# Quality Assurance Project Plan

# Loading of Contaminants to the Lower Duwamish Waterway from Suspended Sediments in the Green River

by
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Cover photo: Footbridge over the Green River at 119th Street in Tukwila, Washington.

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Signatures are not available on the Internet version.
TCP – Toxics Cleanup Program
EAP – Environmental Assessment Program
SCS – Statewide Coordination Section
EIM – Environmental Information Management system
WOS – Western Operations Section

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## Figures



## Tables

# List of Acronyms and Abbreviations

Following are acronyms and abbreviations used frequently in this report:

| | |
|---|---|
| cfs | Cubic feet per second |
| cPAHs | Carcinogenic polycyclic aromatic hydrocarbon compounds |
| CSL | Cleanup Screening Level |
| DOC | Dissolved organic carbon |
| EAP | Environmental Assessment Program |
| Ecology | Washington State Department of Ecology |
| EIM | Environmental Information Management database (Ecology) |
| EAP | Environmental Assessment Program (Ecology) |
| EPA | U.S. Environmental Protection Agency |
| LDW | Lower Duwamish Waterway |
| LDWG | Lower Duwamish Work Group |
| LISST | Laser In-Situ Scattering and Transmissometry |
| MEL | Manchester Environmental Laboratory (Ecology) |
| MQO | Measurement quality objectives |
| PAHs | Polycyclic aromatic hydrocarbon compounds |
| PCBs | Polychlorinated biphenyl compounds |
| PSEP | Puget Sound Estuary Program |
| PSD | Particle size distribution |
| QA | Quality assurance |
| QC | Quality control |
| RM | River mile |
| RSD | Relative standard deviation |
| SMS | Sediment Management Standards |
| SOP | Standard operating procedure |
| SQS | Sediment quality standard |
| STM | Sediment Transport Model |
| TOC | Total organic carbon |
| TSS | Total suspended solids |
| USACE | U. S. Army Corps of Engineers |
| USGS | U.S. Geological Survey |

# Abstract

Predictions of contaminant loading to the Lower Duwamish Waterway sediment cleanup site are based on a computer model of sediment transport and contaminants measured in relatively few whole water samples. Contaminants associated with incoming suspended sediments have not been measured. Field measurements of suspended sediment contaminants, transport pathways, and deposition patterns will increase confidence in model predictions.

The goals of this study are to (1) estimate contaminant loading from suspended Green River sediment, (2) measure contaminants in two size ranges of suspended particles, and (3) provide field results to confirm predictions of the short-term transport and fate of suspended sediments.

Contaminant loading will be estimated by combining river flows, determined by the U.S. Geological Survey (USGS) and the Washington State Department of Ecology (Ecology), with contaminants measured in suspended Green River sediments. Suspended sediments will be collected by pumping river water through flow-through centrifuges. The centrifuged material will be tested for levels of PCBs, dioxins and furans, arsenic, PAHs, and organic carbon. These parameters will sometimes be measured separately in fine-grained (<63 µm diameter) and sandy (>63 µm diameter) sediments. Specific conductivity, suspended solids, *in-situ* particle size distribution, and organic carbon will also be measured.

Fluorescent sediment particles, manufactured to mimic native suspended and surface sediments, will be released into the Lower Duwamish Waterway where they will act as tracers. Results from analysis of tracers in recovered water and sediment samples will be compared to predictions of transport pathways and short-term patterns of deposition.

Note: Each study conducted by Ecology must have an approved Quality Assurance Project Plan. The plan describes the objectives of the study and the procedures to be followed to achieve those objectives. After completion of the study, a final report describing the study results will be posted to the Internet.

# Background

## Setting

The Green/Duwamish River watershed is located in western Washington, entirely within King County. It is a dam-regulated system that drains an area of 492 square miles inhabited by a population of approximately 400,000 (King County, 2008).

The watershed has been divided into several sub-watersheds that feature different land use patterns (Figure 1):

- The Green River begins in an upper sub-watershed that includes the Howard Hanson reservoir and dam at river mile (RM) 63.8. This is a sparely-populated, forested area with some lands dedicated to agriculture.
- The middle and lower Green River flows through residential and light industrial areas, ending where it is joined by the Black River (RM 10.4). The Duwamish River is often considered to begin here.
- The Duwamish Estuary sub-watershed is dominated by urban and industrial development. The channel is altered throughout much of this area.
- The Lower Duwamish Waterway (LDW) sediment cleanup site begins slightly above an upper vessel turning basin (RM 5.0) and continues to the south end of Harbor Island. Here the river splits into the man-made East and West Waterways that empty into Elliott Bay, Seattle (Figure 2).

As the last sub-watershed name indicates, the LDW and lower Duwamish River is an estuary. It is a classic salt wedge estuary. Under normal flow conditions (>1,000 cfs), the salt wedge does not often extend above the East Marginal Way Bridge at RM 6.3 (LDWG, 2008a). However, under conditions of low flow and high tide, a salt wedge has been observed as far upstream as RM 8.7.

To avoid confusion, this Quality Assurance (QA) Project Plan will refer to the entire river upstream of the southern boundary of the Lower Duwamish Waterway cleanup site as the Green River (not Lower Duwamish River).

The study site is entirely within the Duwamish River Estuary sub-watershed.

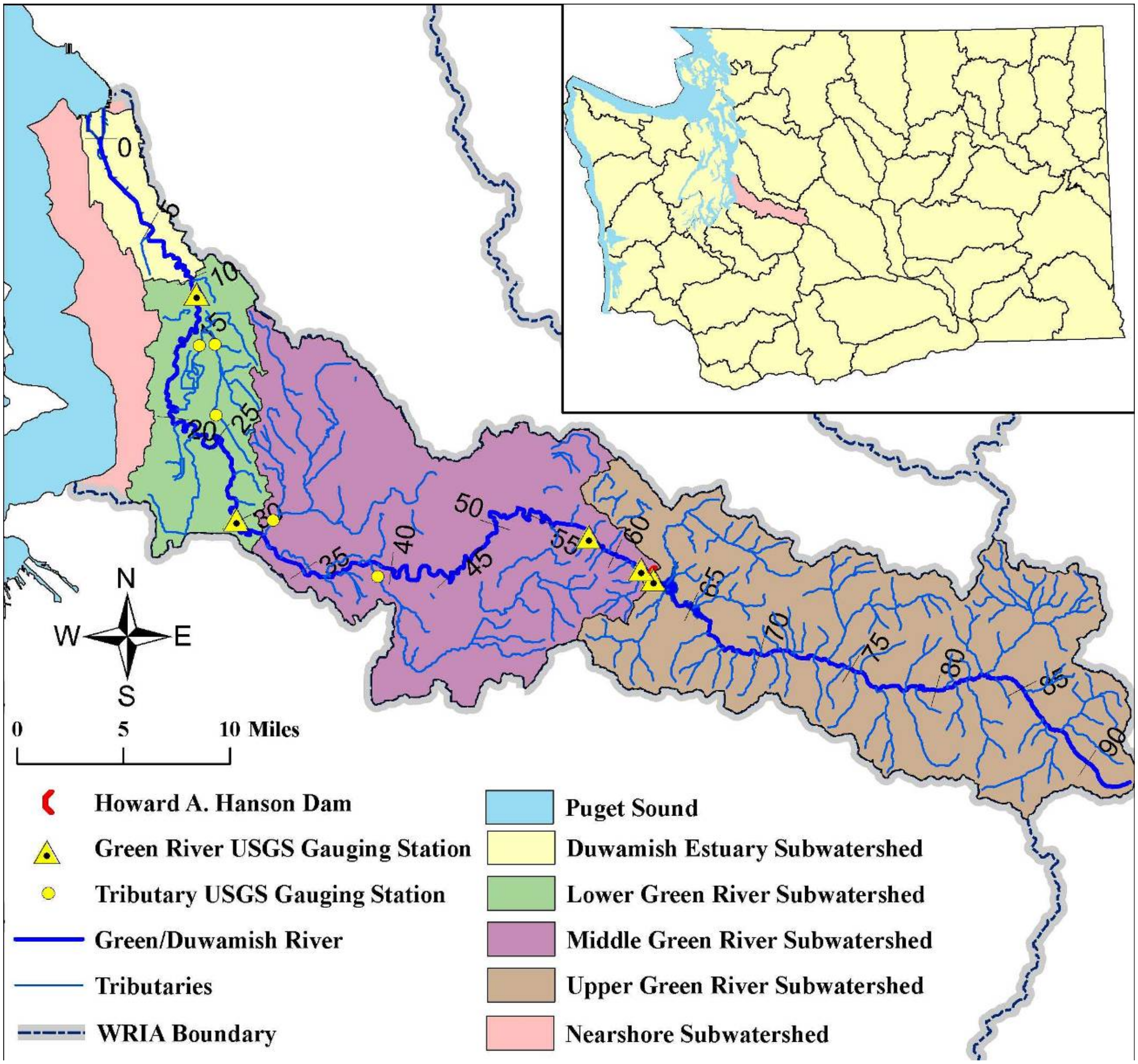


Figure 1. Green River watershed, with sub-watersheds, river miles, and gauging stations shown.

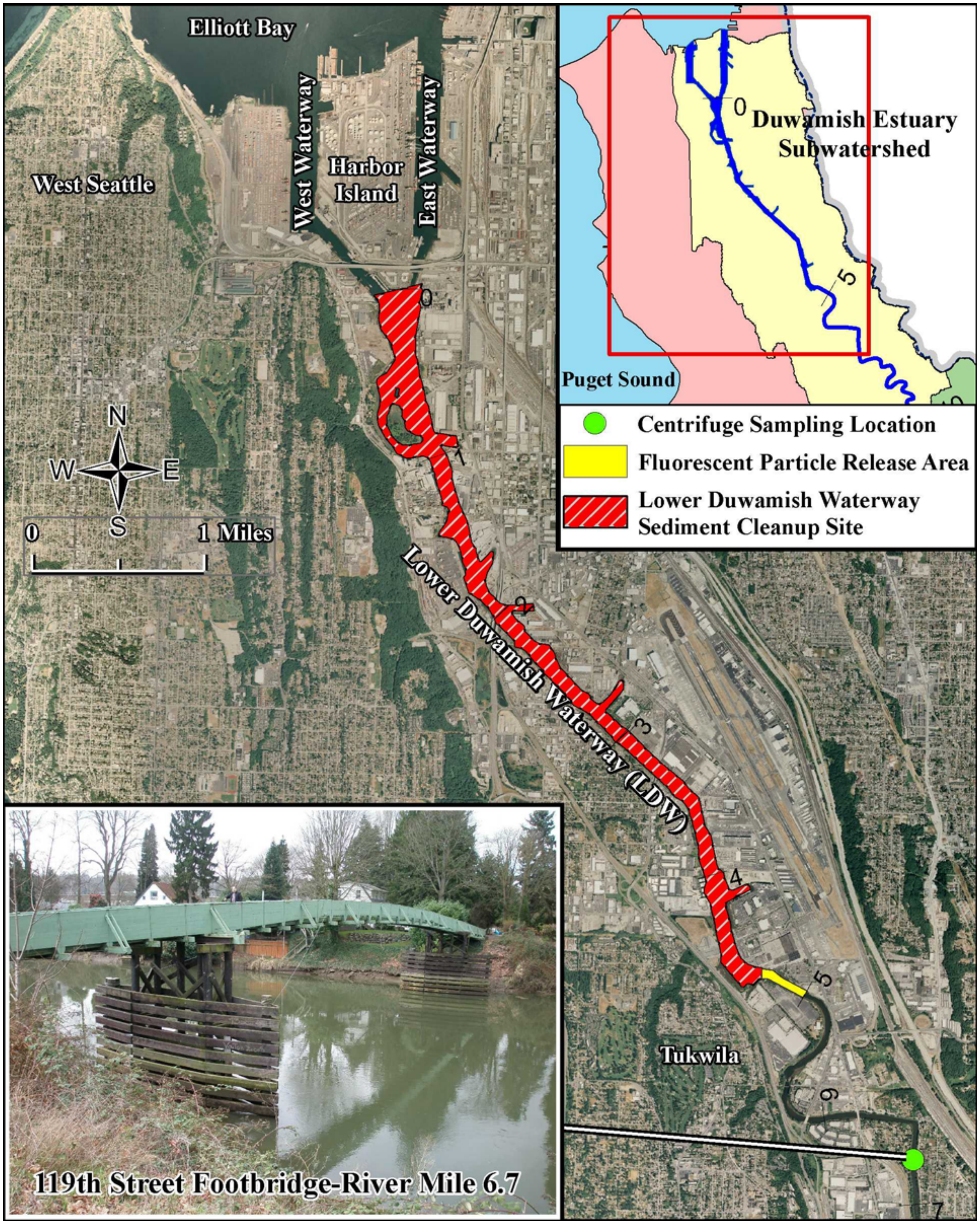


Figure 2. The Lower Duwamish Waterway sediment cleanup site (map) and the Green River near Tukwila, Washington (photo).

# History

Releases of contaminants from various human activities within the combined Green and Duwamish watersheds have resulted in contaminated sediments in the 5-mile long LDW, as well as in the East and West Waterways. Studies of sediments in the LDW began in the 1980s and intensified in the 1990s. In 2001, the U.S. Environmental Protection Agency (EPA) placed the LDW site on the National Priorities List and, with Ecology, signed a joint agreed order with liable parties to conduct remedial investigation and feasibility studies leading to cleanup actions (EPA, 2001).

Since 2001, studies of the LDW have measured contaminant levels, mapped distribution of sediment contaminants, estimated risks associated with exposures to contaminated sediments, modeled movements and fate of sediments, and evaluated options for cleanup (LDWG, 2008b). The contaminants found to represent the greatest risk to humans and animals are, in order, polychlorinated biphenyls (PCBs), chlorinated dioxins and furans, arsenic, and carcinogenic polycyclic aromatic hydrocarbons (cPAHs).

Future cleanup actions may include remedies such as dredging to remove sediments, capping with clean sands, and burial of contaminants by incoming sediments (so-called "natural attenuation"). Selection of appropriate cleanup remedies relies on accurate identification of future contaminant sources and estimates of loading associated with each source.

Recent sediment transport model (STM) and analysis reports (STAR) predict that nearly all sediment entering the LDW comes from upstream (LDWG, 2008a). By extension, it is presumed that most contaminant loading comes from the Green River. However, the model divides the overall LDW cleanup site into three distinct river reaches, based on predicted sediment stability and other factors:

- Reach 1 (RM 0.0 - 2.0) always contains a saline layer of water or salt wedge. It is a zone of net deposition, accumulating an average of 0.5-2.0+ cm sediment per year, with minimal potential for scour[1].
- Reach 2 (RM 2.0 - 3.0) is also a zone of net deposition, but with consistently higher accumulation rates (>2.0 cm/yr) and moderate potential for scour.
- Reach 3 (upstream of RM 3.0) features the highest net sedimentation rates (sometimes much >2.0 cm/yr), but also has the greatest potential for scour (at least in some areas).

The STM also predicts that approximately 50% of the total mass of the sediment entering the LDW passes through the site, into the waterways or Elliott Bay. The most recent model predicts nearly all incoming sands settle out within the site, but the majority of fine suspended sediments leave the site.

[1] Scour is the erosion of deposited bottom sediments by high velocity currents that may be caused by periodic propeller wash, storms, or runoff.

# Project Description

## Description

This study is the result of needing more field-based evidence to confirm or refine current STM predictions and estimates of contaminant loading to the LDW site. Two reasons for this are:

- Levels of contaminants associated with suspended Green River sediment have not been measured.
- Fine-grained suspended sediments in the Green River, expected to have greater levels of contaminants than sandy sediments, are predicted to pass through the LDW to Elliott Bay.

The first part of this study will estimate contaminant loading to the LDW from suspended sediments in the Green River. The estimate will be based on field measurements of flow, water quality parameters, and measurements of contaminants associated with suspended sediment. The second part of the study will trace short-term movements and deposition of suspended sediments that enter the LDW site. This will be done using manufactured fluorescent sediment tracer particles.

The study will occur entirely within the Duwamish River Estuary sub-watershed (Figure 1). Estimates of flow will rely on data from the USGS gauging station located at RM 32.0 in Auburn[2]. The 46-year mean daily flow at this station is shown in Figure 3. The range of flows at this location is approximately 100-10,000 cfs, with daily flow averaging 1,350 cfs. Flow will also be measured where and whenever suspended sediments are collected.

Suspended sediments will be removed from the river by pumping water through 2 flow-through centrifuges. This will occur at a footbridge located upstream of the LDW site at RM 6.7 (Figure 2). Levels of contaminants may vary with the sediment load, so it is important that sampling suspended sediments will represent a range of total suspended solids (TSS).

TSS levels in the Green River are commonly 3-20 mg/l, with the mean being approximately 6 mg/l. TSS increases during periods of higher flow and may exceed 100 mg/l during flood events.

The suspended sediments that are collected will be analyzed for levels of PCBs, dioxins, furans, arsenic, and cPAHs. Contaminants in fine suspended sediments (<63µm diameter) and sandy suspended sediments (>63µm diameter) will be measured separately on some occasions.

[2] The USGS no longer measures flow at its gauging station in Tukwila (RM 12.4).

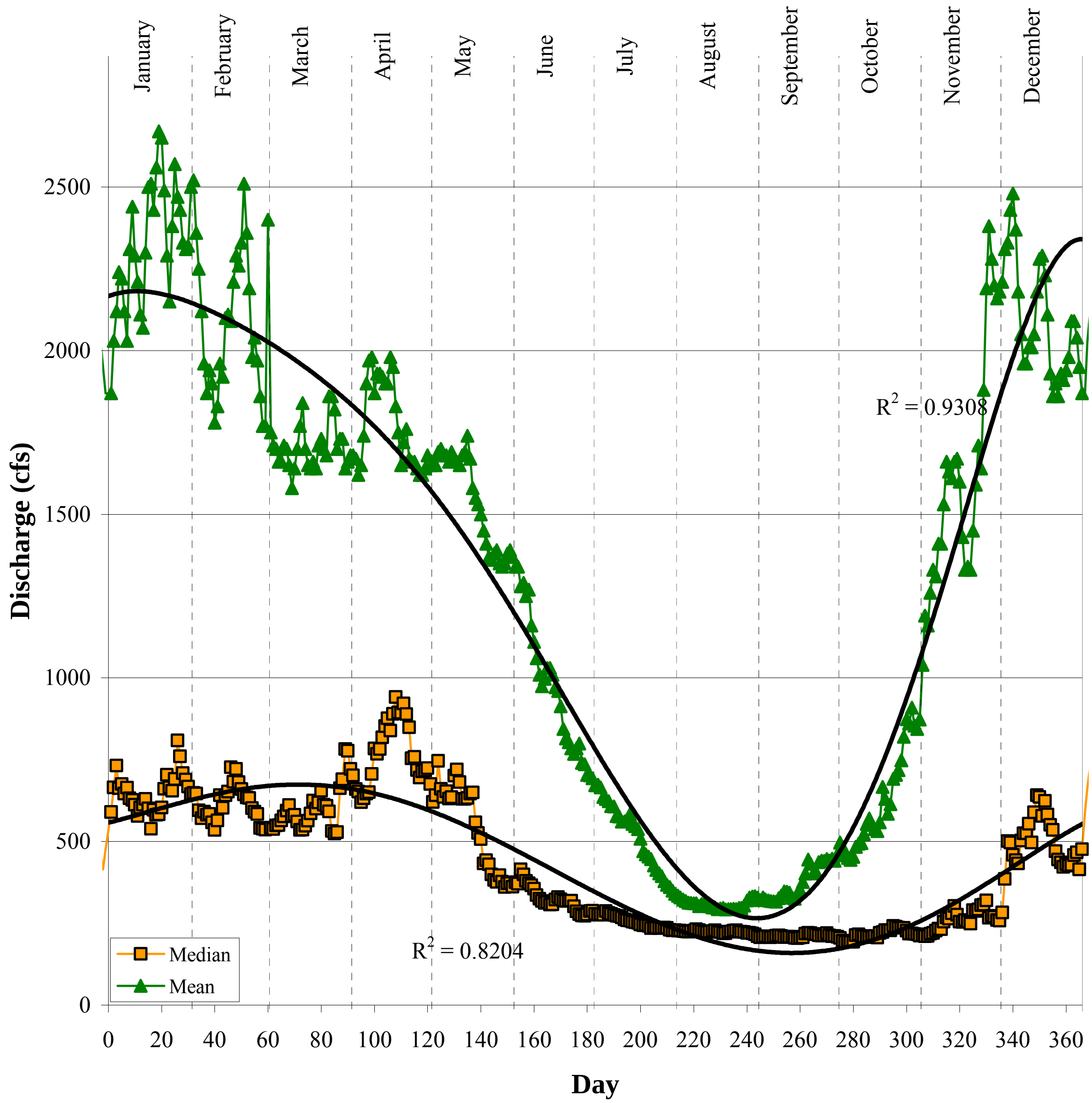


Figure 3. Average Daily Flow (1962-2007) for the Green River at the USGS Gauging Station near Auburn (River Mile 32.0).

This study will also examine movements and deposition of suspended sediments that enter the LDW cleanup site. This will involve the release and recovery of dual-signature (fluorescent and magnetic) sediment particles that mimic sediments found in the Green River and LDW. A separate addendum to this QA Project Plan will describe the tracer study in more detail.

## Goals and Objectives

The 3 goals of this study are as follows:

1. The first goal is to estimate loading of priority contaminants associated with suspended sediments in the Green River to the LDW cleanup site [3]. Current loading estimates are based on computer models, with relatively little supporting field data. The principal objective will be to measure levels of contaminants in representative samples of suspended sediment collected from the Green River. This will be done on at least 9 occasions covering a broad range of river conditions. Loading estimates will inform the choice of sediment cleanup levels and cleanup actions. Results will also be compared to Washington State water and sediment quality standards, as appropriate.

2. The second goal is to compare estimates of priority contaminant loading associated with fine-grained suspended sediments (predicted to pass through the LDW) and sandy suspended sediments (predicted to deposit within the LDW site). Levels of contaminants associated with these size fractions of suspended sediments have not been measured. Objectives include collecting representative samples of at least these 2 size fractions of suspended sediments and measuring levels of priority contaminants in each. Results will help modelers assign contaminant levels to different size fractions of suspended sediment, thereby improving predictions of contaminant loading.

3. The third goal is to identify transport pathways and measure short-term deposition patterns for suspended sediments that enter the LDW from the Green River. A sediment tracer study is perhaps the most direct approach to confirming STM predictions. Objectives are to (1) manufacture sediment tracers that effectively mimic suspended sediments in the Green River, (2) release the tracers into the water column, in a representative way, and (3) recover the tracers from the water column and surface sediments within the LDW site on 3 occasions after their release. An addendum to this QA Project Plan will describe this part of the study in more detail.

[3] The study is not specifically intended to estimate 'streambed loading' of contaminants to the LDW.

# Organization and Schedule

Ecology personnel who will be involved in this study are listed in Table 1, along with their titles and roles. Manchester Environmental Laboratory (MEL) staff will measure certain parameters, while contract laboratory staff will measure others. Stakeholders and volunteers may help collect and analyze water and sediment samples, as needed and if available. Partrac Ltd will manufacture fluorescent sediment particle tracers, help release them into the LDW, and measure them in recovered samples. The proposed schedule for field sampling, laboratory analyses, and report preparation is shown in Table 2.

Table 1. Organization of project staff and responsibilities.

| Staff<br>(EAP unless otherwise noted) | Title | Responsibilities |
|---|---|---|
| Brad Helland<br>Toxics Cleanup Program<br>Northwest Regional Office<br>(425) 649-7138 | EAP Client | Clarifies scope of the project, and reviews and approves final QAPP and report. |
| Tom Gries<br>Toxics Studies Unit, SCS<br>(360) 407-6327 | Project Manager, Principal Investigator | Prepares QAPP, oversees field sampling and transfer of samples to laboratories, conducts QA review of data, analyzes and interprets data, and prepares draft and final reports. |
| Janice Sloan<br>Toxics Studies Unit, SCS<br>(360) 407-6553 | Field Lead | Helps collect samples, record field information, analyze results, and prepare reports. Enters data into EIM. |
| Dale Norton<br>Toxics Studies Unit, SCS<br>(360) 407-6765 | Unit Supervisor for Project Manager | Provides internal review of the QAPP, approves the budget, and approves the final QAPP. |
| Will Kendra<br>SCS<br>(360) 407-6698 | Section Manager for Project Manager | Reviews the project scope and budget, tracks progress, reviews the draft QAPP, and approves the final QAPP. |
| Robert F. Cusimano<br>Western Operations Section<br>(360) 4070-6596 | Section Manager for Study Area | Reviews the draft QAPP. |
| Stuart Magoon<br>Manchester Environmental Laboratory<br>(360) 871-8801 | Director | Reviews and approves the final QAPP. |
| William R. Kammin<br>(360) 407-6964 | Ecology Quality Assurance Officer | Reviews the draft QAPP and approves the final QAPP. |
| Dr. Kevin Brown<br>Partrac, Ltd<br>Glasgow, Scotland | Contractor | Reviews the draft QAPP. Manufactures sediment tracers. Provides technical assistance throughout tracer study. Assists with release of tracers. Analyzes tracers recovered in water and sediment samples. Prepares summary tracer study report. |

EAP – Environmental Assessment Program
SCS – Statewide Coordination Section
EIM – Environmental Information Management system
QAPP – Quality Assurance Project Plan

Table 2. Proposed schedule for field sampling, laboratory analyses, data entry, and reporting results.

| Field and laboratory work | Proposed date and year |
|---|---|
| Field sampling period | July 2008 - February 2009 |
| Laboratory analyses completed | March 31, 2009 |
| Environmental Information System (EIM) system | |
| EIM data engineer | Janice Sloan |
| EIM user study ID | LDW_08 |
| EIM study name | Loading of Contaminants Associated with Suspended Sediments in the Green River to the Lower Duwamish Waterway |
| Data due in EIM | June 30, 2009 |
| Final report | |
| Author lead | Tom Gries |
| Schedule | |
| Draft due to supervisor | April 15, 2009 |
| Draft due to client/peer reviewer | April 30, 2009 |
| Draft due to external reviewer | May 15, 2009 |
| Final report due on web | June 30, 2009 |

# Contaminant Loading from Suspended Sediments

## Quality Objectives

Loading of priority contaminants to the LDW cleanup site from suspended sediments in the Green River will be estimated using river flow and measurements of contaminant levels associated with the suspended sediments. River flow will be measured and estimated using data collected by the USGS at its Auburn gauging station (RM 32.0, Figure 1). Flow will also be measured by Ecology staff at the site where suspended sediment will be collected by pumping river water into 2 continuous, flow-through centrifuges. This will occur at a tidally-influenced site in Tukwila (RM 6.7, Figure 2).

The main quality objective for the contaminant loading part of the study is to ensure that all field and laboratory results are (1) representative of environmental conditions, (2) comparable to results of other studies, as appropriate, and (3) acceptable for the goals and objectives of the study.

### Representativeness

How well samples represent the environment from which they are collected will be important for this study. This will be determined by the timing of sampling events, choice of sampling location, sample collection methods, acceptance criteria, and sample handling and storage. To ensure samples are representative, samples will be collected:

- On occasions that not only capture seasonality but span a broad range of flow and TSS conditions.
- From a location in the Green River not influenced by local contaminant sources.
- During all tidal phases for each sampling event.
- From one or more locations in the water column at RM 6.7 thought to represent average conditions (determined by periodic measurements of conductivity, flow, and *in-situ* particle size distribution (PSD)[4]).
- Over time and space to integrate environmental variability (composite and continuous sampling).
- Using sampling protocols and sample acceptance guidelines comparable to ones used throughout the region, described in Ecology publications (Aasen, 2007; Ecology; 1993, 2008; PSEP, 1997a; Seiders, 1990; Serdar et al., 1994; Serdar, 1997a, 1997b).

Water quality parameters such as TSS, PSD, TOC, and DOC will be measured in samples that will be composited from several discrete water column samples. Aroclor PCBs, dioxins/furans, arsenic, and PAHs will be measured in suspended sediments removed from the water column by the centrifuges. Measurement of these parameters will meet method-specific, quality control requirements developed by MEL and contract laboratories.

[4] PSD will be measured in the field using a flow-through, laser diffraction instrument.

On some occasions, all of the priority contaminants except PAHs will be measured in 2 size fractions of suspended sediments. The 2 size fractions will be separated at Ecology facilities using a 63 µm mesh (#230) stainless steel sieve. Separation of sandy from fine-grained suspended sediments will also occur in the field, using the same stainless steel sieve, because centrifuging may not yield enough mass of sandy suspended sediment to measure priority contaminants.

## Comparability

Standard methods used throughout the region, and operating procedures consistent with previous studies, will be used to measure river flow, water quality parameters, and levels of contaminants in suspended sediments (Ecology, 2008; PSEP, 1997b, 1997c, 1986). Using these methods will ensure consistency and comparability of results.

## Quality control (QC) samples

Standard QC samples will be analyzed for TSS, TOC, and DOC. These will include field blanks to show background levels associated with the sampling process, and in replicates to indicate field variability. Laboratory QC samples will include a blank, duplicate, and laboratory control sample per batch (maximum 20 samples per batch).

Field measurements of *in-situ* PSD made with a pre-calibrated laser diffraction instrument will include the following QC samples: field blanks, field replicates. A standard reference material or sediment of known PSD will be analyzed periodically as an ongoing instrument calibration.

QC samples for centrifuged sediment samples will consist of a field blank, laboratory blank, and laboratory duplicate for each batch (maximum 20 samples per batch). These will be analyzed for PCB congeners, dioxins, furans, arsenic, and PAHs. Results for field blanks will be used to assess contamination of centrifuged sediments due to the sampling process. These blanks will be prepared by pumping deionized water through tubing and centrifuges and collecting the centrifuge effluent. Laboratory blanks will be used to assess any contamination introduced during analysis. Duplicates will be used to evaluate analytical variability.

Field replicates for the centrifuged suspended sediments will not be collected because of limitations on the sample mass easily collected. At average levels of TSS (6 mg/l), several days of continuous centrifugation may be required to obtain enough mass of suspended sediments for analysis of priority contaminants, including laboratory duplicates, and archiving.

When the sample mass that is collected can support more analysis, the principal investigator will seek laboratory staff advice about which other QC samples will most benefit study results. Recommendations will likely consider PSD, water content of the sample, TOC, and other potential interferences.

Laboratory QC samples for water samples will include blanks, duplicates, control samples, and matrix spikes. Analysis of contaminants in centrifuged sediment samples will also include blanks, control samples, and laboratory duplicates. The total number of laboratory duplicates that will be analyzed will be:

- Aroclor PCBs – 6.
- Dioxins/furans – 2.
- PAHs and arsenic – 1 each.

Appropriate QC samples will be collected and analyzed to evaluate any field or laboratory methods that are modified or new. An example is the process of sieving centrifuged suspended sediments to separate fine-grained from sandy material, and the subsequent drying of both fractions. QC in this example will consist of:

- Performing the procedure using a standard reference material or surface sediment samples having a known PSD.
- Comparing results to estimates of masses for the 2 size fractions derived from laser diffraction measurements of particle diameters and volumes.

Measurement quality objectives (MQOs) for field measurements are listed in Table 3. QC samples and MQOs for parameters measured in water and suspended sediment samples are listed in Table 4.

Table 3. Measurement quality objectives for flow and other parameters measured in the field.

| Parameter | Instrument | Range | Resolution | Accuracy | RPD or PSD |
|---|---|---|---|---|---|
| Water Depth | Teledyne/ RDI StreamPro | 1-13 ft | <0.1ft | <0.1 ft | -- |
| Current Velocity | | <0.3- 8 ft/sec | 0.1 ft/sec (each measurement cell) | 1% or 0.2 ft/sec (each measurement cell) | -- |
| Total Flow (cfs) | | -- | -- | -- | <5% |
| Conductivity | Hach Co. Hydrolab | 0-100 mS/cm | 0.001 mS/cm | ± 0.5% of reading + 0.001 mS/cm | ±5% |
| PSD | Sequoia Scientific, SS-LISST | TSS: < 5-3,000 mg/L Particle size: 2.5-500µm | TSS: <5 µL/L Particle size: 32 log spaced size classes | ± 10% for TSS and PSD | ±5% |

Relative percent difference (RPD and relative standard deviation (RSD) are calculated by comparing results of replicate field measurements.

Table 4. Measurement quality objectives for field and laboratory quality control samples.

| Parameter | Initial Calibration (r) | Continuing calibration (% recovery) | Reporting Limits | Field Blanks | | Laboratory blanks | | Field replicates/ Lab duplicates/batch (% RPD, % RSD) | | LSC[1] or SRM (% recovery) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | MQO[2] | No. | MQO | No. | MQO | No. | MQO[3] | No. | MQO[3] |
| *Water samples* | | | | | | | | | | | |
| TSS (mg/l) | -- | -- | 0.5 | 1 | < RL | 1 | < RL | 1/1 | < 20 | 1 | -- |
| TOC (mg/l) | ≥ 0.995 | 90-110 | <0.5 | 1 | < RL | 1 | < RL | 1/1 | < 20 | 1 | 80-120 |
| DOC (mg/l) | -- | -- | <0.5 | 1 | < RL | 1 | < RL | 1/1 | < 20 | 1 | -- |
| *Equipment/field blanks (water) for centrifuged sediment samples* | | | | | | | | | | | |
| PCBs Individual congeners (pg/l) | See Method (Table 8) | See Method (Table 8) | 10 | 3 | <0.5RL | 1 | <0.5RL | 0/1 | < 50 | 1 | 50-150 |
| Dioxins/furans Individual congeners (pg/l) | See Method (Table 8) | See Method (Table 8) | 1.0 - 10 | 3 | <0.5RL | 1 | <0.5RL | 0/1 | < 50 | 1 | 50-150 |
| Arsenic (µg/l) | See Method (Table 8) | See Method (Table 8) | 0.1 | 1 | < RL | 1 | < RL | 0/1 | < 20 | 1 | 80-120 |
| PAHs (µg/l) | See Method (Table 8) | See Method (Table 8) | 1.0 – 5.0 | 1 | <0.5RL | 1 | <0.5RL | 0/1 | < 50 | 1 | 50-150 |
| *Centrifuged sediment samples* | | | | | | | | | | | |
| Percent solids (% wet wt.) | -- | -- | 0.1 | 2 | < RL | 1 | < RL | 0/1 | < 20 | -- | -- |
| TOC (% dry wt) | ≥ 0.995 | 90-110 | 0.1 | 2 | < RL | 1 | < RL | 0/1 | < 20 | 1 | 80-120 |
| PSD (each fraction, phi) | -- | -- | 0.3% | -- | -- | -- | -- | -- | -- | 1 | 90-110 |
| PCBs Individual Aroclors (µg/kg dry wt) | See Method (Table 8) | See Method (Table 8) | 5.0 | -- | <0.5RL | 1 | <0.5RL | 0/1 | < 50 | 1 | 50-150 |
| Dioxins/furans Individual congeners (ng/kg dry wt) | See Method (Table 8) | See Method (Table 8) | Varies <1.0-300 | See above | <0.5RL | 1 | <0.5RL | 0/1 | < 50 | 1 | Varies |

| Parameter | Initial Calibration (r) | Continuing calibration (% recovery) | Reporting Limits | Field Blanks | | Laboratory blanks | | Field replicates/ Lab duplicates/batch (% RPD, % RSD) | | LSC[1] or SRM (% recovery) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | MQO[2] | No. | MQO | No. | MQO | No. | MQO[3] | No. | MQO[3] |
| *Centrifuged sediment samples (continued)* | | | | | | | | | | | |
| Arsenic (mg/kg dry wt) | See Method (Table 8) | See Method (Table 8) | 0.1 | See above | < RL | 1 | < RL | 0/1 | < 20 | | 75-125 |
| PAHs (µg/kg dry wt) | See Method (Table 8) | See Method (Table 8) | 0.5-2.0 | See above | <0.5RL | 1 | <0.5RL | 0/1 | < 50 | | 50-150 |

[1] A laboratory control sample (LCS) is prepared by spiking a reagent blank with the analyte of interest to make a concentration similar to those expected in environmental samples. Analysis of LCS, standard reference material (SRM) samples often document laboratory performance.
[2] See Ecology, 2008 (Table 5).
[3] See Ecology, 2008 (Table 13). RPD and RSD pertain to laboratory duplicates, not field replicates.

Dry wt = dry weight of sample
LCS = laboratory control sample
RSD = relative standard deviation
RPD = relative percent difference
SRM = standard reference material
RL = reporting limit

## Acceptability

Acceptability of laboratory results will be based on review of:

- Field and laboratory methods and standard operating procedures (SOPs) used for analysis.
- Field and laboratory instrument performance (initial and ongoing calibrations).
- Detection limits and reporting limits attained.
- Number and performance of various quality control samples, including field and laboratory blanks, laboratory duplicates, laboratory control samples, and matrix spike samples.

The overall goal for acceptability of results will be 100% for all water quality parameters (TSS, TOC, and DOC). Results may be qualified as estimated values but none should be rejected. The comparable goal for priority contaminants in centrifuged sediments will be 80%. The reduced acceptability reflects uncertainty and potential difficulties associated with measuring contaminants in the centrifuged sediment matrix.

## Data management

The quality objective for data management will be to calculate, transcribe, enter, and transfer data into Ecology's EIM database without error. To evaluate this, results for a randomly-selected 20% of water quality and centrifuged sediment samples will be reviewed. The principal investigator will compare the printed summary of results provided by MEL to data transferred from the Laboratory Information Management System into the EIM. In addition, calculations, formatting, and data entry based on printed deliverables from contract laboratories will be checked for errors. If any of the final results do not match those entered into the EIM database, then the source of errors will be identified and corrected.

## Sampling Process Design (Experimental Design)

This study will develop an estimate of contaminant loading associated with suspended sediments. Instantaneous estimates of loading will be based on field measurements, including:

- Flow - measured and derived from stage records.
- Water quality parameters (TSS, TOC, and DOC).
- Representative levels of contaminants associated with suspended sediments.

Accurate estimates of seasonal and annual contaminant loading will likely depend on strong relationships between contaminant levels measured in suspended sediments and levels of TSS. Such a relationship that covers a broad range of TSS and flow conditions will provide the best means of interpolating contaminant loading rates between sampling events. Therefore, it will be vital to collect time-integrated samples of suspended sediments at least 3 times each during low, average and higher flow conditions. This is discussed further in the section on sampling frequency, schedule, and duration.

Representative samples of suspended sediment will be collected by pumping large volumes of low TSS water through continuous, flow-through centrifuges. Concentrating TSS for analysis of contaminants by means of a passive settling approach would require too much river water and time. Filtering enough mass of suspended sediment from the river for the desired analyses would also be difficult. Centrifugation, given enough time, will result in enough mass to measure the principal contaminants of concern, and has been used by Ecology staff for past projects (Yake, et al, 1993; Serdar, et al., 1994; Serdar, 1997a, 1997b).

### Assumptions

Assumptions associated with study design elements include:

- Downstream tributaries, surface runoff, and groundwater inputs contribute relatively little to flow or contaminant loading between the USGS gauging station in Auburn (RM 32.0) and the cleanup site.
- The presence and duration of a salt wedge at the sampling locations is limited.
- Suspended sediments in any salt wedge do not represent significant net loading to the LDW.
- Upstream transport of suspended particulates in the salt layer to the sampling location is not important. When this does occur, flux of suspended particulates in the salt layer to overlying freshwater is not important.
- Suspended particulates at the sampling location are not influenced by nearby contamination.
- The water column at the sampling location is well mixed, justifying simple deployment of centrifuge intake.
- A relationship between levels of contaminants in suspended sediments and TSS can be established.

## Sampling locations

The main location for sampling suspended sediments will be the footbridge over the Green River located at 119th Street in Tukwila (RM 6.9; Figure 2). The site was chosen after surveying potential sampling locations (see Appendix D, Table D-1 and Figure D-1) because it featured the following:

- Less than 2 river miles from the LDW cleanup site boundary[5].
- Minimally influenced by presence of salt wedge.
- Well-mixed water column (long straight stretch of river, uniform turbidity observed).
- No substantial downstream tributaries.
- No apparent contaminant sources nearby.
- Parking close to bridge and river bank.
- Safe sampling location (residential area, local roads only, foot and bicycle bridge).

## Sampling frequency, schedule, and duration

The main goal for the number and timing of sampling events is to measure contaminants in suspended sediments over a broad range of total suspended solids (TSS) and flow condition.

The median values for minimum and maximum daily discharges at the Auburn USGS station (RM 32) recorded between 1962 and 2007 are 293 and 4,325 cfs, respectively. Sampling will be planned to cover flows throughout this range (Figure 3). A total of 9 sampling events will be planned (roughly monthly) so that 3 each will occur during low, moderate, and higher flows. Sampling during July, August, and September will likely be during low flows (<500 cfs). Flows starting in October and extending into December will likely be more moderate (500-2,000 cfs). Higher flows (2,000-4,000 cfs) will be likely during late December through February.

If no sampling has occurred during higher flows (>2,000 cfs) by the end of November, the remaining sampling events will be timed to correspond with expected storm events and dam releases.

The 119th Street footbridge is tidally influenced. Therefore, each sampling event will occur for intervals of 24 hours, to cover all daily tidal phases. Sampling will start and end during the same tidal phase. Duration of sampling will depend on the amount of time required to obtain the desired sample mass for that sampling event (24, 48, 72, or 96 hours depending on TSS and mass required; see Table 5 and Table 6.

[5] Alternative sampling locations located closer to the cleanup site boundary would be complicated by more frequent presence of a salt wedge layer, and by risk contamination from local sources such as stormwater outfall discharges.

Table 5. Estimated duration of centrifuge sampling events.

| TSS mg/L | Flow L/hr | g/hr | Time (Hrs) | | |
|---|---|---|---|---|---|
| | | | 50g | 100g | 150g |
| 0.003 | 360 | 1.08 | 46 | 93 | - |
| *0.006* | *360* | *2.16* | *23* | *46* | *69* |
| 0.012 | 360 | 4.3 | 11.6 | 23 | 35 |
| **0.025** | **360** | **9.0** | **5.6** | **11.1** | **16.7** |
| 0.050 | 360 | 18 | 11.1 | 5.6 | 8.3 |

Values in italics = approximate mean base flow
Values in bold = approximate mean storm flow

This table assumes 100% (or high) efficiency of particle capture/retention and little moisture in centrifuge pellet. Actual times will likely be greater. Low-flow conditions will likely have <6 mg/L TSS. Moderate flow conditions may have 6-15 mg/L TSS. Mean TSS for storm events is approximately 25 mg/L, while high flows may have 50->100 mg/L TSS.

Table 6. Estimated total number of samples, required quantities, containers, and storage conditions.

<table>
<tr><th>Parameter</th><th>Laboratory</th><th>Samples Number</th><th>Minimum Required</th><th>Containers</th><th>Holding Time</th><th>Storage Conditions</th></tr>
<tr><td colspan="7">Water samples</td></tr>
<tr><td>TSS</td><td rowspan="3">MEL</td><td>63</td><td>1-4 liters</td><td>1 liter HDPE jars</td><td>7 days</td><td rowspan="9">4°C</td></tr>
<tr><td>TOC</td><td>63</td><td rowspan="2">125 ml</td><td rowspan="2">125 ml glass jars</td><td rowspan="2">28 days (acidified)</td></tr>
<tr><td>DOC</td><td>63</td></tr>
<tr><td colspan="6">Equipment/field blanks (water) for centrifuged sediment samples</td></tr>
<tr><td>Aroclor PCBs</td><td>MEL</td><td>3</td><td>1 gallon</td><td rowspan="3">1 liter or 1gallon glass jars</td><td rowspan="3">1 year to extract 1 year to analyze</td></tr>
<tr><td>PCB congeners</td><td rowspan="2">Contract</td><td>3</td><td rowspan="2">1 liter</td></tr>
<tr><td>Dioxins and Furans</td><td>3</td></tr>
<tr><td>Arsenic</td><td rowspan="2">MEL</td><td>1</td><td>500 ml</td><td>500 ml HDPE bottles</td><td>6 months (acidified)</td></tr>
<tr><td>PAHs</td><td>1</td><td>1 gallon</td><td>1 gallon glass jars</td><td>7 days</td></tr>
<tr><td colspan="7">Suspended sediment retained in centrifuges</td></tr>
<tr><td>Percent solids</td><td>MEL/ Contract</td><td>18</td><td>5 grams</td><td rowspan="2">2-oz glass jars</td><td>7 days</td><td>4°C</td></tr>
<tr><td>TOC</td><td>MEL</td><td>21</td><td>1 gram</td><td>14 days<br>6 months</td><td>4°C<br>-18°C</td></tr>
<tr><td>Particle size distribution (PSD)</td><td>Contract</td><td>4</td><td>100 grams</td><td>4-oz glass jars</td><td>6 months</td><td>4°C</td></tr>
<tr><td>PCB Aroclors</td><td>MEL</td><td>21</td><td rowspan="3">10 grams</td><td rowspan="3">4-oz glass jars</td><td rowspan="5">1 year</td><td rowspan="2">4°C, -18°C after extraction</td></tr>
<tr><td>PCB Congeners</td><td rowspan="2">Contract</td><td>10</td></tr>
<tr><td>Dioxins and Furans</td><td>14</td><td rowspan="3">-18°C</td></tr>
<tr><td>Arsenic</td><td rowspan="2">MEL</td><td>10</td><td>1 gram</td><td>2-oz glass jars</td></tr>
<tr><td>PAHs</td><td>4</td><td>10 grams</td><td>4-oz glass jars</td></tr>
</table>

## Field sampling design

Flow measurements during each sampling event will be made using a downward-looking acoustic Doppler current profiler (ADCP, StreamPro, Teledyne/RDI). The mean flow from a minimum of 4 transects will be calculated every 2-3 hours. These will be combined to estimate total flow for each sampling event (harmonic mean flow) and compared to the USGS Auburn station (RM 32.0) flow and additional USGS flows for tributaries (RM 6.7-32). If periodic measurements of specific conductivity indicate a salt wedge is present at the sampling site and contributes substantially to flow, then only the flow of freshwater will be used in calculations.

Field measurements of flow (StreamPro, Teledyne/RDI) and PSD (LISST-Streamside[6], Sequoia Scientific) will be used to position the intake tube to best represent the distribution of suspended sediment in the water column. In addition, the LISST will be used to quantify variability of PSD in the river.

Contaminant levels associated with different levels of TSS in the Green River will be measured using various field and laboratory protocols. Water will be pumped into 2 continuous flow-through centrifuges to collect and concentrate suspended sediment. Samples of centrifuged sediments will be analyzed for total solids, TOC, and Aroclor PCBs for each sampling event and levels of dioxins/furans for 6 sampling events. PAHs and arsenic will be measured for one low-flow, one medium-flow, and one high-flow sampling event each. TOC, Aroclor PCB, dioxins/furans, and arsenic analysis will also be conducted on suspended sediment samples separated into fines and sands. Additional sands retained on a #230 sieve from pumped river water will be used to supplement the separated suspended sediments (Figures 4 and 5).

QC measures to assess centrifuge efficiency will include measuring TSS, PSD, TOC, and DOC in river water samples collected near the tubing intake, in centrifuge influent and effluent. Results will help quantify loss of particles from the centrifuge sampling system (loss at the intake, in the tubing, and from the centrifuge). River water, influent, and effluent samples will consist of composites made of discrete samples collected every 3 hours.

*Proof of method* procedures will test certain field sampling and sample handling methods. Evaluations will include:

1. Effectiveness of pumping to collect representative samples of suspended sediment.
2. Equivalence of results for water quality parameters measured in multiple discrete samples versus in a single composite water sample.
3. Equivalence of two methods of measuring PSD (laser diffraction and settling).
4. Contaminants introduced from pumping, centrifuging, and sample handling process.
5. Changes in mean PSD due to the centrifugation process.
6. Amount and size of suspended sediments passing through centrifuges.
7. Losses of contaminants during the process of the sieving and drying samples.

[6] LISST = Laser In-Situ Scattering and Transmissometry.

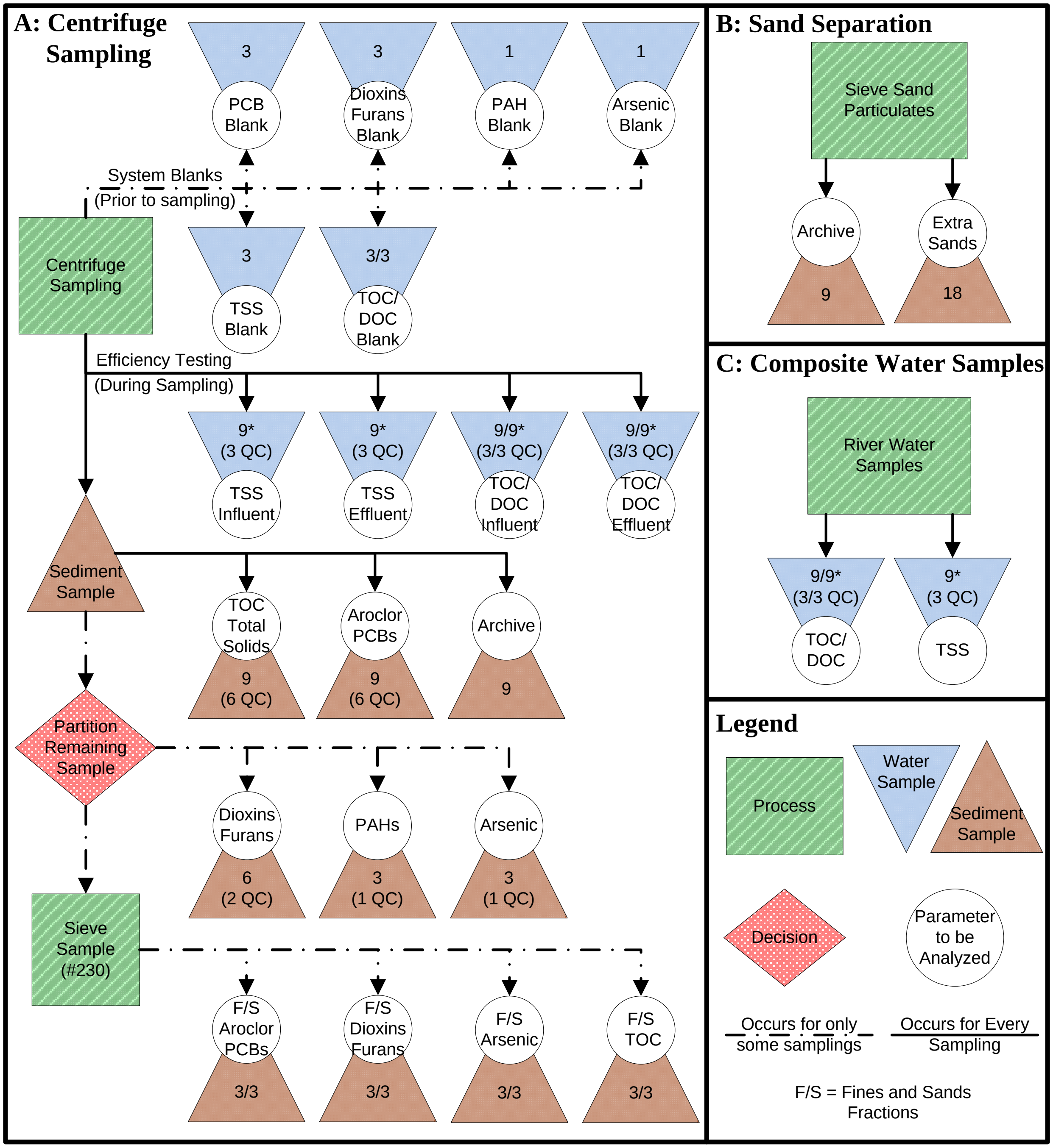


Figure 4. Strategy for collecting and analyzing whole water and suspended sediment samples.

A - Centrifuge sampling; B - Separating sands; C - Composite sampling water column.
Numbers in centrifuged sediment samples (triangles) are for total samples collected.
Numbers in parentheses are for total QC samples (TOC and DOC are separate samples).
* Water samples will be taken every 3 hours for TSS, TOC, and DOC and composited into 1 sample per sampling event (9 samples total).

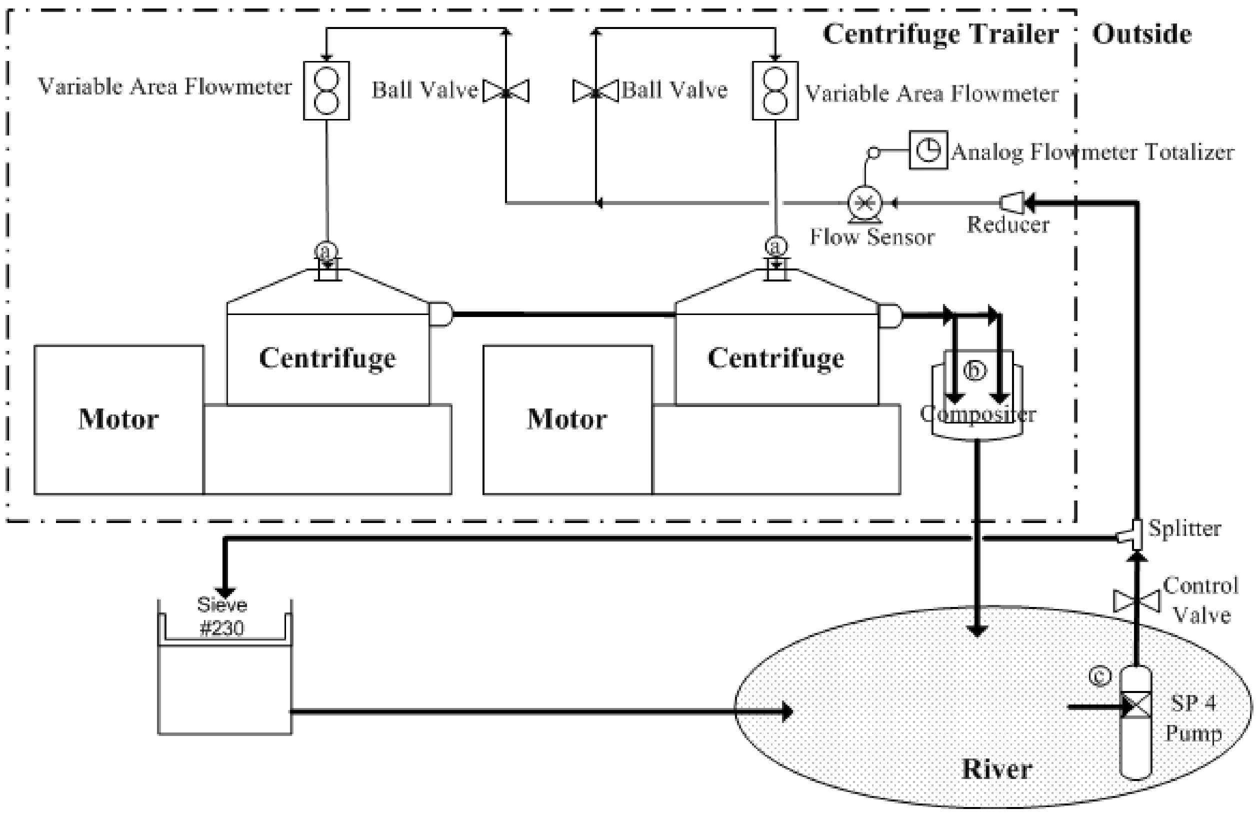


Figure 5. Centrifuge sampling schematic.

This diagram shows the basic set up of the centrifuge apparatus and locations where various types of samples are collected.
a - influent sample
b - effluent sample
c - river water sample

One example (#2) is that discrete water samples, collected every 3 hours during one sampling event, will be analyzed for TSS, TOC, and DOC. Results will be compared to TSS, TOC, and DOC in the composite sample. This will help address uncertainty about the ability to composite samples and obtain equivalent results.

Another example (#3) will involve measuring PSD in uniform suspensions of 3 surface sediment samples using the LISST (laser diffraction). PDS will also be measured in splits of these 3 samples using the standard settling method (PSEP, 1986).

For #7, known levels of contaminants (a PCB or dioxin congener surrogate) will be spiked into replicates of the centrifuged sediment matrix and allowed to equilibrate for one week (at $4^{o}C$). The % recovery calculated from results may help quantify losses from sample handling (sieving or drying samples).

# Sampling Procedures

This section provides a summary of field methods. Details are described in Appendix A.

## Cleaning and decontaminating equipment

Any equipment that will contact river water will be cleaned prior to sampling according to standard methods and operating procedures (Ecology, 2006, 2008; PSEP, 1997a). Upon arrival at the sampling site, equipment will be set up and calibrated. If a sampling event requires a field blank, then that sample will be created by passing organic-free water through the centrifuge system and collecting a sample.

## Positioning pump intake

The default starting position where the pump will draw water from the river will be mid-channel at 6/10 of the maximum depth. The absolute depth will be adjusted with changing water levels. The relative position of the pump may be adjusted based on various field measurements designed to identify the location in the water column (horizontal and vertical) which best represents the average suspended sediment loading. The measurements will include: water depth, current velocity, total flow, specific conductivity, and PSD. These parameters will be measured periodically throughout each individual sampling event, according to the schedule in Table 7, using a staff gauge, StreamPro current profiler, conductivity meter, and LISST particle size analyzer, respectively.

Discrete subsamples of river water, centrifuge influent, and centrifuge effluent will also be collected every 3 hours. These samples will usually be composited for analysis of TSS, TOC and DOC.

Table 7. Schedule for typical 24-hour sampling event.

| Type of Measurement or Sample | Sampling Intervals after Start (minutes) | Sample Quantity for TSS | Sample Volume for TOC and DOC | Composite? |
|---|---|---|---|---|
| *Field Measurements* | | | | |
| Water Depth | +60 | -- | NA | NA |
| Current Velocity and Channel Flow | +120 | -- | NA | NA |
| Conductivity[7] | +120 | -- | NA | NA |
| PSD/TSS | +120 | -- | NA | NA |
| *Water Samples* | | | | |
| River (at Pump Intake) | +180 | 125 ml | 16 ml | N & Y |
| Centrifuge Influent | +180 | 125 ml | 16 ml | Y |
| Centrifuge Effluent | +180 | 500 ml | 16 ml | Y |

[7] Once more is known, conductivity may only be sampled when there is a possibility of a salt wedge (i.e. high tide and low flows).

## Collecting suspended sediments

After priming, a pump (Model SP 4, Grundfos Inc.) will draw water from the location that approximates the average loading of suspended sediment. Water will be pumped to 2 flow-through centrifuges (Alfa-Laval Corporate AB, MAB 103B) where suspended sediments will be separated and concentrated. Figure 6 shows one of these centrifuges along with the panel that controls the inflow rate of river water. Retention of suspended sediment will be monitored, but is expected to be >90%. Centrifuged sediment samples will be analyzed, either whole or after splitting the sample into fine-grained and sandy fractions. Water will also be pumped through a 63 µm mesh sieve to collect sands only. Centrifugation and sieving of sands will be nearly continuous except for when TSS, TOC, and DOC samples are taken. Accumulation of suspended sediments will be removed periodically (e.g., every 24 hours) to prevent reduction in retention efficiency.

## Sample identification

Water and centrifuged sediment samples will be identified with a sample number provided by MEL. Ecology will also identify a sample number that includes location (119FB), date (MM/DD/YY), military time, sample type (suspended sediment-SS; water-W), and parameter to be analyzed (AroPCBs): "119FB-06/06/08-22:00-SS-AroPCBs". All labels will identify the person(s) collecting the sample, preservation requirements, and special instructions for analysis.

## Completion of sampling

Sampling will end after field personnel obtain the minimum required mass of suspended sediment (Table 6), and the tidal phase is the same as when sampling began. All sample mass will be stored in appropriate containers on ice, and equipment will be put away after sampling is completed.

At least 20 grams of centrifuged sediment and 10 grams of field-sieved sand from each sampling event will be archived.

Centrifuged suspended sediments will be homogenized with a Teflon-coated stainless steel spatula. Aliquots will be separated for analysis of total solids, TOC, and Aroclor PCBs. The remaining sample mass will be split and analyzed for dioxins/furans in the whole sample, and other priority contaminants in one or two separate size fractions.

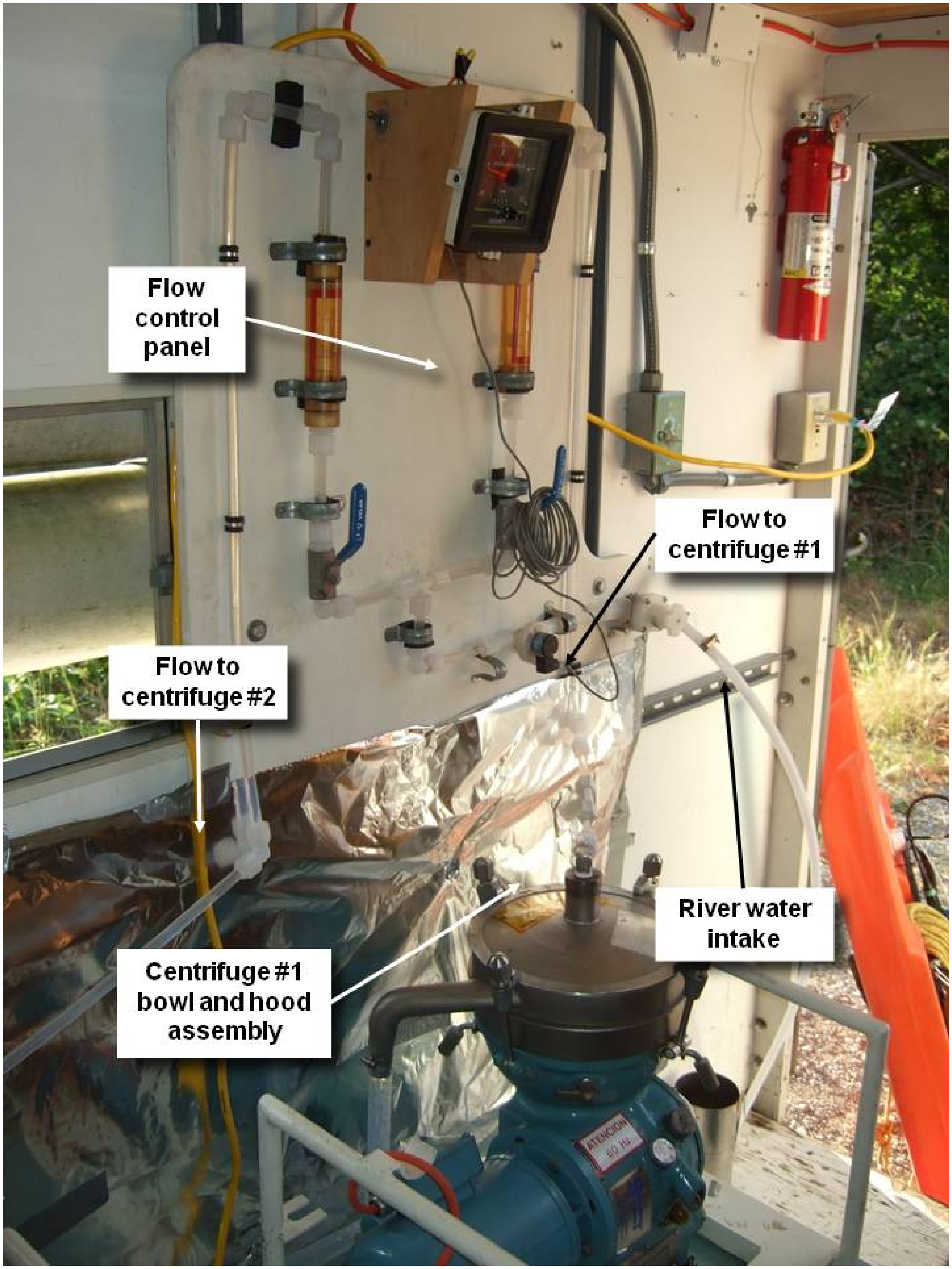


Figure 6. Flow control panel mounted in trailer housing two flow-through centrifuges (one shown).

## Equipment contingencies

All field gear will be cleaned and maintained as needed prior to field sampling events to prevent or minimize failures and delays. Periodic checks of oil levels in the generator and centrifuges will prevent unnecessary strain on vital components.

If a StreamPro ADCP is not available, stage height will be recorded hourly, and flow measurements will be conducted with other available equipment. Backup gear or instruments for most other field equipment will also be available at the sampling site in case of equipment breakage or failure. Examples include:

- Discrete sample conductivity meter (in place of recording conductivity probe).
- Turbidity probe (as surrogate for LISST).
- Extra pump.
- 2 centrifuges.

Generator fuel usage will be monitored during sampling events to prevent unexpected loss of power that could damage centrifuge motors. In the event of loss of power (generator shut down or failure), a new generator will be rented from a local retailer. Alternatively, a direct power source may be installed at the site.

The centrifuge manufacturer (Alfa-Laval, Ltd) will be alerted to upcoming field work so the time required for most of the more common repairs can be minimized.

A field equipment maintenance log will be kept to track measures taken to prevent and correct problems.

## Measurement Procedures

Table 8 shows the expected range of concentrations and desired reporting limits for various parameters to be measured in samples of water and centrifuged sediment. In the case of centrifuged sediments, every attempt will be made to gather more than the minimum mass of sample needed (Table 6) to obtain the desired reporting limits. But centrifuged sediment is an unusual matrix and may present analytical challenges due to high water or TOC content. Centrifuged suspended sediments that have high water content may need to be dried at MEL to levels that produce minimal interference.

Table 8 also cites the methods to be used for preparing water and centrifuged sediment samples for analysis. These are all standard methods commonly used to measure the parameters listed in both water and sediment samples.

Table 8. Parameters, number of samples, and measurement methods for study of contaminant loading associated with suspended sediments.

| Parameter | Number of Samples | Expected Range of Results | Reporting Limits | Sample Preparation Method | Sample Cleanup Methods | Analytical (Instrumental) Method |
|---|---|---|---|---|---|---|
| *Water samples* | | | | | | |
| TSS (mg/l) | 63 | 1.0-50 | 0.25-1.0 | -- | -- | EPA 2540D |
| TOC (mg/l) | 63 | <0.5-10 | 0.5-1.0 | -- | -- | EPA 5310B |
| DOC (mg/l) | 63 | <0.5-5 | 0.5-1.0 | -- | -- | EPA 5310B |
| *Equipment/field blanks (water) for centrifuged sediment samples.* | | | | | | |
| PCBs - Individual congeners (pg/l) | 3 | < RL | 10 | EPA 3535 | EPA 3620<br>EPA 3665 | EPA 1668A |
| Dioxins/furans - Individual congeners (pg/l) | 3 | < RL | 1.0-10 | EPA 1613B | EPA 1613B | EPA 1613B |
| Arsenic (µg/l) | 1 | < RL | 0.1 | EPA 3050B | | EPA 200.8 |
| PAHs (µg/l) | 1 | < RL | 0.5-2.0 | EPA 3510 | EPA 3630 | EPA 8270, SIM |
| *Centrifuged sediment samples* | | | | | | |
| Total solids (% wet wt.) | 18 | 50-90 | 0.1 | -- | -- | PSEP (1986) |
| TOC (% dry wt) | 21 | <0.1-5% | 0.1 | -- | -- | PSEP (1986)<br>EPA 9060 |
| PSD (% of total) | 4 | <1-85 per fraction | 0.1% | -- | -- | PSEP (1986) |
| PCBs - Individual Aroclors (µg/kg dry wt) | 21 | <10-2,000 | 5.0 | EPA 3545 | EPA 3620<br>EPA 3665 | EPA 8082 |
| PCBs - Individual congeners (µg/kg dry wt) | 10 | <10-2,000 | 0.5 | EPA 3545 | EPA 3620<br>EPA 3665 | EPA 1668A |
| Dioxins/furans - Individual congeners (ng/kg dry wt) | 14 | <0.5-~1000 | 1.0-5.0 | EPA 1613B | EPA 1613B | EPA 1613B |
| Arsenic (mg/kg dry wt) | 10 | <50 | 0.1 | EPA 3050B | -- | EPA 200.8 |
| PAHs (µg/kg dry wt) | 4 | 1,000-5,000 | 0.5-2.0 | EPA 3545 | EPA 3630 | EPA 8270, SIM |

# Quality Control Procedures

## Field measurements

A copy of the final QA Project Plan will accompany the principal investigator and field lead to the sampling site for all sampling events. The same staff will be responsible for decisions about any deviations from the QA Project Plan, as well as documenting those decisions.

All field measurement results (conductivity, flow, and PSD by LISST) will be reviewed. Field log books containing additional notes will also be reviewed. These reviews will determine if samples adequately represented river conditions and if MQOs for field measurements are satisfied. Decisions to reject or qualify any sample results will be described in the study report.

Field blank results for water and centrifuged sediment samples will show if equipment cleaning and sampling procedures, sample handling, and laboratory analysis have introduced detectable quantities of each parameter. Elevated blank results will be discussed with the appropriate laboratory staff and may be cause to qualify or reject results.

Field duplicate results for water quality samples will be reviewed as an indication of field variability, but there are no field MQOs. No field replicates of centrifuged sediment will be collected for this study due to limitations of the sampling method.

## Laboratory measurements

Laboratory QC samples for parameters to be measured in water and centrifuged sediment samples are listed in Table 4. Method blanks and laboratory duplicates will be analyzed for conventional parameters in water and (centrifuged) suspended sediment samples, as well as for contaminants in centrifuged sediments. If enough mass of suspended sediments is collected, matrix spiked samples will also be analyzed. In addition, the methods for measuring individual PCB, dioxin, and furan congeners require use of internal standards. These internal standards contain isotopically-labeled analogs of the target compounds and serve much the same function as matrix spiked samples.

Sensitivity of each analysis will be assessed using the reported detection and quantification limits. Precision will be evaluated using results for laboratory duplicates. Accuracy and bias of most results for centrifuged sediment samples will be evaluated using laboratory control samples and samples of the matrix spiked with a known quantity of the parameter.

If sample results exceed control limits, then reasonable corrective actions will be taken by the laboratory. If such actions do not yield acceptable results, the laboratory will discuss the need for additional corrective actions with the principal investigator. Potential corrective actions for the conventionals listed are reanalysis or assignment of appropriate data qualifiers.

Table 9 shows an estimate of the laboratory costs for this study, including a 50% discount for analyses performed by MEL. Equipment or field blanks, prepared using laboratory-supplied water to assess levels of contaminants associated with sampling and sample handling, are listed separately.

Table 9. Laboratory analyses, including estimated unit and total costs.

| Analysis | Laboratory | Sample Number | QC Sample Number | Total Sample Number | Cost/each ($) | Subtotal ($) |
|---|---|---|---|---|---|---|
| Sample containers | MEL | | | | 300 | 300 |
| *Water samples* | | | | | | |
| TSS | MEL | 51 | 12 | 63 | 11 | 693 |
| TOC | | 51 | 12 | 63 | 33 | 2,079 |
| DOC | | 51 | 12 | 63 | 35 | 2,205 |
| *Equipment/field blanks (water) for centrifuged sediment samples* | | | | | | |
| PCB congeners | Contract | | 3 | 3 | 750 | 2,450 |
| Dioxins/furans | | | 3 | 3 | 650 | 1,950 |
| PAHs | MEL | | 1 | 1 | 315 | 315 |
| Arsenic | | | 1 | 1 | 38 | 38 |
| *Centrifuged sediment samples* | | | | | | |
| Percent solids | MEL | 15 | 3 | 18 | 10 | 180 |
| TOC | | 15 | 6 | 21 | 42 | 882 |
| PSD (grain size) | Contract | 3 | 1 | 4 | 90 | 360 |
| PCB Aroclors | MEL | 15 | 6 | 21 | 125 | 2,625 |
| PCB congeners | Contract | 9 | 1 | 10 | 750 | 7,500 |
| Dioxins/furans | | 12 | 2 | 14 | 650 | 9,100 |
| PAHs | MEL | 3 | 1 | 4 | 350 | 1,400 |
| Arsenic | | 9 | 1 | 10 | 40 | 400 |
| Validation of results for PCB congeners, dioxins, and furans | | 4 | -- | 4 | 300 | 1,200 |
| TOTAL | | 206 | 82 | 288 | | 33,677 |

Costs include 50% discount for Manchester Environmental Laboratory (MEL).

## Data Management Procedures

Field notes will be taken during all sampling activities. Notes will include date, time, meteorological observations, position at time of sampling, and water depth. These will be recorded using a form similar to the one provided in Appendix B.

Laboratory results for all water, centrifuged sediment, and QC samples will be submitted to the principal investigator as follows:

- MEL will submit a printed report (with a QA summary) presenting all results for TSS, TOC, and DOC in water samples. A similar report will be submitted that presents results for total solids, TOC, Aroclor PCBs, and QA samples. Output from MEL's Laboratory Information Management System will also be submitted electronically for transfer into Ecology's EIM database.
- Contract laboratory deliverables will include all test and QA sample results for total solids, PSD, PCB congeners, dioxins, and furans. Printed deliverables will include case narratives, tables of analytical results for environmental samples and QC samples, and bench sheets. All analytical results will also be provided as an electronic deliverable in EIM format.

All sediment quality data generated for this project will be evaluated relative to the MQOs listed in Tables 1 and 2. Acceptable results will be used to prepare the final report, entered into Ecology's EIM database, and made available to the public via Ecology's web site.

## Data Verification and Validation

MEL and contract laboratories will review results for all field and QC samples that they analyze. Reviews will be sent to the principal investigator as case narratives. The narrative will include comparisons of QC sample results to method acceptance criteria for all blanks, laboratory replicates, laboratory control samples or standard reference materials, and surrogate and spiked samples, as appropriate. Instrument performance (initial and continuing calibrations) will also be reviewed. All qualifier codes assigned to results will be clearly defined by the laboratory of origin.

The principal investigator will also review all data packages to determine whether procedures in the QA Project Plan, methods, and SOPs were followed. QC sample results will be reviewed for precision, bias, and accuracy.

Precision will be assessed by calculating or confirming the relative percent differences or relative standard deviations associated with field and laboratory replicates. Analytical bias will be revealed by % recoveries associated with laboratory control and surrogate spike samples. Recoveries consistently greater than or less than 100% will show high or low bias, respectively. A wide range of percent recoveries will indicate data of questionable accuracy, but not biased in a particular direction. Matrix spike recoveries will indicate bias due to matrix effects. Accuracy of measurements will be evaluated using results for certified or standard reference materials.

In addition to the data verification procedures described above, MEL will fully validate the results for levels of dioxins and furans measured in 10% of the centrifuged sediment samples.

## Data Quality (usability) Assessment

The principal investigator will:

- Review records of field sampling and sample handling procedures to identify potential sources of bias.
- Evaluate data quality to determine if project objectives have been satisfied.

The latter will be done by means of thorough review, using this project plan, of all field sample and QC sample results. Ecology chemists and other experts may be consulted. All field and laboratory data will also be reviewed to identify and record all sources of bias.

Completeness will be determined by the following comparisons:

- Number of samples collected versus number listed in this QA Project Plan.
- Number of samples accepted by MEL and contract laboratories in good condition.
- Ability of MEL and contract laboratories to produce usable results for each sample.
- Acceptability of sample results to the principal investigator.

## Audits and Reports

The principal investigator will:

- Assess field sampling procedures to ensure consistency with this plan and note any procedural modifications.
- Review field notes for quality of the field data.
- Discuss any apparent problems with laboratory results with chemists at MEL or contract laboratories.
- Prepare a draft data report with help from other EAP staff. The report will undergo both internal and external review and be completed by June 2009. The report will include:
  - A map of the study area showing sampling areas.
  - Descriptions of field and laboratory methods.
  - Sample information including levels of contaminants in centrifuged suspended sediments.
  - Tables listing levels of conventionals and contaminants in surface water, centrifuge influent, and centrifuge effluent concentrations and variability.
  - Description of data quality, significant analytical problems, and data usability.
  - Summary tables of field and laboratory results.
  - An estimate of contaminant loading associated with suspended sediments.
  - Results for levels of contaminants associated with different size ranges of suspended sediment particles.

- Comparison of results to similar studies.
- An uncertainty analysis.
- Appendices that include field notes, laboratory case narratives, raw data, and other detailed analytical results.

Comparisons with previous analytical results will consider estimates of accuracy, precision, and bias in historic results.

Project data will be entered in Ecology's Environmental Information Management (EIM) database prior to completion of the final report.

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# Appendix A.  Collecting Suspended Sediment Using Flow-Through Centrifuges

**Preparing for field work**

- All equipment surfaces that will contact river water or centrifuged sediment will be cleaned appropriately (Ecology, 2006, 2008) to remove metals and organic residue:
  - Wash with phosphorus free soap (e.g., Luminox).
  - Rinse with a large volume of tap water.
  - Rinse with 10% nitric acid.
  - Rinse with deionized/distilled water and let dry.
  - Rinse with acetone and let air dry.
  - Rinse with hexane and let air dry.
  - Cover with foil.
- Replace consumables that have been used.
- Complete any maintenance or repairs.
- Assemble checklists and field logs (examples in Appendix B).
- Label containers.
- Assemble field gear needed (from checklists).
- Complete field itinerary.

**Set-up and pre-sampling**

- Arrive at the sampling site and position centrifuge trailer so that:
  - It does not obstruct the road or bridge traffic.
  - Personnel have adequate access to the interior as well as exterior storage compartments.
  - It is easy to set up for pump sampling.
  - It is reasonably level.
- Set up centrifuge according to procedures described in operations manual (Seiders, 1990).
- Prepare tubing, attach pumps, prepare fish for deployment, and calibrate equipment.
- Start centrifuges and recycle approximately 10L of organic free water through the entire system, including all sample tubing, for 30 minutes.
- Fill a 1L glass jar with water from the effluent (field blank).
- Profile the stream with the conductivity meter, especially near the streambed, to determine presence and extent of salt wedge.
- Profile the stream with the StreamPro according to the SOP to obtain flow and depth characteristics (minimum 4 passes).
- Use LISST or turbidity meter (as surrogate) to map horizontal and vertical variability in profile of PSD in suspended sediments.

- Use the depth, flow, and particle size distribution/turbidity information to estimate most representative location(s) to place centrifuge intake tube. The default location will be center channel and 0.6 times the maximum depth of the freshwater layer.
- Set up tubing and pumps for sampling.
- Turn on pumps and recycle water back to the river for 10 minutes to flush the tubing, establish a constant flow, remove any bubbles in the tubing, and monitor for leaks.

**Sampling**

- After pumps are ready, attach tubing to the centrifuge apparatus and record start time, tide phase, predicted tide height, stage height, centrifuge status, intake tube location, hertz, pump speed, and water flow (Appendix B).
- Start pumping to collect sandy suspended sediment on sieve by connecting the tubing and recording start time, tide phase, predicted tide height, stage height, fish location, pump speed, and water flow (Appendix B).
- Monitor centrifuges for at least 20 minutes: influent, effluent, check for leaks, adjust flows, intake tube position, and overall operation.
- Collect samples of TSS in river water, centrifuge influent, and centrifuge effluent at designated times (Table 3). Samples will be a combination of discrete and composite samples. Replicate and blank samples will also be taken.
    - Effluent water samples will be taken from a compositor located in the collection basin (Figure 5b), while centrifuges are running.
    - Influent water samples will be taken by disconnecting the tubing just before the water enters each centrifuge (Figure 5a). These 2 water samples will be combined into 1 influent sample. The LISST Streamside will be used to measure influent PSD at the same time.
    - After reconnecting tubing to centrifuges, PSD will be measured in the river near the intake tube (Figure 5c).
- Measure flow, conductivity, and PSD at designated time intervals (Table 3).
- Record site conditions, weather, boat traffic, equipment performance, and any other important information in the log.
- Record changes in position of intake tube on centrifuge sample sheet and sand sample sheet including: tide phase, predicted tide height, stage height, fish location, pump speed, water flow, and reason for relocation in the comments/notes column.
- Stop centrifuges and remove accumulation of suspended sediments using a Teflon spatula when substantial accumulation is predicted based on pumping rates and TSS. (Accumulated pellet will be removed to prevent it from contacting the discs in the bowl and decreasing retention efficiency). Place material in a pre-cleaned glass jar and seal. Put jar in cooler with ice. Record centrifuge data; stop time, elapsed time, tide phase, predicted tide height, stage height, and total gallons pumped and sample data; collection time, MEL ID, sample ID, estimated amount of sample, and sample information.
- Restart centrifuges to continue collecting suspended sediment, recording the appropriate data.

- Remove sand-sized sediments from sieves when accumulation starts to restrict flow. Place sample in a pre-cleaned glass jar and put in cooler with ice. Record sieve data; stop time, elapsed time, tide phase, predicted tide height, stage height, and estimated total gallons pumped and sample data; collection time, MEL ID, sample ID, estimated amount of sample, and sample information.
- Restart sieve apparatus to continue collecting sand-sized suspended sediments, recording the appropriate data.

**Post-sampling**

- When sampling is complete, stop centrifuges and pumps. Remove all accumulated sediments from the centrifuge and sieves following the same procedures as removing accumulated sediments above.
- Take post sampling flow and PSD measurements.
- Disassemble all equipment.
- Return to Operations Center and Headquarters in Lacey.

**Sample processing**

- Homogenize the centrifuge pellet using a stainless steel spatula.
- Split sample for analysis of TOC and Aroclor PCBs.
- Decide, with laboratory staff input, which other contaminants to measure with remaining sample mass.
- If a split is designated to be sieved:
  - Weigh split sample.
  - Place small amounts of sample in #230 sieve and gently rinse through with water collected from the centrifuge bowl, continue placing small amounts on the sieve and washing until entire sample is sieved. It is very important to minimize use of rinse water.
  - Remove sandy suspended sediments from the sieve, weigh them, and place in pre-cleaned sample jar. If needed, sandy sample will be sent to MEL for passive removal of the water before analysis and a dry weight recorded.
  - Remove fine-grained suspended sediments from container and place in pre-cleaned sample jar. Fines will be sent to MEL for passive removal of the water before analysis and a dry weight recorded.
- Send samples to appropriate laboratories, using chain-of-custody procedures.

# Appendix B.  Example Field Logs

## Contaminant loading from suspended sediments

Below are sample data sheets for the centrifuge portion of the project.  In addition to these data sheets, a daily log will be kept that details other aspects of sampling such as equipment maintenance, gas usage by the generator,  functioning of the equipment, weather conditions, flow from both the dam and Auburn USGS stations, and any other comments that are pertinent to the success of the project or interpretation of the data.

**ADCP FLOW** **Location:**

| **Date** | **Time** | | **Flow (Total Q)** | | | | | | | **Comments/ Notes** |
|---|---|---|---|---|---|---|---|---|---|---|
| Year:_____ | Start | Stop | 1 | 2 | 3 | 4 | 5 | Mean | Delta Q % Range | |
| MM/DD | Military | Military | cfs | cfs | Cfs | cfs | cfs | cfs | ___-___% | |
| ____/____ | ____:____ | ____:____ | | | | | | | | |
| ____/____ | ____:____ | ____:____ | | | | | | | | |
| ____/____ | ____:____ | ____:____ | | | | | | | | |

**CENTRIFUGE SHEET**
**START/STOP, FLOW, LOCATION** **Location:**

| Date | Time | | | Tide | | | Centrifuge | Fish Location | | Hertz | Pump | Water Flow | | | Comments/ Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year:__ | Start | Stop | Elapsed Time | Time Tide Phase | Pred. Tide Height | Stage Height | Status | Distance From Left Bank | Depth Below Surface | | Speed | Instant 712 | Instant 713 | Total | |
| MM/DD | Military | Military | Hours | HH/HL LL/LH | Feet | Feet | Circle One | Feet | Feet | Hz | 0-100% | Gal/Min. | Gal/Min. | Gal. | |
| __/__ | __:__ | __:___ | | | | | ON OFF | | | | | | | | |
| __/__ | __:__ | __:__ | | | | | ON OFF | | | | | | | | |
| __/__ | __:__ | __:__ | | | | | ON OFF | | | | | | | | |

**FIELD SIEVING OF SANDS** **Location:**

| Date | Time | | | Tide | | | Fish Location | | Pump | Water Flow | | Comments/ Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year:_____ | Start | Stop | Elapsed Time | Time Tide Phase | Pred. Tide Height | Stage Height | Distance From Left Bank | Depth Below Surface | Speed | Measured | Subtotal (Flow Rate X Time) | |
| MM/DD | Military | Military | Hours | HH/HL LL/LH | Feet | Feet | Feet | Feet | 0-100% | Gal/Min. | Gal. | |
| ____/____ | ____:____ | ____:____ | | | | | | | | | | |
| ____/____ | ____:____ | ____:____ | | | | | | | | | | |
| ____/____ | ____:____ | ____:____ | | | | | | | | | | |

**SAMPLE SHEET, CENTRIFUGE WATER** **Location:**

| Date | Time | | Sample | | | | | | | | Comments/ Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Year:_____ | Start | Stop | MEL ID | Sample ID | Influent, Effluent, or Blank | Volume | Discrete or Composite? | Composite Sample # | TSS | | |
| MM/DD | Military | Military | # | # | circle one | ml | D or C | # of # | mg/l | | |
| ____/____ | ___:____ | ___:___ | | | IN EF BL | | D C | | | | |
| ____/____ | ___:____ | ___:___ | | | IN EF BL | | D C | | | | |
| ____/____ | ___:____ | ___:___ | | | IN EF BL | | D C | | | | |

**SAMPLE SHEET, RIVER WATER** **Location:**

| Date | Time | | Location | | Sample | | | | | | Comments/ Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Year:_____ | Start | Stop | Distance From Left Bank | Depth Below Surface | MEL ID | Sample ID | Type of Sample | Volume | Discrete or Composite? | Composite Sample # | |
| MM/DD | Military | Military | Feet | Feet | # | # | | ml | D or C | # of # | |
| ____/____ | ___:__ | __:__ | | | | | | | D C | | |
| ____/____ | ___:__ | __:__ | | | | | | | D C | | |
| ____/____ | ___:__ | __:__ | | | | | | | D C | | |

**CENTRIFUGE SHEET**

**PELLET SAMPLE** **Location:**

| Date | Collection Time | | MEL ID | Sample ID | Amount of Sample | | Sample Information | Comments/ Notes |
|---|---|---|---|---|---|---|---|---|
| Year:_____ | Start | Stop | | | ~Volume | ~Wet Weight | Composited? | |
| MM/DD | Military | Military | # | # | ml | g | Circle One | |
| ____/____ | ____:____ | ____:____ | | | | | YES NO | |
| ____/____ | ____:____ | ____:____ | | | | | YES NO | |
| ____/____ | ____:____ | ____:____ | | | | | YES NO | |

**SAND SAMPLE** **Location:**

| Date | Collection Time | | MEL ID | Sample ID | Amount of Sample | | Sample Information | Comments/ Notes |
|---|---|---|---|---|---|---|---|---|
| Year:_____ | Start | Stop | | | ~Volume | ~Wet Weight | Composited? | |
| MM/DD | Military | Military | # | # | ml | g | Circle One | |
| ____/____ | ____:____ | ____:____ | | | | | YES NO | |
| ____/____ | ____:____ | ____:____ | | | | | YES NO | |
| ____/____ | ____:____ | ____:____ | | | | | YES NO | |

**SAMPLE LOG** **Location:**

| Date | MEL ID | Sample ID | Amount of Sample | | Sample Information | Needs to be Split | Parameter to be Tested | Comments/ Notes |
|---|---|---|---|---|---|---|---|---|
| Year:_____ | | | ~Volume | ~Wet Weight | Composited? | | | |
| MM/DD | # | # | ml | g | Circle One | Circle One | | |
| ____/____ | | | | | YES NO | YES NO | | |
| ____/____ | | | | | YES NO | YES NO | | |
| ____/____ | | | | | YES NO | YES NO | | |

# Appendix C. Health and Safety Plan

## Contaminant loading from suspended sediments

### Health and safety site plan/checklist

Name of Ecology staff: Tom Gries, Janice Sloan

Training requirements for this project: CPR and First Aid, familiarity with the EAP Safety Plan, familiarity with the Chemical Hygiene Plan

Medical monitoring requirements: None

Date(s): Varies June 2008-Feburary 2009 Arrival time: Varies
Total anticipated time on site: 9-12 sampling events, 324 - 432 hours

Site name(s): 119th Street footbridge or East Marginal Way Bridge
Site location: Tukwila, WA
Nearest city: Tukwila, WA
Nearest hospital: Highline Medical Center - 12844 Military Rd S, Tukwila, WA
Emergency numbers Statewide - 911 Hospital: (206) 246-1689 Ambulance

Name of contractor (if on site):

Is the site currently active? Yes___ No_X_ Will the buddy system be used? Yes_X_ No___

Site description:
Side of road, river bank, and footbridge over the Green River (Figure 2).

Scope/objective of work:
Pump water from the Green River to collect suspended sediments that will be analyzed for various contaminants. Results, with ancillary field measurements, will be used to estimate contaminant loading associated with suspended sediments.

Known contaminants on site: Low concentrations of trace metals and organics
Routes of chemical exposure: Inhalation___X___ Dermal_____X__ No exposure
Overall risk of chemical exposure: Serious____ Moderate_____ Low__X__ Unknown____
Physical hazards: Confined space___X__ Noise___X__ Heat/cold stress___X__
Describe any area on site that could function as a confined/enclosed space: Centrifuge trailer front compartments
Was air monitoring conducted? Yes___ No_X_
Personal protection level required A___ B___ C___ D_X_
Personal protective equipment required: boots, foul weather gear, orange safety vest, eye protection, gloves, PFD
Overall risk of physical hazards: Serious_____ Moderate_____ Low__X__ Unknown______

Expected parameters/contaminants to be sampled: Suspended particulate organics and trace metal, surface water carbon content and total suspended solids
Sampling matrix: Air______ Surface water___X__ Groundwater______ Soil______
Sediment___X___ Containers_______________ Other_____________________________

# Appendix D. Selection of Site for Sampling Suspended Sediments

Table D-1. Site selection criteria.

| Name | Boeing | So. 102nd Street | Rapids | Tukwila Internat'l Blvd. | East Marginal Way | 119th Street So. | Riverside Casino Access Point | Fort Dent | Fort Dent | Parallel to Interurban Ave. |
|---|---|---|---|---|---|---|---|---|---|---|
| Car or foot bridge | Foot | Car/ sidewalk | Foot | Car/ sidewalk | Car/ sidewalk | Foot | None | Foot | Car | Foot |
| River mile | 5.6 | 5.8 | 6.5 | 6.8 | 7.1 | 7.6 | 10.7 | 11.2 | 11.9 | 12.4 |
| Distance to trailer from water | Fairly close | Fairly close | Fairy close | Some distance | Some distance | Very close | Very close | Fairly close | Somewhat distant | Somewhat distant |
| Vertical distance to trailer location | Small-Medium | Small-Medium | Small-Medium | Large | Large | Small-Medium | Small | Small | Small-Medium | Small-Medium |
| Area land use | Industrial | Industrial | Industrial-Recreation | Urban | Urban-Business | Residential | Business-Recreation | Industrial-Recreation | Recreation | Recreation-Business |
| Staff risk | Low | Medium | Low | High | High | Low | Low | Low | Low-Medium | Low |
| Distance to location from upstream bend (miles) | 0.35 | 0.21 | 0.06 | 0.62 | 0.32 | 0.45 | 0.2 | 0.11 | 0.07 | 0.08 |
| Stream width | 0.0599 | 0.0428 | 0.0264 | 0.0289 | 0.0284 | 0.0296 | 0.0243 | 0.0232 | 0.0158 | 0.0203 |
| Salt water intrusion | More Frequent | More Frequent | Moderately Frequent | Less Frequent | Less Frequent | Less Frequent | Little to none | Little to none | Little to none | Little to none |
| Outfalls/inputs | Lots, Norfolk, large | Lots, Norfolk, large | Large outfalls & a small stream | One fairly large one just upstream | One or two smaller ones | None Visible | None Visible | Black River | -- | -- |
| Notes | Very secure, very near sediment cleanup site | Very secure, very near sediment cleanup site | Easy access, exposed rapids | Parking distant, possibly dangerous work site | Bridge possibly dangerous to work from | Bridge close to middle of very straight reach | Good proximity to river, no bridge for sampling platform | Just upstream of Black River confluence | -- | Small business parking lot may not be available |

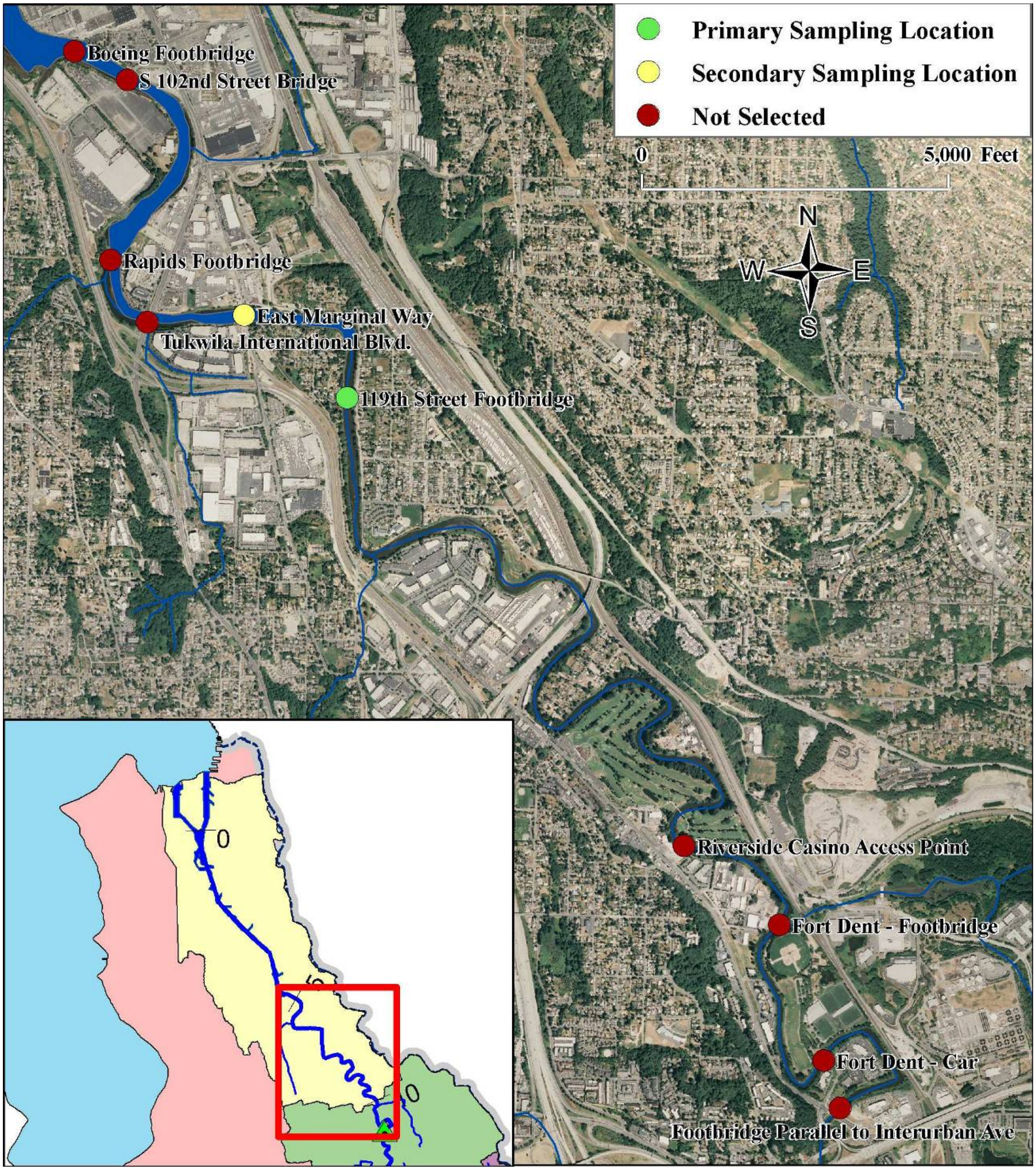


Figure D-1. Site selection: candidate flow measurement and suspended sediment (centrifuge) sampling locations.