately 5 inches below the surface. In the same motion, the sample container is then turned upward so it begins filling with ambient water. The container must remain below the surface until it is full.
4. Once the sample container is filled, the sampler lifts the sample container out of the water and replaces the cap.
5. The sampling team returns to the van for the filtration step.
6. After setting up the peristaltic pump and battery and donning clean PVC gloves, the suction side of the pump tubing is attached to the filter suction port of a fresh pre-cleaned filter apparatus.
7. Both the filter lid and sample container are opened and the container's contents are poured into the filter apparatus, closing the filter lid afterwards.
8. After filtration, the label from the original sample container is removed and reattached to the bottom of the filtering apparatus which holds the filtrate.
9. The filter top is unscrewed from the filtrate bottom and the filtrate bottle is capped. The labeled filtrate bottle is then placed into the cooler filled with ice.

This process is repeated until all sample containers for this site are filled. The sampler must try to avoid collecting any debris, including sticks, seaweed, leaves, feathers, etc. During this process, atmospheric exposure should be kept to a minimum.

8.2.6. Cleaning Procedure between Samples and/or Stations

For grab sampling, no sampling equipment is used besides dedicated sample containers so cleaning is not required between samples aside from changing gloves.

8.3. Sample Login

The samples should be logged in according to standard procedures. Metals samples are then delivered to the Trace Metals Lab for preservation. Subcontracted samples must either be sent to the subcontract lab immediately following the collection event, or placed in a cooler at 4 degrees C and sent out the following morning.

9. QA/QC REQUIREMENTS (FREQUENCY AND ACCEPTANCE LIMITS)

The QC practices defined in this section are subject to change for specific projects. Project-specific QC requirements that differ from this SOP should be defined in a Sampling and Analysis Plan prepared for each project.

9.1. Initial Validation

Validation has been completed for Clean Hands/Dirty Hands methodology. See Ultra Low Level Metals Sampling at Depth Validation Document. King County Environmental Laboratory, 1999. Since no sampling equipment is used except for sample bottles, further validation is unnecessary.

9.2. Continuing Quality Control

For the ultra low trace metals and trace organics samples, field replicates and blanks (atmosphere and field filtration) will be collected at a minimum of one set for each day of the sampling event. If multiple sets are required, they are typically collected at the first and last stations of the day.

9.2.1. Field Replicates

A minimum of one field replicate will be collected per sampling event. If more than 20 field samples are to be collected, a minimum frequency of 5% (ie, 1 replicate for every 20 samples) is required. Field replicates are collected using the same sampling method as the original sample. Gloves should be changed between sample sites.

9.2.2. Atmosphere and Field Filtration Blanks

For ultra low trace metals and trace organics, two sets of atmosphere blanks will be collected per sampling event. These samples will be typically collected at the first station and at the last station simultaneously with the collection of ambient samples. The collection is done by opening the cap (of the previously-filled atmosphere blank) for the equivalent time and within the same physical space that a sample container is being filled.

When dissolved metals samples are to be filtered in the field, one field filtration blank must be collected to test the filtering equipment for contamination prior to collection of the first sample. The collection procedure is described in section 8.2.2.

9.3. Acceptance Limits

The results of each blank analysis should be less than the MDL. If results of a particular blank are above the MDL, the data will be evaluated against results of other Field and Method Blanks, and against measured concentrations in the field samples. The samples and blanks may be re-analyzed if the source of the contamination is identified as a laboratory contaminant. The Relative Percent Different (RPD) of each set of field replicates will be calculated. The acceptance limits will be project-specific.

10. DATA REDUCTION, REPORTING, REVIEW, AND DOCUMENTATION

Field sheet data for each sample will include:

- Time and date of sample collection. (Note: The time recorded for each station is when the first sample is collected.)
- Sample Function (i.e., shows associations between field QC samples and a given environmental sample).
- Sample Method (refer to Sampling Methods Code).
- Precipitation (recorded as None, Light, Medium, or Heavy for ultra low trace metals).
- Sample Information (optional).
- Client locator (optional).
- Wind speed and Direction (if necessary).
- Tide Height and Condition (if necessary).

Field QC data is to be loaded to LIMS using the following locators and QC types:

- Atmosphere Blank – ATMOSBLANK locator and ATB QC type
- Field Filter Blank- FFBLANK locator, and FFB QC type
- Field Replicate- station name where collected, and FREP QC type

Quarterly, the field QC data (field blanks and field replicates) should be downloaded using the Field QC query functions in LIMSView. Results are to be reviewed for trends or consistent problems that might indicate a systematic error.

Field sheet data is entered into the Laboratory Information Management System (LIMS) for each sample. Field observations that could affect the quality of the samples (i.e., weather related and contextual commentary) are loaded to LIMS by way of the Field Observation document. When applicable, field crews note wind speed and direction, air temperature, cloud cover, and precipitation information. The TC then compiles these comments into a Word document that is entered into LIMS and linked to the field sheet data Work Group number.

11. STANDARDS AND REAGENTS

Not applicable.

12. CONTAMINATION

12.1. Trace Metals

EPA method 1669 states that the greatest challenge faced in trace metals determination, including the sampling portion, is preventing the samples from becoming contaminated. Routes of contamination include metal-containing sampling equipment, containers, reagent water, improperly cleaned and stored equipment, atmospheric inputs such as engine exhaust and even human contact. The goal will be to eliminate contamination by ensuring that any object that contacts the sample is nonmetallic and free from potential metal contamination.

Observe the following during the sample collection process:

- Minimize atmospheric exposure. Airborne particulate matter such as dust, dirt, exhaust, smoke, nearby corroded metallic material and human breath (Hg-containing dental amalgam) can contaminate samples.
- Wear clean, non-powdered gloves at all times. When gloves touch any potential contaminant, change them immediately.
- Use metal-free sampling equipment and containers. Materials such as fluorinated ethylene propylene (FEP), polytetrafluoroethylene (PTFE) or Teflon ™, polyethylene, polycarbonate, polysulfone, polypropylene, and ultra pure quartz are free of contaminants when properly cleaned. FEP or PTFE must be used when collecting samples for ultra low or low level mercury determination.
- Pre-clean all sample bottles using a verified cleaning procedure.

12.2. Trace Organics

- Minimize atmospheric exposure.
- Wear clean, non-powdered gloves at all times. When gloves touch any potential contaminant, change them immediately.
- Pre-clean all sampling equipment and sample bottles using a verified cleaning procedure, or purchase pre-cleaned bottles.

13. PREVENTATIVE MAINTENANCE

Not applicable.

14. TRAINING

Clean Hands and Dirty Hands must go through a training process specific to this sampling method and be supervised by an experienced lead. The training process will include use of all sampling equipment and a summary of issues associated with ultra low trace metals data collection. This includes familiarization with all appropriate SOPs and references. Results from field blanks will be used to determine the effectiveness of this training.

15. REFERENCES

Method 1669: Sampling Ambient Water for Determination of Trace Metals at EPA Water Quality Criteria Levels. July 1996. USEPA.

Method 1640: Determination of Trace Elements in Ambient Waters by On-Line Chelation Pre-concentration and Inductively Coupled Plasma-Mass Spectrometry. Draft 1996. USEPA.

Stewart, R. E. (1997) Collection of Freshwaters and Wastewaters for the Determination of Trace Elements. *Virginia Department of Environmental Quality SOP*.

Bewers, J.M. and H.L. Windom (1982) Comparison of Sampling Devices for Trace Metal Determinations in Seawater. *Marine Chemistry*, 11, 71-86.

Nolting, R. F. and J. T. M. de Jong (1994) Sampling and Analytical Methods for the Determination of Trace Metals in Surface Seawater. *Intern. J. Environ. Anal. Chem.*, 57, 189-196.

In Field Sampling Protocol-Dip Method from Rubber Inflatable Boat. UCSC. Date and author unknown.

Ultra Low Level Metals Sampling at Depth Validation Document. King County Environmental Laboratory, 1999.

Method 1631: Mercury in water by Oxidation, Purge and Trap, and CVAFS. Revision E. August 2002. USEPA.

Appendix E. Freshwater Lakes Sampling and Analysis Plan and Quality Assurance Project Plan

The current version of the Major Lakes Sampling and Analysis Plan is attached electronically to this document. This SAP includes the quality assurance information for this program and reflects the protocols and methods used in King County's ambient monitoring program for freshwaters and would apply to the Open Water (freshwater) stations listed in Table 4 (0512, A522, 0540, 0826, 0890).

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Major Lakes
Sampling and Analysis Plan

June 2005

King County

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Major Lakes
Sampling and Analysis Plan

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1.0. INTRODUCTION

1.1 Purpose

The Major Lakes Sampling and Analysis Project Plan provides a comprehensive overview of various activities conducted as part of the long term routine assessment of lakes Sammamish, Washington, and Union. All routine, annual, on-going sampling protocols are included or referenced in this sampling and analysis plan (SAP). Also included are discussions of several sampling programs which are either part of longer term or multi-year studies, or part of more focused, non-routine sample collection efforts. The overarching purpose is to provide one document wherein all current sampling and analysis protocols are organized. Many additional SAPs and Standard Operating Procedures (SOPs) are referenced in this document as sources of more detailed information on specific procedures and coordinated programs. This SAP is based on current activities. It is assumed that the program will evolve over time and those changes will be reflected in revisions to the SAP.

The purpose of the Major Lakes program is to maintain and improve the exceptional water resources that contribute to our quality of life by preventing pollution (both point and non-point) and water resource degradation, and to identify and correct existing water pollution problems. This program is part of King County Department of Natural Resources and Parks, (KCDNRP), Water and Land Resources Division's (WLRD) long standing commitment to protecting and improving the environmental quality of lakes Sammamish, Washington and Union. These goals are addressed both by independent programs carried out by King County, and by close and active cooperation with other public, local, state and federal entities. The Major Lakes Program is the primary source of water quality data for lakes Sammamish, Washington and Union, but is also coordinated with several other King County operating and capital water quality programs.

1.2 Regulatory Application

King County is committed to monitoring the water quality of these lakes to ensure their continued health, as well as the health of the public who utilize and benefit from the lakes' many resources. The program is designed to collect, analyze and interpret the physical, chemical and biological data necessary to protect the financial investment in water quality improvement and protection made by the people of King County. This program, in conjunction with other freshwater studies, provides data used to evaluate the Swimmable/Fishable goal of the Federal Clean Water Act via data submittal to the Washington Department of Ecology 303(d) water quality list, and compliance with Chapter 4, Natural Environment, section C - Water Resources and section H - Water Supply of the King County Comprehensive Plan.

1.3 Program Goals/Objectives

Protection of human health and ecological health are central to the KCDNRP mission. Untreated sewage and treated effluent were previously discharged directly into these lakes and significantly degraded the public health, aquatic resources, and quality of life for the citizens of the region.

Sewage and wastewater now enter secondary treatment facilities at West Point and Renton, from which clean, secondary treated effluent is discharged into the waters of Puget Sound. The result of this diversion was a dramatic improvement in lake water quality. Continued monitoring of the lakes is essential, as point and non-point source pollution related to urbanization of the watershed has the potential to negate the improvements made by the investment in water quality made by the region. Additionally, several pump stations are on or near the shores of the lakes, miles of sewer pipelines lay on the bottom of lakes Sammamish and Washington, most of the influent streams are crossed by one or more sewer pipelines, and the lake watershed continues to develop. During certain strong storm events, combined sewer overflows (CSOs) still discharge some dilute sewage and storm water into Lake Washington, the Ship Canal and Lake Union. In the near future, the Brightwater treatment facility will begin operation and there will be an additional need for water resource information related to design, construction, mitigation and operation. The King County Stream Monitoring Program provides input and loading data that is being used to evaluate both watershed changes and as input to the lake models. The intent is to increase the level of coordination between all of the freshwater monitoring programs in King County.

King County is currently developing hydrodynamic and water quality models of these lakes as part of the Sammamish-Washington Analysis and Modeling Program (SWAMP) in the Freshwater Program. A 3-dimensional water quality models (CE-QUAL-ICM) of the lakes was developed KCDNRP by the U.S. Army Corps of Engineers, Engineer Research and Development Center (ACOE-ERDC) and is currently being implemented by King County staff (DeGasperi, pers comm.). Dispersion and advection of water quality constituents in the water quality model is based on output from a hydrodynamic model of the lakes (Curvilinear Hydrodynamics in 3D, CH3D). All of the freshwater monitoring and modeling programs: lakes, rivers, streams, swimming beaches, phytoplankton, watershed analysis, endangered species response and flows, are being integrated or coordinated under this program. The current monitoring programs will be modified to facilitate integration of monitoring data with modeling capabilities to provide a more efficient and responsive program to protect these waters. All data collection and handling, modeling inputs and outputs/visualization will be integrated in the Integrated Water Resource Modeling System (IWRMS).

The primary objectives of the Major Lakes program phytoplankton and chlorophyll sampling and analysis effort is to evaluate the current trophic status of the major lakes, develop predictive capabilities of future trophic state, evaluate long term trends in trophic state, and identify ecological factors that determine the abundance and species composition of phytoplankton. The method this program will use to define the trophic status of these lakes is a combination of in-situ sampling and the development and calibration of lake water-quality models that simulate multiple groups of phytoplankton. An additional goal is to provide data on the abundance of cyanobacteria species capable of producing toxins, and attempt to determine the ecological triggers for toxin-producing blooms of blue-green bacteria (KCDNRP 2002b).

1.4 Program Goals

- Collect and analyze sufficient, accurate data for coordination with the Major Lake Assessment program, and maintain Major Lakes database.

- Maintain swimmable/fishable quality in lakes Sammamish, Washington and Union.
- Identify and quantify the water quality impacts of urbanization and human activities on the regional water resources.
- Maintain sufficient, accurate water quality data for decision making.
- Encourage and facilitate cooperative actions that will result in effective lake management practices.
- Develop and implement educational activities in the lakes and watersheds.
- Provide technical support to the King County Wastewater Treatment Division on impacts and activities within these lakes
- Monitor the efficacy and impacts of the King County owned sewage collection and transfer system on regional water quality.
- Minimize water quality problems in the major lakes.
- Investigate potential and appropriate Best Management Practices for recommendation.
- Support the Cedar/Lake Washington and Sammamish Watershed Technical Teams with technical assistance.
- Long-term trend analysis.
- Continue to make electronic data available as public access information.
- Continue to expand use of the King County Internet site as a means to share information. This site is:http://dnr.metrokc.gov/wlr/waterres/lakedata/index.htm

1.5 Study Area

The study area includes Lake Sammamish, Lake Washington, and Lake Union, including riparian zones. Routine sampling will be conducted at 7 stations on Lake Sammamish, 13 stations on Lake Washington, and 5 stations on Lake Union/Ship Canal. These stations are located as shown on the map in Figure 1.

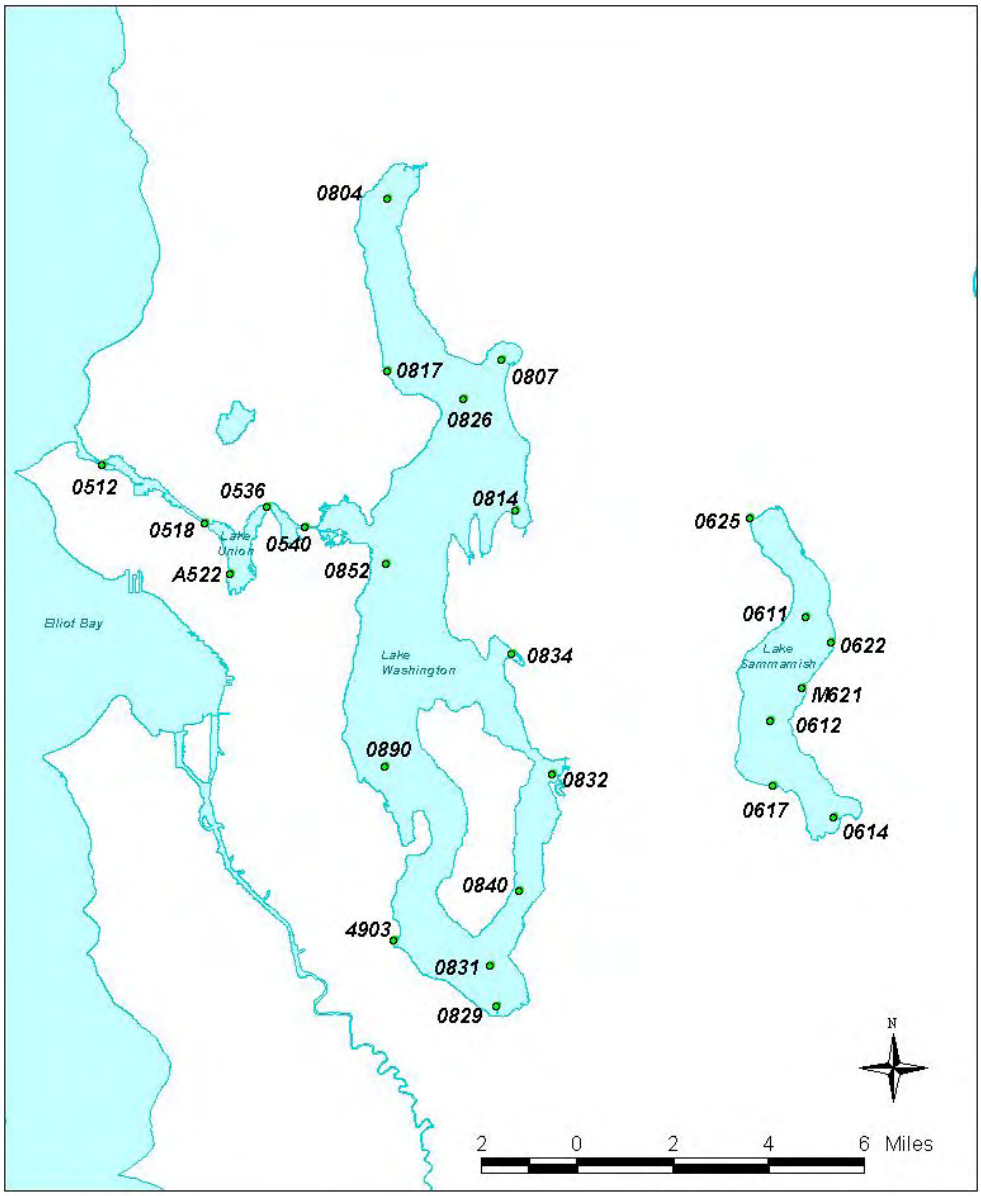

Figure 1. Major Lakes Study Area and Sampling Sites

1.6 Historical Data Review

The first data collection event for the Major Lakes Program was on January 3, 1974. During the first several years, most of the data collection was temporary and sporadic with few vertical profiles collected. Beginning around 1979 data was collected semi-continuously at several locators. Profile data was not collected on a regular basis until the early 1990's. A compilation

of data collection activities since 1992 at all of the locators in the major lakes where data was collected is presented in Appendix A.

1.7 Related Programs

1.7.1 Freshwater Swimming Beach Monitoring

Bacteria samples are collected weekly during warm weather at designated swimming beaches along Lakes Sammamish, Washington, and Union, and in Green Lake.

1.7.2 Toxic Cyanobacteria Study

A short-term study of phytoplankton, zooplankton, and toxic cyanobacteria has been implemented for the major lakes, as described in the Sampling and Analysis Plan - *Phase II For Toxic Cyanobacteria in Lake Washington, Lake Sammamish and Lake Union*, February 2005, at

HTTP://DNRLAB-WEB/SAPS/CURRENT/SWAMP/REVCYANOSAP_DB%20(1)%2004MAR2003FINAL.DOC

Sample collection utilizes the combined efforts of the routine Major Lakes Sampling Program and the Swimming Beach Monitoring Program (SAP in review). The Major Lakes Sampling Program collects samples twice per month between March and October. Swimming Beach Monitoring occurs weekly from mid-May through mid-September. Utilizing both programs will provide for weekly sample collection throughout most of the productive growing season and provide for better tracking of microcystin production in the lakes. Additional focused sampling efforts will be made to collect scums or accumulations of cyanobacteria if they are present within the visual distance of routine lakes sampling sites or as part of the Small Lakes Monitoring Program. A bloom will be defined as a visually observable accumulation of phytoplankton in the water column or as a surface accumulation.

Samples are collected using the same site-specific collection method used for chlorophyll *a* described in section 4.5. In addition, seasonal microcystin and quantitative phytoplankton samples are collected at seven locators with discrete surface sample collection and at all six locators with integrated composite samples. *In situ* profiling will be conducted at every five meter depth (from 1 meter to just above the bottom) at one selected locator.

1.7.3 Zooplankton Study

Zooplankton sample collection in Lake Sammamish is designed to compliment the zooplankton sampling program at the University of Washington. UW sampling is focused on the south end of Lake Washington to provide data on food availability for outmigrating salmonids and an estimate of seasonal grazing pressure on the phytoplankton populations. Qualitative ring net tows are conducted at one location in Lake Sammamish for live zooplankton sampling. Zooplankton analyses are conducted by the University of Washington Zoology laboratory.

1.7.4 Remote Automated Data Collection

Water quality parameters are collected automatically using solar-powered telemetered buoys. A specific SAP for the operation and maintenance of these buoys and the handling and storage of the collected data is in development.

1.7.5 Major Lakes Sediment Monitoring

King County may collect chemistry, toxicity and benthic community data and will use a weight of evidence approach to predict risks to aquatic organisms. If sediment sampling is to be conducted, the specific sampling design will be detailed in the annual workplan, and will generally follow existing sediment SAPs that address SEDQUAL data requirements. Sediment samples will be collected for chemical and biological testing using standardized equipment and procedures. Protocols for sediment sampling in lakes Sammamish, Washington and Union are defined in the following Sampling and Analysis Plans and SOP:

http://dnrlab-web/saps/current/swamp/lksamsedsap081299.doc

http://dnrlab-web/saps/current/swamp/LakeWA%20Baseline%20Sediment-2.doc

http://dnrlab-web/saps/current/swamp/LakeUNIONsedsapfinal.doc

STANDARD OPERATING PROCEDURE for SAMPLING METHODS FOR LAKES SEDIMENTS. SOP # 02-02-015-000. Implemented: May 1, 2003. This laboratory SOP may be found:

http://dnrlab-web/Lab_SOPs/ESS/Sampling%20Procedures/Lakes%20Sediment%20Sampling.doc

1.7.6 Major Lakes Benthic Sampling

The benthic community will be assessed using a variety of indices (e.g., abundance, diversity and the abundance of stress-tolerant or intolerant species). Benthic sampling will occur on an infrequent schedule defined during annual work planning.

Collection and analysis of benthic samples requires significant resources. In order for benthic samples to be comparable across studies, all benthic samples should be collected using standardized protocols. Standardization of bioassessment methods for determining benthic species composition, taxa richness, diversity, evenness, trophic levels and major taxonomic spatial and temporal patterns may be enhanced significantly by the conventional use of a U.S. No. 30 sieve (APHA et al. 1998) during sample collection and initial processing. All samples will be initially preserved with 10% buffered formalin. Alcohol is not a satisfactory tissue fixative, especially for soft body parts. Fixation with formalin stabilizes tissue proteins to retain characteristics of the soft body parts (APHA et al. 1998). A sufficient volume of formalin will be added to sample containers such that the entire volume of pre-screened sample shall be covered with formalin. Specifics of benthic sampling design and collection for Lake Washington can be found in the Lake Washington Baseline Sediment Sampling SAP:

http://dnrlab-web/saps/current/swamp/LakeWA%20Baseline%20Sediment-2.doc

2.0. PROJECT MANAGEMENT

2.1 Roles and Responsibilities

Project team members and their responsibilities are summarized in Table 1. All team members are staff of the King County Department of Natural Resources Water and Land Resources Division.

Table 1. Project Team Members and Responsibilities

Name/Telephone	Title	Affiliation	Responsibility
Jonathan D. Frodge (206) 296-8018	Sr. Limnologist	Science and Technical Resources	Major Lakes Program Manager.
Katherine Bourbonais (206) 684-2382	Laboratory Project Manager	Environmental Laboratory	Coordination of analytical activities, lab QA/QC and data reporting.
David Robinson (206) 684-2329	Environmental Laboratory Scientist	Environmental Laboratory	Coordination of sampling activities, field QA/QC and field analyses.
Debra Bouchard (206) 263-6343	Water Quality Planner	Science and Technical Resources	Coordination between lab and in-house water quality specialist.
Colin Elliott (206) 684-2343	Quality Assurance Officer	Environmental Laboratory	Overall project QA/QC.

The development and operation of the Major Lakes Program is a cooperative effort between the Science and Technical Support Group (STS) and the King County Environmental Laboratory (KCEL).

2.1.1 Modeling, Reporting and Assessment

The Science and Technical Support Group (STS) is responsible for overall project management including project design, data analysis and final reporting. Project managers in STS are

responsible for approval of changes in procedures or significant schedule changes. Often they provide field support and consulting to the King County Environmental Lab (KCEL).

2.1.2 Environmental Laboratory

The Environmental Services unit (ESS) of the KCEL does event scheduling, LIMS sample creation, sample collection, field analysis, QA/QC of field data, entry of final field data to LIMS and communication with the laboratory units and the laboratory project managers (LPMs). Each individual laboratory unit within the KCEL conducts laboratory analysis, QA/QC of laboratory data and entry of final laboratory data to LIMS. The individual laboratory units include Conventional Chemistry, Microbiology, Trace Organics and Trace Metals. The Sample Management Specialists (SMS), part of the Conventionals unit, receive samples at the lab, verify preservation and completeness of the sampling set and deliver the samples to the appropriate laboratory units. Each project at the lab has a Laboratory Project Manager (LPM) and Technical Coordinators (TC) from the various lab units involved in the project. The role of the LPM is to communicate with the Planners in STS, coordinate the sampling and analysis, prepare data reports as needed and review final reports and data. The QA Officer oversees all quality assurance and quality control protocols at the lab.

2.2 Project Deliverables

All field and lab data collected by the King County Environmental Lab are to be reported to LIMS. Field and laboratory data for monthly sampling are reported in LIMS within 30 days of sample collection. Quarterly low level metals and organics sampling data are to be reported between 60 and 180 days following collection. Data generated outside King County will be reported in hardcopy or electronic format as defined in the project specifications.

3.0. STUDY DESIGN

3.1 Approach

The study design and SAPs described in this document are relevant to the Major Lakes Program as it exists in 2005. Specific details documented here may not represent past or future activities associated with this program. Annual updates and corrections will be incorporated into the annual workplans developed by STS and KCEL, SAP addenda or additional SAPs.

Sampling is designed to provide a long term data set that allocates sampling effort to incorporate the natural and anthropogenic, temporal and spatial variability in the lakes. Lake responses can vary from short term responses due to diel, weekly or seasonal patterns; to long term responses due to climate or watershed changes. In these large lakes, response also varies over distance and is non-uniformly affected by shoreline activity, influent streams, depth and proximity and configuration of the sewage collection and conveyance system. In temperate monomictic lakes such as these, thermal stratification and destratification patterns affect the distribution and patterns of most of the water quality parameters and response of the lakes to constituent inputs from the watershed. The geographic distribution of sampling locations permits the description of baseline water quality conditions nearby to possible accidental pollutant inputs. This data may be used to define the extent of pollution spills and determine when the water quality recovers to baseline conditions.

There is insufficient sampling capacity to define the variability of all temporal and spatial scales in detail, so sampling effort is distributed over time and space as a compromise among these various scales. The geographic distribution of sampling effort is designed to provide data both to characterize the spatial variability in these large lakes, and to spatially monitor impacts potentially related to the King County owned and operated sewage collection and conveyance system. The sampling distribution is therefore influenced by the design of the conveyance system. Temporally, a major criterion of the monitoring design is to provide an adequate dataset to evaluate long term trends in lake quality. Long term trend analysis requires continuous data collection at the same locators, which makes it important to maintain data collection at locators that have been sampled since the inception of the program. All sampling is designed to capture the vertical stratification by collecting samples at the same locator coordinates from depths of 1 meter below the water surface and every 5 m to within <5m of the bottom. At locators with maximum depth less than 10 m samples may be collected at depth increments of <5 m.

Each of the lakes has one or more sampling stations located in the pelagic zone or deep central basin of the lake, where the influence of inflows and mixing action of wind and waves on the shoreline is muted by distance and the surrounding water. Changes observed over time at the pelagic sites reflect broad, large scale or landscape scale changes in the watershed and the lake. Other sampling stations are distributed in the littoral zone or nearshore areas of the lake, primarily off the mouths of major influent streams. Changes in water quality at these stations are more directly influenced by shoreline activities (including the sewage collection and conveyance system) and by the quality and quantity of inflowing stream water. Changes at these sites often occur more quickly and are often greater than those observed in the pelagic zone. Sampling and

flow monitoring sites are distributed around the lakes and their influent streams to monitor the long term environmental quality of these waters, the sewage collection and conveyance systems, and non-point source pollution inputs.

3.2 Sampling Frequency and Parameters

Samples are collected monthly from November through February and twice monthly from March through October. Surface water samples collected from the lakes will be analyzed for bacteria and conventional parameters on every sampling trip, unless varying temporal schedules have been specified in the annual workplan for bacterial, conventional, metal and organic constituents listed below. Metals and organics parameters will likely be collected on a quarterly basis.

- Bacteria – *Escherichia coli* and fecal coliform.
- Conventionals –alkalinity (collected at one locator, 0852, and quarterly at all other sites), total nitrogen, ammonia nitrogen, nitrate/nitrite nitrogen, *ortho* phosphorus, total phosphorus, chlorophyll *a*, phaeophytin *a*, silica, total and dissolved organic carbon, turbidity and total suspended solids.
- Metals (total and dissolved) – arsenic, cadmium, chromium, copper, lead, mercury, nickel, zinc and hardness. Additional metals may be reported when results are available.
- Organics – BNAs including polynuclear aromatic hydrocarbons (PAHs), chlorinated herbicides, chlorinated pesticides, endocrine disrupting compounds (EDCs), organophosphorus pesticides and PCBs.

3.3 Data Quality Objective Goals

It is the intent of this study to produce data of sufficient quality to be able to meet project goals defined in the introduction of this document. All project data will undergo rigorous quality assurance review, which will assess, among other things, accuracy, precision and bias, representativeness, completeness and comparability. Chemical concentrations in water will be compared by STS staff to acute and chronic values from one of three sources, named in priority: Washington water quality standards for surface water (***WAC 173-201A***), USEPA ambient water quality criteria for protection of aquatic life, and/or the lowest applicable values selected from in the ECOTOX database.

Data quality objectives typically involve specifications of the required precision, accuracy, and tolerable bias of the analytical data. Discussion is also provided that describes the methods used to ensure that the data are representative of the population targeted for sampling, comparable to other similar studies. Methods and procedures used to minimize the loss of usable data are also described.

3.3.1 Precision

Data precision is the degree of agreement among repeated measurements on the same sample (laboratory replicate) or on separate samples collected as close as possible temporally and spatially (field replicate). A measure of precision gives one an idea of how consistent and reproducible your field or laboratory methods are. However, precision does not reflect how "true" or accurate the results are. Typically, precision is monitored by the analysis of replicate samples. Replicating the analysis of a subset of field samples will assess the precision of the data. Approximately 4 percent of the field and laboratory samples will be analyzed in duplicate to provide a means of assessing analytical precision. One field replicate will be collected at Lake Washington Station 0852 and analyzed for every other Major Lakes phytoplankton sampling event. The same field sample will also be analyzed in duplicate.

Sampling precision will be estimated by calculating the Relative Percent Difference (RPD) of the replicate sample results:

$$RPD = \frac{|X_1 - X_2|}{(X_1 - X_2)/2} 100$$

Sample precision for microbiological analyses by the membrane filtration method is evaluated using laboratory duplicate data. These laboratory duplicates are prepared by removing aliquots from the sample bottle as two separate samples, and duplicating all steps including preparation of dilutions. Duplicate sample results are evaluated by method 9020B.4 prescribed in *Standard Methods for the Examination of Water and Wastewater*, 19th ed., 1995. Briefly, this requires that the log-transformed difference between the two duplicate results be compared to the mean of the log-transformed differences for the previous 15 sample pairs. The acceptance criterion is to be within 3 standard deviations of this value. Failure to meet the criterion is cause to evaluate the entire sample batch for compliance and applicability of the calculation, before qualifying or rejecting the data set.

3.3.2 Accuracy and Bias

Accuracy is a measure of confidence in the analytical results. The smaller the difference between the measurement and the "true" value, the more accurate the results. The pattern of these differences (typically higher or lower) indicate the amount of bias in the results. Results with high precision and low bias are more accurate than results with high bias and precision or high bias and low precision. Results may still be accurate if they have low bias and precision, but there will tend to be a random scatter of replicate results around the true value. Because we plan to take a single sample to estimate the "true" phytoplankton community composition, it is important that our results have low bias and high precision.

Following standard field protocols for the collection and preservation of the samples will ensure the accuracy and bias of the data. Accuracy and bias will also be assessed by independently verifying the results reported by the phytoplankton specialist. This will involve a review of fixed and mounted slides (or photographs) by an independent phytoplankton specialist. It is recommended that two samples from each lake (one from spring and one from summer) be selected each year for independent verification.

3.3.3 Representativeness

Representativeness is the extent to which measurements actually depict the true population under evaluation.

Field and laboratory sampling techniques proposed for this study should provide data that are representative of phytoplankton populations in the surface 10 m and discrete locations. Critical elements in the collection of representative data include homogenization of samples prior to sub-sampling and accurate measurement of volumes if the samples are concentrated prior to analysis.

3.3.4 Comparability

Comparability is the extent to which data from one study can be compared directly to either historical data or data being collected in another project.

It is not an objective of this study to provide data that are comparable to historical phytoplankton data. However, measures described above to evaluate the quality of the data should provide supporting information that may be used to assess the suitability of the data for comparison to historical information or data collected currently by other investigators.

To evaluate the comparability of chlorophyll *a* data collected with a revised compositing technique, paired sampling will be conducted using the previous and proposed techniques to determine if the two methods give substantially different results. If the results are determined to be comparable, then the proposed compositing technique will be used in the future to collect samples for chlorophyll *a* analysis.

3.3.5 Completeness

Completeness is a measure of the number of samples you must take to be able to use the information, as compared to the number of samples you originally planned to take.

Ideally, implementation of this plan will result in collection of usable data for each proposed sample, including fluorometer data. Generally, sample and data tracking systems in place at the laboratory should ensure that all samples are collected, logged, and transferred to the phytoplankton specialist for analysis. However, where data are not complete, decisions regarding re-sampling and/or re-analysis will be made by a collaborative process involving both data users and data generators.

4.0. SAMPLE COLLECTION AND HANDLING

4.1 Station Positioning

The level to which an environmental sample best represents the point from which it was collected is based not just on good sampling methodology, but also on station positioning accuracy. For major lakes stations, the horizontal accuracy achieved by normal efforts to maintain the boat's position at the designated coordinates will be sufficient, as lake waters will likely be well mixed over a much larger horizontal area. Vertical accuracy at the locations should be as accurate as possible (+/- <0.5 m) Vessel positioning to the prescribed station coordinates are entered into both the KCEL's LIMS and the shipboard DGPS laptop computer or Garmin system. Vessel positioning details are included in the lab's standard operating procedure (SOP) SOP #02-02-003-001. Sampling station coordinates are presented in Table 2.

Table 2. Washington North State Plane coordinates and descriptions for the current Major Lakes sampling locators.

Locator	xplan	yplan	Locator Description
Lake Union			
0512	1255339	246408	SHIP CANAL/ABOVE LOCKS
0518	1266598	239969	SHIP CANAL/FREMONT BRDG/NR FREMONT BRDG
A522	1269458	234484	LAKE UNION//DEPTH PROFILE STATION, NEAR WEST SHORE, SAME AS 0522
0536	1273447	241871	SHIP CANAL/I5 BRDG/JUST UNDER I-5 HIST STA. SMPLD IN 86 FOR UN/CSO STUDY
0540	1277624	239584	SHIP CANAL/MONTLAKE BRDG/MONTLAKE BRIDGE
Lake Sammamish			
0611	1332787	229664	LAKE SAMMAMISH//1/3 WIDTH OF LAKE NORTHEAST OF INGLEWOOD
0612	1328938	218211	LAKE SAMMAMISH/MID-LAKE/1/3 WIDTH OF LAKE FROM EAST SHORE, IN LINE WITH SE 20TH
0614	1335828	207560	LAKE SAMMAMISH/SOUTH END/NEAR ISSAQUAH CREEK
M621	1332363	221797	'NEW' PINE LAKE CREEK
0622	1335545	226881	LAKE SAMMAMISH/OFF MOUTH OF GEORGE DAVIS CREEK
0625	1326620	240581	LAKE SAMMAMISH/MOUTH OF SLOUGH
Lake Washington			
0804	1286684	275701	LAKE WASHINGTON/NORTH END/MID BAY BETWEEN 0802 & 0803
0807	1299348	258018	LAKE WASHINGTON/JUANITA BAY/MID BAY BETWEEN 0806 & 0808
0814	1300829	241382	LAKE WASHINGTON/YARROW BAY/SOUTH END
0817	1286727	256754	LAKE WASHINGTON/MATTHEWS BEACH/NEAR THORNTON CREEK
0826	1295117	253655	LAKE WASHINGTON//MID LAKE NORTH - OFF SAND POINT

0829	1298737	186780	LAKE WASHINGTON/SOUTH END/NEAR BOEING RAMP
0831	1297997	191250	LAKE WASHINGTON//MID-LAKE SOUTH
0832	1304926	212424	LAKE WASHINGTON/NEWPORT YACHT BASIN/NEAR COAL CREEK
0834	1300386	225645	LAKE WASHINGTON/MEYDENBAUER BAY/NEAR MEYDENBAUER PARK
0840	1301296	199531	LAKE WASHINGTON
0852	1286567	235474	LAKE WASHINGTON/OFF MADISON PARK S OF 520 BR. EDMONSON SITE
0890	1286489	213199	LAKE WASHINGTON/ S OF I-90 BR
4903	1287443	194030	CSO-LAKE WASHINGTON//COMBINED SEWER OVERFLOW AT HENDERSON ST

4.2 Field Procedures

After arriving on station, two processes will begin simultaneously. The water column will be monitored for water temperature, pH, specific conductivity and dissolved oxygen at specific depths using a Hydrolab multiprobe system, while representative water samples (described below) are being collected. Samples will be collected using either a SBE 25 Sealogger CTD rosette in lakes Union and Washington, Niskin bottles, a Scott bottle or a plastic hose. Secchi transparency measurements will be collected. These results and other field observations may be recorded using fieldsheets (described below), a Hydrolab datalogger, and/or a laptop computer.

Following collection, water samples will be immediately split into appropriate sample containers. Where required, field QC samples will also be collected. Samples will be transported to the KCEL as designated in SOP #02-02-003-001.

4.3 Sampling Equipment, Maintenance and Calibration

4.3.1 Sampling Equipment

4.3.1.1 Routine Ambient

- Set of sample bottles
- Fieldsheets with a clipboard and waterproof pens
- Scott bottles
- Hydrolab with calibrated sonde and datalogger
- Ice chest w/ ice and barrier
- Field clothes and safety gear

4.3.1.2 Quarterly Trace Metals and Trace Organics

- Set of acid-washed double-bagged Teflon sample bottles (for Hg-CVAF)
- Set of acid-washed double-bagged Trace Metals sample bottles (ICP-MS and Hardness only)

- Set of Trace Organics bottles
- Niskin-X sampling bottles for low-level metals sample collection. Niskin bottles for organics sample collection
- Fieldsheets with a clipboard and waterproof pens
- Shoulder-length "Sta-Dri poly gloves"
- "Certi Clean" Co-Polymer gloves
- Ice chest w/ ice and barrier
- Field clothes and safety gear
- 4 Liters of RO water for 'clean' metals sampling.

4.3.2 Maintenance

Sampling bottles require damage monitoring of monofilament, rubber springs and stoppers and are to be replaced when necessary. Triggering mechanisms require adjustment of springs and allen screws. Hydrolabs require daily calibration and periodic dissolved oxygen (DO) probe membrane replacement. Hydrolab probes must be stored in a high humidity environment.

4.4 Field Parameters

Field parameters will be collected using calibrated multi-parameter probes such as a Hydrolab. These probes require calibration prior to sampling runs. Instructions are included in "Attended Hydrolab Multiprobe Operation" SOP #02-01-005-002. Depths at which data will be recorded will be estimated from metric calibration on the probe cables, but actual sampling depths will be determined by the depth indicators on the multiprobes.

Samples will be collected as close to the specified depths as field conditions allow, and no more than 0.5 m above or below the specified collection depths.

Water sample collection for lab analysis will follow the same depth requirements and will be collected as close as possible to the depths at which field data is collected, with an acceptable range of +/- <0.5 m. Field measurements will typically be recorded on a datalogger in a manner that easily identifies the information as analytical data. All hand-written entries will be recorded in waterproof, indelible ink.

Table 3. Field Parameters /Methods

Parameter Name	Method
Sample Temperature, Field	Hydrolab
Dissolved Oxygen, Field	Hydrolab
Conductivity, Field	Hydrolab
pH, Field	Hydrolab
Time, Field	Hydrolab
Sample depth	Hydrolab
Specific conductance (same as Conductivity, Field)	Hydrolab
Secchi Depth	Secchi Disk

See King County Environmental Lab's "Attended Hydrolab Multiprobe Operation" Standard Operating Procedures (SOP) #02-01-005-002. One vertical profile field replicate per day (or 5%, whichever is most frequent) should be analyzed to assess precision of the temperature, dissolved oxygen, conductivity and pH sensors. If any of the parameters are found to be outside of control limits, the sensors must be recalibrated before further use. Upon returning to the lab, a post-run calibration check of dissolved oxygen, conductivity and pH should be completed and documented in the Hydrolab QC notebook. If QC results are found to be outside of control limits, results may be qualified according to standards documented in KCEL's Quality Assurance Manual. Hydrolab data are stored in the data logger and are written on the fieldsheet.

Table 4. Hydrolab QC Requirements

Analyte	Replicate RPD	Check Standard % Recovery	Post Run % Recovery
Dissolved Oxygen	20%	N/A	96 – 104*
Specific Conductivity	10%	90 – 110	90 – 110
pH	0.2 units	± 0.2 units	± 0.2 units
Temperature	0.3 units	N/A	N/A

4.5 Sample Containers, Holding Times and Storage Requirements

Collection of water samples from freshwater lakes follows procedures outlined in *STANDARD OPERATING PROCEDURE for Sampling Methods for Lakes Water Column*, SOP #02-02-003-001, implemented: June 2003. This SOP describes both sample collection and associated field measurement techniques in Lake Washington, Lake Union and the Ship Canal, and Lake Sammamish. Other freshwater monitoring programs associated with the Major Lakes program may have specific procedures and/or analyte requirements; consequently, guidelines contained in this SAP should be used in conjunction with project-specific guidance, where appropriate.

4.5.1 Conventionals Parameters

Conventional parameters include ammonia nitrogen, nitrate/nitrite nitrogen, *ortho*-phosphorus, silica, total phosphorous, total nitrogen, total suspended solids, alkalinity, chlorophyll *a*, phaeophytin *a*, turbidity, total organic carbon and dissolved organic carbon. Once collected, all samples are kept in a cooler on ice until delivery to the lab. Conventional parameters analyzed on a routine basis are presented in Table 5.

Table 5. Conventional Parameters, Sample Containers and Holding Times

Analyte	Container	Holding Times
Ammonia Nitrogen	125 mL HDPE CWM	2 days (1,2,3)
Nitrate/Nitrite Nitrogen	125 mL HDPE CWM	2 days (1,2,3)
Total Nitrogen	125 mL HDPE CWM	2 days (5)
ortho Phosphorus	125 mL HDPE CWM	2 days (1,3)
Total Phosphorous	125 mL HDPE CWM	2 days (5)
Alkalinity	500 mL HDPE CWM	14 days
Silica	125 mL HDPE CWM	28 days (3,4,8)
Total Suspended Solids	1 L HDPE CWM	7 days
Turbidity	500 mL HDPE CWM	2 days
Chlorophyll a	1 L HDPE, AWM	1 day (1,6)
Phaeophytin *a*	1 L HDPE, AWM	1 day (1,6)
Total Organic Carbon	40 mL Amber Glass VOA	2 days (7)
Dissolved Organic Carbon	125 mL Amber HDPE CNM	2 days (1,7)

Notes:
Collect one of each bottle type except collect two amber VOA bottles for TOC.

(1) Must be filtered through a 0.45 micron filter ASAP or within 1 day of collection.
(2) Filtered samples may be preserved with sulfuric acid to a pH < 2. Maximum holding time for preserved samples is 28 days. Samples must be analyzed or preserved within 2 days of collection.
(3) Filtered samples may be preserved by freezing at –20° C. Maximum holding time for frozen samples is 14 days.
(4) Samples must be near room temperature prior to filtration.
(5) Digestate has a 28-day holding time in 20 mL glass tubes.
(6) Following filtration, the filters may be stored in acetone in the freezer for up to 28 days.
(7) Samples are preserved with 0.1 mL of phosphoric acid within 1 day of collection, adding 24 days to holding time.
(8) Silica must be filtered prior to analysis, but not necessarily within 1 day as in (1).

Chlorophyll *a* and phaeophytin *a* samples will be collected using the site-specific collection method identified in Table 6. These methods include either the integrated composite or the discrete surface sample as described below. In addition, *in situ* profiling will be conducted at every five meter depth (from 1 meter to just above the bottom) at station 0852.

Table 6. Chlorophyll *a* and phaeophytin *a* locators and their site specific sample collection methods.

Locator	Integrated Composite	**Discrete Surface**
0804		**X**
0807		**X**
0814		**X**
0817		**X**
0826	X	
0829		**X**
0831	X	
0832		**X**
0834		**X**
0840	X	
0852[a]	X	
0890	X	
04903		**X**
0611	X	
0612	X	
0614		**X**
0617		**X**
0621		**X**
0622		**X**
0625		**X**
0512		**X**
0518		**X**
A522	X	
0536		**X**
0540		**X**

Notes:

a- additional discrete samples will be collected at every five meters for in-situ profiling at 0852.

4.5.1.1 Integrated Composite Sample Collection

Vertically integrated composite samples are collected using a weighted length of ¾-inch tygon tubing let down vertically through the water column as done for the Routine Major Lakes sampling program. This tube is marked so that when fully extended, the distance from the mark at the water surface to the end of the tube is 10 m. The tube is plugged at the surface and at the

submerged end by a check valve and retrieved. The tube contains a vertically integrated sample of the lake from surface to 10 meters.

4.5.1.2 Discrete Surface Sample Collection

Discrete surface samples are grab samples collected 1 m below the water surface using Scott bottles or Niskin bottles on the CTD rosette.

4.5.2 Microbiology

Microbiology parameters analyzed on a routine basis include *Escherichia coli* and fecal coliform bacteria. Note prior to 2003, samples were also routinely analyzed for enterococcus bacteria. Microbiology samples are kept in a cooler at 4° C (± 2° C) and used in full during analysis. Longer-term sample storage is not required. Extra sample volume is collected at a rate of 10% for QC purposes.

Table 7. Microbiology Parameters, Sample Containers, and Holding Times

Analyte	Container	Holding Times
Escherichia coli	500 mL PP, Sterile	24 hours
Fecal coliforms	500 mL PP, Sterile	24 hours

Notes:

Collect one bottle for both parameters. One in ten samples should be collected in a 1-liter bottle for QC purposes.

4.5.3 Trace Organics

Trace organics parameters will be analyzed on a quarterly basis, and may include the following analyses: base/neutral/acid extractable semivolatile compounds (BNAs), chlorinated pesticides, polychlorinated biphenyls (PCBs), endocrine disrupting compounds (EDC and EDC-LVI), organophosphorus pesticides and chlorinated herbicides. A total of six one-liter and one 125-mL containers will be collected if all listed analyses are conducted. At the locator selected for laboratory QC, 9 extra one-liter bottles and three extra 125-mL bottles will be collected. Storage is in a cooler at 4° C without chemical preservation. Trace organics sampling will be coordinated with other surface water Organics or EDC studies that may be conducted simultaneously by KCDNR. Details of these studies will be included in SAPs such as the Major Lakes Monitoring Program Endocrine Disrupting Compounds Survey SAP.

http://dnrlab-web/saps/current/swamp/MajorLakesEDCSAPfinal18JUN2004.doc

Table 8 lists parameters, sample container requirements and holding times for requested organics analyses.

Table 8. Trace Organics Sample Containers and Holding Times

Analysis	Container	Holding Times

BNAs/EDCs	2 L glass ANM	7 days to extract, 40 days to analyze
EDC-LVI	1 L glass ANM	7 days to extract, 40 days to analyze
Chlorinated Pesticides	1 L glass ANM	7 days to extract, 40 days to analyze
PCBs	1 L glass ANM	7 days to extract, 40 days to analyze
Organophosphorus Pesticides	1 L glass ANM	7 days to extract, 40 days to analyze
Chlorinated Herbicides	125 mL glass ANM	7 days to extract, 40 days to analyze

Notes:

Collect a total of 6 1-liter glass ANM bottles. An additional 9 bottles for MS and MSD are to be collected at a selected site during each event. An extra three 125 mL ANM are to be collected as well.

ANM – Amber narrow mouth

4.5.4 Trace Metals

Trace metal samples will be collected on a quarterly basis. All samples for trace metals analysis are collected or split into 500 mL double-bagged, acid-washed sample storage containers (Table 9). Samples are kept in a cooler on ice during transport from the field and are filtered and preserved at the laboratory.

Quarterly samples collected for total and dissolved trace mercury (Hg by CVAF methodology) will be analyzed by the KCEL. Hardness will be calculated. Development of specific sampling of trace metals will be part of the annual workplan process and will specifically address the sampling locations, methodology and detection limits.

Table 9. Trace Metals Parameters Sample Containers and Holding Times

Total and Dissolved Metals by ICP-MS	500 mL HDPE[a], acid washed, double bagged	180 days
Total and Dissolved Mercury	500 mL fluoropolymer, acid washed, double bagged	90 days
Hardness (calculated)	500 mL HDPE[a]	180 days

a- HDPE – High density polyethylene

4.6 Delivery of Samples to the Lab

Samples should be delivered to the analytical laboratory immediately after completion of sampling. This minimizes the number of people handling samples and protects sample quality and security. All samples are to be placed in a cooler with ice and a plastic barrier. This will keep the samples at or near 4° C until they arrive at the lab.

At the analytical laboratory, the sample manager should oversee:

- Receipt of samples,
- Maintenance of sample management records,
- Maintenance of sample tracking logs,
- Distribution of samples for laboratory analyses, and
- Supervision of labeling and log keeping.

4.7 Sample Documentation

This section provides guidance for documenting sampling and data gathering activities. The documentation of field activities provides important project information that can support data generated by laboratory analyses.

4.7.1 Fieldsheets

Fieldsheets are created in LIMS with the sample locators, sample numbers and collect dates, and are printed on 'Rite in the Rain' Paper recorded in indelible ink. Unique sample numbers will be assigned to each sampling location for which sediment, surface water and benthic community samples are collected. Sample numbers will be assigned prior to the sampling event and waterproof labels generated for each sample container. Each station has a set of field observation parameters that must be filled in by field personnel. These may include "fieldsheet" parameters such as PERSONNEL, SAMP DEPTH, SAMP FUNC, SAMP METH, STORM/NON and TIME.

Hydrolab parameters, not typically included on fieldsheets, will be entered into LIMS following logging to the datalogger. These include SAMPLE DEPTH, COND, FIELD; DO, FIELD; pH, FIELD and SAMP TEMP. Any field observations should be written on fieldsheets at the time of observation. Secchi depths will be recorded for each sampling location, including field replicates (FREPS), on the field sheets. Additional information that may be recorded on the field sheets includes sampling methodology, time of sample collection, and any deviations from established sampling protocols. Additional anecdotal information pertaining to observations of unusual sampling events, wildlife observations, unusual human activity or circumstances may also be recorded on the field sheets.

4.7.2 Hydrolab QC sheets

This form is intended for documentation of Hydrolab QC samples. This includes initial calibration, continuing calibration verification, replicates, duplicates and post-run calibration check. The analyst will include calibration and analysis date, standard lot numbers and concentrations, instrument readings, recovery calculations and initials.

4.7.3 Hydrolab logbooks

All maintenance and instrument work should be noted in the logbooks. Each entry is to be dated and signed

4.7.4 Chain-of-Custody Procedures

Field chain-of-custody procedures will be followed from the time a sample is collected until it is relinquished to the analytical laboratory. Laboratory supplied field sheets with appropriate signatures and dates will be used to document chain-of-custody in the field. Information on the fieldsheet will include sample number, date of sampling, name of the sampling personnel relinquishing the samples and requested analyses.

A sample will be considered to be "in custody" when in the possession of sampling personnel or in a secured sampling area such as onboard the research vessel while not docked. Samples will not be considered in custody when left unattended onboard the vessel while docked or in an unlocked field vehicle. Custody seals will be placed on the sample cooler when it is not in the custody of a member of the sampling team.

Chain-of-custody will be maintained throughout the analytical phase of the project according to standard KCEL protocols and any subcontracting laboratory SOPs.

5.0. LABORATORY ANALYTICAL METHODS

Adherence to standardized analytical protocols and associated QA/QC guidelines for both chemical and biological testing will help produce data able to undergo the rigors of data analysis and meet project goals and objectives. The completeness and comparability of a data set may be enhanced by following a standard set of protocols for analyzing samples. Analysis of a prescribed set of laboratory QC samples will allow a data set to be evaluated in terms of precision, accuracy and bias. This section describes analytical methodologies and associated QA/QC protocols that will be employed during analysis of water for the Major Lakes program, along with associated detection limits where appropriate.

5.1 Methods

Methods used should conform to those outlined in *Standard Methods for the Examination of Water and Wastewater* (APHA 1998) or other appropriate references.

The method detection limit (MDL) is defined as that concentration at which an analyte can reliably be detected. The reporting detection limit (RDL) is defined as that concentration at which an analyte can reliably be quantified. The King County Environmental Laboratory will perform all analyses unless otherwise noted.

5.1.1 Conventionals Parameters

Conventional parameters analyzed on a routine basis are presented in Table 10. The Conventional Chemistry unit will subcontract all samples that cannot be done in-house. Routine parameters will not be scheduled for subcontracting.

Table 10. Conventional Parameters, Methods, Detection Limits and Units

Analyte	Method	MDL	RDL	Units
Ammonia Nitrogen	SM4500-NH3-G	0.01	0.02	mg/L
Nitrate/Nitrite Nitrogen	SM4500-NO3-F	0.02	0.04	mg/L
Total Nitrogen	SM4500-N-C	0.05	0.1	mg/L
ortho Phosphorus	SM4500-P-F	0.002	0.005	mg/L
Total Phosphorous	SM4500-P-B, F MOD	0.005	0.01	mg/L
Alkalinity	SM2320-B (4C)	0.2	10	mg $CaCO_3$/L
Silica	Whitledge, 1981	0.05	0.1	mg/L
Total Suspended Solids	SM2540-D	0.5	1.0	mg/L
Turbidity	SM2130-B	0.5	2.0	NTU
Chlorophyll a	EPA 446.0	0.5	1.	µg/L
Phaeophytin *a*	EPA 446.0	1.0	2.	µg/L
Total Organic Carbon	SM5310-B	0.5	1.0	mg/L
Dissolved Organic Carbon	SM5310-B	0.5	1.0	mg/L

5.1.2 Microbiology

Microbiology parameters analyzed on a routine basis include *Escherichia coli* and fecal coliform bacteria. Note prior to 2003, samples were also routinely analyzed for enterococcus bacteria.

Table 11. Microbiology Parameters, Sample Containers, Holding Times, Methods, Detection Limits and Units

Analyte	Method	MDL
Escherichia coli	SM9213D, 20th ed.	1 CFU/100 mL
Fecal coliforms	SM9222D, 20th ed.	1 CFU/100 mL

Notes:

Collect one bottle for both parameters. One in ten samples should be collected in a 1-liter bottle for QC purposes.

5.1.3 Trace Organics

Table 12 lists the MDLs and RDLs calculated for a 1 liter sample concentrated to a final volume of 0.5 mlliliters for the BNA, EDC, EDC-LVI, Pesticide, and PCB analytes. The MDLs and RDLs may vary due to sample volumes of greater than or less than 1 liter. MDLs and RDLs will change if a dilution is required to analyze the sample. The EDCs listed in Table 11. Table 13 lists the Estrogenic EDCs only, which are analyzed by GC/MS using EPA 8270C, in the SIM mode. The products for analyses are: BNASURLL-GW, EDC, PESTLL, PCBLL, OPPEST-SHORT, EDC-LVI, and HERB. Note Tentatively Identified Compounds (TICs) will not be reported. Chlorinated herbicide analysis (HERB) is subcontracted to Severn Trent Laboratories (STL).

Table 12. Trace Organic Parameters, Methods, Detection Limits and Units

Analyte	Method (Preparation/Analysis)	MDL (µg/L)	RDL (µg/L)
1,2,4-Trichlorobenzene	EPA 3520C/8270C	0.025	0.050
1,2-Dichlorobenzene	EPA 3520C/8270C	0.025	0.050
1,2-Diphenylhydrazine	EPA 3520C/8270C	0.025	0.050
1,3-Dichlorobenzene	EPA 3520C/8270C	0.025	0.050
1,4-Dichlorobenzene	EPA 3520C/8270C	0.025	0.050
2,4,5-Trichlorophenol	EPA 3520C/8270C	0.250	0.500
2,4,6-Trichlorophenol	EPA 3520C/8270C	0.250	0.500
2,4-Dichlorophenol	EPA 3520C/8270C	0.05	0.1
2,4-Dimethylphenol	EPA 3520C/8270C	0.025	0.050
2,4-Dinitrophenol	EPA 3520C/8270C	0.250	1.00
2,4-Dinitrotoluene	EPA 3520C/8270C	0.250	0.500

Table 12. Trace Organic Parameters, Methods, Detection Limits and Units

Analyte	Method (Preparation/Analysis)	MDL (µg/L)	RDL (µg/L)
2,6-Dinitrotoluene	EPA 3520C/8270C	0.250	0.500
2-Chloronaphthalene	EPA 3520C/8270C	0.025	0.050
2-Chlorophenol	EPA 3520C/8270C	0.025	0.050
2-Methylnaphthalene	EPA 3520C/8270C	0.025	0.050
2-Methylphenol	EPA 3520C/8270C	0.025	0.050
2-Nitroaniline	EPA 3520C/8270C	0.250	0.500
2-Nitrophenol	EPA 3520C/8270C	0.100	0.200
3,3'-Dichlorobenzidine	EPA 3520C/8270C	0.100	0.200
3-Methylphenol	EPA3520C/8270C	0.050	0.100
3-Nitroaniline	EPA 3520C/8270C	0.250	0.500
4,6-Dinitro-O-Cresol	EPA 3520C/8270C	0.250	1.000
4-Bromophenyl Phenyl Ether	EPA 3520C/8270C	0.050	0.100
4-Chloro-3-Methylphenol	EPA 3520C/8270C	0.125	0.250
4-Chloroaniline	EPA 3520C/8270C	0.050	0.100
4-Chlorophenyl Phenyl Ether	EPA 3520C/8270C	0.050	0.100
4-Methylphenol	EPA 3520C/8270C	0.050	0.100
4-Nitroaniline	EPA 3520C/8270C	0.250	0.500
4-Nitrophenol	EPA 3520C/8270C	0.250	0.500
Acenaphthene	EPA 3520C/8270C	0.010	0.020
Acenaphthylene	EPA 3520C/8270C	0.010	0.020
Aniline	EPA 3520C/8270C	0.025	0.050
Anthracene	EPA 3520C/8270C	0.010	0.020
Atrazine	EPA 3520C/8270C	0.250	0.500
Benzo(a)anthracene	EPA 3520C/8270C	0.010	0.020
Benzo(a)pyrene	EPA 3520C/8270C	0.010	0.020
Benzo(b)fluoranthene	EPA 3520C/8270C	0.010	0.020
Benzo(g,h,i)perylene	EPA 3520C/8270C	0.010	0.020
Benzoic Acid	EPA 3520C/8270C	0.250	0.500
Benzo(k)fluoranthene	EPA 3520C/8270C	0.010	0.020
Benzyl alcohol	EPA 3520C/8270C	0.100	0.200
Benzyl Butyl Phthalate	EPA 3520C/8270C	0.050	0.100
Bis(2-Chloroethoxy)Methane	EPA 3520C/8270C	0.025	0.050
Bis(2-Chloroethyl)Ether	EPA 3520C/8270C	0.025	0.050
Bis(2-Chloroisopropyl)Ether	EPA 3520C/8270C	0.025	0.050
Bis(2-ethylhexyl)Phthalate	EPA 3520C/8270C	0.025	0.050

Table 12. Trace Organic Parameters, Methods, Detection Limits and Units

Analyte	Method (Preparation/Analysis)	MDL (µg/L)	RDL (µg/L)
Caffeine	EPA 3520C/8270C	0.025	0.050
Carbazole	EPA 3520C/8270C	0.025	0.050
Chrysene	EPA 3520C/8270C	0.010	0.020
Coprostanol	EPA 3520C/8270C	1.00	2.00
Diazinon	EPA 3520C/8270C	0.050	0.100
Dibenzo(a,h)anthracene	EPA 3520C/8270C	0.010	0.020
Dibenzofuran	EPA 3520C/8270C	0.025	0.050
Diethyl Phthalate	EPA 3520C/8270C	0.025	0.050
Dimethyl Phthalate	EPA 3520C/8270C	0.025	0.050
Di-N-Butyl Phthalate	EPA 3520C/8270C	0.025	0.050
Di-N-Octyl Phthalate	EPA 3520C/8270C	0.025	0.050
Fluoranthene	EPA 3520C/8270C	0.010	0.020
Fluorene	EPA 3520C/8270C	0.010	0.020
Hexachlorobenzene	EPA 3520C/8270C	0.025	0.050
Hexachlorobutadiene	EPA 3520C/8270C	0.050	0.100
Hexachlorocyclobutadiene	EPA 3520C/8270C	0.250	0.500
Hexachloroethane	EPA 3520C/8270C	0.050	0.100
Indeno(1,2,3-cd)Pyrene	EPA 3520C/8270C	0.010	0.020
Isophorone	EPA 3520C/8270C	0.050	0.100
Naphthalene	EPA 3520C/8270C	0.010	0.020
Nitrobenzene	EPA 3520C/8270C	0.025	0.050
N-Nitrosodimethylamine	EPA 3520C/8270C	0.025	0.050
N-Nitrosodi-N-Propylamine	EPA 3520C/8270C	0.050	0.100
N-Nitrosodiphenylamine	EPA 3520C/8270C	0.025	0.050
Pentachlorophenol	EPA 3520C/8270C	0.250	0.500
Phenanthrene	EPA 3520C/8270C	0.010	0.020
Phenol	EPA 3520C/8270C	0.025	0.050
Pyrene	EPA 3520C/8270C	0.010	0.020
Pyridine	EPA 3520C/8270C	0.050	0.100
Simazine	EPA 3520C/8270C	0.250	0.500
Total 4-Nonylphenol	EPA 3520C/8270C	0.250	0.500
Vinclozolin	EPA 3520C/8270C	0.125	0.250
Bisphenol A	EPA 3520C/8270C	0.050	0.100
Chlordecone	EPA 3520C/8270C	0.250	0.500
Bis(2-ethylhexyl) adipate	EPA 3520C/8270C	0.050	0.100

Table 12. Trace Organic Parameters, Methods, Detection Limits and Units

Analyte	Method (Preparation/Analysis)	MDL (µg/L)	RDL (µg/L)
Testosterone	EPA 3520C/8270C	0.250	0.500
Methyltestosterone	EPA 3520C/8270C	0.250	0.500
Progesterone	EPA 3520C/8270C	0.250	0.500
4,4'-DDD	EPA 3520C/608	0.005	0.010
4,4'-DDE	EPA 3520C/608	0.005	0.010
4,4'-DDT	EPA 3520C/608	0.005	0.010
Aldrin	EPA 3520C/608	0.005	0.010
Alpha-BHC	EPA 3520C/608	0.005	0.010
Beta-BHC	EPA 3520C/608	0.005	0.010
Chlordane (α and γ)	EPA 3520C/608	0.005*	0.010*
Delta-BHC	EPA 3520C/608	0.005	0.010
Dieldrin	EPA 3520C/608	0.005	0.010
Endosulfan I	EPA 3520C/608	0.005	0.010
Endosulfan II	EPA 3520C/608	0.005	0.010
Endosulfan Sulfate	EPA 3520C/608	0.005	0.010
Endrin	EPA 3520C/608	0.005	0.010
Endrin Aldehyde	EPA 3520C/608	0.005	0.010
γ-BHC (Lindane)	EPA 3520C/608	0.005	0.010
Heptachlor	EPA 3520C/608	0.005	0.010
Heptachlor Epoxide	EPA 3520C/608	0.005	0.010
Methoxychlor	EPA 3520C/608	0.025	0.050
Toxaphene	EPA 3520C/608	0.050	0.100
Aroclor 1016	EPA 3520C/608	0.050	0.100
Aroclor 1221	EPA 3520C/608	0.050	0.100
Aroclor 1232	EPA 3520C/608	0.050	0.100
Aroclor 1242	EPA 3520C/608	0.050	0.100
Aroclor 1248	EPA 3520C/608	0.050	0.100
Aroclor 1254	EPA 3520C/608	0.050	0.100
Aroclor 1260	EPA 3520C/608	0.050	0.100
Chlorpyrifos	EPA 3520C/8270C	0.034	0.050
Diazinon	EPA 3520C/8270C	0.043	0.050
Disulfoton	EPA 3520C/8270C	0.027	0.050
Malathion	EPA 3520C/8270C	0.048	0.050
Parathion-Ethyl	EPA 3520C/8270C	0.045	0.050
Parathion-Methyl	EPA 3520C/8270C	0.036	0.050

Table 12. Trace Organic Parameters, Methods, Detection Limits and Units

Analyte	Method (Preparation/Analysis)	MDL (µg/L)	RDL (µg/L)
Phorate	EPA 3520C/8270C	0.033	0.050
2,4,5-T	EPA 8151A (GCMS Mod.)	0.0556	0.16
2,4,5-TP (Silvex)	EPA 8151A (GCMS Mod.)	0.0227	0.08
2,4-D	EPA 8151A (GCMS Mod.)	0.0296	0.08
2,4-DB	EPA 8151A (GCMS Mod.)	0.0577	0.16
Dalapon	EPA 8151A (GCMS Mod.)	0.0124	0.08
Dicamba	EPA 8151A (GCMS Mod.)	0.0221	0.08
Dichloroprop	EPA 8151A (GCMS Mod.)	0.0114	0.08
Dinoseb	EPA 8151A (GCMS Mod.)	0.0292	0.08
MCPA	EPA 8151A (GCMS Mod.)	0.0114	0.08
MCPP	EPA 8151A (GCMS Mod.)	0.0134	0.08

Table 13. Specific Hormones (EDC-LVI) analyzed by low level GC/MS

Hormone	MDL (ug/L)	RDL (ug/L)
Estradiol	0.0005	0.005
Estrone	0.0003	0.005
Ethynyl estradiol	0.0005	0.005

The hormones listed in Table 13 will be analyzed by KCEL SOP entitled *Analysis of Estrogenic Endocrine Disrupting Compounds TMS derivatives by GC/MS-LVI*. The reference for this method is Ternes (2002), which was published in Analytical Chemistry, Vol.74 No. 14 (2002). The KCEL SOP/method code is Ternes (2002) 07-03-022-D. The product name for samples to be analyzed by this test is EDC-LVI.

5.1.4 Trace Metals

Trace metal parameters will be analyzed on a quarterly basis, and include cadmium, chromium, copper, lead, mercury, nickel and zinc (Table 14). All samples are filtered and preserved at the laboratory. Samples for dissolved metals parameters are filtered through 0.45 µm membrane filters as soon as possible after collection and prior to preservation. Samples for total and dissolved metals parameters are acid preserved to pH <2 and stored at room temperature. Filtration and preservation must be completed within 24 hours of collection.

Quarterly samples collected for total and dissolved trace mercury (Hg by CVAF methodology) will be analyzed by the KCEL. Hardness will be calculated, which requires analysis of calcium and magnesium by ICP methodology. Development of specific sampling of trace metals will be

part of the annual workplan process and will specifically address the sampling locations, methodology and detection limits.

Table 14. Trace Metals Parameters, Methods, Detection Limits and Units

Analyte (Total and Dissolved Metals)	Method	MDL (µg/L)	RDL (µg/L)
Arsenic	EPA Method 200.8	0.2	1
Cadmium	EPA Method 200.8	0.02	0.1
Chromium	EPA Method 200.8	0.1	0.5
Copper	EPA Method 200.8	0.2	0.1
Hardness[a]	SM 2340B edit. 19	0.2	1.25
Lead	EPA Method 200.8	0.05	0.25
Mercury	EPA Method 1631E (CVAF)	0.0002	0.0005
Nickel	EPA Method 200.8	0.1	0.5
Zinc	EPA Method 200.8	0.3	1.5

[a]Hardness is calculated on the total portion only; the MDL/RDL units are mg of CaCO3/L

** MDL or RDL listed is for ICP-MS using the preconcentration method (also used for SWAMP)

5.2 Quality Control Requirements

5.2.1 Conventionals

Laboratory QC samples for conventional analyses and associated control limits are summarized in the following table. These QC samples will be analyzed at a frequency of one per analytical batch or a minimum of one per 20 analytical samples.

Table 15. Conventional QC Requirements

Analysis	Method Blank	Duplicate RPD	Spike Blank or LCS % Recovery	Matrix Spike % Recovery
Ammonia Nitrogen	< MDL	20%	85 – 115	75 – 125
Nitrate/Nitrite Nitrogen	< MDL	20%	85 – 115	75 – 125
ortho Phosphorus	< MDL	20%	85 – 115	75 – 125
Silica	<MDL	20%	85 – 115	65 – 120
Total Nitrogen	< MDL	20%	85 – 115	75 – 125
Total Phosphorus	< MDL	20%	85 – 115	75 – 125

Total Suspended Solids	< MDL	25%	80 – 120	N/A
Alkalinity	N/A	10%	85 – 115	N/A
Chlorophyll *a*	<MDL	25%	90 – 110	N/A
Phaeophytin *a*	<MDL	50%	N/A	N/A
Turbidity	N/A	20%	90 – 110	N/A
Total Organic Carbon	< MDL	20%	85 – 115	75 – 125
Dissolved Organic Carbon	< MDL	20%	85 – 115	75 – 125

5.2.2 Microbiology

Laboratory QC samples for microbiology analyses and associated control limits are summarized below. These QC samples will be analyzed at a frequency of one per analytical batch or a minimum of one per 20 analytical samples. Pre- and post-filtration blanks are run at a minimum of one per session.

Positive control organisms are selected to provide the typical reactions exhibited by the target analyte. Negative controls are selected to provide reactions exhibited by non-target analytes. Pre- and post-filtration blanks challenge the system sterility and adequacy of post sample rinsing, respectively.

Table 16. Microbiology QC Requirements

Analysis	Lab Duplicate	Positive Control	Negative Control	Pre/Post Filtration Blanks
Escherichia coli	Pass/Fail*	Pass/Fail	Pass/Fail	Pass/Fail
Fecal coliforms	Pass/Fail*	Pass/Fail	Pass/Fail	Pass/Fail

Notes:

Pass: Meets established guidelines as described in the Associated Standard Operating Procedures .

Fail: Does not meet established guidelines as described in the associated Standard Operating Procedures.

*acceptance limits are determined per the reference method.

5.2.3 Trace Organics

Laboratory QC samples for trace organics analyses and associated control limits are summarized below. These QC samples will be analyzed at a frequency of one per analytical batch or a minimum of one per 20 analytical samples.

Table 17. Trace Organics QC Requirements

Analysis	Method Blank	Blank Spike % Recovery	MS/MSD RPD	Matrix Spike % Recovery	Surrogate % Recovery
BNSURLL-GW and EDC	<MDL	Lab derived limits	Lab derived limits	Lab derived limits	Lab derived limits
Chlorinated Pesticides**	<MDL	Lab derived limits	Lab derived limits	Lab derived limits	Lab derived limits
PCBs**	< MDL	Lab derived limits	Lab derived limits	Lab derived limits	Lab derived limits
Organophosphorus pesticides	< MDL	Lab derived limits	Lab derived limits	Lab derived limits	Lab derived limits
Chlorinated Herbicides***	< MDL	17-136*	22-48*	17-136*	50-135

Notes:

* Low to high range of all compounds used for surrogates and spikes

** CLPestPCB analysis uses the Pesticides matrix spike containing 6 compounds : gamma-BHC, heptachlor, aldrin, dieldrin, endrin and 4,4'-DDT.

*** Chlorinated Herbicide acceptance limits periodically updated by subcontract laboratory. Note, as this is a subcontracted parameter, QC results are not entered into LIMS.

5.2.4 Trace Metals

Laboratory quality control (QC) samples for trace metals analysis and associated control limits are summarized below. These QC samples will be analyzed at a frequency of one per analytical batch or a minimum of one per 20 analytical samples.

Table 18. Trace Metals QC Requirements

Analysis	Method Blank	Blank Spike % Recovery	Filter Blank	Duplicate RPD	SRM % Recovery	Matrix Spike % Recovery
CVAF Mercury	<MDL	77-123	<MDL	24%*	80-120	71 – 125
Hardness (ICP)	< MDL	85-115	< MDL	20%	80-120	70-130%
ICP-MS Metals	< MDL	85 - 115	< MDL	20%	80 - 120	80 - 120

Notes;

***** Method 1631 (E) requires MS/MSD analysis. Therefore, the RPD between the MS and MSD is calculated and the limit is 24%. The recovery of each MS and MSD is noted above.

5.2.5 Qualifiers

Quality assurance acceptance criteria are listed on Tables 15 through 18 above. QC results that exceed acceptance limits will be evaluated to determine appropriate corrective action(s). Samples would typically be reanalyzed if the unacceptable QC results indicate a systematic problem with the overall analysis. Unacceptable QC results caused by a particular sample or matrix would not typically require reanalysis unless an allowed method modification would improve the results. Analytical results may be qualified based on the associated QC results. Data qualifier flags and their interpretations are presented in Table 19.

Table 19. Laboratory Data Qualifiers

Qualifier	Description
General	
H	Indicates that a sample handling criterion was not met in some manner prior to analysis. The sample may have been compromised during the sampling procedure or may not comply with holding times, storage conditions, or preservation requirements. The qualifier will be applied to applicable analyses for a sample.
R	Indicates that the data are judged unusable by the data reviewer. The qualifier is applied based on the professional judgment of the data reviewer rather than any specific set of QC parameters and is applied when the reviewer feels that the data may not or will not provide any useful information to the data user. This qualifier may or may not be analyte-specific.
<MDL	Applied when a target analyte is not detected or detected at a concentration less than the associated method detection limit (MDL). MDL is defined as the lowest concentration at which an analyte can be detected. The MDL is the lowest concentration at which a sample result will be reported.
<RDL	Applied when a target analyte is detected at a concentration greater than or equal to the associated MDL but less than the associated reporting detection limit (RDL). RDL is defined as the lowest concentration at which an analyte can reliably be quantified. The RDL represents the minimum concentration at which method performance becomes quantitative and is not subject to the degree of variation observed at concentrations between the MDL and RDL.
E	The E flag, when applied under this general definition, should be used whenever the magnitude of a QC failure or observed interference, unacceptable qualitative response, compromised analysis conditions would indicate the measured response was outside the expected accuracy of the method.
RDL	Applied when a target analyte is detected at a concentration that, in the raw data is equal to the RDL.
TA	Applied to a sample result when additional narrative information is available in the text field. The additional information may help to qualify the sample result but is not necessarily covered by any of the standard qualifiers.
Chemistry	
B	Applied to a sample result when an analyte was detected at a concentration greater than the MDL in the associated batch method blank. The qualifier is applied in Organics analyses when the sample analyte concentration is less than five times the blank concentration and is applied in Conventionals and Metals analysis when the sample concentration is less than ten times the blank concentration. The qualifier indicates that the analyte concentration in the sample may include laboratory contamination. This is an analyte-specific qualifier.
>MR	Applied when a target analyte concentration exceeds the instrument or method capacity to measure accurately. The qualifier is primarily in the organics section. It is applied when the detected analyte concentration exceeds the upper instrument calibration limit and further dilution is not feasible. The reported value is an estimated analyte concentration.
Biology	
AD	Applied to Benthic data when an adult form of an organism was identified in the sample. Benthic samples are subcontracted.
C	Applied to Microbiology data when the sample analysis exhibits confluent growth of organisms. The value reported is an estimate and can be reliably used as an indicator of relative abundance; however, it can not be used as a reliable or accurate count of the associated organism.
D	Applied to Microbiology data to indicate that a target organism was evaluated to be the dominant or largest sub-population recovered from the sample. The evaluation is based on biomass.
E	Applied to microbiological data when a standard method for estimation of microorganisms has been employed during analysis rather than an actual count. The associated value is an estimate, based upon a mathematical extrapolation.
LV	Applied to Benthic data when a larval form of an organism was identified in the sample. Benthic samples are subcontracted.
>#####	Applied when a population count exceeds the method capacity to measure accurately. The qualifier is applied in Microbiology analyses when the population count exceeds the procedural capacity to measure accurately. The number in the qualifier is the highest procedural count possible. A value is not reported for the sample result. The actual population count is at least as great as or greater than the value shown in the qualifier. This qualifier is used only in microbiology.
NF	Applied to Microbiology data to indicate that a target organism was not recovered or identified in a sample.
P	Applied to Microbiology data to indicate that a target organism was recovered or identified in a sample.
PU	Applied is applied to Benthic data when a pupal form of an organism was identified in the sample. Benthic samples are subcontracted.

Qualifier	Description
S	Applied to Microbiology data to indicate that a target organism was evaluated to be the second largest contributory sub-population recovered from the sample. The evaluation is based on biomass.

5.3 Corrective Action Procedures

Individual SOPs describe specific corrective action for each analytical procedure and quality control measure. If QC samples exceed their control limits, the analysis may be repeated, will be documented and affected sample(s) will be qualified if necessary. If samples are lost or compromised, the project manager must determine whether to re-sample or to disregard the station for the specific parameter or event.

5.4 Documentation/Record Keeping

Within the analytical laboratory, each section and analytical procedure has its own documentation protocol. The minimum documentation required in the lab includes an instrument logbook, analysis log, calibration and analysis documentation and LIMS hardcopy sheets.

For all analytical results generated by lab activities, sufficient hardcopy data must be stored such that a reviewer could verify that the requirements of the reference method and SOP were met. The format of stored data may include logbook entries, field notes, benchsheets and printouts of instrument or data files. Storage of only the electronic version of these documents is not sufficient to meet current data storage requirements. Subcontracted tests are to be documented in a similar manner.

5.4.1 Logbooks

Hand written information used as supporting documentation which is not stored directly with analysis results, such as standards preparation records and equipment calibration checks, must be maintained in logbooks. All logbooks must be paginated. Logbooks prepared from instrument printout or other loose pages should be permanently bound prior to storage. Logbook entries should be made using indelible blue or black ink (no pencil), dated and initialed. Logbooks and individual logbook entries must be uniquely identified if they are to be referenced in other documents. All deletions and corrections must be a single line cross-out, accompanied with the date and initials of the person making the correction.

5.4.2 Data Packages

For each run or analysis sequence a data package will be produced which will include all appropriate raw data for standards, samples and QC analyses. Data packages must include the inclusive dates and times of the analyses and the identity of the analyst(s). If corrective actions were taken or a compromised sample was analyzed, the data package will contain a copy of the Corrective Action Form and/or a Compromised Sample Form (or their equivalent). Specific requirements for the contents of data packages are described in each method SOP. The

analyst(s) who generated the data is responsible for compiling the data package and transferring it to the data reviewer. Prior to data review the data packages are organized according to method SOPs. Data packages may reference other data sets or documents rather than requiring each data package to contain copies of all necessary information. All deletions and corrections to handwritten or printed documentation must be a single line cross-out, accompanied with the date and initials of the person making the correction.

5.4.3 Storage of Lab Data

Procedures for the storage and disposal of hardcopy lab data are summarized in King County Environmental Lab's SOP # 11-01-005-000 (Records Storage) which is based on King County and Washington State governmental records storage requirements. It is the policy of the lab to store all data packages, supporting documentation and project records for a minimum of 10 years, based on the date of sample collection or field data measurement. The subcontract lab is responsible for their own record storage, which should be at least 10 years.

In LIMS, final sample and QC data is maintained indefinitely in the EDS database, which is backed up daily. Additional LIMS information specific to sample management is maintained a minimum of 1 year past the date the final results were posted. Other types of electronic data such as instrument files may be stored but no lab-wide policy is currently in place.

5.5 Sample Archiving Requirements

5.5.1 Conventionals

Following completed data entry into LIMS, conventional chemistry samples are to be held for 30 days at 4° C (± 2°) if available storage space allows, then discarded.

5.5.2 Microbiology

Microbiology samples are used in full during analysis. Sample archiving after analysis is not required.

5.5.3 Trace Organics

Trace organics samples are used in full during analysis. Spare sample containers are kept at 4˚ C (+/- 2) until analysis is complete and data is moved in LIMS. All bottles are discarded following analysis and data review.

5.5.4 Trace Metals

Samples are stored at room temperature for 60 days following the reporting of results.

5.5.5 Biological Samples

All biological samples will be preserved and archived for three years, then discarded.

5.6 Sample Disposal

Following analysis, data review, and the appropriate holding period, samples will be disposed of according to section-specific guidelines. Unless deemed hazardous on the basis of sample analysis results, all unpreserved excess raw sample volume can be disposed of down the drain. Samples that are preserved with acid must be neutralized before disposal. This includes all trace metals samples. Any samples that may be found to contain hazardous or toxic chemicals at "hazardous waste" levels must be reported to the section supervisor and the hazardous waste disposal coordinator.

6.0. DATA MANAGEMENT

6.1 Data review, verification and validation requirements

Data reported by the lab, including field measurements and subcontracted analyses, must pass a review process before final results are available to the client. A "Peer Review" process is used where a second analyst or individual proficient at the method reviews the data set. The reviewer will complete a data review checklist which will document the completeness of the data package and if any QC failures exist.

Once data review is complete and all data quality issues have been resolved or corrected, the status of the data in LIMS will be changed to "approved". Once a data set has been approved, it is "posted" or transferred to the portion of the LIMS database known as the Environmental Data System (EDS) where all historical LIMS data are maintained. Signatures or initials of the lab lead and reviewer(s) indicate formal approval of hardcopy data or reports (non-LIMS), typically on the review checklist. A copy of this approved checklist should be stored with the final hardcopy data package.

6.2 Data Storage

Once raw data has been generated by an analytical procedure or from field measurements, the data must be transformed into a format appropriate for the client. For chemistry and selected microbiological parameters, numerical results are entered into LIMS where additional calculations may take place such as conversion of instrumental concentrations to final sample results.

The format used to load data to LIMS and types of calculations done after loading is specified in each method SOP. The adjustment of the number of significant digits and addition of selected data qualifiers is also accomplished by LIMS. For in-lab data loaded to LIMS, automatic calculation of QC results and comparison to acceptance limits is performed by LIMS. However, data for subcontracted samples for chemistry parameters may also entered into the LIMS database. QC results for subcontracted analyses are not entered into LIMS and any data flags must be manually entered.

Data will not be distributed outside each lab unit or to clients until it has met the full definition of final data. "Final Data" is defined as approved data posted to the historical database (EDS) or is otherwise in its final reportable and stored format (if not a LIMS parameter). This implies the data has been appropriately peer reviewed, properly qualified and is in its final format in terms of units and significant figures. Not only is final data assured of a higher level of quality through peer reviewing and qualification, but it will also match any future reports since it has come from the final storage location.

The standard methods for clients to access final data is either through direct electronic access to LIMS (EDS database) or through hard-copy reports and/or electronic files provided by the LPM or their equivalent. Direct client access to the EDS database is controlled by access privileges provided by the Information Systems and Data Analysis unit for individual clients. Data reporting via hardcopy through LPMs must follow the guidelines in King County Environmental Lab's SOP# 11-03-001-001 (*Project Report Review Guidelines*) before being delivered to the client. Electronic files delivered to clients must also follow King County Environmental Lab's SOP # 08-01-001-000 (*Guidelines for Delivering Electronic Lab Data to Customers*).

6.3 Review of Data Qualifiers Applied by the Laboratory.

LPMs and STS planners review final data and provide feedback to the laboratory units.

6.4 Interpretation of Chemistry Data

Chemistry data will be reviewed by STS staff to determine if any elements or compounds are present in concentrations that might indicate potential toxicity to the aquatic community. Surface water chemistry data will be compared by ST staff to one of three possible values according to the following priority:

1. Washington water quality standards for aquatic life, WAC 173-201(A)

2. USEPA ambient water quality criteria for protection of aquatic life (EPA 2002), and

3. Relevant values derived according to the King County Water Quality Effects Process (King County 2002b).

7.0. HEALTH AND SAFETY PLAN

7.1 General Guidelines

The following general health and safety guidelines have been provided in lieu of a specific Health and Safety Plan. These guidelines will be read and understood by all field personnel prior to any sampling activities. Several hazards are inherent to open water sampling. Vehicle safety and specific lake hazards are discussed below.

- Sampling personnel will wear chemical-resistant gloves whenever coming into contact with potentially hazardous water.
- No eating, drinking, smoking or tobacco chewing by sampling personnel will be allowed during active sampling operations.
- All routine sampling operations will be conducted during daylight hours.
- All accidents, "near misses," and symptoms of possible exposure will be reported to the affected individual's supervisor within 24 hours of occurrence.
- All field personnel will be aware of the potential hazards associated with chemicals used during the sampling event.
- All field personnel will follow King County Safety guidelines.
- All crew of the research vessel will have received vessel safety training that will include proper chain of communication, equipment operation and safe boating practices. Level of training will be determined by the KCEL Safety Committee.

7.2 General Vessel Safety

To help prevent accidents and ensure adequate preparation for emergencies that may possibly arise, the following safety equipment will be required on the King County Lab research vessel *Chinook*, *Liberty*, Boston Whaler or Zodiac:

- one personal floatation device for each crew member as well as at least one throwable floatation device;
- an accessible, clearly labeled, fully stocked first-aid/CPR kit;
- an accessible and clearly labeled eye wash;
- one VHF marine radio(s) with weather channel;
- a cellular telephone;

- a horn;
- navigation lights;
- signal flares; and
- a reach pole or shepherd's hook.

7.3 Vehicle Safety

As a provider of various public services, King County holds safe operation above all other performance criteria. All vehicles and equipment will be operated or activities performed in a manner that reflects the highest regard for safety of the public, the employees and the property of our citizens and organization. In the operation of King County vehicles and equipment, every courtesy and consideration should be given to motorists, cyclists and pedestrians with whom we share the streets and highways. No act that endangers the public well being or our employees will be tolerated. Unsafe equipment should be reported to the appropriate vehicle supervisor.

As an employee driving a King County vehicle one should be familiar with and practice the principles of defensive driving – that is, to make every effort to avoid an accident. Always be prepared to yield.

Driving safety depends on good driving attitudes consisting of skillful and defensive driving, obedience to traffic laws and courtesy to other drivers. Driving demands full concentration. The safe driver, in assuming the responsibility of operating a vehicle, knows the rules of the road, focuses full attention on driving and uses techniques that will help avoid emergency situations. All persons operating King County vehicles should at all times drive carefully and prudently, having regard for traffic conditions and all other circumstances.

Drivers may be required to launch and retrieve boats from trailers. Caution should be used maneuvering vehicles when backing into launches. Spotters should be used to provide unobstructed view to drivers. Tie-downs and turn signals on trailers should be checked prior to any trip with trailered boats. Possession of a boat plug should be verified prior to leaving the laboratory.

7.4 Late Check-in

As a part of ESS' safety protocols, one volunteer from the unit is considered the "Late Check-in." This individual will contact all ESS staff prior to the end of the day, typically by cell phone. Once all field personnel are back at the lab, the Late Check-in person's responsibility is complete. If personnel are unaccounted for, the Late Check-in person will continue to attempt to contact the missing personnel until he or she deems it necessary to call the police or other agencies that may help in contacting the missing field staff.

8.0. REFERENCES

American Public Health Association. 1998. Standard Methods for the Examination of Water and Wastewater, 20th ed. , Washington, D.C.

EPA. 1990. Macroinvertebrate Field and Laboratory Methods for Evaluating the Biological Integrity of Surface Waters. U.S. Environmental Protection Agency, Office of Research and Development. EPA/600/4-09/030.

EPA. 2002. National Recommended Water Quality Criteria: 2002. USEPA Office of Water, Office of Science and Technology, November 2002. EPA-822-R-02-047.

King County. 2002. Water Quality Effects Assessment. King County Department of Natural Resources. October 2001.

King County. 2002b. Sampling and Analysis Plan for the Toxic Cyanobacteria in King County Lakes Study. King County Department of Natural Resources and Parks (KCDNR&P), Water and Land Division, Seattle, WA.

King County Department of Transportation. "King County Vehicle Driver's Operating Manual

King County Environmental Lab. "River and Stream Water Sampling" SOP #02-02-004-000.

King County Environmental Lab. "Clean Sampling for Ultra Trace Metals, Trace Organics, Microbiology, and Conventional Chemistry Parameters Using Surface Grabs" SOP #02-02-013-000.

King County Environmental Lab. "Attended Hydrolab Multiprobe Operation" SOP #02-01-005-002.

King County Environmental Lab. "Quality Assurance Manual- most current version".

Washington State Department of Ecology. "Stream Sampling Protocols for the Environmental Monitoring and Trends Section." October 2001

METRO. 1987. Quality of local lakes and streams: 1985-1986 status report. Prepared by Water Resources Section, Water Pollution Control Department, Municipality of Metropolitan Seattle (METRO), Seattle, WA.

PSEP. 1996. *Quality Assurance and Quality Control Guidelines*. Prepared for U.S. Environmental Protection Agency Region 10, Office of Puget Sound, Seattle, WA and Puget Sound Water Quality Authority, Olympia, WA by King County Environmental Laboratory. Seattle, WA.

9.0. GLOSSARY

ANM - Amber narrow mouth

ASAP- As soon as possible

AWM- Amber wide mouth

BC- Blank corrected (sample concentrations corrected to reflect concentrations detected in blanks)

BMPs- Best management practices

BNA- Base/neutral/acid- extractable semivolatile organic compounds

CFU- Colony forming units

CNM- Clear narrow mouth

CWM- Clear wide mouth

CVAF- Cold vapor atomic fluorescence spectroscopy

EPA- Environmental Protection Agency

ESS- Environmental Services Section (Lab field unit)

GCMS- Gas chromatography mass spectroscopy

GIS- Geographical Information Systems

GPS- Global Positioning System

HDPE- High density polyethylene

ICP-MS- Inductively coupled plasma mass spectroscopy

ISDA- Information Systems and Data Analysis unit

LCS- Laboratory control sample

LIMS- Laboratory information management system

LPM- Laboratory project manager

LVI- Large volume injector (GC-MS)

MDL- Method Detection Limit

mg/L- Milligram per liter

mL- Milliliter

MS- Matrix spike

MSD- Matrix spike duplicate

N/A- Not applicable

NTU- Nephelometric turbidity unit

PP- Polypropylene

QA/QC- Quality assurance and quality control

RDL- Reporting Detection Limit

Scott Bottle- Sampling device consisting of a cylindrical tube with surgical tubing running through the center of the tub connecting rubber stoppers at each end. This device can be kept open until it reaches a desired depth at which point it can be manually closed to collect a grab sample.

RO Water- Reverse osmosis water (reagent water)

RPD- Relative percent difference

SAP- Sampling and Analysis Plan

SM- Standard Method

SOP- Standard operating procedure

SRM- Standard reference material

STS- Science and Technical Support Group

TC- Technical Coordinator (program lead in ESS)

µg/L- Micrograms per liter

µmhos/cm^2- Micromhos per centimeter squared (equivalent to microsiemens)

VOA- Volatile Organic Analysis

WLRD- Water and Land Resources Division

WRIA-Water Resource Inventory Area

Appendix F. Beaches Sampling and Analysis Plan and Quality Assurance Project Plan

The current version of the Swimming Beaches Sampling and Analysis Plan is attached electronically to this document. This SAP includes the quality assurance information for this program and reflects the protocols and methods used in King County's ambient monitoring program for freshwater swimming beaches and would apply to the Swimming Beach stations listed in Table 4 (SD007SB, 0818SB).

Freshwater Swimming Beach Monitoring Sampling and Analysis Project Plan

May 2005

King County

Department of Natural Resources and Parks
Water and Land Resources Division
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Freshwater Swimming Beach Monitoring: Sampling and Analysis Project Plan

Submitted by:

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1.0. INTRODUCTION

Beginning in 1996, a number of public swimming beaches on Lake Sammamish, Lake Washington and Green Lake have been monitored during the summer months to determine presence and levels of bacterial pollution and relative human health risks. Prior to this survey little data on bacterial levels at any local public swimming beaches existed. Substantial amounts of bacterial data are collected in lakes Sammamish and Washington from the King County Major Lakes program. However, these data are collected to monitor overall lake water quality and integrity of the sewage collection system, and are not collected within designated swimming beaches. Low counts of fecal coliform bacteria, e.g., less than 50 colony-forming units per 100 milliliters of water (CFU/100 mL), are routinely found in high quality water. Typical fecal coliform bacteria counts from the middle of lakes Washington and Sammamish during the summer are less than 20 CFU/100 mL. Public perception of the source of high bacteria counts at swimming beaches is often directed at the sewage collection and conveyance system, whether this is the source of the pollution or not. This makes synoptic sampling of the beaches, lakes and streams necessary to identify or rule out a specific source of bacterial pollution, and propose appropriate corrective measures to address pollution sources when necessary.

Fecal coliform bacteria are routinely sampled as an indicator of sewage pollution in water and as an indicator of the associated pathogenic bacteria that may impact human health risk from swimming in contaminated waters. Elevated counts of fecal coliform bacteria always occur when sewage is present in the waters. However, high bacteria counts do not necessarily indicate human sewage pollution because many other mammals, birds and even vegetation can contribute this type of bacteria to the water. According to Chapter *173-201A, WAC WATER QUALITY STANDARDS FOR SURFACE WATERS OF THE STATE OF WASHINGTON*, 'extraordinary primary contact' criteria state freshwaters shall not have fecal coliform levels exceeding 50 colonies/100 mL and not have more than 10% of all samples exceeding 100 colonies/100 mL. The criterion for 'primary contact' is 100 colonies/100 mL and less than 10% of all samples exceeding 200 colonies/100 mL (see Appendix A). These concentrations are often exceeded in urban streams in King County, and frequently at the public swimming beaches. *Escherichia coli* is a better indicator of human health risks associated with fecal contamination, but the State of Washington water quality standards have not yet been updated to use *E.coli* as a more effective bacterial indicator, so both *E.coli* and fecal coliform are sampled in this program.

A supporting technique that has been used to identify sources of fecal bacteria is matching or ribotyping the genetic material RNA (ribonucleic acid) from the bacteria. This provides information on the species of animal which added the bacteria to the water. A study using this RNA method conducted in Piper's Creek in Seattle's Carkeek Park (SPU, 1993) identified domestic cats as the major source of bacteria. A subsequent study at Juanita Beach (King County 1998), identified ducks and geese as the major source of fecal coliform pollution, with seagulls and dogs as secondary sources. These RNA tests are expensive and time consuming, taking weeks to obtain the data. While the results are valuable in designing our long term water quality protection programs, the results are currently not available quickly enough to use this technique for routine monitoring of the beaches or the sewer system. Fecal coliform and *E. coli*

testing (without RNA analysis) takes less than 48 hours, allowing a much faster response to potential problems.

The Swimming Beach Monitoring Program sampling design and logistics are prepared and implemented by the King County Department of Natural Resources and Parks (KCDNRP). Samples are collected by King County Science and Technical Support (KCSTS) and the King County Environmental Laboratory (KCEL). Analysis results are transmitted to the Public Health Department of Seattle & King County (PHS&KC). PHS&KC determines the public health implications of the bacterial data collected from this program, and conveys this information to elected officials, other jurisdictions and the public. KCSTS is responsible for posting data to an internet webpage.

1.1 Project Organization

Project team members and their responsibilities are summarized in Table 1. All team members are staff of the King County Department of Natural Resources and Parks (KCDNRP), Water and Land Resources Division (WLRD) or Public Health Department of Seattle & King County (PHS&KC). Several individuals from different parks departments are associated with this program as well and are identified in Appendix B.

Table 1. Project Team Members and Responsibilities

name/telephone/email/title	Affiliation	Responsibility
Jonathan D. Frodge (206) 296-8018 Jonathan.frodge@metrokc.gov Sr. Limnologist/Program Manager	WLRD, Science and Technical Support Unit	Project manager for the swimming beach monitoring program. Data analysis
Robert Brenner (206) 296-8060 Bob.brenner@metrokc.gov Water Quality Planner	Science and Technical Support Unit	field sampling and data analysis
Katherine Bourbonais (206) 684-2382 Katherine.bourbonais@metrokc.gov Laboratory Project Manager	Environmental Laboratory	Coordination of analytical activities, lab QA/QC, and data reporting.
Robin Revelle, (206) 684-9160 Robin.revelle@metrokc.gov Microbiologist	Environmental Laboratory	Sample and Bacterial data analysis
Judith Ochs (206) 684-2347 Judy.ochs@metrokc.gov Environmental Scientist	Environmental Laboratory	Coordination of sampling activities, field QA/QC, and field analyses.
Daniel Smith (206) 263-6343 Daniel.smith@metrokc.gov Water Quality Planner	WLRD, Science and Technical Support Unit	Data reporting and website support
Fred Bentler (206)296-8050 Fred.bentler@metrokc.gov Information Systems Professional	KCDNRP, WLRD	Web support back-up for Daniel Smith
Colin Elliott (206) 684-2343 Colin.elliott@metrokc.gov KCEL Quality Assurance Officer	Environmental Laboratory	Overall project QA/QC.
Eileen Hennessy (206)205-3489 eileen.hennessy@metrokc.gov Technical Support Senior	Public Health-Seattle & King County	Public Health response
Logan Harris (206)263-6550 Logan.harris@metrokc.gov Media Relations Coordinator	KCDNRP, Director's Office	Public Affairs, media contact coordination

1.2 Study Design

The main purpose of the beach monitoring program is to protect public health by providing timely information about the water quality at public swimming beaches on lakes Sammamish, Washington and Green Lake. The primary method used to accomplish this is by routinely sampling *E.coli* and fecal coliform bacteria, and sampling for cyanobacterial toxins (beginning 2005 for two years) during bloom events. The program also provides additional data that can be used to help identify the source of bacteria, whether from bathers, animals or overflow from the sewage collection and conveyance system. This program implements a plan to coordinate roles of inter-departmental agencies involved in water testing, public health assessments, beach closures and media response. The bacterial data are collected weekly during the swimming season (mid-May through mid-September) and are posted on the King County swimming beach web page. http://dnr.metrokc.gov/wlr/waterres/lakes/bacteria.htm

The swimming beaches selected for this survey are public swimming beaches with officially designated swimming areas. In cooperation with PHS&KC's drowning prevention program, beaches with lifeguards are selected when possible, and all but the Lake Sammamish State Park has posted lifeguards during the swimming season. The beaches are selected to provide a wide geographic coverage of swimming beaches in lakes Sammamish and Washington, with Green Lake providing a high use small lake comparison. No private swimming beaches are sampled as part of this program. However, KCSTS will analyze and post bacterial data collected by jurisdictions that are not part of this program's sampling to the KC webpage, providing data are collected using the protocols defined in this SAP and analyzed at an accredited laboratory.

1.3 Goals and Objectives Protocol for Swimming Beach Monitoring

- Protect public health by providing timely and accessible information on regional bacterial water quality at public swimming beaches in lakes Sammamish, Washington and Green Lake.

- The beach monitoring program is conducted as a cooperative effort of the King County Department of Natural Resources, Science and Technical Support Unit (KCSTS), KC Environmental Laboratory (KCEL), multiple park districts, and Public Health Seattle & King County Department (PHS&KC).

- Approximately twenty public freshwater swimming beaches are sampled weekly from mid May through mid September as part of the routine monitoring program.

- All verified bacterial data are immediately transferred to PHS&KC. The Public Health Department makes all determinations on public health and contacts the local jurisdictions and parks departments on possible beach closures.

- Data from the beach monitoring program is used by the PHS&KC to close beaches by officially posting warning signs at the beach when fecal coliform counts exceed the ***Ten State Standard*** used by the PHS&KC *(geometric mean <200 cfu/100ml and no one*

sample >1000 cfu/100ml). Subsequent testing is conducted to determine if bacteria counts are below the standard before the beach is reopened.

- Preliminary analysis of cyanobacteria toxicity is carried out when bloom events of species capable of producing toxins are identified by field personnel during routine monitoring.

- KCSTS posts data weekly on the KC website http://splash.metrokc.gov/wlr/waterres/lakes/bacteria.htm

1.4 Sampling Locations

Table 2. 2004 Swimming Beach Sampling Locations.

Description	Site	Xplan	Yplan
Idylwood Park	0602SB	1327966	236634
Idylwood Creek	A620	1327254	236932
Lake Sammamish State Park west	0615SB	1334687	205515
NE 130TH PL street end	0805ASB	1289635	264271
OO Denny Park	0805BSB	1291408	261542
Juanita Beach	0806SB	1300025	259865
Juanita Creek	O446	1299812	260125
Luther Burbank	SD017SB	1297194	217536
Matthews Beach south	0817SSB	1286289	256489
Mathews Beach Park	0818SB	1285991	257467
Thornton Creek	A434	1285981	257146
Magneson Park	0826SB	1292290	251401
Madison Park	0852SB	1284654	235167
Mount Baker Park	0820SB	1281623	216172
Madrona Park	SD007SB	1282939	225430
Andrews Bay	0813SB	1288682	204375
Yarrow Bay	0825SB	1299140	240880
Meydenbauer Bay Park	0834SB	1300926	225707
Newcastle Beach	083930SB	1305139	209276

Gene Coulon Park	0828SB	1301896	187039
East Green Lake	A734SB	1271868	251768
Echo Lake	A764SB	1269635	285528
Hidden Lake	0207SB	1262436	278147

Sampling locations are subject to change based on sampling resources, presence or absence of lifeguards, or other program modifications determined prior to the annual swimming season. Samples will be pre-logged and collected as determined by the field collection crew based on workload allocation and efficiency of driving time and sampling.

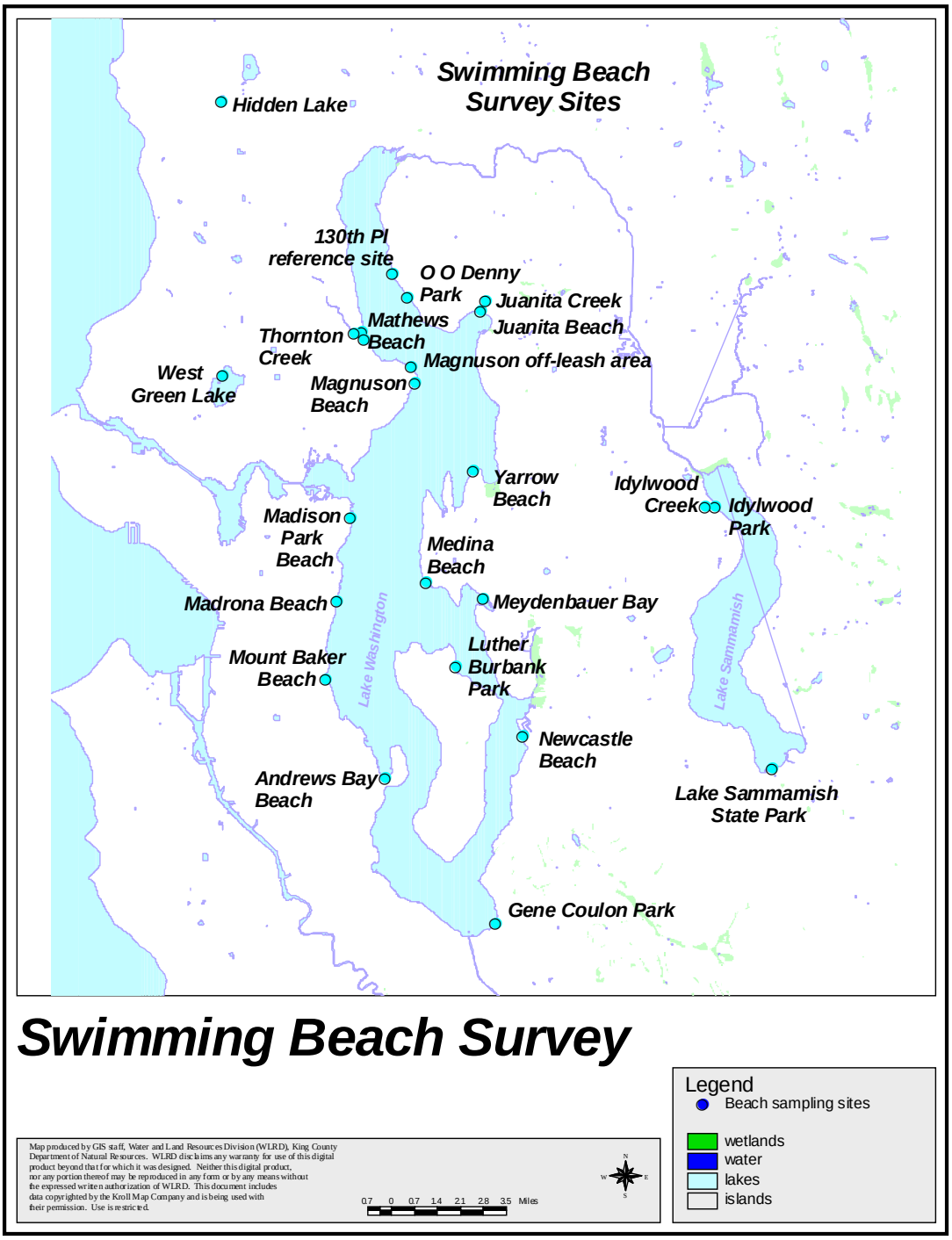

Figure 1. Swimming Beach sampling locations for 2005.

2.0. ROUTINE WATER TESTING

2.1 Location of Sampling

Single grab samples will be collected from near the middle of the officially designated beach area (laterally along the shoreline) at the control rope that designates the shallow "kiddie" portion from the deeper open water area. If there is no rope to designate the shallow area, samples will be collected where the water depth is between three to six feet. The assumption is this is the area where maximum loading and exposure would occur, as it is occupied by younger swimmers, and transited by anyone going into deeper water.

2.2 Frequency of Sampling and Rationale for Re-sampling

Swimming beaches are sampled on a weekly basis from mid-May through mid-September by collecting a single grab sample. Time of day of sampling is determined by field and lab requirements. If the bacterial results from the initial sampling at a beach is above the criteria for closing a beach (geometric mean >200 cfu/100ml or single sample >1000 cfu/100ml), an additional sample will be immediately collected from the same location using the same sampling protocols.

The rationale for immediate re-sampling is based on lack of statistical sampling power with a single grab and the possibility of collecting a false high count from a small localized source not representative of the overall bacterial water quality or human health concern. If the re-sampled value is within the water quality standards, the second sample is used for determining the geometric mean and bacterial water quality of the beach for that week. If the source of the bacteria is not small and isolated but rather a sewage spill or other large persistent source, the re-sampled count will also be high, as the possibility of obtaining a low bacterial count from water polluted by sewage is negligible.

Reliance on a single grab sample is not in compliance with the sampling protocols used by the WDOE Marine Beach Sampling Program funded by the USEPA (minimum of three samples per sampling event), but is a compromise designed to maximize the number of swimming beaches monitored with the sampling capacity available. This approach apparently works, as sewage spills and leaks have been detected at Andrews Bay in 1999 and Meydenbauer Bay in 2004. It is unknown if this sampling approach has missed potentially harmful public health events. If/when WDOE changes the indicator bacteria from fecal coliform to *E. coli* as has been suggested by the USEPA, all of the beach samples could be replicated with no additional increase in the cost of the program.

2.3 Sample Collection, Containers, Preservation and Storage

Grab samples are collected from within one foot of the surface of the water where the swimming area is three to six feet deep. Samples are collected using the dip method. Care must be taken to avoid contamination of the samples. Sampling staff will use either polyvinyl chloride (PVC) or latex gloves. Polypropylene (PP) or high density polyethylene (HDPE) bottles must be autoclaved and identified as sterile with autoclave tape before being used for sample collection. Containers must be filled such that a minimum of 1 inch of headspace is present. Bottles should NOT be rinsed with sample as part of the collection procedure.

Sampling personnel should walk from the dry beach area to the sample site wearing all proper gear including gloves. If a beach has been closed because of high bacterial counts personnel should also wear hip boots or chest waders. Prior to entering the water, the water quality sampler determines the direction of wind, current and effects of wave action. The sampler enters the water down-current or down-wind of the collection site and wades in a manner to avoid disturbing the water with sediment disruption. The sampler removes the cap, tips the sample container downward at a 45 degree angle and plunges the container so that the mouth is at least 5 inches below the surface. In one continuous motion, the sample container is turned upward so it begins filling with ambient water, it is then brought above the surface of the water, in a manner to provide a 1" headspace and the cap replaced. This continuous motion is an arc away from the sampler's body. If the bottle is overfilled, the neck of the bottle is snapped smartly to create a headspace if one does not exist, and the cap replaced. The sample container is then placed into an ice chest packed with ice.

During this process, atmospheric exposure should be kept to a minimum. The sampler must try to avoid collecting any debris, including sticks, seaweed, leaves, feathers, obvious waterfowl droppings, etc. This process is repeated until all sample containers for this site are filled. All sample containers are transported to the laboratory on ice. See the following KCEL Standard Operating Procedure (SOP) for further discussion. SOP for Clean Sampling for Ultra Trace Metals, Trace Organics, Microbiology and Conventional Chemistry Parameters using Surface Grabs, SOP #02-02-13000 (February, 2000). Samples must be stored at 4°C and may be held for up to 24 hours following collection. See SOP for Fecal Coliforms in Environmental Water by Membrane Filtration SOP # 05-03-001-000 (10/15/2002), Supersedes SOP: Microbiology QA Manual Section 6.1.

2.4 Phytoplankton

A qualitative and quantitative grab sample of phytoplankton (2 total) and one for microcystin toxin will be collected when a bloom event is identified by the sampler. A bloom will be defined as an easily noticeable increase in phytoplankton concentrations from the previous sampling event, an obvious high concentration of phytoplankton, the presence of a surface scum or the visual identification of the presence of cyanobacteria. Phytoplankton sampling is a grab sample, typically a skimmed surface sample, but always targeting recovery of the visible algal bloom. The sample is collected and preserved with eight drops of Lugol's Iodine for a 60 mL foil

wrapped glass sample container (Standard Methods 20th Edition, Method 10200B.2). The sample bottle for toxin analysis is not preserved.

Samples will be returned to the KCEL for qualitative identification. If the cyanobacteria are identified as *Aphanizomenon*, *Microcystis*, *Anabaena*, or other cyanobacteria (blue-green algae), an Enzyme Linked Immunosorbent Assay (ELISA) toxicity test for microcystins will be run on the samples (250 ml AWM bottle). The aliquot collected for quantitative phytoplankton analysis will be archived for possible future analysis. Designation of a 'bloom' is at the discretion of the sampler.

2.5 Field Observations and Measurements

2.5.1 Temperature/Number of Swimmers/Number of Waterfowl

Water temperature of the swimming beach will be collected at each sampling event using a certified hand-held, digital thermometer. A count of waterfowl and swimmers (anyone in the water) should be made before completing water sampling. A visual inspection of the swimming area, including both the water and up-land area should be conducted and field notes taken if appropriate.

3.0. SAMPLE ANALYSIS

3.1 Microbiology

Microbiology parameters analyzed on a routine basis will include *Escherichia coli* and other fecal coliform bacteria. Special sampling of phytoplankton blooms for toxicity may be conducted during sampler identified bloom events.

Table 3. Microbiology and Toxicology Parameters and Containers

Analyte	Container	Holding Times
Escherichia coli	500 mL PP or HDPE, sterile	24 hours
Fecal coliforms	500 mL PP or HDPE, sterile (same container as *E. coli*)	24 hours
Qualitative and quantitative phytoplankton identification (Cyanobacteria)	2 x 60 mL Glass wrapped in foil, preserved with Lugol's solution	355 days
Microcystins by ELISA	250 mL AWM	24 to 48 hours, then freeze

Notes:

1. Collect a single bottle for *E. coli* and fecal coliforms.

2. Qualitative phytoplankton analysis is done at the KCEL. Quantitative analysis if needed is subcontracted to WATER Environmental, Inc. When collected, archive one (1) 60 mL foil wrapped bottle for possible future quantitative analysis.

3.2 Method

The method used at the KCEL for fecal coliform testing by membrane filtration (MF) is Standard Method 9222 D, Standard Methods for the Examination of Water and Wastewater, 20th Edition. Dilutions are selected to provide a targeted recovery range of between 1 and 6,000 cfu/100ml.

The method used at the KCEL for *E. coli* testing by membrane filtration (MF) is Standard Method 9213D.3, (Standard Methods for the Examination of Water and Wastewater, 20th Edition), the mTEC method. Dilutions are selected to provide a targeted recovery range of between 1 and 6,000 cfu/100ml.

The qualitative method used at the KCEL for phytoplankton identification is sedimentation followed by visual taxonomic evaluation by an experienced microscopist familiar with algal taxonomic reference texts. A standardized 1.0 ml volume is viewed in a Sedgewick-Rafter slide and the dominant and subdominant species are determined based on size and prevalence (Standard Method 10200B, C and E (Standard Methods for the Examination of Water and Wastewater, 20th Edition).

Table 4. Suggested Volumes for Fecal Coliform Analyses by MF

Project	Volume Analyzed (mL)								
	10^{2}	10^{1}	10^{0}	10^{-1}	10^{-2}	10^{-3}	10^{-4}	10^{-5}	10^{-6}
Streams (routine)	x	x	x						
Streams (storms)	x	x	x	x					
Lake Wash.	x	x							
Lake Samm.	x	x							
Lake Union	x	x							
Beaches (Lakes)	x	x	x						
Sewage (raw)					x	x	x	x	x
CSO		x	x	x	x	x	x		
Trouble Call (water)		x	x	x	x	x	x		
Stormwater	x	x	x	x	x	x			
WP Offshore	x								
Renton Offshore	x								
Beaches * (Marine)	x	x							

* Volumes routinely analyzed are 10, 30 and 100 mL.

3.3 Roles and Responsibilities

The KCEL has the primary role of coordinating resources to collect and analyze swimming beach samples each week. KCSTS, in cooperation with KCEL, will provide data interpretation, immediately post data on the KC website and provide limnological consultative services to PHS&KC and local parks departments.

KCEL will process samples and e-mail a spreadsheet with the weekly testing data results, a running geomean and a five day (sampling event) geometric mean (Table 5), typically within 24 - 48 hours of sampling to KCSTS for analysis and transmission to PHS&KC. Samples will be collected on Tuesdays and results transmitted to PHS&KC as soon as the data have passed the KCEL QA/QC requirements. This schedule is designed to provide time to review the data, make a determination about the bacterial quality of the swimming beaches, and potentially consult with involved parties (the KCEL, Parks, the media etc.) prior to the determination and posting of a weekend beach closure. PHS&KC is responsible for officially transmitting the data to parks departments and the local municipalities. KCSTS will post verified data on the web site.

Table 5. Example of the spreadsheet created by KCEL Microbiology with weekly bacteria data and running geometric means.

RowId	WorkGrp	AnalDate	SampNum	Type	A734WSB, W.Green Lake	A734WSB Mean	0826SB, Magnuson Beach	0826SB Mean	0818SB, Matthews	0818SB Mean	0852SB, Madison	0852SB Mean	SD007SB, Madrona	SD007SB Mean	0820SB, Mt. Baker	0820SB Mean	0813SB, Andrews	0813SB Mean	4903SB, Pritchard	4903SB Mean	0828SB, Gene Coulon
248	WG76027	24-Aug-04	L32797	Reg	190	12	400	23	200	122	420	44	200	26	14	18	100	14		0	214
247	WG76027	24-Aug-04	L32797	Dup																	
246	WG76027	24-Aug-04	L32797	Dup					130												
245	WG75925	17-Aug-04	L32669	Reg	11	10	22	19	150	119	32	38	32	23	12	18	110	12		0	370
244	WG75925	17-Aug-04	L32669	Dup																	
243	WG75925	17-Aug-04	L32669	Dup																	
242	WG75948	12-Aug-04	L32848	Reg		10		19		118		38		22		18		10		0	
241	WG75771	10-Aug-04	L32652	Reg	29	10	350	19	240	118	80	38	44	22	41	18	350	10		0	360

4.0. BEACH CLOSURE

In accordance with WAC 248-98-070 "No bathing beach shall be maintained or operated when such water is determined by the health officer to be so polluted or subject to pollution as to constitute a menace to health if used for bathing. " Any beach closure determination and subsequent action will be under the authority of the Seattle King County Health Department.

4.1 Water Quality Standards for Beach Closure

The State Health Department (DOH) standard for bacteriological water quality will be used to determine when to close a beach. The current standard being used is the "*Ten State Standard*", (Health Education Service 1990, Appendix A) for fecal coliform calculated on a geometric mean with a maximum safe level of a geometric mean of 200 CFU per 100 milliliters, or when the fecal coliform density of any sample exceeds 1,000 CFU per 100 milliliters.

As an alternative to criteria based on fecal coliform counts, the U.S. Environmental Protection Agency has suggested that *E.coli* organisms be used instead as indicator of fecal contamination and associated human health risk. A geometric mean of five samples should not exceed 126 *E.coli* CFU per 100 milliliters. A single sample should not exceed 235 *E.coli* CFU/100ml (Health Education Service 1990). The PHS&KC in communication with the parks department(s) will make a determination on public health risks and whether results of the sampling should lead to beach closure. Parks will inform the supervisor of the swimming beach about the results of the bacteriological analysis and PHS&KC recommendations for closure.

4.2 Media Contact When There is a Closure

PHS&KC, KCSTS, and the parks departments will discuss beach closure prior to releasing the information to the media or posting the beach. Parks will prepare a press release in consultation with PHS&KC and KCSTS to include the name of the beach closed, the address of the beach, date of closure, general reasons for the closure. The beach will remain closed until the bacteriological levels meet standards as determined by PHS&KC. PHS&KC will coordinate with the media specialists in their departments, the affected parks departments, and KCDNRP about the press release. Parks will send the press release to appropriate media contacts.

4.3 Media Contacts:

- All questions on public health are directed to the PHS&KC.
- Technical questions on sampling, data and limnology are answered by KCSTS or KCEL staff and reported to public outreach.
- Staff does not initiate contact with the media. If staff are contacted by the media they are to notify the KCDNRP Media Relations Coordinator, Logan Harris (296-6550) prior to responding to the information request.

4.4 Beach Closure Posting

PHS&KC determines if a beach is to be posted and, based on subsequent data, the duration of the closure. The beach should be posted to inform the public of possible risks of illness and to advise against swimming or water contact. An example posting is included in Appendix B. Parks staff will post the beach as soon as a determination has been made to close the beach. Signs should be posted in a conspicuous area visible to swimmers before they enter the water and where they can be easily read. PHS&KC is responsible for official posting of beach closures. The individual parks departments are responsible for removing postings when directed to do so by PHS&KC. All beach closure notices will be immediately posted to the KC web site as a prominent headline.

4.5 Follow-up Testing

Follow-up water testing will be conducted when the beach is closed to determine the source of bacterial pollution and when bacterial levels are again acceptable such that the beach can be reopened. Bathing beaches may be reopened if a satisfactory sanitary survey is completed, or if the daily averaged fecal coliform density in each of two consecutive daily sets of samples is <200CFU/100ml. These surveys will be conducted by KCEL, KCSTS or PHS&KC staff, and reimbursement to KCEL for the resampling will be the responsibility of the jurisdiction that owns and operates the swimming beach or park. Sampling will continue on a daily basis until bacteriological sample results are low enough to reopen the beach (<200CFU/100ml), with a minimum of three replicates collected within the swimming area (Health Education Service 1990). Replicates should be taken at the usual sampling location and 10 - 15 m on either side of the usual location. Any additional samples that the sampler deems necessary should be collected at this time (i.e. storm drains, stream mouths, etc.). All samples should be described accurately in the field notes, coordinate data collected. New sampling locations will be located as a shapefile in a GIS project by KCEL and KCSTS staff, using the wtrbdy.shp and the image files in the KCGIS system. Copies of the GIS files and maps will be sent by KCSTS to PHS&KC and other jurisdictions or parks departments responsible for the closed beach. .

4.6 Reopening Beaches

PHS&KC will make a determination to reopen a beach if follow-up test results show a decline in fecal coliform to acceptable levels, and if the beach no longer poses a public health risk. PHS&KC and Parks will discuss reopening the beach prior to releasing this information to the media and removing warning signs.

4.7 Media Contact and Removing Warning Signs

Once it has been determined that a beach is to be reopened, the warning signs will be removed by Parks and the notice will be removed from the KC website. The goal is to remove signs as soon as it's been determined by sampling results that the risk to public health has been diminished and the water samples are at acceptable levels. PHS&KC and Parks will inform the media specialists in PHS&KC and KCDNRP about the reopening. The media specialist in

KCDNRP will verify that the beach warning closure notice on the KC website is removed, as there have been problems in the past with the beach closure notice remaining on the KC web site after the swimming beach has been reopened. The appropriate jurisdictional Parks Department will also inform the swimming beach supervisor that the beach may be reopened to swimmers. After consultation with PHS&KC and KCDNRP, the Parks Department will send a press release to the media that the beach has been reopened.

4.8 Cooperation with Other Jurisdictions to Expand the Swimming Beach Monitoring Program

In order to expand the regional freshwater swimming beach monitoring program within the current budget, KCSTS will provide an incentive training program for jurisdictions within the King County service area. This program provides initial sample collection by KCSTS and KCEL staff, microbiological analysis by KCEL, and data analysis by KCSTS. A local jurisdiction participating in this program will designate a staff member(s) who will cooperate with KC staff to select appropriate swimming beach data collection sites and will be trained by KCEL staff to collect the swimming beach data according to the protocols in this SAP. The local jurisdiction will take over sampling after a two to three week training period, and will be responsible for collecting data on the appropriate day and transporting the samples to the KCEL. KCEL will continue to analyze the bacteria samples for the entire first season that the jurisdiction participates in the program.

If the jurisdiction chooses to participate in the program after the first year, the jurisdiction is responsible for sample collection and contracting sample analysis at an accredited laboratory. KCSTS will continue to analyze the data as part of the over all swimming beach monitoring program and post the data on the KC website. The data will be identified as being produced by a different laboratory. The jurisdiction is responsible for the timely transmittal of data to KCSTS.

Examples of this approach are the collection and analysis of data by Seattle Public Utilities at Rattlesnake Lake and participation by the City of Shoreline in the 2004 swimming beaches monitoring program (Appendix C). The KCDNRP swimming beach program will reserve sufficient sampling capacity to bring one additional jurisdiction on under this program each year. If a jurisdiction already has the capacity to collect and analyze samples and collection protocols meet or exceed the protocols in this SAP, those data can be posted to the KC website and analyzed as part of the KC swimming beach program.

5.0. DATA QUALITY OBJECTIVES

Data quality objectives typically involve specifications of the required precision, accuracy and tolerable bias of the analytical data. Discussion is also provided that describes the methods used to ensure that data are representative of the population targeted for sampling and comparable to other similar studies. Methods and procedures used to minimize the loss of usable data are also described.

While a minimum of three replicates are called for in the Washington State Draft Standards for Recreational Water and Beaches (Appendix D), the KC freshwater swimming beach monitoring program collects only a single grab sample. The KC program has a different set of data quality issues stemming from the need to cover a broad geographic area with a limited budget that is available. The scope of the sampling effort and resulting lack of statistical power is directly related to the available budget. Funding for other swimming beach monitoring, such as the USEPA funded sampling at marine beaches in King County, is restricted to marine swimming beaches only. A summary of inconsistencies between the KC swimming beach protocols and those developed by Washington State and USEPA is presented in Appendix D.

5.1 Precision

Data precision is the degree of agreement among repeated measurement of the same sample (laboratory replicate) or of separate samples collected as close as possible temporally and spatially (field replicate). A measure of precision gives an indication how consistent and reproducible field and/or laboratory methods are. However, precision does not reflect how "true" or accurate the results are. Typically, precision is monitored by the analysis of replicate samples. Replicating the analysis of a subset of field samples will assess the precision of the data. Approximately 4 percent of the field and laboratory samples will be analyzed in duplicate to provide a means of assessing analytical precision. One field replicate will be collected at a swimming beach randomly selected by KCEL staff during every sampling event.

Sampling precision will be estimated by calculating the Relative Percent Difference (RPD) of the replicate sample results:

$$RPD = \frac{|X_1 - X_2|}{(X_1 - X_2)/2} 100$$

Analytical precision is determined by performing a duplicate analysis on the same sample and comparing the results. Laboratory duplicates by the membrane filtration method are performed by removing aliquots from the sample bottle as two separate sub-samples, and duplicating all steps including preparation of dilutions. Duplicate sample results are evaluated by method 9020B.4 prescribed in Standard Methods for the Examination of Water and Wastewater, 20th ed., 1998. Briefly, this requires that the log-transformed difference between the two duplicate results be compared to the mean of the log-transformed differences for the previous 15 sample

pairs. The acceptance criterion is to be within 3 standard deviations of this latter value. Failure to meet the criterion is cause to evaluate the entire sample batch for compliance and applicability of the calculation, before qualifying or rejecting the data set.

5.2 Accuracy and bias

Accuracy is a measure of confidence in the analytical results. The smaller the difference between the measured value and the "true" value, the more accurate the results. The pattern of these differences (typically higher or lower) indicates the amount of bias in the results. Results with high precision and low bias are more accurate than results with high bias and precision or high bias and low precision. Results may still be accurate if they have low bias and precision, but there will tend to be a random scatter of replicate results around the true value. Because we plan to take a single sample to estimate the "true" bacterial counts, it is important that our results have low bias and high precision.

Following standard field protocols for the collection and preservation of the samples will ensure the accuracy and bias of the data. Accuracy and bias of phytoplankton identifications may also be assessed by independently verifying the results reported by the phytoplankton specialist. This will involve a review of wet-mount slides (or photographs) by a second phytoplankton specialist. It is recommended that a minimum of two samples be selected for independent verification.

5.3 Representativeness

Representativeness is the extent to which measurements actually depict the true population under evaluation.

Field and laboratory sampling techniques proposed for this study should provide data that are representative of bacterial quality at the sampled swimming beaches.

5.4 Comparability

Comparability is the extent to which data from one study can be compared directly to either historical data or data being collected in another project.

The objective of this study is to provide data that are comparable to historical lake and stream bacteria data. However, measures described above to evaluate the quality of the data should provide supporting information that may be used to assess the suitability of the data for comparison to historical information or data collected currently by other investigators.

5.5 Completeness

Completeness is a measure of the number of samples you must take to be able to use the information, as compared to the number of samples you originally planned to collect.

Ideally, implementation of this plan will result in collection of usable data for each proposed sample. Generally, sample and data tracking systems in place at the laboratory should ensure that all samples are collected, transported, logged in and analyzed in an acceptable manner. However, where data are not complete, decisions regarding re-sampling and/or re-analysis will be made by a collaborative process involving both data users and data generators.

6.0. PROJECT DELIVERABLES

Data will be compiled on a weekly basis by KCSTS staff and put on the web site by noon on Fridays. This requires timely collection and analysis of samples. The KCEL needs to transmit final data by close of business (COB) on Thursdays so the web site can be updated. If a given beach(es) needs to be resampled any resulting, subsequent data will be analyzed when it is verified. Updating the KC web site is the responsibility of the KCSTS staff (Bob Brenner and Daniel Smith). If the individual responsible for updating the web is unavailable, Fred Bentler (296-8050) will provide backup. It is the responsibility of the KCSTS staff to coordinate with backup support if they are unable to carry out the task.

6.1 Timeline

Data and associated documentation descried in this SAP will be transmitted from the KCEL microbiology laboratory to KCSTS (Bob Brenner, Jonathan Frodge) and PHS&KC (Eileen Hennesey) by COB Thursday. KCSTS will update the KC web site by COB on Fridays.

7.0. REFERENCES

American Public Health Association. 1998. Standard Methods for the Examination of Water and Wastewater. 20th Edition.

Chorus, I, I.R. Falconer, H.J. Salas, and J. Bartram. 2000. Health risks caused by freshwater cyanobacteria in recreational waters. J. Toxicol. Environ. Health B. Crit. Rev. 4:323-347.

Health Education Service 1990. Recommended Standards for Bathing Beaches, Policies for the review and approval of plans and specifications for public bathing beaches. 1990 Edition. A Report of the Committee of the Great Lakes – Upper Mississippi River Board of State Public Health and Environmental Managers. Members and Province: Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, New York, Ohio, Ontario, Pennsylvania, Wisconsin.

KCDNR&P. 2002. Sampling and Analysis Plan for the Toxic Cyanobacteria in King County Lakes Study. King County Department of Natural Resources and Parks (KCDNR&P), Water and Land Division, Seattle, WA.

METRO. 1987. Quality of local lakes and streams: 1985-1986 status report. Prepared by Water Resources Section, Water Pollution Control Department, Municipality of Metropolitan Seattle (METRO), Seattle, WA.

Appendix A. Regulations and Policy

The following are the portions of the Washington Administrative Code showing the purpose and authority of Washington Department of Heath (WA-DOH) for Bathing Beaches

WAC 246-260-001 **Purpose and authority.** (1) The purpose of this chapter is to protect the health, safety, and welfare of users of water recreation facilities (WRF). This chapter is established per RCW 70.90.120.

WAC 246-260-180 **Bathing beaches.** No bathing beach shall be maintained or operated when such water is determined by the health officer to be so polluted or subject to pollution as to constitute a menace to health if used for bathing. Where bathhouse and toilet facilities are provided for use of bathers they shall be constructed, maintained and operated in a sanitary manner approved by the health officer.

[Statutory Authority: RCW 43.20.050. 91-02-051 (Order 124B), recodified as § 246-260-180, filed 12/27/90, effective 1/31/91; Regulation .98.070, effective 3/11/60.]

The following are the portions of the Washington Administrative Code showing the water quality criteria used by the Washington Department of Ecology (WDOE) for primary and extraordinary primary contact, including bathing beaches

WAC 173-201A-200 Fresh water designated uses and criteria

(2) **Recreational uses.** The recreational uses are extraordinary primary contact recreation, primary contact recreation, and secondary contact recreation.

(a) **General criteria.** General criteria that apply to fresh water recreational uses are described in WAC 173-201A-260 (2)(a) and (b), and are for:

(i) Toxic, radioactive, and deleterious materials; and

(ii) Aesthetic values.

(b) **Water contact recreation bacteria criteria.** Table 200 (2)(b) lists the bacteria criteria to protect water contact recreation in fresh waters.

Table 200 (2)(b)

Water Contact Recreation Bacteria Criteria in Fresh Water

Category	Bacteria Indicator
Extraordinary Primary Contact Recreation	Fecal coliform organism levels must not exceed a geometric mean value of 50 colonies/100 mL, with not more than 10 percent of all samples (or any single sample when less than ten sample points exist) obtained for calculating the geometric mean value exceeding 100 colonies/100 mL.
Primary Contact Recreation	Fecal coliform organism levels must not exceed a geometric mean value of 100 colonies /100 mL, with not more than 10 percent of all samples (or any single sample when less than ten sample points exist) obtained for calculating the geometric mean value exceeding 200 colonies /100 mL.
Secondary Contact Recreation	Fecal coliform organism levels must not exceed a geometric mean value of 200 colonies/100 mL, with not more than 10 percent of all samples (or any single sample when less than ten sample points exist) obtained for calculating the geometric mean value exceeding 400 colonies /100 mL.

(i) When averaging bacteria sample data for comparison to the geometric mean criteria, it is preferable to average by season and include five or more data collection events within each period. Averaging of data collected beyond a thirty-day period, or beyond a specific discharge event under investigation, is not permitted when such averaging would skew the data set so as to mask noncompliance periods. The period of averaging should not exceed twelve months, and should have sample collection dates well distributed throughout the reporting period.

(ii) When determining compliance with the bacteria criteria in or around small sensitive areas, such as swimming beaches, it is recommended that multiple samples are taken throughout the area during each visit. Such multiple samples should be arithmetically averaged together (to reduce concerns with low bias when the data is later used in calculating a geometric mean) to reduce sample variability and to create a single representative data point.

(iii) As determined necessary by the department, more stringent bacteria criteria may be established for rivers and streams that cause, or significantly contribute to, the decertification or conditional certification of commercial or recreational shellfish harvest areas, even when the preassigned bacteria criteria for the river or stream are being met.

(iv) Where information suggests that sample results are due primarily to sources other than warm-blooded animals (e.g., wood waste), alternative indicator criteria may be established on a site-specific basis by the department.

Recommended Standards for Bathing Beaches, Policies for the review and approval of plans and specifications for public bathing beaches. 1990 Edition. A Report of the Committee of the Great Lakes – Upper Mississippi River Board of State Public Health and Environmental Managers. Members and Province: Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, New York, Ohio, Ontario, Pennsylvania, Wisconsin. Published by: Health Education Service, PO Box 7126, Albany, NY 12224. phone: (518)439-7286.

Water Quality Standards

4.0 Water Quality Standards

4.1 Bacterirological Quality

4.1.1 The bathing beach shall be closed when the fecal coliform density from the last five consecutive daily sets of samples collected on five different days within a 30 day period exceeds a geometric mean of 200 (cfu) per 100 ml or when the fecal density of any sample exceeds 1,000 (cfu) per 100 ml. The fecal density of a daily set of samples shall be the arithmetic mean fecal coliform density of all samples collected that day.

4.1.2 Daily sets of samples shall be collected and analyzed while the bathing beach is closed. The beach may be reopened if the fecal coliform density in a daily set of samples is less than 200 (cfu) per 100 ml and a satisfactory sanitary survey has been conducted or if the fecal coliform density in each of two consecutive daily sets of samples is less than 200 per 100 ml.

4.1.3 As an alternative to 4.1.1 above the United States Environmental Protection Agency (USEPA) has suggested that *E. coli* be used instead of fecal coliform as indicators of contamination. A geometric mean of five samples should not exceed 126 e. coli organisms per 100 ml or 33 enterococcus organisms per 100 ml. A single sample should not exceed 235 e. coli or 61 enterococcus organisms per 100 ml.

4.4 Biological Quality

4.4.1 Algae and aquatic vegetation shall be controlled so that no hazard to bathers results.

4.4.2 Where schistosome dermatitis (swimmer's itch) is known to exist, appropriate measures shall be taken to protect bathers. Such measures may include posting of warning signs, chemical treatment, or closing the beach.

4.4.3 Chemical used for water treatment shall be acceptable to the regulatory agency and shall be applied by properly trained applicators. Any chemical used, when properly applied, shall not be capable of creating toxic reactions, including skin or membrane irritations when the beach is in operation.

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Appendix C. Scope of Work for City of Shoreline participation in King County Swimming Beach Monitoring Program

Echo Lake Swimming Beach Sampling

Under this Scope of Work, the King County Water and Land Resources Environmental Lab will provide services to the City to evaluate water samples from the Echo Lake Swimming Beach for fecal coliforms and *E. coli* (both by the membrane filtration method). Sampling will take place between 18 May 2004 and 21 September 2004. City staff will be trained in sample collection so that they may collect the samples themselves. King County will provide sample bottles, labels and fieldsheets.

- King County field science staff will train City of Shoreline staff on-site in proper sample collection techniques and documentation of observed field conditions. Training will take place during the course of collecting the first two samples.
- Thereafter, City of Shoreline staff will collect the weekly samples and deliver them to the Environmental Laboratory for evaluation. Sample delivery time must be coordinated with the laboratory.
- Analysis results will typically be available within 48 hours of collection, and are reported by the Environmental Laboratory to the Seattle King County Public Health Department, who will in turn transmit data to the parks and municipalities as needed so that beach closures if required can be effected before the weekend. King County Natural Resources and Parks Department will post results to the Swimming Beach Monitoring Program website.
- The Environmental Laboratory will prepare a Comprehensive Data Report for the City of Shoreline (Excel spreadsheet, standard laboratory format), and transmit file electronically within 30 days of sample collection. A separate report will be prepared and transmitted for each weekly sampling event.
- King County will provide a case narrative describing analytical anomalies, if and when any occur. Case narratives will be transmitted as part of the data report.
- Total cost of conducting the program as described above will be $1,500, including sample collection during 2 events, training of City staff and analysis of samples collected during all 19 weekly events.
- If there are elevated counts (e.g., a single sample with fecal coliform counts >1000cfu/100 mL) or beach closure is required by the Public Health Department, additional samples will be collected by King County staff so that rising and falling contamination levels can be monitored. Additional sampling events will be charged at $145 per event. An event is considered to include collection of one sample, and analysis for fecal coliforms and *E. coli* , both by the membrane filtration method.

Appendix D. Inconsistencies between Washington State and USEPA Protocols and KC Swimming Beach Monitoring Program Protocols

- The "Washington State Draft Standards for Recreational Water and Beaches" state that the operator should collect a set of bacteriological samples at least five times per month. Additional samples may be collected as the need for bacteriological surveillance becomes apparent. On the day of testing, a minimum of two samples should be collected from representative locations throughout the bathing area. As stated, KC has field and lab capacity to collect and analyze a single sample in the nearshore swimming area.
- The Draft Standards state one sample will be taken from the shallow portion of the beach several feet from the water's edge. KC collects a sample at or near the rope designating the shallow area.
- The Draft Standards state the second sample will be collected farther out than the first sample, in deeper water. As stated, KC currently does not have the field or lab capacity to collect and analyze this additional sample. Also, collection of this second, deeper sample would require a boat at most or all of the sites included in the program.
- The Draft Standards state that to assure that the samples are representative of the bathing water, they should be collected in an area where the bottom of the lake hasn't been stirred up and in an area that is free of floating debris or isolated evidence of duck or other animal droppings. The KC written protocols may have to be expanded to (ensure?) assure consistent sampling. If samples are collected during periods of peak usage, then the bottom will likely be disturbed. And short of watching the animals defecate, it is impossible to tell if one has done so in the immediate vicinity of the sampling site.

Appendix G. Marine Water Column and Nearshore Sampling and Analysis Plan and Quality Assurance Project Plan

The current version of the Existing Water Quality Conditions Study Sampling and Analysis Plan is attached electronically to this document. This SAP includes the quality assurance information for this program and reflects the protocols and methods used in King County's ambient monitoring program for marine intertidal beaches and would apply to the Intertidal (Beach) stations listed in Table 4 (LSHV01, KSHZ03, KSYV02).

BrightWater

Marine Outfall Siting Study

Existing Water Quality Conditions Study

Offshore Water Column and Intertidal Environments of the Central Puget Sound Basin

Sampling and Analysis Plan

June 2001

King County Department of Natural Resources
Water and Land Resources Division
201 South Jackson Street, Suite 600
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KING COUNTY

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1 Introduction

Regional population growth has necessitated planning a new wastewater treatment plant in northern King or southern Snohomish County, which will include a marine outfall in Puget Sound. King County is conducting a marine outfall siting study (MOSS) as part of the planning process to assist the outfall siting and design process and allow evaluation of potential impacts to the marine environment from secondary treated wastewater. The MOSS project is comprised of the following environmental studies:

- physical oceanography of the central Puget Sound basin;
- nearshore habitat resources of northern King and southern Snohomish counties;
- submarine geophysics and bathymetry along the eastern shore of the central Puget Sound basin;
- marine plant and animal resources of Puget Sound;
- primary productivity in the north central Puget Sound basin; and
- existing water quality conditions in offshore water column and intertidal environments of the central Puget Sound basin.

This sampling and analysis plan (SAP) addresses the existing water quality conditions study and includes a description of the study and study area, data quality objectives, sampling and analytical protocols, quality assurance, and data validation. Sampling and analytical protocols for the other MOSS studies will be addressed in separate project documents.

2 Study and Study Area Descriptions

The first component of the MOSS existing water quality conditions study is water column profiling to evaluate physical, chemical, and microbiological characteristics of offshore, ambient Puget Sound receiving water. The MOSS study area incorporates the central basin of Puget Sound from the southern end of Whidbey Island to Colvos Passage (Figure 1). Parts of Admiralty Inlet and Possession Sound are also included in the study area. Water column profiling results will support the following aspects of MOSS project:

- calibration and verification of plume, meso-scale hydrodynamic/fate and transport, and large-scale steady-state models;
- screening different discharge locations and configurations; and
- human health, aquatic life, and wildlife risk assessments.

The water column profiling component encompasses focused, point-sampling at ten locations in Puget Sound (Figure 2) to assess spatial and temporal variations of physical, chemical, and microbiological parameters. *In situ* water quality data are also collected using electronic instrumentation in a series of transects at six locations in the study area (Figure 3). Water column profiling commenced in December 1998 and will continue through August 2001.

The second component of the MOSS existing water quality conditions study is an intertidal water quality sampling program at 12 locations in a study area that extends from Mukilteo State Park to Shilshole Bay (Figure 4). Intertidal water samples are

collected for analysis of physical, chemical, and microbiological parameters. The intertidal water quality sampling program supports the following aspects of the MOSS project:

- screening different discharge locations and configurations; and
- human health, aquatic life, and wildlife risk assessments.

The intertidal water quality study commenced in March 2000 and will continue through February 2002.

3 Sampling Design

The primary goals of the MOSS existing water quality conditions study are:

- to evaluate spatial and temporal variations in physical, chemical, and microbiological constituents of both offshore and intertidal Puget Sound receiving water;
- to evaluate spatial and temporal variations in physical, chemical, and microbiological constituents of both offshore Puget Sound receiving water both proximal and distal to existing King County wastewater treatment plant outfalls; and
- to establish a baseline for physical, chemical, and microbiological constituents of Puget Sound receiving water against which future monitoring efforts for the new treatment plant outfall can be compared.

3.1 Data Quality Objectives

The data quality objectives (DQOs) of the MOSS existing water quality conditions study are to collect data of sufficient quantity and quality to meet the study goals.

Statistical analysis of data collected for this study will be performed to evaluate whether a sufficient quantity of data has been collected to meet the study goals. The main goal of this study is to characterize existing conditions throughout the MOSS study area for each of the following categories of water quality constituents.

- Metals – The project goal is to characterize water concentrations of various metals at different locations and depths and to evaluate any differences between sites and depths, either spatially or temporally. This characterization will be accomplished through the use of means, standard deviations, and upper 90th confidence intervals for means, with a minimum power of 85% and significance level of 90%, sensitive to within plus or minus 50% of the mean. One-way ANOVA testing will be employed to assess spatial and temporal differences between sites and depths.
- Organics – The project goal is to characterize water concentrations of various organic compounds at different locations and depths and to evaluate any differences between sites and depths, either spatially or temporally. It is anticipated that many organic compounds will not be detected in ambient Puget Sound water. Statistical analysis of data that is generally "undetected" will use binomial calculations on the probability of a sample with a detectable concentration of the organic compound and the probability of finding two and three samples in succession with detectable values at a given site or depth. Statistical analysis of data for those organic compounds that are detected

regularly or occasionally will be accomplished through the use of medians and interquartile ranges.

- Conventionals – The project goal is to characterize water concentrations of various conventional parameters at different locations and depths and to evaluate any differences between sites and depths, either spatially or temporally. Many conventional parameters such as nutrients, salinity, and dissolved oxygen exhibit spatial and temporal variations due to natural processes. Taking that into account, statistical analysis of conventionals data (including both discrete samples and *in situ* data) will employ means and medians, standard deviations and interquartile ranges, and upper 90th confidence intervals for the means and medians. One-way ANOVA tests and Kruskall-Wallace non-parametric tests will be used to assess spatial and temporal differences between sites and depths.
- Microbiology – The project goal is to characterize water concentrations of various bacteria at different locations and depths and to evaluate any differences between sites and depths, either spatially or temporally. Statistical analysis of microbiology data will employ medians, interquartile ranges, and upper 90th confidence intervals for the medians. Kruskall-Wallace non-parametric tests will be used to assess spatial and temporal differences between sites and depths.

Validation of project data will assess whether the data collected is of sufficient quality to meet the study goals. The data quality issues of precision, accuracy, bias, representativeness, completeness, and comparability are described in the following sections.

3.1.1 Precision, Accuracy, and Bias

Precision is the agreement of a set of results among themselves and is a measure of the ability to reproduce a result. Accuracy is an estimate of the difference between the true value and the determined mean value. The accuracy of a result is affected by both systematic and random errors. Bias is a measure of the difference, due to a systematic factor, between an analytical result and the true value of an analyte. Precision, accuracy, and bias for analytical chemistry and microbiology may be measured by one or more of the following quality assurance/quality control (QA/QC) procedures:

- collection and analysis of field replicate samples (field replicate results should exhibit a relative percent difference less than 150% in order for the evaluation of the spatial and temporal chemical concentrations to be meaningful); and
- analysis of various laboratory QC samples such as method blanks, matrix spikes, certified reference materials, and laboratory duplicates or triplicates.

3.1.2 Representativeness

Representativeness expresses the degree to which sample data accurately and precisely represent a characteristic of a population, parameter variations at the sampling point, or an environmental condition. Water samples for chemistry and microbiology analysis will be collected from stations with predetermined coordinates and sampling depths to represent specific site locations and/or fill data gaps. The collection of electronic *in situ* water column data will also be performed at stations with predetermined coordinates.

3.1.3 Completeness

Completeness is defined as the total number of samples analyzed for which acceptable analytical data are generated, compared to the total number of samples submitted for analysis. Sampling at stations with known position coordinates in favorable conditions, along with adherence to standardized sampling and testing protocols will aid in providing a complete set of data for this project. The goal for completeness is 100%. If 100% completeness is not achieved, the project team will evaluate if the data quality objectives can still be met or if additional samples may need to be collected and analyzed.

3.1.4 Comparability

Comparability is a qualitative parameter expressing the confidence with which one data set can be compared with another. This goal is achieved through using standard techniques to collect and analyze representative samples, along with standardized data procedures. By following the guidance of this SAP, the goal of comparability will be achieved. Historical water quality data from the MOSS study area will be compared with data generated from this study to enhance the baseline information. Previous data will be used if comparable sampling and analytical techniques have been employed and if water samples were collected from a similar location and depth.

3.2 Sampling Strategy for Water Column Profiling

Ten point-sampling locations were selected to provide coverage of the entire study area as well as profile water column conditions in areas of particular oceanographic interest. Samples are collected monthly from multiple depths at each of the stations; the number of depths sampled dependent on total depth and parameters of interest. Table 1 presents the ten point-sampling stations, depths sampled, and rationale for selection of the stations.

Table 1
Water Column Point-Sampling Locations and Depths (in meters)

Station	Sample Depths for Conventionals	Sample Depths for Metals and Organics	Rationale
Admiralty Inlet	1, 15, 25, 35, 55, 100, 115	5, 50, 100	Profile oceanic source water coming into the north end of the study area.
Possession Sound	1, 15, 25, 35, 55, 100, 205	5, 50, 190	Profile highly stratified water entering the north end of the study area from Possession Sound.
Edmonds #1	1, 15, 25, 35, 55, 100, 130	N/A	Profile water in the "triple junction" area between Admiralty Inlet and Possession Sound.
Edmonds #2	1, 15, 25, 35, 55	N/A	Profile water in the "triple junction" area between Admiralty Inlet and Possession Sound.
Point Wells	1, 15, 25, 35, 55, 100, 130	5, 50, 120	Profile the water column in the eastern shallower, nearshore environment of the study area.
Jefferson Head	1, 15, 25, 35, 55, 100, 195	5, 50, 210	Profile the water column in deep water of the study area at a long-term monitoring station.
West Point Outfall	1, 15, 25, 35, 55	5, 30, 55	Profile the water column near a shallow (70 m) secondary wastewater treatment plant outfall.
Renton Outfall	1, 15, 25, 35, 55, 100, 150	5, 50, 130	Profile the water column near a deep (200 m) secondary wastewater treatment plant outfall.
Fauntleroy/Vashon	1, 15, 25, 35, 55, 100, 200	5, 50, 170	Profile the water column at the south end of the study area at a long-term monitoring station.
Colvos Passage	1, 15, 25, 35, 55, 100	5, 50, 85	Profile water entering the south end of the study area from Colvos Passage.

Water column samples have been collected since February 1999 at eight of the ten stations for analysis of conventional parameters, including physical water properties and bacterial analysis. This sampling effort will continue through June 2001. The two Edmonds stations were added to the study in September 2000 and sampling at these two stations only will continue through August 2001. Monthly water column samples were collected from all stations except Edmonds #1 and #2 between April 1999 and May 2000 for analysis of trace metals and trace organic compounds.

Conventional parameters include ammonia nitrogen, nitrate/nitrite nitrogen, total phosphorus, silica, total solids, and pigments (chlorophyll-*a* and pheophytin), as well as fecal coliforms, enterococcus bacteria, and *Escherechia coli*. Trace metal parameters include all priority pollutant metals with the exception of beryllium. Organic parameters include base/neutral/acid extractable semivolatile compounds (BNAs), chlorinated pesticides, polychlorinated biphenyls (PCBs), chlorinated herbicides, and organophosphorus pesticides.

In situ water column profiling data are collected on a monthly basis during transects along the following routes:

- from Point No Point, on the Kitsap Peninsula, across Admiralty Inlet to Indian Point, on Whidbey Island;
- from Possession Point, on Whidbey Island, across Possession Sound to Picnic Point, south of Mukilteo, in Snohomish County;
- from Rose Point, on the Kitsap Peninsula, in an arc (touching the "knife-edge" of Possession Bar) across the central basin to the sound end of Brown's Bay, in Edmonds;
- from Appletree Cove, south of Kingston, on the Kitsap Peninsula, across the central basin to Point Wells, near the King-Snohomish county line;
- from Skiff Point, on Bainbridge Island, across the central basin to West Point, in Seattle; and
- from Restoration Point, on Bainbridge Island, across the central basin to Alki Point, in Seattle.

These electronic, real-time data are collected using a CTD instrument. The term "CTD" refers specifically to the parameters *conductivity, temperature, and depth*, however, data for additional physical water quality parameters are also collected during these sampling efforts. The additional parameters include salinity, density, dissolved oxygen, turbidity (as backscatterance), fluorescence (an indicator of chlorophyll), and photosynthetically active radiation (PAR). Each transect consists of five or six stations equidistantly spaced across the transect route. CTD measurements are collected continuously at each station from the surface to a depth of approximately five meters above the bottom during both downcasts and upcasts of the instrument.

CTD transects have been performed since December 1998 at the Possession Sound and Point Wells locations and will continue through July 2001. The Admiralty Inlet transect was performed from December 1998 through May 2000. The transects at Rose Point, Alki Point and West Point were added to the program in July 2000 and will continue through July 2001.

3.3 Sampling Strategy for Intertidal Water Quality

Water quality sampling is performed at intertidal locations throughout the MOSS study area to evaluate physical, chemical, and microbiological characteristics of Puget Sound water in these sensitive environments.

The intertidal water quality program consists of monthly point sampling at 12 locations on the eastern Puget Sound shoreline in King and Snohomish counties to assess spatial and temporal variations of physical, chemical, and microbiological parameters. The 12 point-sampling locations were selected to provide coverage of the entire MOSS study area as well as assess water quality conditions in areas of particular interest for both ecological and human health risk assessments. Samples are collected from a single depth in the intertidal zone at each of the stations. Table 2 presents the intertidal water quality sampling locations and the rationale for selection of each sampling station.

Table 2
Intertidal Water Quality Sampling Locations

Station	Rationale
Mukilteo State Park	Northern extent of the intertidal study area, located in Possession Sound. Public park area with high degree of public access.
Picnic Point Park	Located at entrance to Possession Sound. Public park area with high degree of public access.
Meadowdale Beach Park	Near the mouth of Lund's Gulch Creek, a salmon-bearing stream. Public park area with moderate to high degree of public access.
Ocean Avenue	Within long expanse of even, open shoreline south of Brown's Bay. Broad, open intertidal area with limited public access across railroad tracks.
Brackett's Landing	Small embayment enclosed by ferry dock and constructed jetty. SCUBA diving park with high degree of public access.
Edwards Point	Southern side of Edwards Point within broad, open expanse of exposed shoreline between Edwards Point and Point Wells. Moderate public access in undeveloped park area.
Richmond Beach	South of Point Wells near former wastewater treatment plant outfall. Moderate public access across railroad tracks. Historic King County sampling location.
Boeing Creek	Near the mouth of Boeing Creek, a salmon-bearing stream. Private reserve with limited public access. Some fishing with enhanced reef area for rockfish.
Carkeek Park	Near the mouth of Piper's Creek, a salmon-bearing stream. Public park area with high degree of public access.
Blue Ridge Park	Private beach/park area with limited public access. Near controlled CSO and storm water outfalls. Historic King County sampling location.
Golden Gardens Park	North of heavily-used marina. Public park area with high degree of public access. Historic King County sampling location.
Shilshole Bay	Southern extent of the intertidal study area near entrance to the Lake Washington Ship Canal. Limited public access. High degree of fresh/marine water interchange due to operation of navigational locks. Historic King County sampling location.

Samples have been collected monthly at 11 of the station since March 2000 and the sampling effort will continue through February 2002. The Mukilteo State Park station was added to the intertidal water quality program in March 2001. Intertidal water samples are collected monthly for the analysis of nutrients (ammonia nitrogen, nitrate/nitrite nitrogen, total phosphorus, and silica), salinity, and bacteria (fecal coliforms, enterococcus, and *Escherechia coli*). Samples are collected quarterly for analysis of the same trace metal and trace organic compounds as described in the water

column profiling study. Trace metal and trace organic parameters were also collected monthly from three intertidal locations (Meadowdale Beach Park, Edwards Point, and Carkeek Park) for purposes of additional statistical analysis of the data. Sampling for analysis of organic parameters and monthly sampling at the three locations for analysis of metals parameters was discontinued after February 2001.

4 Sampling and Field Data Collection

The representativeness of a data set may be enhanced by following a standard set of protocols for collecting samples and gathering field data. This section describes field methodologies and protocols for collection of representative offshore and intertidal water samples, as well as the electronic collection of *in situ* field data. Offshore water column samples and CTD field data will generally be collected from either of King County's research vessels, *Liberty* or *Chinook*. If scheduling or maintenance conflicts occur, samples or field data may be collected from the University of Washington School of Oceanography's research vessel, *Clifford Barnes*.

4.1 Water Column Profiling

Focused point-sampling will occur on a monthly basis at the ten locations described in Section 3.2. Samples will be collected from the same stations each month at multiple depths. Each of the sampling studies has been designed to occur for a minimum of one year. After a period of one year, resulting data will be reviewed and statistically analyzed to direct further sampling efforts.

4.1.1 Station Positioning

A precise method of offshore station positioning is important for studies in which sampling stations are revisited multiple times. The water column profiling studies will not only assess spatial differences in water column characteristics over the study area but temporal changes at each particular location as well. In order to assess temporal changes in water column characteristics, the station must be revisited as precisely as possible.

Station positioning for this project will be accomplished using a Differential Global Positioning System (DGPS). Prior to the study, prescribed station coordinates (State Plane NAD83 coordinate system) are loaded into the shipboard DGPS. During the sampling event, the shipboard navigational system will utilize the differential data transmissions from regional Coast Guard base stations to automatically correct its GPS satellite data. The GPS antenna is boom-mounted above the sampler descent line to achieve a more accurate coordinate fix above the sampling point. Previous DGPS usage indicates that an average precision of one to two meters can usually be attained.

4.1.2 Sample Collection and Handling

This section describes sampling methodologies for the collection of water column samples to be analyzed for conventional, metal, organic, and microbiological parameters. Samples will be collected for conventional and microbiological analysis from between five and seven depths, depending on the station. This depth regime mirrors historic

sampling depths from King County's ambient monitoring program with samples collected from depths of 1, 15, 25, 35, 55, and 100 meters and a seventh station approximately 10 to 15 meters above the seafloor. Three of the ten sampling stations have samples collected from five or six depths, due to the total depth at the station.

Samples for analysis of trace metals and trace organics will be collected from three depths; five meters below the surface, a mid-depth of 50 meters, and a deep station approximately 5 to 15 meters above the seafloor. The exception to this regime is at the West Point station due to the shallower depth at this location. Sampling depths for each type of analysis are summarized in Table 1.

4.1.2.1 Conventionals

Samples for analysis of conventional parameters will be collected using a CTD, with Niskin sample bottles deployed on the CTD "rosette." Predetermined sampling depths will be programmed into the CTD and the instrument deployed as described in Section 4.1.3. Analytical samples will be collected on the upcast of the CTD. Upon retrieval of the CTD, sample aliquots will be transferred from the Niskin bottles into sample containers. Samples will be stored in ice-filled coolers until delivery to the laboratory.

Field QC samples will include collection of replicate samples at the rate of one per 20 analytical samples collected. Analytical QC samples will also be collected for three CTD parameters: dissolved oxygen, turbidity, and salinity. A total of seven QC samples will be collected for each of the parameters; one set at a different depth at each of seven sampling stations.

4.1.2.2 Trace Metals

Prior to each sampling event, all sampling equipment and containers are cleaned according to King County Environmental Laboratory SOP #06-05-005-000. The sampling procedures will utilize the "clean hands/dirty hands" technique outlined in EPA Method 1669 (EPA 1995). Before arriving at the initial sampling site, sampling personnel will be designated "clean hands," "dirty hands," and "crane operator." "Clean hands" will handle all operations involving contact with the sample container and transfer of the sample from the sampling device to the sample container. "Dirty hands" is responsible for preparation of the sampling device and for all other activities that do not involve direct contact with the sample. "Crane operator" is responsible for setup and operation of the clean winch system along with backup "dirty hands" responsibilities.

All equipment will be non-metallic and sampling personnel will always wear non-powdered PVC gloves. Prior to the sampling event, a pre-deployment equipment blank is collected and all sampling equipment is double-bagged in zippered, plastic bags. Samples will be collected using Niskin-X bottles attached to a synthetic hydroline. A specialized, non-contaminating winch system mounted on the rear deck of the King County research vessel *Liberty* controls the hydroline. The skipper maneuvers the vessel in a manner that allows the hydroline to remain upwind and upcurrent of engine exhaust. The Niskin-X bottles are attached to the hydroline and lowered to the specified sampling depth. A "messenger" is released down the hydroline to trip the bottles. The Niskin-X

bottles are then brought up and samples dispensed into sample containers immediately upon coming out of the water and while still attached to the hydroline. Samples containers are then double-bagged and stored in ice-filled coolers until delivery to the laboratory.

Field duplicates, field replicates and atmosphere blanks will be collected at a minimum of one set for each day of the sampling event (generally two days' duration). These samples will typically be collected at first station of each day's cruise. Additional sets of duplicates and replicates will be collected at the last station if the total number of field samples collected exceeds 20 or to meet project requirements. An additional atmosphere blank will be collected during the cruise if there are significant changes in atmospheric conditions. Field blanks and carboy blanks will be collected at a minimum of one set each day at the last station of the day's cruise.

4.1.2.3 Trace Organics

Organic analytical samples will be collected in conjunction with the collection of samples for conventional analysis (Section 4.1.2.1). Samples will be transferred from the Niskin bottles into pre-cleaned sample bottles and then stored in ice-filled coolers until delivery to the laboratory. Extra care will be taken to ensure that potential contamination by sampling gloves, diesel exhaust, and other shipboard contaminants is minimized. Field QC will consist of the collection field replicates at the rate of one per 20 samples. An atmosphere blank will also be collected at least once during each cruise and more than once if there is a significant change in atmospheric conditions during the cruise.

4.1.2.4 Microbiology

Microbiology samples will be collected in conjunction with the collection of samples for conventional analysis (Section 4.1.2.1). Samples will be transferred from the Niskin bottles into sterile sample bottles and then stored in ice-filled coolers until delivery to the laboratory. Field QC will consist of the collection field replicates at the rate of one per 20 samples.

4.1.3 CTD In Situ Data Collection

The SBE 25 SEALOGGER® CTD, manufactured by SeaBird Electronics of Bellevue, Washington, is a profiling system for lake, coastal, estuarine, and deep water work. In addition to measuring conductivity, temperature, and depth, the instrument also measures dissolved oxygen, chlorophyll, light intensity (photosynthetically active radiation), and turbidity (optical backscatterance). CTD data measured directly are also used to calculate salinity and density.

The CTD is deployed from the research vessels by hydraulic winch. The instrument is allowed to equilibrate to surface conditions for approximately five minutes before data recording begins. The CTD is lowered at a specified descent rate from the surface to approximately five meters above the sea floor (downcast). Data are recorded both on the down cast and during the instrument's return to the surface, the upcast. Data are recorded

to a datalogger at a frequency of eight hertz or approximately eight recordings per second.

Upon retrieval of the instrument, data are uploaded to a laptop computer from the datalogger prior to the next cast. System software converts parameter data into surface-to-depth plots which are field-reviewed for quality control. Routine "between-cast" maintenance is also performed prior to the next cast. After each CTD transect cruise, system software is employed to convert data for each parameter and location into surface-to-depth plots which are transmitted electronically to project personnel for review and analysis.

QA/QC for the CTD transect task will be maintained through instrument calibration, collection of field samples for laboratory analytical verification, and assessment of data comparability.

The thermometer, conductivity probe, turbidity probe, light intensity probes, and fluorometer will be calibrated, as recommended, on an annual basis by the instrument manufacturer/distributor. The dissolved oxygen probe will be calibrated by project personnel on a regular basis (generally following membrane changes), using Winkler titration methodology. System maintenance and calibration information are kept in instrument logbooks along with cruise-specific notes.

Field samples will be collected during monthly water column sampling cruises for laboratory analysis of dissolved oxygen, salinity, and turbidity. Laboratory results will be compared to electronic *in situ* data as a further QC check. The monthly field QC samples will be collected from various stations and depths for a total of seven QC samples for each of the three parameters.

Data comparability will be assessed after each CTD transect cruise by comparing CTD plots for each parameter to expected field conditions. Current CTD plots will also be compared with long-term trend analysis for each location and parameter.

4.2 Intertidal Water Quality Sample Collection and Handling

Intertidal water quality sampling occurs on a monthly basis at the twelve locations described in Section 3.3. Samples are collected from the same stations each month at a single depth of approximately one-half meter. The sample collector(s) visually position themselves at the site prior to sampling through the use of shoreline benchmarks and then wade into the water to a depth of approximately one meter.

When the sample collector(s) are in position, water samples are collected by removing the caps from the sample containers and submerging the containers in an inverted position. Once under water, the sample containers are then returned to the upright position to allow air to escape and water to enter. Upon retrieval, the sample containers are capped and placed in ice-filled coolers for transport to the laboratory. This methodology will be used for collection of samples for analysis of conventional, organic, and microbiological parameters. Care is taken to alleviate contamination of samples collected for organic analysis by minimizing the time the sample is exposed to air and by minimizing contact with the interior of the sample container by gloved hands.

Intertidal water samples for analysis of trace metal parameters are collected by a minimum of two persons acting as a team. One person acts as "clean hands" and the other person acts as "dirty hands." Sample containers for metal analytes are cleaned as described in Section 4.1.2.2 and maintained in two zippered, plastic bags. "Dirty hands" has contact only with the outer plastic bag, opening it for access by "clean hands." "Clean hands" then opens the inner bag, removes the sample container and proceeds to collect the sample as described for collection of samples for analysis of conventional, organic, and microbiology parameters.

Field data collected for the intertidal water quality task include measurements of water temperature, pH, and dissolved oxygen. Temperature measurements may be collected by means of a digital thermometer by submerging the probe underwater and then recording the reading once the instrument has stabilized. Temperature measurements may also be collected, along with pH and dissolved oxygen, with a YSI® multi-probe datalogger. The datalogger probe is also submerged and temperature, pH, and dissolved oxygen measurements recorded once the instrument has stabilized. All field instruments are calibrated and maintained according to manufacturer's guidance and calibration records are kept in dedicated instrument logbooks.

QA/QC for the intertidal water quality task will include the collection and analysis of field replicate samples for all parameters and the collection and analysis of atmosphere blanks for trace metal and organic parameters. Atmosphere blanks consist of sample containers of laboratory reagent water, which are prepared in the laboratory prior to each sampling event. The atmosphere blank sample containers are uncapped at a designated sampling station and left uncapped for the duration of sample collection for the trace metal and organic parameters. Both field replicate samples and atmosphere blanks are collected at the rate of one per sampling event. QA/QC for field measurements will include the collection of one or more samples per sampling event for laboratory analysis of pH and dissolved oxygen. Laboratory results will be compared with field measurements as a verification of instrument performance.

5 Laboratory Analysis

The completeness and comparability of a data set may be enhanced by following a standard set of protocols for analyzing samples. Analysis of a prescribed set of laboratory QC samples will allow a data set to be evaluated in terms of precision, accuracy, and bias. This section describes analytical methodologies and associated QA/QC protocols that will be employed during analysis of both water column and intertidal water samples for the MOSS project.

5.1 Conventionals

Conventional parameters analyzed on a routine basis will include ammonia nitrogen, nitrate/nitrite nitrogen, total phosphorous, silica, chlorophyll-*a* (including pheophytin) and total suspended solids. Seven to ten samples will also be collected during a number of water column sampling events as QC checks for the CTD field instrument (see Section 4.1.3). These QC samples will be analyzed for dissolved oxygen, salinity, and turbidity.

Analytical methods, appropriate sample containers, and associated detection limits are summarized in Table 3.

The method detection limit (MDL) is that concentration at which an analyte *can reliably be detected.* The reporting detection limit (RDL) is that concentration at which an analyte *can reliably be quantified.*

Table 3
Conventional Parameters

Analyte	Method	Container	MDL	RDL	Units
Ammonia Nitrogen	SM4500-NH3-H	250 ml HDPE CWM	0.01	0.02	mg/L
Nitrate/Nitrite Nitrogen	SM4500-NO3-F	250 ml HDPE CWM	0.02	0.04	mg/L
Total Phosphorous	SM4500-P-B,F (mod.)	250 ml HDPE CWM	0.005	0.01	mg/L
Silica	SM4500-SI-D	250 ml HDPE CWM	0.05	0.10	mg/L
Chlorophyll-*a*	EPA 445.0	250 – 1000 ml HDPE AWM	0.01	0.02	µg/L
Pheophytin	EPA 445.0	250 – 1000 ml HDPE AWM	0.01	0.02	µg/L
Total Suspended Solids	SM2540-D	1000 ml HDPE CWM	0.5	1.0	mg/L
Dissolved Oxygen	SM4500-O-C	300 ml glass BOD bottle	0.5	1.0	mg/L
Salinity	SM2520-B	250 ml HDPE CNM	0.005	0.01	PSS
Turbidity	SM2310-B	500 ml HDPE CWM	0.5	1.0	NTU

SM – Standard Method
EPA – Environmental Protection Agency
HDPE – High Density Polyethylene
CWM – Clear Wide Mouth
AWM – Amber Wide Mouth
CNM – Clear Narrow Mouth
BOD – Biochemical Oxygen Demand
ml – Milliliter
mg/L – Milligram Per Liter
µg/L – Microgram Per Liter
PSS - Practical Salinity Scale
NTU – Nephelometric Turbidity Unit

All analyses will be performed by the King County Environmental Laboratory.

5.1.1 Conventionals Analytical Methodologies

The following section provides a brief description of each of the methods for conventional analyses.

- Ammonia Nitrogen – This is an automated analysis of the ammonium ion, when ammonium is introduced to a basic medium, forms ammonia gas. In the membrane module, the ammonia gas diffuses across a polypropylene membrane and is retained in a slightly acidic stream. Phenol and alkaline hypochlorite react with ammonia to form indophenol blue that is proportional to the ammonia concentration. The blue color formed is intensified with sodium nitroferricyanide. The absorbance is measured at 660 nm.
- Nitrate/Nitrite Nitrogen – This is an automated analysis where nitrate is converted to nitrite by cadmium reduction. Nitrite is determined by diazotizing with sulfanilamide and coupling with N-(1-naphthyl)-ethylenediamine dihydrochloride to form a highly colored azo dye, which is proportional to the nitrite concentration. Nitrite alone may be determined by omitting the reduction step. The absorbance is measured at 540 nm.
- Total Phosphorous – Most forms of phosphorus are oxidized to orthophosphate using ammonium persulfate in an acidic medium and under high pressure and temperature.

The digestate is analyzed by automated colorimetry for orthophosphate. Orthophosphate reacts with molybdenum VI and antimony III in an acidic medium to form an antimonyphosphomolybdate complex. This complex is subsequently reduced with ascorbic acid to form a blue color and the absorbance is read at 660 nm.

- Silica – This is an automated analysis of silica. Silica in solution as silicic acid or silicate reacts with molybdate reagent in acid media to form β-molybdo-silicic acid. The complex is reduced by ascorbic acid to form molybdenum blue. The absorbance is measured at 660 nm.
- Chlorophyll-*a* with Pheophytin – Sample is concentrated by filtering a measured volume of sample through a glass fiber filter at low vacuum. Pigment is extracted from the phytoplankton by ultrasonic disruption of the cells in an acetone medium. Concentration of chlorophyll-a is determined fluorometrically. Because pheophytin is a positive interferent, chlorophyll-a is converted to pheophytin by acidification and then the concentration of pheophytin is determined, allowing calculation of the original concentrations of these related pigments. The fluorometric method provides a procedure for determination of low level chlorophyll-a and pheophytin, in marine phytoplankton using fluorescence detection.
- Total Suspended Solids – A well mixed sample is filtered through a 0.45 µm glass fiber filter, the residue retained on the filter is dried to constant weight at 103 to 105°C. The increase in weight of the filter represents the total suspended solids.
- Dissolved Oxygen – Dissolved oxygen (DO) by the Winkler titration, Azide modification method. The sample is treated with manganous sulfate followed by Alkali-Iodide-Azide(A-I-A) solution. Dissolved oxygen rapidly oxidizes an equivalent amount of the dispersed divalent manganous hydroxide to form a brown precipitate, $Mn(OH)_2$. Upon acidification with sulfuric acid, manganic hydroxide forms manganic sulfate, which then acts as an oxidizing agent to liberate free Iodine from the alkali-iodide. The iodine, which is stoichiometrically equivalent to the dissolved oxygen in the sample, is then titrated with a standard solution of sodium thiosulfate. The titration end point is determined visually with a starch indicator.
- Salinity – Conductance of an electrical current through the sample is measured and compared to the conductivity of a standard seawater solution. This is an automated analysis of salinity in saline waters, between 3-42 on the Practical Salinity Scale.
- Turbidity – The method is based on a comparison of the intensity of light scattered by the sample under defined conditions with the intensity of light scattered by a standard reference suspension under the same conditions. The higher the intensity of scattered light, the higher the turbidity. The range of turbidity from 0 to 40 nephelometric units (NTU), higher values may be obtained with dilution of the sample.

5.1.2 Conventionals QA/QC

Laboratory QC samples for conventional analyses and associated control limits are summarized in Table 4. These QC samples will be analyzed at a frequency of one per analytical batch or a minimum of one per 20 analytical samples.

Table 4
Conventional QC Samples

Analysis	Method Blank	Duplicate RPD	LCS % Recovery	Matrix Spike % Recovery
Ammonia Nitrogen	< MDL	25%	80 – 120	70 – 130
Nitrate/Nitrite Nitrogen	< MDL	25%	80 – 120	70 – 130
Total Phosphorous	< MDL	25%	80 – 120	70 – 130
Silica	< MDL	25%	80 – 120	70 – 130
Chlorophyll-*a*/Pheophytin	< MDL	25%/50%	80 – 120	N/A
Total Suspended Solids	< MDL	25%	N/A	N/A
Dissolved Oxygen	N/A	N/A	N/A	N/A
Salinity	N/A	0.05 PSS**	N/A	N/A
Turbidity	N/A	25%	80 – 120	N/A

RPD – Relative Percent Difference
LCS – Laboratory Control Sample
< MDL – Less Than Method Detection Limit
N/A – Not Applicable
**Duplicate RPD for salinity should be within 0.05 PSS (Practical Salinity Scale).

5.2 Trace Metals

Trace metal parameters analyzed on a routine basis will include antimony, arsenic, cadmium, chromium, cobalt, copper, lead, mercury, nickel, selenium, silver, thallium, vanadium, and zinc. Analytical methods, appropriate sample containers, and associated detection limits are summarized in Table 5.

Table 5
Trace Metal Parameters

Analyte (Total and Dissolved Metals)	Method (Preparation/Analysis)	Container	MDL (µg/L)	RDL (µg/L)
Antimony	Reductive Precipitation/ICP-MS	500 ml HDPE wide mouth	0.01	0.05
Arsenic	Reductive Precipitation/ICP-MS	500 ml HDPE wide mouth	0.03	0.15
Cadmium	Reductive Precipitation/ICP-MS	500 ml HDPE wide mouth	0.005	0.025
Chromium	Reductive Precipitation/ICP-MS	500 ml HDPE wide mouth	0.03	0.15
Cobalt	Reductive Precipitation/ICP-MS	500 ml HDPE wide mouth	0.004	0.02
Copper	Reductive Precipitation/ICP-MS	500 ml HDPE wide mouth	0.02	0.1
Lead	Reductive Precipitation/ICP-MS	500 ml HDPE wide mouth	0.005	0.025
Mercury	EPA Method 1631 (CVAFS)	250 ml Teflon™ narrow mouth	0.0001	0.0005
Nickel	Reductive Precipitation/ICP-MS	500 ml HDPE wide mouth	0.05	0.25
Selenium	Reductive Precipitation/ICP-MS	500 ml HDPE wide mouth	0.15	0.75
Silver	Reductive Precipitation/ICP-MS	500 ml HDPE wide mouth	0.06	0.30
Thallium	Reductive Precipitation/ICP-MS	500 ml HDPE wide mouth	0.005	0.025
Vanadium	Reductive Precipitation/ICP-MS	500 ml HDPE wide mouth	0.02	0.1
Zinc	Reductive Precipitation/ICP-MS	500 ml HDPE wide mouth	0.15	0.75

µg/L – Micrograms Per Liter
HDPE – High Density Polyethylene
ICP-MS – Inductively Coupled Plasma Mass Spectroscopy
EPA – Environmental Protection Agency
CVAFS – Cold Vapor Atomic Fluorescence Spectroscopy

Mercury analysis will be performed by Frontier Geosciences of Seattle, Washington. All other analyses will be performed by the King County Environmental Laboratory.

5.2.1 Trace Metals Analytical Methodologies

The following section provides a brief description of each of the methods for trace metals analyses.

- Mercury (Hg) Sample Preparation – A 100 ml sample aliquot is placed in a specially designed purge vessel made of fluoropolymer to which a 0.2 Normal bromium chloride (BrCl) solution is added, oxidizing all mercury compounds to Hg(II). The sample is then pre-reduced with hydroxamine hydrochloride ($NH_2OH{\cdot}HCl$) to destroy the free halogens from the oxidizing agent.
- Mercury Analysis – The sample is reduced with tin chloride ($SnCl_2$) to convert Hg(II) to volatile Hg(0). The Hg(0) is separated from solution by purging the sample with nitrogen and driving the Hg(0) onto a gold trap. The trapped mercury is thermally desorbed from the gold trap into an inert gas stream that carries the released Hg(0) into the cell of a cold-vapor atomic fluorescence spectrometer (CVAFS) for detection.
- Metals Sample Preparation – Marine water samples for total metals analysis are preserved to a pH of <2 by acidification with ultrapure nitric acid at an equivalent concentration of 0.2%. Dissolved metals samples are also preserved to a pH of <2 by the same method after being filtered through a 0.45 μm filter. The amount of nitric acid used to preserve the samples is important to the subsequent steps in the analytical procedure. Sample pH is adjusted to between 8 and 10 using ammonium hydroxide during the co-precipitation reaction and it is important to minimize the amount of ammonium hydroxide required for this adjustment. Consequently, the amount of nitric acid used for the preservation should be the minimum amount required to maintain a pH of <2. Trace elements are pre-concentrated by a factor of 10 during the reductive precipitation procedure which uses sodium borohydride as a reducing agent. Iron (Fe) and Palladium (Pd) are added to samples to aid co-precipitation of metal borides and to enhance the precipitation of metals coming out in elemental form. The precipitate is collected by filtration through a 0.4 μm filter and the salt matrix is discarded with the filtrate. The filter and precipitate are digested with nitric acid and hydrogen peroxide.
- Metals Analysis – Samples are analyzed by Inductively Coupled Plasma Mass Spectrometry (ICP-MS). Aqueous samples are nebulized into a spray chamber where a stream of argon carries the sample aerosol through a quartz torch and injects it into an RF plasma. There, the sample is decomposed and desolvated. The ions produced are entrained in the plasma gas and, by means of a water-cooled, differentially pumped interface, introduced into a high-vacuum chamber that houses a quadrupole mass spectrometer. The ions are sorted according to their mass-to-charge ratio and measured with a detector.

5.2.2 Trace Metals QA/QC

Laboratory quality control (QC) samples for trace metals analysis and associated control limits are summarized in Table 6. These QC samples will be analyzed at a frequency of one per analytical batch or a minimum of one per 20 analytical samples.

Table 6
Trace Metal QC Samples

Analysis	Method Blank	Blank Spike % Recovery	Filter Blank	Duplicate RPD	SRM % Recovery	Matrix Spike % Recovery
Mercury	BC	N/A	BC	20%	80 - 120	80 - 120
Metals	< MDL	80 - 120	< MDL	20%	80 - 120	80 - 120

BC - Blank Corrected (sample concentrations corrected to reflect concentrations detected in blanks)
RPD – Relative Percent Difference
SRM - Standard Reference Material
< MDL – Less Than Method Detection Limit
N/A – Not Applicable

5.3 Trace Organics

Trace organics parameters analyzed on a routine basis will include base/neutral/acid extractable semivolatile compounds (BNAs), chlorinated pesticides, polychlorinated biphenyls (PCBs), organophosphorus pesticides, and chlorinated herbicides. Analytical methods, appropriate sample containers, and associated detection limits are summarized in Table 7.

Table 7
Trace Organic Parameters

Analyte	Method (Preparation/Analysis)	Container	MDL (µg/L)	RDL (µg/L)
1,2,4-Trichlorobenzene	EPA 3520C/8270C (LVI)	2 1Liter bottles	0.005	0.025
1,2-Dichlorobenzene	EPA 3520C/8270C (LVI)	2 1Liter bottles	0.025	0.125
1,3-Dichlorobenzene	EPA 3520C/8270C (LVI)	2 1Liter bottles	0.025	0.125
1,4-Dichlorobenzene	EPA 3520C/8270C (LVI)	2 1Liter bottles	0.025	0.125
2,4,5-Trichlorophenol	EPA 3520C/8270C (LVI)	2 1Liter bottles	0.063	0.125
2,4,6-Trichlorophenol	EPA 3520C/8270C (LVI)	2 1Liter bottles	0.025	0.125
2,4-Dichlorophenol	EPA 3520C/8270C (LVI)	2 1Liter bottles	0.050	0.125
2,4-Dimethylphenol	EPA 3520C/8270C (LVI)	2 1Liter bottles	0.750	2.500
2,4-Dinitrophenol	EPA 3520C/8270C (LVI)	2 1Liter bottles	0.500	1.250
2,4-Dinitrotoluene	EPA 3520C/8270C (LVI)	2 1Liter bottles	0.025	0.063
2,6-Dinitrotoluene	EPA 3520C/8270C (LVI)	2 1Liter bottles	0.025	0.063
2-Chloronaphthalene	EPA 3520C/8270C (LVI)	2 1Liter bottles	0.005	0.025
2-Chlorophenol	EPA 3520C/8270C (LVI)	2 1Liter bottles	0.050	0.125
2-Methylnaphthalene	EPA 3520C/8270C (LVI)	2 1Liter bottles	0.050	0.250
2-Methylphenol	EPA 3520C/8270C (LVI)	2 1Liter bottles	0.350	1.250
2-Nitroaniline	EPA 3520C/8270C (LVI)	2 1Liter bottles	0.050	0.100
2-Nitrophenol	EPA 3520C/8270C (LVI)	2 1Liter bottles	0.025	0.125
3,3'-Dichlorobenzidine	EPA 3520C/8270C (LVI)	2 1Liter bottles	0.375	2.500
3-Nitroaniline	EPA 3520C/8270C (LVI)	2 1Liter bottles	0.250	0.625
4,6-Dinitro-O-Cresol	EPA 3520C/8270C (LVI)	2 1Liter bottles	0.500	1.250
4-Bromophenyl Phenyl Ether	EPA 3520C/8270C (LVI)	2 1Liter bottles	0.013	0.025
4-Chloro-3-Methylphenol	EPA 3520C/8270C (LVI)	2 1Liter bottles	0.125	0.250
4-Chloroaniline	EPA 3520C/8270C (LVI)	2 1Liter bottles	0.125	0.250
4-Chlorophenyl Phenyl Ether	EPA 3520C/8270C (LVI)	2 1Liter bottles	0.013	0.025
4-Methylphenol	EPA 3520C/8270C (LVI)	2 1Liter bottles	0.125	0.625
4-Nitroaniline	EPA 3520C/8270C (LVI)	2 1Liter bottles	0.250	0.625
4-Nitrophenol	EPA 3520C/8270C (LVI)	2 1Liter bottles	0.250	1.250
Acenaphthene	EPA 3520C/8270C (LVI)	2 1Liter bottles	0.005	0.025

Table 7 (cont.)
Trace Organic Parameters

Analyte	Method (Preparation/Analysis)	Container	MDL (µg/L)	RDL (µg/L)
Acenaphthylene	EPA 3520C/8270C (LVI)	2 1Liter bottles	0.005	0.025
Anthracene	EPA 3520C/8270C (LVI)	2 1Liter bottles	0.005	0.025
Benzo(a)anthracene	EPA 3520C/8270C (LVI)	2 1Liter bottles	0.013	0.025
Benzo(a)pyrene	EPA 3520C/8270C (LVI)	2 1Liter bottles	0.005	0.013
Benzo(b)fluoranthene	EPA 3520C/8270C (LVI)	2 1Liter bottles	0.005	0.013
Benzo(g,h,i)perylene	EPA 3520C/8270C (LVI)	2 1Liter bottles	0.025	0.063
Benzo(k)fluoranthene	EPA 3520C/8270C (LVI)	2 1Liter bottles	0.005	0.013
Benzyl Butyl Phthalate	EPA 3520C/8270C (LVI)	2 1Liter bottles	0.005	0.013
Bis(2-Chloroethoxy)Methane	EPA 3520C/8270C (LVI)	2 1Liter bottles	0.005	0.013
Bis(2-Chloroethyl)Ether	EPA 3520C/8270C (LVI)	2 1Liter bottles	0.005	0.013
Bis(2-Chloroisopropyl)Ether	EPA 3520C/8270C (LVI)	2 1Liter bottles	0.005	0.013
Bis(2-Ethylhexyl)Phthalate	EPA 3520C/8270C (LVI)	2 1Liter bottles	0.005	0.013
Caffeine	EPA 3520C/8270C (LVI)	2 1Liter bottles	0.005	0.013
Carbazole	EPA 3520C/8270C (LVI)	2 1Liter bottles	0.013	0.025
Chrysene	EPA 3520C/8270C (LVI)	2 1Liter bottles	0.013	0.025
Dibenzo(a,h)anthracene	EPA 3520C/8270C (LVI)	2 1Liter bottles	0.025	0.063
Dibenzofuran	EPA 3520C/8270C (LVI)	2 1Liter bottles	0.005	0.013
Diethyl Phthalate	EPA 3520C/8270C (LVI)	2 1Liter bottles	0.005	0.013
Dimethyl Phthalate	EPA 3520C/8270C (LVI)	2 1Liter bottles	0.005	0.013
Di-N-Butyl Phthalate	EPA 3520C/8270C (LVI)	2 1Liter bottles	0.005	0.013
Di-N-Octyl Phthalate	EPA 3520C/8270C (LVI)	2 1Liter bottles	0.005	0.013
Fluoranthene	EPA 3520C/8270C (LVI)	2 1Liter bottles	0.005	0.013
Fluorene	EPA 3520C/8270C (LVI)	2 1Liter bottles	0.005	0.013
Hexachlorobenzene	EPA 3520C/8270C (LVI)	2 1Liter bottles	0.013	0.025
Hexachlorobutadiene	EPA 3520C/8270C (LVI)	2 1Liter bottles	0.025	0.125
Hexachloroethane	EPA 3520C/8270C (LVI)	2 1Liter bottles	0.013	0.063
Indeno(1,2,3-cd)Pyrene	EPA 3520C/8270C (LVI)	2 1Liter bottles	0.025	0.125
Isophorone	EPA 3520C/8270C (LVI)	2 1Liter bottles	0.005	0.013
Naphthalene	EPA 3520C/8270C (LVI)	2 1Liter bottles	0.013	0.025
Nitrobenzene	EPA 3520C/8270C (LVI)	2 1Liter bottles	0.005	0.013
N-Nitrosodimethylamine	EPA 3520C/8270C (LVI)	2 1Liter bottles	0.013	0.025
N-Nitrosodi-N-Propylamine	EPA 3520C/8270C (LVI)	2 1Liter bottles	0.050	0.100
N-Nitrosodiphenylamine	EPA 3520C/8270C (LVI)	2 1Liter bottles	0.125	0.625
Pentachlorophenol	EPA 3520C/8270C (LVI)	2 1Liter bottles	0.063	0.125
Phenanthrene	EPA 3520C/8270C (LVI)	2 1Liter bottles	0.005	0.013
Phenol	EPA 3520C/8270C (LVI)	2 1Liter bottles	0.050	0.100
Pyrene	EPA 3520C/8270C (LVI)	2 1Liter bottles	0.005	0.013
4,4'-DDD	EPA 3520C/608	2 1Liter bottles	0.005	0.01
4,4'-DDE	EPA 3520C/608	2 1Liter bottles	0.005	0.01
4,4'-DDT	EPA 3520C/608	2 1Liter bottles	0.005	0.01
Aldrin	EPA 3520C/608	2 1Liter bottles	0.005	0.01
Alpha-BHC	EPA 3520C/608	2 1Liter bottles	0.005	0.01
Beta-BHC	EPA 3520C/608	2 1Liter bottles	0.005	0.01
Chlordane	EPA 3520C/608	2 1Liter bottles	0.025	0.05
Delta-BHC	EPA 3520C/608	2 1Liter bottles	0.005	0.01
Dieldrin	EPA 3520C/608	2 1Liter bottles	0.005	0.01
Endosulfan I	EPA 3520C/608	2 1Liter bottles	0.005	0.01
Endosulfan II	EPA 3520C/608	2 1Liter bottles	0.005	0.01

Table 7 (cont.)
Trace Organic Parameters

Analyte	Method (Preparation/Analysis)	Container	MDL (µg/L)	RDL (µg/L)
Endosulfan Sulfate	EPA 3520C/608	2 1Liter bottles	0.005	0.01
Endrin	EPA 3520C/608	2 1Liter bottles	0.005	0.01
Endrin Aldehyde	EPA 3520C/608	2 1Liter bottles	0.005	0.01
Gamma-BHC (Lindane)	EPA 3520C/608	2 1Liter bottles	0.005	0.01
Heptachlor	EPA 3520C/608	2 1Liter bottles	0.005	0.01
Heptachlor Epoxide	EPA 3520C/608	2 1Liter bottles	0.005	0.01
Methoxychlor	EPA 3520C/608	2 1Liter bottles	0.025	0.05
Toxaphene	EPA 3520C/608	2 1Liter bottles	0.050	0.10
Aroclor 1016	EPA 3520C/608	2 1Liter bottles	0.05	0.1
Aroclor 1221	EPA 3520C/608	2 1Liter bottles	0.05	0.1
Aroclor 1232	EPA 3520C/608	2 1Liter bottles	0.05	0.1
Aroclor 1242	EPA 3520C/608	2 1Liter bottles	0.05	0.1
Aroclor 1248	EPA 3520C/608	2 1Liter bottles	0.05	0.1
Aroclor 1254	EPA 3520C/608	2 1Liter bottles	0.05	0.1
Aroclor 1260	EPA 3520C/608	2 1Liter bottles	0.05	0.1
Chlorpyrifos	EPA 3520C/8141A	2 1Liter bottles	0.034	0.050
Diazinon	EPA 3520C/8141A	2 1Liter bottles	0.043	0.050
Disulfoton	EPA 3520C/8141A	2 1Liter bottles	0.027	0.050
Malathion	EPA 3520C/8141A	2 1Liter bottles	0.048	0.050
Parathion-Ethyl	EPA 3520C/8141A	2 1Liter bottles	0.045	0.050
Parathion-Methyl	EPA 3520C/8141A	2 1Liter bottles	0.036	0.050
Phorate	EPA 3520C/8141A	2 1Liter bottles	0.033	0.050
2,4,5-T	EPA 8151 (GCMS Mod.)	2 125 ml bottles	0.072	0.094
2,4,5-TP (Silvex)	EPA 8151 (GCMS Mod.)	2 125 ml bottles	0.076	0.094
2,4-D	EPA 8151 (GCMS Mod.)	2 125 ml bottles	0.082	0.094
2,4-DB	EPA 8151 (GCMS Mod.)	2 125 ml bottles	0.085	0.094
Dalapon	EPA 8151 (GCMS Mod.)	2 125 ml bottles	0.087	0.094
Dicamba	EPA 8151 (GCMS Mod.)	2 125 ml bottles	0.077	0.094
Dichloroprop	EPA 8151 (GCMS Mod.)	2 125 ml bottles	0.140	0.190
Dinoseb	EPA 8151 (GCMS Mod.)	2 125 ml bottles	0.061	0.094
MCPA	EPA 8151 (GCMS Mod.)	2 125 ml bottles	0.080	0.094
MCPP	EPA 8151 (GCMS Mod.)	2 125 ml bottles	0.079	0.094

5.3.1 Trace Organics Analytical Methodologies

The following section provides a brief description of each of the methods for trace organics analyses.

- BNA Sample Preparation – The extraction procedure is EPA 3520C (SW 846) which is a continuous liquid-liquid extraction technique. About one liter of sample is acidified to a pH of <2 and extracted with approximately 400 ml of methylene chloride for 18 to 24 hours. The extract is then dried with sodium sulfate and concentrated to a 0.5 ml final volume.
- BNA Analysis – The analytical method is EPA 8270C (SW 846). Instrumentation includes a gas chromatograph with mass spectrometer (GC-MS). The system has been retrofitted with a large volume injector (LVI) to lower detection limits.
- Chlorinated Pesticide and PCB Sample Preparation – The extraction procedure is EPA 3520C (SW 846) which is a continuous liquid-liquid extraction technique. About one liter of sample is extracted with approximately 400 ml of methylene chloride for 18 to 24 hours. The extract is then dried with sodium sulfate and

concentrated to a 0.5 ml final volume. Alumina cleanup by EPA Method 3610 (SW 846) will be used if necessary.

- Chlorinated Pesticide and PCB Analysis – The analytical method is EPA 608 performed by gas chromatograph with electron capture detector (GC-ECD). Dual column confirmation is performed on all chlorinated pesticide and PCB analyses.
- Chlorinated Herbicide Sample Preparation – Preparation for this analysis is conducted by the subcontract laboratory Sound Analytical Services, Inc. The extraction procedure is EPA 3510C (SW 846) which is a separatory funnel extraction technique. The sample goes through a number of extractions and back extractions into different solvents at various pH . The primary solvents are ether and methylene chloride. The extract is dried with sodium sulfate and concentrated to a 1.0 ml final volume.
- Chlorinated Herbicide Analysis – This analysis is conducted by the subcontract laboratory Sound Analytical Services, Inc. The analytical method is modified EPA 8151A (SW 846). Instrumentation includes a gas chromatograph with an ion trap mass spectrometer.
- Organophosphorus Pesticide Sample Preparation - The extraction procedure is EPA 3520C (SW 846) which is a continuous liquid-liquid extraction technique. About one liter of sample is extracted with approximately 400 ml of methylene chloride for 18 to 24 hours. The extract is then dried with sodium sulfate and concentrated to a 0.5 ml final volume.
- Organophosphorus Pesticide Analysis - The analytical method is modified EPA 8141A (SW 846). Instrumentation includes a gas chromatograph with mass spectrometer (GC-MS) run in the selected ion monitoring (SIM) mode.

5.3.2 Trace Organics QA/QC

Laboratory quality control (QC) samples for trace organics analysis and associated control limits are summarized in Table 8. These QC samples will be analyzed at a frequency of one per analytical batch or a minimum of one per 20 analytical samples.

Table 8
Trace Organic QC Samples

Analysis	Method Blank	Blank Spike % Recovery	Duplicate RPD	Matrix Spike % Recovery	Surrogate % Recovery
BNAs	< MDL	9-127*	100%	9-127*	10-141*
Chlorinated Pesticides	< MDL	23-139*	100%	23-139*	50-150
PCBs	< MDL	50-150	100%	50-150	50-150
Organophosphorus pesticides	< MDL	50-150	100%	50-150	50-150
Chlorinated Herbicides	< MDL	20-157*	23-36%*	20-157*	54-142

* Low to high range of all compounds used for surrogates and spikes.

5.4 Microbiology

Microbiology parameters analyzed on a routine basis will include *Enterococcus*, *Escherichia coli*, and other fecal coliform bacteria. Analytical methods for microbiology, appropriate sample containers, and associated detection limits are summarized in Table 9.

Table 9
Microbiology Parameters

Analyte	Method	Container	MDL
Enterococcus	SM9230C, 19th ed.	500 ml PP, Sterile	1 CFU/100 ml
Escherichia coli	SM9213D, 19th ed.	500 ml PP, Sterile	1 CFU/100 ml
Fecal Coliforms	SM9222D, 19th ed.	500 ml PP, Sterile	1 CFU/100 ml

PP – Polypropylene
CFU – Colony Forming Units
ml - milliliter

5.4.1 Microbiology Analytical Methodologies

The following section provides a brief description of each of the methods for microbiology analyses.

- Enterococcus – A subgroup of the traditional fecal streptococci bacteria that includes *Enterococcus faecalis, E. faecium, E. gallinarum,* and *E. avium.* Enterococci are used as indicators of human fecal bacteria contamination. The analysis of environmental water for enterococci will be done by membrane filtration.
- Escherichia coli – A normal inhabitant of the digestive tract and typical component of the fecal coliform group. The analysis of environmental water for *E. coli* will be done by membrane filtration.
- Fecal coliforms – Gram negative rod, non-sporeformers, gas and acid production from lactose fermentation in 24 hours at 44.5 °Celcius. The analysis of environmental water for fecal coliforms will be done by membrane filtration.

5.4.2 Microbiology QA/QC

Laboratory QA/QC samples for microbiology analyses and associated control limits are summarized in Table 8-11. These QC samples will be analyzed at a frequency of one per analytical batch or a minimum of one per 20 analytical samples.

Table 10
Microbiology QC Samples

Analysis	Lab Duplicate	Positive Control	Negative Control	System Control
Enterococcus	Pass/Fail	Pass/Fail	Pass/Fail	Pass/Fail
Escherichia coli	Pass/Fail	Pass/Fail	Pass/Fail	Pass/Fail
Fecal Coliforms	Pass/Fail	Pass/Fail	Pass/Fail	Pass/Fail

Pass: Meets established quality control guidelines as described in the King County Environmental Laboratory QA/QC Standard Operating Procedure Manual.
Fail: Does not meet established quality control guidelines as described in the King County Environmental Laboratory QA/QC Standard Operating Procedure Manual.

6 Data Validation, Reporting, and Record Keeping

Data validation is critical in the evaluation of how well analytical and field data meet project DQOs. Data validation is performed, at some level, during several steps in the process of sample collection and analysis. All analytical data and some field measurements are entered into King County's Laboratory Information Management System (LIMS).

Field data, such as *in situ* data measurements or recorded environmental observations, are peer reviewed prior to entry into LIMS. Laboratory analytical data are reviewed, first by the primary analyst and then by a senior peer reviewer, prior to entry of the data into LIMS. Analytical data are reviewed for completeness and QC sample data are viewed for compliance with project and method QA/QC requirements. If there are any QC failures at this point, corrective action may be taken or qualifier flags applied to the data.

The laboratory project manager for the MOSS project will provide the next data review step, at a project level. The LPM will verify the completeness of an entire data set (multiple parameters for a particular sampling event) and report any QA/QC failures or anomalies. A MOSS project data validator will provide a final review of data to ensure that they meet the project DQOs. Data then will be reported in a variety of formats, depending on the project needs.

All laboratory analytical data and some *in situ* data are maintained *in perpetuity* on LIMS. Data may be viewed on-line in LIMS by King County personnel only. Project data may also be downloaded from LIMS into a hard copy format using Microsoft Excel®. Analytical data will be reported on a routine basis in Excel® format along with an accompanying QA/QC review narrative.

Laboratory analytical data may be stored with data qualifier flags indicating QC failures. The flag "B" is used to indicate possible laboratory contamination of a sample and is applied when the parameter of interest is also detected in the laboratory method blank. Sample results that are less than five times the concentration detected in the method blank will be qualified with a "B" flag. The flag "H" is used to indicate a sample handling condition that did not meet method requirements. Handling conditions may include an improper sample container, improper preservation of the sample, or an exceedence of the method-specific holding time.

Collection of CTD data at a rate of eight readings per seconds generates a very large data set for each sampling event and precludes inclusion of these data on LIMS. Some CTD data that have been averaged at discrete depths will be maintained on LIMS, however, the major portion of these data will be maintained on CDs dedicated to the MOSS project.

Hard copy field notes, field instrument calibration records, raw analytical data, and any other hard copy project information will be stored according to standard King County Environmental Laboratory practices for a period of ten years.

7 References

American Public Health Association. 1995. Standard methods for examination of waste and wastewater. Greenberg, A.E., R. Trussel, and L.S. Clersceri (eds). American Public Health Association, Washington, DC. 1,268 pp.

PSEP, 1996a. Recommended Guidelines for Sampling Marine Sediment, Water Column, and Tissue in Puget Sound. Prepared for the Puget Sound Estuary Program (U.S. Environmental Protection Agency Region 10) by the King County Environmental Laboratory. Seattle, Washington.

PSEP, 1996b. Recommended Guidelines for Measuring Metals in Puget Sound Marine Water, Sediment and Tissue Samples. Prepared for the Puget Sound Estuary Program (U.S. Environmental Protection Agency Region 10) by the King County Environmental Laboratory. Seattle, Washington.

PSEP, 1996c. Recommended Guidelines for Measuring Organic Compounds in Puget Sound Marine Water, Sediment and Tissue Samples. Prepared for the Puget Sound Estuary Program (U.S. Environmental Protection Agency Region 10) by the King County Environmental Laboratory. Seattle, Washington.

PSEP, 1998. Recommended Guidelines for Station Positioning in Puget Sound. Prepared for the Puget Sound Estuary Program (U.S. Environmental Protection Agency Region 10) by the King County Environmental Laboratory. Seattle, Washington.

U.S. Environmental Protection Agency. 1986. Test procedures for solid waste. Vol. 1B. Laboratory manual physical/chemical methods. 3rd ed. SW846. U.S. EPA, Office of Solid Waste and Emergency Response, Washington, DC.

U.S. Environmental Protection Agency. 1987. Contract laboratory program statement of work, inorganic analysis, multi-media, multi-concentration. SOW No. 87 (Revised December 1987). U.S. EPA, Washington, DC.

U.S. Environmental Protection Agency. 1988. Laboratory data validation functional guidelines for evaluating inorganics analyses. Document No. R-582-5-5-01. U.S. EPA, Sample Management Office, Alexandria, VA. 73 pp.

U.S. Environmental Protection Agency. 1995. Method 1669: Sampling Ambient Water for Trace Metals at EPA Water Quality Criteria Levels EPA-R-95-034 (April 1995 Draft), Office of Water, Washington, DC.

Appendix H. Sediment Sampling and Analysis Plan and Quality Assurance Project Plan

The current version of the CSO Sediment Quality Characterization Sampling and Analysis Plan is attached electronically to this document. This SAP includes the quality assurance information for this program and reflects the protocols and methods used by King County for sediment characterization.

King County Sediment Management Plan Update

CSO Sediment Quality Characterization

Final Sampling and Analysis Plan

Prepared for the

King County Department of Natural Resources and Parks
Wastewater Treatment Division

and the

Washington State Department of Ecology

by the

King County Department of Natural Resources and Parks
Marine and Sediment Assessment Group

August 2011

King County

King County Sediment Management Plan Update

CSO Sediment Quality Characterization

Final Sampling and Analysis Plan

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August 2011

King County

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Appendix A
Scaling Analysis for CSO Sediment Sampling

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1 INTRODUCTION

This sampling and analysis plan (SAP) presents project information along with sampling and analytical methodologies that will be employed to conduct sediment quality characterizations at 10 King County combined sewer overflow (CSO) discharge locations. The work will provide information necessary to update the County's Sediment Management Plan as well as providing pre-construction, baseline sediment quality data at four County CSOs, for which CSO-control projects are currently underway.

The SAP includes a description of the project, monitoring history, sampling design, sampling and analytical methodologies, quality assurance/quality control, and reporting requirements. The SAP has been prepared in accordance with the Washington State Department of Ecology (Ecology) guidance document *Sediment Sampling and Analysis Plan Appendix* (Ecology 2008) as well as Chapter 173-204 WAC, the Washington State Sediment Management Standards (Ecology 1995).

2 PROGRAM DIRECTIVES

The County's Sediment Management Plan (King County 1999) develops remedial strategies for correcting short- and long-term hazards associated with contaminated sediments near King County CSO sites. As part of the update to the SMP, the County has developed a near-field sediment model primarily to evaluate recontamination potential for CSOs, following control and sediment remediation projects. Analysis of the model output will be used to inform the scheduled update to the SMP by providing one line of evidence in determining which remaining areas in front of County CSOs require remedial action. Sediment quality data collected during this CSO sediment characterization project will be used to both to populate the model as well as validate the model output. The specific goals of this CSO sediment quality characterization are to:

- populate, calibrate, and verify the County's near-field sediment recontamination model;
- determine if sediment chemical concentrations in the vicinity of 10 CSO outfalls meet or exceed Washington State Sediment Management Standards (SMS) chemical criteria;
- create a pre-construction sediment quality baseline at four locations, for which CSO control projects are currently underway.

After considering the data needs of the near-field sediment recontamination model and SMP update, King County proposed conducting sediment quality characterizations at 10 County CSO discharge points. The 10 CSO sediment sampling sites are shown in Figure 2-1 and include:

- North Beach Pump Station
- Magnolia CSO
- 53rd Avenue Pump Station
- Murray Street Pump Station
- Barton Street Pump Station
- Brandon Street CSO
- Chelan Avenue CSO
- 3rd Avenue West CSO
- University Regulator
- Montlake CSO

Sediment quality data collected during this monitoring effort at the Barton, Murray, Magnolia, and North Beach CSOs (see Figure 2-1) will also provide a sediment quality baseline, against which future post-construction sediment monitoring data will be compared.

Sediment samples will also be collected from three background stations shown in Figure 2-1. All three background stations are located away from anthropogenic inputs and the depths at which the background samples will be collected represent an average of the associated CSO sampling station depths. Data collected from the three background stations will aid in understanding local background sediment quality for interpretation of specific CSO site data.

The station located on the south side of West Point will serve as a background station for the North Beach and Magnolia sites. The station located off of West Seattle will serve as a background station for the 53rd Avenue SW, Murray Street, and Barton Street sites. The

station located in Union Bay will serve as a background station for the University Regulator and Montlake sites. Suitable background stations were not deemed feasible for the Brandon, Chelan, and 3rd Avenue West sites.

North Beach
West Point
3rd Ave W
UREG
Montlake
Lake Washington
Lake Union
Magnolia
Elliott Bay
Seattle
53rd Ave SW
Alki Point
Chelan
Brandon
Murray
Barton
Figure 2-1
2011 CSO Sediment Quality Characterization
CSO Sediment Sampling Site
Background Station
N

3 CSO SEDIMENT MONITORING HISTORY

King County has collected sediment quality data at the majority of its CSO outfall discharge locations, both as part of its NPDES sediment monitoring program as well as during special environmental studies. These data were previously provided in King County's comprehensive sediment quality report (King County 2009). This section provides a brief summary of the sediment monitoring history at each of the 10 CSO discharge locations that will be sampled as part of this monitoring effort. Sampling efforts by other entities may have collected additional sediment data near some of these CSOs but these data have not been researched and are not included in the following discussion. Table 3-1, located at the end of this section, provides a tabular summary, by CSO location, for exceedences of sediment quality criteria or reference values.

3.1 North Beach CSO

Sediment samples were collected from the 0- to 2-cm depth stratum at six locations proximal to the North Beach Pump Station discharge point in October 1996. Five of the stations formed a transect perpendicular to the end of the outfall and the sixth station was located approximately 1,000 feet from the outfall. Organic carbon concentrations in these six samples ranged from approximately 0.1 to 0.2%. Due to these low organic carbon concentrations, non-ionic organic data from this site were compared to dry-weight normalized SQS and CSL values rather than SQS and CSL chemical criteria for those compounds generally normalized to organic carbon. The phenol concentration of 461 μg/Kg DW, detected in the sample collected from one station located approximately 230 feet from the end of the outfall, exceeded the SQS criterion 420 μg/Kg DW. All other detected chemical concentrations were less than their respective SQS criteria.

3.2 Magnolia CSO

Sediment samples were collected from the 0- to 2-cm depth stratum at six locations proximal to the Magnolia CSO discharge point in October 1996. Five of the stations formed a transect perpendicular to the end of the outfall and the sixth station was located approximately 1,000 feet from the outfall. Organic carbon concentrations in these six samples ranged from approximately 0.1 to 0.2%. Due to these low organic carbon concentrations, organic data from this site were compared to dry-weight normalized SQS and CSL values. All detected chemical concentrations were less than their respective SQS criteria.

3.3 53rd Avenue SW CSO

Sediment samples were collected from the 0- to 2-cm depth stratum at six locations proximal to the 53rd Avenue SW Pump Station discharge point in October 1996. Five of the stations formed a transect perpendicular to the end of the outfall and the sixth station was located approximately 1,000 feet from the outfall. Organic carbon concentrations in these six samples ranged from approximately 0.1 to 0.3%. Due to these low organic carbon concentrations, non-ionic organic data from this site were compared to dry-weight normalized SQS and CSL values. The total PCB concentration of 844 μg/Kg DW, detected in the sample collected from the station located approximately 1,000 feet from the end of the outfall, exceeded the dry-weight normalized SQS of 130 μg/Kg DW. The benzyl butyl phthalate concentration of 65.6 μg/Kg DW detected in this sample also exceeded the SQS of

63 μg/Kg DW. All other detected chemical concentrations were less than their respective SQS criteria.

3.4 Murray Street CSO

Sediment samples were collected from the 0- to 2-cm depth stratum at six locations proximal to the Murray Street Pump Station discharge point in October 1997. Five of the stations formed a transect perpendicular to the end of the outfall and the sixth station was located approximately 1,000 feet from the outfall. Organic carbon concentrations in these six samples ranged from approximately 0.2 to 0.4%. Due to these low organic carbon concentrations, non-ionic organic data from this site were compared to dry-weight normalized SQS and CSL values. The mercury concentration of 3.05 mg/Kg DW, detected in the sample collected from the station located approximately 213 feet from the end of the outfall, exceeded the CSL of 0.59 mg/Kg DW. Due to the magnitude of this mercury concentration, this station was re-sampled, in triplicate, in June 1998 for mercury analysis. Mercury concentrations detected in these three samples ranged from 0.0252 to 0.0427 mg/Kg DW. All other detected chemical concentrations were less than their respective SQS criteria.

3.5 Barton Street CSO

Sediment samples were collected from the 0- to 2-cm depth stratum at six locations proximal to the Barton Street Pump Station discharge point in October 1997. Five of the stations formed a transect perpendicular to the end of the outfall and the sixth station was located approximately 1,000 feet from the outfall. Organic carbon concentrations in these six samples ranged from approximately 0.03 to 0.9%. Due to these low organic carbon concentrations, non-ionic organic data from five stations at this site were compared dry-weight normalized SQS and CSL. The organic carbon concentration of 0.9% at the sixth location dictates reporting data normalized to organic carbon. The dry-weight normalized benzyl butyl phthalate concentration of 114 μg/Kg DW, detected in the sample collected from the station located approximately 212 feet from the end of the outfall, exceeded the dry-weight SQS of 63 μg/Kg DW. The organic-carbon normalized benzyl butyl phthalate concentration of 16.4 mg/Kg OC, detected in the sample collected from the station located approximately 106 feet from the end of the outfall, exceeded the SQS of 4.9 mg/Kg OC. The dry-weight normalized dimethyl phthalate concentration of 172 μg/Kg DW, detected in the sample collected from the station located at the end of the outfall, exceeded the SQS of 71 μg/Kg DW. All other detected chemical concentrations were less than their respective SQS criteria.

3.6 Brandon Street CSO

A single sediment sample was collected from one location (depth stratum unknown) proximal to the Brandon Street CSO discharge point in May 1990. The organic carbon content of this sample was approximately 0.7%, therefore, sediment chemical concentrations for non-ionic organic compounds were compared to organic-carbon normalized SQS chemical criteria. The Total PCB concentration of 32.1 mg/Kg OC in this sample exceeded the SQS criterion of 12 mg/Kg OC. The bis(2-ethylhexyl) phthalate concentration of 159 mg/Kg OC exceeded the CSL criterion of 79 mg/Kg OC.

Sediment samples were collected from the 0- to 2-cm depth stratum at four locations proximal to the Brandon Street CSO in September 1992. Organic carbon concentrations in

these four samples ranged from 1.5 to 2.5%. Multiple SQS and/or CSL criteria exceedences were reported at all four stations. Chemicals that exceeded SMS chemical criteria included mercury, acenaphthene, fluoranthene, fluorene, phenanthrene, benzyl butyl phthalate, bis(2-ethylhexyl) phthalate, 1,4-dichlorobenzene, benzoic acid, and dibenzofuran.

During King County's CSO water quality assessment of the Duwamish River, a 10-station composite sample was collected from the 0- to 2-cm depth stratum at the Brandon CSO outfall on a weekly basis, for 12 weeks in the spring of 1997. The weekly samples were each composited from 10 individual sample aliquots, collected on a 5-meter grid proximal to the outfall. Organic carbon concentrations in these 12 samples ranged from 2.5 to 3.3%. SMS chemical criteria were exceeded in only 2 of the 12 samples. The benzyl butyl phthalate concentration of 11.3 mg/Kg OC in one weekly sample exceeded the SQS criterion of 4.9 mg/Kg OC. The bis(2-ethylhexyl) phthalate concentration of 69.9 mg/Kg OC in one weekly sample exceeded the SQS criterion of 47 mg/Kg OC. Note that these two criteria exceedences were in samples collected during different weeks – during the first week of the program for the sample that exceeded the bis(2-ethylhexyl) phthalate criterion and during the third week for the sample that exceeded the benzyl butyl phthalate criterion. All other sediment chemistry results were less than their respective SMS chemical criteria.

3.7 Chelan Avenue CSO

Sediment samples were collected from the 0- to 2-cm depth stratum at six locations proximal to the Chelan Avenue CSO discharge point in June 1995. Five of the stations formed a transect perpendicular to the end of the outfall and the sixth station was located approximately 100 feet east of the end of the outfall. Organic carbon concentrations at the six stations ranged from approximately 0.4 to 3.0%. As a result, all sediment chemistry results were normalized to organic carbon for comparison to SMS chemical criteria. There were no exceedences of SMS sediment chemical criteria at the station located 100 feet east of the outfall, which is near the center channel of the Duwamish River west waterway. There were, however, multiple SMS exceedences at the five transect stations. Chemicals for which stations exhibited SQS exceedences included benzo(g,h,i)perylene, chrysene, dibenzo(a,h)anthracene, fluoranthene, indeno(1,2,3-c,d)pyrene, phenanthrene, total PCBs, 1,4-dichlorobenzene, and phenol. One station, located approximately 200 feet north of the outfall exhibited a CSL exceedence for phenol.

As a result of these SMS chemical criteria exceedences, sediment sampling at the Chelan Avenue CSO was repeated in September 1996, with samples collected for both chemical analysis and bioassay testing, again from the 0- to 2-cm depth stratum. Sediment samples were archived for chemical analysis, with only those samples that failed bioassays to be analyzed for SMS chemicals. Two of the stations failed one of three bioassay tests. The station located at the end of the Chelan Avenue CSO outfall failed the acute larval echinoderm bioassay with an SQS hit. The station located approximately 200 feet south of the end of the outfall failed the juvenile polychaete chronic bioassay, also with an SQS hit. Multiple exceedences of SMS chemical criteria were again reported for these two stations.

3.8 3rd Avenue West CSO

A single sediment sample was collected from one location (depth stratum unknown) proximal to the 3rd Avenue West CSO discharge point in May 1989. Sediment chemistry

results, normalized to dry weight, were compared to Ecology's freshwater sediment quality reference values. This comparison indicated that sediment concentrations of four metals (antimony, copper, mercury, and zinc), total PCBs, bis(2-ethylhexyl) phthalate, dimethyl phthalate, and four PAH compounds exceeded one or more of these freshwater reference values.

3.9 University Regulator CSO

A single sediment sample was collected from one location (depth stratum unknown) proximal to the University Regulator emergency overflow discharge point in November 1986. Sediment chemistry results, normalized to dry weight, were compared to Ecology's freshwater sediment quality reference values. This comparison indicated that sediment concentrations of total PCBs and bis(2-ethylhexyl) phthalate exceeded one or more of these freshwater reference values.

3.10 Montlake CSO

A single sediment sample was collected from one location (depth stratum unknown) proximal to the Montlake CSO discharge point in May 1989. Sediment chemistry results, normalized to dry weight, were compared to Ecology's freshwater sediment quality reference values. This comparison indicated that the sediment concentration bis(2-ethylhexyl) phthalate exceeded one or more of these freshwater reference values.

Table 3-1
Summary of CSO Outfall Sediment Chemistry Data
Compared to Sediment Quality Criteria and Reference Values

Marine CSOs (footnote 1)	**SQS-OC**	**CSL-OC**	**SQS-DW**	**CSL-DW**
North Beach				
Phenol			✓	
53rd Avenue SW				
Total PCBs			✓	
Benzyl Butyl Phthalate			✓	
Murray Street				
Mercury				✓
Barton Street				
Benzyl Butyl Phthalate	✓		✓	
Dimethyl Phthalate				✓
Estuarine CSOs (footnote 1)	**SQS-OC**	**CSL-OC**	**SQS-DW**	**CSL-DW**
Brandon Street				
Mercury			✓	✓
Total PCBs	✓			
1,4-Dichlorobenzene	✓			
Benzyl Butyl Phthalate	✓			
Bis(2-ethylhexyl) Phthalate	✓	✓		
Benzoic Acid		✓		
Dibenzofuran	✓			
Acenaphthene	✓			
Fluoranthene	✓			
Fluorene	✓			
Phenanthrene	✓			

Table 3-1 (cont.)
Summary of CSO Outfall Sediment Chemistry Data
Compared to Sediment Quality Criteria and Guidelines

Estuarine CSOs (footnote 1)	SQS-OC	CSL-OC	SQS-DW	CSL-DW
Chelan Avenue				
Zinc			✓	
Total PCBs	✓			
1,4-Dichlorobenzene		✓		
Benzyl Butyl Phthalate	✓			
Bis(2-ethylhexyl) Phthalate		✓		
Dibenzofuran	✓			
Acenaphthene	✓			
Fluorene	✓			
Phenanthrene	✓			
Benzo(a)anthracene	✓			
Benzo(a)pyrene	✓			
Benzofluoranthenes (Total)	✓			
Benzo(g,h,i)perylene	✓			
Chrysene	✓			
Dibenzo(a,h)anthracene	✓			
Fluoranthene	✓			
Indeno(1,2,3-c,d)pyrene	✓			
Total HPAH	✓			
Freshwater CSOs (footnote 2)	**SL1**	**SL2**	**SQS**	**CSL**
3rd Avenue West				
Antimony				✓
Copper	✓		✓	
Mercury	✓			
Zinc	✓			✓
Total PCBs		✓		✓
Bis(2-ethylhexyl) Phthalate		✓		✓
Dimethyl Phthalate	✓		✓	
Benzo(a)pyrene	✓		✓	
Benzofluoranthenes (Total)		✓		
Dibenzo(a,h)anthracene		✓		✓
Naphthalene	✓		✓	
University Regulator				
Total PCBs	✓		✓	
Bis(2-ethylhexyl) Phthalate		✓		✓
Montlake				
Bis(2-ethylhexyl) Phthalate		✓		✓

Footnote 1

Sediment quality criteria for marine and high-salinity estuarine CSOs used the following two references:

1. Ecology 1995. *Chapter 173-204 WAC – Sediment Management Standards – Tables I and III.* Organic carbon normalized Sediment Quality Standard (SQS-OC) and Cleanup Screening Level (CSL-OC) for those samples in which the total organic carbon content is greater than 0.5%
2. EPA 1988. *Sediment Quality Values Refinement: 1988 Update and Evaluation of Puget Sound AET.* Dry weight normalized Sediment Quality Standard (SQS-DW) and Cleanup Screening Level (CLS-OC) for those samples in which the total organic carbon content is less than 0.5%.

Footnote 2

Sediment quality values for freshwater CSOs used the following two references:

1. USACE, 2009. *Sediment Evaluation Framework for the Pacific Northwest (May 2009 Update)*. Screening Level 1 (SL1) and Screening Level 2 (SL2).
2. Ecology, 2003. *Development of Freshwater Sediment Quality Values for Use in Washington State, Phase II Report (Ecology Pub. No. 03-09-088).* Floating Percentile Guidelines - Sediment Quality Standard (SQS) and Cleanup Screening Level (CSL).

4 SAMPLING DESIGN

The sampling design for this CSO sediment quality characterization project was based on the need to efficiently provide sediment data that would serve the needs of two different programs: 1) populating, calibrating, and verifying the County's near-field sediment recontamination model for the Sediment Management Program; and 2) creating a pre-construction sediment quality baseline at four locations, at which CSO control projects are currently underway.

4.1 Data Quality Objectives

The data quality objectives (DQOs) of the CSO sediment quality characterization project are to collect data of sufficient *quantity* and *quality* to be able to meet the following study goals:

- measure the areal extent and spatial variations of sediment chemical concentrations in front of 10 King County CSO discharge points;
- evaluate these sediment chemical concentrations relative to the current marine sediment quality standards of Chapter 173-204 WAC (Ecology 1995) and the freshwater sediment quality reference values found on Ecology's EIM database;
- provide data for populating, calibrating, and validating the near-field sediment recontamination model, as part of the process to update the County's Sediment Management Plan; and
- provide pre-construction, baseline, sediment quality data at four of the County's CSO facilities, at which CSO control projects are currently underway.

The *quantity* of data to be collected is based on the need to meet multiple project goals at the CSO sites, which discharge at varying volumes and depths, and into varying flow regimes. Collection of six to seven sediment samples at each of the 10 CSO sites will provide sufficient data to meet the study goals listed above.

Validation of project data will assess whether the data collected are of sufficient *quality* to meet the study goals. The data quality issues of precision, accuracy, bias, representativeness, completeness, comparability, and sensitivity are described in the following sections.

4.1.1 Precision, Accuracy, and Bias

Precision is the agreement of a set of results among themselves and is a measure of the ability to reproduce a result. Accuracy is an estimate of the difference between the true value and the determined mean value. The accuracy of a result is affected by both systematic and random errors. Bias is a measure of the difference, due to a systematic factor, between an analytical result and the true value of an analyte. Precision, accuracy, and bias for sediment chemistry will be measured by the following quality control (QC) analyses: method blanks, spike blanks, matrix spikes, matrix spike duplicates, certified reference materials, laboratory control samples, laboratory duplicates or triplicates, and sample-specific surrogates.

4.1.2 Representativeness

Representativeness expresses the degree to which sample data accurately and precisely represent a characteristic of a population, parameter variations at the sampling point, or an environmental condition. Sediment chemistry samples will be collected from stations with pre-selected coordinates to represent specific site locations. Sediment chemistry samples will

be homogenized to minimize variations in the chemical and physical composition of the sediments. Following the guidelines described for sampler decontamination, sample acceptability criteria, and sample processing (Section 6) will also help ensure that samples are representative.

4.1.3 Completeness

Completeness is defined as the total number of samples for which acceptable analytical data are generated, compared to the total number of samples submitted for analysis. Adhering to standardized sampling and testing protocols will aid in providing a complete set of data for this study. The goal for completeness is 100%. If 100% completeness is not achieved, the study team will evaluate whether the DQOs can still be achieved or if additional samples may need to be collected and analyzed.

4.1.4 Comparability

Comparability is a qualitative parameter expressing the confidence with which one data set can be compared to another. This goal is achieved through using standard techniques to collect and analyze representative samples, along with standardized data validation and reporting procedures. By following the guidance of this SAP, the goal of comparability will be achieved.

4.1.5 Sensitivity

Sensitivity is a measure of the capability of analytical methods to meet study goals. The sediment chemistry analytical method detection limits presented in Section 9 are sensitive enough to allow comparison of sediment chemistry data to current Ecology sediment quality criteria, both normalized to dry weight and to organic carbon, as appropriate.

4.2 Sampling Strategy

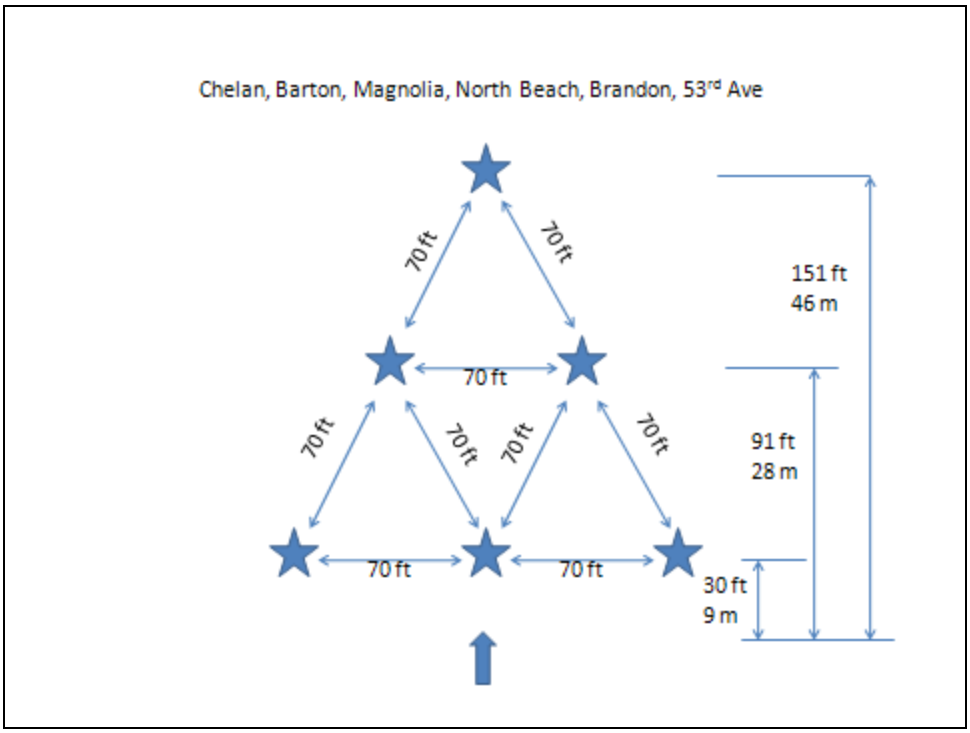
King County modeling staff performed a scaling analysis for the 10 CSOs to be sampled during this project in order to provide the optimal sampling station array that would efficiently meet the needs of the three programs for which these data will be collected. The scaling analysis is included as Appendix A to this SAP. To summarize, the scaling analysis was performed to determine where particulate matter discharged during CSO events would most likely settle to the surface sediment in the receiving water. The model used in the scaling analysis describes the percent of suspended solids that would settle into the sediment and includes the following assumptions:

- the discharged suspended solids are well mixed across the water depth;
- receiving water velocity is primarily in the along-shore direction and, thus, will not affect the offshore extent of the sediment deposition;
- the characteristic offshore velocity of the plume is 10% of the discharge velocity; and
- the characteristic settling velocity of CSO solids most likely to deposit in the vicinity of the outfall is 0.1 cm/s (based on a medial settling velocity of particles in effluent collected from three County CSOs already sampled.

Based on results of the scaling analysis, the sample station location strategies shown graphically in Figure 4-1 were chosen. Sediment samples will be collected from six stations at the North Beach, Magnolia, 53rd Avenue SW, Barton Street, Brandon Street, and Chelan Avenue CSO sites. Samples will be collected from seven stations at the Murray Street, 3rd

Avenue West, University Regulator, and Montlake CSO sites. In each of the 10 sample station arrays, the first station is always located approximately 30 feet in front of the outfall.

Figure 4-1
CSO Sediment Sampling Location Strategy Based on Scaling Analysis



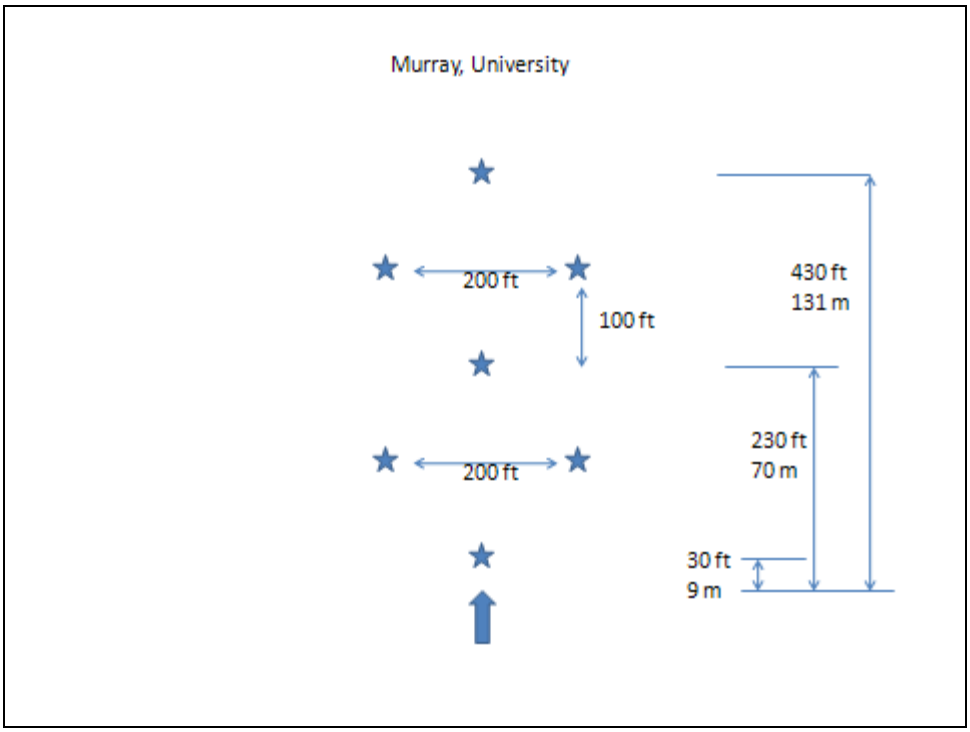
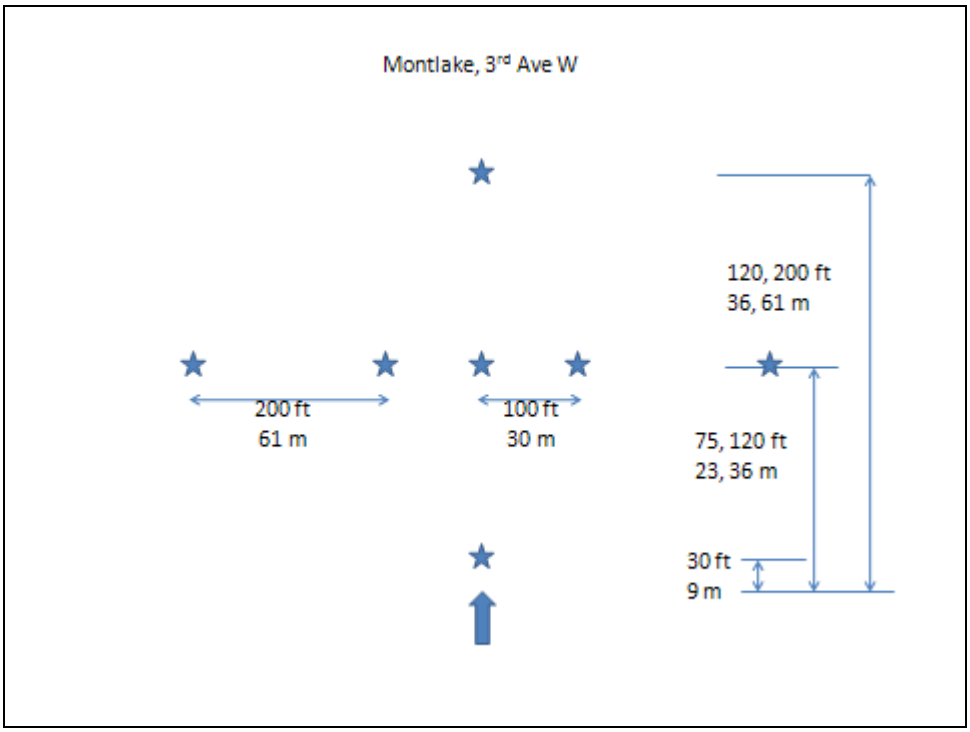


Figure 4-1 (cont.)
CSO Sediment Sampling Location Strategy Based on Scaling Analysis



4.2.1 Location of Sampling Stations

Figures 4-2 through 4-11 show the locations of the sampling stations at each of the 10 CSO sediment characterization sites. Coordinates and water depth for these 64 stations, as well as the three background stations are shown in Table 4-1.

Table 4-1
2011 CSO Sediment Characterization Sampling Stations – Coordinates and Water Depths

Station	Description	Northing[1]	Easting[1]	Approx. Depth[2]
CSO-NB-1	North Beach CSO	260715	1256509	17
CSO-NB-2		260682	1256450	18
CSO-NB-3		260749	1256572	18
CSO-NB-4		260752	1256449	22
CSO-NB-5		260785	1256513	21
CSO-NB-6		260821	1256452	24
CSO-MG-1	Magnolia CSO	233763	1254386	19
CSO-MG-2		233758	1254460	19
CSO-MG-3		233766	1254315	22
CSO-MG-4		233706	1254417	22
CSO-MG-5		233709	1254348	22
CSO-MG-6		233645	1254380	25

Table 4-1 (cont.)
2011 CSO Sediment Characterization Sampling Stations – Coordinates and Water Depths

Station	Description	Northing[1]	Easting[1]	Approx. Depth[2]
CSO-53-1	53rd Ave SW CSO	217294	1253159	21
CSO-53-2		217246	1253104	24
CSO-53-3		217328	1253214	21
CSO-53-4		217315	1253098	32
CSO-53-5		217358	1253150	33
CSO-53-6		217386	1253088	36
CSO-MY-1	Murray Street CSO	201026	1253446	23
CSO-MY-2		200952	1253317	37
CSO-MY-3		201150	1253376	32
CSO-MY-4		201073	1253252	41
CSO-MY-5		201003	1253125	78
CSO-MY-6		201197	1253179	53
CSO-MY-7		201126	1253060	85
CSO-BT-1	Barton Street CSO	195031	1254221	23
CSO-BT-2		194973	1254193	25
CSO-BT-3		195097	1254247	22
CSO-BT-4		195022	1254145	31
CSO-BT-5		195088	1254176	29
CSO-BT-6		195081	1254106	36
CSO-CH-1	Chelan Avenue CSO	212974	1264233	25
CSO-CH-2		213042	1264197	27
CSO-CH-3		212922	1264272	25
CSO-CH-4		213038	1264267	35
CSO-CH-5		212983	1264307	35
CSO-CH-6		213044	1264339	35
CSO-BR-1	Brandon Street CSO	205962	1268162	5
CSO-BR-2		205895	1268179	5
CSO-BR-3		206004	1268106	5
CSO-BR-4		205903	1268123	10
CSO-BR-5		205952	1268083	10
CSO-BR-6		205902	1268059	15
CSO-3W-1	3rd Avenue West CSO	241619	1264168	20
CSO-3W-2		241870	1263985	23
CSO-3W-3		241752	1264143	23
CSO-3W-4		241696	1264222	23
CSO-3W-5		241636	1264304	23
CSO-3W-6		241521	1264462	23
CSO-3W-7		241757	1264269	15
CSO-UR-1	University Regulator CSO	240212	1276143	10
CSO-UR-2		240082	1276095	20
CSO-UR-3		240265	1276008	15
CSO-UR-4		240129	1275956	30
CSO-UR-5		240002	1275913	20
CSO-UR-6		240176	1275821	25
CSO-UR-7		240045	1275777	20

Table 4-1 (cont.)
2011 CSO Sediment Characterization Sampling Stations – Coordinates and Water Depths

Station	Description	Northing[1]	Easting[1]	Approx. Depth[2]
CSO-ML-1	Montlake CSO	239545	1277716	30
CSO-ML-2		239588	1277414	30
CSO-ML-3		239591	1277617	30
CSO-ML-4		239589	1277716	30
CSO-ML-5		239586	1277817	30
CSO-ML-6		239584	1278015	30
CSO-ML-7		239635	1277714	30
CSO-BKGD-NS	Background Stations	243085	1245659	20
CSO-BKGD-WS		204139	1253072	40
CSO-BKGD-UB		240449	1281976	10

[1]State Plane Coordinate System North American Datum 1983 (NAD83) – Washington North 4601.
[2]Depth in feet below surface, referenced to Mean Lower Low Water (MLLW).

4.2.2 Sample Acquisition and Analytical Parameters

Sediment chemistry samples will be collected from the 0- to 10-cm depth stratum to characterize sediment in the biologically-active zone. Samples will be composited from sediment recovered from a single deployment of dual, tandem 0.1 m^2 modified van Veen grab samplers. Samples will be composited, homogenized, and split into laboratory containers in the field. Parameters of interest will include trace metals and organic compounds, as well as conventional sediment chemistry and physical properties.

Sediment chemistry analytical parameters were selected based on guidance for conducting sediment characterizations (Ecology 2008) and will allow comparison of analytical results with published marine sediment quality criteria (Ecology 1995, EPA 1998) as freshwater sediment reference values. Analytical parameters will include:

- conventionals – particle size distribution (PSD), total organic carbon (TOC), and total solids;
- metals – antimony (freshwater CSOs only); arsenic, cadmium, chromium, copper, lead, mercury, nickel (freshwater CSOs only), silver, and zinc; and
- organics - base/neutral/acid semivolatile compounds (BNAs) and polychlorinated biphenyls (PCBs).

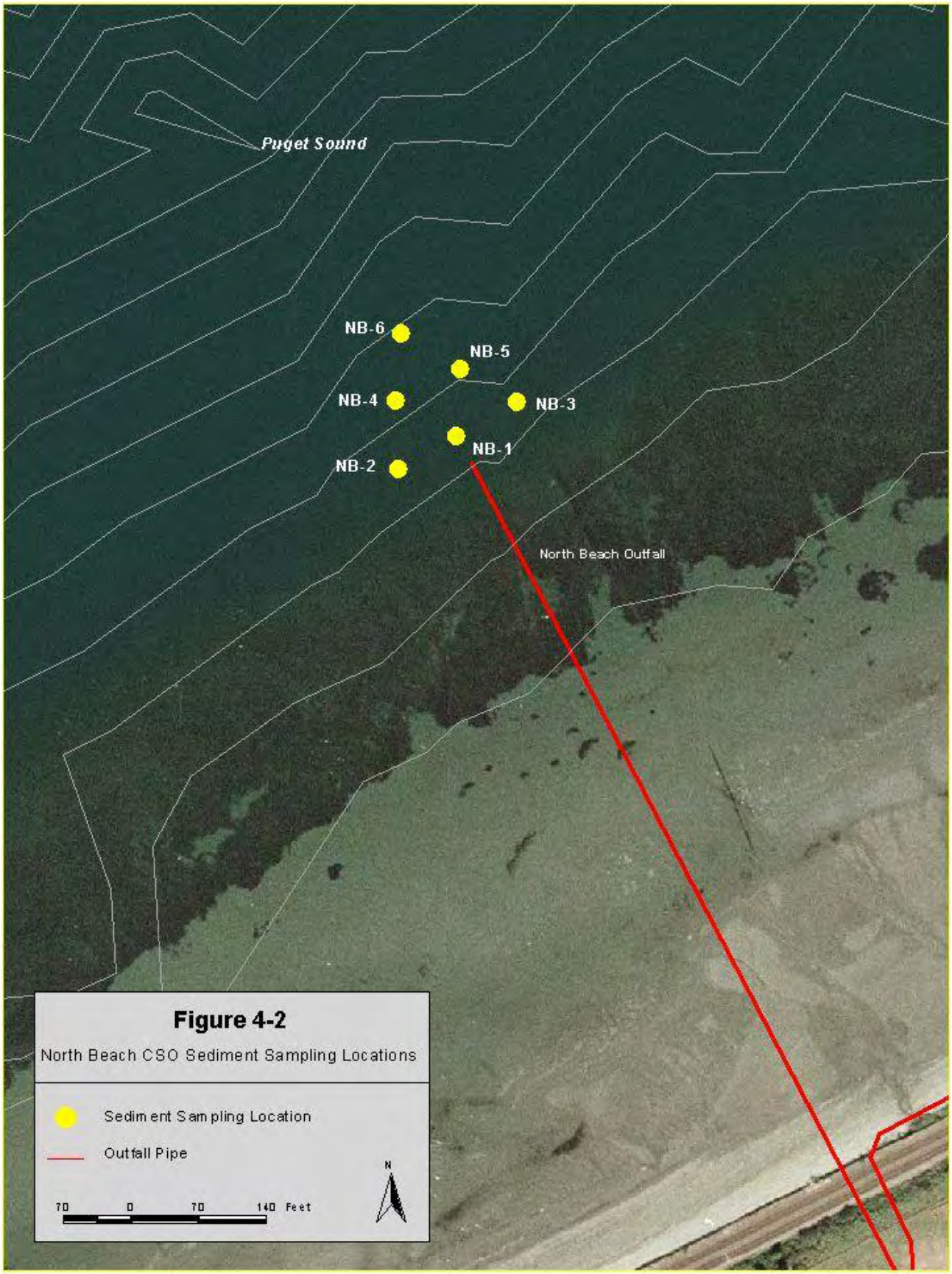
4.3 Data Analysis

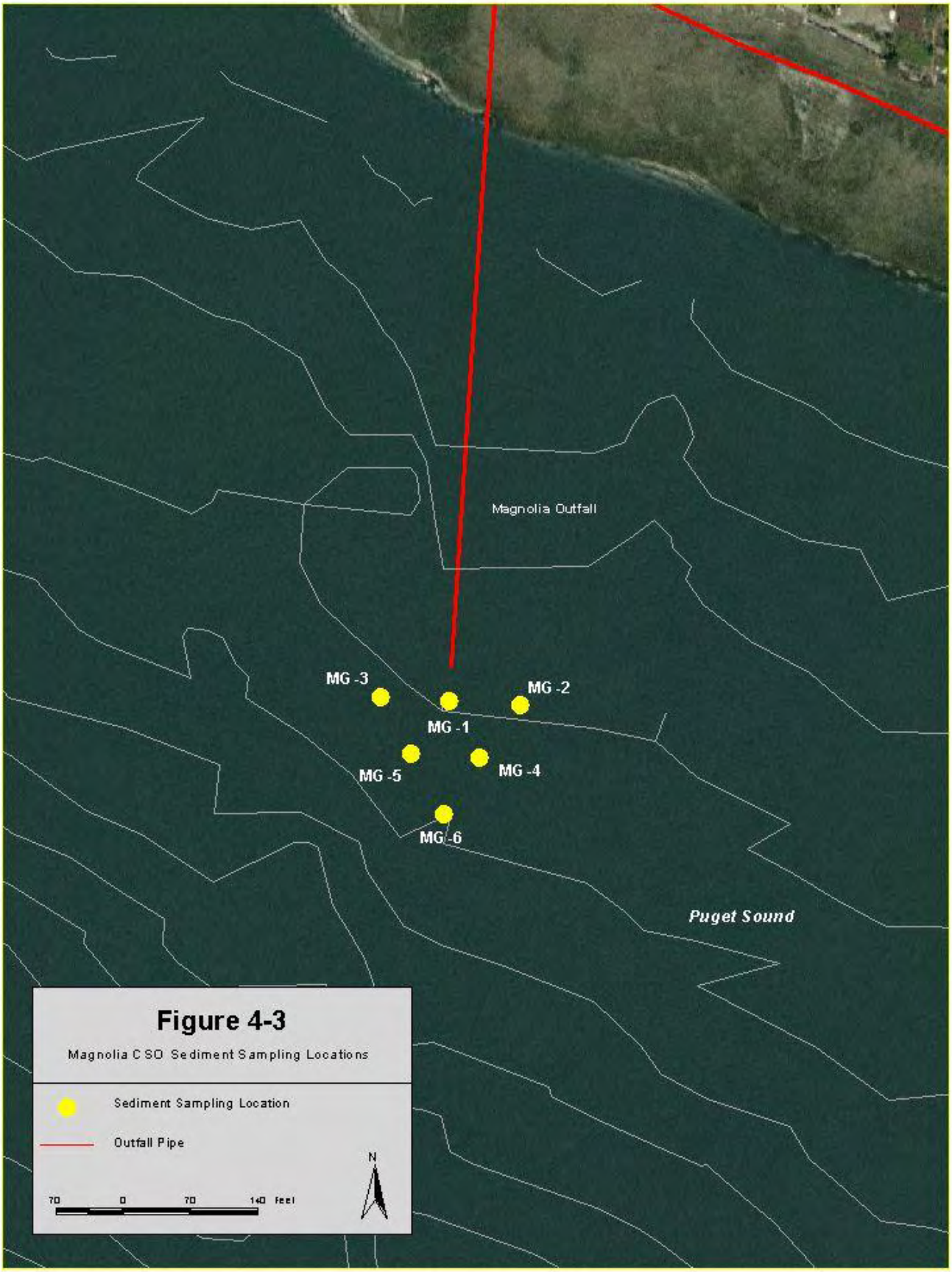
Chemistry data collected at marine or high-salinity estuarine CSOs will be evaluated by comparison to sediment chemical criteria from Tables I and III in the Washington State Sediment Management Standards (SMS) of Chapter 173-204 WAC (Ecology 1995). Sediment data for some organic compounds are generally normalized to organic carbon content for comparison to SMS criteria. Normalization to organic carbon can produce biased results, however, when the organic carbon content of the sample is very low (Ecology 1992). When the organic carbon content of a sample is near 0.1 or 0.2% (1,000 to 2,000 milligrams/kilogram (mg/Kg) dry weight), even background concentrations of certain organic compounds can exceed sediment quality criteria.

If the organic carbon content at any particular station is below 0.5% dry weight, then dry weight-normalized results for non-ionizable organic compounds will be compared to the

1998 Marine Dry Sediment Quality Standard (SQS) and Cleanup Screening Level (CSL) from Ecology's Environmental Information Management (EIM) database (http://www.ecy.wa.gov/eim/myEIM.htm).

Chemistry data collected at freshwater CSOs will be evaluated by comparison to the sediment quality reference guidelines also found on the EIM database. These reference guidelines will include the 2009 Sediment Evaluation Framework (SEF) Update (USACE 2009) and the 2003 Floating Percentile Guidelines (Ecology 2003).


Puget Sound
NB-6
NB-5
NB-4
NB-3
NB-1
NB-2
North Beach Outfall
Figure 4-2
North Beach CSO Sediment Sampling Locations
Sediment Sampling Location
Outfall Pipe
70 0 70 140 Feet
N


Magnolia Outfall
MG -3
MG -2
MG -1
MG -5
MG -4
MG -6
Puget Sound
Figure 4-3
Magnolia CSO Sediment Sampling Locations
Sediment Sampling Location
Outfall Pipe
70
0
70
140 feet
N

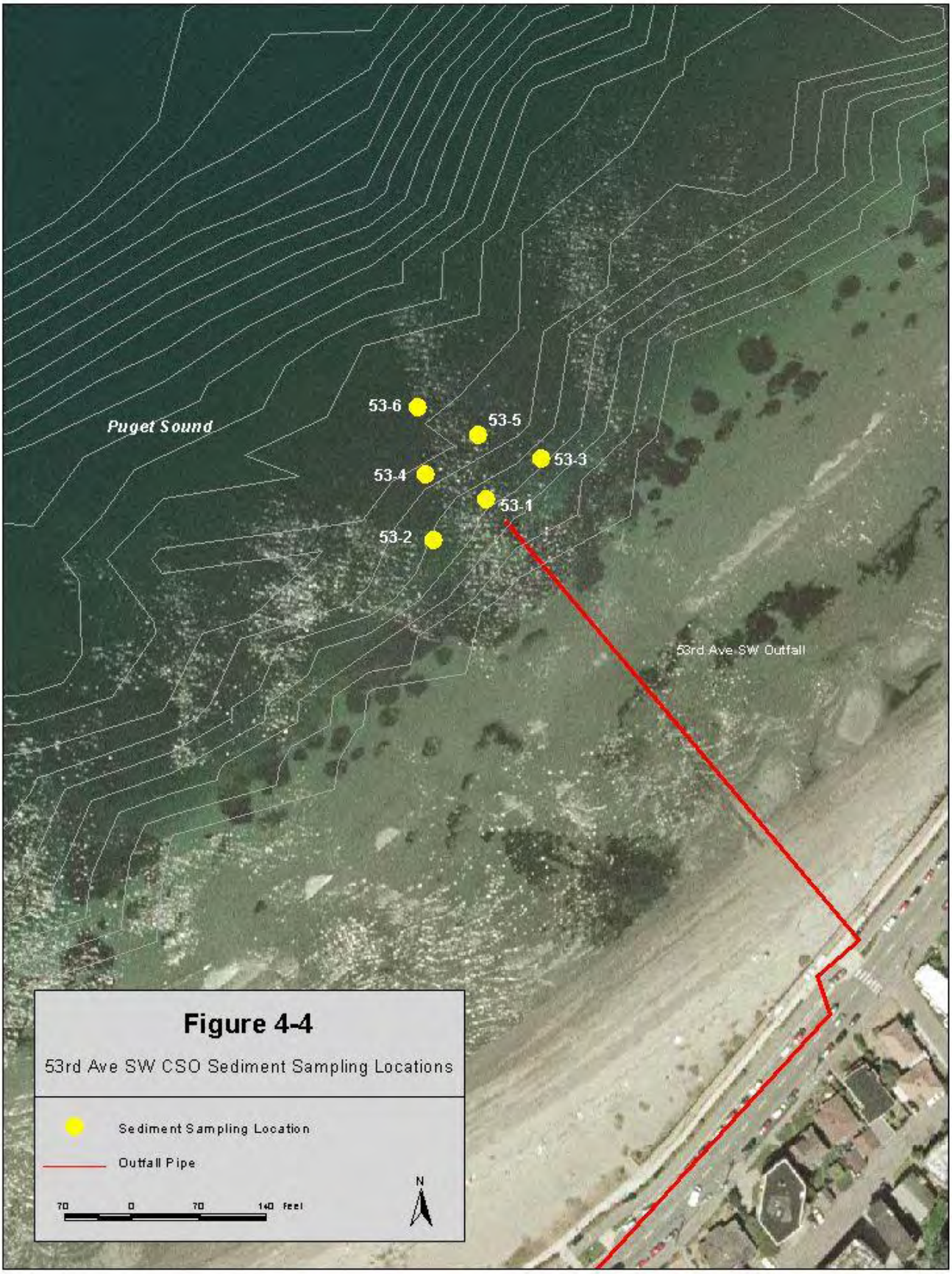


Figure 4-4

53rd Ave SW CSO Sediment Sampling Locations

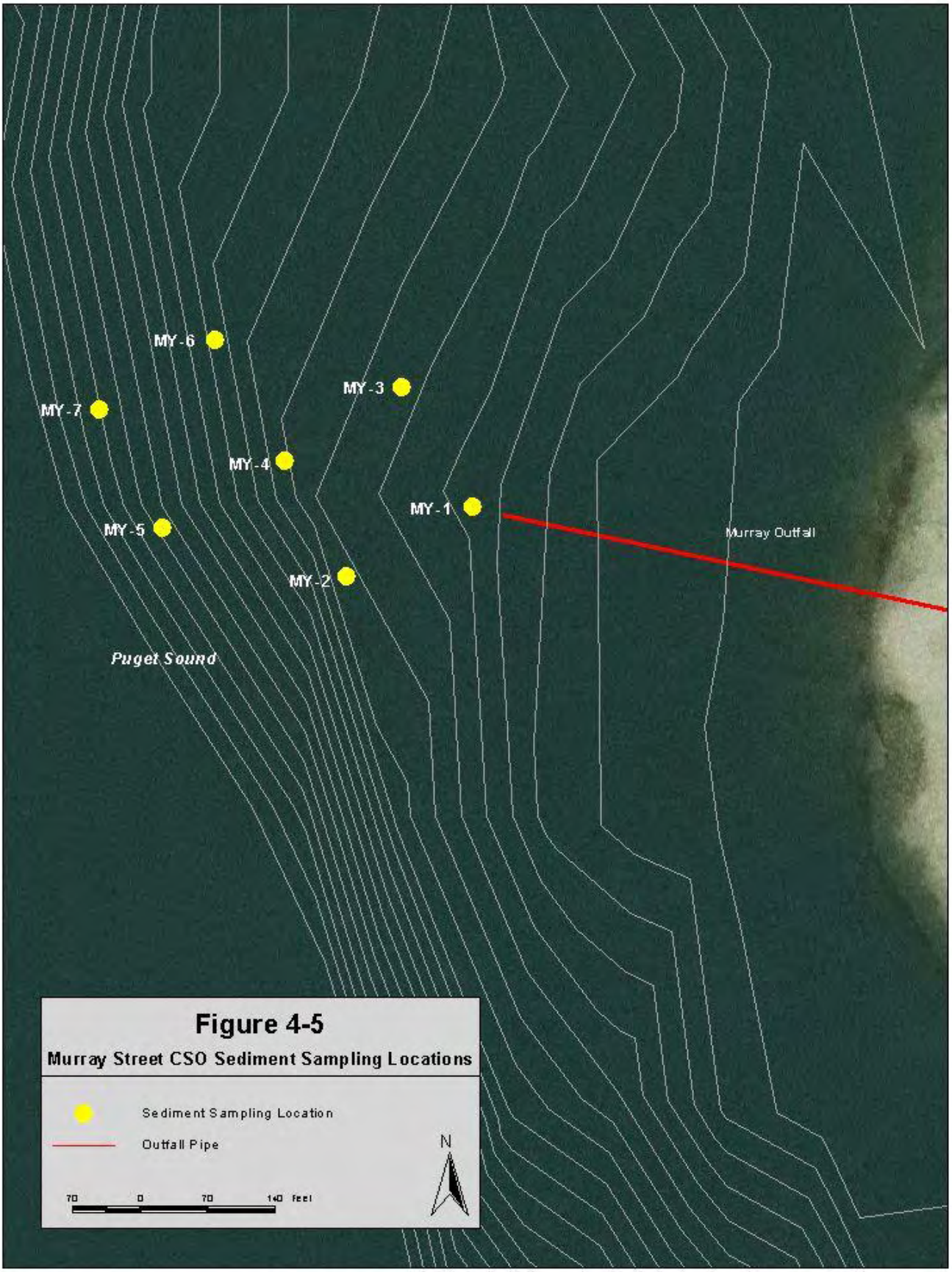


Figure 4-5

Murray Street CSO Sediment Sampling Locations

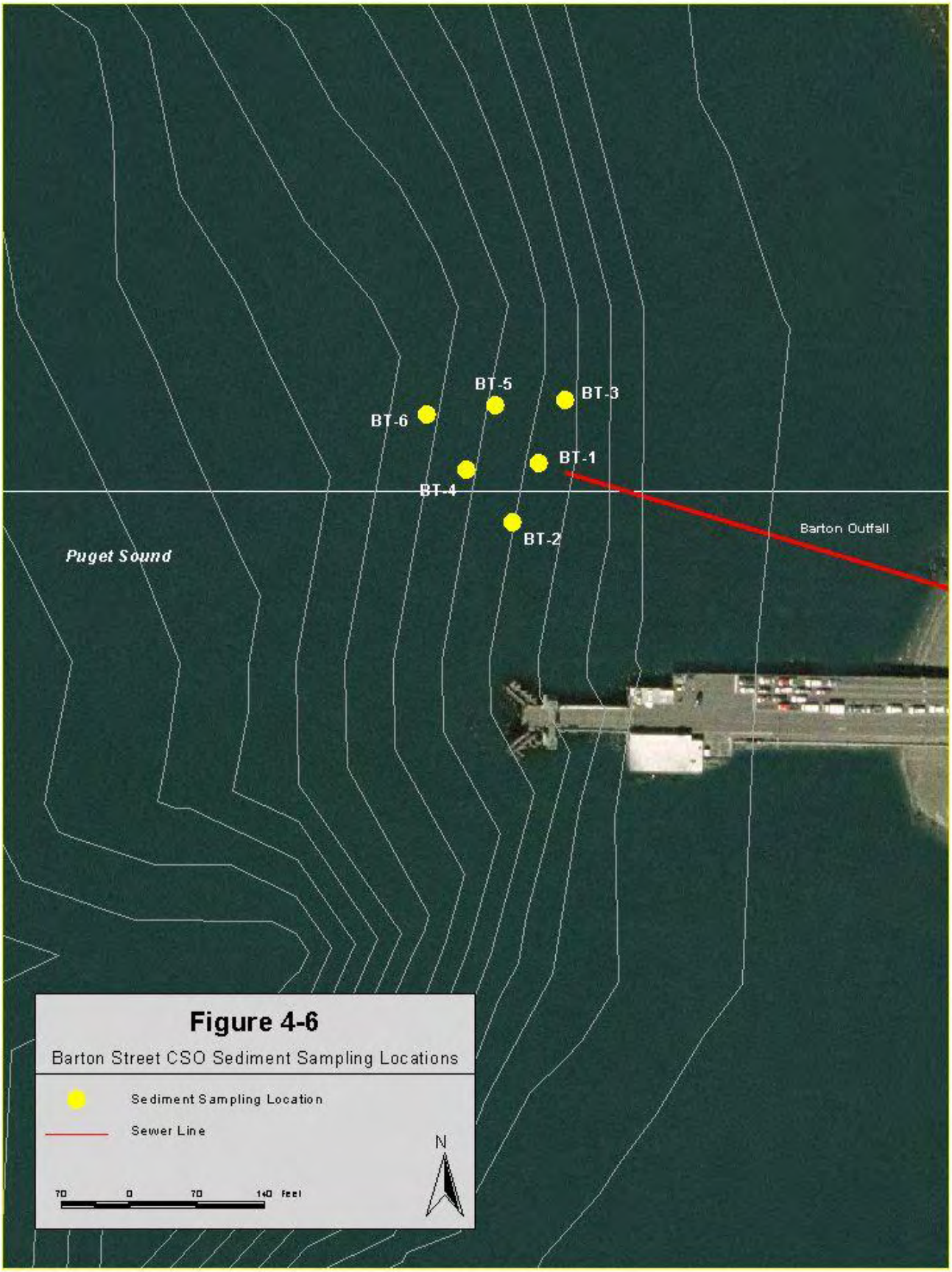


Figure 4-6

Barton Street CSO Sediment Sampling Locations

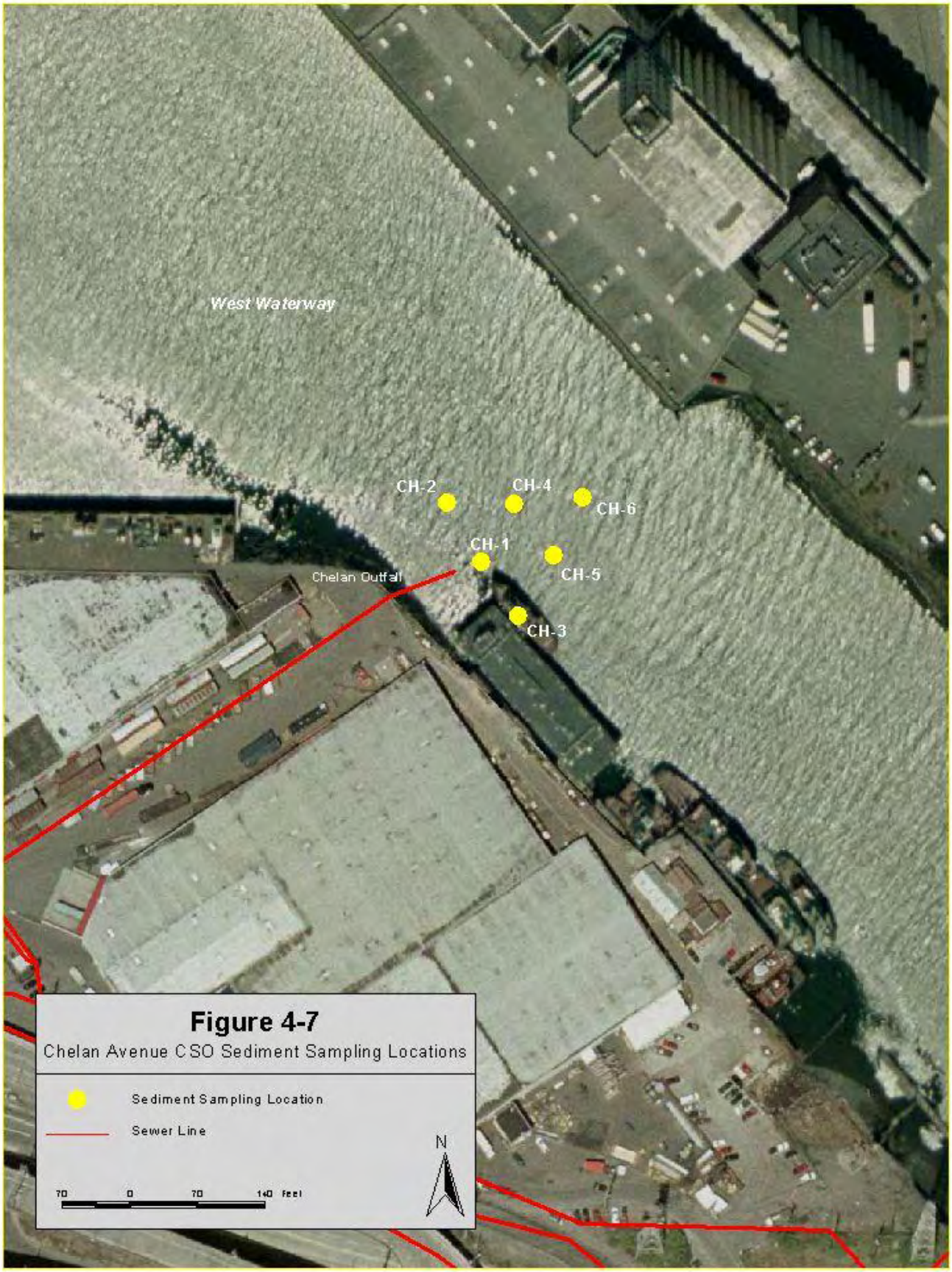


Figure 4-7
Chelan Avenue CSO Sediment Sampling Locations

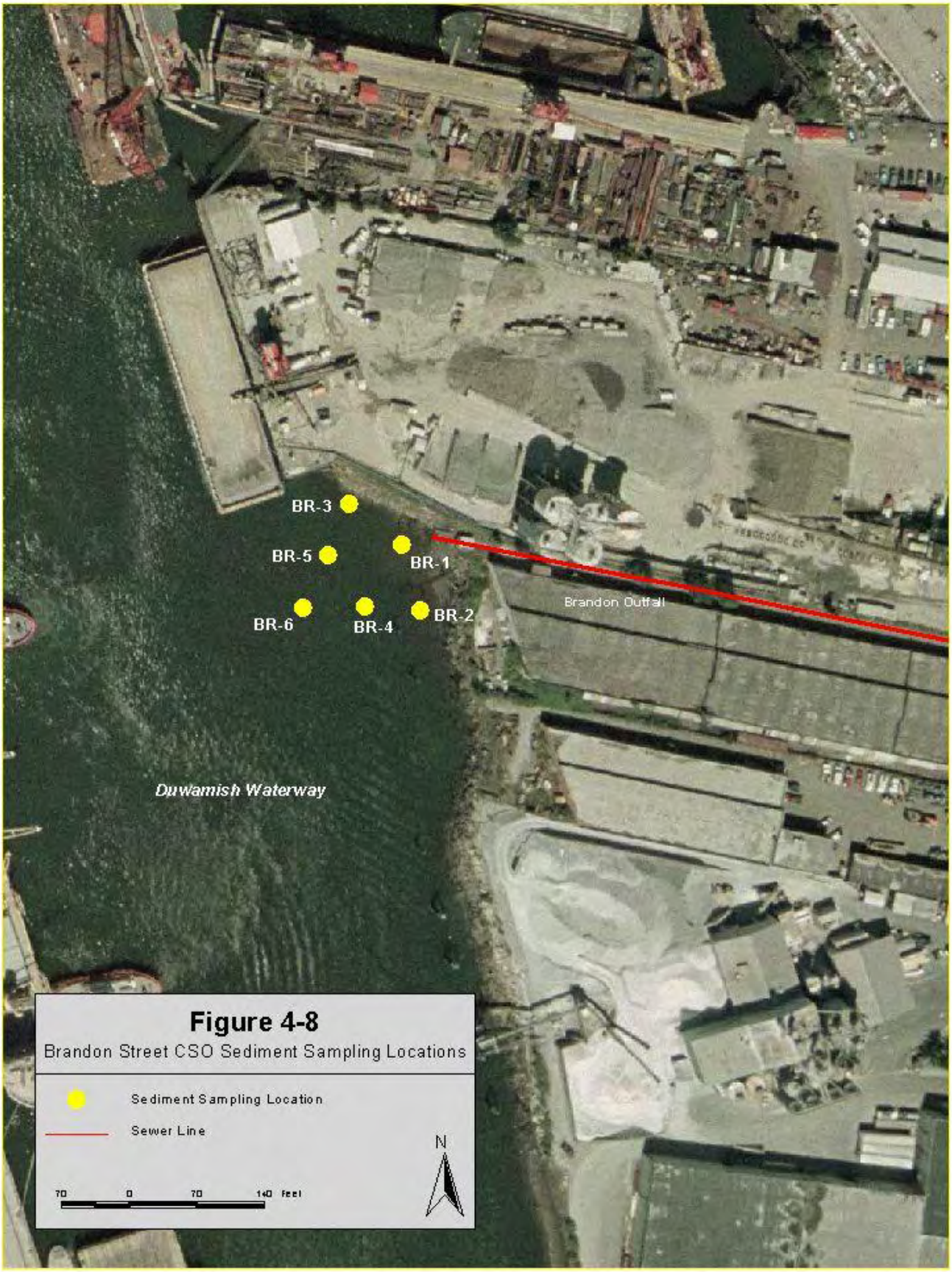


Figure 4-8
Brandon Street CSO Sediment Sampling Locations

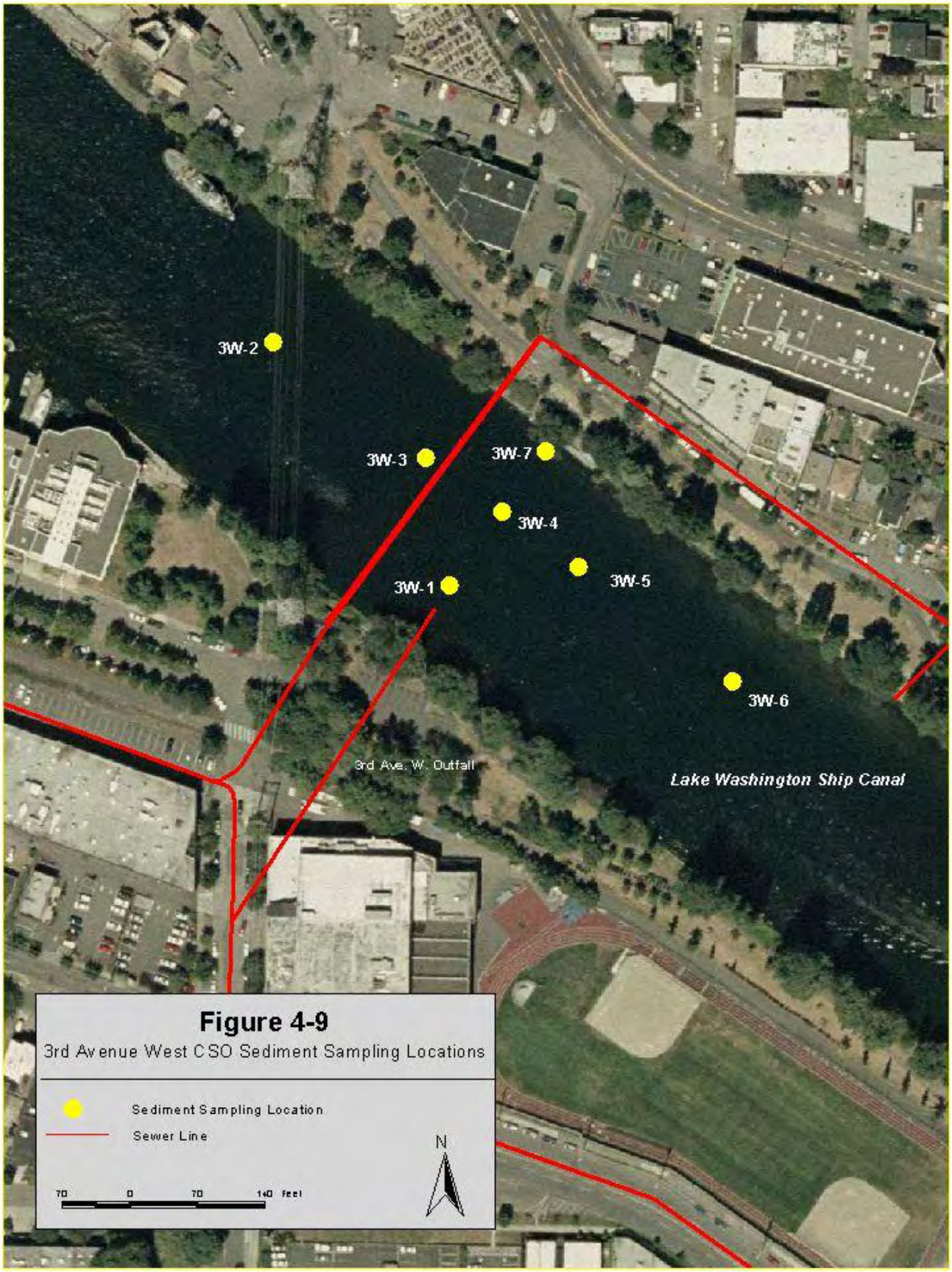


Figure 4-9
3rd Avenue West CSO Sediment Sampling Locations

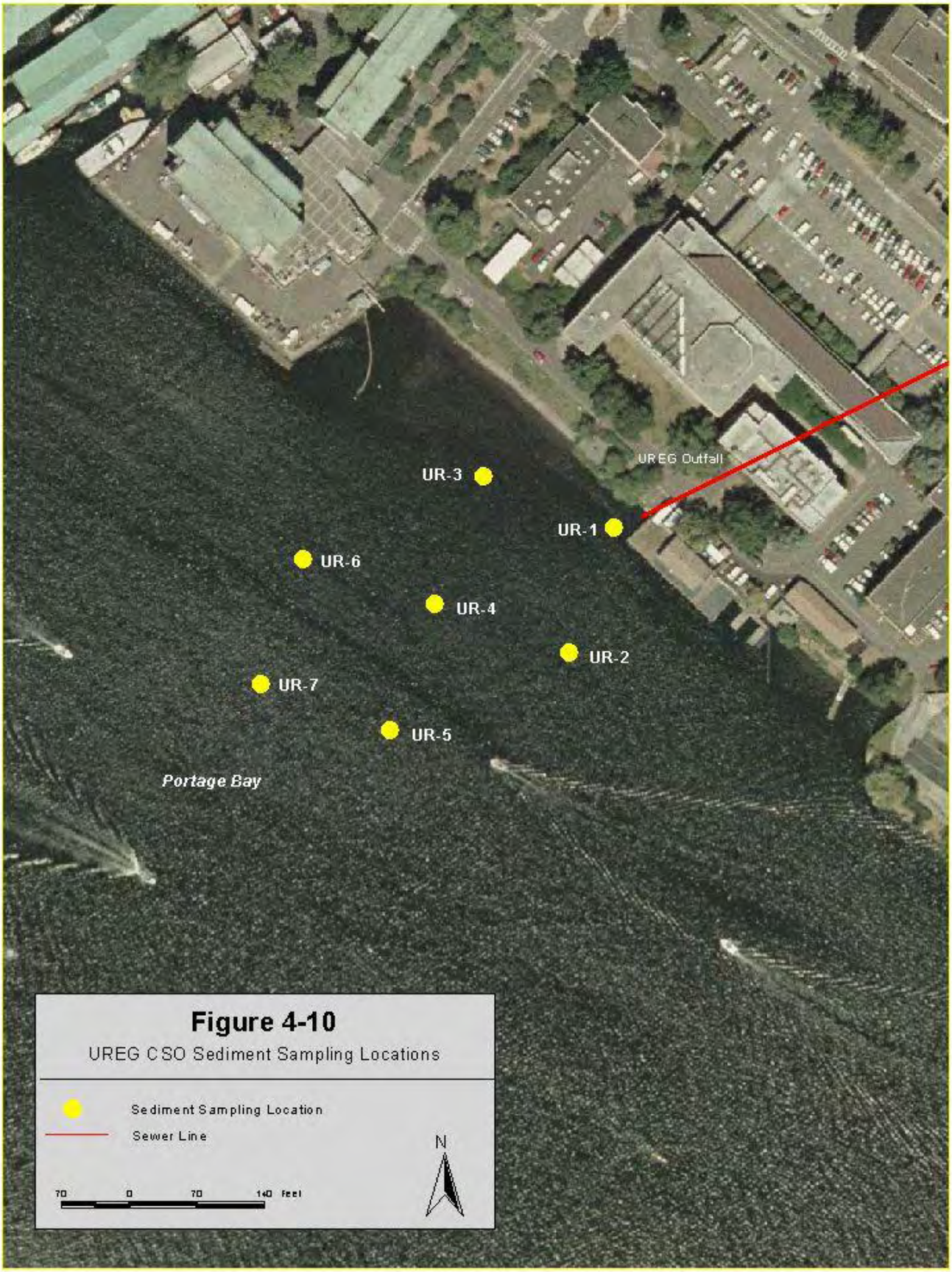


Figure 4-10
UREG CSO Sediment Sampling Locations

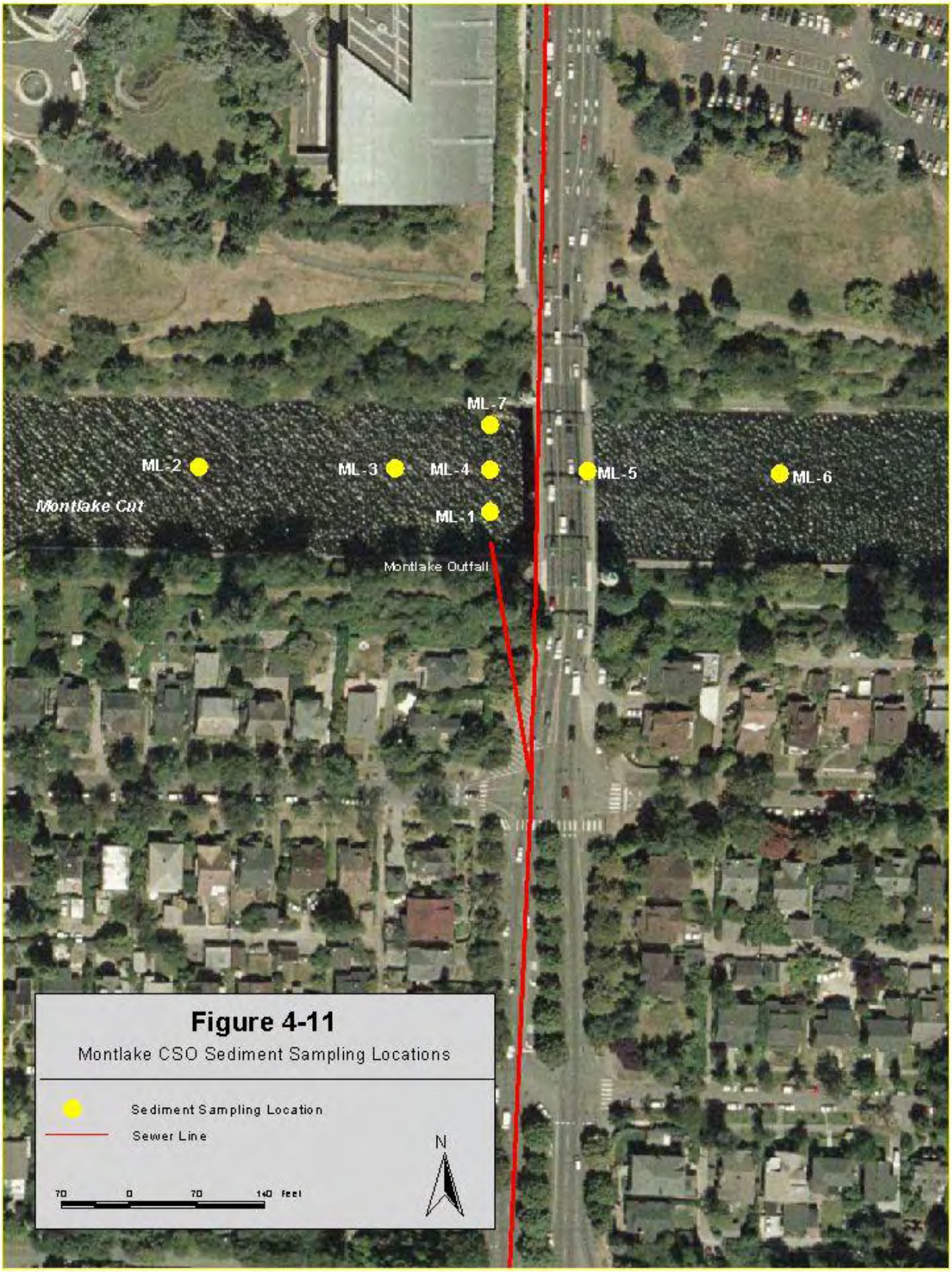


Figure 4-11

Montlake CSO Sediment Sampling Locations

5 PROJECT ORGANIZATION AND SCHEDULE

The tasks involved in conducting the CSO baseline sediment characterization and the personnel responsible for those tasks are shown below.

- **Scott Mickelson** King County Marine and Sediment Assessment Group – (206) 296-8247 scott.mickelson@kingcounty.gov Project management, study design, preparation of draft and final SAPs, data validation and analysis, and preparation of final study report.
- **Jeff Stern** King County Wastewater Treatment Division – (206) 263-6447 jeff.stern@kingcounty.gov Internal review of draft and final SAPs, approval of final SAP. Review of draft and final study reports. Coordination of King County's Sediment Management Plan.
- **Betsy Cooper** King County Wastewater Treatment Division – (206) 263-3728 betsy.cooper@kingcounty.gov Internal review of draft and final SAPs, approval of final SAP. Review of draft and final study reports. Coordination of King County's wastewater NPDES permits.
- **Bob Kruger** King County Environmental Laboratory – (206) 684-2323 bob.kruger@kingcounty.gov Coordination of field activities for sediment chemistry sample collection.
- **Katherine Bourbonais** King County Environmental Laboratory – (206) 684-2382 katherine.bourbonais@kingcounty.gov Coordination of all King County Environmental Laboratory activities, data validation, and data reporting.
- **Colin Elliott** King County Environmental Laboratory – (206) 684-2343 colin.elliott@kingcounty.gov Internal review of draft SAP, data verification, coordination of King County Environmental Laboratory QA/QC programs.

Sample collection is anticipated to require up to two weeks of field time and is anticipated to commence in August 2011. Marine and estuarine CSO sites will be sampled in late August 2011 and freshwater CSO sites will be sampled in early October 2011. Unvalidated sediment chemistry results for all analyses will be available by March 2012.

Validated data packages and electronic data files will be ready for release by August 2012. A final report for this sampling event, along with the associated EIM data submission will be submitted to Ecology no later than January 1, 2013.

6 SAMPLING PROCEDURES

All sampling will be performed according to guidelines recommended by the Puget Sound Estuary Program's (PSEP) Puget Sound Protocols (PSEP 1997a and 1998). Sampling will be performed by staff of the King County Environmental Laboratory. Sediment samples will be collected using dual, tandem 0.1 m^2 modified, stainless steel van Veen grab samplers deployed via hydrowire and hydraulic winch from either of King County's research vessels *Liberty* or *Chinook*.

Samples will consist of the top 10 cm of sediment collected, ideally, from the contents of a single deployment of the dual grab samplers. Additional grab deployments may be necessary, dependent upon the substrate, to collect enough sediment to perform all analyses. Sediment samples will be stored on ice in coolers while in the field, then transported to the King County Environmental Laboratory at the end of each sampling day. Established chain of custody (COC) procedures will be followed for this sampling event.

6.1 Station Positioning

Reliable station positioning is crucial to be able to revisit established stations for future sampling events. Inaccuracies in station positioning when conducting sediment grab sampling in deep water can result from the action of currents and wind on the sampling vessel as well as current forces and viscous drag on the sampler and deployment line.

Station positioning for the CSO baseline sediment characterization will employ a combination of a differential global positioning system (DGPS and positioning software to calculate the exact position of the van Veen grab samplers as they contact the seafloor. For station positioning, the research vessel will employ a Trimble® DGPS. Prior to the sampling event, the prescribed station coordinates will be entered into the shipboard DGPS laptop computer. During the sampling event, the shipboard navigational system will utilize the differential data transmissions from regional Coast Guard base stations to automatically correct its GPS satellite data. The GPS antenna is boom-mounted above the sampler descent line to achieve a more accurate coordinate fix above the sampling point.

Upon contact of the grab samplers with the bottom, the coordinate data representing the actual sediment grab impact point will be electronically recorded in real time. Positioning information will include local time and date that a position is recorded, comments, and coordinate data in both latitude/longitude and NAD 83 State Plane formats.

Sample collection is expected to take place within a 6-meter radius of each station's prescribed position and samples will not be collected if the observed coordinates of the grab deployment are outside of this limit. If conditions such as a steep slope or rocky substrate preclude sample collection at a particular station, the station may be relocated after consultation with the study coordinator, Scott Mickelson, if relocation will not compromise the project goals. Any station relocation will be documented and reported.

6.2 Sampler Deployment and Retrieval

Two 0.1 m^2 modified, stainless-steel van Veen grab samplers will be deployed in tandem at each sampling station. The grab samplers will be lowered at a controlled speed of approximately three feet per second until they near the bottom, at which time the speed will

be decreased to approximately one foot per second to minimize potential bow wake activity and subsequent bottom disturbance.

After the grabs have tripped upon reaching the bottom, they will be raised slowly to allow gentle and complete closure of the sampler jaws to avoid sample disturbance and loss. Once clear of the bottom, the ascent speed will be increased to approximately three feet per second. Care will be taken to ensure that minimal sample disturbance occurs when swinging the grabs on board. Collection of undisturbed sediment requires that the grab samplers:

- create a minimal bow wake when descending;
- form a leak-proof seal upon closure of the jaws;
- are carefully retrieved to prevent excessive sample disturbance; and
- allow easy access to the sediment within the grab.

6.3 Sample Acceptability Criteria

When the grab samplers have been secured on board, the hinged top flaps will be opened and the samples examined for acceptability. Acceptability criteria will include:

- the grabs are not overfilled to the point where there is evidence of sample loss around the access doors;
- overlying water is present, indicating minimal leakage;
- overlying water is not excessively turbid, indicating minimal sample disturbance; and
- a minimum acceptable sample penetration depth of at least 4 cm has been achieved.

Samples collected from the top 10 cm of sediment will require a minimum grab penetration depth of 11 cm. Sampling coarser sediments at deeper depths can occasionally prove problematic when trying to obtain the required penetration depth to collect a sample from the 0- to 10-cm depth stratum. If multiple grab deployments at any station fail to recover 11 cm of sediment, subsequent grab deployments will be accepted with less than 11 cm of sediment, based on the discretion of the lead sampler in consultation with the study coordinator. This situation will be carefully documented on field notes. Care will be taken to extract sediment from the most undisturbed center portion of each grab without collecting sediment that has touched the sides or bottom of the grab. Penetration depth will be determined by measuring the depth of sediment within each grab by sliding a ruler vertically along the inside of the grab's side wall after each successful cast. Penetration depth can also be calculated be measuring the space between the sediment's surface within the grab and the top of the grab, then subtracting this vertical distance from 17 cm, the total inside height of the grab. Overlying water within the grab will be carefully siphoned off of the sediment surface for all acceptable samples.

6.4 Sample Processing

Sediment will be collected from the 0- to 10-cm depth stratum using a stainless steel spoon with sediment from each grab placed into a stainless steel bowl. When sufficient sediment for all analyses has been collected, the sediment in the stainless steel bowl will be thoroughly homogenized. After homogenization, sediment aliquots will be transferred to appropriate laboratory containers. If multiple grab deployments are required prior to homogenization, collected sediments will be stored covered with aluminum foil in coolers between grab deployments.

Head space will be left in all sediment chemistry sample containers to allow further mixing at the laboratory and for expansion should the containers be stored frozen. All sample containers will be stored in insulated, ice-filled coolers while in the field. Sample containers, storage conditions, and hold times are summarized in Table 6-1.

Table 6-1
Sediment Chemistry Sample Containers, Storage Conditions, and Analytical Hold Times

Analyte	Container	Preferred Storage Conditions	Hold Time	Acceptable Storage Conditions	Hold Time
Particle Size Distribution	16-oz. CWM PP or glass	refrigerate at 4°C	6 months to analyze	N/A	N/A
Total Organic Carbon	4-oz. CWM PP or glass	freeze at -18°C	6 months to analyze	refrigerate at 4°C	14 days to analyze
Total Solids (collect w/ TOC)	4-oz. CWM PP or glass	freeze at -18°C	6 months to analyze	refrigerate at 4°C	14 days to analyze
Mercury	250-ml CWM PP	freeze at -18°C	28 days to analyze	N/A	N/A
Other Metals	250-ml CWM PP	freeze at -18°C	2 years to analyze	refrigerate at 4°C	6 months to analyze
BNAs	16-oz. glass	freeze at -18°C	1 year to extract 40 days to analyze	refrigerate at 4°C	14 days to extract 40 days to analyze
PCBs (collect w/ BNAs)	16-oz. glass	freeze at -18°C	1 year to extract 40 days to analyze	refrigerate at 4°C	14 days to extract 40 days to analyze

CWM PP – Clear, wide-mouth polypropylene

6.5 Sampling Equipment Decontamination

The grab samplers will be decontaminated between sampling stations by scrubbing with a brush and ambient water, followed by a thorough *in situ* rinsing. A separate stainless steel bowl and spoon will be dedicated to each sampling station, precluding the need for decontamination of this equipment.

6.6 Sample Storage and Delivery

All sample containers will be stored in an insulated cooler containing ice immediately after collection to maintain the samples at a temperature of approximately 4° Celsius until delivery to the laboratory. Sample containers from each station will be grouped and placed in plastic bags to facilitate sample receipt and login. At the end of each sampling day, all samples will be transported back to the King County Environmental Laboratory.

6.7 Chain of Custody

Chain of custody (COC) will commence at the time that each sample is collected. While in the field, all samples will be under direct possession and control of King County field staff. For chain of custody purposes, the *Liberty* or *Chinook* will be considered a "controlled area." Each day, all sample information will be recorded on a COC form (Figure 6-1). This form will be completed in the field and will accompany all samples during transport and delivery to the laboratory each day. Upon arrival at the King County Environmental Laboratory, the sample delivery person will relinquish all samples to the sample login person. The date and time of sample delivery will be recorded and both parties will then sign off in the appropriate sections on the COC form at this time. Once completed, original COC forms will be archived in the project file. Samples delivered after regular business hours will be stored in a locked chain of custody refrigerator until the next day.

FIGURE 6-1
King County Environmental Laboratory
Chain of Custody Form

LABORATORY WORK ORDER
Chain of Custody

King County Department of Natural Resources
Water and Land Resources Division
Environmental Laboratory
322 West Ewing Street
Seattle, Washington 98119-1507

Project Name:
Project Number:
Laboratory Project Manager:
Telephone Number:

				Analyses															
Sample Number	Locator	Collect Date	Collect Time	BNAS	BUTYLTIN	CHLOROBENZENES	METHYL MERCURY	PCBS	METALS - ICP	MERCURY - CVAA	AMMONIA	OIL & GREASE	PSD	TOC	SOLIDS	SULFIDE		Number of Containers	Comments

Additional Comments:

Total Number of Containers ___

Sampled By:

Relinquished By:		**Received By:**	
Signature	Date	Signature	Date
Printed Name	Time	Printed Name	Time
Organization		Organization King County Environmental Laboratory	

7 SAMPLE DOCUMENTATION

Sampling information and sample metadata will be documented using the methods noted below.

- Field sheets generated by King County's Laboratory Information Management System (LIMS) that will include information such as:
  1. sample ID number
  2. station name
  3. station bottom depth
  4. sediment depth (i.e., sampler penetration depth) for each successful deployment
  5. sediment depth stratum sampled (0 – 10 cm)
  6. physical sediment characteristics
  7. date and time of sample collection
  8. condition and height of tide
  9. initials of all sampling personnel
- LIMS-generated container labels will identify each container with a unique sample number, station and site names, collect date, analyses required, and preservation method.
- The *Liberty's* or *Chinook's* logbook will contain records of all shipboard activities, destinations, arrival and departure times, general weather and positioning information, and the names of shipboard personnel.
- The *Liberty's* or *Chinook's* cruise plan will list the prescribed stations to be sampled, along with their respective coordinates and other associated locating information.
- Electronic DGPS coordinate data will be electronically logged for each acceptable grab sample using both latitude/longitude and NAD 83 State Plane formats.
- COC documentation will consist of the Lab's standard COC form, which is used to track release and receipt of each sample from collection to arrival at the lab.

A sample of a typical field sheet used by the King County Environmental Laboratory is included as Figure 7-1.

FIGURE 7-1
King County Environmental Laboratory
Standard Field Sheet

Fieldsheet ID: 421235_22JUN1999_101133 Page: 1

MAJOR LAKES (wtr col)

Project Number: 421235 Personnel: _____

Sample Number	P15790-1	P15790-2	P15790-3
Locator	0618	0623	0625
Short Loc. Desc.		Rosemnt SD	Sammslough
Locator Desc.		LAKE SAMM/WEST SHORE-ROSEMONT STOR	Lake Sammamish
Site	MAJOR LAKES	MAJOR LAKES	MAJOR LAKES
Sample Depth			
Collect Date			
Comments			
EH, FIELD			
SED DEPTH			
SED SAMP RANGE			
SED TYPE			
TIME			
Dept., Matrix, Prod			
	3 FRSHWTRSED AVS	3 FRSHWTRSED AVS	3 FRSHWTRSED AVS
	3 FRSHWTRSED NH3	3 FRSHWTRSED NH3	3 FRSHWTRSED NH3
	3 FRSHWTRSED PSD	3 FRSHWTRSED PSD	3 FRSHWTRSED PSD
	3 FRSHWTRSED TOC	3 FRSHWTRSED TOC	3 FRSHWTRSED TOC
	3 FRSHWTRSED TOTP	3 FRSHWTRSED TOTP	3 FRSHWTRSED TOTP
	3 FRSHWTRSED TOTS	3 FRSHWTRSED TOTS	3 FRSHWTRSED TOTS
	3 FRSHWTRSED TOTSULFIDE	3 FRSHWTRSED TOTSULFIDE	3 FRSHWTRSED TOTSULFIDE
	6 FRSHWTRSED HG-CVAA	6 FRSHWTRSED HG-CVAA	6 FRSHWTRSED HG-CVAA
	6 FRSHWTRSED PP ICPMS	6 FRSHWTRSED PP ICPMS	6 FRSHWTRSED PP ICPMS
	7 FRSHWTRSED BNA	7 FRSHWTRSED BNA	7 FRSHWTRSED BNA
	7 FRSHWTRSED CHLOROBENZENES	7 FRSHWTRSED CHLOROBENZENES	7 FRSHWTRSED CHLOROBENZENES
	7 FRSHWTRSED CLPESTPCB	7 FRSHWTRSED CLPESTPCB	7 FRSHWTRSED CLPESTPCB
	7 FRSHWTRSED HERB	7 FRSHWTRSED HERB	7 FRSHWTRSED HERB
	7 FRSHWTRSED OPPEST	7 FRSHWTRSED OPPEST	7 FRSHWTRSED OPPEST
	7 FRSHWTRSED TRIBUTYLTIN	7 FRSHWTRSED TRIBUTYLTIN	7 FRSHWTRSED TRIBUTYLTIN
	7 FRSHWTRSED WTPH-HCID	7 FRSHWTRSED WTPH-HCID	7 FRSHWTRSED WTPH-HCID

End of Fieldsheet.

8 FIELD MEASUREMENTS AND OBSERVATIONS

The following field measurements and observations will be recorded on the appropriate field sheet/log for each sample:

- sample (bottom) depth - measured as keel depth by vessel's fathometer;
- sediment depth (grab penetration depth) - measured by ruler inside the grab;
- sediment sampling range (0 – 10 cm);
- sediment type (a mnemonic code indicating color, gross grain size, odor, and debris);
- tide condition and height;
- whether the CSO is discharging at the time of sampling; and
- collect date, start time, and sampling personnel.

9 ANALYTICAL PARAMETERS AND METHODS

Analytical parameters for sediment chemistry samples are presented in the following sections. All analyses will follow guidelines suggested in the Puget Sound Protocols (PSEP 1986, 1997b, and 1997c) and will be performed at the King County Environmental Laboratory.

The terms MDL and RDL, used in the following chemistry analysis sections, refer to *method detection limit* and *reporting detection limit*, respectively. The MDL is defined as *the minimum concentration of a chemical constituent that can be detected*, while the RDL is defined as *the minimum concentration of a chemical constituent that can be reliably quantified*.

9.1 Conventionals – Analytical Methods and Detection Limits

Conventional sediment parameters will include PSD, TOC, and total solids. The analytical methods and detection limits for conventional parameters are summarized in Table 9-1.

Table 9-1
Conventionals Methods and Detection Limits

Parameter	Method	MDL	RDL	Units
PSD (gravel and sand)	ASTM D422	0.1	1.0	percent dry wt.
PSD (silt and clay)	ASTM D422	0.5	1.0	percent dry wt.
Total Organic Carbon	EPA 9060, PSEP 1996	500	1,000	mg/Kg wet wt.
Total Solids	SM 2540-G	0.005	0.01	percent wet wt.

Total solids will be analyzed on all samples to allow normalization of all other sediment chemistry data to dry weight. Total solids analysis will be performed according to the latest edition of Standard Method (SM)2540-G (APHA 1998), which is a gravimetric determination.

TOC analysis will be performed on all samples to allow normalization of some organic parameters to organic carbon. TOC analysis will be performed according to EPA Method 9060/SW-846 (EPA 1995), high-temperature combustion with infrared spectroscopy.

PSD analysis will be performed according to ASTM Method D422 (ASTM 2002), which is a combination of sieve and hydrometer analyses. Results for PSD analysis are presented both for phi sizes and for the four broad classifications of clay, silt, sand, and gravel. Results for the clay and silt fractions are also summed to provide a result for "percent fines."

9.2 Metals – Analytical Methods and Detection Limits

Detection limits for the eight target metals for marine sediment samples and the ten target metals for freshwater sediment samples are summarized in Table 9-2. These MDLs and RDLs are presented on a wet-weight basis and are based on an initial analytical sample weight of 1 (+/- 0.05) gram (g) and a final volume of 100 milliliters (ml) for mercury and 50 for all other metals. Sample weights will be increased if the total solids are low enough that, when dry-weight normalized, the sample-specific RDL will not meet SMS chemical criteria or freshwater sediment quality reference values.

Mercury will be analyzed by cold vapor atomic absorption spectroscopy (CVAA), following EPA Method 7471B (SW-846). The remaining metals in marine sediment samples will be analyzed by inductively coupled plasma optical emission spectroscopy (ICP-OES) with a strong acid digestion, following EPA Methods 3050B/6010C (SW8-846). The remaining metals in freshwater sediment samples will be analyzed by inductively coupled plasma mass spectroscopy (ICP-MS) with a strong acid digestion, following EPA Methods 3050B/6020A.

Table 9-2
Metals Target Analytes and Detection Limits (mg/Kg wet weight)

Analyte	Marine MDL	Marine RDL	Fresh MDL	Fresh RDL
Antimony	--	--	0.075	0.375
Arsenic	1.25	6.25	0.025	0.125
Cadmium	0.10	0.50	0.0125	0.0625
Chromium	0.15	0.75	0.050	0.25
Copper	0.20	1.0	0.10	0.50
Lead	1.0	5.0	0.025	0.125
Mercury	0.005	0.05	0.005	0.05
Nickel	--	--	0.025	0.125
Silver	0.20	1.0	0.010	0.050
Zinc	0.25	1.25	0.125	0.625

Appendix B presents the SMS criteria and freshwater sediment quality reference values that must be met by sample-specific RDL values after normalization to dry weight.

9.3 Trace Organics – Analytical Methods and Detection Limits

Trace organic parameters will include BNAs and PCBs. The analytical methods and detection limits for the target analytes are summarized in Tables 9-3 and 9-4, shown on a wet-weight basis.

Results for certain non-ionizing organic compounds are normalized to organic carbon for comparison to SMS marine chemical criteria when the dry-weight TOC values are between 5,000 and 50,000 mg/Kg (0.5 to 5%). If the dry-weight TOC values are below 5,000 mg/Kg, results for the same non-ionizing organic compounds are dry-weight normalized before comparison to the 1988 Marine Dry Weight criteria found on Ecology's MyEIM website. Ionizing organic compounds are always dry-weight normalized before comparison to their SQS criteria. For freshwater samples, organic compounds are normalized to dry weight for comparison with freshwater sediment quality reference values.

The King County Environmental Laboratory has attempted to optimize its procedures to produce the lowest cost-effective RDLs that are routinely achievable in a standard sediment sample. These RDLs should meet the required SQS chemical criteria or freshwater reference values for each parameter in most cases. The ability of the laboratory to attain detection limits which meet organic-carbon normalized chemical criteria, however, will depend upon the TOC content of each sample.

9.3.1 BNA Target Analytes and Detection Limits

The wet-weight detection limits for the target BNA compounds are summarized in Table 9-3. These MDLs and RDLs are based on a 30 g extraction with gel permeation cleanup and concentration to a final volume of 1.0 ml for analysis. Note that the detection limits can vary if limited sample is available for extraction (less than 30 g) or if dilution is required due to

elevated analyte concentration(s). BNA analysis of both marine and freshwater sediment samples will be performed according to EPA methods 3550B/8270D (SW 846), which employ a solvent extraction with sonication and analysis by gas chromatography/mass spectroscopy (GC/MS).

Table 9-3
BNA Target Analytes and Detection Limits (µg/Kg wet weight)

Analyte	MDL	RDL	Analyte	MDL	RDL
1,2,4-Trichlorobenzene	0.53	1.07	Chrysene	5.3	10.7
1,2-Dichlorobenzene	5.33	5.33	Dibenzo(a,h)anthracene	5.3	10.7
1,4-Dichlorobenzene	8.00	8.00	Dibenzofuran	5.3	10.7
2,4-Dimethylphenol	5.3	10.7	Diethyl phthalate	11	21.3
2-Methylnaphthalene	5.3	10.7	Dimethyl phthalate	10.7	10.7
2-Methylphenol	5.3	10.7	Di-n-butyl phthalate	11	21.3
3-,4-Methylphenol	27	53.3	Di-n-octyl phthalate	10.7	10.7
Acenaphthene	5.3	10.7	Fluoranthene	5.3	10.7
Acenaphthylene	5.3	10.7	Fluorene	5.3	10.7
Anthracene	5.3	10.7	Hexachlorobenzene	0.53	1.07
Benzo(a)anthracene	5.3	10.7	Hexachlorobutadiene	2.7	5.33
Benzo(a)pyrene	5.3	10.7	Indeno(1,2,3-cd)pyrene	5.3	10.7
Benzo(b,j,k)fluoranthene	5.3	10.7	Naphthalene	5.3	10.7
Benzo(g,h,i)perylene	5.3	10.7	N-Nitrosodiphenylamine	13.3	13.3
Benzoic acid	107	107	Pentachlorophenol	80.0	80.0
Benzyl alcohol	13.3	13.3	Phenanthrene	5.3	10.7
Benzyl butyl phthalate	8.00	8.00	Phenol	27	80.0
Bis(2-ethylhexyl) phthalate	11	21.3	Pyrene	5.3	10.7

Prior to BNA preparation and analyses, the total solids and total organic carbon analytical results will be used to verify that the standard 30 g to 1 ml extraction will allow analyte RDLs to meet the appropriate SQS criteria or freshwater reference values (depending upon the compound and/or TOC value). Historical solids and organic carbon data may be used for this purpose if available and consistent over time. The extraction sample amount and final volumes will be adjusted accordingly to ensure that the RDL is at or below the appropriate SQS criteria.

The MDL and RDL for specific analytes requiring dilution (e.g., exceedence of analyte calibration range) will be increased to reflect the dilution. In cases where a dilution is necessitated by a matrix interference or other sample issue, and the resulting RDL for a specific analyte exceeds the SQS criteria but the analyte is not detected, the RDL exceedence of the SQS criteria will be discussed with the project manager and noted in the appropriate analytical case narrative.

Appendix B presents the SQS marine criteria and freshwater reference values that should be met after appropriate normalization to either organic carbon or dry weight.

9.3.2 PCB Target Analytes and Detection Limits

The detection limits for the target PCB Aroclors® are summarized in Table 9-4. These MDLs and RDLs are presented on a wet-weight basis and based on the extraction of a 30 g sample, gel permeation cleanup, and concentration to a final volume of 1.0 ml.

When reporting PCB results, the King County Environmental Laboratory will report each individual Aroclor result and calculate Total Aroclors as the sum of detected Aroclors. If no individual Aroclors are detected in a sample, the reported MDL/RDL for the Total Aroclors parameter will be set equal to the highest MDL/RDL among the individual Aroclors reported for the sample.

Note that the detection limits can vary if limited sample is available for extraction (less than 30 g) or if dilution is required due to elevated analyte concentration(s). PCB analysis of both marine and freshwater sediment samples will be performed according to EPA methods 3550B/8081B/8082A (SW 846), which employ solvent extraction with sonication and analysis by gas chromatography with electron capture detector (GC/ECD) and dual column confirmation.

Table 9-4

PCB Target Analytes and Detection Limits (µg/Kg wet weight)

Analyte	MDL	RDL	Analyte	MDL	RDL
Aroclor 1016	1.3	2.67	Aroclor 1248	1.3	2.67
Aroclor 1221	2.7	5.33	Aroclor 1254	1.3	2.67
Aroclor 1232	2.7	5.33	Aroclor 1260	1.3	2.67
Aroclor 1242	1.3	2.67	Total Aroclors *	1.3	2.67

*When Aroclors are detected, the reported MDL/RDL for the Total Aroclors parameter will be lowest MDL/RDL of the individual Aroclors.

10 LABORATORY QA/QC

The quality control (QC) samples that will be analyzed in association with sediment chemistry samples are summarized in Table 10-1. The frequency of method blanks, duplicates, triplicates, and matrix spikes is one per QC batch (20 samples maximum). The frequency of SRM (standard reference material) or LCS (laboratory control sample) analysis is one per project (40 samples maximum). LCS analysis is used in lieu of SRM analysis for selected analytes when an SRM may not be readily available. Surrogates are analyzed with every organic sample.

Table 10-1
Sediment Chemistry Quality Control Samples

Analyte	Method Blank	Spiked Blank	Duplicate/ Triplicate	Matrix Spike (MS)	MS Duplicate	SRM/LCS	Surrogates
PSD	No	No	Triplicate	No	No	No	No
TOC	Yes	Yes	Triplicate	Yes	No	Yes	No
Total Solids	Yes	No	Triplicate	No	No	No	No
Mercury	Yes	Yes	Duplicate	Yes	Yes	Yes	No
Other Metals	Yes	Yes	Duplicate	Yes	No	Yes	No
BNAs	Yes	Yes	Duplicate	Yes	Yes	Yes	Yes
PCBs	Yes	Yes	Duplicate	Yes	Yes	Yes	Yes

Quality assurance (QA1) sediment chemistry acceptance criteria (Ecology 1989) are shown in Table 10-2.

Table 10-2
QA1 Acceptance Criteria for Sediment Chemistry Samples

Analyte	Method Blank	Spiked Blank	Duplicate/ Triplicate	Matrix Spike	SRM/LCS	Surrogates
PSD	N/A	N/A	RSD ≤ 20%	N/A	N/A	N/A
TOC	< MDL	80 - 120%	RSD ≤ 20%	75 - 125%	80 - 120%	N/A
Total Solids	< MDL	N/A	RSD ≤ 20%	N/A	N/A	N/A
Metals (incl. Hg)	< MDL	85 – 115%	RPD ≤ 20%	75 - 125%	Appendix C	N/A
BNAs	< MDL	Appendix C	RPD ≤ 35%	Appendix C	Appendix C	Appendix C
PCBs	< MDL	Appendix C	RPD ≤ 35%	Appendix C	Appendix C	Appendix C

< MDL - Method Blank result should be less than the *method detection limit*.
RPD – Relative Percent Difference, RSD – Relative Standard Deviation
QC results for matrix spike, SRM/LCS, and surrogates are in *percent recovery of analyte*.

Some trace metal and organic analyses have empirically-derived acceptance limits for various QC samples. These are laboratory-derived, performance-based control limits that may be updated once per calendar year. The limits in effect at the time of analysis will be used as accuracy limits for the spike blank, matrix spike and matrix spike duplicate, laboratory control sample, and ongoing precision and accuracy samples. Current laboratory-derived acceptance limits for metal and organic analyses are included as Appendix C (Tables C1 – C8).

QC results that exceed the acceptance limits will be evaluated to determine appropriate corrective actions. Samples will typically be reanalyzed if the unacceptable QC results indicate a systematic problem with the overall analysis. Unacceptable QC results caused by

a particular sample or matrix will not require reanalysis unless an allowed method modification would improve the results. Analytical results that do not meet QA1 acceptance criteria will be qualified and flagged according to Ecology guidance (Ecology 2008).

11 DATA REPORTING AND RECORD KEEPING

This section provides information on how monitoring data will be reported and interpreted and how project records will be maintained.

11.1 Analytical Data

All sediment chemistry data will be reported in QA1 format (Ecology 1989). The final QA1 report will contain the following information and deliverables:

- a QA1 narrative discussing data quality in relation to study objectives and data criteria;
- all associated QC data (LIMS QC reports and worklists);
- copies of field sheets and COC forms; and
- a comprehensive report containing all analytical and field data (including data qualifier flags).

11.2 Final Report and EIM Files

A CSO sediment monitoring report will be prepared that will include a presentation and interpretation of the sediment chemistry results. The report will compare sediment chemistry results to published marine sediment quality chemical criteria and freshwater sediment reference values (Ecology 1995, Ecology 2003, EPA 1988, USACE 2009). The chemistry data will be also reported in the regional Environmental Information Management (EIM) system format for delivery to Ecology. The final report and EIM files will be delivered to Ecology no later than January 1, 2013.

11.3 Record Keeping

All field and sampling records, custody documents, raw lab data, and summaries and narratives will be archived according to King County Environmental Laboratory policy, for a minimum of 10 years from the date samples were collected. Interpretive reports and memoranda, along with all chemistry data, data analysis project narratives, and reports will be stored in project files for a minimum of 10 years from the date samples were collected. Appendix D includes LIMS “product names” and “list types” under which analytical data will be stored.

12 PROJECT HEALTH AND SAFETY

The following general health and safety guidelines have been provided in lieu of a site-specific Health and Safety Plan. These guidelines will be read and understood by all members of the sampling crew.

- All crew of the research vessel will follow all aspects of the King County Environmental Laboratory Vessel Safety Plan.
- Samplers will wear chemical-resistant gloves when coming into contact with sediment.
- No eating or drinking by sampling personnel will be allowed during active sampling operations.
- All sampling operations will be conducted during daylight hours.
- All accidents, „near misses,' and symptoms of possible exposure will be reported to a crew member's supervisor within 24 hours of occurrence.
- All crew members will be aware of the potential hazards associated with any chemicals used during the sampling effort.

Several hazards are inherent to sediment sampling. General vessel safety, physical hazards unique to sediment grab sampling, and chemical hazards are discussed in sections 12.1 through 12.3.

12.1 General Vessel Safety

To help prevent accidents and ensure adequate preparation for emergencies that may possibly arise, the following safety equipment will be required on the *Liberty* or *Chinook*:

- one personal floatation device (PFD) for each crew member and one throwable PFD;
- an accessible, clearly labeled, fully stocked first-aid/CPR kit;
- an accessible and clearly-labeled eye wash (when sampling suspected contaminated sediments);
- one (preferably two) VHF marine radio(s) with weather channel;
- a cellular telephone;
- a horn;
- navigation lights;
- an emergency life raft;
- an anchor and suitable line;
- signal flares; and
- a reach pole or shepherd's hook.

Personal protective equipment will be selected and used that will protect workers involved in sediment sampling from the hazards and potential hazards likely to be encountered. Minimum required personal protective equipment for sediment sampling shall include the following:

- hard hat;
- steel-toe rubber boots;
- chemical-resistant gloves (e.g. Nitrile); and
- safety glasses.

Recommended additional personal protective equipment will include rain gear and hearing protection (when the research vessel is under way).

12.2 Grab Sampling

Sampler deployment and sediment retrieval present physical hazards due, in part, to the heavy weight of the grab sampler, its suspension above the vessel deck, and the risk of accidental or premature closure. Prior to each sampling event, all cabling, shackles, pins, housings, and swivels will be inspected to ensure the integrity of all points along the sampling assembly.

The sampler will always be set while it is resting on a stable surface. Once set, a safety pin will be set in place on the triggering mechanism and remain in place until the sampler is swung outboard of the vessel rail. Special care will be exercised when removing the safety pin to ensure personal safety in the event of a gear or winch failure. Fingers will not be placed through the ring of the pin when it is removed and hands will be kept completely clear of the sampler interior after the pin has been removed. If a sampler is retrieved that has not been tripped, it will be lowered to a stable surface before any worker contact.
During grab retrieval, one crew member will watch for the appearance of the grab sampler and alert the winch operator when the sampler is first visible below the water surface. Attempting to bring a swinging grab sampler on board poses a serious risk of being hit or knocked overboard. The winch operator will minimize swinging before the grab sampler is brought on board for the crew to secure. Hard hats and gloves will always be worn when handling the grab sampler.

The winch drum, blocks, capstan, and any area between the grab sampler and railings, the deck, and heavy equipment all represent significant pinching and crushing hazards. Only experienced crew members will operate the winch or capstan during a sampling event. Other crew members will exercise care to avoid these potentially hazardous areas.

12.3 Chemical Hazards

Contact with sediment at some sampling stations may present a health hazard from chemical constituents of the sediment, such as PCBs, mercury, phthalates, and PAHs. Potential routes of exposure to chemical hazards include **inhalation, skin and eye absorption, ingestion, and injection**. Crew members will exercise caution to avoid coming into contact with sediment at all stations during sampling operations. Protective equipment will include chemical-resistant gloves, safety glasses or goggles, and protective clothing (e.g. rain gear). Crew members will exercise good personal hygiene after sampling and prior to eating or drinking.

13 REFERENCES

ACOE 2009. *Sediment Evaluation Framework for the Pacific Northwest.* US Army Corps of Engineers, *et al*. Seattle, Washington.

APHA 1998. *Standard Methods for the Examination of Water and Wastewater, 20th Edition.* American Public Health Association. Washington, D.C.

ASTM 2002. *Standard Test Method for Particle-Size Analysis of Soils D422-63(2002).* American Society for Testing and Materials. West Conshohocken, Pennsylvania.

Ecology 1989. *Puget Sound Dredged Disposal Analysis Guidance Manual - Data Quality Evaluation for Proposed Dredged Material Disposal Projects.* Prepared for the Washington State Department of Ecology by PTI Environmental Services. Bellevue, Washington.

Ecology 1992. *Technical Information Memorandum, Organic Carbon Normalization of Sediment Data.* Prepared by Teresa Michelsen for the Washington State Department of Ecology Sediment Management Unit. Olympia, Washington.

Ecology 1995. *Sediment Management Standards, Chapter 173-204 WAC.* Washington State Department of Ecology. Olympia, Washington.

Ecology 2003. *Development of Freshwater Sediment Quality Values for Use in Washington State – Phase II Report: Development and Recommendation of SQVs for Freshwater Sediments in Washington State.* Prepared for the Washington State Department of Ecology by Avocet Consulting. Olympia, Washington.

Ecology 2008. *Sediment Sampling and Analysis Plan Appendix - Guidance on the Development of Sediment Sampling and Analysis Plans Meeting the Requirements of the Sediment Management Standards (Chapter 173-204 WAC).* Ecology Publication No. 03-09-043. Washington State Department of Ecology. Olympia, Washington.

Ecology 2009. *National Pollutant Discharge Elimination System Waste Discharge Permit No. WA-002918-1.* Washington State Department of Ecology. Bellevue, Washington.

Ecology 2010. *King County Wastewater Treatment Plant and Combined Sewer Overflow (CSO) Discharges (NPDES Permit WA-002918-1) Sediment Monitoring Recommendations for CSO Locations.* Memorandum from Donna Podger, Aquatic Lands Cleanup Unit. Washington State Department of Ecology. Olympia, Washington.

EPA 1988. *Sediment Quality Values Refinement: 1988 Update and Evaluation of Puget Sound AET.* Prepared for the U.S. Environmental Protection Agency Region 10 by PTI Environmental Services. Seattle, Washington.

EPA 1995. *Test Methods for Evaluating Solid Waste. Laboratory Manual – Physical/Chemical Methods, SW-846, 3rd Edition, Update IIB.* United State Environmental Protection Agency, Office of Solid Waste and Emergency Response. Washington, D.C.

King County 1999. *Sediment Management Plan.* Prepared for the King County Department of Natural Resources and Parks Sediment Management Program by Anchor Environmental and Herrera Environmental Consultants. Seattle, Washington.

King County 2009. *Comprehensive Sediment Quality Summary Report for CSO Discharge Locations.* King County Department of Natural Resources and Parks, Wastewater Treatment Division. Seattle, Washington.

PSEP 1986. *Recommended Protocols for Measuring Conventional Sediment Variables in Puget Sound.* Prepared for the Puget Sound Estuary Program (U.S. Environmental Protection Agency Region 10) by Tetra Tech, Inc. Seattle, Washington.

PSEP 1997a. *Recommended Guidelines for Sampling Marine Sediment, Water Column, and Tissue in Puget Sound.* Prepared for the Puget Sound Estuary Program (U.S. Environmental Protection Agency Region 10) by the King County Environmental Laboratory. Seattle, Washington.

PSEP 1997b. *Recommended Guidelines for Measuring Metals in Puget Sound Marine Water, Sediment and Tissue Samples.* Prepared for the Puget Sound Estuary Program (U.S. Environmental Protection Agency Region 10) by the King County Environmental Laboratory. Seattle, Washington.

PSEP 1997c. *Recommended Guidelines for Measuring Organic Compounds in Puget Sound Marine Water, Sediment and Tissue Samples.* Prepared for the Puget Sound Estuary Program (U.S. Environmental Protection Agency Region 10) by the King County Environmental Laboratory. Seattle, Washington.

PSEP 1998. *Recommended Guidelines for Station Positioning in Puget Sound.* Prepared for the Puget Sound Estuary Program (U.S. Environmental Protection Agency Region 10) by the King County Environmental Laboratory. Seattle, Washington.

APPENDIX A

SCALING ANALYSIS FOR CSO SEDIMENT SAMPLIN

APPENDIX B
Tables B-1 and B-2

Sediment Management Standards Chemical Criteria
for Trace Metals and Trace Organics
Sediment Quality Standards (SQS) from Chapter 173-204 WAC
and 1988 Marine Dry Weight SQS from MyEIM Database

Freshwater Sediment Quality Reference Values
For Trace Metals and Trace Organics
2003 Floating Percentile – Freshwater SQS
from MyEIM Database

Table B-1
Sediment Management Standards Chemical Criteria – Marine Sediments

Metals	SQS (mg/Kg DW)[1]	Ionizing Organics	SQS (µg/Kg DW)[1]
Arsenic	57	Benzoic Acid	650
Cadmium	5.1	Benzyl Alcohol	57
Chromium	260	Phenol	420
Copper	390	2-Methylphenol	63
Lead	450	4-Methylphenol	670
Mercury	0.41	2,4-Dimethylphenol	29
Silver	6.1	Pentachlorophenol	360
Zinc	410		

Non-Ionizing Organics	SQS (mg/Kg OC)[1]	SQS (µg/Kg DW)[2]
Acenaphthene	16	500
Acenaphthylene	66	1,300
Anthracene	220	960
Fluorene	23	540
2-Methylnaphthalene	38	670
Naphthalene	99	2,100
Phenanthrene	100	1,500
Total LPAHs	370	5,200
Benzo(a)anthracene	110	1,300
Benzo(a)pyrene	99	1,600
Benzo(b,j,k)fluoranthene	230	3,200
Benzo(g,h,i)perylene	31	670
Chrysene	110	1,400
Dibenzo(a,h)anthracene	12	230
Fluoranthene	160	1,700
Indeno(1,2,3-c,d)pyrene	34	600
Pyrene	1,000	2,600
Total HPAHs	960	12,000
1,2-Dichlorobenzene	2.3	35
1,4-Dichlorobenzene	3.1	110
1,2,4-Trichlorobenzene	0.81	31
Hexachlorobenzene	0.38	22
Bis(2-ethylhexyl) Phthalate	47	1,300
Butyl Benzyl Phthalate	4.9	63
Diethyl Phthalate	61	200
Dimethyl Phthalate	53	71
Di-n-butyl Phthalate	220	1400
Di-n-octyl Phthalate	58	6,200
Dibenzofuran	15	540
Hexachlorobutadiene	3.9	11
N-Nitrosodiphenylamine	11	28
Total PCBs	12	130

[1]Sediment Quality Standard (SQS) from Chapter 173-204 WAC (Ecology 1995).
[2]1988 Marine Dry Weight SQS from MyEIM ((http://www.ecy.wa.gov/eim/myEIM.htm).

Table B-2
Freshwater Sediment Quality Reference Values

Trace Metals	SQS (mg/Kg DW)[1]
Antimony	0.4
Arsenic	20
Cadmium	0.6
Chromium	95
Copper	80
Lead	340
Mercury	0.5
Nickel	60
Silver	2
Zinc	140

Trace Organics	SQS (µg/Kg DW)[1]
Acenaphthene	1,100
Acenaphthylene	470
Anthracene	1,200
Fluorene	1,000
2-Methylnaphthalene	470
Naphthalene	500
Phenanthrene	6,100
Total LPAHs	6,600
Benzo(a)anthracene	4,300
Benzo(a)pyrene	3,300
Benzo(b,j,k)fluoranthene	11,000
Benzo(g,h,i)perylene	4,000
Chrysene	5,900
Dibenzo(a,h)anthracene	800
Fluoranthene	11,000
Indeno(1,2,3-c,d)pyrene	4,100
Pyrene	8,800
Total HPAHs	31,000
Bis(2-ethylhexyl) Phthalate	230
Butyl Benzyl Phthalate	260
Dimethyl Phthalate	46
Di-n-octyl Phthalate	26
Dibenzofuran	400
Total PCBs	60

[1]2003 Floating Percentile Freshwater SQS from MyEIM ((http://www.ecy.wa.gov/eim/myEIM.htm).

APPENDIX C
Tables C-1 through C-8

Metals and Trace Organics Performance-Based QC Limits

Table C-1a
Laboratory QC Limits for Sediment Metals – SRM Recoveries (PACS-2)

Parameter	Lower Limit (%)	Upper Limit (%)
Chromium	30	70
Copper	78	118
Lead	74	114
Mercury	80	120
Zinc	73	113

Table C-1b
Laboratory QC Limits for Soil Metals – LCS Recoveries (ERA SOIL)

Parameter	Lower Limit (%)	Upper Limit (%)
Arsenic	80	120
Cadmium	80	120
Silver	66	134

Table C-2
Laboratory QC Limits for Sediment BNAs – Matrix Spike Recoveries

Parameter	Lower Limit (%)	Upper Limit (%)	Parameter	Lower Limit (%)	Upper Limit (%)
1,2,4-Trichlorobenzene	35	117	Chrysene	41	127
1,2-Dichlorobenzene	25	74	Di-N-Butyl Phthalate	34	146
1,4-Dichlorobenzene	19	76	Di-N-Octyl Phthalate	50	155
2,4-Dimethylphenol	5	115	Dibenzo(a,h)anthracene	37	129
2-Methylnaphthalene	10	111	Dibenzofuran	14	129
2-Methylphenol	20	90	Diethyl Phthalate	26	142
3-,4-Methylphenol	10	163	Dimethyl Phthalate	31	127
Acenaphthene	40	95	Fluoranthene	10	168
Acenaphthylene	41	112	Fluorene	18	131
Anthracene	10	150	Hexachlorobenzene	20	130
Benzo(a)anthracene	40	158	Hexachlorobutadiene	21	78
Benzo(a)pyrene	32	143	Indeno(1,2,3-Cd)Pyrene	35	123
Benzo(b,j,k)fluoranthene	31	153	N-Nitrosodiphenylamine	20	135
Benzo(g,h,i)perylene	20	121	Naphthalene	15	107
Benzoic Acid	5	130	Pentachlorophenol	30	151
Benzyl Alcohol	10	95	Phenanthrene	10	146
Benzyl Butyl Phthalate	30	150	Phenol	30	105
Bis(2-Ethylhexyl)Phthalate	30	160	Pyrene	20	150

Table C-3
Laboratory QC Limits for Sediment BNAs – Blank Spike Recoveries

Parameter	Lower Limit (%)	Upper Limit (%)	Parameter	Lower Limit (%)	Upper Limit (%)
1,2,4-Trichlorobenzene	21	115	Chrysene	59	110
1,2-Dichlorobenzene	21	118	Di-N-Butyl Phthalate	50	150
1,4-Dichlorobenzene	32	78	Di-N-Octyl Phthalate	54	146
2,4-Dimethylphenol	5	80	Dibenzo(a,h)anthracene	53	137
2-Methylnaphthalene	25	129	Dibenzofuran	44	106
2-Methylphenol	10	100	Diethyl Phthalate	40	138
3-,4-Methylphenol	10	125	Dimethyl Phthalate	41	128
Acenaphthene	40	100	Fluoranthene	50	120
Acenaphthylene	48	111	Fluorene	45	109
Anthracene	55	112	Hexachlorobenzene	36	112
Benzo(a)anthracene	68	130	Hexachlorobutadiene	17	92
Benzo(a)pyrene	62	113	Indeno(1,2,3-Cd)Pyrene	54	127
Benzo(b,j,k)fluoranthene	61	126	N-Nitrosodiphenylamine	5	128
Benzo(g,h,i)perylene	36	126	Naphthalene	29	100
Benzoic Acid	10	150	Pentachlorophenol	20	121
Benzyl Alcohol	10	90	Phenanthrene	58	106
Benzyl Butyl Phthalate	46	147	Phenol	17	92
Bis(2-Ethylhexyl)Phthalate	49	129	Pyrene	50	125

Table C-4
Laboratory QC Limits for Sediment BNAs – Surrogate Recoveries

Parameter	Lower Limit (%)	Upper Limit (%)
2,4,6-Tribromophenol	20	150
2-Fluorophenol	20	120
d5-Phenol	17	103
d5-Nitrobenzene	16	103
d4-2-Chlorophenol	13	101
d4-1,2-Dichlorobenzene	20	140
2-Fluorobiphenyl	22	135
d14-Terphenyl	45	150

Table C-5
Laboratory QC Limits for Sediment BNAs – SRM Recoveries

Parameter	Lower Limit (%)	Upper Limit (%)
Anthracene	28	98
Benzo(a)anthracene	66	124
Benzo(a)pyrene	60	116
Benzo(b,j,k)fluoranthene	52	190
Benzo(g,h,i)perylene	15	121
Chrysene	77	136
Dibenzo(a,h)anthracene	10	200
Fluoranthene	45	126
Indeno(1,2,3-Cd)Pyrene	33	121
Naphthalene	10	29
Phenanthrene	51	106
Pyrene	36	135

Table C-6
Laboratory QC Limits for Sediment PCBs
Matrix Spike Recoveries

Parameter	Lower Limit (%)	Upper Limit (%)
Aroclor 1016	45	139
Aroclor 1260	20	132

Table C-7
Laboratory QC Limits for Sediment PCBs
Blank Spike Recoveries

Parameter	Lower Limit (%)	Upper Limit (%)
Aroclor 1016	36	117
Aroclor 1260	40	131

Table C-8
Laboratory QC Limits for Sediment PCBs
SRM and Surrogate Recoveries

Parameter	Lower Limit (%)	Upper Limit (%)
Aroclor 1254	57	139
Decachlorobiphenyl	25	150
2,4,5,6-Tetrachloro-m-xylene	20	110

APPENDIX D
Table D-1

Laboratory Information Management System (LIMS)
Products and List Types

Table D-1
King County Environmental Laboratory
Laboratory Information Management System (LIMS)
Products and List Types

Parameter	LIMS Product	LIMS List Type
PSD	PSD	CVPSD
TOC	TOC	CVTOC
Total Solids	TOTS	CVTOTS
Mercury by CVAA	HG-CVAA	MTHG-MIDS, 6-MIDS
Other Metals by ICP	AS-ICP, CD-ICP, CR-ICP, CU-ICP, PB-ICP, AG-ICP, ZN-ICP	MTICP-SED, 6-SED
Other Metals by ICPMS	SB-ICPMS, AS-ICPMS, CD-ICPMS, CR-ICPMS, CU-ICPMS, PB-ICPMS, NI-ICPMS, AG-ICPMS, ZN-ICPMS	MTICPMS-SED, 6-SED
BNA SMS list (low-level)	BNASMS	ORBNASMS
PCBs (low-level)	PCBLL	ORPCBLL

CVAA – Cold vapor atomic absorption spectroscopy.
ICP – Inductively coupled plasma optic emission spectroscopy.