Control of Toxic Chemicals in Puget Sound

Characterization of Toxic Chemicals in Puget Sound and Major Tributaries, 2009-10

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Control of Toxic Chemicals in Puget Sound

Characterization of Toxic Chemicals in Puget Sound and Major Tributaries, 2009-10

by

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Abstract

The Washington State Department of Ecology (Ecology) is conducting a series of technical studies that will inform strategies to control sources of toxic chemicals to Puget Sound. The studies come under the umbrella of the Puget Sound Toxics Loading Analysis (PSTLA). Phases 1 and 2 of the PSTLA developed loading estimates for toxic chemicals and used computer model simulations to predict outcomes of control actions. Ongoing Phase 3 studies are intended to reduce uncertainties associated with chemical loadings and model predictions.

For the present study, Ecology collected seasonal water samples at seven ambient marine sites throughout Puget Sound and its ocean boundary waters, and from the mouths of the five largest rivers flowing into Puget Sound. Samples were analyzed for a wide range of inorganic and organic chemicals of concern.

Many chemicals were seldom or never detected in marine water samples, but concentrations of metals and polychlorinated biphenyls (PCBs) were similar to previously reported values. Concentrations of organic carbon, copper, and PCBs were higher in outgoing Puget Sound waters than in incoming ocean waters. The opposite was true for cadmium. Ocean exchange estimates indicated that most target chemicals of concern appear to be exported from Puget Sound to the ocean.

River water samples contained measurable concentrations of conventional parameters, nutrients, metals, and some organic compounds. Concentrations were generally within ranges previously reported. Petroleum-related compounds, semivolatile organic compounds (BNAs), polycyclic aromatic hydrocarbons (PAHs), and chlorinated pesticides were seldom detected. Daily loads calculated for many chemicals can be compared to estimated loads from other studies and model simulations.

Suspended particulate matter (SPM) was also collected from deep marine waters and river waters, and samples were analyzed for a suite of chemicals similar to those analyzed for water samples. Results from the Hood Canal and South Puget Sound basins were used to estimate loss rates of toxic chemicals from the water column via sedimentation. Toxic chemicals such as PAHs were more often detected in river SPM than in river water.

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Executive Summary

Introduction

The Washington State Department of Ecology (Ecology) is working in collaboration with the Puget Sound Partnership and other state and federal agencies on a multi-phase Puget Sound Toxics Loading Analysis (PSTLA). The purpose of the PSTLA is to quantify various sources of toxic contaminants entering Puget Sound and to better understand the behavior and fate of the contaminants within the ecosystem. Results of the PSTLA will form part of the technical basis for a comprehensive strategy to reduce and control toxic chemical releases to Puget Sound.

In Phase 1 of the PSTLA, existing data were used to estimate loadings of toxic chemicals released to Puget Sound via surface runoff, atmospheric deposition, permitted wastewater discharges, combined sewer overflows, and direct spills (Hart Crowser et al., 2007). Phase 2 of the analysis refined land-use classifications and roadway loadings to improve toxic chemical loading estimates for the entire Puget Sound basin (EnviroVision et al., 2008). Overall estimates of surface runoff loading were later recalculated (Herrera, 2010a).

Ecology expanded numerical modeling begun in Phase 2 to provide insights into the relative importance of various loading pathways. The resulting Puget Sound Toxics Box Model (Pelletier and Mohamedali, 2009) allowed managers to investigate the response of contaminant concentrations in the water, sediment, and biota of Puget Sound to various source-control strategies. Initial modeling exercises were performed for polychlorinated biphenyls (PCBs) due to the relative abundance of existing PCB data. Future modeling efforts will examine fate and transport of other toxic contaminants, including polybrominated diphenyl ethers (PBDEs).

Data Gaps

A review of readily available data collected since 1995 on selected toxic chemicals in Puget Sound and the Straits of Juan de Fuca and Georgia (Serdar, 2008) identified significant gaps and limitations in the existing data. With few exceptions, the available data were deemed inadequate for providing representative concentrations for Box Model input and analyses. Phase 2 simulations using the Box Model also indicated more data would improve the accuracy of predictions. The greatest sources of uncertainty for Box Model predictions were:

- Limited data from which to choose input values representing toxic chemical loading from surface runoff.
- Limited data on concentrations of toxic chemicals likely to be exchanged between Puget Sound and ocean boundary waters [1] (*ocean exchange*).

The authors of the modeling study recommended that Phase 3 studies should fill these data gaps and thereby address uncertainties.

[1] For purposes of this study, ocean boundary waters are defined as the sampling locations in the Straits of Juan de Fuca and Georgia that, although they do not reflect true oceanic waters, represent conditions at the ocean boundary used in the Box Model (external to Puget Sound proper).

Study Purpose

The present 2009-10 study was designed to collect data that would improve input values to the Puget Sound Toxics Box Model, thereby reducing uncertainty in model predictions. These data could also be used to calibrate the model. Specific objectives of the study were:

- Measure concentrations of target toxic chemicals and other water quality parameters in samples representing ocean boundary waters likely to enter and marine waters likely to exit the modeled portion of Puget Sound.
    - Whole water samples collected from the deep layer near the main ocean boundary (Strait of Juan de Fuca and Haro Strait).
    - Whole water samples collected from the surface layer of the four primary Puget Sound basins (Whidbey, Main, Hood Canal, and South Sound).
- Measure concentrations of target toxic chemicals and other water quality parameters in the five rivers having the greatest annual discharges to Puget Sound (Skagit, Snohomish, Nooksack, Stillaguamish, and Puyallup).
- Identify sources of variability in concentrations of target toxic chemicals and other water quality parameters.
- Determine concentrations of toxic chemicals associated with suspended particulate matter (SPM) in marine and river waters.

Study Findings

Marine Water and SPM

Major findings from the marine sampling portion of the 2009-10 study include:

- Suspended solids, organic carbon, metals, PCBs, and PBDEs in samples collected from the surface and deep layers of the marine water column were routinely detected but consistently low. Semivolatile organic compounds (BNAs) and chlorinated pesticides were rarely detected and polycyclic aromatic hydrocarbons (PAHs) were never detected in marine water samples.
- The range of total PCB concentrations measured for ambient marine waters was 6.1-75 pg/L (mean = 26.3 pg/L). The mean concentration in ocean boundary waters (20.4 pg/L) was significantly less than the mean for Puget Sound marine waters (30.7 pg/L). Both values were lower than the mean concentration previously reported for the Strait of Georgia (42 pg/l; Dangerfield et al., 2007).
- Total PCB concentrations in the deep marine waters were significantly higher than those in the surface waters. This was true for the ocean boundary waters and Puget Sound (Figure ES-1). A significant positive relationship between total PCBs and total suspended solids (TSS) suggested that sedimentation plays a key role in the fate of PCBs in the Sound.

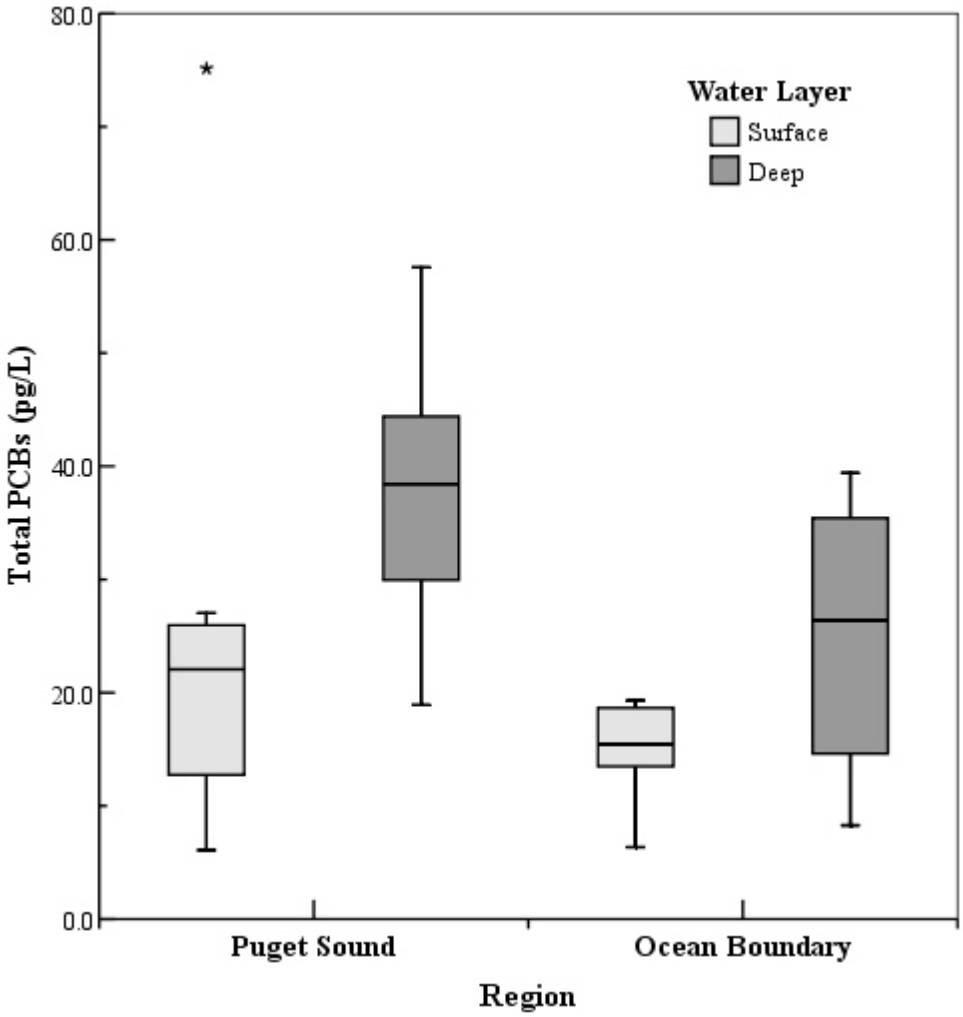

Figure ES-1. Total PCB concentrations in surface and deep marine waters.

- The range of detected total PBDE concentrations in marine waters (51 - 18,700 pg/L) was much wider than the range of total PCB concentrations. Total PBDEs concentrations were often 10 times higher in the present study than concentrations reported by Canadian researchers (Dangerfield et al., 2007). No evidence suggested the higher concentrations were due to sample contamination. Sources of high PBDE concentrations were not identified.
- Organic carbon concentrations in marine water samples resembled concentrations previously reported for the Strait of Georgia (Johannessen et al., 2008), but were substantially lower than marine water concentration records in Ecology's EIM database.
- Calculations of chemical exchange between Puget Sound and ocean waters, based on present study results, indicated most toxic chemicals are probably being exported out of Puget Sound. A notable exception was cadmium, which appeared to be imported into Puget Sound. This was due to incoming ocean waters having significantly higher concentrations than surface waters flowing out of the Sound to the ocean. The direction of net exchange for total PCBs and total PBDEs between the ocean and Puget Sound could not be estimated from the data collected.

- Samples of SPM collected from sediment traps deployed in Hood Canal and South Puget Sound (Case+Carr Inlets) contained similar concentrations of organic carbon, metals, and PBDEs. PCB concentrations in Case+Carr Inlet SPM were more than three times greater than those in Hood Canal.

River Water and SPM

Major findings from the river sampling portion of the study include:

- Concentrations of total suspended solids (TSS), organic carbon, nutrients, hardness, and metals were within the ranges reported from previous studies by Ecology and other monitoring programs (Inkpen and Embry, 1998; Wise et al., 2007).
- River water samples seldom contained detectable concentrations of petroleum-related compounds (oil and grease, TPH-D, and TPH-G), BNAs, PAHs, or chlorinated pesticides. River SPM collected by centrifugation in December 2009 and January 2010 contained detectable concentrations of many individual PAH compounds.
- The average concentration of total PCBs measured in surface water from the five rivers was 16.3 pg/L. The range of concentrations measured was 2.6 - 59 pg/L. This range is somewhat lower than the range reported by King County for the Green/Duwamish Rivers (83 - 814 pg/L; Willston, 2009) that flow through a more urban and industrial watershed.
- PBDEs were detected in less than half of the river water samples. Total PBDE concentrations were highly variable ranging from 10.9 - 265 pg/L, with an average of 55.6 pg/L.
- Total PAH concentrations in SPM (excluding retene) ranged from 32 - 210 µg/Kg, with an average of 120 µg/Kg. Concentrations of individual PAHs were <20 µg/Kg, except for retene which averaged 230 µg/Kg.
- Few other organic compounds (BNAs, TPH-D, chlorinated pesticides) were detected in SPM.
- Estimated daily loading of total PCBs from all five rivers ranged from 0.015 - 0.57 g/day.
- Estimated daily loading of total PBDEs from all five rivers ranged from 0.017 - 4.22 g/day.

Notable relationships between parameters include the following:

- TSS concentrations were significantly correlated with, and explained between 63% and 86% of the variability in, concentrations of total phosphorus and total metals.
- Organic carbon, total nitrogen, and nitrate+nitrite concentrations were significantly lower during July than during the other two sampling periods.
- Congeners belonging to the more polar PCB homolog groups (those with fewer chlorine atoms) were significantly correlated with many parameters in the dissolved phase (ortho-phosphate and dissolved metals). Congeners in the more hydrophobic PCB homologs (those with more chlorine atoms) were significantly correlated with TSS, total organic carbon (TOC), and parameters often found in particulate form (total nitrogen and total phosphorus).

Recommendations

Based on the findings of the present study, the following recommendations are made:

- Future sampling should focus on the collection and analysis of particulate samples to improve the detection frequency of hydrophobic compounds.
- More intensive water column sampling should be conducted near the ocean boundaries to Puget Sound proper (Admiralty Inlet sill and Deception Pass). Samples should be analyzed for a reduced suite of chemicals, with priority given to chemicals exhibiting high variability in the present study (e.g., PBDEs). This would improve current estimates of ocean exchange.
- Depth-integrated water sampling of large rivers should be conducted with focus on increased sampling frequency, a reduced suite of chemicals, and improved detection limits for organic contaminants. More frequent sampling during all phases of runoff-related events is needed to understand seasonal and other temporal patterns. This would facilitate a better characterization of loading during baseflow conditions and runoff-related events.
- Standard operating procedures (SOPs) for the collection and analysis of seawater samples for dissolved (DOC) and particulate organic carbon (POC) should be revised. For example, all equipment used for sample collection and processing should be made exclusively of glass or lined with Teflon.

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Introduction

Puget Sound Toxics Loading Analysis

The State of Washington enacted legislation in 2007 to protect and restore the Puget Sound ecosystem by 2020. The Puget Sound Partnership, while developing the Puget Sound Action Agenda, identified the control of toxic chemical releases as a high priority.

To inform a comprehensive strategy to reduce and control toxic releases, the Washington State Department of Ecology (Ecology) and others [2] undertook a multi-year Puget Sound Toxics Loading Analysis (PSTLA). The PSTLA was intended to quantify various sources of toxic contaminants entering Puget Sound and to better understand the behavior and fate of the contaminants within the ecosystem. Results of the PSTLA will form the technical basis for a toxics control strategy.

Phase 1 of the PSTLA used existing data to estimate loadings of toxic chemicals to Puget Sound via surface runoff, atmospheric deposition, permitted wastewater discharges, combined sewer overflows, and direct spills (Hart Crowser et al., 2007). Phase 2 improved watershed loading estimates for the entire Puget Sound basin by using revised land-use classifications and incorporating roadway loadings (EnviroVision et al., 2008; Herrera, 2010a). Modeling efforts were also expanded to provide insights about the relative importance of various loading pathways. The resulting Puget Sound Toxics Box Model [3] (Pelletier and Mohamedali, 2009) was composed of three parts:

1. Water circulation and transport box model (Appendix B, Figure B-1).
2. Contaminant fate and transport mass balance model.
3. Food web transfer bioaccumulation model.

The Box Model was initially used to predict how concentrations of polychlorinated biphenyls (PCBs) in the water, sediment, and biota of Puget Sound might respond to various source-control strategies. In doing so, the model identified substantial uncertainties and data gaps.

Data Gaps and Recommended Actions

The greatest source of uncertainty about Box Model predictions was the input values used to represent toxic chemical loading to Puget Sound from surface runoff (river loading). Another major source of uncertainty was the limited information available on concentrations and loads of toxic chemicals exchanged between the ocean and Puget Sound (Serdar, 2008). The authors of the modeling study recommended Phase 3 investigations to address these uncertainties. These included the following targeted efforts:

[2] The Puget Sound Partnership, U.S. Environmental Protection Agency (EPA), and other federal, state, and local agencies.

[3] Hereafter, this report often refers to the Puget Sound Toxics Box Model simply as the Box Model.

- **Major tributaries.** Estimates of toxic chemical loadings from surface runoff should be improved by monitoring concentrations of toxic chemicals in rivers, streams, and discharges from publically-owned water treatment facilities (POTWs), especially in relation to land uses and flow regimes (baseflow or storm runoff).
- **Ocean boundary waters.** Estimates of toxic chemicals transported from ocean boundary waters into Puget Sound should be improved because they may:
  - Be similar in magnitude to toxics loadings from major land uses in Puget Sound watersheds.
  - Influence concentrations of toxics observed in Puget Sound and its biota.
- **Puget Sound water column.** Toxic chemical concentrations in major Puget Sound basins, and how they partition between suspended particulate matter (SPM) and water (dissolved), should be measured because they are important determinants of biological uptake.

Goals and Objectives

The principal goal of the present 2009-10 study was to provide concentration data for various toxic chemicals that could be used to address these data gaps. Specific objectives listed in the Quality Assurance (QA) Project Plan (Coots and Osterberg, 2009) included:

- Collect samples representing seawater entering and leaving the modeled portion of Puget Sound, especially:
  - Samples collected from the deep layer of ocean boundary waters (Strait of Juan de Fuca and Haro Strait) [4].
  - Samples collected from the surface layer of four Puget Sound basins (Main, Whidbey, South Sound, and Hood Canal) [5].
- Measure concentrations of the following parameters in seawater samples collected from above *and* below any density gradient (pycnocline) in ocean boundary waters and the four major Puget Sound basins:
  - Total suspended solids (TSS).
  - Total and dissolved organic carbon (TOC and DOC).
  - Total and dissolved fractions of five metals (arsenic, cadmium, copper, lead, and zinc).
  - Semivolatile organic compounds (BNAs).
  - Polycyclic aromatic hydrocarbons (PAHs).
  - Chlorinated pesticides.
  - Polychlorinated biphenyl (PCB) and polybrominated diphenyl ether (PBDE) congeners.

[4] Samples collected from the western end of the Strait of Juan de Fuca would be less representative of seawater entering Puget Sound.

[5] Samples collected from surface layer waters of the Straits of Juan de Fuca and Georgia could include toxic chemicals originating outside of Puget Sound and therefore be less representative of leaving Puget Sound.

- Measure concentrations of the same chemicals of concern *plus* the following parameters in the five rivers with the greatest annual discharges to Puget Sound (Skagit, Snohomish, Nooksack, Stillaguamish, and Puyallup):
  - Hardness.
  - Nutrients (total nitrogen [TN], nitrate+nitrite nitrogen, ammonia nitrogen, total phosphorus [TP], and ortho-phosphate).
  - Petroleum-related compounds.
    - Oil and grease.
    - Diesel and gasoline fractions of petroleum hydrocarbons (TPH-D and TPH-G).
- Identify variability in concentrations of target toxic chemicals and other water quality parameters.
- Determine concentrations of toxic chemicals associated with SPM in marine and river waters.

Outcomes

Results of the present study include the following:

- Concentration ranges for target chemicals in ocean boundary waters and the major Puget Sound basins.
- Estimates of chemical exchange between ocean boundary waters and Puget Sound.
- Concentration ranges for target chemicals near the mouths of five major rivers discharging to Puget Sound.
- Estimates of daily chemical loads from the same rivers to Puget Sound.
- Some indications of spatial and temporal variability in chemical concentrations in the marine water column and near the river mouths.

Study results also provide data for calibrating the existing Puget Sound Toxics Box Model and using it to predict the transport and fate of other toxic chemicals. Consequently, the study contributes to developing a control strategy for toxic chemicals entering Puget Sound.

Study Design

The QA Project Plan (Coots and Osterberg, 2009) described the study design in detail. The following section summarizes the major project elements:

Ocean Exchange of Toxic Chemicals

Ecology collected samples from ocean boundary waters (Strait of Juan de Fuca and Haro Strait) and major Puget Sound basins (Whidbey, Main, South Sound, and Hood Canal) to determine water column concentrations of a suite of chemicals of concern (Figure 1). At each location, samples were collected from two depths representing the surface and deep layers simulated by the Box Model (Table 1). Temporal variability was addressed by sampling the water layers over three seasons. Ecology used the results to estimate the annual mass transport of target chemicals into and out of Puget Sound at the main ocean boundaries (Admiralty Inlet and Deception Pass).

River Loading of Toxic Chemicals

Ecology sampled the five rivers with the greatest mean annual flow near their mouths but upstream of any likely intrusion of marine (salt) water (Figure 1). Each river was sampled on three occasions intended to represent:

- Summer baseflows.
- Fall runoff or storm-related flows.
- Winter baseflows.

Water samples collected using depth-integrated methods were analyzed for the same toxic chemicals as marine waters, plus nutrients and hardness. Surface grab samples were also collected and analyzed for petroleum-related compounds. Instantaneous loads were calculated using measured concentrations of the various parameters and the mean daily flows.

Toxic Chemicals Associated with Particulates

Ecology measured concentrations of toxic chemicals associated with SPM in samples collected during the winter season from the marine water column and from near the five river mouths. Sediment traps were deployed at five locations to collect SPM from the marine water column (Figure 1). Centrifuges were used to concentrate SPM pumped from each river at nearly the same time that whole water samples were collected.

Sampling Methods

Marine Water Column

Ecology chose the marine water column sampling sites shown in Figure 1 to represent ambient conditions in the four major Puget Sound basins and near the main ocean boundaries (Admiralty Inlet and Deception Pass). Sites were established at the deepest location near the centroid of each basin. Two sites in the Strait of Juan de Fuca and one in Haro Strait were chosen to represent boundary waters. All sampling sites were located away from river mouths and nearshore influences. The geographic coordinates for each sampling site are listed in Table 1.

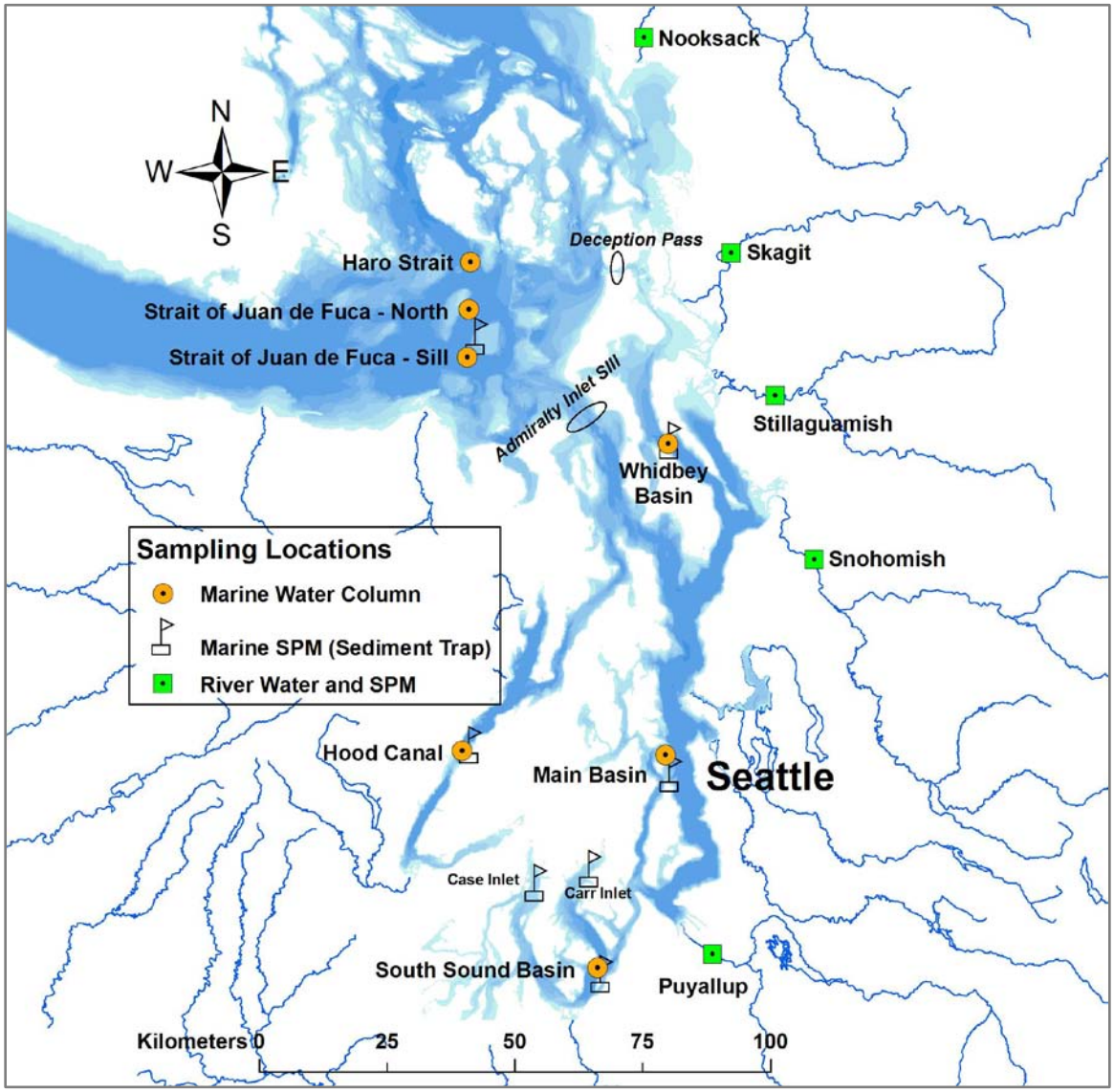

Figure 1. Marine water column and river sampling locations.

Puget Sound Toxics Box Model marine boundaries are shown in italics. Also shown are locations where sediment traps were deployed in Carr and Case Inlets during 2008 (see Results).

Table 1. Marine water column sampling site information.

Coordinates are listed for each sampling site chosen to represent Puget Sound Toxics Box Model regions. Also listed are depths used by the Box Model to divide surface from deep water layers.

Sampling Site ID	Latitude	Longitude	Box Model Region	Depth (meters) Dividing Water Layers
	(Decimal degrees; NAD83)			
Hood	47.5589	-123.0048	Hood Canal South	13
South Sound	47.1847	-122.6378	Puget Sound South	30
Main	47.5616	-122.4759	Puget Sound Main	50
Whidbey	48.1083	-122.4900	Whidbey Basin	9
SJdF at Sill	48.2500	-123.0250	Boundary Conditions	50
SJdF North	48.3333			
Haro Strait	48.4167			

SJdF = Strait of Juan de Fuca.

The circulation and transport component of the Puget Sound Toxics Box Model (Pelletier and Mohamedali, 2009; Babson et al., 2006) divided each basin vertically into surface and deep water column layers, as shown in Table 1. To provide chemical concentration data for model input and calibration, water samples were collected from within the surface and deep layers at the seven sampling locations. To assess the seasonal variability of water column concentrations, each site was sampled on three occasions (July 2009, October 2009, and January 2010).

The platform for marine sampling activities was the research vessel (R.V.) *Skookum*, an aluminum hull vessel with no antifouling coat. The *Skookum* was positioned by GPS within 100 feet of target coordinates, and the engine was off for at least five minutes prior to sampling. All sampling activities were conducted on the windward side to minimize contamination from shipboard sources.

Prior to sampling the water column at each site, a Conductivity/Temperature/Depth profiler (CTD; Model SBE25, Sea-Bird Electronics, Inc.) was deployed to measure temperature, salinity, and density throughout the water column. CTD deployments were conducted according to manufacturer protocols (Sea-Bird, 2009a and 2009b). Density profiles were assessed in the field to evaluate whether the water column was stratified (i.e., a less dense surface layer overlying a more dense deep water layer) and to accordingly select water sampling depths as follows:

- If density stratification was present, sampling depths targeted the approximate middle of the observed surface and deep layers.
- Absent stratification, sample collection targeted depths at the approximate middle of Box Model-defined surface and deep layers (Table 1).

Actual sampling depths are documented in Appendix B (Tables B-1 and B2; Figures B-2 through B-8). CTD data were later post-processed using recommended protocols, standard oceanographic equations, and manufacturer software (Sea-Bird, 2009c and 2010).

Water column samples were collected using a pair of 10-liter, Teflon-coated GO-FLO discrete samplers (General Oceanics, Inc.; Figure 2). Mounted on a non-metallic Vectran rope, the two samplers were deployed simultaneously to collect 20 liters from a targeted depth. Collection of samples from the deep layer preceded surface layer sampling at all locations. To prevent contamination of water samples expected to contain very low concentrations of target chemicals, strict protocols were employed for GO-FLO deployment and sample decanting. These protocols were based on EPA *clean hands / dirty hands* techniques (EPA, 1996), and are documented in Appendix C.

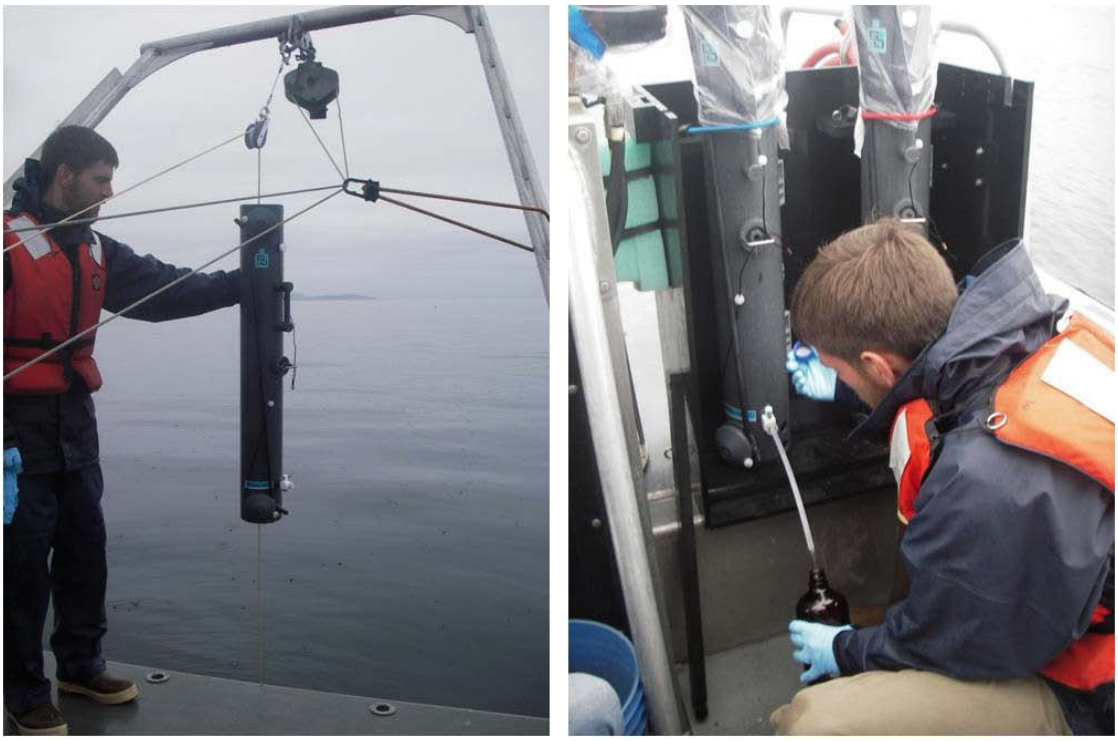

Figure 2. Collecting samples from the marine water column using GO-FLO samplers.

After retrieval, sample water was drained from the GO-FLO samplers through clean Teflon tubing to pre-rinse and then fill certified, pre-cleaned containers. Subsamples were filled in the following order: TSS, particulate organic carbon (POC) and DOC, PCB congeners, PBDE congeners, chlorinated pesticides, PAHs, BNAs, and total and dissolved metals. The volume, container, preservation, and holding times for each of these analytes are listed in Appendix C (Table C-1). Atmospheric exposure of the sample water during a typical bottle fill was minimal, occurring over a distance of approximately one inch (between the end of the Teflon tubing and the receiving bottle) for only 5 to 30 seconds.

Notable modifications to subsampling protocols from those presented in the QA Project Plan included:

- Salinity was not measured to confirm sample collection depth.
- A portable glove box was not used for transferring water to sample bottles (to eliminate exposure of samples to ambient air) because deck space was limited.

No seawater samples were collected for analysis of organic carbon during the first sampling event (July 2009) because previously available methods (Stutes and Bos, 2007) were inadequate for the purposes of this study. New field protocols were developed based on SOPs used by the University of Maryland's Horn Point Environmental laboratory (Lane et al., 2000) and others (Johannessen et al., 2008). The new procedures used an all-glass filtration apparatus and 0.7-µm pore-size glass fiber filters, with the filters and filtrate analyzed for POC and DOC, respectively (see Appendix C for details). Sampling for organic carbon resumed in October 2009 and was conducted at all locations and depths during the final two sampling events.

Various field quality control (QC) samples were also collected during each seasonal sampling. Results were used to assess environmental variability, replicability of sampling and analytical methods, and the potential for sample contamination by sampling equipment and procedures. Appendix D describes the purpose of each type of field QA sample and a description of how it was created in the field. Appendix D also presents field QA data and discusses how these data influenced interpretation of water column sample results.

Marine SPM

Ecology collected samples of SPM settling through the marine water column using moored sediment traps. A total of five moorings were deployed, each equipped with multiple traps. Sampling targeted the four Puget Sound basins where water column sampling was conducted, as well as a single location in the Strait of Juan de Fuca to collect SPM from the ocean boundary waters. All moorings were anchored in water no deeper than 50 meters and located as near as possible to water sampling stations (Figure 1).

Sediment trap moorings were deployed during October 2009. At sites where water column stratification was observed, traps were positioned to collect SPM from both the surface and deep water layers (two traps within each layer). At sites where the water column was completely mixed at the time of deployment, multiple traps were mounted within a single mid-depth zone. The configuration of each site's mooring is presented in Appendix B (Figure B-9).

Individual sediment traps consisted of paired straight-sided glass collection cylinders, each 50 cm tall by 10 cm diameter (5H:1W; 78.5 cm^2 opening area). A schematic of the construction details of the traps and their moorings is presented in the QA Project Plan (Coots and Osterberg, 2009), and further discussion can be found in Norton (2001 and 1996). At deployment, collection cylinders were filled with two liters of high salinity water (4% NaCl) and sodium azide (2% NaN_3) as a preservative to reduce microbial degradation of the samples.

Traps were intended to be deployed for a period of two to three months, collecting SPM between the fall and winter water column samplings. However, efforts to recover the traps during January and February 2010 were mostly unsuccessful, with moorings having either failed or drifted down slope too far to locate. Only the mooring in the Hood Canal was located; unfortunately, it had been disturbed and most of the collection cylinders were damaged. The SPM collected by the deepest (40 meters) sediment trap from the Hood Canal was intact and visibly undisturbed, and was deemed usable.

Upon retrieval, overlying water was removed from the two Hood Canal cylinders using a peristaltic pump. The salinity of the water immediately above the SPM in each cylinder was measured with a refractometer to verify that preservative remained. The SPM from the two cylinders was slurried, combined in a glass sample jar, and allowed to settle overnight. It was then concentrated by laboratory centrifugation (2000 rpm for at least 10 minutes), homogenized, and weighed. Total dry mass was estimated from the measured wet mass and approximate percent solids. Based on the estimated dry mass, chemical analyses were prioritized and subsamples were apportioned into certified, pre-cleaned glass sample containers for each analysis.

The Hood Canal trap yielded enough SPM to analyze a subset of the planned suite of parameters, including percent solids, TOC, five metals, PCB congeners, and PBDE congeners. To supplement these analytical results, archived sediment trap material from a recent Ecology study was also analyzed. The archived SPM had been collected by mid-water column sediment traps (identical to those employed in the present 2009-10 study) moored at sites in the Case and Carr Inlets (Figure 1) between March and June 2008 (Norton, 2009). Archived SPM from the Case and Carr traps was thawed [6], combined, and homogenized. Subsamples were distributed into sample jars for analysis of percent solids, metals, and PCB and PBDE congeners.

River Water

Ecology sampled five rivers contributing the greatest annual discharge to Puget Sound from bridges located beyond the normal upper extent of saline water intrusion. All bridges were near U.S. Geological Survey (USGS) or Ecology gaging stations (Figure 1 and Table 2). Additional details about sampling sites and sampling activities are presented in Appendix B (Table B-3 and Figures B-11 to B-15).

Sampling occurred at times intended to capture three river conditions:

- Baseflows during the dry season (July).
- Flows related to “first fall flush” or storm-related runoff (October).
- Baseflows during the wet season (December/January).

Depth-integrated samples were collected using Teflon one-liter sample bottles fit with Teflon nozzles sized for expected current velocities. Bottles and nozzles were pre-cleaned to priority pollutant standards using laboratory soap, tap water, 10% nitric acid, de-ionized water, acetone, and hexane. Similar cleaning procedures are described elsewhere (PSEP, 1997; Ecology, 2006 and 2008).

[6] Particulate material from Case and Carr Inlet traps had been frozen and stored in glass jars for approximately 18 months.

Table 2. Sampling locations near mouths of the five largest rivers discharging to Puget Sound.

River Name	Watershed Area [1] (km^2)	Annual Flow (Period of Record)		Sampling Location (Decimal degrees, NAD 1983)		Location Description	River Mile (RM)	Nearest Gaging Station
		cfs	cms	Latitude	Longitude			
Skagit	8,010	16,530 (69 yrs)	468	48.4450	-122.3354	Old Hwy 99 Mt. Vernon	15.7	USGS 12200500
Snohomish	4,440	9,810 (38 yrs)	278	47.9107	-122.0987	Avenue D Snohomish	12.7	Ecology 07A090 [2]
Nooksack	2,050	3,925 (38 yrs)	111	48.8189	-122.5801	Slater Road So. of Ferndale	3.4	Ecology 01A050 [3]
Stillaguamish	1,440	3,860 (38 yrs)	109	48.1969	-122.2104	I-5, west of Arlington	11.1	Ecology 05A070
Puyallup	2,460	3,310 (92 yrs)	94	47.2140	-122.3415	66th Avenue Puyallup	5.8	USGS 12101500 [4]

[1] Area of watershed upstream of gaging station where samples were collected.
[2] Mean annual flow based on two USGS gaging stations (12150800 - Snohomish R.; 12155300 Pilchuck River) is 9,993 cfs.
[3] Mean annual flow based on USGS gaging station 12213100 at RM 5.8 is 3,825 cfs.
[4] USGS gaging station is located at RM 6.6, approximately 0.8 miles upstream.

The sampling bottle with nozzle was attached to a US DH-95 sampler (FISP, 2000) that was suspended by steel cable from each bridge deck (Figure 3a). Sampling followed USGS protocols (USGS, 2005) except that water was collected and composited from only three quarter points in the channel. Near-surface grab samples were collected for analysis of petroleum products (oil and grease, TPH-D, and TPH-G), as shown in Figure 3b.

Ecology conducted sample collection and processing activities according to EPA *clean hands / dirty hands* methods (EPA, 1996) to the extent possible to minimize the risk of contamination. However, a portable glove box was not used while compositing and filtering samples because it proved to be cumbersome.

Field QA samples collected during river water sampling are described in Appendix D, which also includes QC sample results and discussion of how these QC samples affected data quality.

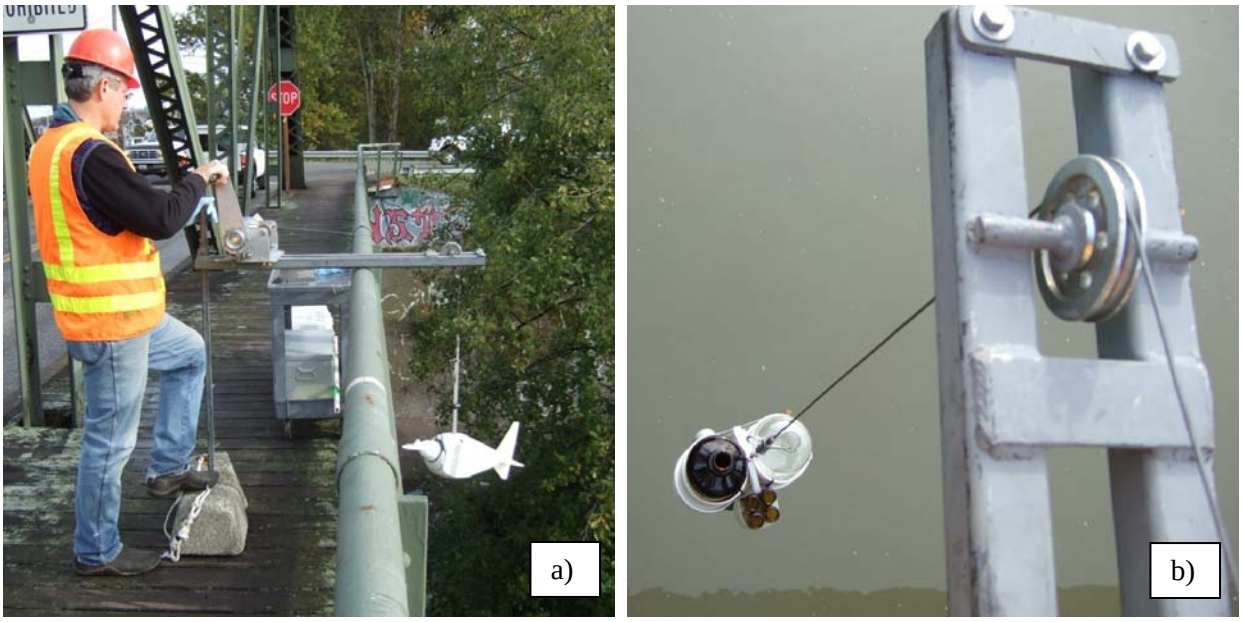

Figure 3. Collecting depth-integrated water samples and surface grabs.

River SPM

Ecology collected SPM from the five rivers only during the winter, as specified in the QA Project Plan. This was done by pumping mid-channel water through continuous-flow centrifuges in which solid material was retained. Sampling occurred within 24 hours of collecting discrete river water samples. A brief description of pump-and-centrifuge field methods follows (also see Coots and Osterberg, 2009; Gries and Sloan, 2009).

A Grundfos groundwater/well pump (Model SP4) was deployed and maintained at about 6/10 maximum mid-channel depth in each river. Water was pumped at about 2.8 gpm through Teflon-lined tubing to two Alpha Laval centrifuges (Sedisamp II, Model 101L). During this process, three discrete samples were collected from both inflow and outflow waters. The samples were composited and analyzed for TSS to assess the efficiency of centrifuges at retaining SPM [7].

After 16 - 22 hours, pumping ceased and centrifuges were shut off. The centrifuged SPM was collected while still at the sampling site. Residual water in the centrifuge bowls was removed using pre-cleaned glass syringes. Solids were collected using stainless steel spoons and Teflon-coated spatulas. Water and solids were placed in separate certified, pre-cleaned glass sample containers. Solids in the bowl water were later concentrated by laboratory centrifugation (approximately 2,000 rpm for at least 20 minutes) and added to the main mass of field-centrifuged solids. The total wet weight of solids collected was recorded. Subsamples were weighed and placed into separate jars for different analyses.

[7] % Efficiency = $[(TSS_{inflow}-TSS_{outflow})/TSS_{inflow}]*100$

Prior to the first river sampling:

- The stainless steel pump was soaked for 48 hours in de-ionized water.
- All tubing and centrifuge parts were cleaned using a 10% solution of nitric acid, de-ionized water, acetone, and hexane.

Between river sampling events, centrifuge parts were cleaned similarly. However, tubing was cleaned using only laboratory detergent, 10% nitric acid, and copious de-ionized water. Water from each river was also pumped through the tubing for at least 15 minutes (>150 liters or >40 gallons) before collecting SPM.

Analytical Methods

This section provides a summary of the analytical methods used for the present study. Additional details can be found in Appendix C, the QA Project Plan (Coots and Osterberg, 2009), and Ecology's Manchester Environmental Laboratory (MEL) *Lab Users Manual* (MEL, 2008).

Marine and River Water

Standard preparation, cleanup, and analytical methods were used to measure the parameters listed in the *Goals and Objectives* section. Table 3 describes the methods used by laboratories to analyze the parameters in the different samples that were collected. The following should be noted:

- The fractions of organic carbon that the Horn Point Lab measured in marine water (DOC and POC) differed from those MEL measured in river water (DOC and TOC).
- MEL measured phosphorus in strong acid extracts of river water samples using a colorimetric method comparable to most nutrient monitoring studies.
- Frontier Geosciences measured concentrations of five metals in marine water samples using methods similar those MEL used to measure the same metals in river water samples.
- The detection limits and reporting limits for oil and grease in river water were based on a grab sample size of one liter.
- MEL's organic chemical analyses provided results for as many as 32 chlorinated pesticides, 55 semivolatile organic compounds (BNAs), and 22 individual PAHs.
- Analytical Perspectives reported concentrations for 209 PCB congeners, and Pacific Rim Labs reported concentrations for 36 PBDE congeners.

SPM from the Marine Water Column and Rivers

Material from the Hood Canal sediment traps was analyzed for percent solids, TOC, five metals, PCBs, and PBDEs. Sediment that was combined from traps previously recovered from Carr and Case Inlets was analyzed for the same metals, PCBs, and PBDEs. Samples of SPM collected from each of the rivers were analyzed for percent solids, TOC, the same five metals, PCBs, and PBDEs. Enough suspended sediment was centrifuged from four of the rivers to also be analyzed for TPH-D, BNAs, PAHs, and chlorinated pesticides. Laboratory methods used for the various analyses are included in Table 3.

Table 3. Analyses of marine water column, river water, and SPM samples.

Parameters	Samples	Method	Method Description	Laboratory
Conventional Parameters, Nutrients, and Hardness (mg/L)				
% Solids	SPM	EPA 160.3		
TSS	S, F	SM 2540 D	Gravimetric	MEL
DOC	S	SM 5310	Combustion; IR detection	Horn Pt
POC			Combustion/oxidation; Thermal conductivity detection	
DOC and TOC	F		Combustion; IR detection	MEL
TOC	SPM	PSEP EPA 415.1	Combustion; IR detection	MEL
Nutrients [1]	F	SM 4500	Colorimetry	MEL
Hardness	F	EPA 200.7	ICP; Calculation	MEL
Total metals [2] (µg/L)	S, F SPM	FGS 054 EPA 200.8	ICP-MS	FGS MEL
Dissolved metals [2] (µg/L)	S, F			
Petroleum-Related Products (mg/L)				
Oil and Grease (HEM)	F	EPA 1664A	Gravimetric	MEL
TPH-D	F, SPM	ECY 97-602	GC/FID	MEL
TPH-G	F		Purge and trap; GC/FID	MEL
Organic Compounds				
Chlorinated Pesticides (ng/L) [3]	S, F	EPA 8081	GC/ECD	MEL
PAHs (µg/L) [4]	S, F SPM	EPA 8270 SIM	GC/MS	MEL
Semivolatile Organic Compounds BNAs (µg/L) [5]	S, F	EPA 8270	Capillary GC/MS	MEL
209 PCB Congeners (pg/L)	S, F SPM	EPA 1668A	GC/HRMS	AP, PRL
36 PBDE Congeners (pg/L)	S, F SPM	EPA 1614		PRL

[1] Includes total nitrogen (TN), nitrate+nitrite-N, ammonia-N, total phosphorus (TP), and ortho-phosphate (ortho-P)
[2] Includes arsenic, cadmium, copper, lead, and zinc.
[3] See Appendix E, Table E-2, for list of 32 chlorinated pesticides measured.
[4] See Appendix E, Table E-8, for list of 22 PAH compounds measured.
[5] See Appendix E, Table E-14, for list of 55 semivolatile organic compounds measured.

See LEGEND on following page.

LEGEND:

Analytes or Parameters

BNAs = base/neutral/acid extractable, semivolatile organic compounds
DOC = dissolved organic carbon
PAHs = polycyclic aromatic hydrocarbon compounds
PCBs = polychlorinated biphenyls
PBDEs = polybrominated diphenyl ethers
TOC = total organic carbon
TPH-D = total petroleum hydrocarbons - diesel fraction
TPH-G = total petroleum hydrocarbons - gasoline fraction
TOC = total organic carbon
TSS = total suspended solids

Sample Type

F = freshwater (river samples)
S = seawater (ocean boundary and Puget Sound water samples)
SPM = suspended particulate matter (trap and centrifuge samples)

Method

ECD = electron capture detection
ECY = Washington State Department of Ecology (method number)
EPA = U.S. Environmental Protection Agency (method number)
FID = flame ionization detection
GC = gas chromatography
HR = high resolution
ICP = inductively-coupled plasma detection
MS = mass spectrometric confirmation
PSEP = Puget Sound Estuary Program Protocols and Guidelines (PSEP, 1986; PSEP, 1997)
SIM = selective ion monitoring
SM = Standard Methods (APHA, 2005)

Laboratories

AP = Analytical Perspectives, Inc.
FGS = Frontier GeoSciences, Inc.
Horn = University of Maryland Environmental Laboratory, Horn Point, Maryland
MEL = Manchester Environmental Laboratory
PRL = Pacific Rim Laboratories, Inc.

Data Quality

Data Verification

Laboratory chemists, MEL's QA Officer, and project staff conducted data quality reviews. The reviews evaluated the acceptability of sampling and analytical results based on the measurement quality objectives (MQOs) outlined in the QA Project Plan. This section describes the data quality review process and summarizes the findings. Additional details can be found in Appendix D.

Field Data Quality Review and Findings

Project staff reviewed field notes and found that measurements were made consistent with methods described in the QA Project Plan, except as noted in the *Sampling Methods* section. Three minor data quality concerns were identified:

- Some salinity results from marine water column CTD profiles were flagged as suspect.
- Water depths recorded for river samplings (quarter points and pump intake depths) were only accurate to ± 1 foot due to water levels that changed with tides or flows.
- Flow rates and the water volume pumped to collect SPM from the Puyallup River (December 2009) were uncertain because debris sometimes accumulated in the tubing and impeded flow.

Analytical Data Quality Review and Findings

MEL and contract laboratory chemists conducted initial QA reviews to verify that samples were handled and analyzed according to QA Project Plan requirements. The reviews focused on:

- Sample storage conditions and holding times.
- Sample preparation, extraction, and analytical methods.
- Instrument calibrations.
- Method detection limits (MDLs) and reporting limits (RLs).
- Lab QC sample results.

MEL staff found that the results, with few exceptions, reflected the storage conditions, holding times, and analytical methods listed in the QA Project Plan. Results that met all MQOs were accepted without qualification.

Results were assigned a "J" qualifier code (indicating an estimated value) if the detected concentrations were less than the RL, or if one or more lab QC samples failed to meet MQOs. For example, chemical concentrations were qualified with a "J" if spiked QC samples showed consistently low recovery. However, the number of "J" qualifier codes assigned for different reasons was not easily quantified. Ecology's QA Officer assigned an "N" qualifier code for PCB and PBDE congeners that could only be tentatively identified (or "NJ" if also below reporting limits). A "UJ" qualifier code was assigned to sample results for various reasons but usually

because concentrations were less than ten times (<10 X) those measured in batch-specific method blanks. This indicated potential contamination from sample handling and analysis in the laboratory. Analytes for which this occurred were lead, zinc, Lindane, di-N-butyl phthalate, PCB-011, PBDE-047, PBDE-099, and PBDE-100. Consistent with laboratory best practices (EPA and MEL), results assigned "N", "NJ", "U" and "UJ" qualifiers were not used in analyses unless stated otherwise.

Analytical results were rarely rejected (0.5% of all individual chemical concentrations reported). The chemicals for which concentrations were sometimes assigned a "REJ" qualifier code were 2-chloronaphthalene, 3-nitroaniline, 4-chloroaniline, acenaphthylene, benzoic acid, n-nitroso-diphenylamine, PBDE-007, PBDE- 010, and PBDE-015.

In terms of traditional measures of data quality:

- *Accuracy* of results was ensured by verifying calculations of final concentrations. Only a few corrections were required. The accuracy of metals results for marine water samples was also assessed by analyzing certified reference materials (CRM) [8]. CRM results were generally within the range of acceptable values, with exceptions often close to the limits of the acceptable range. Sample results were not qualified based on CRM analyses.
- *Bias* was evaluated by examining the recoveries of parameters spiked into de-ionized water or samples. Concentrations in laboratory control samples, matrix spikes, surrogate spikes, and internal standards were generally recovered within MQOs for the different parameters. Sample results were assigned a "J" when results for more than one QC sample were outside the MQOs. The nature of any potential analytical bias (high or low) was not preserved in this report or in Ecology's EIM database.
- *Precision* was assessed by analyzing laboratory and matrix spike duplicates. A relative percent difference (RPD) between concentrations in duplicates and their associated field samples that did not meet the relevant MQO was cause to assign a "J" qualifier [9].

MEL summarized data quality review findings in laboratory narratives and compiled final analytical results in printed-copy format and electronic data deliverables (EDDs) [10]. Project staff used these to conduct a similar data quality review and to apply study-specific data quality rules, as documented in Appendix D. This review resulted in some changes to laboratory-assigned qualifier codes and to reported concentrations. Important modifications included:

- Results for TSS, organic carbon, nutrients (nitrogen and phosphorus compounds), hardness, metals, and oil and grease were reported down to the MDL.
- Sample results were assigned a "UJ" only if they were less than or equal to three times (≤ 3X) the batch-specific method blank concentration.
- Concentrations of DOC and POC in marine water samples were adjusted to account for concentrations detected in method and field blanks.

[8] National Research Council Canada CASS-4 and NASS-5 CRMs were the only reference materials analyzed during this study.
[9] Relative standard deviation (RSD) control limits applied to results for more than two lab replicates.
[10] Copies of laboratory narratives may be requested from the authors.

- Concentrations of metals in marine water samples were recalculated (the contract laboratory had subtracted the mean method blank concentration).

Rules pertaining to each of the modifications listed above are described in Appendix D. The number of each type of revision made by project staff to laboratory qualifier codes is shown in Tables D-1 to D-4. Reporting down to the MDL (instead of the RL) did not affect any marine water column data, but 62 river water sample results (1.2% of freshwater samples) were changed from nondetects ("U") to "J"-qualified or unqualified results. Of more than 19,000 individual chemical analyses of marine and river water samples, project staff assigned "UJ" or "J" qualifiers codes to 432 results received from MEL (2.3%) due to parameter concentrations in the lab method blanks.

Field Quality Assurance Sample Review and Findings

The various field QA samples from marine and river water sampling are described and discussed in Appendix D. Field QA sample results are presented in Tables D-5 through D-14.

Results for the field replicates and duplicates usually indicated a homogeneous environment and repeatable analytical results (Tables D-5 to D-8, D-11, D-13, and D-14). No chemical qualifier code was assigned to field replicate results that were substantially different because there were no pre-defined MQOs for such samples and the results may reflect spatial or temporal variability.

Bottle, filter, transfer, and equipment blanks sometimes contained measurable concentrations of copper, dissolved lead, zinc, PCB congeners, and PBDE congeners (Tables D-9, D-10, D- 12, and D-14). This indicated potential for marine and river water samples to become contaminated with low concentrations of these parameters during routine sampling, handling, and analysis. Field blank concentrations exceeding those in method blanks appeared to implicate sampling equipment and the sampling process as sources of contamination. Similar concentrations in field and method blanks indicated contamination likely occurred in laboratory settings.

Chemical concentrations in field blanks were not subtracted from sample results. Despite attempts to mimic marine water column and river water sampling procedures described in *Sampling Methods*, field blanks could not be created in exactly the same manner. Field blanks were exposed to sources of contamination longer than were marine and river water samples. For example, marine water was only exposed to ambient air while clean sample containers were being filled, whereas the associated field blanks were also exposed to air while being created. There was also evidence that rinsing sampling devices with ambient marine or river water eliminated or at least reduced contamination from the cleaning, storage, and handling processes. Therefore, subtracting field blank concentrations would inappropriately underestimate sample concentrations. Further discussion can be found in Appendix D.

Data Usability

Field measurements were nearly all usable. CTD results flagged as "suspect" did not affect interpretation of water column profiles because the suspect results always represented a single depth or limited depth range. Uncertain pumping rates and volumes pumped did not prevent calculation of centrifuge efficiency or alter chemistry results for samples of SPM.

In terms of traditional descriptions of data usability:

- *Representativeness*. Marine water column samples were collected from locations representing ocean boundary and main basin waters and from depths representing layers defined by the Box Model. River water samples were depth-integrated and SPM samples were time-integrated. Whether the results for marine and river water samples collected during three seasons represented average seasonal or annual conditions could not be determined.
- *Completeness*. The total number of water samples collected, the number of SPM samples collected from rivers, and the total number of QC samples created were similar to what was planned. The total number of analyses conducted using these samples also reflected plans. Only the deepest sediment traps deployed in Hood Canal were recovered, so the number of marine SPM samples and analyses failed to meet targets.
- *Comparability*. Sampling and analytical methods were chosen based on their history of previous use within and outside of the region. With the exception of oil and grease, analytical detection and reporting limits were similar to ones achieved for other studies. Limits for oil and grease were elevated relative to a related study (Herrera, 2010b) because these limits were based on a one-liter sample size instead of four liters.

Based on all data quality reviews, this study collected samples that were reasonably representative of environmental conditions, stored and handled appropriately, and analyzed for parameters of interest using methods comparable to other regional studies. Most laboratory results met study MQOs. Those that did not were appropriately qualified. All analytical results were deemed usable for the purposes of the present study except for:

- A few results for individual BNA and PAH compounds that were rejected.
- Some results for several PCB and PBDE congeners qualified with "N" and "NJ".
- Results for dissolved lead and zinc concentrations in marine water column samples (discussed below).

Marine water column samples sometimes contained dissolved metal concentrations greater than the associated total metal results. In most cases, the dissolved form was within 100% - 120% of the total concentration. This indicated a high fraction of the total metal concentration was in dissolved form and that the analysis could not distinguish between two low concentrations. However, some dissolved metal results were as much as 250% of the total. These samples appeared to reflect contamination of the dissolved sample at some stage of collection and handling. The marine water column data for metals were handled as follows:

- Arsenic and cadmium concentrations in marine water column samples were low, and it was often difficult to distinguish between them [11]. There was no evidence of sample contamination from filter blank results (Table D-9, Appendix D). Dissolved concentrations were included in summary statistics and data analyses.
- The dissolved copper concentration exceeded the corresponding total concentration in only two marine water column samples. The ratios of dissolved to total copper were 109% and 123%. All dissolved copper data were considered usable.
- Dissolved lead and zinc concentrations were more variable than those of the other metals and sometimes were more than two times the corresponding total concentration. For these reasons it was difficult to determine which dissolved results were analytically indistinguishable from total results and which reflected field or lab contamination. Therefore, descriptive statistics for dissolved lead and dissolved zinc are not presented in this report, and dissolved concentrations of these chemicals were not used in analyses.

Overall, perhaps the three greatest limitations on data usability are:

- Concentrations of organic chemicals detected in less than 50% of all samples (e.g., oil and grease in river water) or that were highly variable when detected (e.g., PBDEs in marine water samples) may not represent the normal range and variability. Uncertainty associated with estimates of loading or ocean exchange for these chemicals is relatively high.
- Concentrations of some organic chemicals (TPH, BNAs, chlorinated pesticides) were seldom detected in marine water column or river water samples. Consequently, transport estimates for these chemicals based on one-half the RL or MDL are likely biased high and also uncertain.
- Data for toxic chemicals associated with marine SPM collected during this study were limited because of the failure to recover most sediment traps. Estimates of the downward flux of toxic chemicals due to sedimentation will be limited and difficult to apply to other areas of Puget Sound and the ocean boundary.

[11] For 21 arsenic results where the dissolved concentration exceeded the total, the average ratio was 1.05 (max=1.13). For 16 cadmium results, the average exceedance ratio was 1.08 (max=1.25).

Results

Marine Water Column

Ecology collected marine water column samples at seven sites during three seasonal sampling events (July 2009, October 2009, and January 2010). Sampling depths targeted surface and bottom waters, the division between layers being determined by CTD profiles and Box Model-defined boundaries. Details of sampling activities and water column conditions are provided in Appendix B, Tables B-1 and B-2. Collection depths from each location and sampling event are shown with vertical water density profiles and Box Model layers in Figures B-1 through B-7 of Appendix B.

Density profiles revealed that water column stratification at the three ocean boundary water sites varied seasonally. Stratification at these sites was strongest during July, became slightly degraded in October, and was absent in January apart from a near-surface freshwater lens. The stratification depths observed at the four Puget Sound basin sites did not differ markedly between the sampling events and were consistent with divisions defined by the Box Model. Stratification in the South Sound basin was always weak-to-absent, except for a shallow lens of freshwater from recent heavy rains was present at the surface in January 2010.

For each sampling location, the total number of samples collected and analyzed is summarized in Table 4. Nearly 500 analyses were conducted by a total of five laboratories. This section summarizes the marine water column results, with complete results tabulated in Appendix E and available from Ecology's EIM database.

Conventional Parameters

The TSS results from marine water column sampling are summarized in Table 5. With the exception of several elevated TSS concentrations in the Whidbey basin and at the San Juan de Fuca (SJdF) North station, values at all sites were between 0.8 and 2.3 mg/L over the course of the three sampling events. The average concentration of TSS was significantly lower in samples collected during October than in samples collected at other times. Results of various statistical analyses are presented in the *Discussion* section.

Organic carbon concentration results for samples collected during October 2009 and January 2010 are also summarized in Table 5. Measured DOC and POC concentrations were summed to represent TOC concentrations.

The concentration of DOC averaged 0.76 mg/L (63.1 µM) across all samples and showed little variability (CV = 0.12). Concentrations differed little between the seven sampling sites and between the surface and deep water layers. The average DOC concentration was greater at Puget Sound basins sites than at ocean boundary water sites. Concentrations were also greater in October than in January, but the apparent temporal difference was small (< 0.20 mg/L).

Table 4. Inventory of marine water column samples collected and analyzed.

Parameter → / Marine Site ↓	TSS	POC	DOC	Metals – Total [1]	Metals – Dissolved [1]	BNAs [2]	PAHs [3]	Chlor. Pesticides [4]	PCBs [5]	PBDEs [6]	Total
Hood Canal	6	4	4	6	6	6	6	6	6	6	56
South Sd Basin	6	4	4	6	6	6	6	6	6	6	56
Main Basin	6	4	4	6	6	6	6	6	6	6	56
Whidbey Basin	6	4	4	6	6	6	6	6	6	6	56
SJdF at Sill	6	4	4	6	6	6	6	6	6	6	56
SJdF North	6	4	4	6	6	6	6	6	6	6	56
Haro Str	6	4	4	6	6	6	6	6	6	6	56
Field QA samples	6	21	14	6	5	6	5	4	11	5	83
Total =	48	49	42	48	47	48	47	46	53	47	475

[1] Metals included arsenic, cadmium, copper, lead, zinc analyses.
[2] BNAs included 55 individual compounds.
[3] PAHs included 22 individual compounds.
[4] Chlorinated Pesticides included 33 individual compounds.
[5] PCBs included 209 individual congeners.
[6] PBDEs included 36 individual congeners.

Table 5. Summary statistics for TSS, DOC, POC, and TOC in the marine water column.

Parameter (mg/L)	Times Detected	Percent Detected	Min.	25th %ile	Median	Mean	CV	75th %ile	Max.
All 7 Stations									
TSS	42	100	0.80	1.2	1.6	1.8	0.60	1.9	6.0
DOC	28	100	0.61	0.70	0.75	0.76	0.12	0.81	0.97
POC	28	100	0.03	0.05	0.06	0.13	2.44	0.09	1.78
TOC *	28	100	0.66	0.75	0.81	0.89	0.43	0.87	2.75
Ocean Boundary Stations (3)									
TSS	18	100	1.0	1.2	1.6	1.9	0.59	2.2	6.0
DOC	12	100	0.61	0.66	0.70	0.70	0.09	0.71	0.81
POC	12	100	0.04	0.04	0.05	0.06	0.35	0.07	0.11
TOC *	12	100	0.66	0.73	0.75	0.76	0.08	0.77	0.89
Puget Sound Stations (4)									
TSS	24	100	0.8	1.2	1.4	1.7	0.61	1.7	5.5
DOC	16	100	0.71	0.75	0.78	0.80	0.10	0.84	0.97
POC	16	100	0.03	0.05	0.07	0.19	2.25	0.12	1.78
TOC *	16	100	0.74	0.81	0.85	0.99	0.48	0.99	2.75

CV = Coefficient of variation.
* Values for TOC are calculated as the sum of DOC and POC concentrations.

The average POC concentration was 0.13 mg/L (11 µM). Concentrations in surface waters of Puget Sound basin sites during October were the most variable (Figure 4) and exceeded concentrations measured in ocean boundary waters. The average POC concentration was greater in October samples than in January samples.

The pool of organic carbon was dominated by the dissolved fraction, with DOC averaging more than 90% of TOC. The October Whidbey Basin surface water sample was an exception. It contained an unusually high POC concentration (Figure 4) that was 65% of TOC.

As was true for DOC, average TOC concentrations were greater in Puget Sound basins than in boundary waters, and greater during the fall than in the winter. TOC concentrations in surface water samples collected in October exceeded those in the deep waters by an average of nearly 0.6 mg/L. However, by January, TOC concentrations at the two depths differed little.

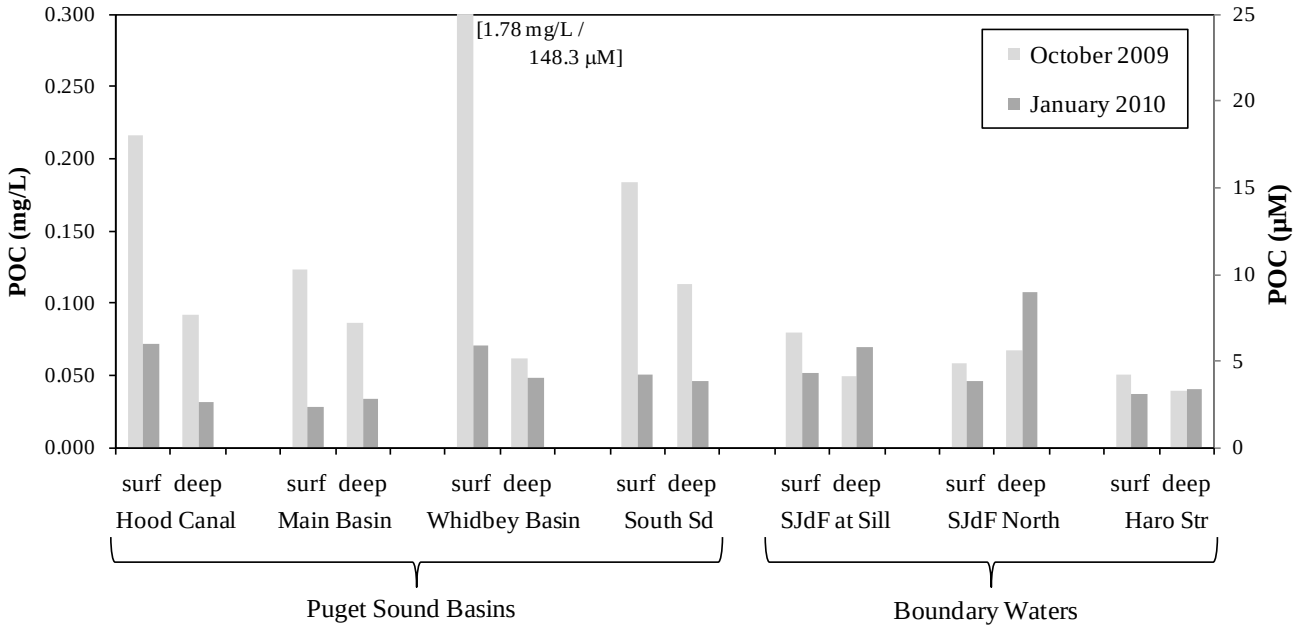

Figure 4. Summary of marine water column POC results.

Metals

Marine water column samples were analyzed for total and dissolved forms of arsenic, cadmium, copper, lead, and zinc. Summary statistics for marine metals are presented in Table 6, and complete results can be found in Table E-1 of Appendix E.

Dissolved metal results sometimes exceeded their corresponding total concentration. For the purposes of this project, all dissolved results for arsenic, cadmium, and copper were deemed usable. However, uncertainties associated with the results for dissolved lead and dissolved zinc caused these data to be excluded from analyses. See *Data Usability* section.

Table 6. Summary statistics for total and dissolved metals in the marine water column.

Parameter (µg/L)	Times Detected	Percent Detected	Min.	25th %ile	Median	Mean	CV	75th %ile	Max.
All 7 Stations									
Arsenic, Total	42	100	1.16	1.36	1.41	1.42	0.06	1.49	1.56
Arsenic, Dissolved	42	100	1.26	1.35	1.42	1.42	0.06	1.46	1.70
Cadmium, Total	42	100	0.059	0.079	0.084	0.085	0.12	0.091	0.112
Cadmium, Dissolved	42	100	0.067	0.074	0.081	0.083	0.13	0.089	0.111
Copper, Total	42	100	0.19	0.29	0.38	0.41	0.52	0.44	1.37
Copper, Dissolved	42	100	0.16	0.24	0.30	0.30	0.26	0.37	0.51
Lead, Total *	37	88	0.015	0.043	0.070	0.085	0.64	0.110	0.230
Zinc, Total *	42	100	0.41	0.55	0.69	0.86	1.23	0.84	7.44
Ocean Boundary Stations (3)									
Arsenic, Total	18	100	1.31	1.36	1.45	1.43	0.06	1.52	1.56
Cadmium, Total	18	100	0.080	0.087	0.089	0.090	0.07	0.092	0.105
Copper, Total	18	100	0.19	0.24	0.29	0.34	0.43	0.38	0.72
Lead, Total	15	83	0.025	0.050	0.070	0.086	0.62	0.109	0.230
Zinc, Total	18	100	0.41	0.52	0.58	0.69	0.39	0.79	1.44
Puget Sound Stations (4)									
Arsenic Total	24	100	1.16	1.35	1.41	1.40	0.07	1.47	1.54
Cadmium, Total	24	100	0.059	0.076	0.081	0.081	0.13	0.086	0.112
Copper, Total	24	100	0.26	0.36	0.40	0.47	0.51	0.46	1.37
Lead, Total	22	92	0.015	0.039	0.074	0.085	0.66	0.114	0.206
Zinc, Total	24	100	0.48	0.60	0.70	1.00	1.38	0.85	7.44

***** Summary statistics for concentrations of dissolved lead and zinc are not presented here. Dissolved concentrations often exceeded total concentrations to a degree that complicated distinguishing valid results from ones that reflected field or laboratory contamination.

Arsenic

The range of total arsenic concentrations measured in regional marine waters was 1.16 - 1.56 μg/L (Figure 5). The overall average concentration was 1.42 μg/L. Total arsenic concentrations were greater in January than in October and also greater in deep waters than in surface waters.

Results for dissolved arsenic are shown in Figure 6. Dissolved arsenic averaged 96% of the total concentration in one-half of all samples (21/42). However, the dissolved fraction marginally exceeded the total concentration in the remaining 21 samples. Filter blanks showed no evidence of contamination. Therefore, these apparently anomalous results were attributed to the analytical difficulty of differentiating between dissolved and total forms at such low concentrations.

Cadmium

Total cadmium concentrations, shown in Figure 7, ranged from 0.059 - 0.112 μg/L. The average concentration at all locations and depths was 0.085 μg/L. Ocean boundary water concentrations were greater than those in Puget Sound. In addition, the average deep water concentration exceeded that for surface waters.

Like arsenic, dissolved cadmium was the predominant form. In 23 samples, dissolved cadmium averaged 91% of the total concentration. The dissolved form exceeded the total concentration in the remaining 19 samples. Filter blanks again showed no evidence of contamination (similar to the arsenic results) so these exceedances were also attributed to difficulties distinguishing between the dissolved fraction and the total at low concentrations.

As with total concentrations, dissolved cadmium was greater in ocean boundary waters than in Puget Sound. Surface water dissolved concentrations at all sites except SJdF Sill increased from July to October and again from October to January (Figure 8). Dissolved cadmium was greater in deep waters than in surface waters during July and October. This was especially true for ocean boundary sites, where concentrations exceeded those in surface waters by as much as 0.028 μg/L. However, by January the ocean boundary sites had higher dissolved cadmium concentrations in the surface waters than in deep waters.

Copper

Total copper concentrations in the marine water column ranged from 0.19 - 1.37 μg/L (Figure 9) and were more variable than dissolved concentrations (Figure 10). Elevated total copper concentrations occurred on one occasion at the Hood Canal, Main Basin, SJdF North, and Haro Strait sites. The elevated results did not appear to be associated with any spatial or temporal pattern. Dissolved copper concentrations ranged from 0.16 - 0.51 μg/L, representing 30% to 100% of the total (average of 80%). Dissolved copper was greater than the total in only two samples.

The waters of Puget Sound contained greater concentrations of total and dissolved copper than did ocean boundary waters. For example, dissolved copper in Puget Sound ranged from 0.28 - 0.51 μg/L while boundary waters contained 0.16 - 0.28 μg/L. Total and dissolved copper

concentrations were lowest in October in all but one location. The maximum observed total and dissolved copper concentrations were in the deep water sample collected from Hood Canal in July.

Lead

Total lead in the marine water column, shown in Figure 11, ranged from 0.015 - 0.230 μg/L. Total lead concentrations in the deep waters usually exceeded those in surface waters. October concentrations of total lead in five samples (SJdF North, surface; SJdF Sill, surface and deep; South Sound, surface and deep) were within three times the concentration in the associated laboratory method blank. These results were qualified as "UJ" (as described in Appendix D). Dissolved lead results were not usable for the purposes of this project (see *Data Usability*).

Zinc

The range of total zinc concentrations in the marine water column was 0.41 - 7.44 μg/L (Figure 12). The average for all locations, seasons, and depths was 0.86 μg/L. Total zinc concentrations in deep waters were often greater than in surface waters, especially during October and January. Dissolved zinc results were not usable for the purposes of this project (see *Data Usability*).

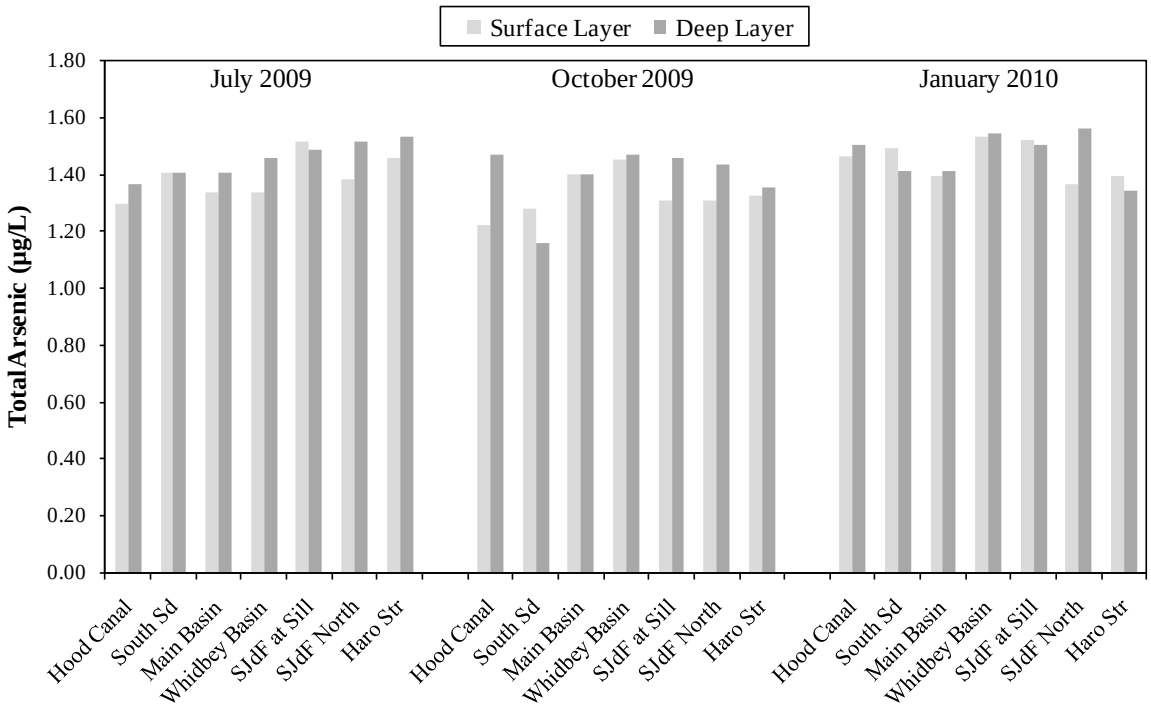

Figure 5. Concentrations of total arsenic in the marine water column.

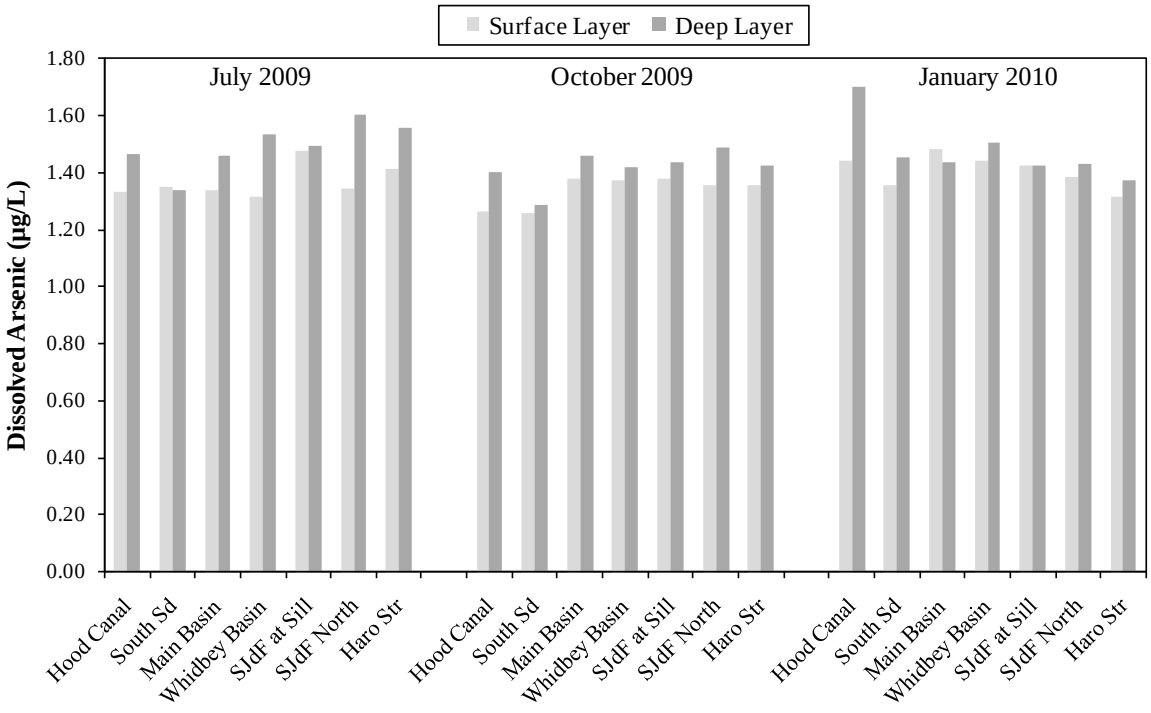

Figure 6. Concentrations of dissolved arsenic in the marine water column.

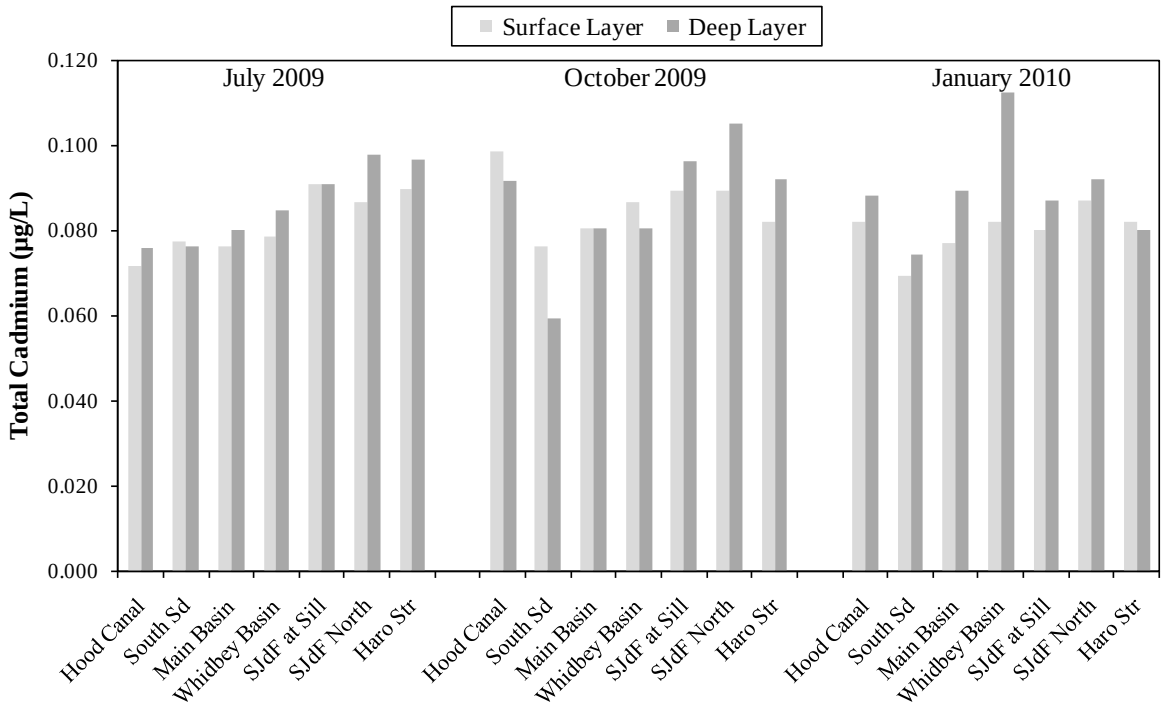

Figure 7. Concentrations of total cadmium in the marine water column.

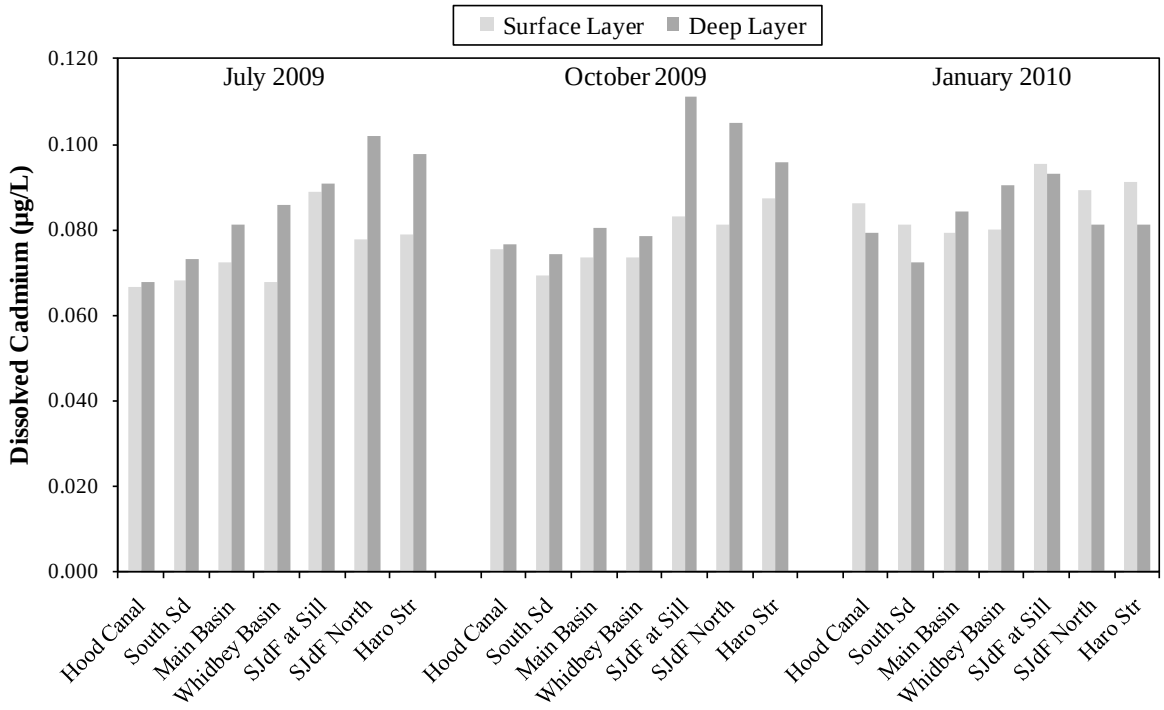

Figure 8. Concentrations of dissolved cadmium in the marine water column.

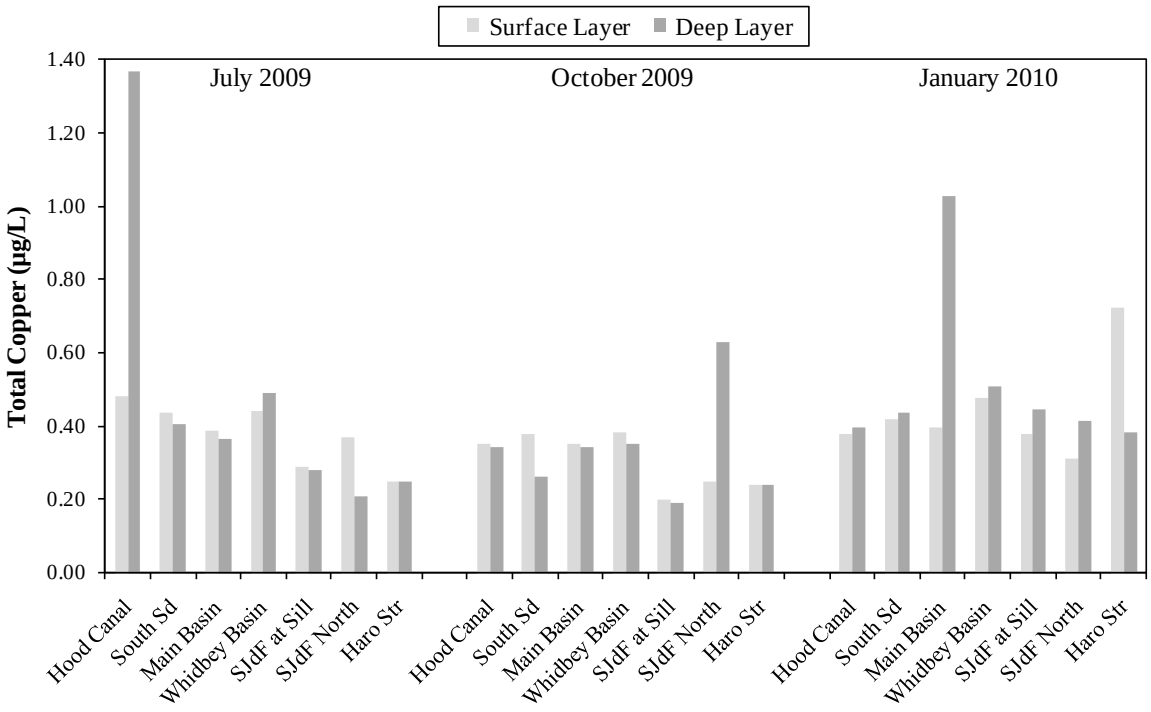

Figure 9. Concentrations of total copper in the marine water column.

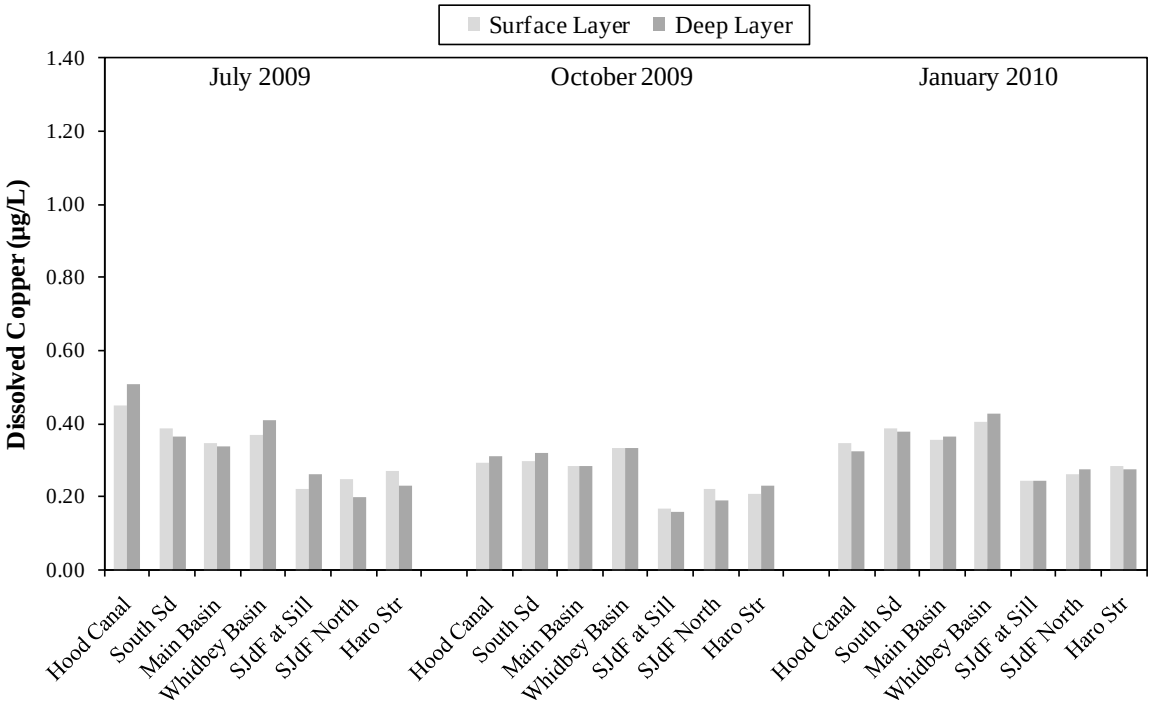

Figure 10. Concentrations of dissolved copper in the marine water column.

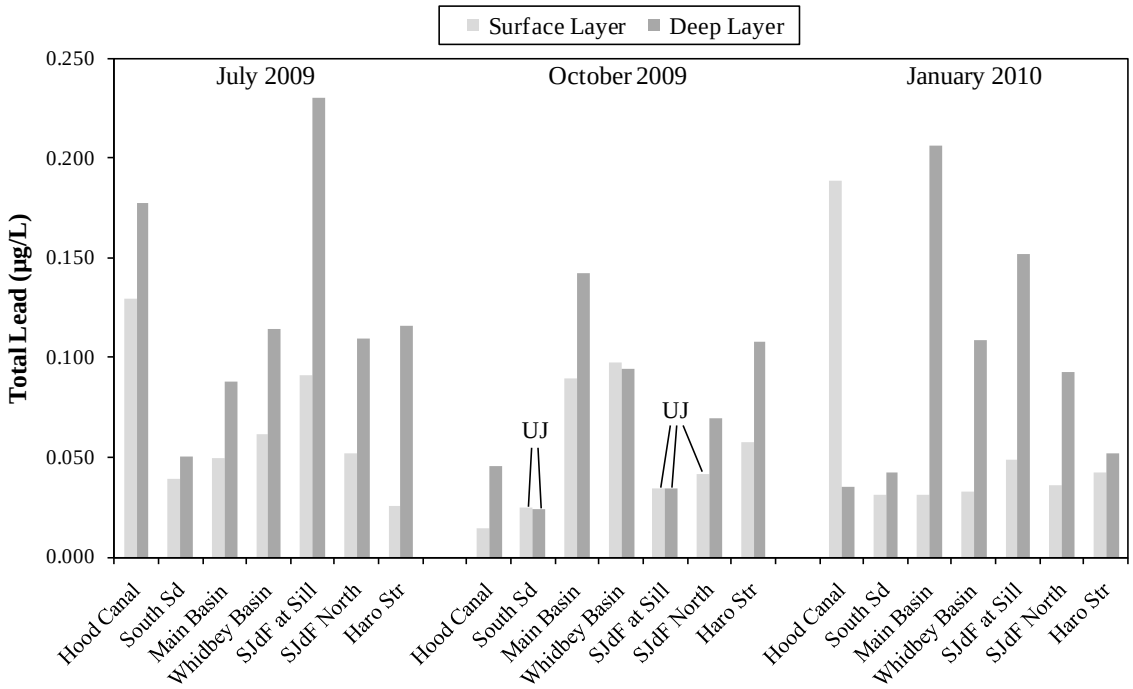

Figure 11. Concentrations of total lead in the marine water column.

Samples collected during October qualified as "UJ" were within three times the laboratory method blank concentration. Dissolved lead results not shown (see Data Usability).

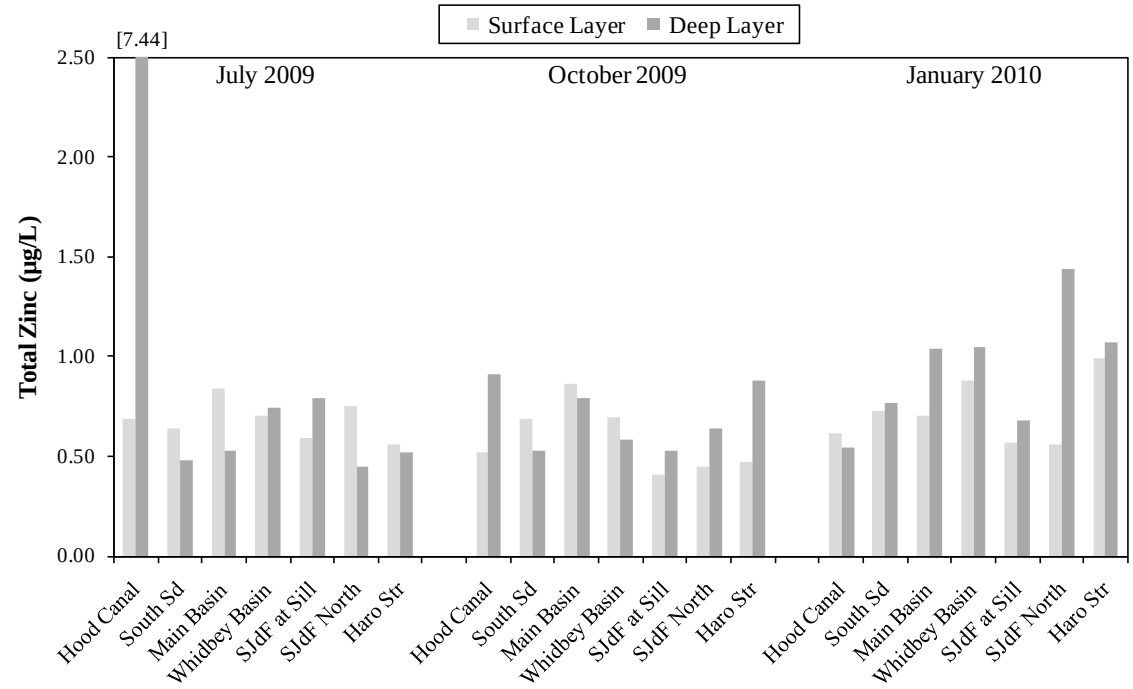

Figure 12. Concentrations of total zinc in the marine water column.

Dissolved zinc results not shown (see Data Usability).

Organics

Marine water column samples were analyzed for 33 chlorinated pesticide compounds, but only five were detected (Table 7). These compounds were found in samples collected during July and October, while no measurable concentrations were detected in January samples. Chlorinated pesticides were detected infrequently and only in the northern boundary waters.

Table 7. Summary of measurable chlorinated pesticides in the marine water column.

Date	Sampling Location	Water Column Layer	4,4'-DDE (ng/L)	Alpha-BHC (ng/L)	Beta-BHC	Delta-BHC (ng/L)	Hexachloro-benzene (ng/L)
7/8/09	SJdF North	surface	0.21 J				
		deep	0.39				
7/8/09	Haro Str	deep	0.21				
9/28/09	Whidbey	deep		0.21	0.32	0.25 J	
10/7/09	SJdF North	surface					0.21

Of the 55 BNA compounds targeted by the analyses, 11 were detected at least once (Table 8). All of these except Triclosan were detected in samples collected during July. A narrow range of cholesterol concentrations was detected in October and January samples. Triclosan was only detected in the samples collected during October. No measureable concentrations of any compounds were found in January.

PAH analyses targeted 22 compounds. PAHs were not detected in any marine water column sample at the detection limits (from 0.0005 to 0.033 μg/L).

PCBs and PBDEs

Results for marine water column PCBs and PBDEs are summarized in Table 9. All results were method blank-qualified at the congener level before calculating homolog totals.

PCBs were detected in all marine water column samples (Figure 13). Total PCBs ranged from 6.09 to 75.1 pg/L, averaging 26.3 pg/L. The sum of the congeners in the tetra- and penta-chlorinated homolog groups comprised an average of 80% of the total PCBs.

Table 8. Summary of measurable BNA compounds in the marine water column.

Date	Sampling Location	Water Column Layer	2,4-Dichlorophenol (µg/L)	2-Methylphenol (µg/L)	3B-Coprostanol (µg/L)	4-Chloro-3-Methylphenol (µg/L)	Bis(2-Ethylhexyl) Phthalate (µg/L)	Bisphenol A (µg/L)	Caffeine (µg/L)	Cholesterol (µg/L)	Ethanol, 2-Chloro-, Phosphate (3:1) (µg/L)	Phenol (µg/L)	Triclosan (µg/L)
7/7/09	Hood Canal	surface	0.06 J	0.01 J	1.2 J	0.06 J	0.05 J			0.62 J			
		deep	0.16 J	0.04 J		0.33 J	0.01 J	0.19 J				0.02 J	
7/7/09	SJdF at Sill	deep				0.03 J							
7/8/09	SJdF North	deep				0.02 J							
7/8/09	Haro Str	deep	0.06 J	0.01 J		0.09 J	0.06 J						
7/9/09	South Sd	surface							0.03 J	0.76 J	0.1		
		deep				0.03 J				0.64 J			
7/10/09	Whidbey	surface	0.04 J	0.01 J		0.02 J				0.75 J			
9/28/09	Whidbey	surface								1.1			
		deep								0.73 J			
9/29/09	Main Basin	surface								0.73 J			
		deep								0.71 J			
9/30/09	Hood Canal	surface								0.77 J			
		deep								0.7 J			
10/1/09	South Sd	surface								0.73 J			
		deep								0.73 J			
10/7/09	SJdF at Sill	surface								0.73 J			0.048 J
		deep								0.71 J			0.048 J
10/7/09	SJdF North	surface								0.73 J			0.051 J
		deep								0.72 J			0.05 J
10/7/09	Haro Str	surface											0.047 J
		deep								0.74 J			0.051 J

Table 9. Summary statistics for PCB and PBDE homologs in the marine water column.

Congener summation rules are described in Appendix D. Congeners in each homolog group are listed in Appendix E (Tables E-20 to E-22, and E-24). Concentrations of tentatively-identified congeners (results qualified as N or NJ) were not included in homolog or overall totals. Note: Homolog concentrations in a single sample can be summed to equal the total concentration in that sample, but summing the homolog statistics below will not result in the total concentration statistics.

Parameter (pg/L)	Times Detected	Percent Detected	Min.	25th %ile	Median	Mean	CV	75th %ile	Max.
PCB homologs and totals (pg/L)									
Mono-chlorinated	11	26	0.40	0.96	1.73	4.28	1.45	2.84	18.7
Di-chlorinated	22	52	1.03	2.58	3.58	3.65	0.47	4.09	7.31
Tri-chlorinated	27	64	0.67	1.61	2.41	3.21	0.63	4.74	8.79
Tetra-chlorinated	42	100	2.84	11.9	14.0	16.5	0.47	21.4	37.1
Penta-chlorinated	31	74	0.98	2.45	3.50	4.08	0.55	5.38	8.92
Hexa-chlorinated	22	52	0.87	1.26	2.25	2.85	0.70	3.38	7.39
Hepta-chlorinated	3	7	1.63	1.74	2.06	2.24	0.32	2.80	3.04
Octa-chlorinated	2	5	0.29	0.29	0.78	0.78	0.89	1.27	1.27
Nona-chlorinated	0	0	n/a	n/a	n/a	n/a	n/a	n/a	n/a
PCB-209	0	0	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Total PCBs	42	100	6.09	14.6	24.0	26.3	0.57	36.8	75.1
PBDE homologs and totals (pg/L)									
Mono-brominated	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Di-brominated	0	0	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Tri-brominated	1	2	10.7	n/a	10.7	10.7	1.00	n/a	10.7
Tetra-brominated	3	7	87.5	106	163	279	0.96	480	586
Penta-brominated	6	14	51.0	91.5	194	404	1.25	521	1,380
Hexa-brominated	3	7	61.1	69.4	94.2	126	0.68	192	224
Hepta-brominated	0	0	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Octa-brominated	2	5	43	43.0	121	121	0.91	199	199
Nona-brominated	2	5	399	399	1,870	1,870	1.11	3,330	3,330
PBDE-209	5	12	904	945	1,300	4,200	1.47	5,820	15,200
Total PBDEs	10	24	51.0	266	749	2,860	1.98	3,100	18,700

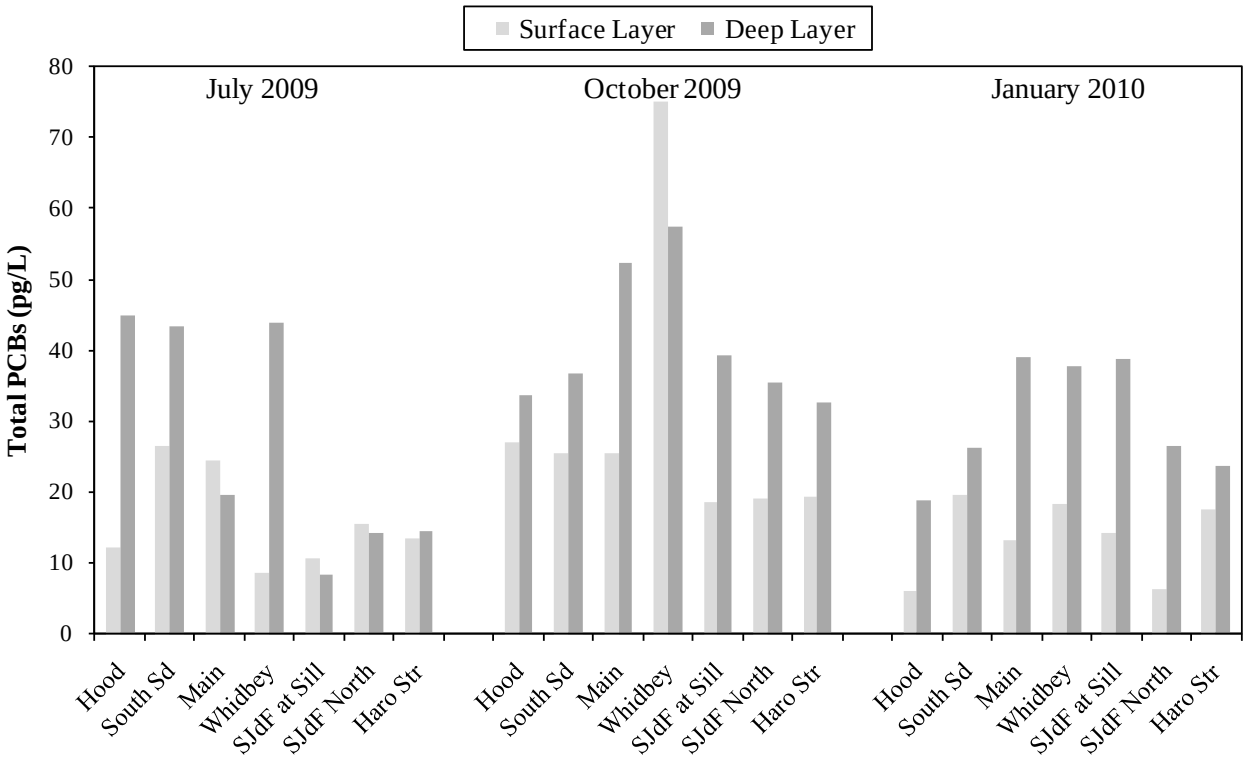

Figure 13. Summary of results for total PCBs in marine water column samples.

Tentatively-identified congeners (qualified as N or NJ) were not included in total PCB sums.

The average concentration of total PCBs in Puget Sound was greater than the average in ocean boundary water samples. October samples usually contained greater concentrations than those in samples collected at other times. Deep layer total PCB concentrations generally exceeded surface water concentrations (Figure 13). One notable exception was that July samples from all three boundary water sites had nearly identical surface and deep layer concentrations. Another exception was the October surface sample from Whidbey Basin, where the highest total PCB concentration of the study was observed (75.1 pg/L). This latter sample also had extremely elevated results for TSS, POC, dissolved lead, and dissolved zinc.

Measureable concentrations of PBDEs were detected in 10 of the 42 samples. Detected total PBDEs ranged from 51 to 18,700 pg/L and were highly variable (CV=1.98). The average total PBDE concentration was 2,860 pg/L, while the median value was much lower at 749 pg/L. Penta-brominated congeners and PBDE-209 were detected most frequently.

The maximum detected total PBDE concentration of 18,700 pg/L was measured in the January sample from the deep water layer at the Haro Strait site. The only other chemical concentration elevated in this sample was total zinc. The next highest concentration of total PBDEs was 3,190 pg/L, also from the Haro Strait site but in the October surface water sample. These and other PBDE concentrations were identified as statistical outliers (Appendix J, Table J-1), but were included in analyses because there was no evidence that the samples had been contaminated.

Marine SPM

As previously mentioned, after a deployment period of three months only one of the five sediment trap moorings was successfully recovered. The particulate sample collected from this mooring represented the deep layer of Hood Canal. Analyses included % solids, TOC, five metals, PCB congeners, and PBDE congeners. To partially compensate for the paucity of marine SPM samples, archived particulates collected from traps deployed in Case and Carr Inlets during the spring of 2008 were submitted for the same analyses of metals, PCBs, and PBDEs. Marine SPM results are presented in Table 10. The Case+Carr results were qualified as estimated values ("J") because the samples were analyzed beyond recommended holding times.

Table 10. Results for sediment trap collections of marine suspended particulates.

Parameter	Hood Canal	Case+Carr Inlets
Conventionals (%)		
TOC	2.75	n/a
Total Recoverable Metals (mg/Kg dry)		
Arsenic	7.53	5.72 J
Cadmium	0.87	1.04 J
Copper	82.0	18.5 J
Lead	9.13	8.78 J
Zinc	90.0	72.0 J
PCB Homologs (ng/Kg dry) *		
Mono-chlorinated	ND	35.3 J
Di-chlorinated	429	840 J
Tri-chlorinated	280	1,290 J
Tetra-chlorinated	343 J	1,230 J
Penta-chlorinated	948	2,290 J
Hexa-chlorinated	642	2,920 J
Hepta-chlorinated	284	909 J
Octa-chlorinated	11.6 J	249 J
Nona-chlorinated	ND	53.4 J
PCB-209	27.8	32.3 J
Total PCBs	2,970	9,850 J
PBDE Homologs (ng/Kg dry) *		
Mono-brominated	n/a	n/a
Di-brominated	14 UJ	17.4 UJ
Tri-brominated	10.2 J	68.7 J
Tetra-brominated	138 J	498 J
Penta-brominated	131 J	269 J
Hexa-brominated	43.6 J	58.4 J
Hepta-brominated	54.1 J	41.2 J
Octa-brominated	57.3 J	28.4 J
Nona-brominated	270 J	92.1 J
PBDE-209	879	174 UJ
Total PBDEs	1,580 J	1,060 J

* Homolog and total concentrations do not include tentatively-identified results (those qualified with "N" or "NJ").

Of the five metals analyzed, Hood Canal particulate concentrations exceeded those found in Case+Carr particulates for four of these metals. Differences in particulate copper concentrations between the two sites were especially large, with Hood Canal concentrations more than four times higher than those measured in Case+Carr solids. Cadmium was the only metal for which Case+Carr particulate concentrations were greater than Hood Canal values, although the difference was small (0.17 mg/Kg dry).

Sediment trap collections revealed marked differences in particulate PCB concentrations between the two sites. Solids from the Case+Carr sample had a total PCB concentration over three times that found in the Hood Canal particulates, and all 10 PCB homolog concentrations were higher in the Case+Carr sample.

In contrast, PBDE homolog concentrations varied between the two locations. Congeners with lower levels of bromination (tri-, tetra-, and penta-BDEs) were found in higher concentrations in Case+Carr SPM. Hexa- and hepta-brominated congeners had similar concentrations at the two sites. Octa-, nona-, and deca-BDEs had higher concentrations in Hood Canal SPM. Overall, the concentration of total PBDEs in Hood Canal particulates was 50% higher than that measured in Case+Carr SPM.

River Water

Ecology sampled the five largest rivers flowing into Puget Sound three times between late July 2009 and early January 2010. Sampling conditions in each river spanned a range of discharges and conditions. The upper panels of Figures 14-18 highlight the mean daily flow in each river on each sampling date atop hydrographs of mean daily flow for the calendar year. For context, hydrographs of long-term median daily flow are also shown for each river. Periods of relatively high flow appear as the darkest areas, while periods of relatively low flow appear under the white areas. In general, the rivers had lower-than-normal flows in 2009, but periods of higher flows did occur in late spring and late fall.

Daily flows encountered while sampling were usually below the long-term median flow for the same dates. Exceptions (higher-than-normal flows) were encountered in the Stillaguamish (October 2009), the Snohomish (December 2009), and the Nooksack (January 2010). Overall, mean daily flows ranged from 13.3 cms (470 cfs) in the Stillaguamish in July to 521 cms (18,500 cfs) in the Skagit in December (Table 11). These flows represented baseflows and runoff-related flows, with the flow regime determined after examining:

- Seasonal hydrographs.
- Mean daily flows preceding and following each sampling (lower panels of Figures 14-18).
- Recent climate records (especially for precipitation).
- Other evidence (long-term flow records, turbidity).

In July, dry-season baseflows were evident in all rivers except the Puyallup (Figure 18). The Puyallup was highly turbid, carrying a high concentration of suspended solids (233 mg/L). However, the relatively high TSS was consistent with long-term ambient monitoring data for late-summer and was probably due to silts in glacier meltwaters enhanced by recent high air temperatures.

In October, baseflows were encountered while sampling the Skagit and Nooksack (Figures 14 and 16). The Snohomish and Stillaguamish were sampled during late stages of obvious runoff events (Figures 15 and 17). It was less obvious in Figure 18 that Puyallup River flow was related to runoff. However, elevated flow and concentrations of suspended solids reflected an early stage of runoff from 1.33 inches of rain that fell upstream the day before.

Sampling during December 2009 and January 2010 found wet-season baseflows in the Stillaguamish and Puyallup. The other three rivers had flows in the rising or falling stage of runoff-related events. River water in the Skagit was running clear when sampling began but became visibly turbid soon afterward.

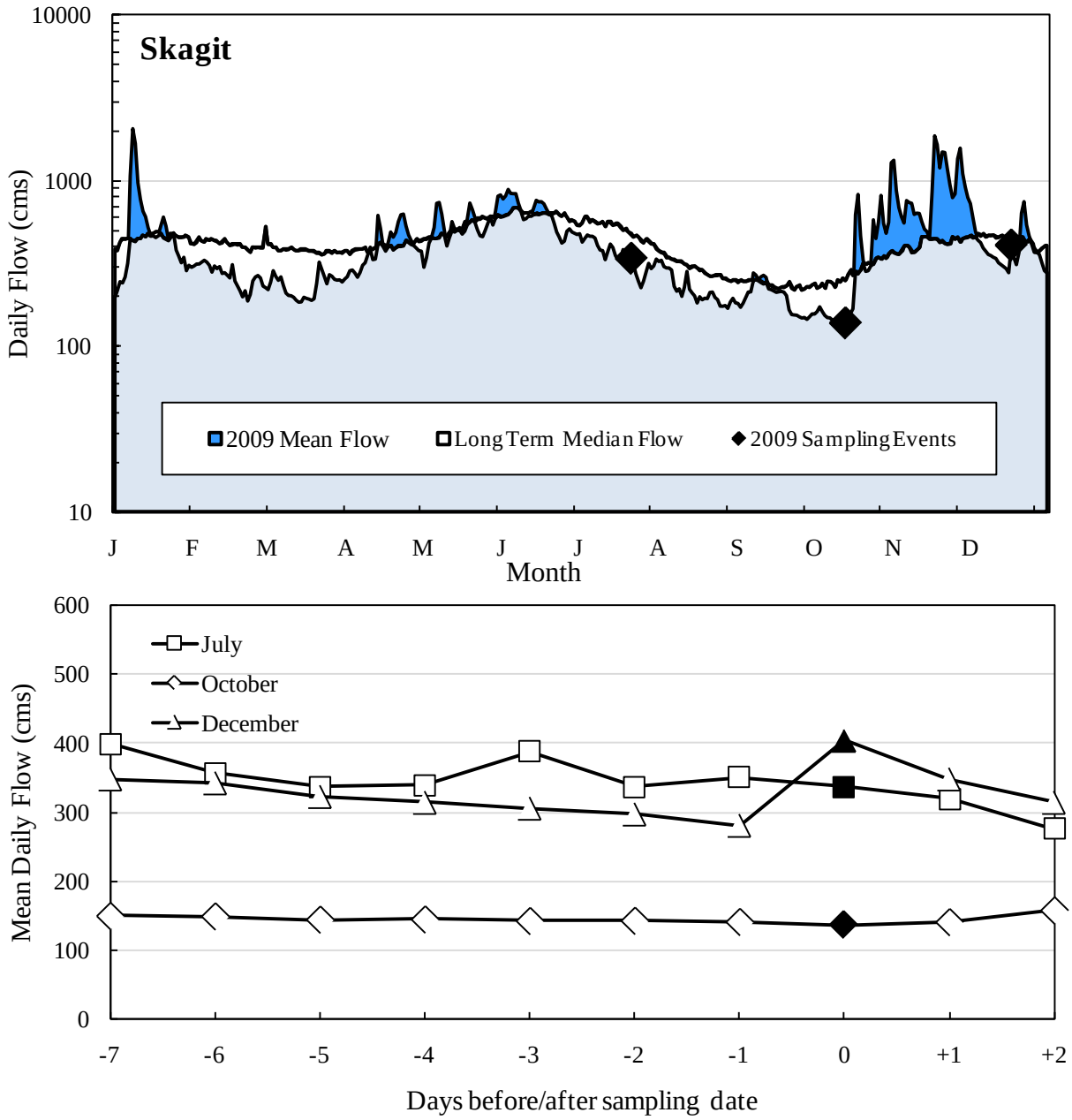

Figure 14. Skagit River daily flows.

- Upper: Sampling events are shown as black diamonds on the hydrograph for mean daily flows during 2009 (shaded beneath). Relative to long-term median flows, periods of high flow appear as the darkest areas and periods of low flow appear under the white areas.
- Lower: Mean daily flows prior to, during, and immediately after each sampling event (solid black symbols).

  July and October sampling occurred during baseflows, while sampling in December was during the late stages of a runoff event.

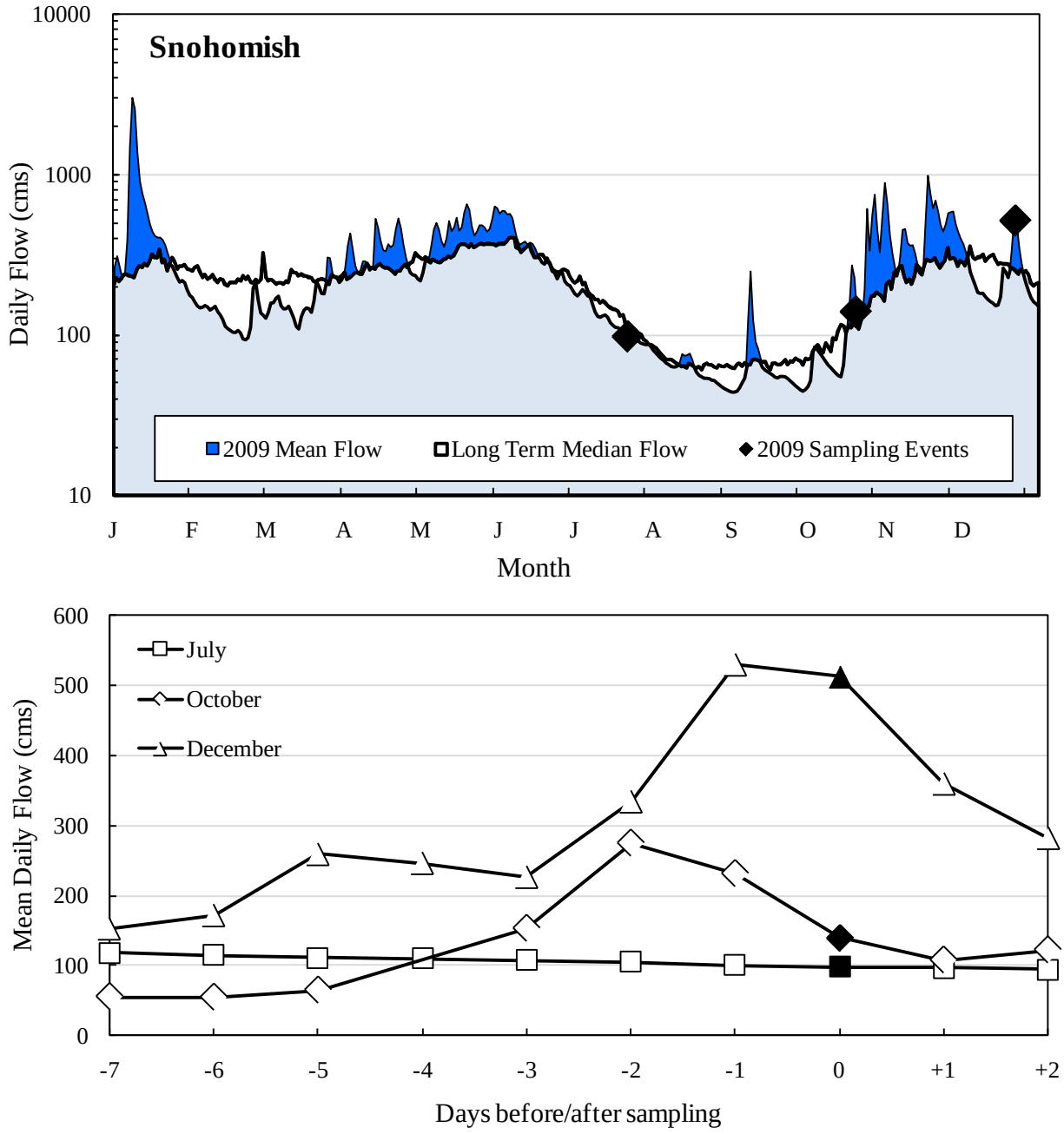

Figure 15. Snohomish River daily flows.

- Upper: Sampling events are shown as black diamonds on the hydrograph for mean daily flows during 2009 (shaded beneath). Relative to long-term median flows, periods of high flow appear as the darkest areas and periods of low flow appear under the white areas.
- Lower: Mean daily flows prior to, during, and immediately after each sampling event (shown as solid black symbols).

Sampling in July was during baseflows. October and December sampling events occurred near the end and peak of runoff events, respectively.

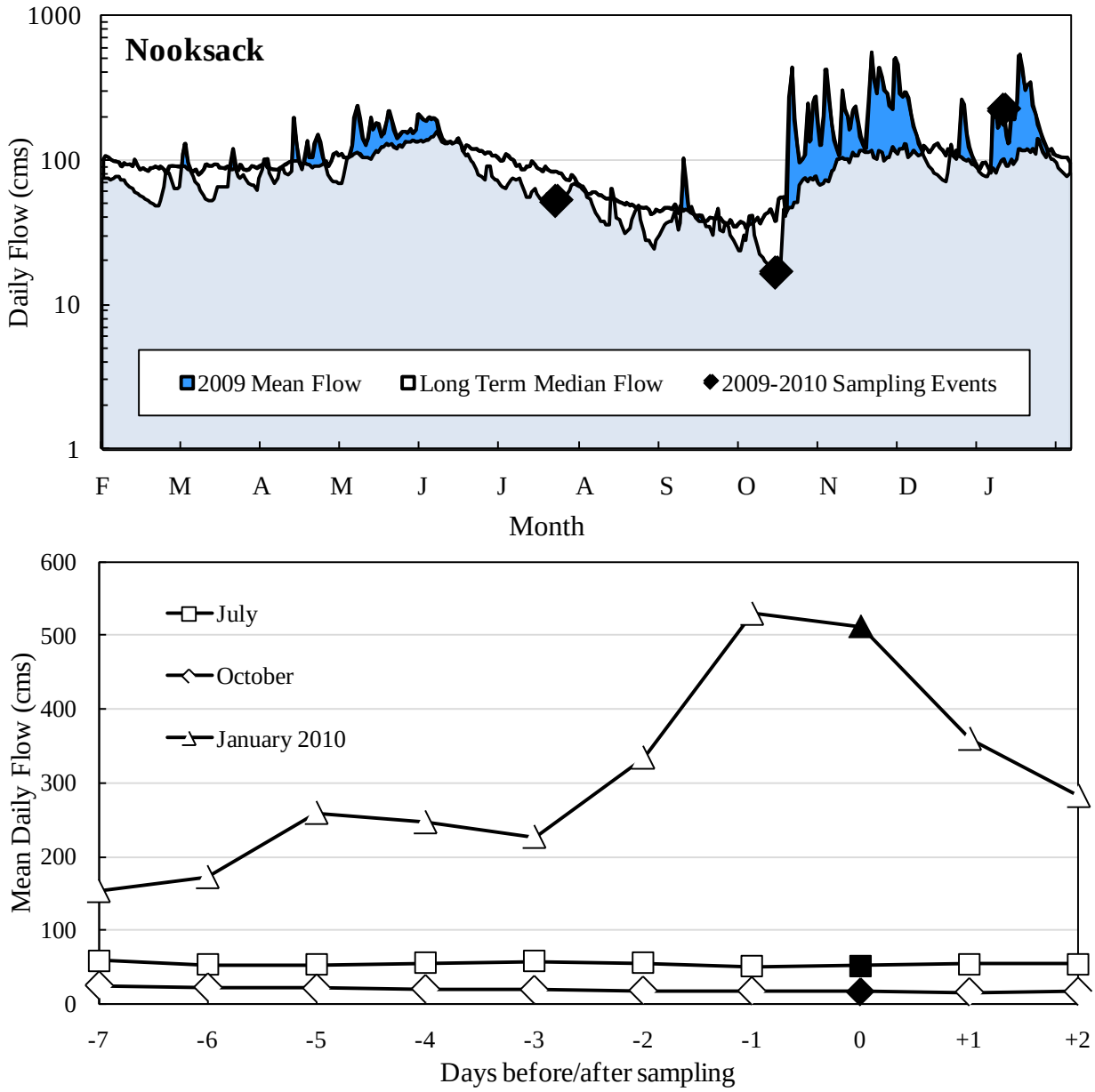

Figure 16. Nooksack River daily flows.

- Upper: Sampling events are shown as black diamonds on the hydrograph for mean daily flows during 2009 (shaded beneath). Relative to long-term median flows, periods of high flow appear as the darkest areas and periods of low flow appear under the white areas.
- Lower: Mean daily flows prior to, during, and immediately after each sampling event (solid black symbols).

July and October sampling occurred during baseflows, while sampling in January 2010 was near the peak of a runoff event.

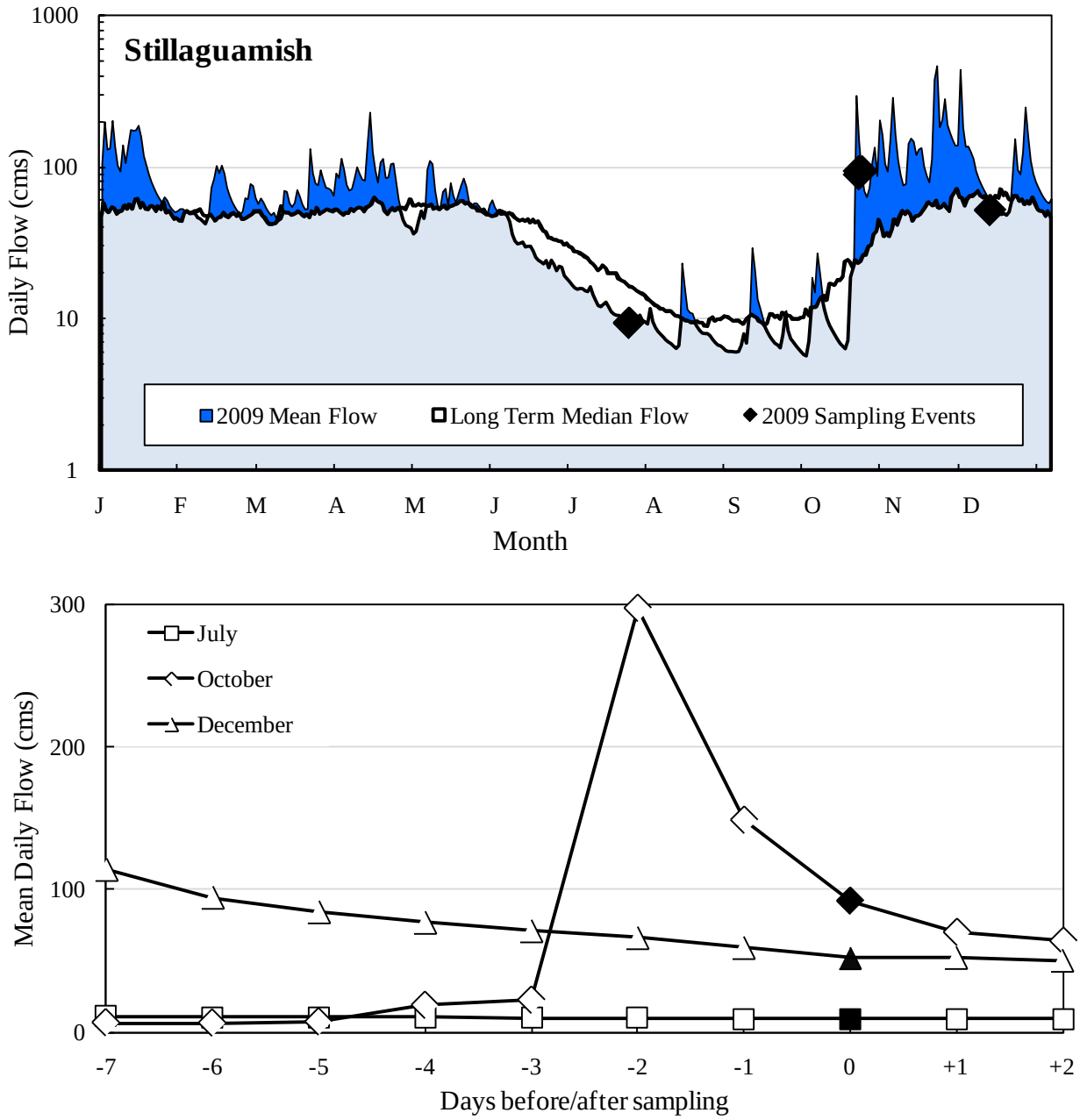

Figure 17. Stillaguamish River daily flows.

- Upper: Sampling events are shown as black diamonds on the hydrograph for mean daily flows during 2009 (shaded beneath). Relative to long-term median flows, periods of high flow appear as the darkest areas and periods of low flow appear under the white areas.
- Lower: Mean daily flows prior to, during, and immediately after each sampling event (solid black symbols).

  July and December sampling occurred during baseflows, while sampling in October was during the falling stage of a runoff event.

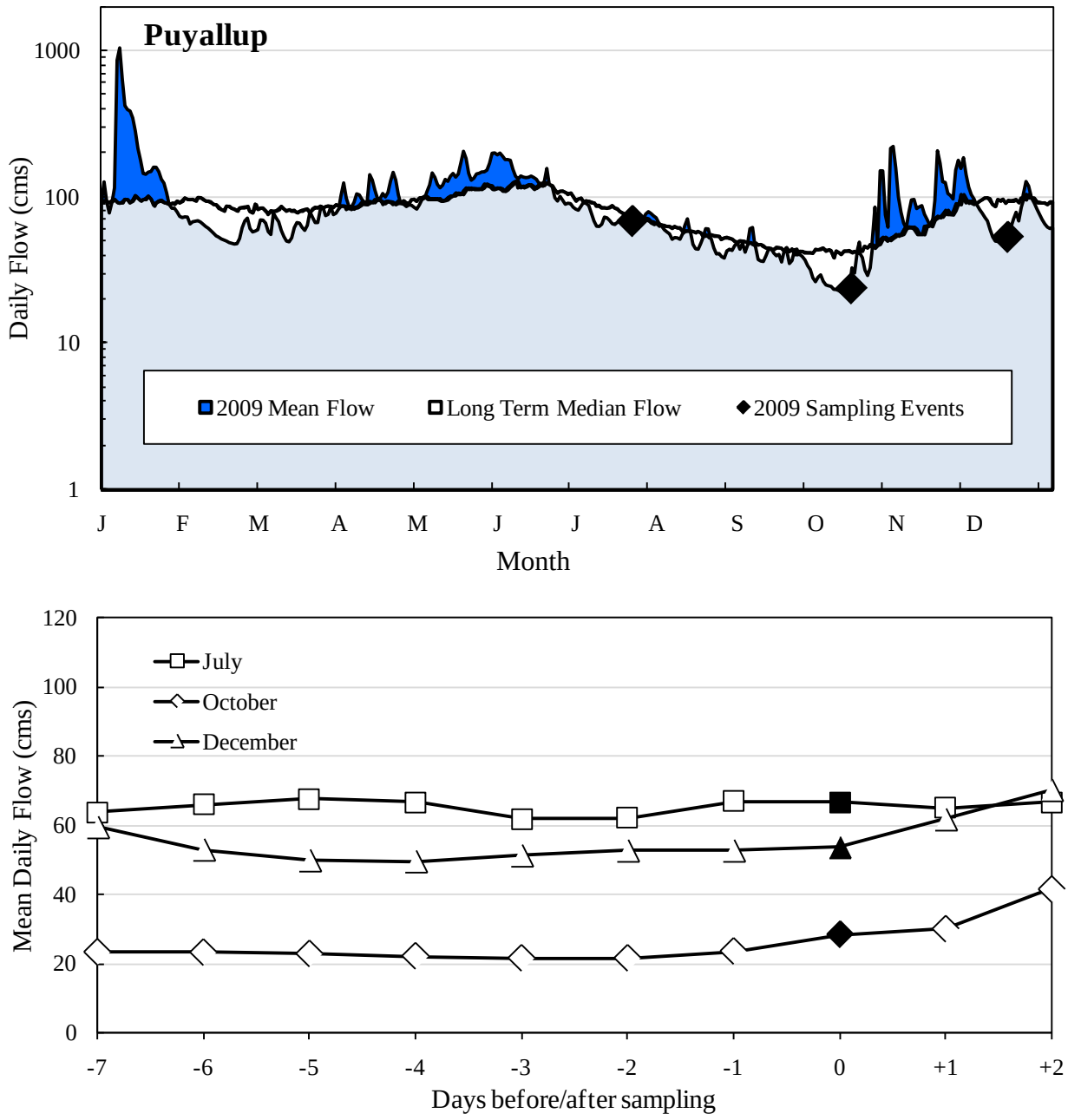

Figure 18. Puyallup River daily flows.

- Upper: Sampling events are shown as black diamonds on the hydrograph for mean daily flows during 2009 (shaded beneath). Relative to long-term median flows, periods of high flow appear as the darkest areas and periods of low flow appear under the white areas.
- Lower: Mean daily flows prior to, during, and after each sampling event (solid black symbols).

Sampling in July was during late seasonal runoff from melting Mt. Rainier glaciers. October sampling was during runoff from 1.33" of rainfall that fell upstream the previous day. The December sampling occurred under winter baseflow conditions, just prior to a runoff event.

Table 11 summarizes the mean daily flows for each river and sampling date, either measured or predicted from gaging station records. Base or runoff-related flow designations are also shown.

Flow conditions did not hinder sampling efforts except as follows. Swift currents made collecting water samples and pumping SPM from the desired depth (0.6 times the maximum mid-channel depth) more difficult. Sampling the Stillaguamish River in December was also complicated by the constant presence of disintegrating ice floes.

Table 11. Summary of field sampling activities for five major rivers discharging to Puget Sound.

River	Date	Mean Daily Flow [1]		Flow Type
		cfs	cms	
Summer – Sampling Event 1				
Skagit	7/21/09	10,500	297	Base
Snohomish	7/22/09	3,470	98.3	Base
Nooksack	7/21/09	1,840 [2]	52.1	Base
Stillaguamish	7/22/09	470 [2]	13.3	Base
Puyallup	7/23/09	2,380	67.4	-- [3]
QA replicate				
Fall – Sampling Event 2				
Skagit	10/13/09	5,400	153	Base
Snohomish	10/20/09	4,940	140	Runoff
Nooksack	10/12/09	590	16.7	Base
Stillaguamish	10/19/09	3,240	91.8	Runoff
Puyallup	10/15/09	1,000	28.3	Runoff
QA replicate				
Winter – Sampling Event 3				
Skagit	12/17/09	13,850	392	Runoff
Snohomish	12/22/09	18,400	521	Runoff
Nooksack	01/06/10	7,880	223	Runoff
Stillaguamish	12/08/09	~1,900	53.8	Base
Puyallup	12/14/09	1,860	52.7	Base
QA replicate				

[1] Flow predicted from stage height recorded at nearby USGS gaging station.
[2] Flow measured by Ecology stream monitoring staff on day of sampling.
[3] Neither baseflow nor related to recent precipitation. Suspended solids were related to seasonal runoff from glaciers, not from recent precipitation events.

The final number of samples collected (328) and analyses conducted (534) was similar to what was planned (Coots and Osterberg, 2009). Table 12 summarizes the analyses conducted on whole or filtered water samples.

Table 12. Inventory of analyses conducted on river water samples.

Parameter → / River ↓	TSS	TOC	DOC	Nutrients *	Hardness	Total Metals **	Dissolved Metals **	Oil & Grease	TPH-D	TPH-G	BNAs	PAHs	Chlorinated Pesticides	PCBs	PBDEs	Total
Skagit	3	3	3	15	3	15	15	3	3	5	3	3	3	3	3	83
Snohomish	3	3	3	15	3	15	15	3	3	5	3	3	3	3	3	83
Nooksack	3	3	3	15	3	15	15	3	3	5	3	3	3	3	3	83
Stillaguamish	3	3	3	15	3	15	15	3	3	5	3	3	3	3	3	83
Puyallup	3	3	3	15	3	15	15	3	3	5	3	3	3	3	3	83
QC samples	3	3	3	10	3	30	30	3	3	5	5	5	5	6	5	119
Total	18	18	18	85	18	105	105	18	18	30	20	20	20	21	20	534

* *Nutrients* include total nitrogen (TN), nitrate+nitrite, ammonia, total phosphorus, and ortho-phosphate (5 analyses per sample).

** 5 analyses (arsenic, cadmium, copper, lead, and zinc) per sample.

Conventional Parameters and Nutrients

Table 13 summarizes results for conventional parameters and nutrients. TSS ranged from a minimum 2.6 mg/L to a maximum 233 mg/L, and averaged 38 mg/L. The greatest concentrations of TSS in four rivers were associated with fall or winter runoff events (Figure 19). The maximum TSS in the Puyallup River (233 mg/L), measured in July, was from seasonal melting of glaciers. The overall mean TSS decreased to 24 mg/L when this value was excluded.

TOC and DOC averaged 1.3 mg/L and 1.5 mg/L, respectively. DOC exceeded TOC in 10 of 15 samples, averaging 115% of TOC. Organic carbon was consistently lowest in the summer. Concentrations were greatest in fall or winter and were usually associated with runoff events or increased TSS (Figure 20).

The mean concentration of total nitrogen (TN), 0.285 mg/L, was 85% dissolved inorganic forms. Concentrations of nitrate+nitrite nitrogen averaged about five times those of ammonia nitrogen. TN in all of the rivers was lower in the summer than in fall and winter (Figure 21), with the Skagit River containing the lowest concentrations. Concentrations of total phosphorus (TP) were associated with TSS, indicating that elevated TP concentrations would be expected in rivers carrying a high load of solids. Ortho-phosphate averaged 41% of TP. Ortho-P concentrations were greatest in the Puyallup River and least in the Skagit River (Figure 22).

Table 13. Summary statistics for conventional parameters and nutrients in river water.

Parameter	Times Detected	Percent Detected	Min.	25th %ile	Median	Mean	CV	75th %ile	Max.
Conventional Parameters (mg/L)									
TSS	15	100	2.6	5.1	11.9	38.0*	1.56	51.2	233
TOC	15	100	0.5	0.6	1.1	1.33	0.66	2.0	3.3
DOC	15	100	0.6	0.8	1.0	1.47	0.65	2.0	4.0
Nutrients (mg/L)									
Total Nitrogen (TN)	15	100	0.057	0.140	0.321	0.285	0.62	0.386	0.656
Nitrite (NO_2^-) + Nitrate (NO_3^-) Nitrogen	15	100	0.045	0.087	0.276	0.221	0.65	0.307	0.544
Ammonia Nitrogen	10	67	0.007	0.010	0.025	0.041	1.17	0.046	0.162
Total Phosphorus	15	100	0.006	0.016	0.032	0.054	1.15	0.078	0.250
Ortho-phosphate	15	100	0.003	0.005	0.010	0.014	0.89	0.019	0.048

* The mean concentration of TSS was 24 mg/L when the maximum (Puyallup River) value was excluded.

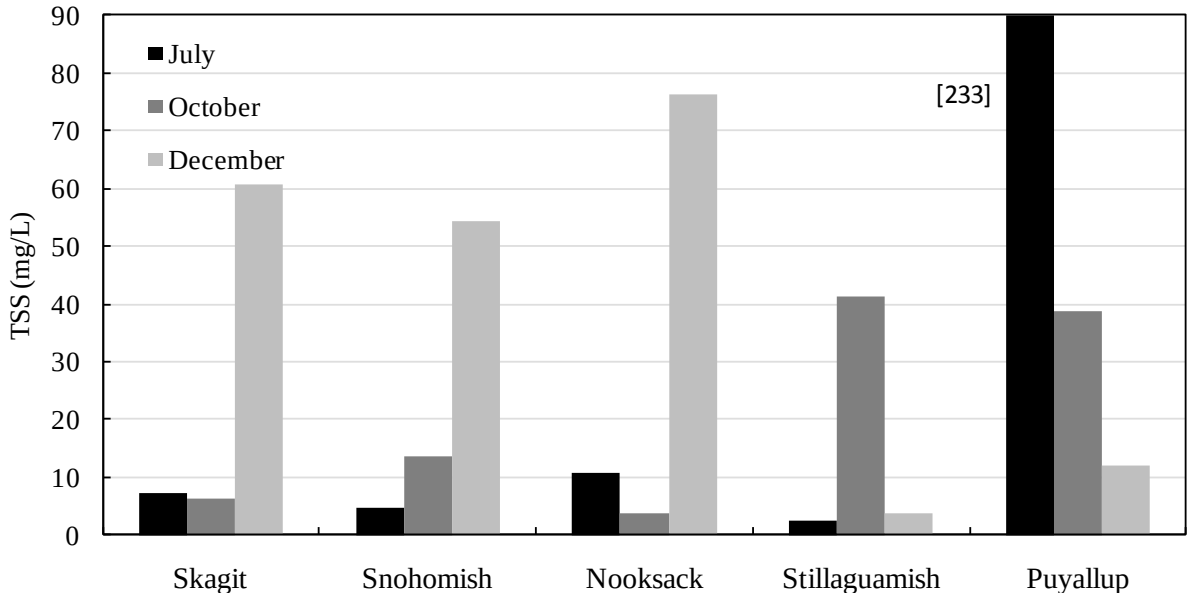

Figure 19. TSS near the mouths of major rivers discharging to Puget Sound in 2009.

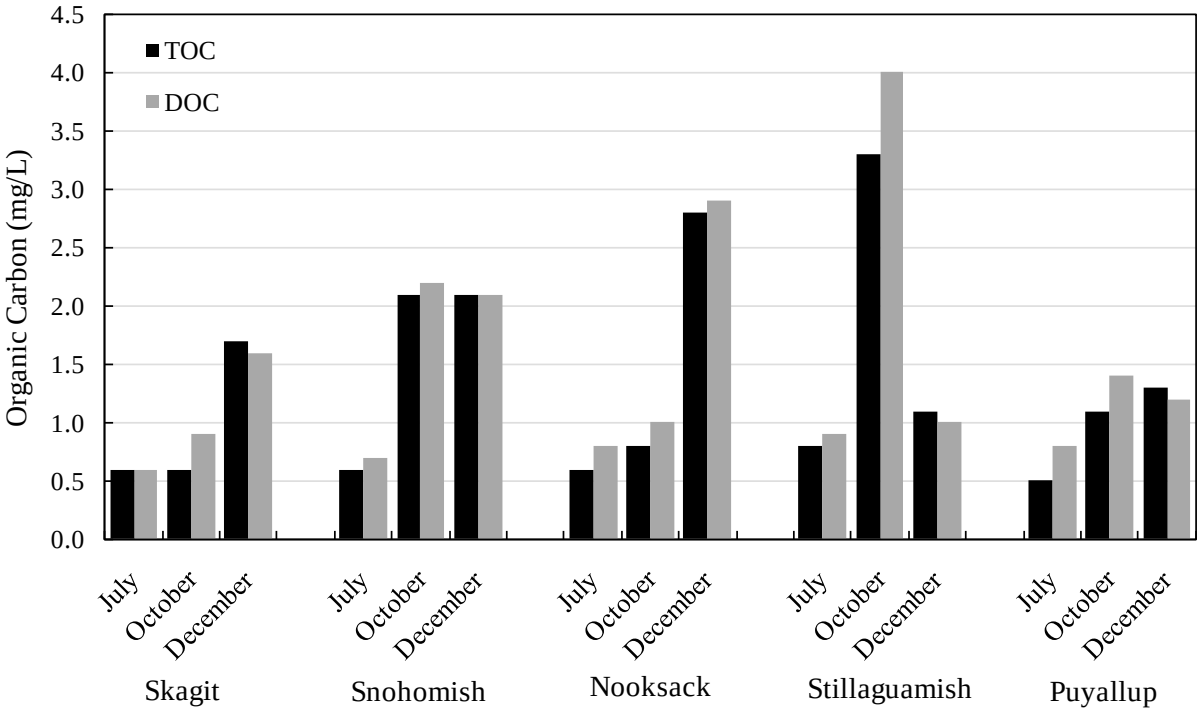

Figure 20. Organic carbon near the mouths of major rivers discharging to Puget Sound in 2009.

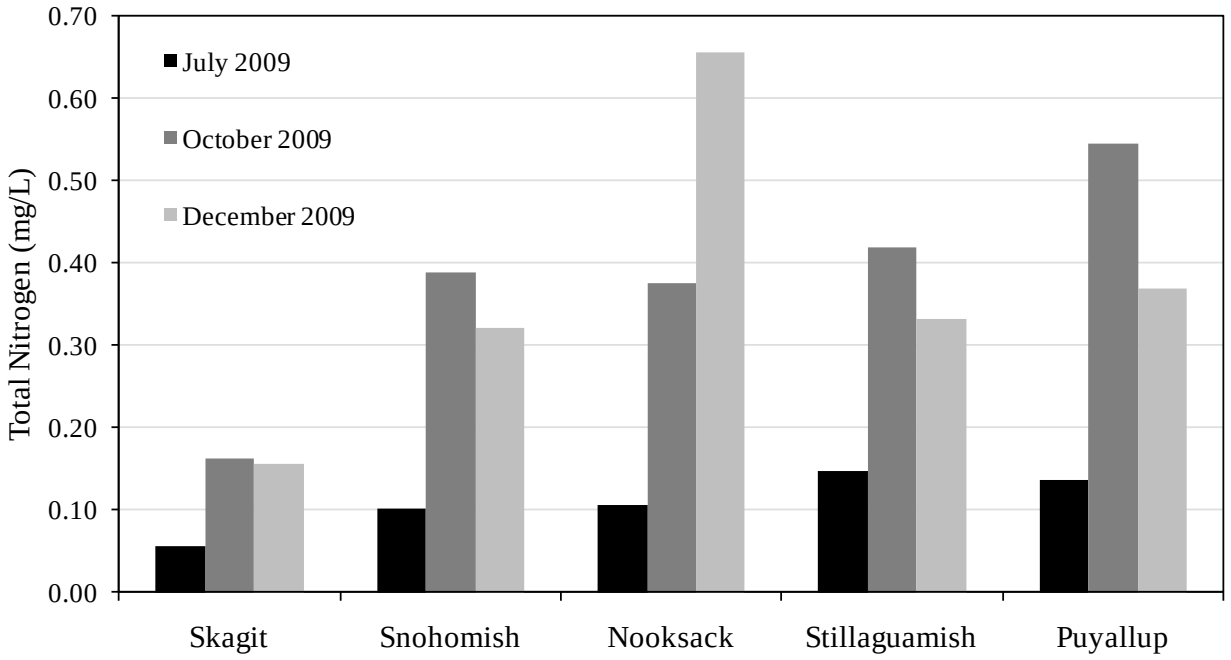

Figure 21. Total nitrogen near the mouths of major rivers discharging to Puget Sound in 2009.

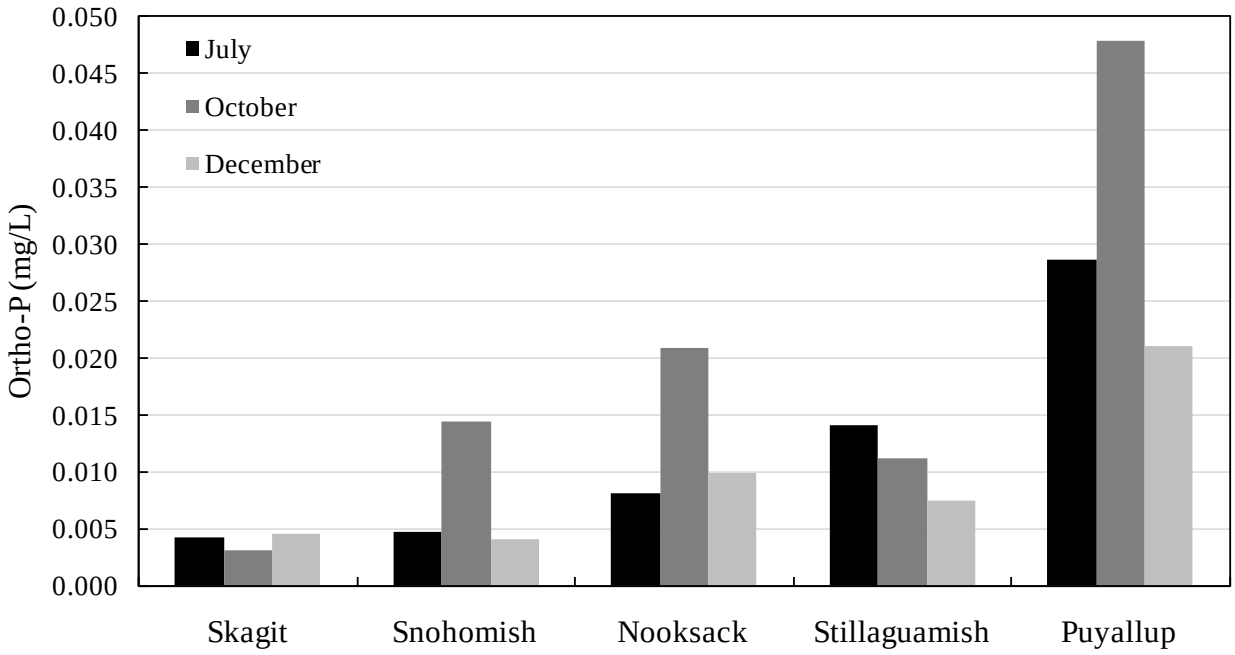

Figure 22. Ortho-phosphate near the mouths of major rivers discharging to Puget Sound in 2009.

Metals

Table 14 summarizes results for hardness, as well as for total recoverable and dissolved fractions of the five metals. The mean hardness for all water samples was 27.3 mg/L (as $CaCO_3$), and the low coefficient of variation (0.41) indicated relatively little variability between rivers. Mean values for total metal concentrations, ranked from high to low, were 6.41 µg/L zinc, 2.99 µg/L copper, 0.75 µg/L arsenic, 0.44 µg/L lead, and 0.012 µg/L cadmium. High total metal concentrations were associated with high TSS that usually accompanied runoff-related flows. This is shown for total copper and total zinc in Figures 23-24. Seasonal variability in concentrations of total arsenic, cadmium, and lead was similar.

The dissolved fraction generally made up the majority of total arsenic and cadmium concentrations. But the majority of copper, lead, and zinc was in particulate form. The relative contribution of particulate metals (total concentration minus dissolved concentration) tended to increase with TSS.

Table 14. Summary statistics for hardness and five metals measured in river water samples.

Parameter	Times Detected	Percent Detected	Min.	25th %ile	Median	Mean	CV	75th %ile	Max.
Hardness (mg/L)	15	100	13.2	20.5	29.9	29.8	0.41	35.6	62
Metals (µg/L)									
Arsenic, Total	15	100	0.26	0.52	0.73	0.75	0.41	0.99	1.24
Arsenic, Dissolved	15	100	0.300	0.463	0.500	0.524	0.30	0.595	0.860
Cadmium, Total	15	100	0.005	0.005	0.007	0.012	0.88	0.018	0.040
Cadmium, Dissolved	9	60	0.003	0.003	0.005	0.008	1.23	0.008	0.035
Copper, Total	15	100	0.75	1.13	1.81	2.99	0.99	4.33	11.6
Copper, Dissolved	15	100	0.35	0.547	1.00	1.20	0.82	1.57	4.19
Lead, Total	13	87	0.05	0.10	0.30	0.44	0.96	0.78	1.42
Lead, Dissolved	11	73	0.014	0.027	0.040	0.059	1.27	0.051	0.28
Zinc, Total	14	93	2.4	3.2	4.55	6.41	0.71	9.7	17.7
Zinc, Dissolved	15	100	0.70	0.92	1.40	1.88	0.65	2.95	4.40

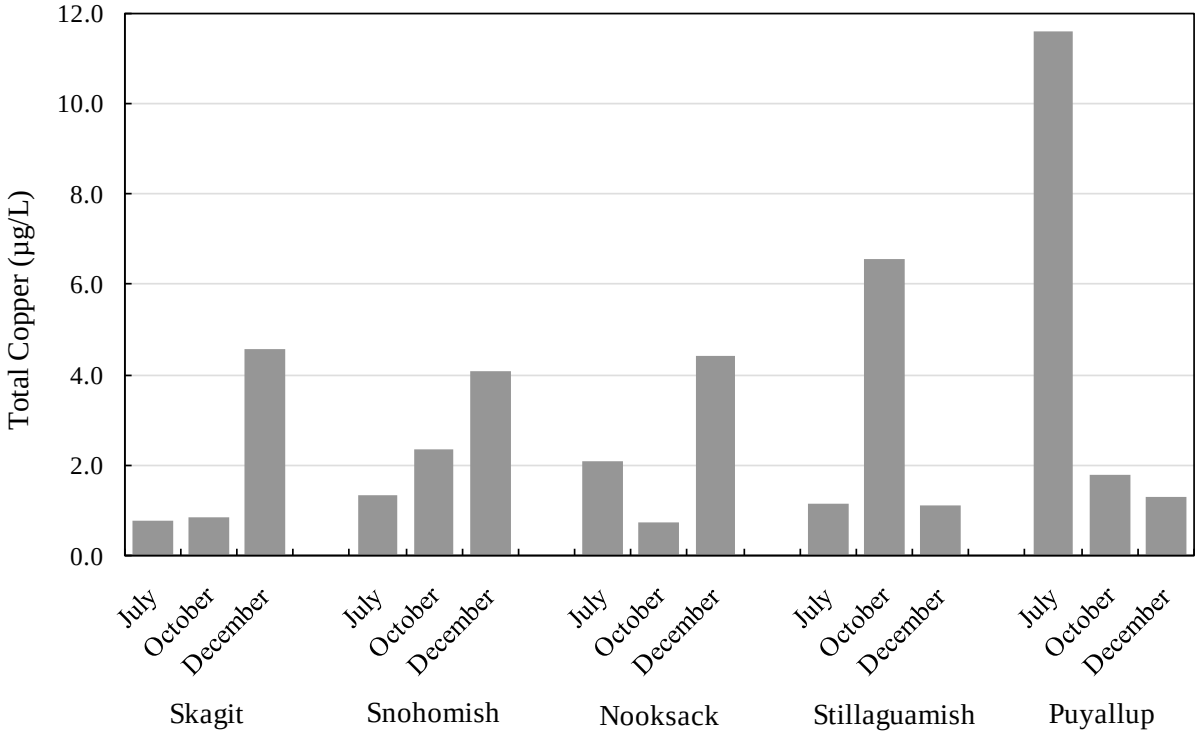

Figure 23. Total copper near the mouths of major rivers discharging to Puget Sound in 2009.

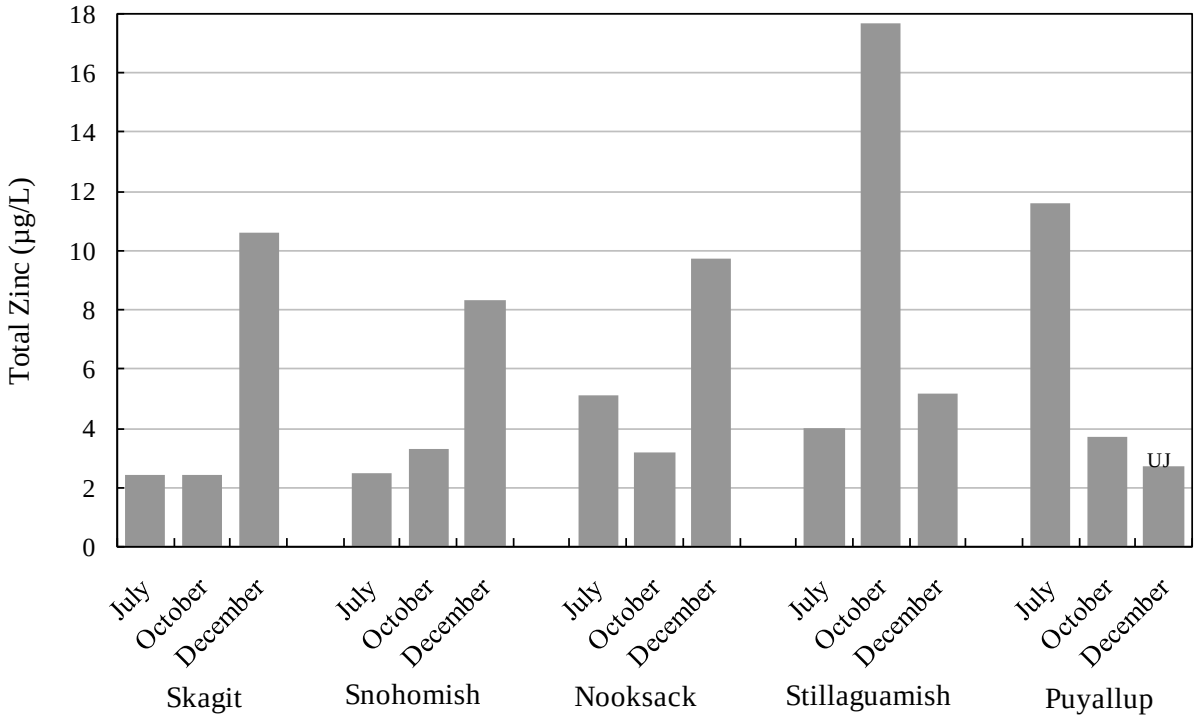

Figure 24. Total zinc near the mouths of major rivers discharging to Puget Sound in 2009.

Organics

Concentrations of 55 BNA, 22 PAH, and 32 chlorinated pesticide compounds were seldom detected. When detected, the compounds were often present in the corresponding method blank at a similar concentration. Table 15 summarizes results for these groups of organics. It shows that only five of the more than 100 compounds in these classes were detected in two or more samples:

- 4-methylphenol (various origins).
- Cholesterol (a biogenic steroid sometimes used as a marker for fecal material).
- Triethyl citrate (food additive, ingredient in cosmetics and pharmaceuticals, plasticizer).
- 1-methyl naphthalene (an occasional pesticide).
- Retene (a biomarker for higher order plants).

Measured concentrations were in the 0.0009 - 0.110 µg/L range. If one-half the RL was used to represent concentrations in nondetect samples, total PAH concentrations were in the range of 0.076 - 0.106 µg/L, and averaged 0.084 µg/L. The subset of seven carcinogenic PAH (cPAH) compounds [12] had toxic equivalent (TEQ) concentrations in the range of 0.009 - 0.014 µg/L, and a mean TEQ of 0.011 µg/L.

Table 16 summarizes results for petroleum-related compounds, total PCBs, and total PBDEs. Petroleum-related compounds were seldom detected. Oil and grease was detected in 40% of the samples (6 of 15), with MDLs ranging from 0.5 to 1.5 mg/L. Measured concentrations ranged from 0.9 - 2.8 mg/L, and averaged 1.6 mg/L. TPH-D or TPH-G were never detected despite MDLs of approximately 0.006 mg/L and 0.014 mg/L, respectively.

PCBs were present in all five rivers and 15 river water samples, with maximum concentrations recorded in three rivers during the fall (Figure 25). Total concentrations were always low: 2.6 - 59 pg/L. After assigning a "UJ" to congener concentrations less than three times (< 3X) those in corresponding method blanks, the average concentration of total PCBs was 16.3 pg/L [13]. The congeners detected most frequently were in the tri-chlorinated, tetra-chlorinated, and penta-chlorinated homolog groups. Congeners in the tri-chlorinated through hexa-chlorinated homolog groups made up an average 84% of total PCBs.

In contrast, PBDEs were detected in less than half of the river water samples. Total concentrations averaged 55.6 pg/L, but results were highly variable (CV = 1.67) within a range of 10.9 - 265 pg/L. PBDEs were detected in all five rivers during the summer, only in the Nooksack and Puyallup Rivers during the fall, and in no river during the winter. Congeners belonging to the tri-brominated and penta-brominated homolog groups were detected most frequently.

[12] Carcinogenic PAH compounds (cPAH) include benzo(a)pyrene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-c,d)pyrene

[13] If tentatively identified congeners were included, the mean concentration increased 55% to 25.3 pg/L.

Table 15. Summary of measurable BNAs, chlorinated pesticides, and PAHs in river waters.

		BNAs (µg/L)									PAHs (µg/L)					Chlorinated Pesticides (ng/L)	
Tributary	Date (2009)	2-methyl phenol	4-methyl phenol	4-nonyl phenol	BEHP	Bisphenol-A	Cholesterol	DINOP	Triclosan	Triethyl citrate	1-methyl naphthalene	2-methyl naphthalene	Benzo(a) anthracene	Naphthalene	Retene	Endosulfan sulfate	Hexachloro benzene
Skagit	10/13	--	--	--	--	--	0.63 J	--	--	0.058 J	0.0049 J	0.0089 J	--	--	--	--	--
	12/17	--	--	0.052 J	--	--	0.56 J	--	--	--	--	--	--	--	0.11	--	--
Snohomish	07/21	--	--	--	--	--	--	--	--	--	--	--	--	0.01	--	--	--
	10/20	--	0.093 J	--	--	--	0.73 J	--	--	--	--	--	--	--	--	--	--
	12/22	--	--	--	--	--	--	--	--	--	--	--	0.0009 J	--	0.003 J	--	--
Nooksack	10/12	--	--	--	--	--	--	--	--	0.06 J	0.0039 J	--	--	--	--	--	--
	01/06/10	--	--	--	--	--	--	--	--	--	--	--	--	--	0.0097 J	0.42	
Stillaguamish	10/19	--	0.05 J	--	--	0.072 J	0.49 J	--	--	--	--	--	--	--	--	--	1.6
	12/08	--	0.13 J	--	--	--	0.51 J	--	--	--	--	--	--	--	--	--	--
Puyallup	07/23	0.0058 J	--	--	--	--		--	--	--	--	--	--	--	--	--	--
	10/15	--	--	--	--	--	1.4	--	--	--	--	--	--	--	--	--	--
	12/14	--	--	--	0.074 J	--	0.57 J	--	--	--	--	--	--	0.024	0.0015 J	--	--
QA REP [1] (Puyallup)	10/15	--	--	--	--	--	1.4	0.16 J	0.081	0.31 J	0.0034 J	--	--	--	--	--	--

BEHP = Bis(2-Ethylhexyl) Phthalate; DINOP = Di-N-Octyl Phthalate

[1] QA replicate included only because some analytes were uniquely detected in this field replicate.

Table 16. Summary statistics for petroleum-related compounds, PCBs, and PBDEs in river waters.

Congener summation rules are described in Appendix D. Congeners in each homolog group are listed in Appendix E (Tables E-20 to E-22, and E-24). Concentrations of tentatively-identified congeners (results qualified as N or NJ) were not included in homolog or overall totals. Note: Homolog concentrations in a single sample can be summed to equal the total concentration in that sample, but summing the homolog statistics will not result in the total concentration statistics.

Parameter	Times Detected	Percent Detected	Min.	25th %ile	Median	Mean	CV	75th %ile	Max.
Petroleum-related compounds (mg/L)									
TPH-D and TPH-G	0	0	-	-	-	-	-	-	-
Oil and Grease	6	40	0.9	1.4	1.4	1.6	0.40	1.6	2.8
PCB homologs and totals (pg/L)									
Mono-chlorinated	5	33	1.71	1.75	1.80	2.03	0.21	2.14	2.73
Di-chlorinated	9	60	0.71	1.78	2.04	2.52	0.62	2.98	6.14
Tri-chlorinated	13	87	0.80	2.11	3.37	3.73	0.68	3.91	9.68
Tetra-chlorinated	12	80	0.54	1.40	2.10	3.85	1.16	4.51	16.5
Penta-chlorinated	13	87	0.81	1.16	2.74	5.76	1.38	6.49	28.7
Hexa-chlorinated	12	80	0.60	1.12	2.66	3.00	0.77	3.86	8.63
Hepta-chlorinated	2	13	0.72	--	1.11	1.11	--	--	1.51
Octa-chlorinated	2	13	1.14	--	1.21	1.21	--	--	1.28
Nona-chlorinated	0	0	--	--	--	--	--	--	--
PCB-209	1	7	1.09	--	1.09	1.09	--	--	1.09
Total PCBs	15	100	2.61	5.95	9.96	16.27 *****	0.95	19.2	59.0
PBDE homologs and totals (pg/L)									
Mono-brominated	0	0	--	--	--	--	--	--	--
Di-brominated	0	0	--	--	--	--	--	--	--
Tri-brominated	4	27	5.18	7.94	11.6	10.4	0.35	12.9	13.3
Tetra-brominated	1	7	17.0	--	17.0	17.0	--	--	17.0
Penta-brominated	4	27	10.8	11.2	12.6	17.6	0.64	24.0	34.2
Hexa-brominated	0	0	--	--	--	--	--	--	--
Hepta-brominated	0	0	--	--	--	--	--	--	--
Octa-brominated	0	0	--	--	--	--	--	--	--
Nona-brominated	0	0	--	--	--	--	--	--	--
PBDE-209	1	7	260	--	260	260	--	--	260
Total PBDEs	7	47	10.9	13.4	22.3	55.6	1.67	33.0	265

***** The mean concentration of total PCBs in river water would be approximately 60% higher if concentrations of tentatively-identified congeners ("N" and "NJ") were also included.

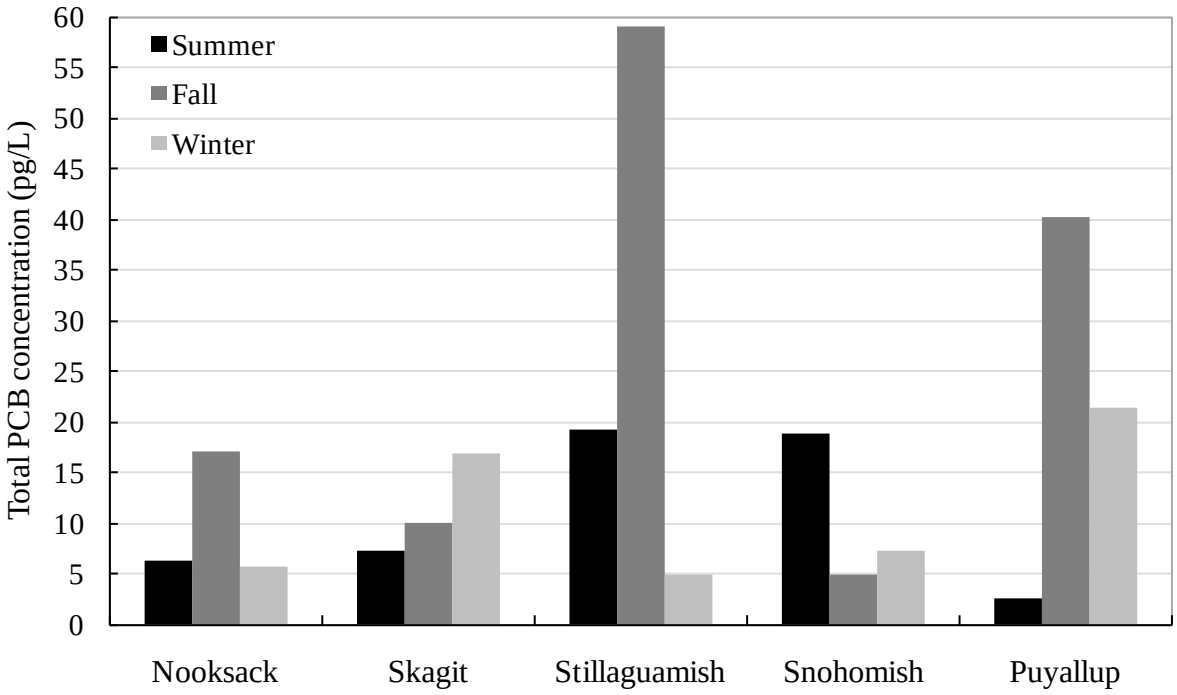

Figure 25. Total PCBs near the mouths of major rivers discharging to Puget Sound in 2009.

River SPM

Collecting suspended solids from river water using pump-and-centrifuge methods required an average of 18 hours per site (Table 17), not including setup and demobilization time. River water was usually pumped at rates of 10 - 13 liters (2.6 - 3.4 gallons) per minute. At these pump rates, SPM retention efficiencies were highly correlated with inflowing TSS concentrations ($r^2 = 0.95$), and the mean efficiency was 72%. Five samples of suspended solids were collected by the centrifuges, one from each river. Sample mass ranged from 153 to 960 wet grams, which was equivalent to approximately 67 to 660 dry grams.

Table 17. Collection of suspended solids from five rivers by continuous-flow centrifuges.

River	Start Date	End Date	Average Pump Rate		Pump Time (hrs)	Volume Pumped (liters)	Inflow TSS (mg/L)	Outflow TSS (mg/L)	Estimated Efficiency (%)
			gpm	L/hr					
Skagit	12/16/09	12/17/09	2.31	524	17.13	8,970	65.8	22.1	66
Snohomish	12/22/09	12/23/09	2.37	539	16.00	8,620	42.6	8.8	79
Nooksack	01/05/10	01/06/10	2.34	531	14.67	7,790	168	97.8	42
Stillaguamish	12/08/09	12/09/09	2.64	599	22.00	13,180	6.4	0.3	95
Puyallup	12/13/09	12/14/09	2.59	588	20.08	11,800	72.2	17.7	75

Conventional Parameters

Table 18 summarizes results for the five samples of suspended river solids. Suspended particulate matter contained 0.36 - 1.88% TOC (mean = 1.2 %).

Metals

Mean concentrations of total metals were rank ordered as were whole water samples: 68.7 mg/kg zinc, 36.5 mg/Kg copper, 7.79 mg/Kg arsenic, 5.86 mg/Kg lead, and 0.16 mg/Kg cadmium.

Organics

BNAs were rarely detected. Only cholesterol, its degradate (3-beta coprostanol), and BEHP were found in all samples. TPH-D, analyzed in BNA extracts, was not detected. Unlike whole water, 16 of 22 PAH compounds were detected in more than one-half the SPM samples. Individual PAHs averaged less than 20 µg/Kg, except for retene (mean = 230 µg/Kg). Mean concentrations of high and low molecular weight PAHs were similar. Total PAHs, excluding retene, ranged from 32 - 210 µg/Kg and averaged 119 µg/Kg. Pesticides were virtually absent from particulates collected this time of year (winter). PCBs were measured in all samples, as were PBDEs. The average concentrations of total PCBs and total PBDEs were 408 ng/Kg and 1680 ng/Kg, respectively.

Table 18. Summary statistics for parameters measured in SPM collected from five rivers.

Parameter (dry weight basis units)	Times Detected	Percent Detected	Min.	25th Percentile	Median	Arithmetic Mean	CV	75th Percentile	Max.
Conventional Parameters (%)									
TOC	5	100	0.36	0.81	1.46	1.23	0.48	1.59	1.88
Metals (mg/Kg)									
Arsenic	5	100	1.45	5.21	6.62	7.79	0.59	11.65	13.3
Cadmium	5	100	0.04	0.11	0.17	0.16	0.49	0.21	0.24
Copper	5	100	17.2	24.6	33.0	36.5	0.43	52.1	53.5
Lead	5	100	1.57	3.74	5.35	5.86	0.54	8.66	9.55
Zinc	5	100	20.3	45.4	77.4	68.7	0.48	91	106
BNAs (µg/Kg)									
3-Beta Coprostanol	5	100	220	235	260	340	0.55	400	670
4-Methylphenol	3	60	43	45	52	58	0.32	72	78
4-Nonylphenol	1	20	15	-	15	15	1.0	-	15
Benzoic acid	1	20	310	-	310	310	1.0	-	310
BEHP	5	100	170	215	510	490	0.67	655	1,000
Bisphenol A	1	20	20	-	20	20	1.0	-	20
Cholesterol	5	100	410	928	1,300	2,560	1.33	3,200	8,600
Phenol	1	20	26	-	26	26	1.0	-	26
TPH-D	0	0	-	-	-	-	-	-	-
PAHs (µg/Kg)									
1-Methylnaphthalene	5	100	3.6	4.9	6.4	9.3	0.65	14.3	18
2-Chloronaphthalene	0	0	-	-	-	-	-	-	-
2-Methylnaphthalene	5	100	6.1	7.4	11	15.2	0.67	23.3	30
Acenaphthene	0	0	-	-	-	-	-	-	-
Acenaphthylene	0	0	-	-	-	-	-	-	-
Anthracene	4	80	1.5	1.5	2.1	3.1	0.79	4.6	6.6
Benzo(a)anthracene	4	80	1.6	2.6	4.1	4.2	0.53	5.8	6.9
Benzo(a)pyrene	3	60	2.8	3.0	3.7	4.5	0.48	6.1	6.9
Benzo(b)fluoranthene	4	80	2.0	5.0	9.5	8.8	0.59	12.5	14

Table 18 (continued). Summary statistics for parameters measured in SPM collected from five rivers.

Parameter (dry weight basis units)	Times Detected	Percent Detected	Min.	25th Percentile	Median	Arithmetic Mean	CV	75th Percentile	Max.
PAHs (µg/Kg)									
Benzo(g,h,i)perylene	5	100	1.8	2.0	5.2	5.7	0.74	8.8	12
Benzo(k)fluoranthene	2	40	1.7	1.7	1.9	1.9	0.15	2.1	2.1
Total Benzofluoranthenes	4	80	2.0	6.1	11.4	9.7	0.56	13.4	14
Carbazole	0	0	--	--	--	--	--	--	--
Chrysene	5	100	2.3	2.7	9.6	8.3	0.67	13	15
Dibenzo(a,h)anthracene	2	40	0.9	0.9	1.0	1.0	0.14	1.1	1.1
Dibenzofuran	5	100	1.4	1.6	3.2	3.9	0.78	5.4	8.8
Fluoranthene	5	100	2.1	2.9	8.9	9.0	0.74	14	18
Fluorene	4	80	1.1	2.5	4.1	4.2	0.63	6.0	7.6
Indeno(1,2,3-c,d)pyrene	5	100	0.9	1.2	3.1	3.6	0.77	5.6	7.5
Naphthalene	5	100	2.7	3.2	8.8	9.0	0.74	13	19
Phenanthrene	5	100	6.7	6.7	22	20	0.66	30	36
Pyrene	5	100	3.5	4.2	11	11	0.64	18	18
Retene	5	100	60	90	280	230	0.63	333	400
Individual PAHs *	82	71	--	--	--	--	--	--	--
Low molecular weight PAHs	5	100	20.9	23.2	55.1	59.1	0.68	88.1	117
High molecular weight	5	100	10.6	15.6	64.3	51.8	0.70	78.6	93.3
Total PAHs	5	100	31.5	38.9	119	111	0.68	167	211
Chlorinated Pesticides (µg/Kg)									
DDE, DDT, hexachlorobenzene, pentachloroanisole	1 each	<1	--	--	--	--	--	--	--
Other pesticides	0	0	--	--	--	--	--	--	--
PCBs and PBDEs (ng/Kg)									
Total PCBs	5	100	150	202	366	408	0.67	557	845
Total PBDEs	5	100	522	671	1,033	1,676	1.03	2,230	4,696

* 82 detected concentrations out of 105 possible results (23 individual PAH compounds measured per sample x 5 samples).

Discussion

Marine Water Column

Comparison with Historical Data

Serdar (2008) conducted a review of readily available data collected since 1995 on selected toxic chemicals in Puget Sound and the boundary waters of the Straits of Juan de Fuca and Georgia. Little existing data were found, especially for organic compounds. Despite the paucity of existing data for the region, the information compiled provides an indication of the range of concentrations that might be expected for each target chemical. Table 19 presents a comparison of results from the present 2009-10 study to existing data.

While data collected for the present study were in good agreement with concentration ranges from historical data (with few exceptions), the 2009-10 results yielded new insights into the variability and range of ambient concentrations:

- Total and dissolved measurements of arsenic, cadmium, and copper agreed well with previously reported values, but also revealed slightly broader ranges of ambient concentrations. Arsenic and cadmium results tended to be somewhat higher than comparable data, while copper concentrations were generally lower than historical values.
- Previously reported total lead concentrations for the region were at the low end of the range of 2009-10 project results, which tended to be markedly higher and more variable. Nearly half of the project measurements were above the highest historical concentration.
- Total zinc concentrations were in good agreement with previous measurements. The exception was the maximum concentration of 7.44 mg/L measured in the deep water sample collected from Hood Canal in July 2009. This was five times greater than the concentration measured in any other sample and may represent the high end of the concentration range for total zinc in marine ambient waters [14].
- The mean concentration of total PCBs in regional marine waters (26.3 pg/L) and for boundary waters (20.4 pg/L) were lower than the mean concentrations reported by Dangerfield et al. (2007) for surface and deep Canadian waters. The diversity of sites and multiple depths sampled for the present study may provide a better indication of the variability in total PCBs concentrations that can be expected in regional waters.
- Total PBDE concentrations spanned a wide range throughout the region. Previously available data were limited and provided a low estimate of typical ambient concentrations. Current project data, however, exposed marked variability in total PBDEs. Concentrations were below detection limits in more than 75% of project samples, but detected total PBDE concentrations were often at least 10 times greater than those reported by Dangerfield et al. (2007). There was no evidence from QC data that the samples had been contaminated. One explanation for the dissimilar results may be that the discrete samples from the present study

[14] It was noted that concentrations of most metals in Hood Canal SPM were also greater than those measured in SPM collected from traps deployed in the more developed South Sound region.

captured heterogeneous concentrations of PBDEs that could be diluted when collecting time-integrated pump samples as was done by Dangerfield et al.

- Organic carbon concentrations throughout Puget Sound and the oceanic boundary waters were very similar to those reported by Johannessen et al. (2008).
  - Results of the present study indicate that the organic carbon concentration records taken from Ecology's EIM database and used by Pelletier and Mohamedali (2009) were above typical ambient concentrations. Past methods used to collect and handle seawater samples for analysis of organic carbon were likely susceptible to contamination. The rigorous sampling procedures used throughout the present study (see Appendix C) appeared to be more successful at preventing contamination.
  - A single high POC result (1.78 mg/L) fell outside the range of concentrations observed by Johannessen et al. (2008; maximum observed POC of 0.36 mg/L). However this result is not unrealistic and may be representative of POC concentrations associated with elevated productivity, as there was high TSS and a strong phytoplankton bloom (revealed by CTD fluorescence profile) at the time of sample collection.
  - The median concentration of TOC in deep waters entering Puget Sound (0.73 mg//L) was greater than the mean of 0.53 mg/L TOC reported for deep waters further west in the Strait of Juan de Fuca (Johannessen et al., 2008) and for typical mid-ocean concentrations (0.5 mg/L; J. Sharp, pers. comm.).

Table 19. Marine water column results compared to previously reported concentration ranges.

Parameter	Present Study Results					Historical Data		
	N	Median	Mean	Low	High	Reported Values		Data Sources*
						Low	High	
Conventional Parameters (mg/L)								
TSS	42	1.6	1.75	0.8	6.0	0.0	64.1	4, 7
DOC	28	0.754	0.757	0.611	0.969	< 0.44	2.16	3, 7
POC	28	0.059	0.133	0.028	1.780	< 0.01	> 5.0	3, 7
TOC	28	0.807	0.891	0.660	2.749	< 0.48	79	3, 7
Metals (µg/L)								
Arsenic, Total	42	1.41	1.42	1.16	1.56	0.41	2.0	1, 8, 9
Arsenic, Dissolved	42	1.42	1.42	1.26	1.70	0.42	2.0	1, 8, 9
Cadmium, Total	42	0.084	0.085	0.059	0.112	0.040	0.075	1, 8, 9
Cadmium, Dissolved	42	0.081	0.083	0.067	0.111	0.031	0.076	1, 8, 9
Copper, Total	42	0.38	0.41	0.19	1.37	0.19	1.3	1, 4, 5, 8, 9
Copper, Dissolved	42	0.30	0.31	0.16	0.51	0.31	1.0	1, 4, 5, 6, 8
Pb Total	37	0.070	0.085	0.015	0.230	< 0.006	0.069	1, 4, 5, 8, 9
Zn Total	42	0.69	0.87	0.41	7.44	0.20	1.3	1, 4, 5, 8
Organics (pg/L)								
Total PCBs	42	24.0	26.3	6.09	75.1	40.3	43.5	2
Total PBDEs	10	749	2,860	51	18,700	14.8	23.4	2

* Data sources:

1. Crecelius (1998) data from the Straits of Georgia and Juan de Fuca, 1997.
2. Dangerfield et al. (2007) data from Boundary Pass and Rosario Strait, Strait of Georgia.
3. Johannessen et al. (2008) data from the Straits of Juan de Fuca and Georgia, 2003.
4. Johnson (2009) data from the Strait of Juan de Fuca, Guemes Channel, and Commencement Bay, 2008-2009.
5. Johnson (2009) summary of King County Department of Natural Resources and Parks data from the Strait of Juan de Fuca for the period 1997-2000.
6. Johnson (2009) summary of Johnson and Summers (1999) data from Commencement Bay, 1997-1998.
7. Pelletier and Mohamedali (2009) summary of EIM data for various Box Model regions; POC calculated as the difference of TOC and DOC.
8. Serdar (2008) summary of KCDNR data for Puget Sound, 1996-2002.
9. Serdar (2008) summary of EIM data for Puget Sound, 1995-2007.

Patterns and Relationships

The nonparametric Kruskal Wallis Test and Test of Medians were used to determine the significance of differences in parameter concentrations. These tests were used because chemical concentrations seldom reflected a normal distribution and only some log-normal distributions became normal when transformed (Appendix J, Table J-1). Test results provided in Table J-2 showed that concentrations of some chemicals were statistically different between regions, seasons, and depth layers.

- **Regional differences**. Comparing all sample results from the three ocean boundary sites (from both depths and all seasons) to those from the four Puget Sound basin sites revealed:
  - Mean concentrations of DOC, TOC, total and dissolved copper, and total PCBs were significantly greater in Puget Sound samples than in ocean boundary waters.
  - Mean concentrations of total and dissolved cadmium in ocean boundary waters were significantly greater than in the basins of Puget Sound.

- **Seasonal differences**. Comparisons of the seasonal mean chemical concentrations (measured at all stations and depths) yielded the following:
  - TSS, total arsenic, and total and dissolved copper concentrations were significantly lower in October than in July or January.
  - Concentrations of all forms of organic carbon were significantly higher in October 2009 than in January 2010.
  - Total PCB concentrations were greatest in the fall.

- **Water column depth layer differences.** Results from all stations and seasons were pooled by collection depth for comparison of surface and deep layer concentrations. Samples were additionally separated by region to test for layer differences within the boundary waters or the Puget Sound basin waters.
  - For the entire sampling area, mean concentrations of total and dissolved arsenic and total lead were significantly lower in the surface layer than in the deep layer.
  - In the Puget Sound basins, dissolved arsenic had significantly greater mean concentrations in the deep layer compared to the surface layer.
  - In ocean boundary waters, mean concentrations of dissolved arsenic, total and dissolved cadmium, and total lead in the deep layer were significantly greater than those in the surface layer.
  - For ocean boundary waters, the mean DOC concentration in the surface layer was significantly greater than the mean DOC in the deep layer.
  - Mean concentrations of total PCBs were significantly lower in the surface layer of ocean boundary waters, Puget Sound basins, and all locations combined than in the deep layer (Figure 26).

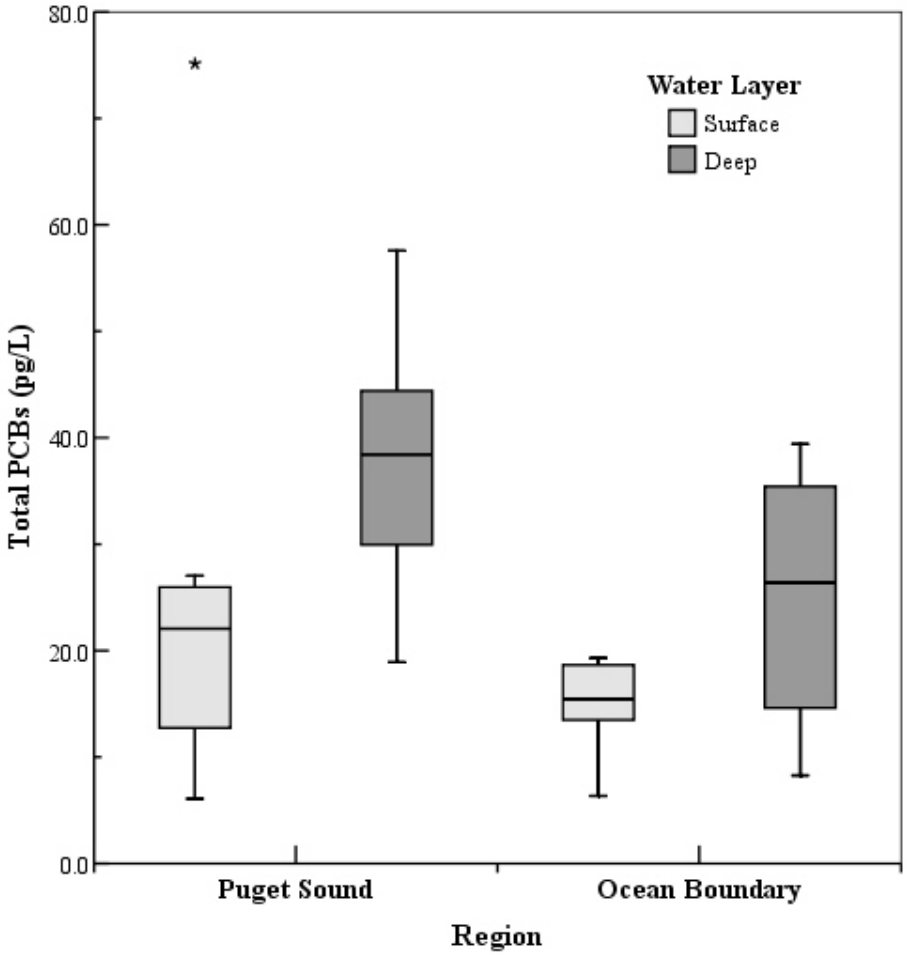

Figure 26. Total PCB concentrations in surface and deep marine water column samples.

Spearman rank correlation analysis was conducted to identify relationships between different chemicals. Results are presented in Appendix J, Table J-3. Significant relationships included:

- Suspended solids were negatively correlated with organic carbon. Both dissolved and particulate forms of organic carbon tended to decrease with increasing TSS.
- Organic carbon was negatively correlated with total and dissolved forms of arsenic and cadmium. When DOC (the main fraction of TOC) was relatively high, concentrations of these metals were low.
- Concentrations of most metals species were positively correlated.
- Total PCBs appeared linked to the presence of particles, as indicated by positive correlations with TSS.
- Total PCB concentrations were negatively correlated with TOC, and its main constituent DOC, in water column samples. (There was no correlation between PCBs and POC.)
- There was no apparent relationship between concentrations of PBDEs and other parameters.

Of the spatial patterns, temporal trends, and parameter relationships identified through statistical analyses, an interesting discovery was that total PCB concentrations in the deep waters were significantly higher than in the surface waters. This was true for all samples but also for the four Puget Sound basin sites and the three ocean boundary water sites separately (Figure 26). This finding was somewhat counterintuitive, as major sources of PCBs were expected to be surface inputs from urban-industrial centers (e.g., stormwater, surface runoff, atmospheric deposition). PCBs from land-based sources may have diminished by the time they reached the mid-basin and ocean boundary sampling sites because:

- Total PCB concentrations derived from land-based sources are diluted by Puget Sound surface waters containing lower PCB concentrations.
- Suspended, particle-bound PCBs settle through the water column into deeper waters.
- Total PCBs are transported downslope from the nearshore environment because of bathymetry- or density-driven focusing processes.

The significant positive correlation between total PCBs and TSS (Table J-3) suggests that sedimentation and sediment focusing contribute to total PCB concentrations in deep waters greater than those in surface waters.

Ocean Exchange

One objective of the present 2009-10 study was to measure concentrations of toxic chemicals in ocean boundary waters. These are generally considered to be near the west entrance to the Strait of Juan de Fuca. However, models of Puget Sound circulation and transport consider the north end of Admiralty Inlet to be the main seaward boundary (Pelletier and Mohamedali, 2009; Babson et al., 2006). This is where higher salinity and density deep waters flow *into* Puget Sound, and lower salinity and density surface waters flow *out of* the Sound. Accordingly, water column samples were collected from sites in the Strait of Juan de Fuca and Haro Strait (Figure 1) where deep water chemistry better represents that of water entering Puget Sound.

Samples were collected from central locations in four Puget Sound basins (Figure 1), but only results from the Main, Whidbey, and Hood Canal basin sites were used to represent water flowing out of Puget Sound for ocean exchange calculations [15]. Chemical concentrations measured in these samples were weighted in proportion to predicted flows from each basin into Admiralty Inlet and used to represent concentrations that exit Puget Sound [16]. To represent chemical concentrations in water leaving Puget Sound through Deception Pass (near Anacortes, Washington), Whidbey Basin surface water sample results were used.

The direction of net exchange with the ocean (ocean exchange) for different chemicals was evaluated using estimates of annual mass transport into and out of Puget Sound. A range of annual mass transport was calculated using 25th and 75th percentile chemical concentrations.

[15] Results for Strait of Juan de Fuca and Haro Strait surface samples were not used to represent water flowing out of Puget Sound because they may have been influenced by sources outside of Puget Sound (Fraser River water).

[16] The Box Model predicted that Main, Whidbey, and Hood Canal basins contribute 56.4%, 27.4%, and 16.2% of the flow into Admiralty Inlet, respectively.

These were multiplied by Box Model-predicted flows into and out of Puget Sound across the two seaward boundaries:

- The long-term median flow of deep water *into* Puget Sound through Admiralty Inlet was -18,555 cms (-5.85 x 10^{11} m^3/year).
- The long-term median flow of surface water *out of* Puget Sound was 20,300 cms (6.40 x 10^{11} m^3/year), with 18,771 cms flowing out through Admiralty Inlet and 1,529 cms flowing out through Deception Pass.

Results of ocean exchange calculations are presented in Tables 20-22. Concentration ranges for TSS, TOC, metals, and organic compounds measured in deep ocean boundary waters are shown in Table 20. The table also presents probable ranges for annual chemical mass transport into Puget Sound. Table 21 shows concentrations of the same chemicals in Puget Sound surface waters, along with ranges for chemical mass transport out of Puget Sound. Table 22 combines results from the previous tables to yield estimates of net chemical exchange between Puget Sound and the ocean boundary waters. Example calculations follow.

The procedure for calculating net exchange of total arsenic, based on median concentrations, is described here. First, the mass of arsenic imported into Puget Sound was calculated by multiplying the median deep boundary water concentration (1.49 µg/L = 1.49 mg/m^3) by the annual incoming volume of water (-5.85 x 10^{11} m^3/year). This resulted in an estimate of -8.72 x 10^{11} mg/year, equivalent to -872 mT/year (see Table 20). Second, the mass of total arsenic exported from Puget Sound through Admiralty Inlet was calculated as the flow-weighted median surface water concentration of the three most northern Puget Sound stations times the outflow volume. The mass exported through Deception Pass was calculated as the median surface water concentration measured at the Whidbey Basin site times the Deception Pass outflow volume. The total exported mass was estimated to be 895 mT/year (Table 21). Finally, the net exchange based on median concentrations, 23 mT/year, was the sum of the exported and imported masses (see Table 22).

The net ocean exchange is positive - out of Puget Sound - for most chemicals. This assumes that the chemical concentrations measured in marine water column samples for the present study adequately represent those transported into and out of the Sound.

Estimates of net exchange predicted that copper and organic carbon were exported from Puget Sound. The export resulted from concentration differentials combined with the net flow of water out of the Sound. For copper, mean and median concentrations in deep boundary waters were not significantly different from those in surface waters leaving the Sound [17]. Nevertheless, the flow-weighted median total copper concentration exiting Puget Sound (0.40 µg/L) was 43% greater than the median value for incoming boundary deep waters (0.28 µg/L). Factors contributing to the concentration differential included:

- Relatively high copper concentrations in surface runoff (the median concentration of total copper in 15 river water samples was 1.81 µg/L).
- Formation of copper complexes that remain dissolved in surface waters.

[17] Kruskal Wallis (means), p = 0.18; Test of Medians, p = 0.64.

TOC concentrations in surface waters of Puget Sound were significantly greater than concentrations in deep waters near the ocean boundary [18]. The flow-weighted median TOC concentration in surface waters leaving Puget Sound (1.17 mg/L) was 60% greater than the median deep water concentration near the ocean boundary (0.73 mg/L). The difference was likely due to:

- Organic carbon loading from surface runoff (rivers).
- Primary productivity in the euphotic zone (especially when the water column was stratified).
- Decomposition of organic carbon in deep waters.

Table 22 shows that TSS, arsenic, zinc, and PAHs were probably exported from Puget Sound. For these parameters, there was no more than a 13% difference between concentrations in surface waters leaving and concentrations in deep boundary waters entering Puget Sound [19]. Therefore, the net flow of water out of Puget Sound played more of a role in the export of these chemicals than did concentration differences. These chemicals could have been imported into Puget Sound if 75th percentile concentrations were used to represent inflows and 25th percentile concentrations represented outflows.

The negative net exchange values in Table 22 indicated that cadmium and lead were imported into Puget Sound. For cadmium, the median concentration in deep boundary waters (0.92 µg/L) was significantly greater than the median for surface waters leaving Puget Sound (0.80 µg/L) [20]. As in the case of copper, concentrations of lead were not significantly different for inflow and outflow waters. However, the median concentration in deep boundary waters (0.109 µg/L total lead) was sufficiently higher than and the flow-weighted median concentration in surface waters leaving Puget Sound (0.065 µg/L) to cause a net import. Only if the 75th percentile concentration of total lead was used to represent outflows and the 25th percentile concentration represented inflows was export indicated.

The direction of net exchange for total PCBs and total PBDEs between ocean boundary waters and Puget Sound was unclear based on results of the present study. Combinations of annual mass transport into or out of Puget Sound indicated these chemicals could be imported or exported (Table 22). Net ocean exchange for total PCBs could range from an export of approximately 2-12 kg/yr to an import of approximately 1-11 kg/yr. Total PBDE concentrations were detected in four deep boundary water samples and two surface water samples. Variable concentrations (CV = 2) led to a large interquartile range for PBDE concentrations and net annual ocean exchange estimates that indicated total PBDEs might be exported or imported. Total PCBs and total PBDEs were likely exported because concentrations in deep boundary waters entering and surface waters leaving Puget Sound were not significantly different [21] and net flow of water is out of Puget Sound. Any net import of total PCBs or total PBDEs into Puget Sound would need to be confirmed by means of future sampling and analysis. If

[18] Kruskal Wallis and Test of Medians, $p<0.01$.

[19] Test of Medians showed no significant difference between inflow and outflow concentrations for these chemicals.

[20] Test of Medians, $p<0.02$. The mean concentration of total cadmium in deep boundary waters was also significantly greater than the mean concentration in Puget Sound surface layer waters (Kruskal Wallis, $p<0.02$).

[21] Kruskal Wallis test results for chemistry of deep boundary water vs. surface Puget Sound waters: $p<0.27$ for total PCBs and $p<0.64$ for total PBDEs.

confirmed, and caused by a substantial concentration differential, then the explanation might involve:

- Adsorption of total PCBs and PBDEs to suspended particles in surface runoff (rivers) entering the Sound.
- Dilution and settling of such suspended particles into the deep waters of major basins before being transported beyond ocean boundaries.
- Ongoing sources of PCBs and PBDEs contributing to the deep boundary waters entering Admiralty Inlet.

To summarize, ranges of values for net ocean exchange of various chemicals were presented in this section (Table 22). The ranges were derived from different estimates of annual chemical mass transport into and out of Puget Sound. Each mass transport estimate was based on two variables – annual flow and chemical concentration. Annual flows across the two boundaries between the Sound and the ocean (Admiralty Inlet and Deception Pass) were long-term median values predicted by the Puget Sound Toxics Box Model [22]. Concentration ranges were calculated from the limited chemical results of the present study.

As such, this evaluation of net ocean exchange was exploratory in nature. Furthermore, this evaluation did not attempt to address transport and fate processes within Puget Sound (e.g., chemical partitioning, horizontal transport, sedimentation and resuspension, burial, volatilization, and biological degradation) that are better examined by modeling.

[22] Calculations did not incorporate interannual variability in flows.

Table 20. Chemical concentrations in deep ocean boundary waters and estimates of annual mass transport *into* Puget Sound.

Percentile concentrations were derived from results for Haro Strait, SJdF North, and SJdF Sill stations.
Annual mass transport estimates were based on the concentrations shown and the predicted median annual flow of deep water into Admiralty Inlet for 2000-2050 (see text). Flows and transports into the Sound are shown as negative values.

			Percentile Concentrations			Range of Mass Transport *into* Puget Sound (mT/year)		
Parameter	UOM	N	25%	Median	75%	25%	Median	75%
Conventional Parameters and Metals								
TSS	mg/L	9	1.2	1.6	2.0	-700,000	-940,000	-1,200,000
DOC	mg/L	6	0.63	0.66	0.69	-370,000	-380,000	-410,000
POC	mg/L	6	0.04	0.06	0.07	-25,000	-34,000	-41,000
TOC	mg/L	6	0.70	0.73	0.75	-410,000	-430,000	-440,000
Arsenic, Total	µg/L	9	1.44	1.49	1.52	-842	-872	-889
Arsenic, Dissolved	µg/L	9	1.43	1.44	1.50	-835	-841	-875
Cadmium, Total	µg/L	9	0.091	0.092	0.097	-53	-54	-57
Cadmium, Dissolved	µg/L	9	0.091	0.096	0.102	-53	-56	-60
Copper, Total	µg/L	9	0.24	0.28	0.41	-140	-160	-240
Copper, Dissolved	µg/L	9	0.20	0.23	0.26	-120	-140	-150
Lead, Total [1]	µg/L	8	0.087	0.11	0.12	-51	-63	-73
Zinc, Total [1]	µg/L	9	0.53	0.68	0.88	-310	-400	-520
Total PAHs								
∑ Nondetects (ND = ½ RL)	µg/L	0	0.080	0.080	0.084	-47	-47	-49
∑ Nondetects (ND = MDL)	µg/L	0	0.024	0.050	0.081	-14	-29	-48
Total PCBs								
∑ Congeners or Homologs	pg/L	9	14.6	26.4	35.4	-0.0086	-0.0155	-0.0207
Total PBDEs								
∑ Detected values only	pg/L	4	290	1,740	7,000	-0.17	-1.0	-4.1
∑ All values (ND = ½ EQL)	pg/L	9	760	830	1,600	-0.44	-0.49	-0.94
∑ All values (ND = EQL_{max})	pg/L	9	130	135	370	-0.076	-0.079	-0.22
∑ All values (ND = 0)	pg/L	9	0.0	0.0	370	0.000	0.000	-0.22

[1] Summary statistics for concentrations of dissolved lead and zinc are not presented because dissolved concentrations sometimes exceeded total concentrations such that distinguishing valid results from ones that reflected field or laboratory contamination was difficult.

UOM = units of measure

N = number of detected values upon which estimates were based

ND = nondetect

½ RL = one-half reporting limit; MDL = method detection limit; EQL_{max} = maximum estimated quantitation limit (similar to RL) for individual PBDE congeners

Table 21. Concentrations of chemicals in surface Puget Sound waters and estimates of annual mass transport *out of* Puget Sound.

Percentile concentrations were derived from results for Main, Whidbey, and Hood Canal stations. Annual mass transport estimates were based on concentrations shown and the predicted median annual flows of surface water out through Admiralty Inlet and Deception Pass for 2000-2050.

			Flow-weighted (see text) Percentile Concentrations			Range of Annual Mass Transport *out of* Puget Sound through Admiralty Inlet (mT/yr)				Percentile Concentrations			Range of Mass Transport *out of* Puget Sound through Deception Pass (mT/yr)		
Parameter	UOM	N	25%	Median	75%	25%	Median	75%	N	25%	Median	75%	25%	Median	75%
Conventional Parameters and Metals															
TSS	mg/L	9	1.3	1.7	2.2	780,000	1,000,000	1,300,000	3	1.7	2.6	4.05	82,000	125,000	195,000
DOC	mg/L	6	0.77	0.80	0.82	460,000	470,000	490,000	2	0.87	0.87	0.87	42,000	42,000	42,000
POC	mg/L	6	0.18	0.32	0.46	110,000	190,000	270,000	2	0.93	0.93	0.93	45,000	45,000	45,000
TOC	mg/L	6	0.96	1.12	1.28	570,000	661,000	755,000	2	1.80	1.80	1.80	87,000	87,000	87,000
As Total	µg/L	9	1.36	1.39	1.42	803	825	841	3	1.39	1.45	1.49	67.2	70.0	72.0
As Dissolved	µg/L	9	1.35	1.37	1.42	797	812	840	3	1.34	1.37	1.41	64.8	66.2	67.9
Cd Total	µg/L	9	0.078	0.079	0.082	46	47	49	3	0.081	0.082	0.084	3.9	4.0	4.1
Cd Dissolved	µg/L	9	0.072	0.074	0.077	43	44	46	3	0.071	0.074	0.077	3.4	3.5	3.7
Cu Total	µg/L	9	0.38	0.40	0.42	230	240	250	3	0.41	0.44	0.46	20	21	22
Cu Dissolved	µg/L	9	0.33	0.35	0.37	190	210	220	3	0.35	0.37	0.39	17	18	19
Pb Total [1]	µg/L	9	0.047	0.066	0.087	28	39	51	3	0.047	0.061	0.080	2.3	3.0	3.8
Zn Total [1]	µg/L	9	0.72	0.77	0.80	430	450	480	3	0.70	0.70	0.79	34	34	38
Total PAHs															
∑ Nondetects (ND = ½ RL)	µg/L	0	0.079	0.080	0.081	47	47	48	0	0.078	0.078	0.080	3.8	3.8	3.9
∑ Nondetects (ND = MDL)	µg/L	0	0.036	0.049	0.065	21	29	39	0	0.036	0.049	0.064	1.7	2.4	3.1
Total PCBs															
∑ Congeners or Homologs	pg/L	9	15.8	20.8	30.1	0.0094	0.0138	0.0178	3	13.6	18.4	46.8	6.5E-4	8.9E-4	2.2E-3
Total PBDEs															
∑ Detects only	pg/L	2	460	460	460	0.27	0.27	0.27	1	1,300	1,300	1,300	0.063	0.063	0.063
∑ All values (ND = ½ EQL)	pg/L	9	600	770	1,100	0.36	0.46	0.65	3	800	840	1,100	0.039	0.041	0.053
∑ All values (ND = EQL_{max})	pg/L	9	140	160	350	0.083	0.095	0.21	3	130	140	720	6.3E-3	6.8E-3	0.035
∑ All values (ND = 0)	pg/L	9	0.0	0.0	230	0.000	0.000	0.14	3	0.0	0.0	650	0.000	0.000	0.031

[1] Summary statistics for concentrations of dissolved lead and zinc are not presented here. Dissolved concentrations sometimes exceeded total concentrations such that distinguishing valid results from ones that reflected field or laboratory contamination was difficult.

Abbreviations as in Table 20.

Table 22. Range of net ocean exchange of various chemicals based on estimated annual mass transport *into* and *out of* Puget Sound.
Positive net exchange transport values indicate export from Puget Sound.

		Range of Annual Mass Transport *into* Puget Sound (Table 20)			Range of Annual Mass Transport *out of* Puget Sound (Table 21)			Range of Estimated Net Annual Ocean Exchange (*Sum of values in appropriate columns to the left*)				
Parameter	UOM	25%	Median	75%	25%	Median	75%	25% *in*/ 25% *out*	Median *in*/ Median *out*	75% *in*/ 75% *out*	Low 75% *in*/25% *out*	High 25% *in*/75% *out*
Conventional Parameters and Metals												
TSS	mT/yr	-700,000	-940,000	-1,200,000	860,000	1,100,000	1,500,000	160,000	160,000	300,000	-340,000	800,000
DOC	mT/yr	-370,000	-380,000	-410,000	500,000	510,000	530,000	130,000	130,000	120,000	90,000	160,000
POC	mT/yr	-25,000	-34,000	-41,000	150,000	230,000	320,000	125,000	200,000	280,000	110,000	300,000
TOC	mT/yr	-410,000	-430,000	-440,000	650,000	750,000	840,000	240,000	320,000	400,000	210,000	430,000
As Total	mT/yr	-842	-872	-889	870	895	913	28	23	24	-19	71
As Dissolved	mT/yr	-835	-841	-875	861	878	908	26	37	33	-14	73
Cd Total	mT/yr	-53	-54	-57	50	51	53	-3.2	-2.9	-3.9	-7	-0.4
Cd Dissolved	mT/yr	-53	-56	-60	46	47	50	-7.1	-8.8	-10	-14	-3.7
Cu Total	mT/yr	-140	-160	-240	250	260	270	110	100	30	10	130
Cu Dissolved	mT/yr	-120	-140	-150	210	230	240	90	90	90	60	120
Pb Total [1]	mT/yr	-51	-63	-73	30	42	55	-21	-21	-18	-43	4.3
Zn Total [1]	mT/yr	-310	-400	-520	460	480	510	150	80	-10	-60	200
Total PAHs												
∑ Nondetects (ND = ½ RL)	mT/yr	-47	-47	-49	51	51	52	3.9	4.1	3.0	1.9	5.1
∑ Nondetects (ND = MDL)	mT/yr	-14	-29	-48	23	32	42	8.8	2.6	-5.8	-25	28
Total PCBs												
∑ Congeners or Homologs	mT/yr	-0.0086	-0.0155	-0.0207	0.0100	0.0147	0.0201	0.0014	-0.0008	-0.0006	-0.0107	0.0115
Total PBDEs												
∑ Detected values only	mT/yr	-0.17	-1.0	-4.1	0.33	0.33	0.33	0.16	-0.67	-3.77	-3.8	0.16
∑ All values with ND = ½ EQL	mT/yr	-0.44	-0.49	-0.94	0.40	0.50	0.70	-0.041	0.011	-0.24	-0.54	0.26
∑ All values with ND = EQL_{max}	mT/yr	-0.076	-0.079	-0.22	0.089	0.10	0.24	0.013	0.021	0.025	-0.13	0.16
∑ All values with ND = 0	mT/yr	-0.00	-0.00	-0.22	0.000	0.000	0.17	0.000	0.000	-0.049	-0.22	0.17

[1] Summary statistics for concentrations of dissolved lead and zinc are not presented here. Dissolved concentrations often exceeded total concentrations such that distinguishing valid results from ones that reflected field or laboratory contamination was difficult.
Abbreviations as in Table 20.

Sedimentation Rates for Toxics

Sediment traps deployed in Hood Canal from October 2009 through January 2010 collected marine particulates from that basin's deep layer. Archived mid-water solids from the Case and Carr Inlets, composited from material collected from March to June 2008 (Norton, 2009), were resurrected for comparison.

Sedimentation rates ($g/cm^2/yr$) were calculated for both locations by dividing the total dry mass of solids collected by the surface area of the traps, and by the duration of deployment. Since resuspended particulates could potentially be included in the trap material, these values should be considered estimates of *gross* sedimentation. Mass accumulation rates ($mass/cm^2/yr$; also called "downward flux") for each parameter were determined by multiplying the measured concentration by the sedimentation rate.

Sedimentation rates from the present study are summarized in relation to historical rates for other areas of Puget Sound in Table 23. The sedimentation rate in the deep waters of Hood Canal was comparable to rates measured by Norton (2009) in the Case+Carr Inlets. Both rates were markedly lower than rates typical of more urban embayments.

Table 23. Gross sedimentation rates for various areas of Puget Sound.

Source	Location	Mean Sedimentation Rate (dry $g/cm^2/yr$)
Present Study (2009-10)	Hood Canal	0.2
Present Study; Norton, 2009	Carr+Case Inlets	0.3
Norton, 2009	Eld Inlet	1.6
Norton, 2009	Budd Inlet	1.0
Norton and Boatman, 1998	Inner Budd Inlet	1.4
Norton, 1996	Inner Commencement Bay	1.5
Norton and Michelson, 1995	Elliott Bay Waterfront	0.7

Analyses conducted on the Hood Canal solids and on the archived Case+Carr Inlet material from Norton (2009) allowed estimation of the downward flux for various parameters. The measured concentrations and calculated mass accumulation rates are presented in Table 24.

Downward flux of organic carbon was low at both sites relative to rates found in more urban embayments. Norton (2009) measured average TOC accumulation rates of 0.048 and 0.033 $g/cm^2/yr$ in the Eld and Budd Inlets, while the Case+Carr Inlet solids averaged 0.011 $g/cm^2/yr$. The Hood Canal TOC accumulation rate from the present study was even lower at 0.007 $g/cm^2/yr$. Likely contributing factors included distance from anthropogenic inputs, lower biological productivity during the late fall and early winter period of deployment, and depth of collection (below the surface mixed layer).

Table 24. Summary of mass accumulation rates for solids, TOC, metals, PCBs, and PBDEs.

All concentrations reported on a dry weight basis.

Parameter	Hood Canal		Case+Carr Inlets	
	Concentration	Mass Accumulation Rate ($g/m^2/yr$)	Concentration	Mass Accumulation Rate ($g/m^2/yr$)
Solids (g)	7.9	2,400	20.7*	3,440
TOC (%)	2.75	66	4.47*	154
As (mg/Kg)	7.53	0.018	5.72	0.020
Cd (mg/Kg)	0.87	0.002	1.04	0.004
Cu (mg/Kg)	82.0	0.197	18.5	0.064
Pb (mg/Kg)	9.13	0.022	8.78	0.030
Zn (mg/Kg)	90.0	0.217	72.0	0.248
PCBs (ng/Kg)	2,970	7.1E-6	9,850	33.9E-6
PBDEs (ng/Kg)	1,580	3.8E-6	1,060	3.6E-6

* Values from Norton (2009)

Metals concentrations in Hood Canal particulates were slightly higher than those from the Case+Carr Inlets for four of the five metals analyzed. With the exception of copper, however, mass accumulation rates of all metals were similar at these sites. Hood Canal copper concentrations were more than four times higher than those measured in Case+Carr Inlet SPM, and the resulting mass accumulation rate in Hood Canal was estimated to be three times greater than that of the Case+Carr Inlets.

Total PCB concentrations were markedly higher in SPM from the Case+Carr Inlets than in SPM collected from Hood Canal. This was consistent with expectations, as South Puget Sound is more highly developed and has more potential sources of PCBs than Hood Canal. Mass accumulation rates in the Case+Carr Inlets and Hood Canal were estimated to be 0.0339 and 0.0071 $mg/m^2/yr$, respectively.

Differences in total PBDE concentrations and mass accumulation rates between the two sites were minor. Rates of total PBDE accumulation were estimated to be 0.0038 and 0.0036 $Kg/m^2/yr$ in Hood Canal and Case+Carr Inlets, respectively.

Rivers

Comparison with Historical Data

Average concentrations of TSS, TOC, and nutrients in the five rivers, based on three seasonal samples, were within ranges obtained from EIM data and other studies (Table 25). The mean values were also remarkably similar to historical median or mean values (Appendix I, Table I-4). In general, the same was true for river water hardness and total metal concentrations (Table 26; Appendix I, Table I-5).

Table 27 compares the concentrations of organic compounds that were measured or estimated for the present 2009-10 study with concentrations reported by other studies. TPH concentrations were never detected. The detection frequency for oil and grease was 40% (6/15), and the measured concentrations ranged from 0.9 - 2.8 mg/L in the five rivers. The mean concentration of 1.6 mg/L changed little when nondetect values were included (1.7 mg/L when ND = ½ RL; 1.2 mg/L when ND = MDL). According to Herrera (2010a), this mean concentration would be observed with reasonable frequency in all land use categories except commercial/industrial.

Possible reasons for the low detection frequency and low mean concentrations included:

- The compounds were not present at the time of sampling (e.g., lost due to volatilization).
- Standard sampling methods failed to collect the surface-most layers most likely to contain compounds less dense than water.
- Current analytical methods could not detect the compounds after the dilution that occurred between points of discharge and sampling locations.

MEL seldom detected PAHs in whole river water samples even with low detection limits. Six of the 15 samples contained concentrations of individual PAHs in the 0.0009 - 0.11 µg/L range. Assuming nondetect concentrations are one-half the RL, total PAH concentrations ranged from 0.076 - 0.11 µg/L. Assuming nondetect concentrations are one-half the MDL, the range was 0.012 - 0.055 µg/L. Using the latter assumption, the range of cPAH concentrations was 0.009 - 0.014 µg/L. This was within the range of cPAH concentrations measured in Lower Green River near Tukwila (<0.001 - 0.040 µg/L; Willston, 2008).

The range of total PCB concentrations measured in the five rivers (2.6 - 59 pg/L) was lower than the range reported for the Green/Duwamish River system (83 - 814 pg/L). It was also lower than most probability-of-exceedance concentrations listed for different land uses in Herrera (2010a). Lower concentrations of toxic organic compounds would generally be expected in the five rivers sampled for the present study than in the Green/Duwamish River system, other areas of commercial/industrial land use, or highway runoff.

Table 25. Concentrations of conventional parameters and nutrients (mg/L) measured in major rivers discharging to Puget Sound.

River	Study/ Data Source	TSS	TOC	DOC	Total Nitrogen	Nitrite/Nitrate Nitrogen	Ammonia - Nitrogen	Total Phosphorous	Ortho-Phosphorous
Skagit	Present Study Mean (n=3 or as noted) Range	24.8 6.4-60.8	1.0 0.6-1.7	1.0 0.6-1.6	0.13 0.057-0.163	0.08 0.045-0.126	0.046 (1) --	0.033 0.006-0.086	0.004 0.003-0.005
	EIM Range [1]	1.0-1,230	0.5-7.0	--	0.033-0.48	0.020-0.200	0.010-2.65	0.003-0.737	0.001-0.030
	Wise et al., 2007 Range [2]	13.6-78.5	--	--	0.13-0.17	--	--	0.02-0.05	--
Snohomish	Present Study Mean and Range	24.3 4.7-54.5	1.6 0.6-2.1	1.7 0.7-2.2	0.271 0.102-0.389	0.211 0.077-0.281	0.044 0.008-0.079	0.032 0.009-0.053	0.008 0.004-0.014
	EIM Range	1.0-260	0.8-6.1	--	0.030-0.840	0.073-0.368	0.010-0.780	0.005-0.160	0.002-0.100
	Wise et al., 2007 Range	9.7-42.4	--	--	0.32-0.34	--	--	0.02-0.03	--
Nooksack	Present Study Mean and Range	30.3 3.7-76.3	1.4 0.6-2.8	1.6 0.8-2.9	0.379 0.106-0.656	0.325 0.087-0.544	0.022 (1) --	0.046 0.021-0.090	0.013 0.009-0.021
	EIM Range	1.0-2,600	--	--	0.097-1.22	0.076-0.684	0.010-0.510	0.009-0.132	0.004-0.121
	Embrey & Frans, 2003 [3] Range	8-2,890	0.7-6.8	--	--	0.13-0.94	<0.015-0.08	<0.01-.30	<0.01-0.02
	Wise et al., 2007 Range	48-301	--	--	0.49-0.55	--	--	0.05-0.20	--
Stillaguamish	Present Study Mean and Range	15.9 2.6-41.3	1.7 0.8-3.3	2.0 0.9-4.0	0.299 0.147-0.418	0.243 0.088-0.341	0.019 0.007-0.039	0.035 0.016-0.072	0.011 0.008-0.014
	EIM Range	0.1-2,700	1.4-2.0	--	0.054-0.767	0.010-0.728	0.010-0.760	0.008-0.698	0.002-0.110
Puyallup	Present Study Mean and Range	94.5 11.9-233	1.0 0.5-1.3	1.1 0.8-1.4	0.351 0.137-0.545	0.240 0.110-0.309	0.066 0.010-0.162	0.124 0.044-0.250	0.033 0.021-0.048
	EIM Range	1.0-2,890	0.9-9.1	1.1-3.2	0.074-0.826	0.056-0.399	0.004-0.580	0.010-1.66	0.007-0.120
	Wise et al., 2007 Range	77.1-407	--	--	0.27-0.41	--	--	0.09-0.15	--

[1] Derived from EIM data representing similar locations in each river and equivalent analytical methods.

[2] Flow-weighted annual mean concentrations for 1997, 2000, and 2001 based on LOADEST model annual loads and annual flows.

[3] Based on approximately 40 samples collected near Brennan, Washington, in 1996-1998.

Table 26. Hardness and concentrations of metals in major rivers discharging to Puget Sound.

River	Study/ Data Source	Hardness	Total Arsenic	Total Cadmium	Total Copper	Total Lead	Total Zinc
		mg/L	μg/L				
Skagit	Present Study Mean (n=3 or as noted) and Range	26.4 21.8-29.9	0.75 0.43 - 1.24	0.012 0.006-0.020	2.06 0.77-4.56	0.31 0.05-0.78	5.1 2.4-10.6
	EIM Range [1]	13-48	0.45-1.09	--	0.280-12.0	0.023-0.47	0.55-9.34
Snohomish	Present Study Mean and Range	15.4 13.2-17.4	1.00 0.92-1.14	0.015 0.005-0.030	2.60 1.35-4.08	0.34 0.09-0.63	4.7 2.5-8.3
	EIM Range	3.0-52.0	0.48-1.9	--	0.39-5.9	0.020-1.50	0.61-33.9
Nooksack	Present Study Mean and Range	46.2 38.1-62.0	0.55 0.26-1.01	0.017 0.005-0.040	2.41 0.75-4.41	0.32 0.05-0.82	6.0 3.2-9.7
	EIM Range	10.0-71.0	0.23-5.22	--	0.27-21	0.020-3.86	0.34-35.3
Stillaguamish	Present Study Mean and Range	27.0 19.2-31.9	0.79 0.52-1.12	0.011 0.005-0.020	2.95 1.16-6.58	0.58 (2) 0.37-0.79	9.0 4.0-17.7
	EIM Range	11.0-43.0	0.37-2.65	--	0.50-18.0	0.020-0.450	0.45-20
Puyallup	Present Study Mean and Range	33.9 27.7-40.8	0.68 0.52-0.92	0.007 0.005-0.010	4.91 1.32-11.6	0.81 (2) 0.20-1.42	7.7 (2) 3.7-11.6
	EIM Range	14.0-60.4	0.33-1.16	0.003-0.200	0.45-41.4	0.022-6.30	0.21-43.5
Green/Duwamish	Williston (2009) King County (2007) [1,2]	--	0.34-2.4	--	13.1	--	21.3
Surface Runoff	PSTLA (Herrera, 2010a) [3] Concentration Range	--	0.2 -14.9	0.0002 - 9.2	0.1 - 110	0.02 - 309	0.28 - 527

[1] Range of total arsenic concentrations measured during 2006-2008.
[2] Mean copper and zinc concentrations derived from 2003-2005 total annual loads and discharges listed in Table 5-9.
[3] Range of values from Herrera (2010a), Table 2: Probability of exceedance concentrations used to represent major land use types and highways.

Table 27. Concentration of organic compounds in river discharges and surface runoff to Puget Sound.

River	Study/ Data Source	Oil and Grease		Total PAH	cPAH *	Total PCBs	Total PBDEs
		Including ND=MDL/2	Detects only	Including ND=MDL/2			
		µg/L				pg/L	
Skagit, Snohomish, Nooksack, Stillaguamish, and Puyallup	Present Study Mean (n) Range	920 (15) 250 – 2,800	1,600 (6) 900 – 2,800	0.032 (15) 0.012 - 0.055	0.011 (15) 0.009 - 0.014	16.1 (15) 2.6 - 59.0	55.6 (7) 10.9 - 265
Green/Duwamish	Williston (2009) [1] Range	--		0.015 - 0.05	<0.001 - 0.040	38 - 2,360	--
	Gries and Sloan (2009) [2]	--		--	1.2 - 14.3	140 - 1,600	--
Total Surface Runoff	Phase II probability of exceedance concentrations (Herrera, 2010a) [3]	3.7 - 26,400		0.001 - 56.6	0.0002 - 11.8	16 - 810,000	0.30 - 810

* Carcinogenic PAH compounds (cPAH) include benzo(a)pyrene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-c,d)pyrene.

[1] Based on PAH data collected in 2008.

[2] Estimated range for annual flow-weighted mean concentrations.

[3] Range of values from Herrera et al. (2010a), Table 2: Probability of exceedance concentrations used to represent major land use types and highways.

Patterns and Relationships

The same graphic and statistical methods used to explore marine water column results were used to examine the river water data obtained from this study. Few differences in mean or median concentrations of the various chemicals could be attributed to different seasons, rivers, or flow regimes. This was expected from such a limited data set. However, some statistically significant relationships were identified. As with the marine water column results, most chemicals measured in river waters were not normally distributed (Appendix J, Table J-4) and the nonparametric Kruskal Wallis Test and Test of Medians were conducted. Results are shown in Appendix J, Tables J-5 and J-6. They show the following significant differences between seasons:

- TSS was lowest during the summer (excluding Puyallup River result).
- TOC and DOC were lowest in the summer (Figure 27a).
- Total nitrogen (TN) and nitrate+nitrite N were lowest during the summer (Figure 27b).
- Ammonia nitrogen concentrations were highest during the fall (not shown).
- Concentrations of total lead and zinc were highest in winter (not shown).

The only chemicals for which the mean concentrations (across all seasons) differed between the five rivers were:

- Ortho-phosphate concentrations were highest in the Puyallup River (Figure 28a).
- Hardness was lowest in the Snohomish River and highest in the Nooksack and Puyallup Rivers (not shown).
- Dissolved arsenic concentrations were lowest in the Nooksack River (Figure 28b).

The flow regimes assigned to each seasonal sampling in each river (base or runoff-related in Table 11) were not significant determinants of mean chemical concentrations. This was no doubt due to the limited number of samplings conducted in different systems with high natural variability. Total PCB concentrations were greater during runoff-related events, but the significance level was only $p<0.16$.

Spearman rank-correlations showed significant relationships between many chemical pairings. These are summarized in Appendix J, Table J-6. Total phosphorus (TP) and total metal concentrations were correlated with TSS. The total fractions of the five metals covaried. PCB homologs that were more polar (fewer chlorine atoms) correlated with chemicals such as ortho-phosphate and dissolved metals, while non-polar homologs (more chlorines) sometimes correlated with parameters common in particulate form (TSS, TOC, TN, TP, and total metals).

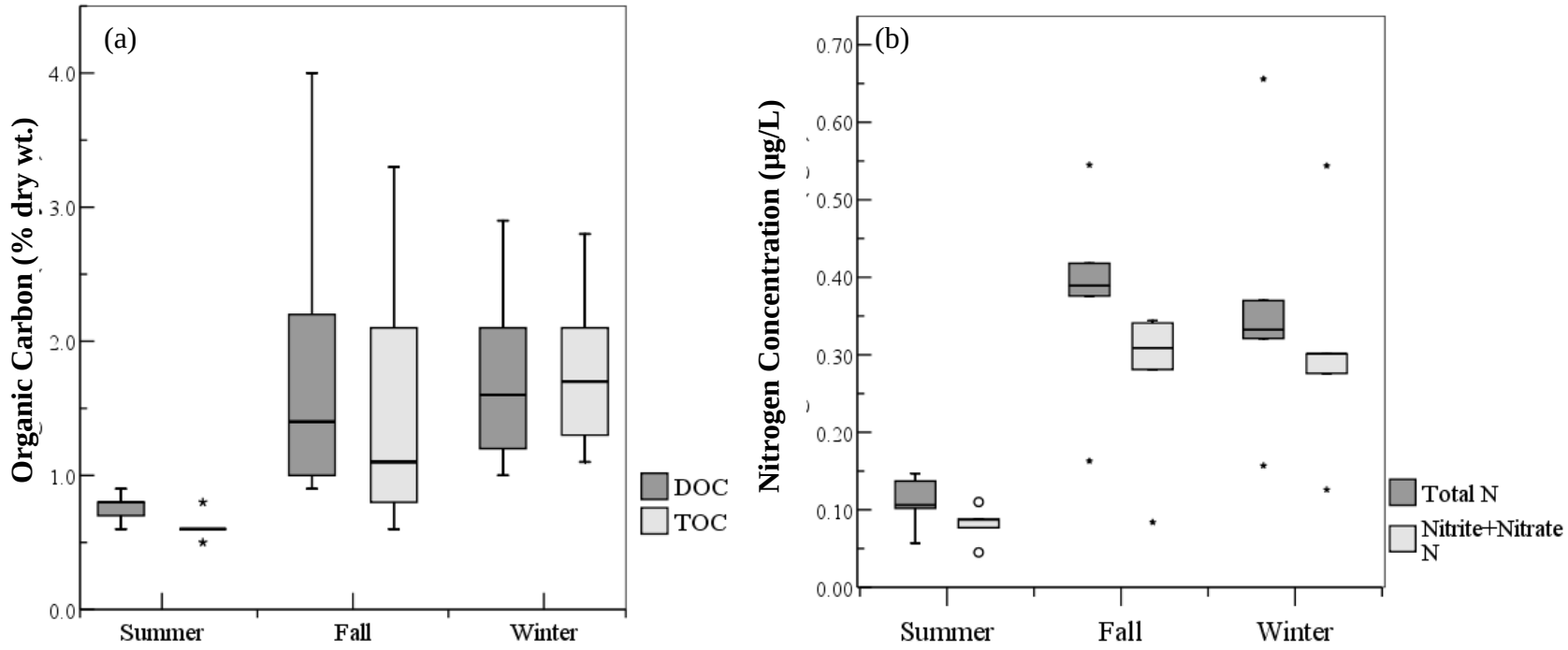

Figure 27. Box plots showing seasonal concentrations of organic carbon and nitrogen species.

*The heavy bars are median concentrations, with the boxes representing the interquartile range. Possible outliers appear as *.*

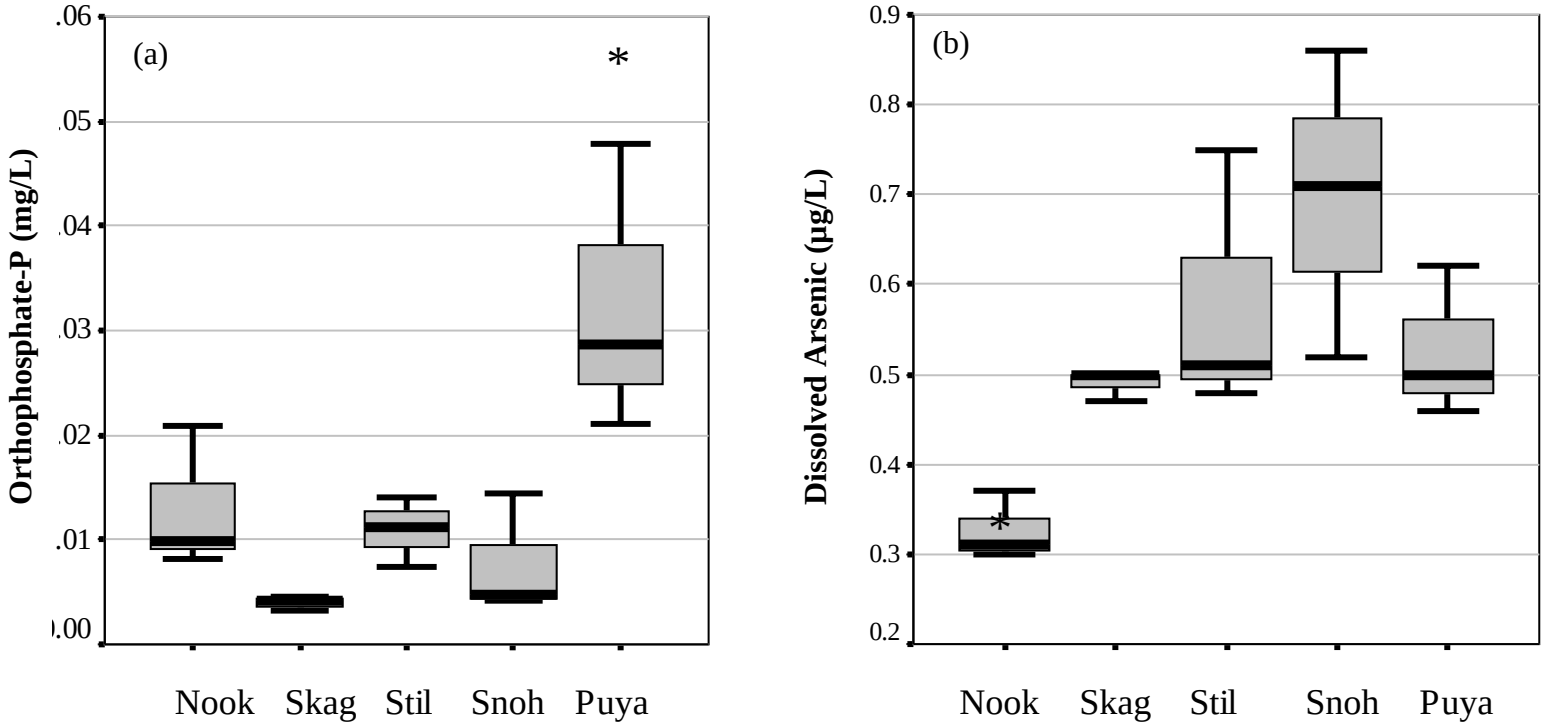

Figure 28. Box plots showing river water concentrations of ortho-phosphate and dissolved arsenic.

The heavy bars show median concentrations, with the boxes representing the interquartile range.

***** *Concentration significantly different from the mean concentration.*

Abbreviations: Nook = Nooksack, Skag = Skagit, Stil = Stillaguamish, Snoh = Snohomish, Puya = Puyallup.

Loading

Instantaneous mass loading rates for TSS, TOC, total nitrogen, total phosphorus, and total metals for the five rivers were calculated by multiplying the mean daily flows (Table 11) by the chemical concentrations measured on the same date (Appendix G, Table G-1). The results are shown as daily loads in Table 28. Total arsenic daily loads for the three smaller rivers studied here ranged from 0.96 - 19 kg/day. This was similar to the 0.13 - 7.28 kg/day arsenic load associated with SPM from the Green/Duwamish River system (Gries and Sloan, 2009) despite different mean annual flows.

Daily loading rates for petroleum-related compounds, total PCBs, and total PBDEs are presented in Table 29. Rates for oil and grease, TPH-D, and TPH-G were based on nondetect concentrations set at one-half the RL and at the MDL. The range of estimated daily loads for the sum of all petroleum-related compounds was 445 - 94,500 kg. The daily loading of total PCBs from the five rivers ranged from 0.015 - 0.57 g. This was lower than but comparable to the 0.06 - 1.2 g PCBs/ day load associated with SPM measured in the Green/Duwamish River system (Gries and Sloan, 2009). Daily loading of total PBDEs was between 0.11 - 5.6 g (using one-half the single highest RL when no PBDEs were detected). Daily loading was not calculated for BNAs, PAHs, or chlorinated pesticides because of their low frequency of detection.

Much of the variability in the daily loads was due to the wide range in mean daily flows. To reduce the influence of flows, instantaneous loads were also normalized to the area of each watershed above the gaging station where sampling occurred (see Table 2). Summary statistics for daily loading across all rivers and sampling events are presented in Table 30 (not normalized) and Table 31 (area-normalized). These rates of daily loading can be compared to results from ongoing and future studies.

Table 28. Instantaneous loads of conventional parameters, nutrients, and total metals from major rivers discharging to Puget Sound.

Instantaneous loads (kg/day) were calculated using measured concentrations and mean daily flow.

		Skagit			Snohomish			Nooksack			Stillaguamish			Puyallup		
		Jan 2010	Jul 2009	Oct 2009	Jul 2009	Oct 2009	Dec 2009	Jul 2009	Oct 2009	Dec 2009	Jul 2009	Oct 2009	Dec 2009	Jul 2009	Oct 2009	Dec 2009
Daily Flow	cfs	7,880	10,500	5,400	3,470	4,940	18,400	1,760	587	13,800	320	350	1,900	2,380	1,000	1,860
	cms	223	297	153	98.3	140	521	49.8	16.6	391	9.1	9.9	53.8	67.4	28.3	52.7
Parameter - Loading (kg/day)																
TSS		1.85E5	8.46E4	2.05E6	3.99E4	1.64E5	2.45E6	4.694	5.3E3	1.47E6	3.0E3	3.54E4	1.72E4	1.36E6	9.47E4	5.42E4
TOC		15,400	7,930	57,400	5,090	25,400	94,500	2,580	1,150	54,000	924	2,830	5,110	2,910	2,690	5,920
Total Nitrogen		1,460	2,150	5,300	866	4,700	14,500	456	540	12,600	170	358	1,540	798	1,330	1,680
Total Phosphorus		188	77.9	2,890	78.1	392	2,400	91.3	36.9	1,740	19.9	61.5	72.1	1,460	195	199
Arsenic, Total		14.6	56.8	41.9	7.81	11.4	51.3	1.59	3.73	19.5	0.84	0.96	2.42	5.36	1.47	2.37
Cadmium, Total		0.23	0.79	0.68	0.042	0.12	1.4	0.022	0.072	0.77	5.8E-3	0.017	0.033	0.058	0.015	0.023
Copper, Total		20	110	150	11	29	180	9.0	11	85	1.30	5.6	5.2	68	4.4	6.0
Lead, Total		2.8	6.6	26	0.76	3.6	28	0.43	0.72	16	0.017	0.68	1.7	8.3	0.49	0.27
Zinc, Total		62	320	360	21	40	370	22	46	190	4.6	15	39	68	9.1	6.4

E = exponent.

Table 29. Instantaneous daily loads for petroleum-related compounds, total PCBs, and total PBDEs from major rivers discharging to Puget Sound.

Instantaneous loads (kg/day) were calculated using measured concentrations and mean daily flow.

		Skagit			Snohomish			Nooksack			Stillaguamish			Puyallup		
		Jul 2009	Oct 2009	Dec 2009	Jul 2009	Oct 2009	Dec 2009	Jul 2009	Oct 2009	Jan 2010	Jul 2009	Oct 2009	Dec 2009	Jul 2009	Oct 2009	Dec 2009
Daily Flow	cfs	10500	5400	13800	3470	4940	18400	1760	587	7880	320	350	1900	2380	1000	1860
	cms	297	153	391	98.3	140	521	49.8	16.6	223	9.1	9.9	53.8	67.4	28.3	52.7
Parameter - Loading (kg/day)																
Oil and Grease (ND=½RL)		36,000	*13,000*	*91,000*	24,000	*11,000*	72,000	6,000	*1,300*	*53,000*	1,600	*770*	*13,000*	5,200	*2,200*	*12,500*
Oil and Grease (ND=MDL)		36,000	*6,600*	*51,000*	24,000	*6,000*	72,000	6,000	*720*	*29,000*	1,600	*430*	*7,000*	5,200	*1,200*	*6,800*
TPH-D (ND=½RL)		*2,300*	*1,100*	*1,000*	*760*	*1,030*	*1,350*	*370*	*120*	*580*	*100*	*77*	*400*	*520*	*210*	*140*
TPH-D (ND=MDL)		*150*	*79*	*54*	*51*	*73*	*72*	*26*	*8.6*	*29*	*6.9*	*5.1*	*28*	*35*	*15*	*7.3*
TPH-G (ND=½RL)		*1,800*	*920*	*2,400*	*590*	*850*	*3,150*	*300*	*100*	*1,400*	*81*	*60*	*320*	*410*	*170*	*320*
TPH-G (ND=MDL)		*360*	*180*	*470*	*120*	*170*	*630*	*60*	*20*	*270*	*16*	*12*	*65*	*82*	*34*	*64*
PCBs (g)		1.9E-4	1.3E-4	5.7E-4	1.6E-4	6.0E-5	3.3E-4	2.8E-5	7.4E-5	2.5E-5	2.2E-5	5.1E-5	2.3E-5	1.5E-5	9.8E-5	1.1E-4
PBDEs (g)		3.4E-4	*1.6E-3*	*4.2E-3*	1.2E-4	1.5E-3	5.6E-3	1.5E-4	1.3E-4	*5.4E-4*	2.6E-5	*1.1E-4*	*5.8E-4*	6.3E-5	6.5E-4	5.7E-4

Daily load in *italics* if >10% was based on nondetect values.

E = exponent.

Table 30. Summary statistics for instantaneous daily loads from five major rivers discharging to Puget Sound.

Instantaneous Loading (kg/day)								
Parameter	Detection Frequency	Calculation Basis (N)	Minimum	25%	Median	Mean	75%	Maximum
TSS	15/15	15	3.0	38	85	540	770	2,450
TOC	15/15	15	920	2,800	5,100	19,000	20,000	94,000
Total Nitrogen	15/15	15	170	670	1,500	3,200	3,400	14,000
Total Phosphorus	15/15	15	20	75	190	660	920	2,900
Arsenic, Total	15/15	15	0.843	1.98	5.36	14.8	17.1	56.8
Cadmium, Total	15/15	15	0.0058	0.022	0.058	0.28	0.45	1.4
Copper, Total	15/15	15	1.3	5.8	11	47	76	180
Lead, Total (Detects only)	13/15	13	0.017	0.58	1.7	6.5	7.4	28
Zinc, Total (Detects only)	14/15	14	4.6	18	40	100	130	370
Oil and Grease (Detects only)	6/15	6	1,600	5,400	15,000	24,000	33,000	72,000
Oil and Grease (ND=½RL)	6/15	15	*770*	*3,700*	*12,500*	*23,000*	*30,000*	*91,000*
Oil and Grease (ND=MDL)	6/15	15	*430*	*3,400*	*6,600*	*17,000*	*26,000*	*72,000*
TPH-D (ND=½RL)	0/15	15	*77*	*170*	*520*	*670*	*1,000*	*2,300*
TPH-D (ND=MDL)	0/15	15	*5*	*12*	*29*	*43*	*63*	*150*
TPH-G (ND=½ RL)	0/15	15	*60*	*240*	*410*	*850*	*1,100*	*3,200*
TPH-G (ND=MDL)	0/15	15	*12*	*47*	*82*	*170*	*230*	*630*
Total PCBs (Detects only)	15/15	15	0.015	0.026	0.074	0.126	0.146	0.573
Total PBDEs ((Detects only)	7/15	7	0.026	0.090	0.13	0.21	0.24	0.65
Total PBDEs (ND=max RL)	7/15	15	*0.026*	*0.12*	*0.54*	*1.1*	*1.1*	*5.6*

Daily load in *italics* if >10% was based on nondetect values.

Table 31. Summary statistics for area-normalized instantaneous daily loads from five major rivers discharging to Puget Sound.

Watershed areas (km^2) above gaging stations: Skagit = 8,010, Snohomish = 4,440, Nooksack = 2,045, Stillaguamish = 1,445, Puyallup = 2,455.

Area-normalized loading (kg/km^2-day)								
Parameter	Detection Frequency	Calculation Basis (N)	Minimum	25%	Median	Mean	75%	Maximum
TSS	15/15	15	2.1	11	23	150	150	720
TOC	15/15	15	0.56	1.1	1.9	5.2	4.6	26
Total Nitrogen	15/15	15	0.12	0.24	0.32	1.0	0.90	6.2
Total Phosphorus	15/15	15	0.010	0.021	0.050	0.19	0.22	0.85
Arsenic, Total	15/15	15	5.84E-04	8.71E-04	1.82E-03	3.25E-03	3.89E-03	1.16E-02
Cadmium, Total	15/15	15	4.0E-06	1.0E-05	2.4E-05	7.0E-05	6.0E-05	3.8E-04
Copper, Total	15/15	15	9.3E-04	2.5E-03	4.4E-03	1.2E-02	1.7E-02	4.2E-02
Lead, Total (Detects only)	13/15	13	1.2E-05	2.0E-04	4.7E-04	1.7E-03	2.2E-03	7.7E-03
Zinc, Total (Detects only)	14/15	14	2.6E-03	6.2E-03	1.1E-02	2.6E-02	3.4E-02	9.1E-02
Oil and Grease (Detects only)	6/15	6	1.1	2.3	3.7	5.4	5.1	16.2
Oil and Grease (ND=½RL)	6/15	15	*0.53*	*1.3*	*3.0*	*6.0*	*7.0*	*26*
Oil and Grease (ND=MDL)	6/15	15	*0.30*	*0.97*	*2.8*	*4.2*	*5.19*	*16*
TPH-D (ND=½RL)	0/15	15	*0.053*	*0.078*	*0.17*	*0.17*	*0.25*	*0.30*
TPH-D (ND=MDL)	0/15	15	*0.003*	*0.005*	*0.011*	*0.011*	*0.015*	*0.019*
TPH-G (ND=½ RL)	0/15	15	*0.04*	*0.09*	*0.15*	*0.21*	*0.23*	*0.71*
TPH-G (ND=MDL)	0/15	15	*0.01*	*0.02*	*0.03*	*0.04*	*0.05*	*0.14*
Total PCBs (Detects only)	15/15	15	6.19E-09	1.45E-08	2.35E-08	3.02E-08	3.81E-08	7.39E-08
Total PBDEs ((Detects only)	7/15	7	1.8E-08	2.6E-08	4.3E-08	7.3E-08	6.7E-08	2.6E-07
Total PBDEs (ND=max RL)	7/15	15	*1.8E-08*	*5.2E-08*	*2.1E-07*	*2.5E-07*	*3.0E-07*	*1.3E-06*

Daily load in *italics* if >10% was based on nondetect values.

Conclusions

The primary purpose of the present 2009-10 study was to measure toxic chemical concentrations in Puget Sound marine waters, ocean boundary waters (Strait of Juan de Fuca and Haro Strait), and freshwater near the mouths of the five largest rivers discharging to Puget Sound. The concentration data obtained will help identify the largest remaining sources of uncertainty in the Puget Sound Toxics Box Model and the data gaps that still require field studies or analysis.

Marine Water and SPM

Major findings from the marine water column sampling portion of this study include:

- Low concentrations of suspended solids, organic carbon, metals, PCBs, and PBDEs were routinely detected in marine water samples. Chlorinated pesticides, BNAs, and PAHs were rarely or never detected in the same samples. Analytical detection limits were not adequate to detect these organic compounds at sampling sites far removed from sources.
- The range of total PCB concentrations measured for ambient marine waters was 6.1 - 75 pg/L. Average concentrations in the ocean boundary waters (20.4 pg/L) and Puget Sound (30.7 pg/L) were significantly different and both were lower than those previously reported for the Strait of Georgia (42 pg/l) by Canadian researchers (Dangerfield et al., 2007).
- Total PCB concentrations in the deep waters were significantly greater than those in the surface waters. This was true for the ocean boundary waters and Puget Sound. A significant positive relationship between total PCBs and TSS suggested that sedimentation may play a key role in the fate of PCBs in Puget Sound.
- The range of detected total PBDE concentrations in marine waters (51 - 18,700 pg/L) was much wider than the range of total PCB concentrations. Total PBDEs concentrations were often 10 times higher in the present study than concentrations reported by Canadian researchers (Dangerfield et al., 2007) and apparently not related to TSS. No evidence suggested the higher concentrations were due to sample contamination. Potential sources of high PBDE concentrations were not identified.
- Organic carbon concentrations in marine water samples resembled concentrations previously reported for the Strait of Georgia (Johannessen et al., 2008) but were substantially lower than marine water concentration records in Ecology's EIM database.
- Estimates of two-directional transport across Box Model boundaries (Admiralty Inlet and Deception Pass) were calculated from concentrations of toxic chemicals in Puget Sound surface waters and deep ocean boundary waters. Estimates showed that most chemicals were probably exported from Puget Sound. Notable exceptions were cadmium and possibly lead, which appeared to be imported into Puget Sound. This was due to significantly higher concentrations in incoming ocean boundary waters than in the surface waters flowing out of the Sound. The direction of net exchange for total PCBs and total PBDEs at the ocean boundaries could not be determined from data collected.

- Samples of SPM collected by sediment traps moored in Hood Canal and the Case+Carr Inlets contained similar concentrations of organic carbon, metals, and PBDEs. PCB concentrations in Case+Carr SPM were more than three times greater than those in Hood Canal SPM.

River Water and SPM

Major findings from the river water sampling portion of this study include:

- Concentrations of TSS, organic carbon, nutrients, hardness, and metals were within the concentration ranges reported from previous studies by Ecology and other monitoring programs (Inkpen and Embry, 1998; Wise et al., 2007).
- River water samples seldom contained detectable concentrations of petroleum-related compounds, BNAs, PAHs, or chlorinated pesticides. SPM centrifuged from December 2009 and January 2010 contained detectable concentrations of a number of PAHs.
- The mean concentration of total PCBs measured in surface water from the five rivers was 16.3 pg/L. The range of concentrations measured was 2.6 - 59 pg/L. This range is somewhat lower than that measured by King County in the Green/Duwamish Rivers (83 - 814 pg/L). This is likely because land use in the lower watershed of the Green/Duwamish Rivers is more urban and industrial in character than the rivers sampled for this 2009-10 study.
- PBDEs were detected in 7 of the 15 river water samples. Total PBDE concentrations were highly variable ranging from 10.9 - 265 pg/L, with an average of 55.6 pg/L.
- Total PAH concentrations in SPM (excluding retene) ranged from 32 - 210 µg/Kg, with an average of 120 µg/Kg. Concentrations of individual PAHs were <20 µg/Kg, except for retene which averaged 230 µg/Kg.
- Few other organic compounds (BNAs, TPH-D, chlorinated pesticides) were detected in SPM.
- Estimated daily loading of total PCBs for the five rivers ranged from 0.015 - 0.57 g/day.
- Estimated daily loading of total PBDEs for the five rivers ranged from 0.017 - 5.63 g/day.

Notable relationships between parameters include:

- TSS concentrations were significantly correlated with, and explained between 63% and 86% of the variability in, concentrations of total phosphorus and total metals.
- TOC, DOC, total nitrogen, and nitrate+nitrite concentrations were significantly lower during July than during the other two sampling periods.
- Congeners belonging to the more polar PCB homolog groups (those with fewer chlorine atoms) were significantly correlated with many parameters in the dissolved phase (ortho-phosphate and dissolved metals). Congeners in the more highly-chlorinated PCB homologs were significantly correlated with TSS, TOC, and parameters often found in particulate form (total nitrogen and total phosphorus).

Recommendations

The following recommendations pertain to the use of present 2009-10 study results for modeling purposes and for future monitoring programs. In particular, more monitoring is needed to better define the normal range of concentrations for various toxic chemicals in marine and river waters.

- Selected study results should be used to revise input values to the Box Model and to calibrate the model.
- Future sampling should place more emphasis on collection and analysis of suspended particulate matter (SPM) in order to improve frequency of detection for hydrophobic compounds such as PAHs.
- More intensive water column sampling should be conducted near the ocean boundaries (Admiralty Inlet sill and Deception Pass). Samples should be analyzed for a reduced suite of chemicals, with priority given to chemicals exhibiting high variability (PBDEs) in the present study. This would improve the assessment of chemical exchange between ocean boundary waters and Puget Sound.
- Depth-integrated water sampling of large rivers should be conducted with focus on increased sampling frequency, a reduced suite of chemicals, and improved detection limits for organic contaminants. More frequent sampling during all phases of runoff-related events is needed to understand seasonal and other temporal patterns. This would facilitate a better characterization of loading during baseflow conditions and runoff-related events.
- Estimates of petroleum-related compound loadings to Puget Sound should be improved by:
    - Refining sampling methods or developing new methods better suited to capturing such compounds.
    - Refining analytical methods for measuring different petroleum fractions in whole water or other collection media (adsorbent material).
- Standard operating procedures (SOPs) for the collection and analysis of seawater samples for DOC and POC should be revised. For example, all equipment used for sample collection and processing should be made exclusively of glass or lined with Teflon.

References

APHA, 2005. Standard Methods for the Analysis of Water and Wastewater, 21st Edition. Joint publication of the American Public Health Association, American Water Works Association, and Water Environment Federation. www.standardmethods.org.

Babson, A.L., M. Kawase, and P. MacCready, 2006. Seasonal and Interannual Variability in the Circulation of Puget Sound, Washington: A Box Model Study. Atmosphere-Ocean 44(1): 29-45.

Coots, R. and D. Osterberg, 2009. Control of Toxic Chemicals in Puget Sound: Quality Assurance Project Plan for Phase 3: Characterization of Toxic Chemicals in Puget Sound and Selected Major Tributaries. Washington State Department of Ecology, Olympia, WA. Publication No. 09-03-118. www.ecy.wa.gov/biblio/0903118.html.

Crecelius, E.A., 1998. Background Metals Concentrations in Selected Puget Sound Marine Receiving Waters. Prepared for Western States Petroleum Association by Battelle Marine Sciences Laboratory, Sequim, WA.

Dangerfield, N., R. Macdonald, S. Johannessen, N. Crewe, P. Shaw, and P. Ross, 2007. PCBs and PBDEs in the Georgia Basin Water Column. Poster presented at the 2007 Georgia Basin Puget Sound Research Conference, Vancouver, British Columbia.

Dangerfield, N., 2010. Personal communication, Institute of Ocean Sciences (Fisheries and Oceans Canada).

Ecology, 2006. Chemical Hygiene Plan and Hazardous Materials Management Plan. Washington State Department of Ecology, Olympia, WA.

Embry, S.S. and Frans, L.M., 2003. Surface-Water Quality of the Skokomish, Nooksack, and Green-Duwamish Rivers and Thornton Creek, Puget Sound Basin, Washington, 1995-1998. USGS Water-Resources Investigations Report 02-4190. http://pubs.usgs.gov/wri/wri024190.

EnviroVision Corporation; Herrera Environmental Consultants, Inc.; and Washington State Department of Ecology, 2008. Phase 2: Improved Estimates of Toxic Chemical Loadings to Puget Sound from Surface Runoff and Roadways. Ecology Publication No. 08-10-084. August 2008. Olympia, WA. www.ecy.wa.gov/biblio/0810089.html.

EPA, 1996. Method 1669: Sampling Ambient Water for Trace Metals at EPA Water Quality Criteria Levels. U.S. Environmental Protection Agency, Office of Water Quality, Washington D.C. Publication No. EPA-R-95-034.

FISP, 2000. Sampling with the US DH-95 Suspended-Sediment Sampler, June 2000. Federal Interagency Sedimentation Project, Vicksburg, MS. http://fisp.wes.army.mil/Instructions%20US%20DH-95%20000608.pdf.

Gries, T. and J. Sloan, 2009. Contaminant Loading to the Lower Duwamish Waterway from Suspended Sediment in the Green River. Washington State Department of Ecology, Olympia, WA. Publication No. 09-03-028. www.ecy.wa.gov/biblio/0903028.html.

Hart Crowser, Inc., Washington State Department of Ecology, U.S. Environmental Protection Agency, and Puget Sound Partnership, 2007. Control of Toxic Chemicals in Puget Sound - Phase 1: Initial Estimate of Toxic Chemical Loadings to Puget Sound. Ecology Publication No. 07-10-079. October 2007. Olympia, WA. www.ecy.wa.gov/biblio/0710079.html.

Herrera Environmental Consultants, Inc., 2010a. Addendum 2, Phase 1 and Phase 2 Toxics Loadings Reports. Technical Memorandum, January 8, 2010. Washington State Department of Ecology, Olympia, WA. Publication No. 08-10-084addendum2. www.ecy.wa.gov/biblio/0810084Addendum2.html.

Herrera Environmental Consultants, Inc., 2010b. Toxics in Surface Runoff to Puget Sound: Phase 3 Data and Load Estimates. DRAFT, December 2010. Final Report Publication No. will be 11-03-010. www.ecy.wa.gov/biblio/1103010.html (link will be active by 4-15-11).

Inkpen, E.L. and S.S Embry, 1998. Nutrient Transport in the Major Rivers and Streams of the Puget Sound Basin, Washington. USGS Fact Sheet FS-009-98, March 1998.

Johannessen, S., G. Potentier, C.A. Wright, D. Masson, and R.W. Macdonald, 2008. Water Column Organic Carbon in a Pacific Marginal Sea (Strait of Georgia, Canada). Marine Environmental Research. 66(S1): S49–S61.

Johnson, A., 2009. Puget Sound Boatyards: Zinc, Copper, Lead, and Hardness Concentrations in Receiving Waters. Washington State Department of Ecology, Olympia, WA. Publication No. 09-03-051. www.ecy.wa.gov/biblio/0903051.html.

Johnson, A. and J. Summers, 1999. Metals Concentrations in Commencement Bay Waterways During 1997-1998. Washington State Department of Ecology, Olympia, WA. Publication No. 99-308. www.ecy.wa.gov/biblio/99308.html.

King County, 2001. Water Quality Status Report for Marine Waters, 1999 and 2000. King County Department of Natural Resources, Seattle, WA.

King County, 2007. Water Quality Statistical and Pollutant Loading Analysis. Green-Duwamish Watershed Water Quality Assessment. Prepared by Herrera Environmental Consultants, Inc., Seattle, WA.

Lane, L., 2000. Analytical Services Laboratory Standard Operating Procedures 2000. Horn Point Marine Laboratory, University of Maryland. Technical Report No. TS-264-00.

MEL, 2008. Manchester Environmental Laboratory Lab Users Manual, Ninth Edition. Manchester Environmental Laboratory, Washington State Department of Ecology, Manchester, WA.

Norton, D., 1996. Commencement Bay Sediment Trap Monitoring Program. Washington State Department of Ecology, Olympia, WA. Publication No. 96-315. www.ecy.wa.gov/biblio/96315.html.

Norton, D., 2001. Contaminants Associated with Settling Particulate Matter and Bottom Sediments at Two Marinas in Thea Foss Waterway. Washington State Department of Ecology, Olympia, WA. Publication No. 01-03-023. www.ecy.wa.gov/biblio/0103023.html.

Norton, D., 2009. Sediment Trap Monitoring in Four Inlets of South Puget Sound. Washington State Department of Ecology, Olympia, WA. Publication No. 09-03-006. www.ecy.wa.gov/biblio/0903006.html.

Norton, D. and C. Boatman, 1998. Determination of Seasonal Trends for Carbon, Nitrogen, Pigments, and Sediment Resuspension Rates in Budd Inlet Using Moored Sediment Traps. Puget Sound Research 1998 Conference Platform Presentation. Seattle, WA.

Norton, D. and T. Michelson, 1995. Elliott Bay Waterfront Recontamination Study, Volume 1: Field Investigation Report. Prepared for Elliott Bay/Duwamish Restoration Program by Washington State Department of Ecology, Olympia, WA. Publication No. 95-335. www.ecy.wa.gov/biblio/95335.html.

Pelletier, G. and T. Mohamedali, 2009. Control of Toxic Chemicals in Puget Sound: Phase 2, Development of Simple Numerical Models: The Long-Term Fate and Bioaccumulation of Polychlorinated Biphenyls in Puget Sound. Washington State Department of Ecology, Olympia, WA. Publication No. 09-03-015. www.ecy.wa.gov/biblio/0903015.html.

PSEP (Puget Sound Estuary Program), 1986. Recommended Protocols for Measuring Conventional Sediment Variables in Puget Sound. Prepared for U.S. Environmental Protection Agency Region 10, Office of Puget Sound, Seattle, WA and Puget Sound Water Quality Authority, Olympia, WA. Prepared by Tetra Tech, Inc., Bellevue, WA. Minor revisions in 2003. 43 pages.

PSEP, 1997. Recommended Guidelines for Sampling Marine Sediment, Water Column, and Tissue in Puget Sound. Final Report. Prepared for the U.S. Environmental Protection Agency, Seattle, WA.

Sea-Bird Electronics Inc., 2009a. User's Manual for SBE 25 SEALOGGER CTD. Version #017, 12/29/09, Sea-Bird Electronics, Bellevue, WA. www.seabird.com.

Sea-Bird Electronics Inc., 2009b. Sea-Bird Application Notes (www.seabird.com/application_notes/ANindex.htm), accessed 6/25/2009, Sea-Bird Electronics, Bellevue, WA.

Sea-Bird Electronics Inc., 2009c. User's Manual for SEASOFT V2, SBE CTD Data Processing and Plotting Software for Windows 2000/XP; Software Release 7.19, 7/23/2009, Sea-Bird Electronics, Bellevue, WA.

Sea-Bird Electronics Inc., 2010. Sea-Bird Technical Papers (www.seabird.com/technical_references/paperindex.htm), accessed 4/9/2010, Sea-Bird Electronics, Bellevue, WA.

Serdar, D., 2008. Control of Toxic Chemicals in Puget Sound: Identification and Evaluation of Water Column Data for Puget Sound and Its Ocean Boundary. Washington State Department of Ecology, Olympia, WA. Publication No. 08-03-008. www.ecy.wa.gov/biblio/0803008.html.

Sinclair, K. and C. Pitz, 1999. Estimated baseflow characteristics of selected Washington rivers and streams. Water Supply Bulletin No. 60. Washington State Department of Ecology, Olympia, WA. Publication No. 99-327. www.ecy.wa.gov/biblio/99327.html.

Stutes, A. and J. Bos, 2007. Standard Operating Procedure (SOP) for Seawater Sampling Version 1.0. Washington State Department of Ecology, Olympia, WA. SOP Number EAP033. www.ecy.wa.gov/programs/eap/quality.html.

USGS, 2005. National Field Manual for the Collection of Water-Quality Data: U.S. Geological Survey Techniques of Water-Resources Investigations, Book 9, Chapters A1-A4. http://pubs.water.usgs.gov/twri9A.

Willston, D., 2009. Personal communications, King County Department of Natural Resources and Parks.

Wise, D.R., F.A. Rinella, III, J.F. Rinella, G.J. Fuhrer, S.S. Embrey, G.M. Clark, G.E. Schwarz, and S. Sobieszczyk, 2007. Nutrient and Suspended-Sediment Transport and Trends in the Columbia River and Puget Sound Basins, 1993-2003. USGS National Water-Quality Assessment Program. Scientific Investigations Report 2007–5186. http://pubs.usgs.gov/sir/2007/5186.

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Appendix A. Glossary, Acronyms, Abbreviations, and Units of Measurement

Glossary

Ambient: Something commonly found in one's immediate surroundings. In this case, ambient concentrations of toxic chemicals are those within the normal range found in a box within the Puget Sound Toxics Box Model and not influenced by point sources of pollution.

Analyte: Water quality constituent being measured (parameter).

Baseflow: Groundwater discharge. The component of total streamflow that originates from direct groundwater discharges to a stream.

Basin: A drainage area or watershed in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation.

Biota: Flora (plants) and fauna (animals).

Box Model: The simplest type of model. A box model assumes the object being modeled has the shape of a box and substances inside the box are distributed uniformly. In this case, the Puget Sound Toxics Box Model assumes different basins and water layers have the shape of a box and that chemical concentrations in each box are all the same.

Congener: In chemistry, congeners are related chemicals. For example, polychlorinated biphenyls (PCBs) are a group of 209 related chemicals that are called congeners.

Conventional pollutants: Non-toxic pollutants.

Euphotic zone: The uppermost part of a waterbody that receives enough light to allow photosynthesis to occur.

Geometric mean: A mathematical expression of the central tendency (an average) of multiple sample values. A geometric mean, unlike an arithmetic mean, tends to dampen the effect of very high or low values. The calculation is performed by: (1) taking the nth root of a product of n factors, or (2) taking the antilogarithm of the arithmetic mean of the logarithms of the values.

Harmonic Mean: A second expression of central tendency (average) among multiple values. The calculation takes the reciprocal of the arithmetic mean of the reciprocals. The harmonic mean is commonly used when average rates are calculated. It tends to mitigate the impact of large outlier values but aggravate the impact of small ones.

Homolog: One of several groups of similar organic chemical compounds whose successive members have a regular difference in composition. For example, mono-chlorinated biphenyls compounds contain one chlorine atom and belong to the homolog group, and bi-phenyl compounds containing 2-9 chlorine atoms belong to the other nine homolog groups.

Load(ing): The mass substance (suspended sediment or contaminant) passing by a horizontal or vertical plane per unit time. For example, the metric tons of sediment calculated to be transported downstream of a particular location.

Marine: Of or having to do with an ocean or sea (salt water).

Marine water column: The vertical column of water representing the entire depth of a marine waterbody. For the present 2009-2010 study, water samples were collected from various subsurface depths in the marine water column, not just dipped from the surface.

Nonpoint source: Pollution entering waters of the state from dispersed land-based or water-based activities, including atmospheric deposition, surface water runoff, subsurface or underground sources, or discharges from boats or marine vessels not otherwise regulated under the NPDES program. Generally, any unconfined and diffuse source of contamination.

Nutrient: Substance such as carbon, nitrogen, and phosphorus used by organisms to live and grow. Too many nutrients in the water can promote algal blooms and rob the water of oxygen vital to aquatic organisms.

Ocean boundary waters: Strait of Juan de Fuca and Haro Strait

Ortho-phosphate: The soluble inorganic phosphate ion (PO_4^{3-}) reported as the mass of phosphorus per unit volume (µg P/liter).

Outlier: A number (or observation) that deviates markedly from other numbers in a sample population (group of observations).

Parameter: Water quality constituent being measured (analyte). A physical, chemical, or biological property whose values determine environmental characteristics or behavior.

Particulate: Solid matter, such as a grain of fine sand, small enough to be suspended in a gas or liquid.

Pesticide: Any substance or mixture of substance intended for preventing, destroying, repelling or mitigating any pest. Pests include nuisance microbes, plants, fungus, and animals.

Point source: Sources of pollution that discharge at a specific location from pipes, outfalls, and conveyance channels to a surface water. Examples of point source discharges include municipal wastewater treatment plants, municipal stormwater systems, industrial waste treatment facilities, and construction sites that clear more than 5 acres of land.

Pollution: Contamination, or alteration of the physical, chemical, or biological properties, of any waters of the state. This includes change in temperature, taste, color, turbidity, or odor of waters. It also includes discharge of any liquid, gaseous, solid, radioactive, or other substance into any waters of the state. This definition assumes changes will, or are likely to, create a nuisance or render such waters harmful, detrimental, or injurious to (1) public health, safety, or welfare, or (2) domestic, commercial, industrial, agricultural, recreational, or other legitimate beneficial uses, or (3) livestock, wild animals, birds, fish, or other aquatic life.

Pycnocline: Depth at which water density increases most rapidly with depth.

Runoff: The variety of ways by which water moves across the land, including surface (diffuse) runoff and channelized runoff.

Seawater: Water from a sea or ocean, averaging 35 grams of dissolved salts per liter (parts per thousand).

Sediment: Solid fragmented material (soil and organic matter) that is transported and deposited by water and covered with water (example, river or lake bottom).

Spatial: How concentrations differ among various parts of the river.

Stormwater: The portion of precipitation that does not naturally percolate into the ground or evaporate but instead runs off roads, pavement, and roofs during rainfall or snow melt. Stormwater can also come from hard or saturated grass surfaces such as lawns, pastures, playfields, and from gravel roads and parking lots.

Surface waters of the state: Lakes, rivers, ponds, streams, inland waters, salt waters, wetlands and all other surface waters and watercourses within the jurisdiction of Washington State.

Suspended sediment: Solid fragmented material (soil and organic matter) in the water column.

Temporal trends: Characterize trends over time.

Total suspended solids (TSS): The suspended particulate matter in a water sample as retained by a filter.

Watershed: A drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation

X th percentile: A statistical number obtained from a distribution of a data set, above which 100-X % of the data exists and below which X % of the data exists.

Acronyms and Abbreviations

AP	Analytical Perspectives
BEHP	Bis 2-ethylhexyl phthalate
BMP	Best management practices
BNA	(Base/neutral/acid extractable) semivolatile organic compound
cPAH	Carcinogenic PAH compounds [benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-c,d)pyrene)]
CRM	Certified reference material
CTD	Conductivity, temperature, depth measurement devices
CV	Coefficient of variation (standard deviation divided by the mean)
Ecology	Washington State Department of Ecology
DDD	Dichloro-diphenyl-dichloroethane
DDE	Dichloro-diphenyl-trichloroethylene
DDT	Dichloro-diphenyl-trichloroethane
DOC	Dissolved organic carbon
DUP	Duplicate

EIM	Environmental Information Management database
EPA	U.S. Environmental Protection Agency
EDL	Estimated detection limit
EQL	Estimated quantitation limit
Frontier	Frontier Global (formerly Frontier Geosciences)
GFF	Glass fiber filter
GIS	Geographic Information System software
GPS	Global Positioning System
HDPE	High-density polyethylene
HEM	Hexane-extractable material (synonymous with oil and grease)
HPAH	High molecular weight PAHs [benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(g,h,i)perylene, chrysene, dibenzo(a,h)anthracene, fluoranthene, indeno(1,2,3-c,d)pyrene, and pyrene]
KCDNR	King County Department of Natural Resources
LPAH	High molecular weight PAHs [acenaphthylene, acenaphthene, anthracene, fluorene, naphthalene, and phenanthrene]
MDL	Method detection limit
MEL	Manchester Environmental Laboratory
MQO	Method quality objective
MS/MSD	Matrix spike/matrix spike duplicate
N	Number
n/a	Not applicable
NAD	North American Datum
ND	Not detected, nondetect
NPDES	National Pollutant Discharge Elimination System
NTR	National Toxics Rule
Ortho-P	Ortho-phosphate
P	Phosphorus
p	Probability of a result as extreme as the one observed assuming the null hypothesis is true
PAH	Polycyclic aromatic hydrocarbon compounds
PBDE	Polybrominated diphenyl ethers
PBT	Persistent, bioaccumulative, and toxic substance
PCB	Polychlorinated biphenyls
POC	Particulate organic carbon
POTW	Publically-owned treatment works
PRL	Pacific Rim Laboratories
PSTLA	Puget Sound Toxics Loading Analysis
QA	Quality assurance
QC	Quality control
REP	Replicate
RL	Reporting Limit
RM	River mile
RPD	Relative percent difference
RSD	Relative standard deviation
Sd	Sound
SJdF	Strait of Juan de Fuca

SOP	Standard operating procedure
SPM	Suspended particulate matter
SRM	Standard reference materials
Stdev	Standard deviation
Str	Strait
TEQ	Toxic Equivalents (for carcinogenic PAHs, relative to toxicity of benzo(a)pyrene)
TOC	Total organic carbon
TPAH	Total PAHs (sum of HPAH and LPAH concentrations)
TPH	Total petroleum hydrocarbons
TPH-D	Total petroleum hydrocarbons - diesel fraction
TPH-G	Total petroleum hydrocarbons - gasoline fraction
TSS	(See Glossary above)
USGS	U.S. Geological Survey
WDFW	Washington Department of Fish and Wildlife
WRIA	Water Resource Inventory Area

Metals

As	Arsenic
Cd	Cadmium
Cu	Copper
Pb	Lead
Zn	Zinc

Units of Measurement

cfs	cubic feet per second
cm	centimeters
cms	cubic meters per second, a unit of flow.
dw	dry weight
ft	feet
g	gram, a unit of mass
gpm	gallons per minute
kg	kilograms, a unit of mass equal to 1,000 grams.
kg/d	kilograms per day
km	kilometer, a unit of length equal to 1,000 meters.
L	liters
m	meter
mg/Kg	milligrams per kilogram (parts per million)
mg/L	milligrams per liter (parts per million)
mL	milliliters
ng/Kg	nanograms per kilogram (parts per trillion)
pg/L	picograms per liter (parts per quadrillion)
psu	practical salinity units
rpm	revolutions per second
µg/Kg	micrograms per kilogram (parts per billion)
µg/L	micrograms per liter (parts per billion)
µM	micromolar (a chemistry unit)

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Appendix B. Sampling Sites and Field Records

Puget Sound Toxics Box Model

Marine Water Column Sampling

Marine SPM Sampling

River Water Sampling

Puget Sound Toxics Box Model

The Puget Sound Toxics Box Model depicted below, taken from Pelletier and Mohamedali (2009), provides context for the sampling conducted for the present 2009-2010 study. It shows the relative volume of surface and deep water layers in Puget Sound basins, the relative volume of surface runoff to each surface layer, and the relative volume exchanged between each basin and layer. To address data gaps identified by the Box Model, the present study analyzed toxic chemicals in samples collected from surface and deep layers of the four main basins and from the five rivers representing the largest sources of surface runoff. Samples were also collected from surface and deep layers in ocean boundary waters outside Admiralty Inlet.

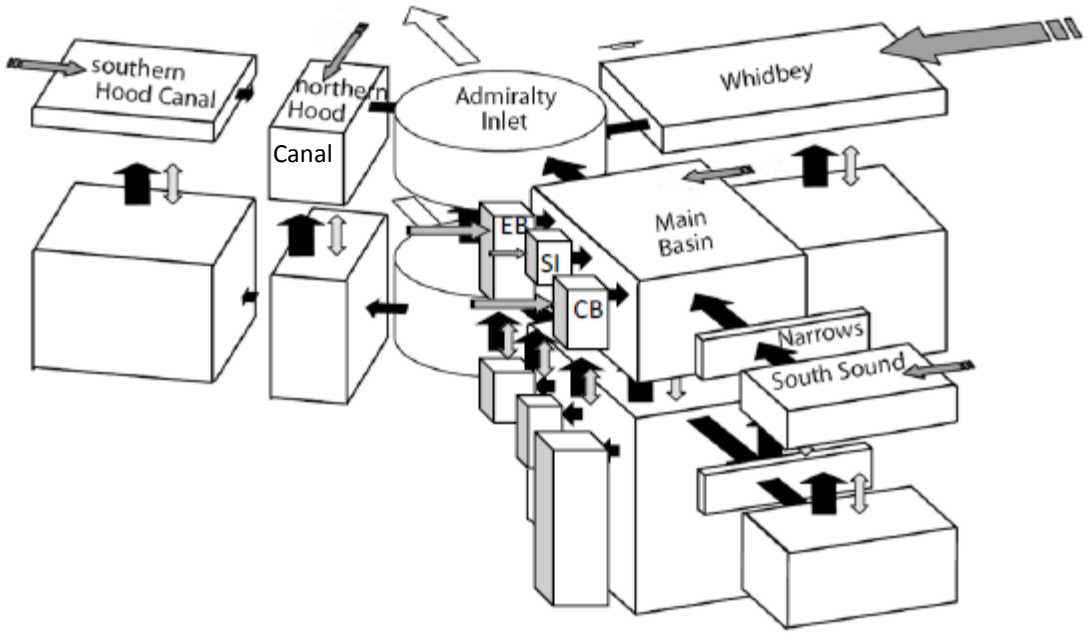

Figure B-1. Diagram of the Box Model of water circulation and transport in Puget Sound.

Grey arrows with dashed ends represent river inputs.
White arrows show exchange with the Strait of Juan de Fuca (ocean boundary waters).
Black arrows show advective transport.
Two-way grey arrows represent mixing between compartments.

Boxes are scaled to show relative volumes of water.
Arrows for rivers are log-scaled.

EB = Elliott Bay; SI = Sinclair Inlet; CB = Commencement Bay.

Marine Water Column Sampling

Table B-1. Sampling depths at Puget Sound basin sites relative to Box Model features and stratification. Two GO-FLO samplers were deployed simultaneously, collecting water at depths A and B.

Station	Seasonal Sampling Event	Date	Station Depth (m)	Box Model Surface/Deep Division (m)	Approx. Pycnocline Depth (m)	Sample Depth A (m)	Sample Depth B (m)	Water Column Layer
Hood Canal	1	7/7/09	152	13	10-15	5	7	surface
						40	35	deep
	2	9/30/09	150		5	2	5	surface
						80	85	deep
	3	1/13/10	n/a		10	25	30	surface
						100	105	deep
South Sound	1	7/9/09	165	30	<10	10	15	surface
						85	90	deep
	2	10/1/09	180		none	10	15	surface
						80	85	deep
	3	1/11/10	170		5	10	10	surface
						90	90	deep
Main	1	7/9/09	160	50	62	15	20	surface
						95	100	deep
	2	9/29/09	230		57	20	25	surface
						80	85	deep
	3	1/12/10	n/a		<5	20	20	surface
						80	80	deep
Whidbey	1	7/10/09	149	9	10	5	10	surface
						75	80	deep
	2	9/28/09	148		8	5	10	surface
						45	40	deep
	3	1/26/10	152		17	15	20	surface
						95	100	deep

Table B-2. Sampling depths at ocean boundary water sites relative to Box Model features and stratification. Two GO-FLO samplers were deployed simultaneously, collecting water at depths A and B.

Station	Seasonal Sampling Event	Date	Station Depth (m)	Box Model Surface/Deep Layer Division (m)	Approx. Pycnocline Depth (m)	Sample Depth A (m)	Sample Depth B (m)	Water Column Layer
SJdF at Sill	1	7/7/09	156	50	30	10	15	surface
						45	50	deep
	2	10/7/09	154		none	15	20	surface
						95	100	deep
	3	2/2/10	156		none	15	20	surface
						120	125	deep
SJdF North	1	7/8/09	136	50	85	15	20	surface
						110	115	deep
	2	10/7/09	134		55	15	20	surface
						95	100	deep
	3	2/2/10	140		<5	15	20	surface
						120	125	deep
Haro Strait	1	7/8/09	183	50	<90	15	20	surface
						115	120	deep
	2	10/7/09	185		50, 115	15	20	surface
						95	100	deep
	3	2/1/10	184		<5	15	20	surface
						95	100	deep

SJdF = Strait of Juan de Fuca.

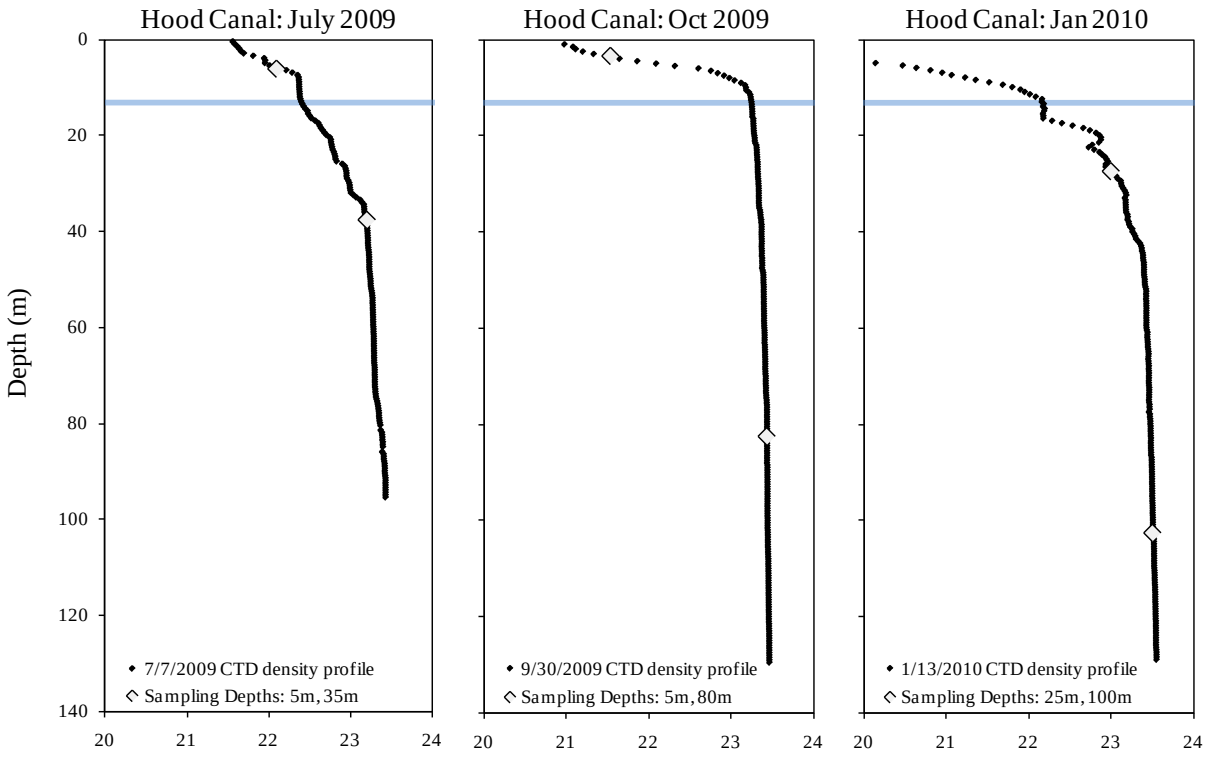

Figure B-2. Hood Canal water column sampling depths in relation to density profiles.
Density (x-axis) given in kg/m^3. Depth of the division between Box Model layers is shown at 13m.

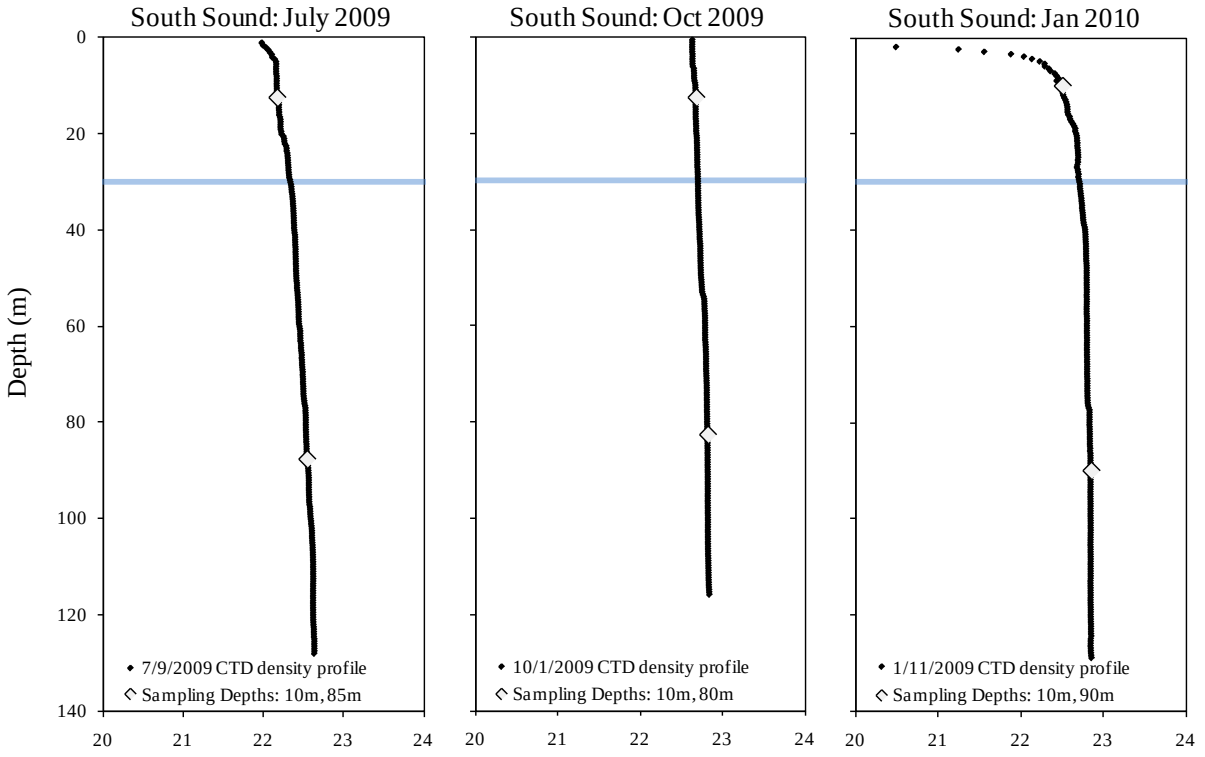

Figure B-3. South Sound water column sampling depths in relation to density profiles.
Density (x-axis) given in kg/m^3. Depth of the division between Box Model layers is shown at 30m.

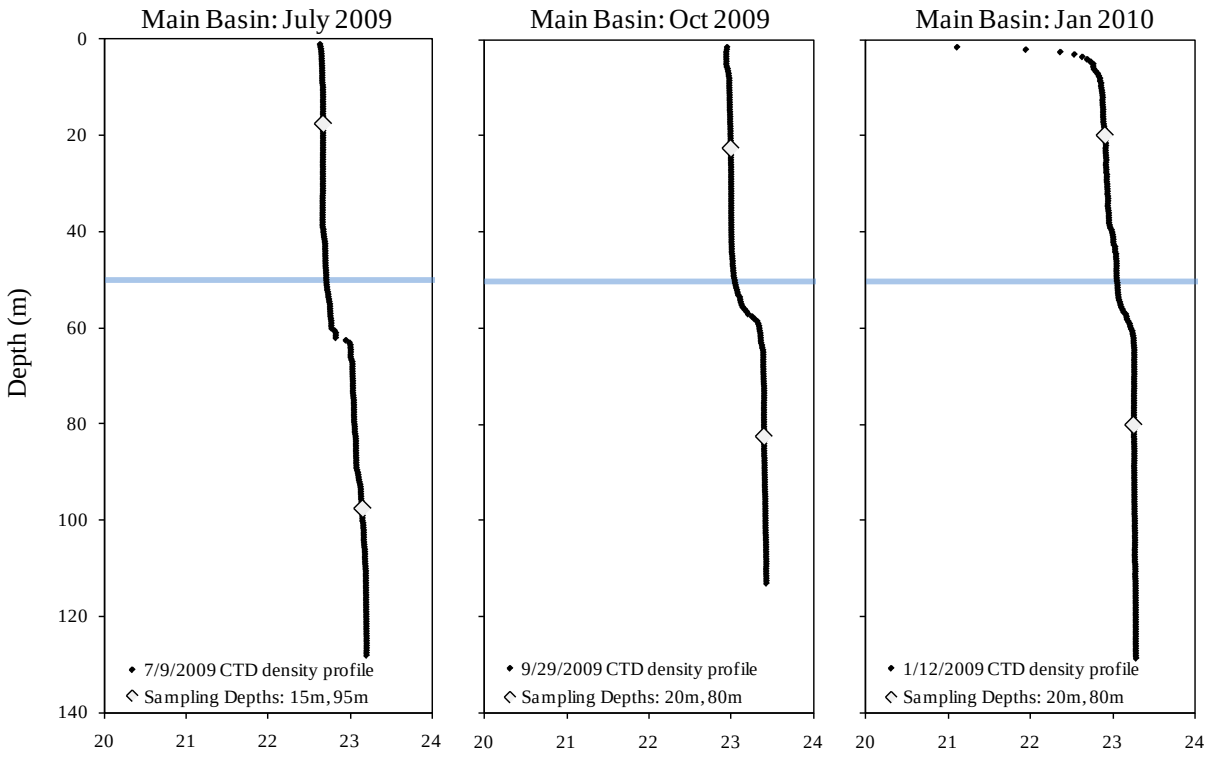

Figure B-4. Main Basin water column sampling depths in relation to density profiles.
Density (x-axis) given in kg/m^3. Depth of the division between Box Model layers is shown at 50m.

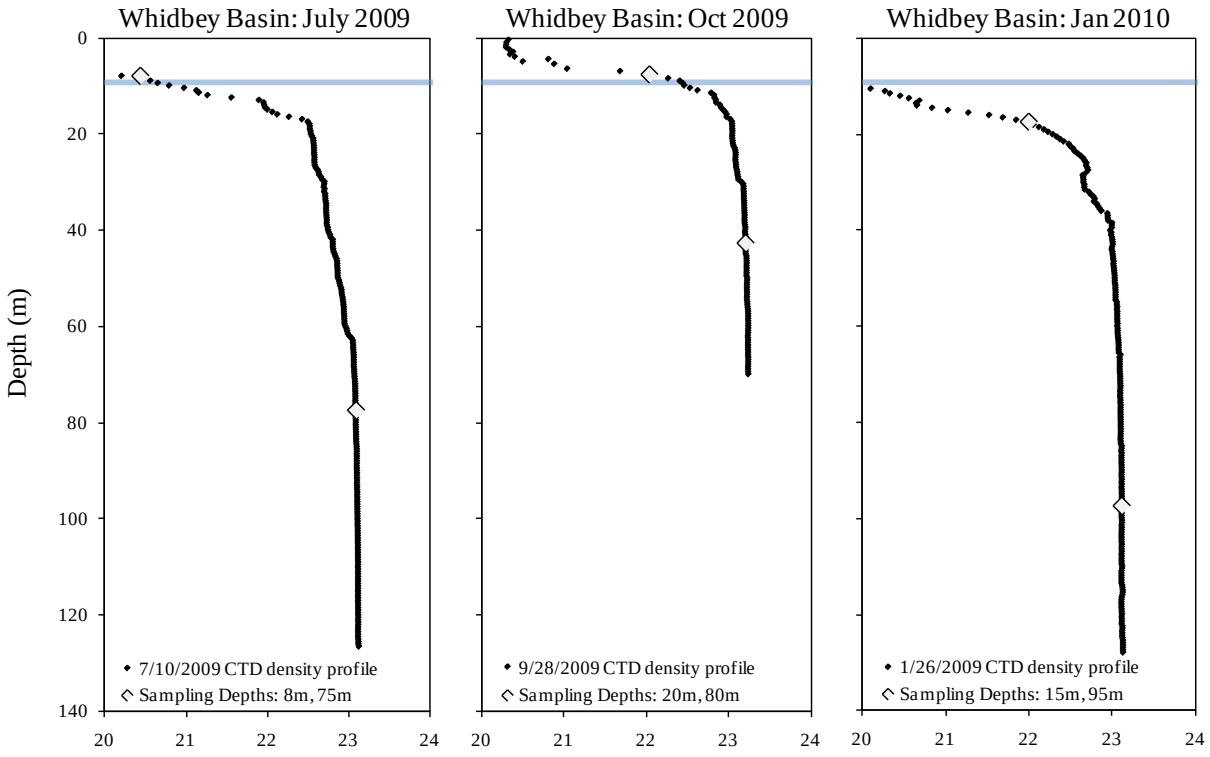

Figure B-5. Whidbey Basin water column sampling depths in relation to density profiles.
Density (x-axis) given in kg/m^3. Depth of the division between Box Model layers is shown at 9m.

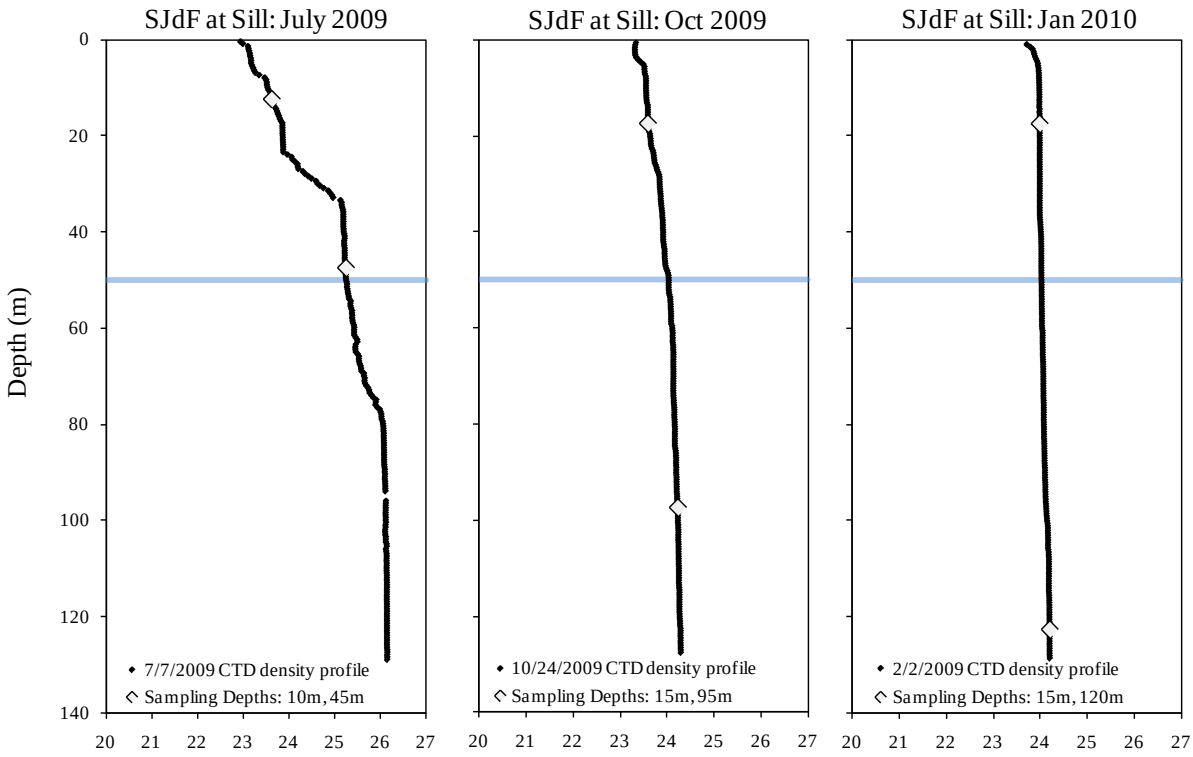

Figure B-6. SJdF at Sill water column sampling depths in relation to density profiles.
Density (x-axis) given in kg/m^3. Depth of the division between Box Model layers is shown at 50m.

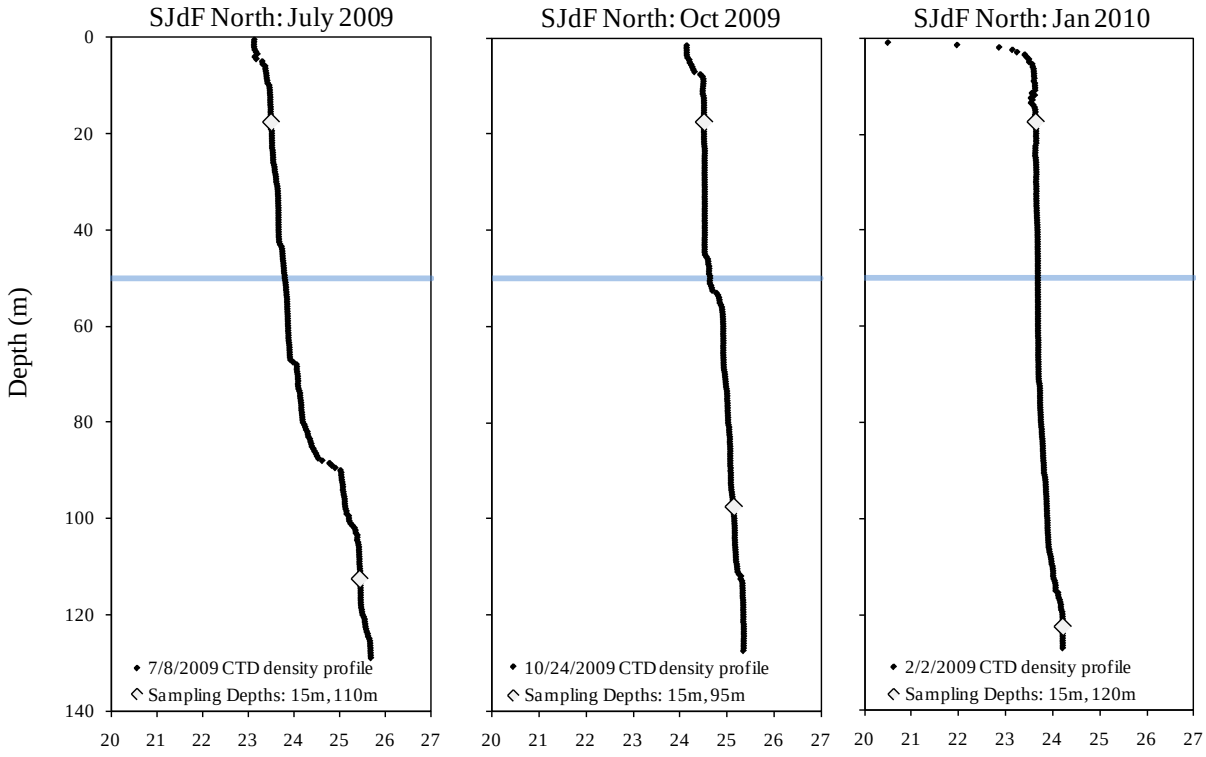

Figure B-7. SJdF North water column sampling depths in relation to density profiles.
Density (x-axis) given in kg/m^3. Depth of the division between Box Model layers is shown at 50m.

Figure B-8. Haro Strait water column sampling depths in relation to density profiles.
Density (x-axis) given in kg/m^3. Depth of the division between Box Model layers is shown at 50m.

Marine SPM Sampling

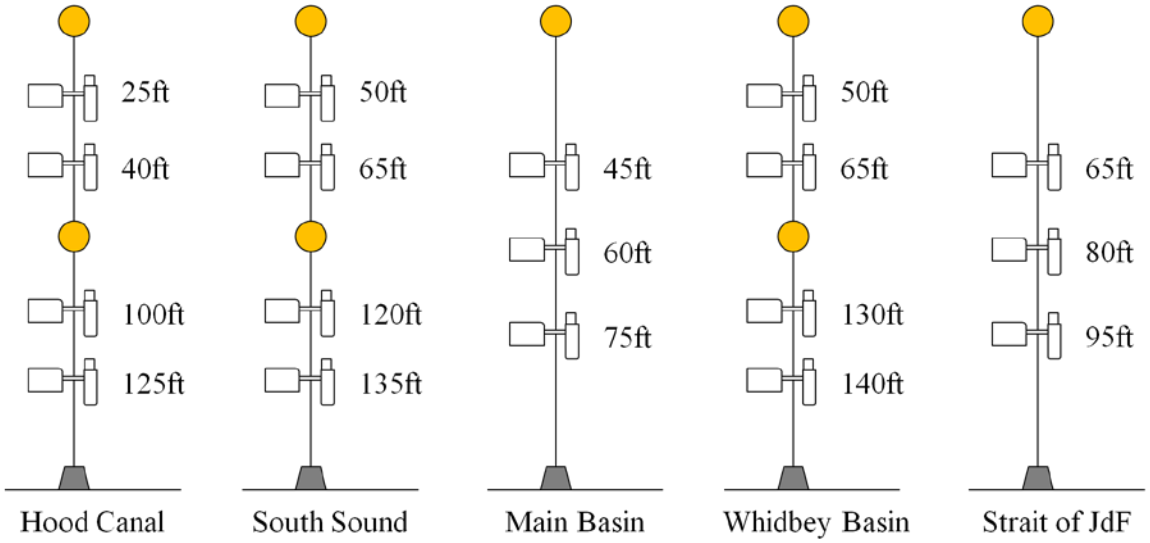

Figure B-9. Configuration of sediment trap deployments at each mooring location.

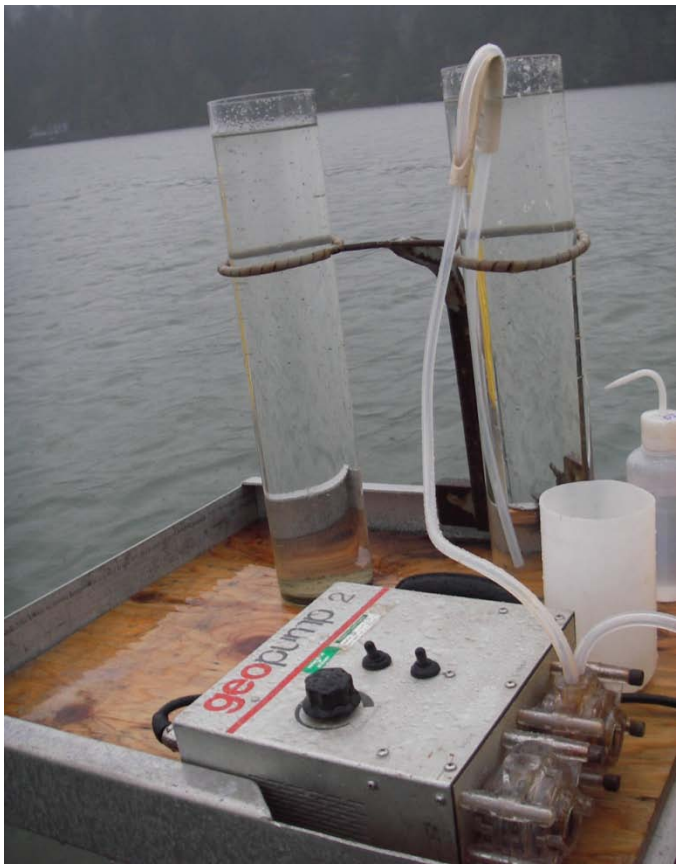

Figure B-10. Drawing overlying water from glass sediment trap cylinders.

River Water Sampling

Table B-3. Summary of water sampling activities at the five major rivers discharging to Puget Sound.

River	Date	Start Time	End Time	Channel Depths Sampled (ft)				Mean Daily Flow [1]		Flow Type	Conditions/Notes
				Left	Center	Pump/ (Channel)	Right	ft^3/s (cfs)	$m^{3/}s$ (cms)		
Nooksack	7/21/09	0928	1200	5.5	5.7	-	6.6	1,840 [2]	52.1	Base	USGS predicted flow of 1,760 cfs.
Skagit	7/21/09	1603	1932	5.2	4.1	-	8.4	10,500	297	Base	Approx. 50% of long-term mean flow for July [4].
Stillaguamish	7/22/09	0900	1125	11.7	8.7	-	6.4	470 [2]	13.3	Base	USGS predicted flow of 333 cfs.
Snohomish	7/22/09	1417	1711	15	13.2	-	17.6	3,470	98.3	Base	Current slowing with flood tide near end of sampling.
Puyallup	7/23/09	0907	1225	2.6	4.2	-	7.5	2,380	67.4	-- [3]	Water chalky brown except near small tributary. Glacial silts from late seasonal snow melt?
QA REP											
Nooksack	10/12/09	1353	1625	4.3	4.8	-	5.4	590	16.7	Base	Flow 38% of long-term mean October baseflow
Skagit	10/13/09	0823	1153	2.8	3.3	-	6.3	5,400	153	Runoff	Low flow, quite shallow. 44% of long-term mean flow for October [4].
Stillaguamish	10/19/09	1129	1300	14.8	11.5	-	8.6	3,240	91.8	Base	Falling stage. Still five times monthly mean baseflow [4].
Snohomish	10/20/09	1030	1211	20.5	23.6	-	26	4,940	140	Runoff	Falling stage of runoff event.
Puyallup	10/15/09	0847	1043	2.9	5.5	-	7	1,000	28.3	Runoff	Early phase runoff.
QA REP		1304	1522								
Nooksack	01/06/10	1039	1222	8.7	11.1	6 (10-10.5)	11.2	7,880	223	Runoff	Strong current, high turbidity. Flow based on USGS 15-minute records. Discharge 300% mean baseflow [4].
Skagit	12/17/09	0921	1110	9.0	7.5	***~4.5*** (7.5)	7.5	13,850	392	Runoff	Water clear initially, turning visibly turbid later.
Stillaguamish	12/08/09	1326	1534	13.2	11.3	7.8 (13.2)	8.7	~1,900	53.8	Runoff	Clear and cold, with ice on banks and in river. USGS 15-minute flow records, stage variable.
Snohomish	12/22/09	1525	1733	≤18.0	≤25.1	9-11 (32)	≤30.5	18,400	521	Base	Swift current, changing water levels.
Puyallup	12/14/09	0949	1147	3.5	4.8	4.2 (7)	6.7	1,860	52.7	Base	Light rain throughout evening. Becoming colder – morning frost.
QA REP		1355	1510	3.4	5.3		6.5				

[1] Flow predicted from stage height recorded at nearby USGS gaging station.
[2] Flow measured by Ecology stream monitoring staff on day of sampling.
[3] Sampling conditions reflected neither baseflow nor runoff related to recent precipitation. Suspended solids were related to seasonal runoff from glaciers, not from recent precipitation events.
[4] From Sinclair and Pitz (1999).
QA REP = Quality assurance replicate.

Figure B-11. Skagit River sampling site.

Top: Aerial view of Riverside Drive (Old Highway 99) bridge over the Skagit River. Bottom: Photograph taken from the northwest, just downstream (shown as star at top).

Figure B-12. Snohomish River sampling site.

Top: Aerial view of Airport Way / Avenue D bridge over the Snohomish River in the City of Snohomish.

Bottom: Photograph taken from the north side of the river just downstream of the bridge (shown as star at top).

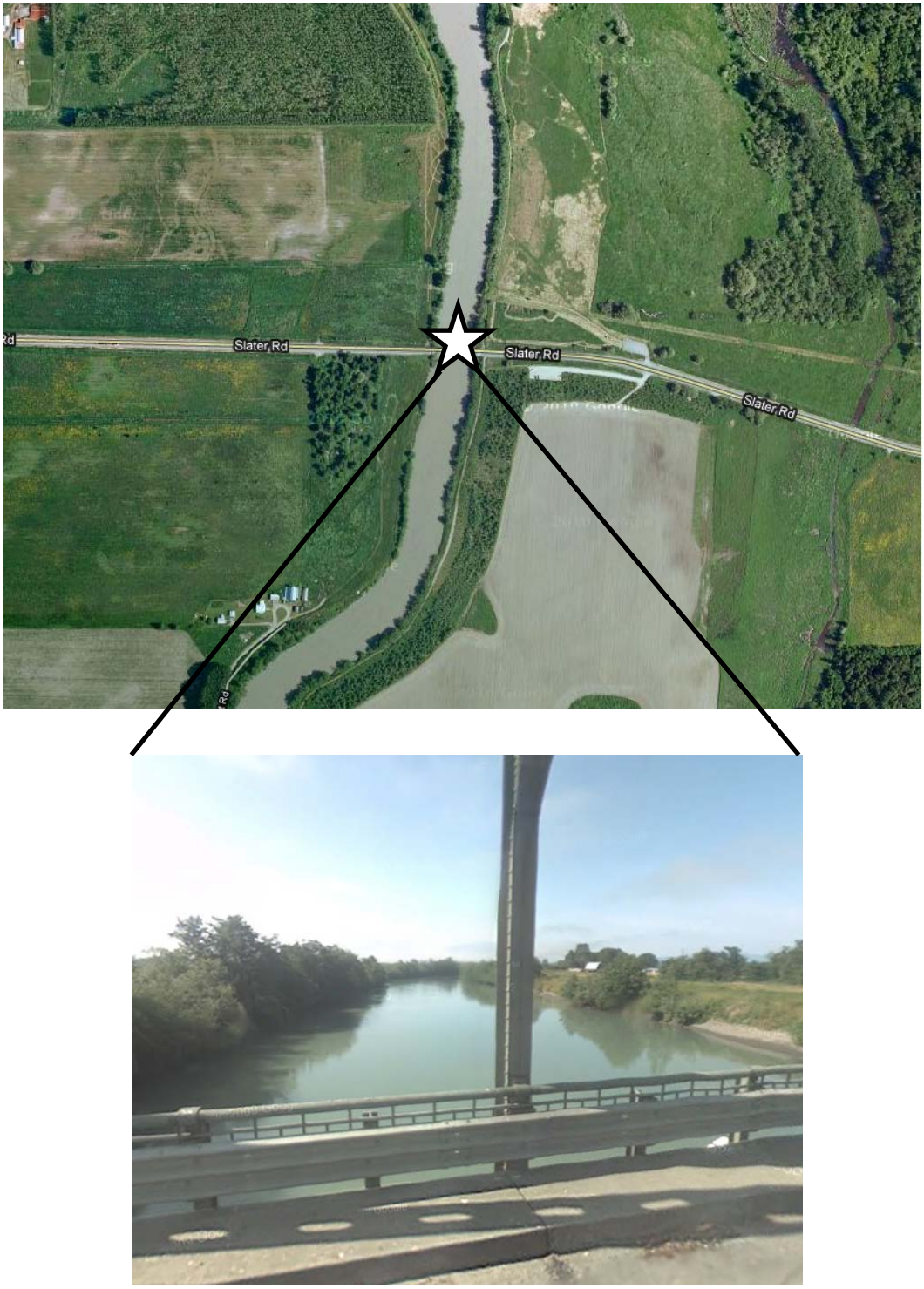

Figure B-13. Nooksack River sampling site.

Top: Aerial view of the Slater Road bridge over the Nooksack River (south of Ferndale, Washington).

Bottom: Photograph taken from the bridge deck looking approximately south (downstream).

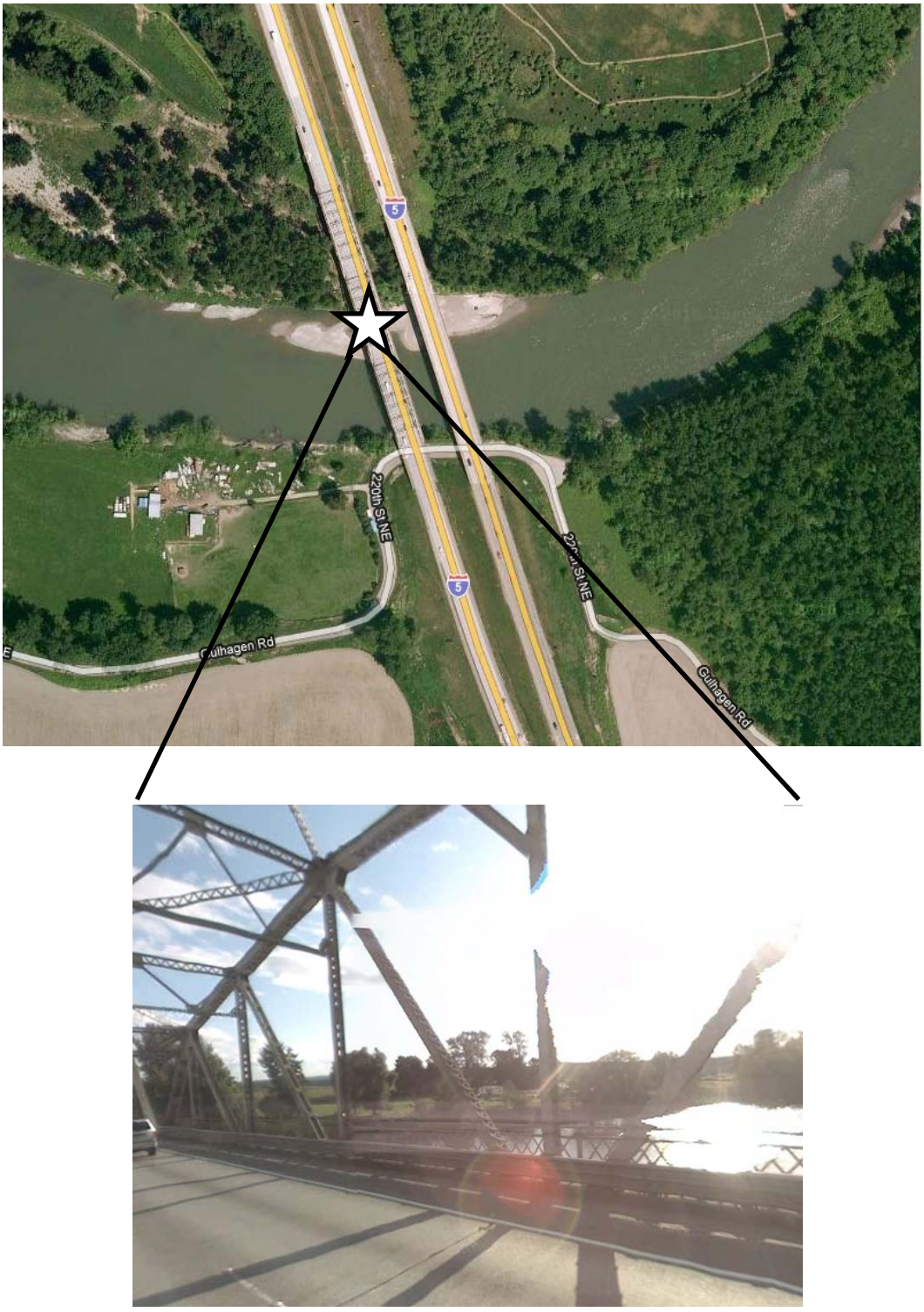

Figure B-14. Stillaguamish River sampling site.

Top: Aerial view of the Interstate-5 bridges over the Stillaguamish River near Silvana (west of Arlington, Washington).

Bottom: Photograph taken from the western (southbound) span of the bridge looking southwest.

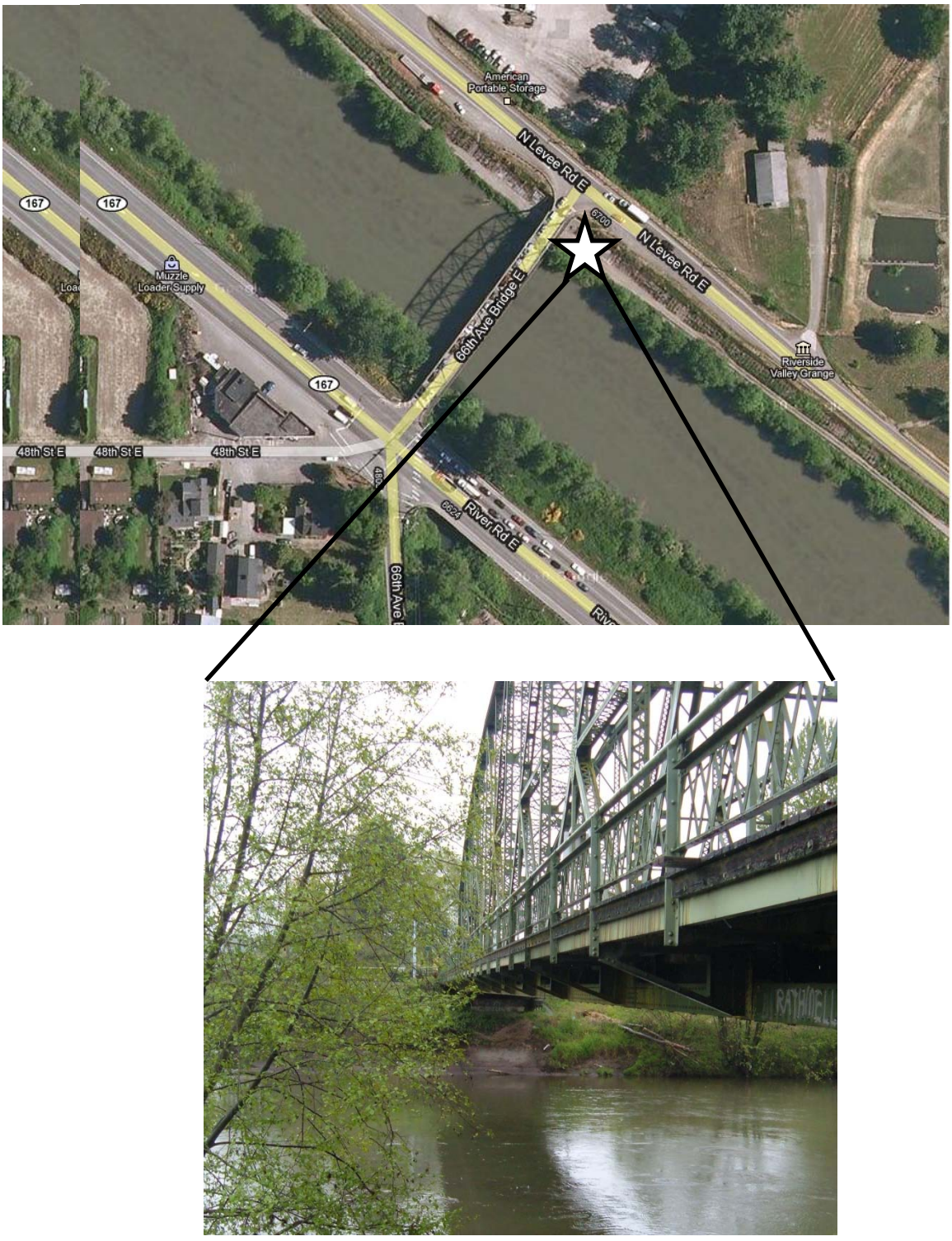

Figure B-15. Puyallup River sampling site.

Top: Aerial view of the 66th Avenue bridge over the Puyallup River west of the City of Puyallup.

Bottom: Photograph taken from the north bank of the river, just upstream of the bridge (location shown as star at the top).

Appendix C. Sampling and Analysis Methods

Sampling for Trace Levels of Analytes in Marine Waters using GO-FLO Samplers

Sampling Marine Waters for Organic Carbon

Sample Containers, Preservation, and Holding Times

Analytical Methods

Sampling for Trace Levels of Analytes in Marine Waters using GO-FLO Samplers

Effective control of contamination during the collection and handling of marine water column samples is of paramount importance. Many of the target analytes are ubiquitous on the sampling platform and equipment, often at several orders of magnitude higher than concentrations expected in ambient waters. Introduction of contamination at this stage will negate all care taken in subsequent analytical steps.

These field protocols are intended to provide a step-by-step procedure for the collection of contamination-free water samples from depth in marine waters. Guidance was taken from the sampling literature, and to the extent possible EPA *clean hands / dirty hands* techniques are employed (EPA, 1996). Performance of these protocols should be routinely measured through the collection and analysis of field blanks and replicates.

Overview

While there is no "standard" method for obtaining at-depth samples of marine waters for trace analyses, a proven and widespread technique involves the deployment of one or more Teflon-coated GO-FLO samplers (General Oceanics, Inc.) on a non-metallic hydrowire (typically Kevlar). The sampling procedures employed in the present study are based on this "standard" foundation as follows:

Two Teflon-coated GO-FLO samplers are mounted back-to-back (or several meters apart) on a non-metallic Vectran rope and are lowered by hand into the water with their end caps *closed* to avoid potential contamination from the microlayer at the water surface. The samplers open automatically by hydrostatic pressure release at a depth of approximately 10 meters. Site water flushes through the open samplers as they are lowered to the predetermined sampling depth. The samplers are remotely triggered by Teflon-coated messengers. A non-metallic windlass drum and Acetal sheave facilitate recovery of the GO-FLO samplers and ensure that the rope does not contact potentially contaminating materials. Once on-board, the sampler end caps are kept covered by polyethylene bags to minimize atmospheric exposure, and the samplers are secured in a purpose-built storage cabinet.

Subsampling activities are conducted within a simple portable glove box. Water samples are decanted from each GO-FLO sampler via clean Teflon tubing that connects to the sampler drain valve inside the storage cabinet and to a Teflon petcock inside the glove box. In this way, sample bottles for the various analytes are filled in an environment isolated from major air- and ship-borne contamination sources. If the project lead judges the protection of a glove box to be unnecessary, the GO-FLO samplers may simply be drained through Teflon tubing and into the various analyte sample bottles (with minimal exposure to potential atmospheric contaminants).

At the completion of a sampling cruise, the GO-FLO samplers undergo cleaning and storage procedures.

Principal equipment

- 10-liter GO-FLO samplers (2) – Teflon-coated with Teflon drain valves and air vent screws; spare parts kit.
- Vectran 12-strand rope (600 ft) – marked at 1- and 5-meter increments.
- Teflon-coated messengers.
- Snatch block and non-metal sheave – Ronstan single snatch block with Trunnion head and Acetal sheave.
- Non-metallic line weight – 20-lb. lead weight encased in epoxy resin.
- Cabinet for clean storage and transportation of GO-FLO samplers – constructed of UHMW polyethylene and Teflon materials.
- Large polyethylene bags capable of completely enclosing a single 10-liter GO-FLO sampler.
- Elasticized polyethylene "shower caps" (Saranwrap Quick Covers) or 2-gallon Ziplock bags.
- Talc-free Nitrile gloves.
- Clinometer or like instrument.
- Metals tubing train – 2-in. segment of MasterFlex 73 (3/8" O.D.) connects to GO-FLO drain valve, 6-ft segment of Teflon tubing (3/16" I.D.), and 2-ft segment of MasterFlex 73 tubing (3/8" O.D.) at peristaltic pump.
- Metals filter – in-line Gelman capsule filter, 0.45 µm.
- Peristaltic pump.

General rules

- Personnel must wear clean Nitrile gloves during all sampling and subsampling operations. If glove contamination is detected or suspected, work must be halted, the contaminated gloves removed, and a new pair of clean gloves put on. Wearing multiple layers of clean gloves allows the old pair to be quickly stripped with minimal disruption to the work activity.
- The upper ball valve of each GO-FLO sampler must be covered with an elasticized polyethylene "shower cap" at all times except during active deployment. The drain valve of each GO-FLO sampler must be covered with a Nitrile glove at all times except during active deployment and sample decanting.
- Samplers are transported around the vessel within polyethylene bags when possible, and are handled only by gloved personnel. The samplers should never be placed directly on deck or any hard surface where foreign particles might be lodged in the ball valves and cause contamination of subsequent samples. Improper use and handling of GO-FLO samplers can result in permanent contamination.
- Ensure at all times that the Vectran 12-strand rope does not make contact with any part of the vessel (other than the Acetal sheave and windlass drum). When not in use, remove the rope from the snatch block and coil it inside a clean polyethylene bag. Place the bagged rope within a sealed plastic container to minimize exposure to air- and ship-borne contaminants.
- Store the snatch block, line weights, and messengers in clean polyethylene bags when not in use.

- All polyethylene storage bags are considered "one-time use." That is, once a piece of equipment is removed from its storage bag, a separate clean bag must be used for subsequent storage.

Preparation

- Upon arrival at the sampling location, turn the engine off and wait 10 minutes before placing any sampling equipment in the water. Allow the vessel to drift during all sampling operations and conduct all sampling on the windward side of the vessel to minimize contamination from shipboard sources.
- Remove the snatch block from its polyethylene storage bag and secure it to the A-frame.
- Tie off the bitter end of the Vectran rope to a plastic cleat to secure it in case of mishap. Feed the working end of the rope over the sheave, being careful not to touch any metal objects that could embed foreign particles in the braid. Keep as much standing rope inside the covered plastic container as possible.
- Remove the line weights from storage bags and attach the weights to the loop eye at the working end of the Vectran rope. Lift the weights overboard and lower them into the water so that at least 10 meters of rope extend above the weights. Secure the rope to a plastic cleat to maintain this configuration, and replace any extra rope into the rope storage box.
- Arm the GO-FLO samplers and secure each to the Vectran rope – *This is a 2-person activity and personnel must wear clean gloves*. Layering of gloves is recommended to facilitate rapid discarding of dirty/contaminated gloves. Technicians should work carefully but quickly, striving to minimize the duration of atmospheric exposure for GO-FLO samplers secured to the Vectran rope. Follow the procedures listed below for the first GO-FLO sampler, and then repeat the procedure to arm and secure the second GO-FLO sampler.
    - Technician #1 (T1) removes the sampler from the storage cabinet (keeping it inside the polyethylene bag in which it was stored).
    - Technician #2 (T2) places a clean polyethylene bag flat on a stable surface away from contamination sources. T1 places the GO-FLO sampler (still inside its polyethylene storage bag) on the bag.
    - T2 puts on clean gloves and reaches inside the storage bag to arm the GO-FLO sampler; contact with the GO-FLO sampler is only made by T2. T1 assists by stabilizing the sampler and manipulating the storage bag for T2.
        - Reverse the spring over the pulley to release tension.
        - Pull the pressure release valve all the way out and position the lanyard poly-balls on either side between the valve and the stainless steel frame.
        - Attach the lanyard to the plunger mechanism by inserting the slack loop into the trip release.
        - Re-span the spring by rotating it over the pulley so that the spring and the lanyards are under tension.
        - *Optional:* Test the closing mechanism to verify that it functions properly.
            - Push the pressure release valve to cause the ball valves to move to the open position.
            - Press the plunger to release the lanyard, which results in bottle closure.
            - Re-arm the GO-FLO sampler after this check.

- T1 carries the armed sampler (still inside the storage bag) to the Vectran rope. T2 reaches inside the storage bag and checks that the protective "shower cap" and Nitrile glove are securely covering the upper ball valve and drain valve, respectively. T2 then removes the GO-FLO sampler from the storage bag. T1 discards the storage bag and secures the GO-FLO sampler to the Vectran rope at the 10-meter marking above the line weights.
- T1 puts on clean gloves, and the above procedure is repeated for the remaining GO-FLO sampler. Mount the second sampler above the first and note the distance between the vertical centers of the samplers. Samplers are typically spaced two to five meters apart to ensure triggering of the lower sampler by a serial messenger.

- To prepare the samplers for serial firing, attach a Teflon-coated messenger by its lanyard to the plunger mechanisms of the upper GO-FLO sampler, and then snap the messenger onto the Vectran rope between the two samplers.

Deployment

- GO-FLO samplers armed using the above procedures are set to be deployed in a *closed* position to avoid potential contamination from the surface microlayer. If the number of line weights needed to overcome the buoyancy of the air trapped in the GO-FLO samplers becomes prohibitive, consider deploying the samplers in the *open* position. The ball valves can be easily released to the *open* position by depressing the pressure release piston. Note that the poly-balls on the lanyards are under tension and will snap quite suddenly when the pressure release piston is pressed in. Keep hands well clear of the poly-balls, and use a pen wrapped in either a polyethylene bag or a clean glove to depress the pressure valve.
- By convention, at the water surface the GO-FLO samplers are at 0 meters depth. Record the depth marking at which the GO-FLO samplers are mounted on the Vectran rope. This length of rope between each sampler and the line weights is called the "Weight Segment". In calm conditions when the rope angle (deviation from vertical) is negligible, the length of rope from the depth of the GO-FLO samplers in the water column to the surface (called the Sampler Segment) is equal to the total length of rope payed out (Total Length) minus the Weight Segment.

$$\text{Sampler Segment} = (\text{Total Length}) - (\text{Weight Segment})$$

- Immediately before deployment, remove the protective "shower cap" from the upper ball valve and the Nitrile glove from the drain valve of each GO-FLO sampler. Wearing clean gloves, check that all drain valves and air vent screws are tightly closed.
- Lower the samplers quickly and completely through the water surface to minimize contact with the surface microlayer. Once submerged, slowly lower the GO-FLO samplers by hand to ~15-20 meters depth. The hydrostatic pressure release valve should cause the ball valves to open at approximately 10 meters.
- Verify that the ball valves have opened properly: the parcel of air trapped in each sampler will be visible as it bubbles to the surface. If bubbles are not seen and there is concern that a sampler did not open, raise the rope slowly until the status of the ball valves can be assessed visually. However, note that contamination risks increase as the samplers approach the surface and the vessel. If water conditions are turbid or rough, assume that the bottle is open

and accept that redeployment may be necessary. The weight of a retrieved sampler will be indicative of it being empty or filled with water.

- Lower the GO-FLO samplers to the desired sampling depth.
- Pay out additional rope as needed to adjust for significant rope angles (e.g., caused by strong currents or wind).
  - Read the Total Length and subtract the Weight Segment to determine the Sampler Segment.
  - Measure the angle of the rope from vertical (called Rope Angle) using a clinometer.
  - Calculate the actual depth of the GO-FLO samplers, the "Sampler Depth":

    (Sampler Depth) = (Sampler Segment) x cosine (Rope Angle)

  - Use the vessel's depth sounder for general verification (GO-FLO samplers should be detected by the sounder).
- Remove a Teflon-coated messenger from its storage bag, attach it to the Vectran rope, and release. This messenger will trigger closure of the upper GO-FLO sampler, followed by release of the serial messenger and subsequent triggering of the lower GO-FLO sampler.
- Allow adequate time for the messenger to reach the GO-FLO samplers before retrieval.

Recovery

- Use the windlass to recover the GO-FLO samplers, and feed the rope into the storage container as it is collected to minimize the potential for contact with contamination sources. It may be necessary to have the vessel's engine running to avoid complete draw-down of the battery by the windlass. In that case, engine assistance may only be used to raise the samplers to a depth of 10 meters. Above (i.e., shallower than) 10 meters depth, the engine must be off to avoid introducing excess contamination to the water column through which the GO-FLO samplers will travel. After the engine is off, allow at least one minute for ship-influenced water to dissipate before resuming sampler recovery.
- Once the GO-FLO samplers are retrieved to deck level, quickly inspect for leakage. If leakage is detected or suspected, prepare all samplers for re-deployment as follows:
  - Empty each GO-FLO sampler.
  - Rinse the sample chamber, the drain valve, and the air vent screw with de-ionized water.
  - Wearing clean gloves, and with the GO-FLO samplers still mounted on the Vectran rope, re-arm the samplers.
  - Re-deploy the GO-FLO samplers.
- If no leakage is apparent, immediately place clean polyethylene "shower caps" on the GO-FLO samplers' top ball valves. Rinse the samplers' drain valves with de-ionized water and cover each with a Nitrile glove.
- Remove the messengers and place them in a polyethylene bag for storage.
- Disengage the GO-FLO samplers individually and transport each to the storage cabinet. *This is a 2-person activity and all personnel must wear clean gloves*. Follow the steps below for the first GO-FLO sampler, and then repeat for the second sampler.

- T1 supports the GO-FLO sampler to be removed, and T2 releases the screws that secure the sampler to the line.
- While T1 holds the GO-FLO sampler, T2 places a clean polyethylene bag over the unit. T1 adjusts so that the sampler is completely contained in the bag.
- T1 carries the GO-FLO sampler to the storage cabinet; T2 acts as a spotter. The sampler should not make contact with any part of the vessel.
- T1 places the GO-FLO sampler inside the storage cabinet in an upright position (it should remain in the polyethylene bag). T1 secures the GO-FLO sampler inside the cabinet using bungee cords.
- T2 puts on clean gloves, opens the GO-FLO sampler's air vent screw, and removes the glove from the drain valve.
- Inside the glove box (situated under the cabinet), T1 removes a clean Teflon tubing/ petcock assembly from its storage bag. The open end of the tubing remains covered with foil, and the petcock remains protected by a Nitrile glove until subsampling activities commence. T1 feeds the tubing from inside the glove box to the GO-FLO sampler cabinet, and checks that the petcock inside the glove box is closed.
- T2 receives the Teflon tubing at the storage cabinet, removes the foil from the end, and connects the tubing to the drain valve's compression fitting. T2 opens the drain valve, and T1 makes sure that the petcock isn't leaking in the glove box.

- Wearing clean gloves, remove the line weights and place them in polyethylene bags for storage. Release the Vectran rope from the snatch block. Coil the rope, place it in a polyethylene bag, and store it within the sealed container to protect against air- and ship-borne contaminants. Place the snatch block in a polyethylene bag for storage.

Subsampling

- Begin decanting from the GO-FLO samplers as soon as possible to prevent settling, biological activity, or adsorptive losses.
- Prior to the cruise, pre-labeled bottles for a specific sampling location and depth (henceforth called a "set") will have been assembled in two large, layered polyethylene bags. Wearing clean gloves, remove the outer polyethylene bag and transfer the set (still contained in the inner polyethylene bag) to the inside of the glove box.
- Place a wide-mouthed waste container inside the glove box.
- The flow of water from a GO-FLO sampler is controlled from inside the glove box using the Teflon petcock. Remove the protective Nitrile glove to access a petcock. Be extremely careful, and ensure that nothing in the glove box makes contact with the exposed petcock at any time.
- Drain the first 0.5 liters of water from each GO-FLO sampler into the waste container before decanting sample water for chemical analyses.
- Decant whole-water subsamples.
  - Remove the analyte bottle(s) from the set bag as they are needed, and follow analyte-specific handling procedures (e.g. bottle rinses).
  - The recommended sequence for decanting analyte samples is as follows:

    - GO-FLO sampler #1:
        1. Total Suspended Solids – 2 L
        2. DOC and POC – 1 L
        3. PCB Congeners – 2.5 L
        4. PBDE Congeners – 1 L
        5. Chlorinated Pesticides – 1 L
        6. Backup volume in case of mishap – 1 L
    - GO-FLO sampler #2:
        7. PAHs – 1 L
        8. BNAs – 3.5 L
  - Filtration for DOC and POC is carried out immediately after their 1-liter subsample is decanted from the GO-FLO sampler (i.e., while other analyte subsamples are still being drained from the samplers). Filtration protocols are detailed elsewhere in this Appendix.
  - After each analyte bottle is filled, attach a sample tag with the required identification information (e.g., sample I.D., date/time, location, analyte, etc.). Seal the individual bottle inside a polyethylene bag and then inside another polyethylene bag.
  - *Do not* allow the mouth of an analyte bottle to contact the petcock at any time.
  - *Do not* swirl or shake the GO-FLO samplers to re-suspend settled material, as this can alter partitioning between dissolved and particulate size fractions.
- Observing *clean hands / dirty hands* guidelines, set up a clean tubing train for collecting metals samples from GO-FLO #2.
  - Use the peristaltic pump to flush 250 mL of sample water through the tubing train before rinsing and filling the total metals bottle. Label and double-bag the bottle.
  - Attach the in-line metals filter to the tubing train. Remove the end of the tubing train from the drain valve of GO-FLO #2 and place it in a bottle of laboratory-provided reagent water. Use the peristaltic pump to flush the filter with 750 mL of reagent water. Re-connect the end of the tubing train to the drain valve of sampler #2, and flush the filter with 250 mL of sample water before rinsing and filling the dissolved metals bottle with filtrate. Label and double-bag the bottle.
- Remove the set of subsample bottles from the glove box and place them in a cooler on ice.

Between stations or sampling events

- To minimize the risk of contamination to the GO-FLO samplers during short-term storage, adhere to the following precautions:
  - Store the samplers in polyethylene bag(s) inside the storage cabinet, and only remove a sampler just prior to deployment.
  - All valves (i.e., ball valves, air vent screws, drain valves) should be stored in their final closed position.
  - Cover the upper ball valve with an elasticized “shower cap,” even when the sampler is inside a polyethylene storage bag.
  - Protect the drain valve by storing it covered by a Nitrile glove.
- If contamination of any GO-FLO sampler is suspected, stop using the sampler and return it to the lab for a thorough cleaning.

Extended storage

- Prior to long-term storage, rinse the GO-FLO samplers with de-ionized water.
- Ensure that all valves are in their final closed position.
- Cover the upper ball valve with a clean elasticized "shower cap," and place a clean Nitrile glove over the drain valve.
- Store the GO-FLO samplers in one or more clean polyethylene bag(s) and secure them in the storage cabinet.
- If GO-FLO samplers are not to be used within 30-60 days, return the samplers to the lab and schedule a thorough cleaning and maintenance. Procedures will be guided by existing standard techniques for the cleaning of Teflon-coated sampling equipment for priority pollutant sampling.

References for Additional Information

Ahlers, W.W., M.R. Reid, J.P. Kim, and K.A. Hunter, 1990. Contamination-free sample collection and handling protocols for trace elements in natural fresh waters. Aust. J. Mar. Freshwater Res. 41: 713-720.

Bruland, K.W., K.J. Orians, and J.P. Cowen, 1994. Reactive trace metals in the stratified North Pacific. Geochim. et Cosmochim. Acta. 58(15): 3171-3182.

Bruland, K.W., R. Franks, G.A. Knauer, and J.H. Martin, 1979. Sampling and analytical methods for the determination of copper, cadmium, zinc and nickel at the nanogram per liter level in sea water. Analytica Chimica Acta. 105: 233-245.

De Baar, H.J.W., K.R. Timmermans, P. Laan, H.H. De Porto, S. Ober, J.J. Bloom, M.C. Bakker, J. Schilling, G. Sarthou, M.G. Smit, and M. Klunder, 2008. Titan: a new facility for ultraclean sampling of trace elements and isotopes in the deep ocean in the international GEOTRACES program. Mar. Chem. 111: 4-21.

EPA, 1996. Method 1669: Sampling Ambient Water for Trace Metals at EPA Water Quality Criteria Levels. U.S. Environmental Protection Agency, Office of Water Quality, Washington D.C. Publication No. EPA-R-95-034.

Grasshoff, K., M. Ehrhardt, and K. Kremling, Eds., 1999. Methods of Seawater Analysis, 3rd. rev. ed. Verlag Chemie GmbH. Weinheim, Germany. 600 pp.

Hunter, C.N., R.M. Gordon, S.E. Fitzwater, and K.H. Coale, 1996. A rosette system for the collection of trace metal clean seawater. Limnol. Oceanogr. 41(6): 1367-1372.

Landing, W.M., G.A. Cutter, J.A. Dalzier, A.R. Flegal, R.T. Powell, D. Schmidt, A. Schiller, P. Statham, S. Westerlund, and J. Resing, 1995. Analytical intercomparison results from the 1990 IOC open-ocean baseline survey for trace metals: Atlantic Ocean. Mar. Chem. 49: 253-265.

Mason, R.P. and K.A. Sullivan, 1996. Standard Operating Procedure for site selection and sampling for mercury in lakewater. In: Lake Michigan Mass Balance Methods Compendium Volume 1, Sample Collection Techniques. LMMB 012: 177-183. www.epa.gov/glnpo/lmmb/methods/index.html.

Measures, C.I., W.M. Landing, M.T. Brown, and C.S. Buck, 2008. A commercially available rosette system for trace metal-clean sampling. Limnol. Oceanogr.: Methods. 6: 384-394.

Paulson, A.J., H.C. Curl, Jr., R.A. Freely, K.A. Krogslund et al., 1991. Trace metal and ancillary data in Puget Sound: August 1986. NOAA Data Report ERL PMEL-31.

Sanderson, M.P., C.N. Hunter, S.E. Fitzwater, R.M. Gordon, and R.T. Barber, 1995. Primary productivity and trace-metal contamination measurements from a clean rosette system versus ultra-clean GO-FLO bottles. Deep-Sea Res. II. 42: 431-440.

Schaule, B.K. and C.C. Patterson, 1980. The occurrence of lead in the Northeast Pacific and the effects of anthropogenic inputs. In: M. Branica and Z. Konrad, Eds. Lead in the Marine Environment. Oxford: Pergamon Press. p. 31-43.

Schaule, B.K. and C.C. Patterson, 1981. Lead concentrations in the Northeast Pacific: evidence for global anthropogenic perturbations. Earth and Planetary Science Letters. 54: 97-116.

USGS, 1994. A Protocol for the Collection and Processing of Surface-Water Samples for Subsequent Determination of Trace Elements, Nutrients, and Major Ions in Filtered Water. Office of Water Quality Technical Memorandum 94.09. Office of Water Quality, Water Resources Division, U.S. Geological Survey, Reston, VA. Jan. 28, 1994.

Sampling Marine Waters for Organic Carbon

The following standard operating procedures (SOPs) represent a modified version of those used by Horn Point Marine Laboratory, University of Maryland (Lane, 2000).

Procedure for collecting particulate organic carbon (POC) samples

Equipment

- All-glass filter apparatus, pre-washed with 10% HCl (400 mL capacity filter column, scintered filter support with silicone stopper for 1000 ml side arm flask).
- Stainless steel forceps, similarly pre-cleaned.
- Certified pre-cleaned 30-50 ml amber glass DOC storage vials.
- GFF filters (25 mm diameter, 0.7 μm pore size), pre-combusted at 450°C for 90 min, handled with clean forceps only, and stored in aluminum foil packets on which the filter number is pre-recorded.

Filtration Procedure

- Assemble filtration apparatus with pre-combusted filter in place (unpatterned side up) between scintered support and funnel.
- Connect side arm flask to hand pump using pharmaceutical grade tubing.
- Apply gentle vacuum with hand pump (<10 inches Hg or <5 psi) and, ideally, filter water sample for no more than 5 minutes.
  - Volumes requiring 5 minutes filtration may be estimated by filtering incremental volumes of sample water through a discardable filter.
  - Multiple filtrations/filters may be needed to collect sufficient filtrate for DOC analysis.
- Record *total volume filtered* to 3 significant places (e.g., 1020 ml, 102 ml, 10.2 ml).
- Use clean forceps to fold used filter, still on scintered column, in half (top side of filter with POC is folded in on itself).
- Enclose individual used filters in aluminum foil packets.
- Record date/time, sample identification number, and filtrate volume legibly on exterior of aluminum foil packet with a permanent marker (CAUTION: do not puncture foil packet).
- Store aluminum foil packet in a plastic bag and refrigerate in the dark.

Drying Filters

- Within 48 hours, transfer POC filter in aluminum foil packets to laboratory environment.
- Partially open packets using cleaned forceps, place in convection oven, and dry overnight at 60°C.
- Close aluminum foil packet and place in dry plastic bag for shipment.
- Re-label aluminum foil packet if any information on label is no longer visible.

Procedure for collecting dissolved organic carbon (DOC) samples
(DOC is also referred to as NPOC or non-purgeable organic carbon)

- Collect one duplicate sample for every 10 samples to increase precision.
- Rinse side arm flask with approximately ½ sample volume expected to be filtered for POC.
- Remove filter column from flask (leaving filter in place between support and funnel), swirl filtrate thoroughly in flask and discard.
- Reassemble apparatus.
- Filter remaining volume for POC.
- Record station, date, and total volume filtered through filter for POC procedure (see above).
- Remove filter (described above).
- Rinse sample vial(s):
  - Transfer a few milliliters filtrate vial and cap.
  - Shake filtrate and discard.
- Fill vial with at least 20 mLs filtrate.
- Store vial in refrigerator in the dark (4°C).
- DO NOT FREEZE OR ADD ACID!
- Ship overnight within 2 weeks, using ice packs to keep samples cold but not frozen.

Sample Containers, Preservation, and Holding Times

Table C-1. Sample containers, requested volumes, preservation, and holding times for marine water column samples.

Parameter	Bottle Type and Volume	Sample Volume Requested	Preservation	Holding Time
TSS	1 L Poly	2 L	Cool to $\leq 6^{o}$ C	7 days
DOC	40 mL Amber Glass	40 mL	Filter in field w/ 0.7 µm GFF filter; Cool to $\leq 6^{o}$ C	28 days
POC	1 L Amber Glass	variable	Dry filter w/in 2 days; Cool to $\leq 6^{o}$ C	28 days
Total Metals	1000 mL HDPE	1 L	HNO_3 to pH < 2; Cool to $\leq 6^{o}$ C *	6 months
Dissolved Metals	1000 mL HDPE	1 L	Filter in field w/ 0.45 µm filter; HNO_3 to pH < 2; Cool to $\leq 6^{o}$ C *	6 months
Semivolatiles (BNA)	1 Gallon Glass	3 L	Cool to $\leq 6^{o}$ C	7 days
PAHs	1 L Amber Glass	1 L	Cool to $\leq 6^{o}$ C	7 days
Chlorinated Pesticides	1 L Amber Glass	1 L	Cool to $\leq 6^{o}$ C	7 days
PCB Congeners	2.5 L Amber Glass	2.5 L	Cool to $\leq 6^{o}$ C	1 year
PBDE Congeners	1 L Amber Glass	1 L	Cool to $\leq 6^{o}$ C	1 year
Total 13.54 L				

* Metals samples were acidified at the analyzing laboratory to avoid introducing contamination in the field and for safety of staff.

Table C-2. Sample containers, requested mass, preservation, and holding times for marine particulate samples.

Parameter	Bottle Type and Volume	Sample Mass Requested * (wet weight)	Preservation	Holding Time
Percent Solids	2 oz Glass	50 Grams	Cool to $\leq 6^{o}$ C	7 days
TOC			Cool to $\leq 6^{o}$ C; may freeze at -18^{o}C	14 days; 6 months frozen
Total Recoverable Metals			Cool to $\leq 6^{o}$ C; may freeze at -18^{o}C	6 months
Semivolatiles (BNA)	8 oz Glass	250 Grams	Cool to $\leq 6^{o}$ C	14 days; 1 year frozen
PAHs				
Chlorinated Pesticides		250 Grams	Cool to $\leq 6^{o}$ C	14 days; 1 year frozen
PCB Congeners		50 Grams	Cool to $\leq 6^{o}$ C; may freeze at -18^{o}C	1 year
PBDE Congeners		50 Grams	Cool to $\leq 6^{o}$ C; may freeze at -18^{o}C	1 year
Total 650 Grams				

* The minimum mass required to obtain specified detection limits for each analysis is less than the mass requested by analytical laboratories listed here and in the QA Project Plan.

Table C-3. Sample containers, requested volumes, preservation, and holding times for river water samples.

Parameter	Bottle Type and Volume	Sample Volume Requested	Preservation	Holding Time
TSS	1 L Poly	2 L	Cool to $\leq 6^{o}$ C	7 days
TOC	60 mL Poly	50 mL	1:1 HCl to pH < 2; Cool to $\leq 6^{o}$ C	28 days
DOC	60 mL Poly	50 mL	Field filter w/ 0.45 µm; 1:1 HCl to pH < 2; Cool to $\leq 6^{o}$ C	28 days
Hardness	125 mL Poly	100 mL	H_2SO_4 to pH <2; Cool to $\leq 6^{o}$ C	6 months
Nutrients: Ortho-phosphate	125 mL Amber Poly	125 mL	Field filter w/ 0.45 µm; Cool to $\leq 6^{o}$ C	48 hours
Nutrients: Total phosphorus	60 mL Poly	50 mL	1:1 HCl to pH < 2; Cool to $\leq 6^{o}$ C	28 days
Nutrients: Ammonia, Nitrate+Nitrite, and Total Nitrogen	125 mL Clear Poly	125 mL	Pre-acidify w/ H_2SO_4; Cool to $\leq 6^{o}$ C	28 days
Total Metals	500 mL HDPE	350 mL	HNO_3 to pH < 2; Cool to $\leq 6^{o}$ C	6 months
Dissolved Metals	500 mL HDPE	350 mL	Field filter w/ 0.45 µm; HNO_3 to pH < 2; Cool to $\leq 6^{o}$ C	6 months
TPH-D	1 L Amber Glass	3 L	Cool to $\leq 6^{o}$ C	14 days
TPH-G	40 mL VOAs	360 mL	1:1 HCl to pH < 2; Cool to $\leq 6^{o}$ C	14 days
Oil and grease	1 L Glass	3 L	1:1 HCl, pH < 2; Cool to $\leq 6^{o}$ C	28 days
BNAs	1 Gallon Glass	3 L	Cool to $\leq 6^{o}$ C	7 days
PAHs	1 L Amber Glass	1 L	Cool to $\leq 6^{o}$ C	7 days
Chlorinated Pesticides	1 L Amber Glass	1 L	Cool to $\leq 6^{o}$ C	7 days
PCB Congeners	2.5 L Amber Glass	2.5 L	Cool to $\leq 6^{o}$ C	1 year
PBDE Congeners	1 L Amber Glass	1 L	Cool to $\leq 6^{o}$ C	1 year
Total 18.06 L				

Table C-4. Sample containers, requested mass, preservation, and holding times for river particulate samples.

Parameter	Bottle Type and Volume	Sample Mass Requested * (wet weight)	Preservation	Holding Time
Percent Solids	2 oz Glass	50 Grams	Cool to $\leq 6^{o}$ C	7 days
TOC			Cool to $\leq 6^{o}$ C; may freeze at -18^{o}C	14 days; 6 months frozen
Metals Total Recoverable			Cool to $\leq 6^{o}$ C; may freeze at -18^{o}C	6 months; 2 years frozen
BNAs **	8 oz Glass	250 Grams	Cool to $\leq 6^{o}$ C; may freeze at -18^{o}C	14 days; 1 year frozen
PAHs **				
TPH-D **			Cool to $\leq 6^{o}$ C	14 days
PCB Congeners		50 Grams	Cool to $\leq 6^{o}$ C; may freeze at -18^{o}C	1 year
PBDE Congeners		50 Grams	Cool to $\leq 6^{o}$ C; may freeze at -18^{o}C	1 year
Total 450 Grams				

* The minimum mass required to obtain specified detection limits for each analysis is less than the mass requested by analytical laboratories listed here and in the QA Project Plan.

** Insufficient particle mass was collected at the Stillaguamish River to conduct these analyses.

Analytical Methods

Table C-5. Summary of marine water column sample analyses.

Number of samples analyzed includes field QA samples.

Parameter	Samples Analyzed	Final Reporting Limits	Preparation/ Extraction	Cleanup	Analytical Method	Method Description
Conventionals (mg/L)						
TSS	48	0.5 - 2.0	-	-	SM 2540 D	Gravimetric
POC	48	0.015 *	Acidification of dried samples	-	SM 5310	Combustion/oxidation Thermal conductivity
DOC	42	0.018 *	Filter 0.7 µm GFF	-		Combustion, Infrared detection
Total Recoverable and Dissolved Metals (µg/L)						
Arsenic	48 (total) and 47 (diss.)	0.05	• Reductive co-precipitation • Acid Digest • For dissolved metals, prefilter through 1.2 µm glass microfiber filters	-	FGS 054	ICP-MS
Cadmium		0.01				
Copper		0.05				
Lead		0.05				
Zinc		0.25				
Organic Compounds (µg/L unless noted otherwise)						
BNAs	48	0.08 - 3.6	Extraction	-	EPA 8270	Capillary GC/MS
PAHs	47	0.01- 0.02	Solid Phase	-	EPA 8270 SIM	GC/MS
Chlor. Pesticides (ng/L)	46	0.2 - 1.0	EPA 3510	-	EPA 8081	GC/ECD
PCB Congeners (pg/L)	53	3.9 - 0.6	Dichloromethane	Acid/base wash	EPA 1668A	GC/HRMS
PBDE Congeners (pg/L)	47	24 - 255			EPA 1614	

* These values are detection limits. The detection limit for POC is based on filtering 0.75 liters of seawater.

EPA = U.S. Environmental Protection Agency
FGS = Frontier GeoSciences
GC/HRMS = Gas Chromatography / High Resolution Mass Spectrometry
GC/MS = Gas Chromatography / Mass Spectrometry
ICP-MS = Inductively-coupled plasma detector, mass spectrometer confirmation
SIM = Selective Ion Monitoring
SM = Standard Methods (APHA, 2005)

Table C-6. Summary of river water sample analyses.

Number of samples analyzed includes field QA samples.

Parameter	Samples Analyzed	Final Reporting Limits	Preparation Method	Cleanup Method	Analytical Method	Method Description
Conventionals, Nutrients, and Hardness (mg/L)						
TSS	18	0.6 - 4.3	-	-	SM 2540 D	Gravimetric
TOC		1.0	Acidification	-	SM 5310 C	Combustion to CO_2 Infrared detection
DOC			Filtration (0.45 μm), Acidification			
Nutrients *	17	0.003 - 0.025	Reaction, Reduction or Digestion	-	SM 4500	Colorimetric
Hardness	18	0.3	Acidification	-	EPA 200.7	ICP, Calculation
Petroleum Products (mg/L)						
Oil and Grease	18	1.6 - 5.6	Hexane extraction	-	EPA 1664A	Gravimetric
TPH-D		0.02 - 0.13	Extraction	Acid/ silica	ECY 97-602	GC/FID
TPH-G	30	0.14	Acidification and Extraction			Purge and Trap GC/FID
Total Recoverable and Dissolved Metals (µg/L)						
Arsenic, Copper	21 (total) and 21 (diss.)	0.10	Acidification and Filtration (0.45um) + Acidification	-	EPA 200.8	ICP - MS
Cadmium, Lead		0.02 - 0.10				
Zinc		1.0 - 5.0				
Organic Compounds (µg/L unless noted otherwise)						
BNAs	19	0.08 - 3.4	Extraction	-	EPA 8270	Capillary GC/MS
PAHs	19	0.01 - 0.02	Solid Phase Extraction	-	EPA 8270 SIM	GC/MS
Chlorinated Pesticides (ng/L)	19	0.2 - 11	Extraction, EPA 3510	-	EPA 8081	GC/ECD
PCBs (pg/L)	21	3.8 - 11.4	Dichloromethane Extraction	Acid/ base wash	EPA 1668A	High Resolution GC/MS
PBDEs (pg/L)	20	12 - 280			EPA 1614	

* Total persulfate, nitrite plus nitrate, and ammonia nitrogen; total available and ortho-phosphate.
GC/FID = Gas chromatography/flame ionization detection
GC/ECD = Gas chromatography/electron capture detection

Table C-7. Summary of analyses for SPM collected from marine sediment traps and rivers.

Parameter	Sediment Trap Samples	Suspended River Solids	Final Reporting Limits	Sample Preparation Method	Sample Cleanup Method	Analytical Method	Method Description
Conventional parameters (%)							
Percent Solids	1	5	1	-	-	EPA 160.3	
TOC			0.1	-	-	PSEP, 1986/1997 EPA 415.1	
Metals - Total Recoverable (mg/Kg)							
Arsenic, Cadmium, Copper, Lead	2	5	0.05 - 0.1	SW-846 3050B	-	EPA 200.8	ICP - MS
Zinc			2.5 - 5.0				
Organic compounds (µg/Kg unless noted otherwise)							
TPH-D (mg/Kg)	-	4	10 - 44	SW-846 Extraction	-	EPA 8270	GC/FID
BNAs			21 - 740				Capillary GC/MS
PAHs			1.4 - 14	Soxhtherm Extraction	Silica Gel	EPA 8270 SIM	GC/MS
Chlorinated Pesticides			0.12 – 3.2	Extraction EPA 3541	-	EPA 8081	GC/ECD
PCB Congeners (ng/Kg)	2	5	4 - 22	Soxhlet Extraction	Acid/base wash	EPA 1668A	High Resolution GC/MS
PBDE Congeners (ng/Kg)			14 - 174			EPA 1614	

Appendix D. Data Quality

Study-Specific Data Quality Rules

Chemical Qualifier Code Revisions

Field QA Sample Descriptions and Results

Study-Specific Data Quality Rules

Assigning chemical qualifiers

- No chemical qualifier code was assigned when:
  - a concentration was greater or equal to the estimated quantitation limit (EQL), practical quantitation limit (PQL), or reporting limit (RL) listed by the laboratory, *and*
  - all or nearly all lab QC sample results were within specified control limits, *and*
  - the analyte of interest was positively identified.
- An "N" qualifier code was assigned to an otherwise unqualified result when the analyte could not be positively identified but there was evidence it was present [third condition above not met].
- A "J" qualifier code, indicating an estimated concentration, was assigned when:
  - a result was greater than or equal to the EQL, PQL, or RL, *and*
  - some lab QC sample results were outside specified control limit, *and*
  - the analyte of interest was positively identified.
- An "NJ" was assigned to an estimated concentration of a tentatively identified analyte.
- A "J" qualifier code, indicating an estimated concentration, was assigned when a detected concentration was less than the EQL, PQL or RL, but greater than or equal to the estimated detection limit (EDL) or method detection limit (MDL) listed by the laboratory. Concentrations were reported down to the listed EDL or MDL whenever possible.
- Valid EIM result data qualifiers (e.g., "G" or "L") that preserve evidence of low or high analytical bias were not assigned.
- An "REJ" qualifier code was assigned when the presence or absence of an analyte was not verified because of serious problems associated with the sample analysis or lab QC sample performance (results consistently or well outside of control limits). The result was unusable.
- A "U" was assigned when the analyte was not detected at or above a defined numeric value. Depending on the parameter and analytical purpose, nondetect values were set at the quantitation limit (EQL, PQL, or RL) or the detection limit (EDL or MDL). Sometimes results were presented using both methods of assigning concentrations to nondetect results.
- A "UJ" qualifier code was assigned to an individual analytical result for a variety of reasons:
  - The analyte was not detected at or above a quantification limit that is uncertain.
  - Initial or ongoing instrument calibrations were unacceptable.
  - Results for one or more lab QC samples were outside control limits.
  - The analyte was also detected in the lab method blank (see below).

Assigning chemical qualifiers and data flags due to elevated method blank concentrations

- No chemical qualifier code was assigned to a sample concentration that was ≥ a quantitation limit (EQL, PQL, or RL) and ≥ 10 times the concentration in the associated method blank.
- A "J" qualifier code was assigned to a sample concentration greater than or equal to three times (≥3 X) and less than or equal to ten times (≤ 10X) the concentration detected in the associated method blank. A "B" flag was entered into the associated EIM comment field to indicate that "J" was assigned because of the elevated blank concentration.
- A "UJ" qualifier code was assigned to a sample concentration ≥ EDL or MDL and less than three times (< 3X) the concentration detected in the associated method blank. A "B" flag was entered into the associated EIM comment field to indicate that "UJ" was assigned because of the elevated blank concentration and that the result may be used for some purposes.

Correcting for analytes detected in method blanks

Sample concentration results were not corrected for the presence of the same analyte in the batch-specific method blank. Exceptions included the following marine water column sample results:

- DOC. The mass of carbon (µg C) measured on batch-specific filter adsorption blanks was added to the µg C measured in filtered marine water column samples.
- POC. The µg C measured on batch-specific filter trip blanks was subtracted from the µg C measured on marine water column sample filters. The resulting sample concentration was then adjusted for the µg C (DOC) measured on batch-specific filter adsorption blanks.
- Metals. The contract laboratory adjusted the measured concentrations of metals in marine water column samples by subtracting the mean concentration measured in 3 batch-specific "preparation" (method) blanks. Ecology staff derived the original (uncorrected) lab result by adding the mean preparation blank concentration to the reported results. A different chemical qualifier code was then assigned if appropriate.

Correcting for analytes detected in field blanks

Sample results were not modified when field blanks (bottle, filter, transfer, and sampler blanks) showed presence of the same analyte. This decision was based on the following lines of evidence:

- Field blanks, although attempting to mimic sampling processes, were exposed to sources of contamination that the marine and river water samples were not.
    - Marine water column samples were thoroughly pre-rinsed with seawater.
    - Marine water column and river water samples were not exposed to ambient air to the same extent as were field blanks.
- The "fingerprint" of organic compounds (PCB and PBDE congeners) in field blanks was different from that found in field samples.

Summing analytes to estimate total concentrations

Summing rules were developed from Ecology internal *Guidance for Calculating Total Values of Selected Analytes for the EAP Toxics Studies Unit and EIM Parameter Names to Use (2008):*

- If some of the individual analytes were detected (greater than or equal to EDL or MDL), then only detected concentrations were summed to represent the total concentration.
- If none of the individual analytes was detected (greater than or equal to EDL or MDL), then various alternatives were taken:
  - For summed PAH values, ½ the RL was assigned to each PAH compound.
  - For summed PAH values, the MDL was assigned to each PAH compound.
  - For total PCBs and total PBDEs, the largest nondetect concentration (RL) for an individual congener was used.

Using nondetect values

Descriptive statistics and other statistical analyses, as well as estimates of annual mass exchange and loading of toxic chemicals, sometimes involved chemicals or chemical classes that were never or seldom detected in the water samples collected. Therefore, it was important to determine how to use nondetect ("U") values in statistics and calculations.

Several options were considered for using nondetect values for toxic chemicals such as petroleum-related compounds, BNAs, PAHs, chlorinated pesticides, and PBDEs. For statistical summaries and analyses, nondetect values were not used unless stated otherwise in the report. For calculations of annual mass fluxes and loadings, based on multiplying mean water concentrations by predicted water flux or river flow, nondetect values were used as follows:

- When all or most samples had detected concentrations, nondetect values were not used to calculate mean water concentrations.
- When a parameter was never or seldom detected, flux and loading calculations were based on:
  - Nondetects = 1/2 the RL.
  - Nondetects = the detection limit (EDL or MDL), if available.

Chemical Qualifier Code Revisions

Table D-1. Summary of data qualifier changes made to marine water column results (not including field QA samples) during project staff review.

QC Code Change	TSS	POC	DOC	As	As dissolved	Cd total	Cd dissolved	Cu total	Cu dissolved	Pb total	Pb dissolved	Zn total	Zn dissolved	Chlor Pest	BNAs	PAHs	PCBs	PBDEs	Total Changes
"_" → J	-	-	-	-	-	-	-	1	3	2	1	35	31	-	-	-	-	-	73
"_" → UJ	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1
J → "_"	-	-	-	-	-	-	-	-	-	2	1	-	-	-	-	-	-	-	3
J → UJ	-	-	-	-	-	-	-	-	-	5	3	-	2	-	1	-	-	-	11
U → J	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	3
U → UJ	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0
U1 → U2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0
B → UJ	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	10
UJ → "_"	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2
UJ → J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	7
B Flag *	-	-	-	-	-	-	-	1	3	8	8	38	37	51	37	2	38	110	333
Total Changes	0	0	0	0	0	0	0	2	6	17	16	73	71	51	38	2	48	119	443

* Entered into EIM, separate from chemical qualifier codes, to clearly denote presence of analyte in method blank(s).

Table D-2. Summary of data qualifier changes made to marine water field QA sample results during project staff review.

QC Code Change	TSS	POC	DOC	As	As dissolved	Cd total	Cd dissolved	Cu total	Cu dissolved	Pb total	Pb dissolved	Zn total	Zn dissolved	Chlor Pest	BNAs	PAHs	PCBs	PBDEs	Total Changes
"_" → J	-	-	-	-	-	-	-	-	1	-	-	5	4	-	-	-	-	-	10
"_" → UJ	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0
J → "_"	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0
J → UJ	-	-	-	-	-	-	-	2	1	1	1	1	-	-	-	-	-	-	6
U → J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0
U → UJ	-	-	-	-	-	-	-	1	1	1	1	-	1	-	-	-	-	-	5
U1 → U2	-	2	3	3	3	3	3	-	-	-	1	-	-	-	-	-	-	-	18
B → UJ	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-	6
UJ → "_"	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0
UJ → J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
B Flag *	-	-	-	-	-	-	-	3	3	2	2	6	5	4	6	-	10	14	55
Total Changes	0	2	3	3	3	3	3	6	6	4	5	12	10	4	6	0	16	15	101

* Entered into EIM, separate from chemical qualifier codes, to clearly denote presence of analyte in method blank(s).

Table D-3. Summary of data qualifier changes made to river water results (not including field QA samples) during project staff review.

QC Code Change	TSS	TOC	DOC	Ammonia	Nitrate+Nitrite	Total N (TN)	Total P (TP8)	Ortho-P	Hardness	As total	As dissolved	Cd total	Cd dissolved	Cu total	Cu dissolved	Pb total	Pb dissolved	Zn total	Zn dissolved	HEM	TPH-D	TPH-G	Chlor Pest	BNAs	PAHs	PCBs	PBDEs	Total Changes
"_" → J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	2	-	-	-	-	-	-	-	-	-	5
"_" → UJ	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1
J → UJ	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1
U → "_"	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	3
U → J	-	7	6	2	-	-	-	-	-	-	-	15	8	-	-	3	2	7	4	5	-	-	-	-	-	-	-	59
U → UJ	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-	1	-	-	-	-	-	-	-	-	-	3
U1 → U2	-	-	-	5	-	-	-	-	-	-	-	-	5	-	-	-	4	-	-	-	-	-	-	-	-	-	-	14
B Flag *	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	8	-	7	-	-	-	-	16	12	10	15	27	96
Total Changes	0	7	7	8	0	0	0	0	0	0	0	15	15	0	0	16	6	17	5	5	0	0	16	12	11	15	27	182

* Entered into EIM, separate from chemical qualifier codes, to clearly denote presence of analyte in method blank(s).

Table D-4. Summary of data qualifier changes made to river water QC sample results during project staff review.

QC Code Change	TSS	TOC	DOC	Ammonia	Nitrate+Nitrite	Total N (TN)	Total P (TP8)	Ortho-P	Hardness	As total	As dissolved	Cd total	Cd dissolved	Cu total	Cu dissolved	Pb total	Pb dissolved	Zn total	Zn dissolved	HEM	TPH-D	TPH-G	Chlor Pest	BNAs	PAHs	PCBs	PBDEs	Total Changes
"_" → J	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1
"_" → UJ	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0
J → UJ	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0
U → "_"	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0
U → J	-	1	1	1	-	-	-	-	-	-	-	3	2	-	1	1	1	3	1	1	-	-	-	-	-	-	-	16
U → UJ	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	2	-	-	-	-	-	-	-	-	-	5
U1 → U2	-	-	-	-	-	-	-	-	-	3	3	3	4	1	-	-	2	-	-	-	-	-	-	-	-	-	-	16
B Flag *	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	4	-	4	-	-	-	-	5	3	4	8	7	36
Total Changes	0	1	1	1	0	0	0	0	0	3	3	6	6	3	1	8	3	9	1	1	0	0	5	3	4	8	7	74

* Entered into EIM, separate from chemical qualifier codes, to clearly denote presence of analyte in method blank(s).

Field Quality Control Sample Descriptions and Results

Field replicates

Replicate sampling involved the analysis of two samples collected in an identical manner and in close spatial and temporal proximity. Field replicates provide a measure of field precision and allow for the assessment of the environmental variability of concentrations of target parameters.

Marine water column field replicates

- Parameters analyzed: All.
- Procedure: Following water collection from a regular sampling site, the GO-FLO samplers were immediately redeployed and collection was repeated at the same location and depth.

River water field replicates

- Parameters analyzed: All.
- Procedure: First, the complete set of depth-integrated river water samples was collected (compositing from three quarter points). After these samples were processed and stored, the river was sampled a second time using a new, acid-cleaned sampler.

Results for each replicate sample are presented beside the regular station sample results in Tables D-5, D-7, and D-8 for marine water, and in Tables D-11, D-13, and D-14 for river water. Replicate results were in good agreement with their corresponding station sample results for most parameters, as indicated by low relative percent difference (RPD) values. Marine water POC, marine water dissolved lead, and river water total cadmium occasionally had elevated RPDs that were attributable to low measured concentrations (i.e., near the analytical method detection limit) that exaggerated differences.

Elevated RPDs for other parameters suggested environmental variability. Slightly elevated RPDs for total PCB replicate sample pairs in both marine and river waters showed that samples collected in close spatial and temporal proximity may yield slightly variable concentration measurements, likely as a consequence of the affinity of these chemicals for particulates. Marine total lead and freshwater dissolved copper replicate pairs also had instances of anomalously high RPDs, but the observed variability was nowhere above what might be expected for samples collected up to three hours apart in dynamic bodies of water. As such, replicate results did not warrant the re-qualification of any project data.

For the purposes of this report, field replicates were used for QA assessment only; field replicate results were not averaged with their corresponding station sample results for data analyses presented in this document.

Field Duplicates

Duplicate sampling involved the analysis of two samples obtained from a single water collection. Field duplicates allow for the evaluation of analytical variability, or lab precision.

Marine water column field duplicates

- Parameters analyzed: TSS, DOC, POC, and PCB congeners.
- Procedure: Two samples for a given parameter were decanted from a single GO-FLO water collection. Organic carbon samples were processed simultaneously on separate clean filtration apparatuses.

Results for each duplicate sample are presented beside their corresponding station samples in Tables D-6 and D-7. These pairs of results generally agreed very well, as indicated by their low RPDs. Thus, duplicates were not used to re-qualify any project data.

For the purposes of this report, the results of the field duplicate analyses were not averaged with their corresponding station sample results.

Bottle and transfer blanks

Bottle blanks involved the analysis of analyte-specific blank water that was carried unopened into the field and treated as a sample. Transfer blanks involved pouring the same lab-provided blank water into a sample bottle in the field. These types of blanks allow for the evaluation of contamination arising from the sample bottles themselves, from general bottle handling, and from the atmosphere during sample transfers. Results also allow evaluation of the cleanliness of the blank water that was used for other field QA samples, such as equipment blanks.

Marine water column bottle blanks

- Parameters analyzed: PCB congeners.
- Procedure: Lab blank water obtained from Analytical Perspectives was brought unopened into the field and treated as a sample.

River water transfer blanks

- Parameters analyzed: Total metals, chlorinated pesticides, BNAs, PAHs, PCB congeners, and PBDE congeners.
- Procedure: For total metals, blank water from MEL's metals lab was transferred (by pouring) to an acidified sample bottle. For organics, blank water from MEL's organics lab was carried in 1-gallon glass containers and transferred into individual sample bottles.

Results for the two marine PCB bottle blanks are presented in Table D-10. Both bottle blanks showed low concentrations of four PCB congeners in Analytical Perspectives reagent water. These congeners were not detected in the corresponding method blanks, suggesting that the detected contamination was associated with bottle transport and handling. From only two blanks it was unclear whether this congener-specific contamination might be pervasive throughout the marine water column samples. For the purposes of this project, results were not re-qualified at the congener level based on this potential contamination.

Results for the freshwater transfer blanks are given in Tables D-12 and D-14. A low concentration of zinc was detected in the total metals transfer blank, likely attributable to atmospheric exposure during the unprotected transfer process. No contamination was detected in the transfer blanks for chlorinated pesticides and BNAs, and only a low concentration of naphthalene was detected in the PAH transfer blank. The results for both PCB and PBDE

transfer blanks were deemed unusable due to the improper creation of these samples (blank water should have come from Analytical Perspectives and Pacific Rim laboratories, not MEL). Overall, transfer blanks for river water sampling did not warrant re-qualification of project results.

Tubing and filter blanks

Tubing and filter blanks were created by mimicking transfers through tubing and contact with filtration apparatuses that occur during regular sampling. These blanks help assess metals contamination arising from the pumping and filtration systems.

Marine water column tubing and filter blanks

- Parameters analyzed: Total and dissolved metals.
- Procedure: Metals reagent water (supplied by Frontier Geosciences) was drawn directly from its bottle using a peristaltic pump and a clean tubing train. The tubing train was flushed with 250-500 mL of reagent water before rinsing and filling the tubing blank bottle. A new, clean filter was connected in-line and the filter was flushed with at least 500 mL of blank water before filling the filter blank bottle.

River water filter blanks

- Parameters analyzed: Dissolved metals.
- Procedure: Reagent water from MEL's metals lab was filtered through a clean filtration apparatus, and the filtrate was poured into a pre-acidified sample bottle.

Results for tubing and filter blanks from marine sampling are presented in Table D-9. Lead and zinc were detected in the tubing blank. It had been necessary to modify the tubing train in the field prior to conducting this tubing blank (using a Teflon-coated tubing cutter of uncertain cleanliness), and the detected lead and zinc were likely attributable to that adjustment. Project results for marine metals were not re-qualified based on tubing and filter blanks.

Results for the freshwater filter blank are shown in Table D-12. Very low concentrations of dissolved copper and zinc were detected in the blank, but these were deemed insufficient to warrant the re-qualification of project results for river water metals.

Sampler blanks

Sampler blanks involved the placement of analyte-specific laboratory reagent water into the sampling gear (GO-FLO samplers for marine water, DH-95 bottle/cap/nozzle set-up for river water) to mimic sample water contact with the collection equipment. These blanks allow assessment of contamination arising from pre-cleaning methods, the sampling equipment itself, and sample decanting procedures.

Marine water column sampler blanks

- Parameters analyzed: All.
- Procedure: GO-FLO samplers were rinsed thoroughly with analyte-specific blank water and emptied, re-filled with blank water, and then a subsample was decanted through clean Teflon tubing following standard procedures. Sampler blanks were conducted using GO-FLO

samplers immediately after acid-cleaning, as well as samplers that had been used (or "conditioned") by previous deployments to collect site water.

River water sampler blanks

- Parameters analyzed: Total and dissolved metals, chlorinated pesticides, BNAs, PAHs, PCB congeners, and PBDE congeners.
- Procedure: The DH-95 bottle/cap/nozzle was rinsed with analyte-specific blank water and emptied, re-filled, assembled, and left for two minutes to approximate the duration that a typical water collection would be in contact with the sampling gear. In September 2009 the sampler was left exposed to the bridge atmosphere for the two minutes, while in December 2009 the opening of the bottle/cap/nozzle was covered with a nitrile glove to minimize exposure to airborne contaminants.

Results for marine sampler blanks are presented in Tables D-9 and D-10. All parameter results for the July 2009 "used" sampler blank were discarded, for these blanks were improperly created using blank water that was not obtained from the appropriate analytical laboratories. Blanks created immediately after acid-cleaning the sampling equipment detected low concentrations of total and dissolved lead and zinc, as well as several BNA and PAH compounds and a number of PCB congeners. However, "used" sampler blanks revealed that nearly all of these contaminants were absent after normal use of the equipment during sampling. During deployment the GO-FLO samplers were flushed with site water as they were lowered to the collection depth, and this appeared to be sufficient to remove residual contamination from pre-cleaning procedures.

Potential PCB contamination from marine sampling gear was investigated in January 2010. A blank was first created using an acid-cleaned sampler. Next the sampler was deployed to a depth of 60 meters (flushing to depth) where site water was collected. Finally a "used" (or "conditioned") sampler blank was created. A bottle blank was also conducted to determine the presence of congener-specific contamination from the laboratory reagent water used in the creation of the sampler blanks. After accounting for congener-specific, low-level contamination from the lab water and from cleaning procedures (i.e., contamination that was noted to "wash away" during deployment), only three to six PCB congeners appeared to persist in the "conditioned" sampler blank. These lines of evidence suggested that much of the residual contamination from pre-cleaning procedures was removed by the thorough flushing of the sampler during deployment.

Results for river sampler blanks are shown in Tables D-12 and D-14. September 2009 sampler blanks appeared to have been influenced by exposure to the bridge atmosphere during creation. This exposure was well in excess of that experienced by regular samples during standard collection procedures, and so the results of these sampler blanks were deemed unrepresentative. Despite precautions in December 2009, those sampler blanks also appear to have been exposed to contamination sources not experienced during normal sampling activities.

This contention is supported by PCB congener *fingerprints*, which showed that field blanks tended to contain greater abundance of mono- to tri-chlorinated congeners and relatively lower concentrations of tetra- to hepta-chlorinated congeners. This was not the pattern for river water or marine water column samples. If PCBs in water samples were derived from the same sources as field blanks, then similar total concentrations and similar congener compositions would be

expected. Therefore, the sources of elevated PCB congener concentrations in field blanks were different from the sources of PCBs in marine water column or river water samples.

One explanation is that the high-quality de-ionized water used to create most field blanks (<15 pg/L) effectively scavenged PCBs from the ambient air (to which field blanks were exposed longer than actual water samples).

Overall, it was concluded that sampler blanks did not exactly reproduce conditions encountered during normal sampling procedures. Sampler blanks reflected opportunities for contamination not shared with actual marine and river water samples, and so sampler blank results were not used to further interpret or qualify sample results.

Organic Carbon Blanks

A variety of field blanks were created to evaluate the newly developed protocols for marine organic carbon sampling. These included the following:

Laboratory filter blanks

- Purpose: Quantification of the mass of "background" carbon inherent in a typical filter.
- Procedure: The analytical lab (Horn Point) retained and analyzed several clean, unused filters from the batch that was sent for field sampling.

Filter trip blanks

- Purpose: Quantification of the mass of carbon that accumulated on a filter during typical transport and handling activities.
- Procedure: A filter from the batch provided by the analytical lab was carried unopened into the field and treated as a POC sample. During October 2009 and January 2010 sampling, a total of eight filter trip blanks were conducted.

Adsorption blanks

- Purpose: Determination of the concentration of carbon that was adsorbed to a typical filter during filtration.
- Procedure: Standard marine carbon filtration procedures were followed, but using two "stacked" filters. After subtracting the background carbon mass inherent in a typical filter, the mass of carbon measured on the lower filter and the volume of sample water filtered were used to calculate the concentration of adsorbed carbon. The mass of carbon adsorbed was assumed to increase linearly with the volume of sample filtered.

Results for the various organic carbon blanks were used to blank-correct marine sample results. The average mass of background carbon inherent in a filter was 8.40 μg C, and the average mass accumulated during transport and handling was 4.84 μg C. That combined mass of carbon (13.24 μg C) accounted for an average of 25% of each regular project sample's total measured (i.e., uncorrected) POC. After these "filter effects" were subtracted from POC measurements, the average carbon concentration contributed by adsorption of DOC to the filter (mg C per liter filtered) was 0.0045 mg/L C, accounting for approximately 7% of the remaining total measured POC. This adsorbed carbon was also subtracted from the total measured POC to arrive at a final

result. For DOC, the only blank correction needed was to add the carbon that was lost due to adsorption during filtration (proportional to the volume filtered).

Example series of measurements and calculations for blank-correction of POC results

a) The POC sample was obtained by filtering 600 mL of sample water.
b) The instrument-measured carbon signal of the sample filter = 1445 µVolts.
c) The average carbon signal measured in three lab filter blanks = 168 µVolts.
d) Sample filter carbon signal, corrected for average lab filter blank carbon signal, equals:
   1445 – 168 = 1277 µVolts.
e) Average carbon signal measured in three filter trip blanks = 74.7 µVolts.
f) Sample filter carbon signal, corrected for average filter trip blank carbon signal, equals:
   1277 – 74.7 = 1202.3 µVolts.
g) "K-factor" (provided by the lab) allows conversion of a carbon signal to mass:
   "K-factor" = 23.0 µVolts / µg carbon.
h) Mass of carbon on filter, corrected for lab and field filter blanks, equals:
   1202.3 / 23.0 = 53.6 µg carbon.
i) Calculate the carbon concentration of the three individual adsorption blanks. For example, the creation of one adsorption blank had involved "stacked" filtration of 435 mL of sample water. After correcting the measured carbon signal for lab and field filter blanks and then applying the K-factor, the mass of adsorbed carbon was 2.51 µg carbon. Thus, the carbon adsorbed to the filter was:
   2.51 / 435 = 0.006 mg/L carbon.
   That is, 0.006 mg carbon was adsorbed to the filter for every liter filtered.
j) The average carbon concentration of the three adsorption blanks = 0.0045 mg/L carbon.
k) The mass of carbon adsorbed for the sample of interest equals:
   600 mL filtered X 0.0045 mg/L carbon = 2.70 µg carbon.
l) The mass of carbon on the filter, corrected for the adsorbed mass, equals:
   53.6 – 2.7 = 50.9 µg carbon.
m) Finally, the concentration of POC in the sample water equals:
   50.9 µg carbon / 600 mL filtered = 0.085 mg/L POC.

Table D-5. Summary of field replicate results for marine water samplings.

Non-detect values for the listed BNA compounds are given at the reporting limit (RL). Total PCB values are sums of detected congeners (unqualified and J-qualified results). PCB homolog and congener results for field replicates are detailed in Tables D-7 and D-8, respectively.

Parameter	Field Replicates									
	July 2009			Sept 2009			Jan 2010			Mean RPD
	Sample	QA Rep	RPD	Sample	QA Rep	RPD	Sample	QA Rep	RPD	
Conventional Parameters (mg/L)										
TSS	3.5	2.1	50	1.1	1.1	0.0	0.8	1.0	22	24
POC	-	-	-	0.093	0.063	38	0.071	0.028	86	62
DOC	-	-	-	0.756	0.747	1.1	0.771	0.799	3.6	2.4
Metals (µg/L)										
Arsenic, total	1.46	1.44	1.4	1.47	1.36	7.8	1.53	1.56	1.9	3.7
Arsenic, dissolved	1.54	1.46	5.3	1.40	1.35	3.6	-	-	-	4.5
Cadmium, total	0.085	0.085	0.0	0.092	0.080	14	0.082	0.080	2.5	5.5
Cadmium, dissolved	0.086	0.086	0.0	0.077	0.093	19	-	-	-	9.0
Copper, total	0.49	0.45	8.5	0.34	0.31	9.2	0.48	0.47	2.1	7.1
Copper, dissolved	0.41	0.39	5.8	0.31	0.30	4.2	-	-	-	5.0
Lead, total	0.114	0.056	68	0.046 J	0.025 UJ	-	0.033 J	0.048 J	37	53
Lead, dissolved	0.033 J	0.021 J	44	0.018 J	0.021 UJ	-	-	-	-	44
Zinc, total	0.74 J	0.99 J	29	0.91 J	0.48 J	62	0.88 J	0.76 J	15	35
Zinc, dissolved	0.69 J	0.72 J	4.3	0.70 J	0.46 J	42	-	-	-	23
Chlorinated Pesticides (ng/L)										
All 33 chlorinated pesticide compounds	ND	ND	-	ND	ND	-	ND	ND	-	-
BNAs (µg/L)										
4-Chloro-3-Methylphenol	0.91 UJ	0.006 J	-	0.8 UJ	0.85 UJ	-	-	-	-	-
Cholesterol	0.91 UJ	0.84 U	-	0.7 J	0.74 J	5.6	-	-	-	5.6
54 other BNA compounds	ND	ND	-	ND	ND	-	-	-	-	-
PAHs (µg/L)										
All 22 PAH compounds	ND	ND	-	ND	ND	-	ND	ND	-	-
PCB Congeners (pg/L)										
Total PCBs	43.92 J	31.12 J	34	33.583 J	19.058 J	55	18.39 J	22.59 J	20	36
PBDE Congeners (pg/L)										
BDE-099	10.9 UJ	53.9 J	-	17.9 UJ	14.1 UJ	-	-	-	-	-
BDE-100	10 UJ	19.4 J	-	10 UJ	10 UJ	-	-	-	-	-
34 other PBDE congeners	ND	ND	-	ND	ND	-	-	-	-	-
Total PBDEs	127.6 U	73.3 J	-	122.5 U	130.2 U	-	-	-	-	-

Table D-6. Summary of field duplicate results for marine water samplings.

Non-detect values for POC are given at the method detection limit (MDL). Total PCB values are sums of detected congeners (unqualified and J-qualified results). PCB homolog and congener results for field duplicates are detailed in Tables D-7 and D-8, respectively.

Parameter	Field Duplicates									
	July 2009			Sept 2009			Jan 2010			Mean RPD
	Sample	QA Dup	RPD	Sample	QA Dup	RPD	Sample	QA Dup	RPD	
TSS (mg/L)	2.6	2.4	8.0	1.1	0.9	20	-	-	-	14
	3.5	2.5	33	-	-	-	-	-	-	33
POC (mg/L)	-	-	-	0.063	0.068	7.6	0.028	0.049	55	31
	-	-	-	0.058	0.051	13	0.011 U	0.011 U	-	13
DOC (mg/L)	-	-	-	0.035	0.045	25	0.799	0.757	5.4	15
	-	-	-	0.802	0.722	11	0.084	0.162	63	37
Total PCBs (pg/L)	31.12 J	30.31 J	2.6	-	-	-	-	-	-	2.6

Table D-7. Summary of PCB homolog totals in field replicates and field duplicates for marine water samplings.

Homolog totals and Total PCB values are sums of detected congeners (unqualified and J-qualified results). PCB congener results for field replicates and field duplicates are detailed in Table D-8.

PCB Homolog (pg/L)	Field Replicates										Field Duplicates		
	July 2009			Sept 2009			Jan 2010			Mean RPD	July 2009		
	Sample	QA Rep	RPD	Sample	QA Rep	RPD	Sample	QA Rep	RPD		Sample	QA Dup	RPD
Mono-CBs	5.21 U	10.2 U	-	2.793 J	5 U	-	3.91 U	4.15 U	-	-	10.2 U	10.3 U	-
Di-CBs	4.09 J	3.15 J	26	3.783 J	2.14 J	55	3.91 U	1.7 J	-	41	3.15 J	2.6 J	19
Tri-CBs	4.87 J	10.2 U	-	4.814 J	0.798 J	143	3.91 U	1.28 J	-	143	10.2 U	1.84 J	-
Tetra-CBs	18.748 J	11.34 J	49	14.27 J	11.58 J	21	15.96	11.99 J	28	33	11.34 J	14.58 J	25
Penta-CBs	8.822 J	9.73 J	9.8	6.623 J	3.45 J	63	2.43 J	2.55 J	4.8	26	9.73 J	8.72 J	11
Hexa-CBs	7.39 J	6.9 J	6.9	1.3 J	1.09 J	18	3.91 U	5.07 J	-	12	6.9 J	2.57 J	91
Hepta-CBs	5.21 U	10.2 U	-	4.13 U	5 U	-	3.91 U	4.15 U	-	-	10.2 U	10.3 U	-
Octa-CBs	5.21 U	10.2 U	-	4.13 U	5 U	-	3.91 U	4.15 U	-	-	10.2 U	10.3 U	-
Nona-CBs	5.21 U	10.2 U	-	4.13 U	5 U	-	3.91 U	4.15 U	-	-	10.2 U	10.3 U	-
PCB-209	5.21 U	10.2 U	-	4.13 U	5 U	-	3.91 U	4.15 U	-	-	10.2 U	10.3 U	-
Total PCBs	43.92 J	31.12 J	34	33.583 J	19.058 J	55	18.39 J	22.59 J	20	36	31.12 J	30.31 J	3

Table D-8. Summary of PCB congener detects in field replicates and duplicates for marine water samplings.

Congener concentrations are listed only if detected in at least one of these blanks. U- and UJ-qualified results are not shown.

PCB Congener (pg/L)	Field Replicates						Field Duplicates	
	July 2009		Sept 2009		Jan 2010		July 2009	
	Sample	QA Rep	Sample	QA Rep	Sample	QA Rep	Sample	QA Dup
PCB-001	1.3 NJ		2.46 NJ					
PCB-002	1.4 NJ		0.336 NJ					
PCB-003	1.82 NJ		0.399 J					
PCB-004	2.27 J		1.62 J	1.35 J		1.7 J		
PCB-006			0.397 J					
PCB-008	1.82 J	3.15 J	1.41 J	0.79 J			3.15 J	2.6 J
PCB-016			0.503 J					
PCB-017	2.43 J		0.687 NJ			0.935 NJ		
PCB-018/030	2.44 J		1.12 J	0.877 NJ	1.22 NJ	1.28 J		1.8 NJ
PCB-019			0.348 J					
PCB-020/028			1.06 J	0.798 J		0.949 NJ		1.84 J
PCB-021/033			0.595 J					
PCB-022			0.35 J					
PCB-031			0.822 J			0.854 NJ		
PCB-032			0.34 NJ					
PCB-040/071	0.731 J							0.775 NJ
PCB-044/047/065	6.5	5.42 J	5.48 J	5.39 J	14.6	6.57 J	5.42 J	5.67 J
PCB-049/069	1.26 J	1.36 NJ	0.482 NJ	0.654 NJ	1.36 J	1.22 J	1.36 NJ	1.32 J
PCB-051	3.74 J	3.16 J	4.01 J	3.6 J	8.69 NJ	3.78 NJ	3.16 J	3.77 J
PCB-052	2.51 J	2.76 J	1.24 J	1.54 J	2.28 NJ	2.67 J	2.76 J	2.59 J
PCB-061/070/074/076	1.54 J		1.05 J					
PCB-064								0.594 NJ
PCB-066	0.867 J							
PCB-068	1.6 J		0.96 J	1.05 J	2.71 NJ	1.53 J		1.23 J
PCB-086/087/097/108/119/125	1.29 NJ		0.903 J					
PCB-090/101/113	3.01 J	2.75 J	1.09 J	1.87 J	2.43 J		2.75 J	3.47 J
PCB-095	2.35 J	2.34 J	0.933 J	1.58 J		2.55 J	2.34 J	3.01 J
PCB-099	0.974 NJ							
PCB-105	0.932 J		0.371 NJ					
PCB-110	2.53 J	2.63 J	0.841 J	0.867 NJ	1.52 NJ	1.12 NJ	2.63 J	1.85 NJ
PCB-118	1.42 NJ	2.01 J	0.573 J	0.852 NJ			2.01 J	2.24 J
PCB-129/138/163	2.98 J	2.49 J	0.609 J	1.09 J		2.15 J	2.49 J	2.25 NJ
PCB-147/149	1.94 J	2.19 J	0.366 NJ			1.41 J	2.19 J	1.64 NJ
PCB-153/168	2.47 J	2.22 J	0.383 J	0.642 NJ	1.11 NJ	1.51 J	2.22 J	2.57 J
PCB-169			0.337 J					
PCB-194				0.806 NJ				1.41 NJ
Total PCBs								
…including N,NJ	52.124 J	32.48 J	34.756 J	23.756 J	35.92 J	30.228 J	32.48 J	40.629 J
…excluding N,NJ	43.92 J	31.12 J	33.583 J	19.058 J	18.39 J	22.59 J	31.12 J	30.31 J

Table D-9. Summary of equipment blank results for marine water samplings.

Non-detect values for POC and metals are given at the method detection limit (MDL). Non-detect values for organic compounds are given at the reporting limit (RL).

Parameter	Tubing	Filter	Used Sampler		Acid-Cleaned Sampler	
	July 2009	July 2009	July 2009	Sept 2009	Sept 2009	Jan 2010
Conventional Parameters (mg/L)						
POC	-	-	-	-	0.063	0.011 U
	-	-	-	-	0.068 (Dup)	0.011 U (Dup)
DOC	-	-	-	-	0.035	0.084
Metals (µg/L)						
Arsenic, total	0.006 U	-	-	0.006 U	-	0.006 U
Arsenic, dissolved	-	0.006 U	-	0.006 U	-	0.006 U
Cadmium, total	0.003 U	-	-	0.003 U	-	0.003 U
Cadmium, dissolved	-	0.003 U	-	0.003 U	-	0.003 U
Copper, total	0.023 UJ	-	-	0.027 UJ	-	0.029 UJ
Copper, dissolved	-	0.033 UJ	-	0.08 J	-	0.05 UJ
Lead, total	0.015 J	-	-	0.012 UJ	-	1.85
Lead, dissolved	-	0.005 U	-	0.010 UJ	-	1.81
Zinc, total	0.440 J	-	-	0.250 UJ	-	0.350 J
Zinc, dissolved	-	0.130 UJ	-	0.510 J	-	0.390 J
Chlorinated Pesticides (ng/L)						
All 33 chlor pest compounds	-	-	ND	-	ND	-
BNAs (µg/L)						
2-Methylphenol	-	-	0.02 J	0.81 U	0.013 J	0.82 U
4-Chloro-3-Methylphenol	-	-	0.04 J	0.81 UJ	0.82 UJ	0.82 U
4-Methylphenol	-	-	0.03 J	0.81 U	0.82 U	0.82 U
Bis(2-Ethylhexyl) Phthalate	-	-	5.8	0.16 U	0.083 J	0.16 U
Bisphenol A	-	-	0.24 J	0.33 U	0.08 J	0.33 U
Butyl benzyl phthalate	-	-	2	0.33 U	0.33 U	0.33 U
Diethyl phthalate	-	-	1.1	0.16 U	0.16 U	0.16 U
Dimethyl phthalate	-	-	0.04 J	0.16 U	0.16 U	0.16 U
Ethanol, 2-Chloro-, Phosphate (3:1)	-	-	0.11 NJ	0.081 UJ	0.082 UJ	0.082 U
Phenol	-	-	0.06 J	0.33 U	0.33 U	0.33 U
Triclosan	-	-	0.17 NJ	0.057 J	0.082 U	0.082 U
45 other BNA compounds	-	-	ND	ND	ND	ND
PAHs (µg/L)						
1-Methylnaphthalene	-	-	0.037	-	0.01 U	0.01 U
2-Methylnaphthalene	-	-	0.061	-	0.01 U	0.01 U
Fluorene	-	-	0.016	-	0.01 U	0.01 UJ
Naphthalene	-	-	0.096	-	0.049	0.01 U
Phenanthrene	-	-	0.021	-	0.01 U	0.01 U
17 other PAH compounds	-	-	ND	-	ND	ND
PBDE congeners (pg/L)						
All 36 PBDE congeners	-	-	ND	-	ND	ND

Table D-10. Summary of PCB congener detects in equipment blanks for marine water samplings.

Congener concentrations are listed only if detected in at least one of these blanks. Table continues on the following page.

PCB Congener (pg/L)	July 2009	September 2009		January 2010			
	Used Sampler	Bottle Blank	Acid-Cleaned Sampler	Bottle Blank	Acid-Cleaned Sampler	Site Reference	Used Sampler
PCB-001	15.4	2.5 J	2.35 NJ	2.01 J	3.06 J		2.57 J
PCB-002	3.65 NJ	3.21 NJ	1.17 NJ	2.41 J	2.1 NJ	1.22 NJ	2.45 J
PCB-003	10.4 N	4.36 NJ	2.37 NJ	2.84 J	4.71 J	0.885 NJ	4.34 NJ
PCB-004	33.6		6.83		4.03 J		2.69 J
PCB-006	9.09		1.15 J				
PCB-007	3.37 J						
PCB-008	38.5		5.66		4.01 J	1.45 J	2.75 J
PCB-009	2.88 J						
PCB-011	46						
PCB-012/013	6.36						
PCB-015	24.6		1.55 J				
PCB-016	25.6		1.84 J		0.849 NJ		
PCB-017	26.9		3.79 J		2.19 J		2.06 NJ
PCB-018/030	48.6	0.968 J	3.58 NJ	1.3 J	2.66 J	1.45 NJ	2 J
PCB-019	8.42		1.09 NJ				
PCB-020/028	29.4		2.48 J		1.27 J	1.3 NJ	
PCB-021/033	25		3.2 J				
PCB-022	13.6						
PCB-025	4.99 J						
PCB-026/029	6.97						
PCB-027	4.58 J						
PCB-031	34		2.51 J		1.76 J	0.82 NJ	
PCB-032	13.9		1.22 NJ		0.719 NJ		
PCB-035	3.2 NJ						
PCB-037	27.4						
PCB-040/071	13.8						
PCB-041	3.37 J						
PCB-042	8.32						
PCB-044/047/065	212		101		35.7	6.76 J	19.7
PCB-046	3.04 J						
PCB-048	5.93						
PCB-049/069	34		2.99 J		1.12 NJ	1.23 J	
PCB-050/053	11.9						
PCB-051	124		75.1		24.8	3.33 J	15.9
PCB-052	157		6.94	1.11 NJ	2.88 J	2.68 J	1.61 NJ
PCB-056	8.47						
PCB-059/062/075	1.66 NJ						
PCB-060	3.27 J						
PCB-061/070/074/076	78		5.83 J				
PCB-064	18.5						
PCB-066	11.6 N		1.67 J				
PCB-068	28.5		18.2		4.22 NJ		3.57 NJ
PCB-077	16.3						
PCB-082	8.93						
PCB-083	4.99 NJ						
PCB-084	44.4		2.63 J				
PCB-085/116	12.4						
PCB-086/087/097/108/119/125	63.6		8.5 J				

PCB Congener (pg/L)	July 2009	September 2009		January 2010			
	Used Sampler	Bottle Blank	Acid-Cleaned Sampler	Bottle Blank	Acid-Cleaned Sampler	Site Reference	Used Sampler
PCB-090/101/113	105		10.8 J		2.24 NJ	2.65 NJ	
PCB-091	11.2 N						
PCB-092	18.7						
PCB-095	134		7.24 NJ		1.55 J	2.05 NJ	
PCB-096	1.89 NJ						
PCB-099	27		2.81 NJ				
PCB-105	13.9		3.1 NJ				
PCB-107/124	2.06 NJ						
PCB-109	3.11 J						
PCB-110	84.1		9.37		1.51 NJ		
PCB-118	32.5		6.33		0.946 NJ	1.63 J	
PCB-128/166	4.16 NJ						
PCB-129/138/163	26.7		5.95 J			1.49 NJ	
PCB-130	2.52 NJ						
PCB-132	14.4 N		2.93 NJ				
PCB-134	3.01 J						
PCB-135/151	14.8						
PCB-136	11.3						
PCB-137	1.67 J						
PCB-139/140	0.966 NJ						
PCB-141	5.4						
PCB-144	2.03 NJ						
PCB-146	3.22 J						
PCB-147/149	31.9		3.98 NJ			1.44 NJ	
PCB-153/168	16.1		2.28 NJ			2.31 J	
PCB-156/157	2 J						
PCB-158	2.4 NJ						
PCB-164	1.62 NJ						
PCB-170	1.39 NJ						
PCB-174	1.9 NJ						
PCB-179	1.62 NJ						
PCB-180/193	2.72 NJ						
PCB-183	1.19 NJ						
PCB-187	1.62 NJ						
Total PCBs							
…including N,NJ	1928.486	11.038 J	318.44 J	9.67 J	102.324 J	32.695 J	59.64 J
…excluding N,NJ	1839.3	3.468 J	284.32 J	8.56 J	88.62 J	19.39 J	48.06 J

Table D-11. Summary of field replicate results for river water samplings.

Total PCB and PBDE values are sums of detected congeners (unqualified and J-qualified results). PCB homolog and congener results for field replicates are detailed in Tables D-13 and D-14, respectively.

Parameter	Field Replicates									
	July 2009			Sept 2009			Dec 2009			Mean
	Sample	QA Rep	RPD	Sample	QA Rep	RPD	Sample	QA Rep	RPD	RPD
Conventional Parameters (mg/L)										
TSS	233	235	0.85	38.7	40.5	4.6	11.9	13.2	10	5.2
TOC	0.5 J	0.4 J	22	1.1	1.3	17	1.3	1.2	8.0	16
DOC	0.8 J	0.9 J	12	1.4	1.3	7.4	1.2	1.2	0.0	6.5
Ammonia	0.01	0.009 J	11	0.162	0.179	10	-	-	-	11
Nitrate+Nitrite	0.11	0.105	4.7	0.309	0.320	3.5	-	-	-	4.1
Total Nitrogen	0.137	0.132	3.7	0.545	0.580	6.2	-	-	-	5.0
Total Phosphorus	0.250	0.197	24	0.0795	0.110	32	-	-	-	28
Ortho-phosphate	0.0287	0.0319	11	0.0478	0.0527	9.8	-	-	-	10
Hardness	27.7	28.1	1.4	40.8	39.5	3.2	33.2	33.5	0.90	1.8
Metals (µg/L) [1]										
Arsenic, total	0.92	0.98	6.3	0.6	0.68	13	0.52	0.53	1.9	7.1
Arsenic, dissolved	0.46	0.47	2.2	0.62	0.64	3.2	0.5	0.49	2.0	2.5
Cadmium, total	0.01 J	0.02 J	67	0.006 J	0.006 J	0.0	0.005 J	0.006 J	18	28
Cadmium, dissolved	0.003 J	0.002 U	-	0.003 J	0.003 J	0.0	0.002 U	0.002 J	-	0.0
Copper , total	11.6	11.6	0.0	1.81	2.16	18	1.32	1.22	7.9	8.6
Copper, dissolved	4.19	0.78	137	0.91	0.73	22	0.63	1.64	89	83
Lead, total	1.42	1.49	4.8	0.2	0.28	33	0.11 UJ	0.08 UJ	-	19
Lead, dissolved	0.006 U	0.006 U	-	0.035	0.034	2.9	0.024	0.022	8.7	5.8
Zinc, total	11.6	22.2	63	3.7 J	3.4 J	8.5	2.7 UJ	2.8 UJ	-	36
Zinc, dissolved	2	4.2	71	1.2	1.5	22	1	2	67	53
Petroleum-related Products (mg/L) [2]										
Oil and grease	0.9 J	1 J	11	1.8 U	1.8 U	-	5.5 U	5.5 U	-	11
TPH-D #2 Diesel	0.05 U	0.05 U	-	0.05 U	0.05 U	-	0.02 U	0.02 U	-	-
TPH-D Lube Oil	0.13 U	0.13 U	-	0.12 U	0.12 U	-	0.04 U	0.04 U	-	-
TPH-G	0.14 U	0.14 U	-	0.14 U	0.14 U	-	0.14 U	0.14 U	-	-
Chlorinated Pesticides (ng/L) [2]										
All 33 chlorinated pesticide compounds	ND	ND	-	ND	ND	-	-	-	-	-
BNAs (µg/L) [2]										
2-Methylphenol	0.0058 J	0.81 U	-	0.8 U	0.78 U	-	-	-	-	-
Cholesterol	0.79 U	0.81 U	-	1.4	1.4	0.0	-	-	-	0.0
Di-N-Octyl Phthalate	0.16 U	0.16 U	-	0.16 U	0.16 J	-	-	-	-	-
Pentachlorophenol	0.079 UJ	0.081 UJ	-	0.083 NJ	0.081 NJ	2.4	-	-	-	2.4
Triclosan	0.079 U	0.081 U	-	0.08 U	0.081	-	-	-	-	-
Triethyl citrate	0.31 U	0.33 U	-	0.32 U	0.31 J	-	-	-	-	-
49 other BNA compounds	ND	ND	-	ND	ND	-	-	-	-	-
PAHs (µg/L) [2]										
1-Methylnaphthalene	0.01 UJ	0.01 U	-	0.01 U	0.0034 J	-	-	-	-	-
21 other PAH compounds	ND	ND	-	ND	ND	-	-	-	-	-
PCB Congeners (pg/L) [2]										
Total PCBs	2.61 J	6.701 J	88	40.18 J	33.35 J	19	21.497 J	23.509 J	8.9	39
PBDE Congeners (pg/L) [2]										
BDE-100	10.9 J	10.8 J	0.92	11.1 UJ	10 UJ	-	10 UJ	10.7 UJ	-	0.92
BDE-209	250 U	250 UJ	-	260	260		250 U	250 U	-	-
34 other PBDE congeners	ND	ND	-	ND	ND	-	ND	ND	-	-
Total PBDEs	10.9 J	10.8 J	0.92	265.18	260	2.0	250 U	250 U	-	1.5

[1] Non-detect results for metals are given at the method detection limit (MDL).

[2] Non-detect results for petroleum-related products, chlorinated pesticides, BNAs, PAHs, PCB congeners, and PBDE congeners are given at the reporting limit (RL).

Table D-12. Summary of field QA sample results for river water samplings.

Total PCB and PBDE values are sums of detected congeners (unqualified and J-qualified results).

Parameter	Bottle / Filter Blanks	Acid-Cleaned Sampler Blanks	
	July 2009	Sept 2009	Dec 2009
Metals (µg/L) [1]			
Arsenic, total	0.05 U	0.05 U	0.05 U
Arsenic, dissolved	0.03 U	0.03 U	0.03 U
Cadmium, total	0.003 U	0.003 U	0.003 U
Cadmium, dissolved	0.002 U	0.002 U	0.002 U
Copper, total	0.02 U	0.12 J	0.33
Copper, dissolved	0.04 J	0.26	0.31
Lead, total	0.02 UJ	0.01 UJ	0.02 J
Lead, dissolved	0.006 U	0.007 J	0.037
Zinc, total	2.8 J	2.3 UJ	2.3 J
Zinc, dissolved	0.3 J	1.4	2.8
Chlorinated Pesticides (ng/L) [2]			
All 33 chlorinated pesticide compounds	ND	ND	-
BNAs (µg/L) [2]			
2-Methylphenol	0.82 U	0.82 U	-
Cholesterol	0.82 U	0.82 UJ	-
Di-N-Octyl Phthalate	0.16 U	0.16 U	-
Pentachlorophenol	0.082 UJ	0.082 U	-
Triclosan	0.082 U	0.082 U	-
Triethyl citrate	0.33 U	0.33 U	-
49 other BNA compounds	ND	ND	-
PAHs (µg/L) [2]			
1-Methylnaphthalene	0.01 U	0.01 U	-
Naphthalene	0.01	0.01 U	-
20 other PAH compounds	ND	ND	-
PCB Congeners (pg/L) [2]			
Total PCBs	11.2 U	47.066 J	13.959 J
PBDE Congeners (pg/L) [2]			
BDE-099	382	22.8 UJ	-
BDE-100	81.9	10 UJ	-
BDE-154	18.3 NJ	10 UJ	-
33 other PBDE congeners	ND	ND	-
Total PBDEs	807.9	124 U	-

[1] Non-detect results for metals are given at the method detection limit (MDL).
[2] Non-detect results for petroleum-related products, chlorinated pesticides, BNAs, PAHs, PCB congeners, and PBDE congeners are given at the reporting limit (RL).

Table D-13. Summary of PCB homolog totals in field replicates for river water samplings.

Homolog totals and Total PCB values are sums of detected congeners (unqualified and J-qualified results). PCB congener results for field replicates are detailed in Table D-14.

PCB Homolog (pg/L)	Field Replicates									
	July 2009			Sept 2009			Dec 2009			Mean RPD
	Sample	QA Rep	RPD	Sample	QA Rep	RPD	Sample	QA Rep	RPD	
Mono-CBs	10.3 U	10.2 U	-	1.8 J	0.779 J	79	2.726 J	0.688 J	119	99
Di-CBs	10.3 U	10.2 U	-	2.04 J	4.8 J	81	3.91 U	1.39 J	-	81
Tri-CBs	10.3 U	10.2 U	-	5.2 J	5.696 J	9.1	3.557 J	5.232 J	38	24
Tetra-CBs	1.45 J	10.2 U	-	5.89 J	3.22 J	59	5.467 J	6.641 J	19	39
Penta-CBs	1.16 J	4.52 J	118	15.11 J	9.76 J	43	6.487 J	4.245 J	42	68
Hexa-CBs	10.3 U	0.761 J	-	8.63 J	7.59 J	13	3.26 J	4.7 J	36	25
Hepta-CBs	10.3 U	10.2 U	-	1.51 J	0.756 J	67	3.91 U	0.613 J	-	67
Octa-CBs	10.3 U	1.42 J	-	5 U	0.749 J	-	3.91 U	4.17 U	-	-
Nona-CBs	10.3 U	10.2 U	-	5 U	5 U	-	3.91 U	4.17 U	-	-
PCB-209	10.3 U	10.2 U	-	5 U	5 U	-	3.91 U	4.17 U	-	-
Total PCBs	2.61 J	6.701 J	88	40.18 J	33.35 J	19	21.497 J	23.509 J	8.9	39

Table D-14. Summary of PCB congener detects in field QA results for river water sampling.

Congener concentrations are listed only if detected in at least one of these blanks.

PCB Congener (pg/L)	Field Replicates						Bottle Blank	Acid-Cleaned Sampler Blanks	
	July 2009		September 2009		December 2009		July '09	Sept '09	Dec '09
	Sample	QA Rep	Sample	QA Rep	Sample	QA Rep	Result	Result	Result
PCB-001				0.779 J	0.976 J			2.99 J	0.752 NJ
PCB-002					1.73 NJ	0.832 NJ		0.956 J	
PCB-003			1.8 J		1.75 J	0.688 J		3.64 J	1.76 J
PCB-004				1.85 J				3 J	
PCB-005								0.469 J	
PCB-006				0.489 J				1.53 J	0.971 J
PCB-007								0.65 J	
PCB-008			2.04 J	1.72 J				5.37	2.4 J
PCB-009								0.734 J	
PCB-012/013								0.781 J	
PCB-015				0.741 J		1.39 J		2.19 J	1.2 J
PCB-016								2.98 J	0.66 J
PCB-017				0.826 J		0.885 NJ		2.39 J	0.943 J
PCB-018/030		10.2 NJ	1.69 J	1.86 J	1.49 J	1.98 J		4.43 J	1.55 J
PCB-019								0.744 J	
PCB-020/028	10.3 NJ	10.2 NJ	1.77 J	1.57 J	1.04 NJ	1.32 NJ		1.98 J	1.31 J
PCB-021/033				0.442 NJ	0.897 J	0.851 J		1.95 J	0.936 J
PCB-022				0.45 NJ		0.661 J		1.09 J	0.424 NJ
PCB-026/029								0.453 NJ	
PCB-027								0.406 NJ	
PCB-031	10.3 NJ		1.74 J	1.44 J	1.17 J	1.74 J		2.03 J	1.18 J
PCB-032				0.471 NJ		4.17 NJ		1.5 J	0.516 J
PCB-039				0.314 NJ					
PCB-040/071								0.568 NJ	3.75 NJ
PCB-044/047/065				1.75 NJ	1.57 J	1.95 J		1.74 J	0.726 NJ
PCB-049/069			1.27 NJ	1.06 J	0.751 J	0.988 J		0.891 NJ	0.533 J
PCB-052	1.45 J	10.2 NJ	2.76 J	2.16 J				1.65 J	0.974 UJ
PCB-061/070/074/076			3.13 J	1.72 NJ	1.72 J	2.31 J			
PCB-064					0.585 J	0.551 J		0.391 NJ	
PCB-066				0.641 NJ	0.841 J	0.842 J			
PCB-086/087/097/108/119/125				2.02 J		0.794 NJ			
PCB-090/101/113	10.3 NJ	1.69 J	3.04 J	2.65 J	1.76 J	2.11 J		0.601 NJ	
PCB-095			3.37 J	1.9 NJ	1.4 J	1.35 NJ		1.1 J	
PCB-099			1.63 J	1.08 J	0.497 J	0.48 NJ			
PCB-105			1.86 J	1.05 NJ		0.585 J			
PCB-110	1.16 J	1.44 J	2.66 J	2.28 J	1.58 J	1.55 J		0.519 J	0.434 NJ
PCB-118		1.39 J	2.55 J	1.73 J	1.25 J	1.11 NJ			
PCB-128/166						4.17 NJ			
PCB-129/138/163		10.2 NJ	3.19 J	2.67 J	1.85 J	1.92 J		0.653 J	
PCB-132				1.05 J					
PCB-135/151				1.04 NJ					
PCB-147/149			2.43 J	1.97 J	1.41 J	1.42 J			
PCB-153/168			3.01 J	1.9 J	1.17 NJ	1.36 J			
PCB-169		0.761 J							
PCB-177				0.765 NJ				0.686 NJ	
PCB-180/193				0.757 NJ		0.923 NJ			
PCB-187			1.51 J	0.756 J		0.613 J		0.707 NJ	0.616 NJ
PCB-194		1.42 J		0.749 J				0.442 NJ	
Total PCBs									
…including N,NJ	33.51 J	47.501 J	41.45 J	49.65 J	25.437 J	39.543 J	11.2 U	57.211 J	20.661 J
…excluding N,NJ	2.61 J	6.701 J	40.18 J	33.35 J	21.497 J	23.509 J	11.2 U	47.066 J	13.959 J

Appendix E. Analytical Results - Marine Water Column

Table E-1. Summary of Marine Water Results for Conventionals and Metals.

Non-detect results were assigned the method detection limit (MDL) value. POC and DOC samples were not collected in July 2009.

July 2009:

Parameter	Hood Canal		SJdF at Sill		SJdF North		Haro Strait		Whidbey Basin		Main Basin		South Sound	
	Surface	Deep	Surface	Deep	Surface	Deep	Surface	Deep	Surface	Deep	Surface	Deep	Surface	Deep
Conventional Parameters (mg/L)														
TSS	1.9	1.5	2.2	1.7	1.6	1.6	1.6	2.0	2.6	3.5	1.4	1.4	1.6	1.4
POC	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
DOC	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Metals (µg/L)														
Arsenic, total	1.30	1.37	1.52	1.49	1.39	1.52	1.46	1.54	1.34	1.46	1.34	1.41	1.41	1.41
Arsenic, dissolved	1.34	1.47	1.48	1.50	1.35	1.61	1.42	1.56	1.32	1.54	1.34	1.46	1.35	1.34
Cadmium, total	0.072	0.076	0.091	0.091	0.087	0.098	0.090	0.097	0.079	0.085	0.076	0.080	0.077	0.076
Cadmium, dissolved	0.067	0.068	0.089	0.091	0.078	0.102	0.079	0.098	0.068	0.086	0.072	0.081	0.068	0.073
Copper, total	0.48	1.37	0.29	0.28	0.37	0.21	0.25	0.25	0.44	0.49	0.39	0.37	0.44	0.41
Copper, dissolved	0.45	0.51	0.22	0.26	0.25	0.20	0.27	0.23	0.37	0.41	0.35	0.34	0.39	0.37
Lead, total	0.129	0.177	0.091	0.230	0.052	0.109	0.025 J	0.116	0.061	0.114	0.049 J	0.088	0.039 J	0.050
Lead, dissolved	0.119	0.064	0.056	0.153	0.060	0.056	0.050	0.131	0.043 J	0.033 J	0.028 J	0.035 J	0.084	0.090
Zinc, total	0.69 J	7.44	0.59 J	0.79 J	0.75 J	0.45 J	0.56 J	0.52 J	0.70 J	0.74 J	0.84 J	0.53 J	0.64 J	0.48 J
Zinc, dissolved	1.25	2.30	0.70 J	0.72 J	0.36 J	0.51 J	0.36 J	0.63 J	1.78	0.69 J	0.62 J	0.50 J	0.41 J	0.68 J

October 2009:

Parameter	Hood Canal		SJdF at Sill		SJdF North		Haro Strait		Whidbey Basin		Main Basin		South Sound	
	Surface	Deep	Surface	Deep	Surface	Deep	Surface	Deep	Surface	Deep	Surface	Deep	Surface	Deep
Conventional Parameters (mg/L)														
TSS	1.2	1.1	1.3	1.2	1.1	1.2	1.1	1.0	5.5	1.2	0.9	1.7	0.9	0.8
POC	0.216	0.093	0.08	0.049	0.058	0.068	0.051	0.039	1.78	0.061	0.123	0.086	0.184	0.114
DOC	0.874	0.756	0.805	0.611	0.802	0.625	0.697	0.716	0.969	0.968	0.773	0.755	0.844	0.831
Metals (µg/L)														
Arsenic, total	1.22	1.47	1.31	1.46	1.31	1.44	1.33	1.36	1.45	1.47	1.40	1.40	1.28	1.16
Arsenic, dissolved	1.26	1.40	1.38	1.44	1.36	1.49	1.36	1.43	1.37	1.42	1.38	1.46	1.26	1.29
Cadmium, total	0.099	0.092	0.089	0.096	0.089	0.105	0.082	0.092	0.087	0.081	0.081	0.081	0.076	0.059
Cadmium, dissolved	0.076	0.077	0.083	0.111	0.081	0.105	0.087	0.096	0.074	0.079	0.074	0.081	0.069	0.074
Copper, total	0.35	0.34	0.20	0.19 J	0.25	0.63	0.24	0.24	0.38	0.35	0.35	0.34	0.38	0.26
Copper, dissolved	0.29	0.31	0.17 J	0.16 J	0.22	0.19 J	0.21	0.23	0.33	0.33	0.28	0.28	0.30	0.32
Lead, total	0.015 J	0.046 J	0.035 UJ	0.035 UJ	0.042 UJ	0.070 J	0.058 J	0.108 J	0.098	0.095	0.090	0.143	0.025 UJ	0.024 UJ
Lead, dissolved	0.013 J	0.018 J	0.030 UJ	0.042 UJ	0.045 J	0.057 J	0.058 J	0.068 J	0.235	0.133	0.078	0.048 J	0.039 UJ	0.045 J
Zinc, total	0.52 J	0.91 J	0.41 J	0.53 J	0.45 J	0.64 J	0.47 J	0.88 J	0.69 J	0.58 J	0.86 J	0.79 J	0.69 J	0.53 J
Zinc, dissolved	0.38 UJ	0.70 J	0.45 J	0.43 J	0.58 J	0.47 J	0.71 J	0.66 J	1.42 J	1.06 J	0.46 UJ	0.69 J	0.73 J	0.36 J

Table E-1, continued. Summary of Marine Water Results for Conventionals and Metals.

Non-detect results were assigned the method detection limit (MDL) value.

January 2010:

Parameter	Hood Canal		SJdF at Sill		SJdF North		Haro Strait		Whidbey Basin		Main Basin		South Sound	
	Surface	Deep	Surface	Deep	Surface	Deep	Surface	Deep	Surface	Deep	Surface	Deep	Surface	Deep
Conventional Parameters (mg/L)														
TSS	1.3	1.1	2.2	2.3	2.3	6.0	1.9	1.6	0.8	2.0	1.6	1.4	1.3	1.6
POC	0.072	0.031	0.051	0.07	0.046	0.108	0.037	0.041	0.071	0.048	0.028	0.034	0.05	0.047
DOC	0.705	0.712	0.691	0.646	0.705	0.667	0.697	0.702	0.771	0.808	0.754	0.724	0.811	0.786
Metals (µg/L)														
Arsenic, total	1.46	1.50	1.52	1.50	1.36	1.56	1.39	1.34	1.53	1.54	1.39	1.41	1.49	1.41
Arsenic, dissolved	1.44	1.70	1.42	1.42	1.38	1.43	1.31	1.37	1.44	1.50	1.48	1.43	1.35	1.45
Cadmium, total	0.082	0.088	0.080	0.087	0.087	0.092	0.082	0.080	0.082	0.112	0.077	0.089	0.069	0.074
Cadmium, dissolved	0.086	0.079	0.095	0.093	0.089	0.081	0.091	0.081	0.080	0.090	0.079	0.084	0.081	0.072
Copper, total	0.38	0.40	0.38	0.45	0.31	0.41	0.72	0.38	0.48	0.51	0.40	1.03	0.42	0.44
Copper, dissolved	0.35	0.33	0.24	0.24	0.26	0.27	0.28	0.27	0.41	0.43	0.36	0.37	0.39	0.38
Lead, total	0.189	0.035 J	0.049 J	0.152	0.036 J	0.093	0.043 J	0.052	0.033 J	0.109	0.031 J	0.206	0.031 J	0.042 J
Lead, dissolved	0.010 J	0.019 J	0.016 J	0.056	0.025 J	0.033 J	0.030 J	0.050 J	0.045 J	0.063	0.007 J	0.012 J	0.006 J	0.007 J
Zinc, total	0.62 J	0.55 J	0.57 J	0.68 J	0.56 J	1.44	0.99	1.07	0.88 J	1.05 J	0.71 J	1.04 J	0.73 J	0.77 J
Zinc, dissolved	0.54 J	0.54 J	0.40 UJ	0.41 J	0.46 J	0.73	0.65	0.43 J	0.81 J	0.76 J	0.75 J	0.59 J	0.59 J	0.69 J

Table E-2. July 2009 Chlorinated Pesticides Results for Marine Water Samples from Puget Sound Basin Sites.

Non-detect values are given at the reporting limit (RL). The method detection limit (MDL) is presented for comparison.

Parameter (ng/L)	Hood Canal				Whidbey Basin				Main Basin				South Sound			
	Surface		Deep		Surface		Deep		Surface		Deep		Surface		Deep	
	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL
2,4'-DDD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2,4'-DDE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2,4'-DDT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4,4'-DDD	0.20 U	0.18	0.20 U	0.17	0.20 U	0.17	0.20 U	0.18	0.20 U	0.17	0.21 U	0.18	0.21 U	0.18	0.20 U	0.17
4,4'-DDE	0.20 U	0.17	0.20 U	0.17	0.20 U	0.17	0.20 U	0.17	0.20 U	0.17	0.21 U	0.18	0.21 U	0.18	0.20 U	0.17
4,4'-DDT	0.20 U	-	0.20 U	-	0.20 U	-	0.20 U	-	0.20 U	-	0.21 U	-	0.21 U	-	0.20 U	-
Aldrin	0.20 U	0.062	0.20 U	0.06	0.20 U	0.06	0.20 U	0.062	0.20 U	0.06	0.21 U	0.065	0.21 U	0.064	0.20 U	0.061
Alpha-BHC	0.20 U	0.041	0.20 U	0.04	0.20 U	0.04	0.20 U	0.041	0.20 U	0.04	0.21 U	0.043	0.21 U	0.043	0.20 U	0.041
Beta-BHC	0.20 U	0.15	0.20 U	0.14	0.20 U	0.14	0.20 U	0.15	0.20 U	0.14	0.21 U	0.15	0.21 U	0.15	0.20 U	0.14
Chlorpyriphos	0.20 U	-	0.21 UJ	-	0.56 UJ	-	0.25 UJ	-	0.24 UJ	-	0.32 UJ	-	0.21 U	-	0.20 U	-
cis-Chlordane	0.20 U	0.092	0.20 U	0.089	0.20 U	0.089	0.20 U	0.092	0.20 U	0.089	0.21 U	0.096	0.21 U	0.095	0.20 U	0.09
Cis-Nonachlor	0.20 U	0.13	0.20 U	0.13	0.20 U	0.12	0.20 U	0.13	0.20 U	0.13	0.21 U	0.14	0.21 U	0.13	0.20 U	0.13
Dacthal (DCPA)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DDMU	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Delta-BHC	0.20 U	0.041	0.20 U	0.04	0.20 U	0.039	0.20 U	0.041	0.20 U	0.04	0.21 U	0.043	0.21 U	0.042	0.20 U	0.04
Dieldrin	0.51 U	0.21	0.50 U	0.2	0.49 U	0.2	0.51 U	0.21	0.50 U	0.2	0.53 U	0.21	0.53 U	0.21	0.50 U	0.2
Endosulfan I	0.20 U	0.092	0.20 U	0.09	0.20 U	0.089	0.20 U	0.092	0.20 U	0.09	0.21 U	0.096	0.21 U	0.095	0.20 U	0.091
Endosulfan II	0.20 U	0.075	0.20 U	0.074	0.20 U	0.073	0.20 U	0.075	0.31 UJ	0.074	0.21 U	0.079	0.25 UJ	0.078	0.20 U	0.074
Endosulfan Sulfate	0.20 U	0.16	0.20 U	0.16	0.20 U	0.16	0.20 U	0.16	0.20 U	0.16	0.21 U	0.17	0.21 U	0.17	0.20 U	0.16
Endrin	0.51 U	0.22	0.50 U	0.21	0.49 U	0.21	0.51 U	0.22	0.50 U	0.21	0.53 U	0.23	0.53 U	0.23	0.50 U	0.22
Endrin Aldehyde	0.20 U	0.15	0.20 U	0.15	0.20 U	0.15	0.20 U	0.15	0.20 U	0.15	0.21 U	0.16	0.21 U	0.16	0.20 U	0.15
Endrin Ketone	0.76 U	0.61	0.74 U	0.6	0.74 U	0.59	0.76 U	0.61	0.74 U	0.6	0.80 U	0.64	0.79 U	0.64	0.75 U	0.61
Gamma-BHC (Lindane)	13 UJ	0.26	2.6 UJ	0.05	2.9 UJ	0.049	3.7 UJ	0.051	2.8 UJ	0.05	3.0 UJ	0.054	3.3 UJ	0.053	2.8 UJ	0.05
Heptachlor	0.20 U	0.089	0.20 U	0.087	0.20 U	0.086	0.20 U	0.089	0.20 U	0.087	0.21 U	0.093	0.21 U	0.092	0.20 U	0.088
Heptachlor Epoxide	0.20 U	0.12	0.20 U	0.12	0.20 U	0.12	0.20 U	0.12	0.20 U	0.12	0.21 U	0.13	0.21 U	0.13	0.20 U	0.12
Hexachlorobenzene	0.20 U	-	0.20 U	-	0.20 U	-	0.20 U	-	0.20 U	-	0.21 U	-	0.21 U	-	0.20 U	-
Methoxychlor	0.51 U	0.26	0.50 U	0.25	0.49 U	0.25	0.51 U	0.26	0.50 U	0.25	0.53 U	0.27	0.53 U	0.27	0.50 U	0.25
Mirex	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oxychlordane	0.20 U	0.074	0.20 U	0.072	0.20 U	0.072	0.20 U	0.074	0.20 U	0.072	0.21 U	0.078	0.21 U	0.077	0.20 U	0.073
Pentachloroanisole	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Toxaphene	1.0 U	-	0.98 U	-	0.97 U	-	1.0 U	-	0.98 U	-	1.1 U	-	1.0 U	-	0.99 U	-
trans-Chlordane	0.20 U	0.15	0.20 U	0.15	0.20 U	0.14	0.20 U	0.15	0.20 U	0.15	0.21 U	0.16	0.21 U	0.16	0.20 U	0.15
Trans-Nonachlor	0.20 U	-	0.20 U	-	0.20 U	-	0.20 U	-	0.20 U	-	0.21 U	-	0.21 U	-	0.20 U	-

Table E-3. July 2009 Chlorinated Pesticides Results for Marine Water Samples from Boundary Water Sites.

Non-detect values are given at the reporting limit (RL). The method detection limit (MDL) is presented for comparison.

Parameter (ng/L)	SJdF at Sill				SJdF North				Haro Strait			
	Surface		Deep		Surface		Deep		Surface		Deep	
	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL
2,4'-DDD	-	-	-	-	-	-	-	-	-	-	-	-
2,4'-DDE	-	-	-	-	-	-	-	-	-	-	-	-
2,4'-DDT	-	-	-	-	-	-	-	-	-	-	-	-
4,4'-DDD	0.20 U	0.17	0.20 U	0.17	0.21 U	0.18	0.20 U	0.17	0.21 U	0.18	0.21 U	0.18
4,4'-DDE	0.20 U	0.17	0.20 U	0.17	0.21 J	0.17	0.39	0.17	0.21 U	0.18	0.21	0.18
4,4'-DDT	0.20 U	-	0.20 U	-	0.21 U	-	0.20 U	-	0.21 U	-	0.21 U	-
Aldrin	0.20 U	0.062	0.20 U	0.061	0.21 U	0.062	0.20 U	0.062	0.21 U	0.063	0.21 U	0.064
Alpha-BHC	0.20 U	0.041	0.20 U	0.041	0.21 U	0.041	0.20 U	0.041	0.21 U	0.042	0.21 U	0.042
Beta-BHC	0.20 U	0.15	0.20 U	0.14	0.21 U	0.15	0.20 U	0.15	0.21 U	0.15	0.21 U	0.15
Chlorpyriphos	0.20 U	-	0.20 U	-	0.21 U	-	0.20 U	-	0.21 U	-	0.21 U	-
cis-Chlordane	0.20 U	0.091	0.20 U	0.09	0.21 U	0.092	0.20 U	0.091	0.21 U	0.094	0.21 U	0.094
Cis-Nonachlor	0.20 U	0.13	0.20 U	0.13	0.21 U	0.13	0.20 U	0.13	0.21 U	0.13	0.21 U	0.13
Dacthal (DCPA)	-	-	-	-	-	-	-	-	-	-	-	-
DDMU	-	-	-	-	-	-	-	-	-	-	-	-
Delta-BHC	0.20 U	0.04	0.20 U	0.04	0.21 UJ	0.041	0.20 U	0.04	0.21 U	0.041	0.21 U	0.042
Dieldrin	0.51 U	0.2	0.50 U	0.2	0.51 U	0.21	0.51 U	0.2	0.52 U	0.21	0.52 U	0.21
Endosulfan I	0.20 U	0.092	0.20 U	0.091	0.21 U	0.093	0.20 U	0.092	0.21 U	0.094	0.21 U	0.094
Endosulfan II	0.20 U	0.075	0.20 U	0.074	0.21 U	0.076	0.20 U	0.075	0.21 U	0.077	0.21 U	0.077
Endosulfan Sulfate	0.20 U	0.16	0.20 U	0.16	0.21 U	0.16	0.20 U	0.16	0.21 U	0.17	0.21 U	0.17
Endrin	0.51 U	0.22	0.50 U	0.22	0.51 U	0.22	0.51 U	0.22	0.52 U	0.22	0.52 U	0.22
Endrin Aldehyde	0.20 U	0.15	0.20 U	0.15	0.21 U	0.15	0.20 U	0.15	0.21 U	0.16	0.21 U	0.16
Endrin Ketone	0.76 U	0.61	0.75 U	0.61	0.77 U	0.62	0.76 U	0.61	0.78 U	0.63	0.78 U	0.63
Gamma-BHC (Lindane)	9.4 UJ	0.051	3.0 UJ	0.05	2.8 UJ	0.051	1.8 UJ	0.051	4.2 UJ	0.052	6.4 UJ	0.052
Heptachlor	0.20 U	0.089	0.20 U	0.088	0.21 U	0.09	0.20 U	0.089	0.21 U	0.091	0.21 U	0.091
Heptachlor Epoxide	0.20 U	0.12	0.20 U	0.12	0.21 U	0.13	0.20 U	0.12	0.21 U	0.13	0.21 U	0.13
Hexachlorobenzene	0.20 U	-	0.20 U	-	0.21 U	-	0.20 U	-	0.21 U	-	0.21 U	-
Methoxychlor	0.51 U	0.26	0.50 U	0.25	0.51 U	0.26	0.51 U	0.26	0.52 U	0.26	0.52 U	0.26
Mirex	-	-	-	-	-	-	-	-	-	-	-	-
Oxychlordane	0.20 U	0.074	0.20 U	0.073	0.21 U	0.075	0.20 U	0.074	0.21 U	0.076	0.21 U	0.076
Pentachloroanisole	-	-	-	-	-	-	-	-	-	-	-	-
Toxaphene	1.0 U	-	0.99 U	-	1.0 U	-	1.0 U	-	1.0 U	-	1.0 U	-
trans-Chlordane	0.20 U	0.15	0.20 U	0.15	0.21 U	0.15	0.20 U	0.15	0.21 U	0.15	0.21 U	0.15
Trans-Nonachlor	0.20 U	-	0.20 U	-	0.21 U	-	0.20 U	-	0.21 U	-	0.21 U	-

Table E-4. September 2009 Chlorinated Pesticides Results for Marine Water Samples from Puget Sound Basin Sites.

Non-detect values are given at the reporting limit (RL). The method detection limit (MDL) is presented for comparison.

Parameter (ng/L)	Hood Canal				Whidbey Basin				Main Basin				South Sound			
	Surface		Deep		Surface		Deep		Surface		Deep		Surface		Deep	
	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL
2,4'-DDD	0.21 U	-	0.21 U	-	0.23 U	-	0.20 U	-	0.21 U	-	0.20 U	-	0.20 U	-	0.20 U	-
2,4'-DDE	0.21 U	-	0.21 U	-	0.23 U	-	0.20 U	-	0.21 U	-	0.20 U	-	0.20 U	-	0.20 U	-
2,4'-DDT	0.21 U	-	0.21 U	-	0.23 U	-	0.20 U	-	0.21 U	-	0.20 U	-	0.20 U	-	0.20 U	-
4,4'-DDD	0.21 U	0.18	0.21 U	0.18	0.23 U	0.2	0.20 U	0.18	0.21 U	0.18	0.20 U	0.17	0.20 U	0.17	0.20 U	0.17
4,4'-DDE	0.21 U	0.17	0.21 U	0.17	0.23 U	0.19	0.20 U	0.17	0.21 U	0.17	0.20 U	0.17	0.20 U	0.17	0.20 U	0.17
4,4'-DDT	0.21 U	-	0.21 U	-	0.23 U	-	0.20 U	-	0.21 U	-	0.20 U	-	0.20 U	-	0.20 U	-
Aldrin	0.21 UJ	0.062	0.21 UJ	0.062	0.23 UJ	0.069	0.20 UJ	0.062	0.21 UJ	0.062	0.20 UJ	0.062	0.20 UJ	0.061	0.20 UJ	0.061
Alpha-BHC	0.21 U	0.041	0.21 U	0.041	0.23 U	0.046	0.21	0.041	0.21 U	0.041	0.20 U	0.041	0.20 U	0.041	0.20 U	0.041
Beta-BHC	0.21 U	0.15	0.21 U	0.15	0.23 U	0.16	0.32	0.15	0.21 U	0.15	0.20 U	0.15	0.20 U	0.14	0.20 U	0.14
Chlorpyriphos	14 UJ	-	0.21 U	-	0.23 U	-	1.9 UJ	-	1.1 UJ	-	3.0 UJ	-	0.93 UJ	-	1.8 UJ	-
cis-Chlordane	0.21 U	0.092	0.21 U	0.092	0.23 U	0.1	0.20 U	0.092	0.21 U	0.092	0.20 U	0.091	0.20 U	0.09	0.20 U	0.09
Cis-Nonachlor	0.21 U	0.13	0.21 U	0.13	0.23 U	0.14	0.20 U	0.13	0.21 U	0.13	0.20 U	0.13	0.20 U	0.13	0.20 U	0.13
Dacthal (DCPA)	0.21 U	-	0.21 U	-	0.23 U	-	0.24 UJ	-	0.21 U	-	0.20 U	-	0.20 U	-	0.20 U	-
DDMU	0.21 U	-	0.21 U	-	0.23 U	-	0.38 UJ	-	0.21 U	-	0.20 U	-	0.20 U	-	0.20 U	-
Delta-BHC	0.21 U	0.041	0.21 U	0.041	0.23 U	0.045	0.25 J	0.041	0.21 U	0.041	0.20 U	0.04	0.20 U	0.04	0.20 U	0.04
Dieldrin	0.51 U	0.21	0.51 U	0.21	0.57 U	0.23	0.51 U	0.21	0.51 U	0.21	0.51 U	0.2	0.50 U	0.2	0.50 U	0.2
Endosulfan I	0.21 U	0.093	0.21 U	0.093	0.23 U	0.1	0.20 U	0.092	0.21 U	0.093	0.20 U	0.092	0.20 U	0.091	0.20 U	0.091
Endosulfan II	0.21 UJ	0.076	0.21 UJ	0.076	0.31 UJ	0.084	0.20 UJ	0.075	0.21 UJ	0.076	0.20 UJ	0.075	0.20 UJ	0.074	0.20 UJ	0.074
Endosulfan Sulfate	0.21 UJ	0.16	0.21 UJ	0.16	0.23 UJ	0.18	0.20 UJ	0.16	0.21 UJ	0.16	0.20 UJ	0.16	0.20 UJ	0.16	0.20 UJ	0.16
Endrin	0.51 UJ	0.22	0.51 UJ	0.22	0.57 UJ	0.24	0.51 UJ	0.22	0.51 UJ	0.22	0.51 UJ	0.22	0.50 UJ	0.22	0.50 UJ	0.22
Endrin Aldehyde	0.38 UJ	0.15	0.49 UJ	0.15	0.68 UJ	0.17	0.37 UJ	0.15	0.40 UJ	0.15	0.32 UJ	0.15	0.46 UJ	0.15	0.42 UJ	0.15
Endrin Ketone	0.77 U	0.62	0.77 U	0.62	0.85 U	0.69	0.76 U	0.61	0.77 U	0.62	0.76 U	0.61	0.75 U	0.61	0.75 U	0.61
Gamma-BHC (Lindane)	2.4 UJ	0.051	1.3 UJ	0.051	2.5 UJ	0.057	2.4 UJ	0.051	1.9 UJ	0.051	2.0 UJ	0.051	3.5 UJ	0.05	3.3 UJ	0.05
Heptachlor	0.21 U	0.09	0.21 U	0.09	0.23 U	0.1	0.20 U	0.089	0.21 U	0.09	0.20 U	0.089	0.20 U	0.088	0.20 U	0.088
Heptachlor Epoxide	0.21 U	0.13	0.21 U	0.13	0.23 U	0.14	0.20 U	0.12	0.21 U	0.13	0.20 U	0.12	0.20 U	0.12	0.20 U	0.12
Hexachlorobenzene	0.21 U	-	0.21 U	-	0.23 U	-	0.20 U	-	0.21 U	-	0.20 U	-	0.20 U	-	0.20 U	-
Methoxychlor	0.51 UJ	0.26	1.1 UJ	0.26	0.57 UJ	0.29	0.51 UJ	0.26	0.51 UJ	0.26	0.51 UJ	0.26	0.50 UJ	0.25	0.50 UJ	0.25
Mirex	0.21 U	-	0.21 U	-	0.23 U	-	0.20 U	-	0.21 U	-	0.20 U	-	0.20 U	-	0.20 U	-
Oxychlordane	0.21 U	0.075	0.21 U	0.075	0.23 U	0.083	0.20 U	0.074	0.21 U	0.075	0.20 U	0.074	0.20 U	0.073	0.20 U	0.073
Pentachloroanisole	0.21 U	-	0.21 U	-	0.23 U	-	0.20 U	-	0.21 U	-	0.20 U	-	0.20 U	-	0.20 U	-
Toxaphene	10 U	-	10 U	-	11 U	-	10 U	-	10 U	-	10 U	-	9.9 U	-	9.9 U	-
trans-Chlordane	0.21 U	0.15	0.21 U	0.15	0.23 U	0.17	0.20 U	0.15	0.21 U	0.15	0.20 U	0.15	0.20 U	0.15	0.20 U	0.15
Trans-Nonachlor	0.21 U	-	0.21 U	-	0.23 U	-	0.20 U	-	0.21 U	-	0.20 U	-	0.20 U	-	0.20 U	-

Table E-5. September 2009 Chlorinated Pesticides Results for Marine Water Samples from Boundary Water Sites.

Non-detect values are given at the reporting limit (RL). The method detection limit (MDL) is presented for comparison.

Parameter (ng/L)	SJdF at Sill				SJdF North				Haro Strait			
	Surface		Deep		Surface		Deep		Surface		Deep	
	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL
2,4'-DDD	0.21 U	-	0.20 U	-	0.21 U	-	0.21 U	-	0.21 U	-	0.20 U	-
2,4'-DDE	0.21 U	-	0.20 U	-	0.21 U	-	0.21 U	-	0.21 U	-	0.20 U	-
2,4'-DDT	0.21 U	-	0.20 U	-	0.21 U	-	0.21 U	-	0.21 U	-	0.20 U	-
4,4'-DDD	0.21 U	0.18	0.20 U	0.17	0.21 U	0.18	0.21 U	0.18	0.21 U	0.18	0.20 U	0.17
4,4'-DDE	0.21 U	0.18	0.20 U	0.17	0.21 U	0.18	0.21 U	0.17	0.21 U	0.18	0.20 U	0.17
4,4'-DDT	0.21 U	-	0.20 U	-	0.21 U	-	0.21 U	-	0.21 U	-	0.20 U	-
Aldrin	0.21 U	0.063	0.20 U	0.062	0.21 U	0.063	0.21 U	0.062	0.21 U	0.064	0.20 U	0.062
Alpha-BHC	0.21 U	0.042	0.20 U	0.041	0.21 U	0.042	0.21 U	0.041	0.21 U	0.042	0.20 U	0.041
Beta-BHC	0.21 U	0.15	0.20 U	0.15	0.21 U	0.15	0.21 U	0.15	0.21 U	0.15	0.20 U	0.15
Chlorpyriphos	0.53 UJ	-	0.20 U	-	0.76 UJ	-	0.36 UJ	-	0.64 UJ	-	0.54 UJ	-
cis-Chlordane	0.21 U	0.093	0.20 U	0.091	0.21 U	0.094	0.21 U	0.092	0.21 U	0.094	0.20 U	0.091
Cis-Nonachlor	0.21 U	0.13	0.20 U	0.13	0.21 U	0.13	0.21 U	0.13	0.21 U	0.13	0.20 U	0.13
Dacthal (DCPA)	0.21 U	-	0.20 U	-	0.21 U	-	0.21 U	-	0.21 U	-	0.20 U	-
DDMU	0.21 U	-	0.20 U	-	0.21 U	-	0.21 U	-	0.21 U	-	0.20 U	-
Delta-BHC	0.21 U	0.041	0.20 U	0.04	0.21 U	0.041	0.21 U	0.041	0.21 U	0.042	0.20 U	0.04
Dieldrin	0.52 U	0.21	0.51 U	0.2	0.52 U	0.21	0.51 U	0.21	0.52 U	0.21	0.51 U	0.2
Endosulfan I	0.21 U	0.093	0.20 U	0.092	0.21 U	0.094	0.21 U	0.093	0.21 U	0.094	0.20 U	0.092
Endosulfan II	0.30 UJ	0.077	0.21 UJ	0.075	0.21 UJ	0.077	0.23 UJ	0.076	0.22 UJ	0.077	0.29 UJ	0.075
Endosulfan Sulfate	0.21 UJ	0.17	0.20 UJ	0.16	0.21 UJ	0.17	0.26 UJ	0.16	0.21 UJ	0.17	0.20 UJ	0.16
Endrin	0.52 UJ	0.22	0.51 UJ	0.22	0.52 UJ	0.22	0.51 UJ	0.22	0.52 UJ	0.22	0.51 UJ	0.22
Endrin Aldehyde	0.62 UJ	0.16	0.52 UJ	0.15	0.66 UJ	0.16	0.59 UJ	0.15	0.52 UJ	0.16	0.42 UJ	0.15
Endrin Ketone	0.77 U	0.62	0.76 U	0.61	0.78 U	0.63	0.77 U	0.62	0.78 U	0.63	0.76 U	0.61
Gamma-BHC (Lindane)	3.6 UJ	0.052	2.2 UJ	0.051	3.6 UJ	0.052	4.2 UJ	0.051	1.5 UJ	0.052	4.0 UJ	0.051
Heptachlor	0.21 U	0.09	0.20 U	0.089	0.21 U	0.091	0.21 U	0.09	0.21 U	0.091	0.20 U	0.089
Heptachlor Epoxide	0.21 U	0.13	0.20 U	0.12	0.21 U	0.13	0.21 U	0.13	0.21 U	0.13	0.20 U	0.12
Hexachlorobenzene	0.21 U	-	0.20 U	-	0.21	-	0.21 U	-	0.21 U	-	0.20 U	-
Methoxychlor	0.52 UJ	0.26	0.51 UJ	0.26	0.52 UJ	0.26	0.51 UJ	0.26	0.52 UJ	0.26	0.51 UJ	0.26
Mirex	0.21 U	-	0.20 U	-	0.21 U	-	0.21 U	-	0.21 U	-	0.20 U	-
Oxychlordane	0.21 U	0.075	0.20 U	0.074	0.21 U	0.076	0.21 U	0.075	0.21 U	0.076	0.20 U	0.074
Pentachloroanisole	0.21 U	-	0.20 U	-	0.21 U	-	0.21 U	-	0.21 U	-	0.20 U	-
Toxaphene	10 U	-	10 U	-	10 U	-	10 U	-	10 U	-	10 U	-
trans-Chlordane	0.21 U	0.15	0.20 U	0.15	0.21 U	0.15	0.21 U	0.15	0.21 U	0.15	0.20 U	0.15
Trans-Nonachlor	0.21 U	-	0.20 U	-	0.21 U	-	0.21 U	-	0.21 U	-	0.20 U	-

Table E-6. January 2010 Chlorinated Pesticides Results for Marine Water Samples from Puget Sound Basin Sites.

Non-detect values are given at the reporting limit (RL). The method detection limit (MDL) is presented for comparison.

Parameter (ng/L)	Hood Canal				Whidbey Basin				Main Basin				South Sound			
	Surface		Deep		Surface		Deep		Surface		Deep		Surface		Deep	
	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL
2,4'-DDD	0.20 U	-	0.21 U	-	0.20 U	-	0.20 U	-	0.21 U	-	0.20 U	-	0.21 U	-	0.20 U	-
2,4'-DDE	0.20 U	-	0.21 U	-	0.20 U	-	0.20 U	-	0.21 U	-	0.20 U	-	0.21 U	-	0.20 U	-
2,4'-DDT	0.20 U	-	0.21 U	-	0.20 U	-	0.20 U	-	0.21 U	-	0.20 U	-	0.21 U	-	0.20 U	-
4,4'-DDD	0.20 U	0.17	0.21 U	0.18	0.20 U	0.17	0.20 U	0.17	0.21 U	0.18	0.20 U	0.18	0.21 U	0.18	0.20 U	0.17
4,4'-DDE	0.20 U	0.17	0.21 U	0.17	0.20 U	0.17	0.20 UJ	0.17	0.21 U	0.17	0.20 U	0.17	0.21 U	0.18	0.20 U	0.17
4,4'-DDT	0.20 U	-	0.21 U	-	0.20 U	-	0.20 U	-	0.21 U	-	0.20 U	-	0.21 U	-	0.20 U	-
Aldrin	0.20 UJ	0.062	0.21 UJ	0.063	0.20 U	0.062	0.20 U	0.06	0.21 UJ	0.062	0.20 UJ	0.062	0.21 UJ	0.064	0.20 UJ	0.06
Alpha-BHC	0.20 UJ	0.041	0.21 UJ	0.042	0.20 U	0.041	0.20 U	0.04	0.21 UJ	0.041	0.20 UJ	0.041	0.21 UJ	0.042	0.20 UJ	0.04
Beta-BHC	0.20 U	0.15	0.21 U	0.15	0.20 U	0.15	0.20 U	0.14	0.21 U	0.15	0.20 U	0.15	0.21 U	0.15	0.20 U	0.14
Chlorpyriphos	0.20 U	-	0.21 U	-	0.20 U	-	0.22 UJ	-	0.21 U	-	0.20 U	-	0.21 U	-	0.20 U	-
cis-Chlordane	0.20 U	0.091	0.21 U	0.093	0.20 U	0.091	0.20 U	0.089	0.21 U	0.092	0.20 U	0.092	0.21 U	0.094	0.20 U	0.089
Cis-Nonachlor	0.20 U	0.13	0.21 U	0.13	0.20 U	0.13	0.20 U	0.12	0.21 U	0.13	0.20 U	0.13	0.21 U	0.13	0.20 U	0.13
Dacthal (DCPA)	0.20 U	-	0.21 U	-	0.20 U	-	0.20 U	-	0.21 U	-	0.20 U	-	0.21 U	-	0.20 U	-
DDMU	0.20 U	-	0.21 U	-	0.20 U	-	0.20 U	-	0.21 U	-	0.20 U	-	0.21 U	-	0.20 U	-
Delta-BHC	0.20 U	0.04	0.21 U	0.041	0.20 U	0.04	0.20 U	0.039	0.21 U	0.041	0.20 U	0.041	0.21 U	0.042	0.20 U	0.039
Dieldrin	0.51 U	0.2	0.51 U	0.21	0.51 U	0.2	0.49 U	0.2	0.51 U	0.21	0.51 U	0.21	0.52 U	0.21	0.49 U	0.2
Endosulfan I	0.20 U	0.092	0.21 U	0.093	0.20 UJ	0.092	0.20 UJ	0.089	0.21 U	0.093	0.20 U	0.092	0.21 U	0.094	0.20 U	0.089
Endosulfan II	0.20 U	0.075	0.21 U	0.076	0.20 U	0.075	0.20 U	0.073	0.21 U	0.076	0.20 U	0.075	0.21 U	0.077	0.20 U	0.073
Endosulfan Sulfate	0.20 U	0.16	0.21 U	0.17	0.20 U	0.16	0.20 U	0.16	0.21 U	0.16	0.20 U	0.16	0.21 U	0.17	0.20 U	0.16
Endrin	0.51 U	0.22	0.51 U	0.22	0.51 U	0.22	0.49 U	0.21	0.51 U	0.22	0.51 U	0.22	0.52 U	0.22	0.49 U	0.21
Endrin Aldehyde	0.20 U	0.15	0.21 U	0.16	0.20 U	0.15	0.20 U	0.15	0.21 U	0.15	0.20 U	0.15	0.21 U	0.16	0.20 U	0.15
Endrin Ketone	0.76 U	0.61	0.77 U	0.62	0.76 U	0.61	0.74 U	0.59	0.77 U	0.62	0.76 U	0.61	0.78 U	0.63	0.74 U	0.6
Gamma-BHC (Lindane)	0.43 UJ	0.051	0.21 UJ	0.052	0.40 UJ	0.051	0.31 UJ	0.049	0.21 U	0.051	0.20 U	0.051	0.21 U	0.052	0.20 U	0.05
Heptachlor	0.20 U	0.089	0.21 U	0.09	0.20 U	0.089	0.20 U	0.086	0.21 U	0.09	0.20 U	0.089	0.21 U	0.091	0.20 U	0.086
Heptachlor Epoxide	0.20 U	0.12	0.21 U	0.13	0.20 UJ	0.12	0.20 UJ	0.12	0.21 U	0.13	0.20 U	0.12	0.21 U	0.13	0.20 U	0.12
Hexachlorobenzene	0.20 U	-	0.21 U	-	0.20 U	-	0.20 U	-	0.21 U	-	0.20 U	-	0.21 U	-	0.20 U	-
Methoxychlor	0.51 U	0.26	0.51 U	0.26	0.51 U	0.26	0.49 UJ	0.25	0.51 U	0.26	0.51 U	0.26	0.52 U	0.26	0.49 U	0.25
Mirex	0.20 U	-	0.21 U	-	0.20 U	-	0.20 U	-	0.21 U	-	0.20 U	-	0.21 U	-	0.20 U	-
Oxychlordane	0.20 U	0.074	0.21 U	0.075	0.20 U	0.074	0.20 U	0.072	0.21 U	0.075	0.20 U	0.074	0.21 U	0.076	0.20 U	0.072
Pentachloroanisole	0.20 U	-	0.21 U	-	0.20 U	-	0.20 U	-	0.21 U	-	0.20 U	-	0.21 U	-	0.20 U	-
Toxaphene	10 U	-	10 U	-	10 U	-	9.7 U	-	10 U	-	10 U	-	10 U	-	9.8 U	-
trans-Chlordane	0.20 U	0.15	0.21 U	0.15	0.20 U	0.15	0.20 U	0.14	0.21 U	0.15	0.20 U	0.15	0.21 U	0.15	0.20 U	0.15
Trans-Nonachlor	0.20 U	-	0.21 U	-	0.20 U	-	0.20 U	-	0.21 U	-	0.20 U	-	0.21 U	-	0.20 U	-

Table E-7. January 2010 Chlorinated Pesticides Results for Marine Water Samples from Boundary Water Sites.

Non-detect values are given at the reporting limit (RL). The method detection limit (MDL) is presented for comparison.

Parameter (ng/L)	SJdF at Sill				SJdF North				Haro Strait			
	Surface		Deep		Surface		Deep		Surface		Deep	
	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL
2,4'-DDD	0.21 UJ	-	0.21 U	-	0.21 UJ	-	0.21 U	-	0.21 UJ	-	0.20 UJ	-
2,4'-DDE	0.21 UJ	-	0.21 U	-	0.21 UJ	-	0.25 UJ	-	0.21 UJ	-	0.20 UJ	-
2,4'-DDT	0.21 UJ	-	0.21 UJ	-	0.21 UJ	-	0.24 UJ	-	0.21 UJ	-	0.25 UJ	-
4,4'-DDD	0.21 UJ	0.18	0.21 U	0.18	0.21 UJ	0.18	0.21 U	0.18	0.21 UJ	0.18	0.20 UJ	0.17
4,4'-DDE	0.21 UJ	0.17	0.21 UJ	0.18	0.21 UJ	0.18	0.21 UJ	0.18	0.21 UJ	0.17	0.20 UJ	0.17
4,4'-DDT	0.21 UJ	-	0.21 UJ	-	0.21 UJ	-	0.21 UJ	-	0.33 UJ	-	0.20 UJ	-
Aldrin	0.21 UJ	0.062	0.28 UJ	0.063	0.23 UJ	0.064	0.27 UJ	0.064	0.23 UJ	0.062	0.20 UJ	0.061
Alpha-BHC	0.21 UJ	0.041	0.21 U	0.042	0.21 UJ	0.042	0.21 U	0.042	0.21 UJ	0.041	0.20 UJ	0.041
Beta-BHC	0.21 UJ	0.15	0.21 U	0.15	0.21 UJ	0.15	0.21 U	0.15	0.21 UJ	0.15	0.20 UJ	0.14
Chlorpyriphos	0.21 UJ	-	0.21 U	-	0.21 UJ	-	0.21 U	-	0.21 UJ	-	0.20 UJ	-
cis-Chlordane	0.21 UJ	0.092	0.21 U	0.094	0.21 UJ	0.094	0.21 U	0.094	0.21 UJ	0.092	0.20 UJ	0.09
Cis-Nonachlor	0.21 UJ	0.13	0.21 U	0.13	0.21 UJ	0.13	0.21 U	0.13	0.21 UJ	0.13	0.20 UJ	0.13
Dacthal (DCPA)	0.21 UJ	-	0.21 U	-	0.21 UJ	-	0.21 U	-	0.21 UJ	-	0.20 UJ	-
DDMU	0.36 UJ	-	0.62 UJ	-	0.21 UJ	-	0.59 UJ	-	0.21 UJ	-	0.20 UJ	-
Delta-BHC	0.21 UJ	0.041	0.21 UJ	0.041	0.21 UJ	0.042	0.21 UJ	0.042	0.21 UJ	0.041	0.20 UJ	0.04
Dieldrin	0.51 UJ	0.21	0.52 UJ	0.21	0.52 UJ	0.21	0.52 UJ	0.21	0.51 UJ	0.21	0.50 UJ	0.2
Endosulfan I	0.21 UJ	0.093	0.21 UJ	0.094	0.21 UJ	0.094	0.21 UJ	0.094	0.21 UJ	0.093	0.20 UJ	0.091
Endosulfan II	0.21 UJ	0.076	0.21 UJ	0.077	0.21 UJ	0.077	0.21 UJ	0.077	0.21 UJ	0.076	0.20 UJ	0.074
Endosulfan Sulfate	0.21 UJ	0.16	0.21 UJ	0.17	0.21 UJ	0.17	0.22 UJ	0.17	0.21 UJ	0.16	0.20 UJ	0.16
Endrin	0.51 UJ	0.22	0.52 UJ	0.22	0.52 UJ	0.22	0.52 UJ	0.22	0.51 UJ	0.22	0.50 UJ	0.22
Endrin Aldehyde	0.21 UJ	0.15	0.21 U	0.16	0.21 UJ	0.16	0.21 U	0.16	0.21 UJ	0.15	0.20 UJ	0.15
Endrin Ketone	0.77 UJ	0.62	0.78 U	0.63	0.78 UJ	0.63	0.78 U	0.63	0.77 UJ	0.62	0.75 UJ	0.61
Gamma-BHC (Lindane)	0.39 UJ	0.051	0.29 UJ	0.052	0.57 UJ	0.052	0.47 UJ	0.052	0.33 UJ	0.051	0.33 UJ	0.05
Heptachlor	0.21 UJ	0.09	0.21 UJ	0.091	0.21 UJ	0.091	0.21 UJ	0.091	0.21 UJ	0.09	0.20 UJ	0.088
Heptachlor Epoxide	0.21 UJ	0.13	0.21 UJ	0.13	0.21 UJ	0.13	0.21 UJ	0.13	0.21 UJ	0.13	0.20 UJ	0.12
Hexachlorobenzene	0.21 UJ	-	0.21 U	-	0.21 UJ	-	0.21 U	-	0.21 UJ	-	0.20 UJ	-
Methoxychlor	0.51 UJ	0.26	0.52 UJ	0.26	0.52 UJ	0.26	0.52 UJ	0.26	0.51 UJ	0.26	0.50 UJ	0.25
Mirex	0.49 UJ	-	0.53 UJ	-	0.51 UJ	-	0.51 UJ	-	0.49 UJ	-	0.32 UJ	-
Oxychlordane	0.21 UJ	0.075	0.21 U	0.076	0.21 UJ	0.076	0.21 U	0.076	0.21 UJ	0.075	0.20 UJ	0.073
Pentachloroanisole	0.21 UJ	-	0.21 U	-	0.21 UJ	-	0.21 U	-	0.21 UJ	-	0.20 UJ	-
Toxaphene	10 UJ	-	10 U	-	10 UJ	-	10 U	-	10 UJ	-	9.9 UJ	-
trans-Chlordane	0.79 UJ	0.15	1.1 UJ	0.15	1.1 UJ	0.15	1.4 UJ	0.15	0.77 UJ	0.15	0.75 UJ	0.15
Trans-Nonachlor	0.21 UJ	-	0.21 U	-	0.21 UJ	-	0.21 U	-	0.21 UJ	-	0.20 UJ	-

Table E-8. July 2009 PAH Results for Marine Water Samples from Puget Sound Basin Sites.

Non-detect values are given at the reporting limit (RL). The method detection limit (MDL) is presented for comparison.

Parameter (µg/L)	Hood Canal				Whidbey Basin				Main Basin				South Sound			
	Surface		Deep		Surface		Deep		Surface		Deep		Surface		Deep	
	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL
1-Methylnaphthalene	0.010 U	0.011	0.0099 U	0.010	0.0098 U	0.010	0.010 U	0.011	0.010 U	0.010	0.010 UJ	0.010	0.0099 U	0.010	0.010 U	0.010
2-Chloronaphthalene	0.010 U	0.0096	0.0099 U	0.0092	0.0098 U	0.0091	0.010 U	0.0097	0.010 U	0.0095	0.010 UJ	0.0095	0.0099 U	0.0092	0.010 U	0.0095
2-Methylnaphthalene	0.010 U	0.0089	0.0099 U	0.0085	0.0098 U	0.0084	0.010 U	0.0090	0.010 U	0.0088	0.010 UJ	0.0088	0.0099 U	0.0085	0.010 U	0.0088
Acenaphthene	0.010 U	0.0088	0.0099 U	0.0085	0.0098 U	0.0084	0.010 U	0.0089	0.010 U	0.0088	0.010 U	0.0088	0.0099 U	0.0085	0.010 U	0.0088
Acenaphthylene	0.010 U	0.0087	0.0099 U	0.0084	0.0098 U	0.0083	0.010 U	0.0088	0.010 U	0.0086	0.010 U	0.0086	0.0099 U	0.0084	0.010 U	0.0086
Anthracene	0.010 U	0.0052	0.0099 U	0.0050	0.0098 U	0.0050	0.010 U	0.0053	0.010 U	0.0052	0.010 U	0.0052	0.0099 U	0.0050	0.010 U	0.0052
Benzo(a)anthracene	0.010 U	0.0009	0.0099 U	0.0009	0.0098 U	0.0009	0.010 U	0.0009	0.010 U	0.0009	0.010 U	0.0009	0.020 U	0.0009	0.020 U	0.0009
Benzo(a)pyrene	0.010 UJ	0.0017	0.0099 UJ	0.0016	0.0098 UJ	0.0016	0.010 UJ	0.0017	0.010 UJ	0.0017	0.010 UJ	0.0017	0.020 UJ	0.0016	0.020 UJ	0.0017
Benzo(b)fluoranthene	0.010 U	0.0011	0.0099 U	0.0010	0.0098 UJ	0.0010	0.010 UJ	0.0011	0.010 UJ	0.0010	0.010 UJ	0.0010	0.020 UJ	0.0010	0.020 UJ	0.0010
Benzo(ghi)perylene	0.010 UJ	0.0016	0.0099 UJ	0.0016	0.0098 UJ	0.0016	0.010 UJ	0.0017	0.010 UJ	0.0016	0.010 UJ	0.0016	0.020 U	0.0016	0.020 U	0.0016
Benzo(k)fluoranthene	0.010 U	0.0005	0.0099 UJ	0.0005	0.0098 U	0.0005	0.010 U	0.0006	0.010 U	0.0005	0.010 U	0.0005	0.020 UJ	0.0005	0.020 UJ	0.0005
Carbazole	0.010 U	0.0015	0.0099 U	0.0015	0.0098 U	0.0014	0.010 U	0.0015	0.010 U	0.0015	0.010 U	0.0015	0.0099 U	0.0015	0.010 U	0.0015
Chrysene	0.010 U	0.0009	0.0099 U	0.0008	0.0098 U	0.0008	0.010 U	0.0009	0.010 U	0.0009	0.010 U	0.0009	0.020 U	0.0008	0.020 U	0.0009
Dibenzo(a,h)anthracene	0.010 UJ	0.0014	0.0099 UJ	0.0014	0.0098 UJ	0.0014	0.010 UJ	0.0015	0.010 UJ	0.0014	0.010 UJ	0.0014	0.020 UJ	0.0014	0.020 UJ	0.0014
Dibenzofuran	0.010 U	0.0081	0.0099 U	0.0078	0.0098 U	0.0077	0.010 U	0.0082	0.010 U	0.0081	0.010 U	0.0081	0.0099 U	0.0078	0.010 U	0.0081
Fluoranthene	0.010 U	0.0016	0.0099 U	0.0015	0.0098 U	0.0015	0.010 U	0.0016	0.010 U	0.0016	0.010 U	0.0016	0.0099 U	0.0015	0.010 U	0.0016
Fluorene	0.010 U	0.0076	0.0099 U	0.0073	0.0098 U	0.0072	0.010 U	0.0077	0.010 U	0.0076	0.010 U	0.0076	0.0099 U	0.0073	0.010 U	0.0076
Indeno(1,2,3-cd)pyrene	0.010 U	0.0020	0.0099 U	0.0020	0.0098 U	0.0019	0.010 U	0.0021	0.010 U	0.0020	0.010 UJ	0.0020	0.020 UJ	0.0020	0.020 U	0.0020
Naphthalene	0.010 U	0.032	0.0099 U	0.031	0.0098 U	0.031	0.010 U	0.033	0.010 U	0.032	0.010 UJ	0.032	0.0099 U	0.031	0.010 U	0.032
Phenanthrene	0.010 U	0.0063	0.0099 U	0.0060	0.0098 U	0.0060	0.010 U	0.0063	0.010 U	0.0062	0.010 U	0.0062	0.0099 U	0.0060	0.010 U	0.0062
Pyrene	0.010 U	0.0018	0.0099 U	0.0018	0.0098 U	0.0017	0.010 U	0.0019	0.010 U	0.0018	0.010 U	0.0018	0.020 U	0.0018	0.020 U	0.0018
Retene	0.010 U	0.0010	0.0099 U	0.0009	0.0098 U	0.0009	0.010 U	0.0010	0.010 U	0.0010	0.010 U	0.0010	0.020 U	0.0009	0.020 U	0.0010
Total PAHs																
…ND at ½ RL	0.11 U		0.11 U		0.11 U		0.11 U		0.11 U		0.11 U		0.16 U		0.16 U	
…ND at MDL	0.12 U		0.12 U		0.12 U		0.12 U		0.12 U		0.12 U		0.12 U		0.12 U	
Total cPAHs*																
…ND at ½ RL	0.035 U		0.035 U		0.034 U		0.035 U		0.035 U		0.035 U		0.070 U		0.070 U	
…ND at MDL	0.0085 U		0.0082 U		0.0081 U		0.0088 U		0.0084 U		0.0084 U		0.0082 U		0.0084 U	

* The carcinogenic PAH compounds (cPAHs) are: benzo(a)pyrene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene.

Table E-9. July 2009 PAH Results for Marine Water Samples from Boundary Water Sites.

Non-detect values are given at the reporting limit (RL). The method detection limit (MDL) is presented for comparison.

Parameter (µg/L)	SJdF at Sill				SJdF North				Haro Strait			
	Surface		Deep		Surface		Deep		Surface		Deep	
	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL
1-Methylnaphthalene	0.010 U	0.010	0.010 U	0.010	0.010 U	0.010	0.010 U	0.010	0.010 U	0.010	0.010 U	0.011
2-Chloronaphthalene	0.010 U	0.0093	0.010 U	0.0095	0.010 U	0.0093	0.010 U	0.0094	0.010 U	0.0095	0.010 U	0.0096
2-Methylnaphthalene	0.010 U	0.0086	0.010 U	0.0088	0.010 U	0.0086	0.010 U	0.0087	0.010 U	0.0088	0.010 U	0.0089
Acenaphthene	0.010 U	0.0086	0.010 U	0.0088	0.010 U	0.0086	0.010 U	0.0087	0.010 U	0.0087	0.010 U	0.0089
Acenaphthylene	0.010 U	0.0085	0.010 U	0.0086	0.010 U	0.0084	0.010 U	0.0085	0.010 U	0.0086	0.010 U	0.0087
Anthracene	0.010 U	0.0051	0.010 U	0.0052	0.010 U	0.0051	0.010 U	0.0051	0.010 U	0.0052	0.010 U	0.0053
Benzo(a)anthracene	0.010 U	0.0009	0.010 U	0.0009	0.010 U	0.0009	0.010 U	0.0009	0.010 U	0.0009	0.010 U	0.0009
Benzo(a)pyrene	0.010 UJ	0.0016	0.010 UJ	0.0017	0.010 UJ	0.0016	0.010 UJ	0.0016	0.010 UJ	0.0017	0.010 UJ	0.0017
Benzo(b)fluoranthene	0.010 UJ	0.0010	0.010 UJ	0.0010	0.010 UJ	0.0010	0.010 UJ	0.0010	0.010 UJ	0.0010	0.010 UJ	0.0011
Benzo(ghi)perylene	0.010 UJ	0.0016	0.010 UJ	0.0016	0.010 UJ	0.0016	0.010 UJ	0.0016	0.010 UJ	0.0016	0.010 UJ	0.0017
Benzo(k)fluoranthene	0.010 U	0.0005	0.010 U	0.0005	0.010 U	0.0005	0.010 U	0.0005	0.010 U	0.0005	0.010 U	0.0005
Carbazole	0.010 U	0.0015	0.010 U	0.0015	0.010 U	0.0015	0.010 U	0.0015	0.010 U	0.0015	0.010 U	0.0015
Chrysene	0.010 U	0.0009	0.010 U	0.0009	0.010 U	0.0009	0.010 U	0.0009	0.010 U	0.0009	0.010 U	0.0009
Dibenzo(a,h)anthracene	0.010 UJ	0.0014	0.010 UJ	0.0014	0.010 UJ	0.0014	0.010 UJ	0.0014	0.010 UJ	0.0014	0.010 UJ	0.0015
Dibenzofuran	0.010 U	0.0079	0.010 U	0.0081	0.010 U	0.0079	0.010 U	0.0079	0.010 U	0.0080	0.010 U	0.0081
Fluoranthene	0.010 U	0.0015	0.010 U	0.0016	0.010 U	0.0015	0.010 U	0.0016	0.010 U	0.0016	0.010 U	0.0016
Fluorene	0.010 U	0.0074	0.010 U	0.0076	0.010 U	0.0074	0.010 U	0.0075	0.010 U	0.0075	0.010 U	0.0077
Indeno(1,2,3-cd)pyrene	0.010 U	0.0020	0.010 U	0.0020	0.010 U	0.0020	0.010 U	0.0020	0.010 U	0.0020	0.010 U	0.0020
Naphthalene	0.010 U	0.032	0.010 U	0.032	0.010 U	0.031	0.010 U	0.032	0.010 U	0.032	0.010 U	0.033
Phenanthrene	0.010 U	0.0061	0.010 U	0.0062	0.010 U	0.0061	0.010 U	0.0061	0.010 U	0.0062	0.010 U	0.0063
Pyrene	0.010 U	0.0018	0.010 U	0.0018	0.010 U	0.0018	0.010 U	0.0018	0.010 U	0.0018	0.010 U	0.0018
Retene	0.010 U	0.0010	0.010 U	0.0010	0.010 U	0.0010	0.010 U	0.0010	0.010 U	0.0010	0.010 U	0.0010
Total PAHs												
…ND at ½ RL	0.11 U		0.11 U		0.11 U		0.11 U		0.11 U		0.11 U	
…ND at MDL	0.12 U		0.12 U		0.12 U		0.12 U		0.12 U		0.12 U	
Total cPAHs												
…ND at ½ RL	0.035 U		0.035 U		0.035 U		0.035 U		0.035 U		0.035 U	
…ND at MDL	0.0083 U		0.0084 U		0.0083 U		0.0083 U		0.0084 U		0.0086 U	

Table E-10. September 2009 PAH Results for Marine Water Samples from Puget Sound Basin Sites.

Non-detect values are given at the reporting limit (RL). The method detection limit (MDL) is presented for comparison.

Parameter (µg/L)	Hood Canal				Whidbey Basin				Main Basin				South Sound			
	Surface		Deep		Surface		Deep		Surface		Deep		Surface		Deep	
	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL
1-Methylnaphthalene	0.010 U	0.0010	0.010 U	0.0010	0.0098 U	0.0010	0.0099 U	0.0010	0.0099 U	0.0010	0.0099 U	0.0010	0.010 U	0.0010	0.010 U	0.0010
2-Chloronaphthalene	0.010 U	0.0093	0.010 U	0.0093	0.0098 U	0.0092	0.0099 U	0.0092	0.0099 U	0.0092	0.0099 U	0.0092	0.010 U	0.0096	0.010 U	0.0095
2-Methylnaphthalene	0.010 U	0.0086	0.010 U	0.0086	0.0098 U	0.0085	0.0099 U	0.0085	0.0099 U	0.0085	0.0099 U	0.0086	0.010 U	0.0089	0.010 U	0.0088
Acenaphthene	0.010 U	0.0086	0.010 U	0.0086	0.0098 U	0.0084	0.0099 U	0.0085	0.0099 U	0.0085	0.0099 U	0.0085	0.010 U	0.0089	0.010 U	0.0088
Acenaphthylene	0.010 UJ	0.0085	0.010 UJ	0.0084	0.0098 UJ	0.0083	0.0099 UJ	0.0084	0.0099 UJ	0.0084	0.0099 UJ	0.0084	0.010 UJ	0.0087	0.010 UJ	0.0086
Anthracene	0.010 U	0.0051	0.010 U	0.0051	0.0098 U	0.0050	0.0099 U	0.0050	0.0099 U	0.0050	0.0099 U	0.0051	0.010 U	0.0053	0.010 U	0.0052
Benzo(a)anthracene	0.010 U	0.0009	0.010 U	0.0009	0.0098 U	0.0009	0.0099 U	0.0009	0.0099 U	0.0009	0.0099 U	0.0009	0.010 U	0.0009	0.010 U	0.0009
Benzo(a)pyrene	0.010 U	0.0016	0.010 U	0.0016	0.0098 U	0.0016	0.0099 U	0.0016	0.0099 U	0.0016	0.0099 U	0.0016	0.010 U	0.0017	0.010 U	0.0017
Benzo(b)fluoranthene	0.010 U	0.0010	0.010 U	0.0010	0.0098 U	0.0010	0.0099 U	0.0010	0.0099 U	0.0010	0.0099 U	0.0010	0.010 U	0.0011	0.010 U	0.0010
Benzo(ghi)perylene	0.010 U	0.0016	0.010 U	0.0016	0.0098 U	0.0016	0.0099 U	0.0016	0.0099 U	0.0016	0.0099 U	0.0016	0.010 U	0.0017	0.010 U	0.0016
Benzo(k)fluoranthene	0.010 U	0.0005	0.010 U	0.0005	0.0098 U	0.0005	0.0099 U	0.0005	0.0099 U	0.0005	0.0099 U	0.0005	0.010 U	0.0005	0.010 U	0.0005
Carbazole	0.010 UJ	0.0015	0.010 UJ	0.0015	0.0098 UJ	0.0015	0.0099 UJ	0.0015	0.0099 UJ	0.0015	0.0099 UJ	0.0015	0.010 UJ	0.0015	0.010 UJ	0.0015
Chrysene	0.010 U	0.0009	0.010 U	0.0009	0.0098 U	0.0008	0.0099 U	0.0008	0.0099 U	0.0008	0.0099 U	0.0008	0.010 U	0.0009	0.010 U	0.0009
Dibenzo(a,h)anthracene	0.010 U	0.0014	0.010 U	0.0014	0.0098 U	0.0014	0.0099 U	0.0014	0.0099 U	0.0014	0.0099 U	0.0014	0.010 U	0.0015	0.010 U	0.0014
Dibenzofuran	0.010 U	0.0079	0.010 U	0.0079	0.0098 U	0.0077	0.0099 U	0.0078	0.0099 U	0.0078	0.0099 U	0.0078	0.010 U	0.0081	0.010 U	0.0081
Fluoranthene	0.010 U	0.0015	0.010 U	0.0015	0.0098 U	0.0015	0.0099 U	0.0015	0.0099 U	0.0015	0.0099 U	0.0015	0.010 U	0.0016	0.010 U	0.0016
Fluorene	0.010 U	0.0074	0.010 U	0.0074	0.0098 U	0.0073	0.0099 U	0.0073	0.0099 U	0.0073	0.0099 U	0.0074	0.010 U	0.0077	0.010 U	0.0076
Indeno(1,2,3-cd)pyrene	0.010 U	0.0020	0.010 U	0.0020	0.0098 U	0.0019	0.0099 U	0.0020	0.0099 U	0.0020	0.0099 U	0.0020	0.010 U	0.0020	0.010 U	0.0020
Naphthalene	0.010 U	0.0011	0.010 U	0.0011	0.0098 U	0.0011	0.0099 U	0.0011	0.0099 U	0.0011	0.0099 U	0.0011	0.010 U	0.0012	0.010 U	0.0011
Phenanthrene	0.010 U	0.0061	0.010 U	0.0061	0.0098 U	0.0060	0.0099 U	0.0060	0.0099 U	0.0060	0.0099 U	0.0060	0.010 U	0.0063	0.010 U	0.0062
Pyrene	0.010 U	0.0018	0.010 U	0.0018	0.0098 U	0.0018	0.0099 U	0.0018	0.0099 U	0.0018	0.0099 U	0.0018	0.010 U	0.0018	0.010 U	0.0018
Retene	0.010 U	0.0010	0.010 U	0.0010	0.0098 U	0.0009	0.0099 U	0.0009	0.0099 U	0.0009	0.0099 U	0.0009	0.010 U	0.0010	0.010 U	0.0010
Total PAHs																
…ND at ½ RL	0.11 U		0.11 U		0.11 U		0.11 U		0.11 U		0.11 U		0.11 U		0.11 U	
…ND at MDL	0.079 U		0.079 U		0.078 U		0.078 U		0.078 U		0.079 U		0.082 U		0.081 U	
Total cPAHs*																
…ND at ½ RL	0.035 U		0.035 U		0.034 U		0.035 U		0.035 U		0.035 U		0.035 U		0.035 U	
…ND at MDL	0.0083 U		0.0083 U		0.0081 U		0.0082 U		0.0082 U		0.0082 U		0.0086 U		0.0084 U	

* The carcinogenic PAH compounds (cPAHs) are: benzo(a)pyrene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene.

Table E-11. September 2009 PAH Results for Marine Water Samples from Boundary Water Sites.

Non-detect values are given at the reporting limit (RL). The method detection limit (MDL) is presented for comparison.

Parameter (µg/L)	SJdF at Sill				SJdF North				Haro Strait			
	Surface		Deep		Surface		Deep		Surface		Deep	
	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL
1-Methylnaphthalene	0.0098 U	0.0010	0.010 U	0.0010	0.0099 U	0.0010	0.0099 U	0.0010	0.010 U	0.0010	0.0098 U	0.0010
2-Chloronaphthalene	0.0098 U	0.0092	0.010 U	0.0093	0.0099 U	0.0092	0.0099 U	0.0092	0.010 U	0.0096	0.0098 U	0.0092
2-Methylnaphthalene	0.0098 U	0.0085	0.010 U	0.0086	0.0099 U	0.0085	0.0099 U	0.0086	0.010 U	0.0089	0.0098 U	0.0085
Acenaphthene	0.0098 U	0.0084	0.010 U	0.0086	0.0099 U	0.0085	0.0099 U	0.0085	0.010 U	0.0089	0.0098 U	0.0084
Acenaphthylene	0.0098 U	0.0083	0.010 U	0.0084	0.0099 U	0.0084	0.0099 U	0.0084	0.010 U	0.0087	0.0098 U	0.0083
Anthracene	0.0098 U	0.0050	0.010 U	0.0051	0.0099 U	0.0050	0.0099 U	0.0051	0.010 U	0.0053	0.0098 U	0.0050
Benzo(a)anthracene	0.0098 U	0.0009	0.010 U	0.0009	0.0099 U	0.0009	0.0099 U	0.0009	0.010 U	0.0009	0.0098 U	0.0009
Benzo(a)pyrene	0.0098 U	0.0016	0.010 U	0.0016	0.0099 U	0.0016	0.0099 U	0.0016	0.010 U	0.0017	0.0098 U	0.0016
Benzo(b)fluoranthene	0.0098 U	0.0010	0.010 U	0.0010	0.0099 U	0.0010	0.0099 U	0.0010	0.010 U	0.0011	0.0098 U	0.0010
Benzo(ghi)perylene	0.0098 U	0.0016	0.010 U	0.0016	0.0099 U	0.0016	0.0099 U	0.0016	0.010 U	0.0017	0.0098 U	0.0016
Benzo(k)fluoranthene	0.0098 U	0.0005	0.010 U	0.0005	0.0099 U	0.0005	0.0099 U	0.0005	0.010 U	0.0005	0.0098 U	0.0005
Carbazole	0.0098 UJ	0.0015	0.010 UJ	0.0015	0.0099 UJ	0.0015	0.0099 UJ	0.0015	0.010 UJ	0.0015	0.0098 UJ	0.0015
Chrysene	0.0098 U	0.0008	0.010 U	0.0009	0.0099 U	0.0008	0.0099 U	0.0008	0.010 U	0.0009	0.0098 U	0.0008
Dibenzo(a,h)anthracene	0.0098 U	0.0014	0.010 U	0.0014	0.0099 U	0.0014	0.0099 U	0.0014	0.010 U	0.0015	0.0098 U	0.0014
Dibenzofuran	0.0098 U	0.0077	0.010 U	0.0079	0.0099 U	0.0078	0.0099 U	0.0078	0.010 U	0.0081	0.0098 U	0.0077
Fluoranthene	0.0098 U	0.0015	0.010 U	0.0015	0.0099 U	0.0015	0.0099 U	0.0015	0.010 U	0.0016	0.0098 U	0.0015
Fluorene	0.0098 U	0.0073	0.010 U	0.0074	0.0099 U	0.0073	0.0099 U	0.0074	0.010 U	0.0077	0.0098 U	0.0073
Indeno(1,2,3-cd)pyrene	0.0098 U	0.0019	0.010 U	0.0020	0.0099 U	0.0020	0.0099 U	0.0020	0.010 U	0.0020	0.0098 U	0.0019
Naphthalene	0.0098 U	0.0011	0.010 U	0.0011	0.0099 U	0.0011	0.0099 U	0.0011	0.010 U	0.0012	0.0098 U	0.0011
Phenanthrene	0.0098 U	0.0060	0.010 U	0.0061	0.0099 U	0.0060	0.0099 U	0.0060	0.010 U	0.0063	0.0098 U	0.0060
Pyrene	0.0098 U	0.0018	0.010 U	0.0018	0.0099 U	0.0018	0.0099 U	0.0018	0.010 U	0.0018	0.0098 U	0.0018
Retene	0.0098 U	0.0009	0.010 U	0.0010	0.0099 U	0.0009	0.0099 U	0.0009	0.010 U	0.0010	0.0098 U	0.0009
Total PAHs												
…ND at ½ RL	0.11 U		0.11 U		0.11 U		0.11 U		0.11 U		0.11 U	
…ND at MDL	0.078 U		0.079 U		0.078 U		0.079 U		0.082 U		0.078 U	
Total cPAHs												
…ND at ½ RL	0.034 U		0.035 U		0.035 U		0.035 U		0.035 U		0.034 U	
…ND at MDL	0.0081 U		0.0083 U		0.0082 U		0.0082 U		0.0086 U		0.0081 U	

Table E-12. January 2010 PAH Results for Marine Water Samples from Puget Sound Basin Sites.

Non-detect values are given at the reporting limit (RL). The method detection limit (MDL) is presented for comparison.

Parameter (µg/L)	Hood Canal				Whidbey Basin				Main Basin				South Sound			
	Surface		Deep		Surface		Deep		Surface		Deep		Surface		Deep	
	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL
1-Methylnaphthalene	0.0099 U	0.0010	0.0099 U	0.0010	0.0097 U	0.0010	0.010 U	0.0010	0.0097 U	0.0010	0.0099 U	0.0010	0.0097 U	0.0010	0.0099 U	0.0010
2-Chloronaphthalene	0.0099 U	0.0010	0.0099 U	0.0010	0.0097 U	0.0010	0.010 U	0.0010	0.0097 U	0.0010	0.0099 U	0.0010	0.0097 U	0.0009	0.0099 U	0.0010
2-Methylnaphthalene	0.0099 U	0.0013	0.0099 U	0.0013	0.0097 U	0.0013	0.010 U	0.0013	0.0097 U	0.0013	0.0099 U	0.0013	0.0097 U	0.0013	0.0099 U	0.0013
Acenaphthene	0.0099 U	0.0010	0.0099 U	0.0010	0.0097 U	0.0010	0.010 U	0.0011	0.0097 U	0.0010	0.0099 U	0.0010	0.0097 U	0.0010	0.0099 U	0.0010
Acenaphthylene	0.0099 U	0.0018	0.0099 U	0.0018	0.0097 UJ	0.0018	0.010 UJ	0.0019	0.0097 UJ	0.0018	0.0099 UJ	0.0018	0.0097 UJ	0.0018	0.0099 UJ	0.0018
Anthracene	0.0099 U	0.0023	0.0099 U	0.0023	0.0097 U	0.0022	0.010 U	0.0023	0.0097 U	0.0022	0.0099 U	0.0022	0.0097 U	0.0022	0.0099 U	0.0022
Benzo(a)anthracene	0.0099 U	0.0010	0.0099 U	0.0010	0.0097 U	0.0010	0.010 U	0.0010	0.0097 U	0.0010	0.0099 U	0.0010	0.0097 U	0.0010	0.0099 U	0.0010
Benzo(a)pyrene	0.020 U	0.0018	0.020 U	0.0018	0.019 U	0.0018	0.020 U	0.0019	0.019 U	0.0018	0.020 U	0.0018	0.019 U	0.0018	0.020 U	0.0018
Benzo(b)fluoranthene	0.0099 U	0.0011	0.0099 U	0.0011	0.0097 U	0.0011	0.010 U	0.0011	0.0097 U	0.0011	0.0099 U	0.0011	0.0097 U	0.0011	0.0099 U	0.0011
Benzo(ghi)perylene	0.0099 U	0.0017	0.0099 U	0.0017	0.0097 UJ	0.0017	0.010 UJ	0.0017	0.0097 UJ	0.0017	0.0099 UJ	0.0017	0.0097 UJ	0.0017	0.0099 UJ	0.0017
Benzo(k)fluoranthene	0.0099 U	0.0006	0.0099 U	0.0006	0.0097 U	0.0006	0.010 U	0.0006	0.0097 U	0.0006	0.0099 U	0.0006	0.0097 U	0.0006	0.0099 U	0.0006
Carbazole	0.0099 U	0.0013	0.0099 U	0.0013	0.0097 U	0.0012	0.010 U	0.0013	0.0097 U	0.0012	0.0099 U	0.0012	0.0097 U	0.0012	0.0099 U	0.0012
Chrysene	0.0099 U	0.0009	0.0099 U	0.0009	0.0097 U	0.0009	0.010 U	0.0009	0.0097 U	0.0009	0.0099 U	0.0009	0.0097 U	0.0009	0.0099 U	0.0009
Dibenzo(a,h)anthracene	0.0099 U	0.0015	0.0099 U	0.0015	0.0097 UJ	0.0015	0.010 UJ	0.0015	0.0097 UJ	0.0015	0.0099 UJ	0.0015	0.0097 UJ	0.0015	0.0099 UJ	0.0015
Dibenzofuran	0.0099 U	0.0009	0.0099 U	0.0009	0.0097 U	0.0009	0.010 U	0.0009	0.0097 U	0.0009	0.0099 U	0.0009	0.0097 U	0.0009	0.0099 U	0.0009
Fluoranthene	0.0099 U	0.0010	0.0099 U	0.0010	0.0097 U	0.0010	0.010 U	0.0010	0.0097 U	0.0010	0.0099 U	0.0010	0.0097 U	0.0010	0.0099 U	0.0010
Fluorene	0.0099 U	0.0007	0.0099 U	0.0007	0.0097 U	0.0007	0.010 U	0.0007	0.0097 U	0.0007	0.0099 U	0.0007	0.0097 U	0.0007	0.0099 UJ	0.0007
Indeno(1,2,3-cd)pyrene	0.0099 U	0.0020	0.0099 U	0.0020	0.0097 U	0.0020	0.010 U	0.0021	0.0097 U	0.0020	0.0099 U	0.0020	0.0097 U	0.0020	0.0099 U	0.0020
Naphthalene	0.0099 U	0.0011	0.0099 U	0.0011	0.0097 U	0.0011	0.010 U	0.0011	0.0097 U	0.0011	0.0099 U	0.0011	0.0097 U	0.0011	0.0099 U	0.0011
Phenanthrene	0.0099 U	0.0024	0.0099 U	0.0024	0.0097 U	0.0023	0.010 U	0.0025	0.0097 U	0.0023	0.0099 U	0.0024	0.0097 U	0.0023	0.0099 U	0.0024
Pyrene	0.0099 U	0.0020	0.0099 U	0.0020	0.0097 U	0.0019	0.010 U	0.0020	0.0097 U	0.0019	0.0099 U	0.0020	0.0097 U	0.0019	0.0099 U	0.0020
Retene	0.0099 U	0.0011	0.0099 U	0.0011	0.0097 U	0.0011	0.010 U	0.0011	0.0097 U	0.0011	0.0099 U	0.0011	0.0097 U	0.0010	0.0099 U	0.0011

Total PAHs																
…ND at ½ RL	0.11 U		0.11 U		0.11 U		0.12 U		0.11 U		0.11 U		0.11 U		0.11 U	
…ND at MDL	0.030 U		0.030 U		0.029 U		0.030 U		0.029 U		0.029 U		0.029 U		0.029 U	

Total cPAHs*																
…ND at ½ RL	0.040 U		0.040 U		0.039 U		0.040 U		0.039 U		0.040 U		0.039 U		0.040 U	
…ND at MDL	0.0089 U		0.0089 U		0.0089 U		0.0091 U		0.0089 U		0.0089 U		0.0089 U		0.0089 U	

* The carcinogenic PAH compounds (cPAHs) are: benzo(a)pyrene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene.

Table E-13. January 2010 PAH Results for Marine Water Samples from Boundary Water Sites.

Non-detect values are given at the reporting limit (RL). The method detection limit (MDL) is presented for comparison.

Parameter (µg/L)	SJdF at Sill				SJdF North				Haro Strait			
	Surface		Deep		Surface		Deep		Surface		Deep	
	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL
1-Methylnaphthalene	0.0098 UJ	0.0010	0.011 U	0.0011	0.0099 U	0.0010	0.010 UJ	0.0010	0.0098 U	0.0010	0.0098 U	0.0010
2-Chloronaphthalene	0.0098 U	0.0010	0.011 U	0.0010	0.0099 U	0.0010	0.010 U	0.0010	0.0098 U	0.0010	0.0098 U	0.0010
2-Methylnaphthalene	0.0098 UJ	0.0013	0.011 U	0.0014	0.0099 U	0.0013	0.010 UJ	0.0013	0.0098 U	0.0013	0.0098 U	0.0013
Acenaphthene	0.0098 U	0.0010	0.011 U	0.0011	0.0099 U	0.0010	0.010 U	0.0011	0.0098 U	0.0010	0.0098 U	0.0010
Acenaphthylene	0.0098 U	0.0018	0.011 U	0.0019	0.0099 U	0.0018	0.010 U	0.0019	0.0098 U	0.0018	0.0098 U	0.0018
Anthracene	0.0098 U	0.0022	0.011 U	0.0024	0.0099 U	0.0023	0.010 U	0.0023	0.0098 U	0.0022	0.0098 U	0.0022
Benzo(a)anthracene	0.0098 U	0.0010	0.011 U	0.0011	0.0099 U	0.0010	0.010 U	0.0010	0.0098 U	0.0010	0.0098 U	0.0010
Benzo(a)pyrene	0.020 U	0.0018	0.021 U	0.0020	0.020 U	0.0018	0.021 U	0.0019	0.020 U	0.0018	0.020 U	0.0018
Benzo(b)fluoranthene	0.0098 U	0.0011	0.011 U	0.0012	0.0099 U	0.0011	0.010 U	0.0012	0.0098 U	0.0011	0.0098 U	0.0011
Benzo(ghi)perylene	0.0098 U	0.0017	0.011 U	0.0018	0.0099 U	0.0017	0.010 U	0.0018	0.0098 U	0.0017	0.0098 U	0.0017
Benzo(k)fluoranthene	0.0098 U	0.0006	0.011 U	0.0006	0.0099 U	0.0006	0.010 U	0.0006	0.0098 U	0.0006	0.0098 U	0.0006
Carbazole	0.0098 U	0.0012	0.011 U	0.0013	0.0099 U	0.0013	0.010 U	0.0013	0.0098 U	0.0012	0.0098 U	0.0012
Chrysene	0.0098 U	0.0009	0.011 U	0.0010	0.0099 U	0.0009	0.010 U	0.0009	0.0098 U	0.0009	0.0098 U	0.0009
Dibenzo(a,h)anthracene	0.0098 UJ	0.0015	0.011 UJ	0.0016	0.0099 UJ	0.0015	0.010 UJ	0.0016	0.0098 UJ	0.0015	0.0098 UJ	0.0015
Dibenzofuran	0.0098 U	0.0009	0.011 U	0.0010	0.0099 U	0.0009	0.010 U	0.0009	0.0098 U	0.0009	0.0098 U	0.0009
Fluoranthene	0.0098 U	0.0010	0.011 U	0.0011	0.0099 U	0.0010	0.010 U	0.0010	0.0098 U	0.0010	0.0098 U	0.0010
Fluorene	0.0098 U	0.0007	0.011 U	0.0007	0.0099 U	0.0007	0.010 U	0.0007	0.0098 U	0.0007	0.0098 U	0.0007
Indeno(1,2,3-cd)pyrene	0.0098 U	0.0020	0.011 U	0.0021	0.0099 U	0.0020	0.010 U	0.0021	0.0098 U	0.0020	0.0098 U	0.0020
Naphthalene	0.0098 UJ	0.0011	0.011 U	0.0012	0.0099 U	0.0011	0.010 UJ	0.0012	0.0098 U	0.0011	0.0098 U	0.0011
Phenanthrene	0.0098 U	0.0024	0.011 U	0.0025	0.0099 U	0.0024	0.010 U	0.0025	0.0098 U	0.0024	0.0098 U	0.0024
Pyrene	0.0098 U	0.0020	0.011 U	0.0021	0.0099 U	0.0020	0.010 U	0.0021	0.0098 U	0.0020	0.0098 U	0.0020
Retene	0.0098 U	0.0011	0.011 U	0.0011	0.0099 U	0.0011	0.010 U	0.0011	0.0098 U	0.0011	0.0098 U	0.0011
Total PAHs												
…ND at ½ RL	0.11 U		0.13 U		0.11 U		0.12 U		0.11 U		0.11 U	
…ND at MDL	0.029 U		0.031 U		0.030 U		0.031 U		0.029 U		0.029 U	
Total cPAHs												
…ND at ½ RL	0.039 U		0.044 U		0.040 U		0.041 U		0.039 U		0.039 U	
…ND at MDL	0.0089 U		0.0096 U		0.0089 U		0.0093 U		0.0089 U		0.0089 U	

Table E-14. July 2009 BNA Results for Marine Water Samples from Puget Sound Basin Sites.

Non-detect values are given at the reporting limit (RL). The method detection limit (MDL) is presented for comparison.

Parameter (µg/L)	Hood Canal				Whidbey Basin				Main Basin				South Sound			
	Surface		Deep		Surface		Deep		Surface		Deep		Surface		Deep	
	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL
1,2,4-Trichlorobenzene	0.083 U	-	0.088 U	-	0.089 U	-	0.091 U	-	0.086 U	-	0.086 U	-	0.090 U	-	0.085 U	-
1,2-Dichlorobenzene	0.083 U	-	0.088 U	-	0.089 U	-	0.091 U	-	0.086 U	-	0.086 U	-	0.090 U	-	0.085 U	-
1,2-Diphenylhydrazine	0.083 U	-	0.088 UJ	-	0.089 UJ	-	0.091 UJ	-	0.086 UJ	-	0.086 UJ	-	0.090 UJ	-	0.085 UJ	-
1,3-Dichlorobenzene	0.083 UJ	-	0.088 UJ	-	0.089 UJ	-	0.091 UJ	-	0.086 UJ	-	0.086 UJ	-	0.090 UJ	-	0.085 UJ	-
1,4-Dichlorobenzene	0.083 U	-	0.088 U	-	0.089 U	-	0.091 U	-	0.086 U	-	0.086 U	-	0.090 U	-	0.085 U	-
2,2'-Oxybis[1-chloropropane]	0.08 U	-	0.09 U	-	0.09 U	-	0.09 U	-	0.09 U	-	0.09 U	-	0.09 U	-	0.08 U	-
2,4,5-Trichlorophenol	0.33 U	-	0.35 U	-	0.36 U	-	0.36 U	-	0.34 U	-	0.34 U	-	0.36 U	-	0.34 U	-
2,4,6-Trichlorophenol	0.33 UJ	-	0.35 UJ	-	0.36 UJ	-	0.36 UJ	-	0.34 UJ	-	0.34 UJ	-	0.36 UJ	-	0.34 UJ	-
2,4-Dichlorophenol	0.062 J	-	0.16 J	-	0.043 J	-	0.91 U	-	0.86 U	-	0.86 U	-	0.90 U	-	0.85 U	-
2,4-Dimethylphenol	0.83 U	-	0.88 U	-	0.89 U	-	0.91 U	-	0.86 U	-	0.86 U	-	0.90 U	-	0.85 U	-
2,4-Dinitrophenol	0.83 U	-	0.88 U	-	0.89 U	-	0.91 U	-	0.86 U	-	0.86 U	-	0.90 U	-	0.85 U	-
2,4-Dinitrotoluene	0.33 UJ	-	0.35 UJ	-	0.36 UJ	-	0.36 UJ	-	0.34 UJ	-	0.34 U	-	0.36 U	-	0.34 U	-
2,6-Dinitrotoluene	0.33 U	-	0.35 U	-	0.36 U	-	0.36 U	-	0.34 U	-	0.34 U	-	0.36 U	-	0.34 U	-
2-Chlorophenol	0.33 U	-	0.35 U	-	0.36 U	-	0.36 U	-	0.34 U	-	0.34 U	-	0.36 U	-	0.34 U	-
2-Methylphenol	0.011 J	-	0.037 J	-	0.010 J	-	0.91 U	-	0.86 U	-	0.86 U	-	0.90 U	-	0.85 U	-
2-Nitroaniline	1.7 U	-	1.8 U	-	1.8 U	-	1.8 U	-	1.7 U	-	1.7 U	-	1.8 U	-	1.7 U	-
2-Nitrophenol	0.17 UJ	-	0.18 UJ	-	0.18 UJ	-	0.18 UJ	-	0.17 UJ	-	0.17 UJ	-	0.18 UJ	-	0.17 UJ	-
3,3'-Dichlorobenzidine	0.17 UJ	-	0.18 UJ	-	0.18 UJ	-	0.18 UJ	-	0.17 UJ	-	0.17 U	-	0.18 U	-	0.17 U	-
3B-Coprostanol	1.2 J	-	0.88 UJ	-	0.89 UJ	-	0.91 UJ	-	0.86 UJ	-	0.86 U	-	0.90 U	-	0.85 U	-
3-Nitroaniline	0.33 U	-	0.35 U	-	0.36 U	-	0.36 U	-	0.34 U	-	0.34 U	-	0.36 U	-	0.34 U	-
4,6-Dinitro-2-Methylphenol	0.33 U	-	0.35 U	-	0.36 U	-	0.36 U	-	0.34 U	-	0.34 U	-	0.36 U	-	0.34 U	-
4-Bromophenyl phenyl ether	0.17 U	-	0.18 U	-	0.18 U	-	0.18 U	-	0.17 U	-	0.17 U	-	0.18 U	-	0.17 U	-
4-Chloro-3-Methylphenol	0.060 J	-	0.33 J	-	0.024 J	-	0.91 UJ	-	0.86 UJ	-	0.86 UJ	-	0.90 UJ	-	0.026 J	-
4-Chloroaniline	3.3 REJ	-	3.5 REJ	-	3.6 REJ	-	3.6 REJ	-	3.4 REJ	-	3.4 REJ	-	3.6 REJ	-	3.4 REJ	-
4-Chlorophenyl-Phenylether	0.083 U	-	0.088 U	-	0.089 U	-	0.091 U	-	0.086 U	-	0.086 U	-	0.090 U	-	0.085 U	-
4-Methylphenol	0.83 U	-	0.88 U	-	0.89 U	-	0.91 U	-	0.86 U	-	0.86 U	-	0.90 U	-	0.85 U	-
4-Nitroaniline	0.33 UJ	-	0.35 UJ	-	0.36 UJ	-	0.36 UJ	-	0.34 UJ	-	0.34 UJ	-	0.36 UJ	-	0.34 UJ	-
4-Nitrophenol	0.83 UJ	-	0.88 UJ	-	0.89 UJ	-	0.91 UJ	-	0.86 UJ	-	0.86 UJ	-	0.90 UJ	-	0.85 UJ	-
4-nonylphenol	0.33 U	0.033	0.35 U	0.035	0.36 U	0.036	0.36 U	0.036	0.34 U	0.034	0.34 U	0.034	0.36 U	0.036	0.34 U	0.034
Benzoic Acid	0.83 UJ	-	0.88 UJ	-	0.89 UJ	-	0.91 UJ	-	0.86 UJ	-	0.86 UJ	-	0.90 UJ	-	0.85 UJ	-
Benzyl Alcohol	0.83 UJ	-	0.88 UJ	-	0.89 UJ	-	0.91 UJ	-	0.86 UJ	-	0.86 UJ	-	0.90 UJ	-	0.85 UJ	-
Bis(2-chloro-1-methylethyl) ether	0.083 U	-	0.088 U	-	0.089 U	-	0.091 U	-	0.086 U	-	0.086 U	-	0.090 U	-	0.085 U	-
Bis(2-Chloroethoxy)Methane	0.083 U	-	0.088 U	-	0.089 U	-	0.091 U	-	0.086 U	-	0.086 U	-	0.090 U	-	0.085 U	-
Bis(2-Chloroethyl)Ether	0.17 U	-	0.18 U	-	0.18 U	-	0.18 U	-	0.17 U	-	0.17 U	-	0.18 U	-	0.17 U	-
Bis(2-Ethylhexyl) Phthalate	0.048 J	-	0.012 J	-	0.18 U	-	0.18 U	-	0.17 U	-	0.17 U	-	0.18 U	-	0.17 U	-
Bisphenol A	0.33 UJ	0.033	0.19 J	0.035	0.36 U	0.036	0.36 U	0.036	0.34 U	0.034	0.34 U	0.034	0.36 U	0.036	0.34 U	0.034
Butyl benzyl phthalate	0.069 UJ	0.033	0.35 UJ	0.035	0.36 U	0.036	0.36 U	0.036	0.34 U	0.034	0.34 U	0.034	0.36 U	0.036	0.34 U	0.034
Caffeine	0.17 U	-	0.18 U	-	0.18 U	-	0.18 U	-	0.17 U	-	0.17 U	-	0.029 J	-	0.17 U	-
Cholesterol	0.62 J	-	0.88 UJ	-	0.75 J	-	0.91 UJ	-	0.86 UJ	-	0.86 U	-	0.76 J	-	0.64 J	-

Table E-14, continued. July 2009 BNA Results for Marine Water Samples from Puget Sound Basin Sites.

Non-detect values are given at the reporting limit (RL). The method detection limit (MDL) is presented for comparison.

Parameter (µg/L)	Hood Canal				Whidbey Basin				Main Basin				South Sound			
	Surface		Deep		Surface		Deep		Surface		Deep		Surface		Deep	
	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL
Diethyl phthalate	0.17 U	0.033	0.18 U	0.035	0.18 U	0.036	0.18 U	0.036	0.17 U	0.034	0.17 U	0.034	0.18 U	0.036	0.17 U	0.034
Dimethyl phthalate	0.17 U	0.033	0.18 U	0.035	0.18 U	0.036	0.18 U	0.036	0.17 U	0.034	0.17 U	0.034	0.18 U	0.036	0.17 U	0.034
Di-N-Butylphthalate	0.29 UJ	-	0.34 UJ	-	0.23 UJ	-	0.20 UJ	-	0.12 UJ	-	0.14 UJ	-	0.15 UJ	-	0.17 UJ	-
Di-N-Octyl Phthalate	0.17 UJ	-	0.18 UJ	-	0.18 U	-	0.18 U	-	0.17 U	-	0.17 U	-	0.18 U	-	0.17 U	-
Ethanol, 2-Chloro-, Phosphate (3:1)	0.083 U	-	0.088 U	-	0.089 U	-	0.091 U	-	0.086 U	-	0.086 U	-	0.099	-	0.085 U	-
Hexachlorobenzene	0.083 U	-	0.088 U	-	0.089 U	-	0.091 U	-	0.086 U	-	0.086 U	-	0.090 U	-	0.085 U	-
Hexachlorobutadiene	0.083 UJ	-	0.088 UJ	-	0.089 UJ	-	0.091 UJ	-	0.086 UJ	-	0.086 UJ	-	0.090 UJ	-	0.085 UJ	-
Hexachlorocyclopentadiene	0.33 UJ	-	0.35 UJ	-	0.36 UJ	-	0.36 UJ	-	0.34 UJ	-	0.34 UJ	-	0.36 UJ	-	0.34 UJ	-
Hexachloroethane	0.083 UJ	-	0.088 UJ	-	0.089 UJ	-	0.091 UJ	-	0.086 UJ	-	0.086 UJ	-	0.090 UJ	-	0.085 UJ	-
Isophorone	0.17 U	-	0.18 U	-	0.18 U	-	0.18 U	-	0.17 U	-	0.17 U	-	0.18 U	-	0.17 U	-
Nitrobenzene	0.083 U	-	0.088 U	-	0.089 U	-	0.091 U	-	0.086 U	-	0.086 U	-	0.090 U	-	0.085 U	-
N-Nitrosodi-n-propylamine	0.10 U	-	0.11 U	-	0.11 U	-	0.11 U	-	0.10 U	-	0.10 U	-	0.11 U	-	0.10 U	-
N-Nitrosodiphenylamine	0.17 U	-	0.18 U	-	0.18 U	-	0.18 U	-	0.17 U	-	0.17 UJ	-	0.18 UJ	-	0.17 UJ	-
Pentachlorophenol	0.083 UJ	-	0.088 UJ	-	0.089 UJ	-	0.091 UJ	-	0.086 UJ	-	0.086 UJ	-	0.090 UJ	-	0.085 UJ	-
Phenol	0.33 U	-	0.017 J	-	0.36 U	-	0.36 U	-	0.34 U	-	0.34 U	-	0.36 U	-	0.34 U	-
Triclosan	0.083 UJ	-	0.088 UJ	-	0.089 UJ	-	0.091 UJ	-	0.086 UJ	-	0.086 U	-	0.090 U	-	0.085 U	-
Triethyl citrate	0.33 U	0.033	0.35 U	0.035	0.36 U	0.036	0.36 U	0.036	0.34 U	0.034	0.34 U	0.034	0.36 U	0.036	0.34 U	0.034

Table E-15. July 2009 BNA Results for Marine Water Samples from Boundary Water Sites.

Non-detect values are given at the reporting limit (RL). The method detection limit (MDL) is presented for comparison.

Parameter (µg/L)	SJdF at Sill				SJdF North				Haro Strait			
	Surface		Deep		Surface		Deep		Surface		Deep	
	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL
1,2,4-Trichlorobenzene	0.085 U	-	0.079 U	-	0.090 U	-	0.088 U	-	0.082 U	-	0.079 U	-
1,2-Dichlorobenzene	0.085 U	-	0.079 U	-	0.090 U	-	0.088 U	-	0.082 U	-	0.079 U	-
1,2-Diphenylhydrazine	0.085 UJ	-	0.079 UJ	-	0.090 UJ	-	0.088 UJ	-	0.082 UJ	-	0.079 UJ	-
1,3-Dichlorobenzene	0.085 UJ	-	0.079 UJ	-	0.090 UJ	-	0.088 UJ	-	0.082 UJ	-	0.079 UJ	-
1,4-Dichlorobenzene	0.085 U	-	0.079 U	-	0.090 U	-	0.088 U	-	0.082 U	-	0.079 U	-
2,2'-Oxybis[1-chloropropane]	0.08 U	-	0.08 U	-	0.09 U	-	0.09 U	-	0.08 U	-	0.08 U	-
2,4,5-Trichlorophenol	0.34 U	-	0.32 U	-	0.36 U	-	0.35 U	-	0.33 U	-	0.31 U	-
2,4,6-Trichlorophenol	0.34 UJ	-	0.32 UJ	-	0.36 UJ	-	0.35 UJ	-	0.33 UJ	-	0.31 UJ	-
2,4-Dichlorophenol	0.85 U	-	0.79 U	-	0.90 U	-	0.88 U	-	0.82 U	-	0.063 J	-
2,4-Dimethylphenol	0.85 U	-	0.79 U	-	0.90 U	-	0.88 U	-	0.82 U	-	0.79 U	-
2,4-Dinitrophenol	0.85 U	-	0.79 U	-	0.90 U	-	0.88 U	-	0.82 U	-	0.79 U	-
2,4-Dinitrotoluene	0.34 UJ	-	0.32 UJ	-	0.36 UJ	-	0.35 UJ	-	0.33 UJ	-	0.31 UJ	-
2,6-Dinitrotoluene	0.34 U	-	0.32 U	-	0.36 U	-	0.35 U	-	0.33 U	-	0.31 U	-
2-Chlorophenol	0.34 U	-	0.32 U	-	0.36 U	-	0.35 U	-	0.33 U	-	0.31 U	-
2-Methylphenol	0.85 U	-	0.79 U	-	0.90 U	-	0.88 U	-	0.82 U	-	0.013 J	-
2-Nitroaniline	1.7 U	-	1.6 U	-	1.8 U	-	1.8 U	-	1.6 U	-	1.6 U	-
2-Nitrophenol	0.17 UJ	-	0.16 UJ	-	0.18 UJ	-	0.18 UJ	-	0.16 UJ	-	0.16 UJ	-
3,3'-Dichlorobenzidine	0.17 UJ	-	0.16 UJ	-	0.18 UJ	-	0.18 UJ	-	0.16 UJ	-	0.16 UJ	-
3B-Coprostanol	0.85 UJ	-	0.79 UJ	-	0.90 UJ	-	0.88 UJ	-	0.82 UJ	-	0.79 UJ	-
3-Nitroaniline	0.34 U	-	0.32 U	-	0.36 U	-	0.35 U	-	0.33 U	-	0.31 U	-
4,6-Dinitro-2-Methylphenol	0.34 U	-	0.32 U	-	0.36 U	-	0.35 U	-	0.33 U	-	0.31 U	-
4-Bromophenyl phenyl ether	0.17 U	-	0.16 U	-	0.18 U	-	0.18 U	-	0.16 U	-	0.16 U	-
4-Chloro-3-Methylphenol	0.85 UJ	-	0.025 J	-	0.90 U	-	0.016 J	-	0.82 UJ	-	0.094 J	-
4-Chloroaniline	3.4 REJ	-	3.2 REJ	-	3.6 REJ	-	3.5 REJ	-	3.3 REJ	-	3.1 REJ	-
4-Chlorophenyl-Phenylether	0.085 U	-	0.079 U	-	0.090 U	-	0.088 U	-	0.082 U	-	0.079 U	-
4-Methylphenol	0.85 U	-	0.79 U	-	0.90 U	-	0.88 U	-	0.82 U	-	0.79 U	-
4-Nitroaniline	0.34 UJ	-	0.32 UJ	-	0.36 UJ	-	0.35 UJ	-	0.33 UJ	-	0.31 UJ	-
4-Nitrophenol	0.85 UJ	-	0.79 UJ	-	0.90 UJ	-	0.88 UJ	-	0.82 UJ	-	0.79 UJ	-
4-nonylphenol	0.34 U	0.034	0.32 U	0.032	0.36 U	0.036	0.35 U	0.035	0.33 U	0.033	0.31 U	0.031
Benzoic Acid	0.85 UJ	-	0.79 UJ	-	0.90 UJ	-	0.88 UJ	-	0.82 UJ	-	0.79 UJ	-
Benzyl Alcohol	0.85 UJ	-	0.79 UJ	-	0.90 UJ	-	0.88 UJ	-	0.82 UJ	-	0.79 UJ	-
Bis(2-chloro-1-methylethyl) ether	0.085 U	-	0.079 U	-	0.090 U	-	0.088 U	-	0.082 U	-	0.079 U	-
Bis(2-Chloroethoxy)Methane	0.085 U	-	0.079 U	-	0.090 U	-	0.088 U	-	0.082 U	-	0.079 U	-
Bis(2-Chloroethyl)Ether	0.17 U	-	0.16 U	-	0.18 U	-	0.18 U	-	0.16 U	-	0.16 U	-
Bis(2-Ethylhexyl) Phthalate	0.17 U	-	0.16 UJ	-	0.18 UJ	-	0.18 UJ	-	0.16 U	-	0.059 J	-
Bisphenol A	0.34 U	0.034	0.32 UJ	0.032	0.36 UJ	0.036	0.35 UJ	0.035	0.33 U	0.033	0.31 UJ	0.031
Butyl benzyl phthalate	0.34 U	0.034	0.32 UJ	0.032	0.36 UJ	0.036	0.35 UJ	0.035	0.33 U	0.033	0.31 UJ	0.031
Caffeine	0.17 U	-	0.16 U	-	0.18 U	-	0.18 U	-	0.16 U	-	0.16 U	-
Cholesterol	0.85 UJ	-	0.79 UJ	-	0.90 UJ	-	0.88 UJ	-	0.82 UJ	-	0.79 UJ	-
Diethyl phthalate	0.17 U	0.034	0.16 U	0.032	0.18 U	0.036	0.18 U	0.035	0.16 U	0.033	0.16 U	0.031
Dimethyl phthalate	0.17 U	0.034	0.16 U	0.032	0.18 U	0.036	0.18 U	0.035	0.16 U	0.033	0.16 U	0.031
Di-N-Butylphthalate	0.19 UJ	-	0.23 UJ	-	0.21 UJ	-	0.16 UJ	-	0.13 UJ	-	0.17 UJ	-
Di-N-Octyl Phthalate	0.17 U	-	0.16 UJ	-	0.18 UJ	-	0.18 UJ	-	0.16 U	-	0.16 UJ	-
Ethanol, 2-Chloro-, Phosphate (3:1)	0.085 U	-	0.079 U	-	0.090 U	-	0.088 U	-	0.082 U	-	0.079 U	-
Hexachlorobenzene	0.085 U	-	0.079 U	-	0.090 U	-	0.088 U	-	0.082 U	-	0.079 U	-
Hexachlorobutadiene	0.085 UJ	-	0.079 UJ	-	0.090 UJ	-	0.088 UJ	-	0.082 UJ	-	0.079 UJ	-
Hexachlorocyclopentadiene	0.34 UJ	-	0.32 UJ	-	0.36 UJ	-	0.35 UJ	-	0.33 UJ	-	0.31 UJ	-
Hexachloroethane	0.085 UJ	-	0.079 UJ	-	0.090 UJ	-	0.088 UJ	-	0.082 UJ	-	0.079 UJ	-
Isophorone	0.17 U	-	0.16 U	-	0.18 U	-	0.18 U	-	0.16 U	-	0.16 U	-
Nitrobenzene	0.085 U	-	0.079 U	-	0.090 U	-	0.088 U	-	0.082 U	-	0.079 U	-
N-Nitrosodi-n-propylamine	0.10 U	-	0.095 U	-	0.11 U	-	0.11 U	-	0.098 U	-	0.094 U	-
N-Nitrosodiphenylamine	0.17 U	-	0.16 U	-	0.18 U	-	0.18 U	-	0.16 U	-	0.16 U	-
Pentachlorophenol	0.085 UJ	-	0.079 UJ	-	0.090 UJ	-	0.088 UJ	-	0.082 UJ	-	0.079 UJ	-
Phenol	0.34 U	-	0.32 U	-	0.36 U	-	0.35 U	-	0.33 U	-	0.31 U	-
Triclosan	0.085 UJ	-	0.079 UJ	-	0.090 UJ	-	0.088 UJ	-	0.082 UJ	-	0.079 UJ	-
Triethyl citrate	0.34 U	0.034	0.32 U	0.032	0.36 U	0.036	0.35 U	0.035	0.33 U	0.033	0.31 U	0.031

Table E-16. September 2009 BNA Results for Marine Water Samples from Puget Sound Basin Sites.

Non-detect values are given at the reporting limit (RL). The method detection limit (MDL) is presented for comparison.

Parameter (µg/L)	Hood Canal				Whidbey Basin				Main Basin				South Sound			
	Surface		Deep		Surface		Deep		Surface		Deep		Surface		Deep	
	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL
1,2,4-Trichlorobenzene	0.082 U	-	0.080 U	-	0.081 U	-	0.080 U	-	0.081 U	-	0.079 U	-	0.077 U	-	0.079 U	-
1,2-Dichlorobenzene	0.082 U	-	0.080 U	-	0.081 U	-	0.080 U	-	0.081 U	-	0.079 U	-	0.077 U	-	0.079 U	-
1,2-Diphenylhydrazine	0.082 U	-	0.080 U	-	0.081 U	-	0.080 U	-	0.081 U	-	0.079 U	-	0.077 U	-	0.079 U	-
1,3-Dichlorobenzene	0.082 U	-	0.080 U	-	0.081 U	-	0.080 U	-	0.081 U	-	0.079 U	-	0.077 UJ	-	0.079 UJ	-
1,4-Dichlorobenzene	0.082 U	-	0.080 U	-	0.081 U	-	0.080 U	-	0.081 U	-	0.079 U	-	0.077 U	-	0.079 U	-
2,2'-Oxybis[1-chloropropane]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2,4,5-Trichlorophenol	0.33 U	-	0.32 U	-	0.33 U	-	0.32 U	-	0.32 U	-	0.32 U	-	0.31 U	-	0.32 U	-
2,4,6-Trichlorophenol	0.33 U	-	0.32 U	-	0.33 UJ	-	0.32 UJ	-	0.32 UJ	-	0.32 UJ	-	0.31 UJ	-	0.32 UJ	-
2,4-Dichlorophenol	0.82 U	-	0.80 U	-	0.81 U	-	0.80 U	-	0.81 U	-	0.79 U	-	0.77 U	-	0.79 U	-
2,4-Dimethylphenol	0.82 U	-	0.80 U	-	0.81 U	-	0.80 U	-	0.81 U	-	0.79 U	-	0.77 U	-	0.79 U	-
2,4-Dinitrophenol	0.82 U	-	0.80 U	-	0.81 U	-	0.80 U	-	0.81 U	-	0.79 U	-	0.77 U	-	0.79 U	-
2,4-Dinitrotoluene	0.33 U	-	0.32 U	-	0.33 U	-	0.32 U	-	0.32 U	-	0.32 U	-	0.31 U	-	0.32 U	-
2,6-Dinitrotoluene	0.33 U	-	0.32 U	-	0.33 U	-	0.32 U	-	0.32 U	-	0.32 U	-	0.31 U	-	0.32 U	-
2-Chlorophenol	0.33 U	-	0.32 U	-	0.33 U	-	0.32 U	-	0.32 U	-	0.32 U	-	0.31 U	-	0.32 U	-
2-Methylphenol	0.82 U	-	0.80 U	-	0.81 U	-	0.80 U	-	0.81 U	-	0.79 U	-	0.77 U	-	0.79 U	-
2-Nitroaniline	1.6 U	-	1.6 U	-	1.6 U	-	1.6 U	-	1.6 U	-	1.6 U	-	1.5 U	-	1.6 U	-
2-Nitrophenol	0.16 U	-	0.16 U	-	0.16 U	-	0.16 U	-	0.16 U	-	0.16 U	-	0.15 U	-	0.16 U	-
3,3'-Dichlorobenzidine	0.16 UJ	-	0.16 UJ	-	0.16 UJ	-	0.16 UJ	-	0.16 UJ	-	0.16 UJ	-	0.15 UJ	-	0.16 UJ	-
3B-Coprostanol	0.82 U	-	0.80 U	-	0.81 U	-	0.80 U	-	0.81 U	-	0.79 U	-	0.77 U	-	0.79 U	-
3-Nitroaniline	0.33 UJ	-	0.32 UJ	-	0.33 UJ	-	0.32 UJ	-	0.32 UJ	-	0.32 UJ	-	0.31 UJ	-	0.32 UJ	-
4,6-Dinitro-2-Methylphenol	0.33 U	-	0.32 U	-	0.33 U	-	0.32 U	-	0.32 U	-	0.32 U	-	0.31 U	-	0.32 U	-
4-Bromophenyl phenyl ether	0.16 U	-	0.16 U	-	0.16 U	-	0.16 U	-	0.16 U	-	0.16 U	-	0.15 U	-	0.16 U	-
4-Chloro-3-Methylphenol	0.82 UJ	-	0.80 UJ	-	0.81 UJ	-	0.80 UJ	-	0.81 UJ	-	0.79 UJ	-	0.77 UJ	-	0.79 UJ	-
4-Chloroaniline	3.3 REJ	-	3.2 REJ	-	3.3 REJ	-	3.2 REJ	-	3.2 REJ	-	3.2 REJ	-	3.1 REJ	-	3.2 REJ	-
4-Chlorophenyl-Phenylether	0.082 U	-	0.080 U	-	0.081 U	-	0.080 U	-	0.081 U	-	0.079 U	-	0.077 U	-	0.079 U	-
4-Methylphenol	0.82 U	-	0.80 U	-	0.81 U	-	0.80 U	-	0.81 U	-	0.79 U	-	0.77 U	-	0.79 U	-
4-Nitroaniline	0.33 U	-	0.32 U	-	0.33 U	-	0.32 U	-	0.32 U	-	0.32 U	-	0.31 U	-	0.32 U	-
4-Nitrophenol	0.82 U	-	0.80 U	-	0.81 U	-	0.80 U	-	0.81 U	-	0.79 U	-	0.77 U	-	0.79 U	-
4-nonylphenol	0.33 U	0.033	0.32 U	0.032	0.33 U	0.033	0.32 U	0.032	0.32 U	0.032	0.32 U	0.032	0.31 U	0.031	0.32 U	0.032
Benzoic Acid	0.82 U	-	0.80 U	-	0.81 UJ	-	0.80 UJ	-	0.81 UJ	-	0.79 UJ	-	0.77 UJ	-	0.79 UJ	-
Benzyl Alcohol	0.82 U	-	0.80 U	-	0.81 UJ	-	0.80 UJ	-	0.81 UJ	-	0.79 UJ	-	0.77 UJ	-	0.79 UJ	-
Bis(2-chloro-1-methylethyl) ether	0.082 U	-	0.080 U	-	0.081 U	-	0.080 U	-	0.081 U	-	0.079 U	-	0.077 U	-	0.079 U	-
Bis(2-Chloroethoxy)Methane	0.082 U	-	0.080 U	-	0.081 U	-	0.080 U	-	0.081 U	-	0.079 U	-	0.077 U	-	0.079 U	-
Bis(2-Chloroethyl)Ether	0.16 U	-	0.16 U	-	0.16 U	-	0.16 U	-	0.16 U	-	0.16 U	-	0.15 U	-	0.16 U	-
Bis(2-Ethylhexyl) Phthalate	0.16 U	-	0.16 U	-	0.16 U	-	0.16 U	-	0.16 U	-	0.16 U	-	0.15 U	-	0.19 UJ	-
Bisphenol A	0.33 U	0.033	0.32 U	0.032	0.33 U	0.033	0.32 U	0.032	0.32 U	0.032	0.32 U	0.032	0.31 U	0.031	0.32 U	0.032
Butyl benzyl phthalate	0.33 U	0.033	0.32 U	0.032	0.33 U	0.033	0.32 U	0.032	0.32 U	0.032	0.32 U	0.032	0.31 U	0.031	0.32 U	0.032
Caffeine	0.16 U	-	0.16 U	-	0.16 U	-	0.16 U	-	0.16 U	-	0.16 U	-	0.15 U	-	0.16 U	-
Cholesterol	0.77 J	-	0.70 J	-	1.1	-	0.73 J	-	0.73 J	-	0.71 J	-	0.73 J	-	0.73 J	-

Table E-16, continued. September 2009 BNA Results for Marine Water Samples from Puget Sound Basin Sites.

Non-detect values are given at the reporting limit (RL). The method detection limit (MDL) is presented for comparison.

Parameter (µg/L)	Hood Canal				Whidbey Basin				Main Basin				South Sound			
	Surface		Deep		Surface		Deep		Surface		Deep		Surface		Deep	
	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL
Diethyl phthalate	0.16 U	0.033	0.16 U	0.032	0.16 U	0.033	0.16 U	0.032	0.16 U	0.032	0.16 U	0.032	0.15 U	0.031	0.16 U	0.032
Dimethyl phthalate	0.16 U	0.033	0.16 U	0.032	0.16 U	0.033	0.16 U	0.032	0.16 U	0.032	0.16 U	0.032	0.15 U	0.031	0.16 U	0.032
Di-N-Butylphthalate	0.27 UJ	-	0.23 UJ	-	0.081 U	-	0.080 U	-	0.081 U	-	0.079 U	-	0.077 U	-	0.079 U	-
Di-N-Octyl Phthalate	0.16 UJ	-	0.16 UJ	-	0.16 UJ	-	0.16 UJ	-	0.16 UJ	-	0.16 UJ	-	0.15 UJ	-	0.16 UJ	-
Ethanol, 2-Chloro-, Phosphate (3:1)	0.082 UJ	-	0.080 UJ	-	0.081 UJ	-	0.080 UJ	-	0.081 UJ	-	0.079 UJ	-	0.077 UJ	-	0.079 UJ	-
Hexachlorobenzene	0.082 U	-	0.080 U	-	0.081 U	-	0.080 U	-	0.081 U	-	0.079 U	-	0.077 U	-	0.079 U	-
Hexachlorobutadiene	0.082 U	-	0.080 U	-	0.081 U	-	0.080 U	-	0.081 U	-	0.079 U	-	0.077 UJ	-	0.079 UJ	-
Hexachlorocyclopentadiene	0.33 UJ	-	0.32 UJ	-	0.33 UJ	-	0.32 UJ	-	0.32 UJ	-	0.32 UJ	-	0.31 UJ	-	0.32 UJ	-
Hexachloroethane	0.082 U	-	0.080 U	-	0.081 U	-	0.080 U	-	0.081 U	-	0.079 U	-	0.077 UJ	-	0.079 UJ	-
Isophorone	0.16 U	-	0.16 U	-	0.16 U	-	0.16 U	-	0.16 U	-	0.16 U	-	0.15 U	-	0.16 U	-
Nitrobenzene	0.082 U	-	0.080 U	-	0.081 U	-	0.080 U	-	0.081 U	-	0.079 U	-	0.077 U	-	0.079 U	-
N-Nitrosodi-n-propylamine	0.098 U	-	0.096 U	-	0.098 U	-	0.096 U	-	0.097 U	-	0.095 U	-	0.092 U	-	0.095 U	-
N-Nitrosodiphenylamine	0.16 UJ	-	0.16 UJ	-	0.16 UJ	-	0.16 UJ	-	0.16 UJ	-	0.16 UJ	-	0.15 UJ	-	0.16 UJ	-
Pentachlorophenol	0.082 U	-	0.080 U	-	0.081 U	-	0.080 U	-	0.081 U	-	0.079 U	-	0.077 U	-	0.079 U	-
Phenol	0.33 U	-	0.32 U	-	0.33 U	-	0.32 U	-	0.32 U	-	0.32 U	-	0.31 U	-	0.32 U	-
Triclosan	0.082 U	-	0.080 U	-	0.081 U	-	0.080 U	-	0.081 U	-	0.079 U	-	0.077 U	-	0.079 U	-
Triethyl citrate	0.33 UJ	0.033	0.32 UJ	0.032	0.33 UJ	0.033	0.32 UJ	0.032	0.32 UJ	0.032	0.32 UJ	0.032	0.31 UJ	0.031	0.32 UJ	0.032

Table E-17. September 2009 BNA Results for Marine Water Samples from Boundary Water Sites.

Non-detect values are given at the reporting limit (RL). The method detection limit (MDL) is presented for comparison.

Parameter (µg/L)	SJdF at Sill				SJdF North				Haro Strait			
	Surface		Deep		Surface		Deep		Surface		Deep	
	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL
1,2,4-Trichlorobenzene	0.080 U	-	0.081 U	-	0.082 U	-	0.081 U	-	0.081 U	-	0.081 U	-
1,2-Dichlorobenzene	0.080 U	-	0.081 U	-	0.082 U	-	0.081 U	-	0.081 U	-	0.081 U	-
1,2-Diphenylhydrazine	0.080 U	-	0.081 U	-	0.082 U	-	0.081 U	-	0.081 U	-	0.081 U	-
1,3-Dichlorobenzene	0.080 U	-	0.081 U	-	0.082 U	-	0.081 U	-	0.081 U	-	0.081 U	-
1,4-Dichlorobenzene	0.080 U	-	0.081 U	-	0.082 U	-	0.081 U	-	0.081 U	-	0.081 U	-
2,2'-Oxybis[1-chloropropane]	-	-	-	-	-	-	-	-	-	-	-	-
2,4,5-Trichlorophenol	0.32 U	-	0.32 U	-	0.33 U	-	0.32 U	-	0.32 U	-	0.32 U	-
2,4,6-Trichlorophenol	0.32 UJ	-	0.32 UJ	-	0.33 UJ	-	0.32 UJ	-	0.32 UJ	-	0.32 UJ	-
2,4-Dichlorophenol	0.80 U	-	0.81 U	-	0.82 U	-	0.81 U	-	0.81 U	-	0.81 U	-
2,4-Dimethylphenol	0.80 U	-	0.81 U	-	0.82 U	-	0.81 U	-	0.81 U	-	0.81 U	-
2,4-Dinitrophenol	0.80 U	-	0.81 U	-	0.82 U	-	0.81 U	-	0.81 U	-	0.81 U	-
2,4-Dinitrotoluene	0.32 U	-	0.32 U	-	0.33 U	-	0.32 U	-	0.32 U	-	0.32 U	-
2,6-Dinitrotoluene	0.32 U	-	0.32 U	-	0.33 U	-	0.32 U	-	0.32 U	-	0.32 U	-
2-Chlorophenol	0.32 U	-	0.32 U	-	0.33 U	-	0.32 U	-	0.32 U	-	0.32 U	-
2-Methylphenol	0.80 U	-	0.81 U	-	0.82 U	-	0.81 U	-	0.81 U	-	0.81 U	-
2-Nitroaniline	1.6 U	-	1.6 U	-	1.6 U	-	1.6 U	-	1.6 U	-	1.6 U	-
2-Nitrophenol	0.16 U	-	0.16 U	-	0.16 U	-	0.16 U	-	0.16 U	-	0.16 U	-
3,3'-Dichlorobenzidine	0.16 UJ	-	0.16 UJ	-	0.16 UJ	-	0.16 UJ	-	0.16 UJ	-	0.16 UJ	-
3B-Coprostanol	0.80 U	-	0.81 U	-	0.82 U	-	0.81 U	-	0.81 U	-	0.81 U	-
3-Nitroaniline	0.32 UJ	-	0.32 UJ	-	0.33 UJ	-	0.32 UJ	-	0.32 UJ	-	0.32 UJ	-
4,6-Dinitro-2-Methylphenol	0.32 U	-	0.32 U	-	0.33 U	-	0.32 U	-	0.32 U	-	0.32 U	-
4-Bromophenyl phenyl ether	0.16 U	-	0.16 U	-	0.16 U	-	0.16 U	-	0.16 U	-	0.16 U	-
4-Chloro-3-Methylphenol	0.80 UJ	-	0.81 UJ	-	0.82 UJ	-	0.81 UJ	-	0.81 UJ	-	0.81 UJ	-
4-Chloroaniline	3.2 REJ	-	3.2 REJ	-	3.3 REJ	-	3.2 REJ	-	3.2 REJ	-	3.2 REJ	-
4-Chlorophenyl-Phenylether	0.080 U	-	0.081 U	-	0.082 U	-	0.081 U	-	0.081 U	-	0.081 U	-
4-Methylphenol	0.80 U	-	0.81 U	-	0.82 U	-	0.81 U	-	0.81 U	-	0.81 U	-
4-Nitroaniline	0.32 U	-	0.32 U	-	0.33 U	-	0.32 U	-	0.32 U	-	0.32 U	-
4-Nitrophenol	0.80 U	-	0.81 U	-	0.82 U	-	0.81 U	-	0.81 U	-	0.81 U	-
4-nonylphenol	0.32 U	0.032	0.32 U	0.032	0.33 U	0.033	0.32 U	0.032	0.32 U	0.032	0.32 U	0.032
Benzoic Acid	0.80 UJ	-	0.81 UJ	-	0.82 UJ	-	0.81 UJ	-	0.81 UJ	-	0.81 UJ	-
Benzyl Alcohol	0.80 UJ	-	0.81 UJ	-	0.82 UJ	-	0.81 UJ	-	0.81 UJ	-	0.81 UJ	-
Bis(2-chloro-1-methylethyl) ether	0.080 U	-	0.081 U	-	0.082 U	-	0.081 U	-	0.081 U	-	0.081 U	-
Bis(2-Chloroethoxy)Methane	0.080 U	-	0.081 U	-	0.082 U	-	0.081 U	-	0.081 U	-	0.081 U	-
Bis(2-Chloroethyl)Ether	0.16 U	-	0.16 U	-	0.16 U	-	0.16 U	-	0.16 U	-	0.16 U	-
Bis(2-Ethylhexyl) Phthalate	0.16 U	-	0.16 U	-	0.16 U	-	0.16 U	-	0.16 U	-	0.16 U	-
Bisphenol A	0.32 U	0.032	0.32 U	0.032	0.33 U	0.033	0.32 U	0.032	0.32 U	0.032	0.32 U	0.032
Butyl benzyl phthalate	0.32 U	0.032	0.32 U	0.032	0.33 U	0.033	0.32 U	0.032	0.32 U	0.032	0.32 U	0.032
Caffeine	0.16 U	-	0.16 U	-	0.16 U	-	0.16 U	-	0.16 U	-	0.16 U	-
Cholesterol	0.73 J	-	0.71 J	-	0.73 J	-	0.72 J	-	0.81 U	-	0.74 J	-
Diethyl phthalate	0.16 U	0.032	0.16 U	0.032	0.16 U	0.033	0.16 U	0.032	0.16 U	0.032	0.16 U	0.032
Dimethyl phthalate	0.16 U	0.032	0.16 U	0.032	0.16 U	0.033	0.16 U	0.032	0.16 U	0.032	0.16 U	0.032
Di-N-Butylphthalate	0.080 U	-	0.081 U	-	0.082 U	-	0.30 UJ	-	0.081 U	-	0.081 U	-
Di-N-Octyl Phthalate	0.16 UJ	-	0.16 UJ	-	0.16 UJ	-	0.16 UJ	-	0.16 UJ	-	0.16 UJ	-
Ethanol, 2-Chloro-, Phosphate (3:1)	0.080 UJ	-	0.081 UJ	-	0.082 UJ	-	0.081 UJ	-	0.081 UJ	-	0.081 UJ	-
Hexachlorobenzene	0.080 U	-	0.081 U	-	0.082 U	-	0.081 U	-	0.081 U	-	0.081 U	-
Hexachlorobutadiene	0.080 UJ	-	0.081 UJ	-	0.082 UJ	-	0.081 UJ	-	0.081 UJ	-	0.081 UJ	-
Hexachlorocyclopentadiene	0.32 UJ	-	0.32 UJ	-	0.33 UJ	-	0.32 UJ	-	0.32 UJ	-	0.32 UJ	-
Hexachloroethane	0.080 UJ	-	0.081 UJ	-	0.082 UJ	-	0.081 UJ	-	0.081 UJ	-	0.081 UJ	-
Isophorone	0.16 U	-	0.16 U	-	0.16 U	-	0.16 U	-	0.16 U	-	0.16 U	-
Nitrobenzene	0.080 U	-	0.081 U	-	0.082 U	-	0.081 U	-	0.081 U	-	0.081 U	-
N-Nitrosodi-n-propylamine	0.096 U	-	0.097 U	-	0.098 U	-	0.097 U	-	0.097 U	-	0.097 U	-
N-Nitrosodiphenylamine	0.16 UJ	-	0.16 UJ	-	0.16 UJ	-	0.16 UJ	-	0.16 UJ	-	0.16 UJ	-
Pentachlorophenol	0.080 U	-	0.081 U	-	0.082 U	-	0.081 U	-	0.081 U	-	0.081 U	-
Phenol	0.32 U	-	0.32 U	-	0.33 U	-	0.32 U	-	0.32 U	-	0.32 U	-
Triclosan	0.048 J	-	0.048 J	-	0.051 J	-	0.050 J	-	0.047 J	-	0.051 J	-
Triethyl citrate	0.32 UJ	0.032	0.32 UJ	0.032	0.33 UJ	0.033	0.32 UJ	0.032	0.32 UJ	0.032	0.32 UJ	0.032

Table E-18. January 2010 BNA Results for Marine Water Samples from Puget Sound Basin Sites.

Non-detect values are given at the reporting limit (RL). The method detection limit (MDL) is presented for comparison.

Parameter (µg/L)	Hood Canal				Whidbey Basin				Main Basin				South Sound			
	Surface		Deep		Surface		Deep		Surface		Deep		Surface		Deep	
	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL
1,2,4-Trichlorobenzene	0.079 U	0.020	0.082 U	0.020	0.079 U	0.020	0.079 U	0.019	0.079 U	0.020	0.079 U	0.019	0.080 U	0.020	0.081 U	0.020
1,2-Dichlorobenzene	0.079 U	0.019	0.082 U	0.019	0.079 U	0.019	0.079 U	0.019	0.079 U	0.019	0.079 U	0.019	0.080 U	0.019	0.081 U	0.019
1,2-Diphenylhydrazine	0.079 U	0.051	0.082 U	0.052	0.079 U	0.051	0.079 U	0.050	0.079 U	0.050	0.079 U	0.050	0.080 U	0.051	0.081 U	0.051
1,3-Dichlorobenzene	0.079 UJ	0.016	0.082 UJ	0.017	0.079 U	0.016	0.079 U	0.016	0.079 UJ	0.016	0.079 UJ	0.016	0.080 UJ	0.016	0.081 UJ	0.016
1,4-Dichlorobenzene	0.079 U	0.017	0.082 U	0.018	0.079 U	0.017	0.079 U	0.017	0.079 U	0.017	0.079 U	0.017	0.080 U	0.017	0.081 U	0.018
2,2'-Oxybis[1-chloropropane]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2,4,5-Trichlorophenol	0.32 U	0.063	0.33 U	0.065	0.32 U	0.063	0.31 U	0.062	0.32 U	0.063	0.31 U	0.062	0.32 U	0.063	0.32 U	0.064
2,4,6-Trichlorophenol	0.32 U	0.048	0.33 U	0.050	0.32 U	0.048	0.31 U	0.048	0.32 U	0.048	0.31 U	0.048	0.32 U	0.048	0.32 U	0.049
2,4-Dichlorophenol	0.79 U	0.042	0.82 U	0.043	0.79 U	0.042	0.79 U	0.041	0.79 U	0.041	0.79 U	0.041	0.80 U	0.042	0.81 U	0.042
2,4-Dimethylphenol	0.79 U	0.047	0.82 U	0.048	0.79 U	0.047	0.79 U	0.046	0.79 U	0.047	0.79 U	0.046	0.80 U	0.047	0.81 U	0.048
2,4-Dinitrophenol	0.79 U	-	0.82 U	-	0.79 U	-	0.79 U	-	0.79 U	-	0.79 U	-	0.80 U	-	0.81 U	-
2,4-Dinitrotoluene	0.32 U	0.045	0.33 U	0.046	0.32 U	0.045	0.31 U	0.044	0.32 U	0.045	0.31 U	0.044	0.32 U	0.045	0.32 U	0.046
2,6-Dinitrotoluene	0.32 U	0.054	0.33 U	0.056	0.32 U	0.054	0.31 U	0.054	0.32 U	0.054	0.31 U	0.054	0.32 U	0.054	0.32 U	0.055
2-Chlorophenol	0.32 U	0.041	0.33 U	0.043	0.32 U	0.041	0.31 U	0.041	0.32 U	0.041	0.31 U	0.041	0.32 U	0.042	0.32 U	0.042
2-Methylphenol	0.79 U	0.040	0.82 U	0.041	0.79 U	0.040	0.79 U	0.040	0.79 U	0.040	0.79 U	0.040	0.80 U	0.040	0.81 U	0.041
2-Nitroaniline	1.6 UJ	0.053	1.6 UJ	0.055	1.6 UJ	0.053	1.6 UJ	0.053	1.6 UJ	0.053	1.6 UJ	0.053	1.6 UJ	0.053	1.6 UJ	0.054
2-Nitrophenol	0.16 UJ	0.036	0.16 UJ	0.037	0.16 UJ	0.036	0.16 UJ	0.035	0.16 UJ	0.036	0.16 UJ	0.035	0.16 UJ	0.036	0.16 UJ	0.036
3,3'-Dichlorobenzidine	0.16 UJ	-	0.16 UJ	-	0.16 UJ	-	0.16 UJ	-	0.16 UJ	-	0.16 UJ	-	0.16 UJ	-	0.16 UJ	-
3B-Coprostanol	0.79 UJ	-	0.82 UJ	-	0.79 UJ	-	0.79 UJ	-	0.79 UJ	-	0.79 UJ	-	0.80 UJ	-	0.81 UJ	-
3-Nitroaniline	0.32 REJ	0.046	0.33 REJ	0.047	0.32 REJ	0.046	0.31 REJ	0.045	0.32 REJ	0.045	0.31 REJ	0.045	0.32 REJ	0.046	0.32 REJ	0.046
4,6-Dinitro-2-Methylphenol	1.6 U	0.53	1.6 U	0.55	1.6 U	0.53	1.6 U	0.53	1.6 U	0.53	1.6 U	0.53	1.6 U	0.53	1.6 U	0.54
4-Bromophenyl phenyl ether	0.16 U	0.071	0.16 U	0.074	0.16 U	0.071	0.16 U	0.071	0.16 U	0.071	0.16 U	0.071	0.16 U	0.072	0.16 U	0.072
4-Chloro-3-Methylphenol	0.79 UJ	0.063	0.82 UJ	0.065	0.79 UJ	0.063	0.79 UJ	0.062	0.79 UJ	0.063	0.79 UJ	0.062	0.80 UJ	0.063	0.81 UJ	0.064
4-Chloroaniline	3.2 REJ	0.13	3.3 REJ	0.13	3.2 REJ	0.13	3.1 REJ	0.13	3.2 REJ	0.13	3.1 REJ	0.13	3.2 REJ	0.13	3.2 REJ	0.13
4-Chlorophenyl-Phenylether	0.079 U	0.071	0.082 U	0.073	0.079 U	0.071	0.079 U	0.070	0.079 U	0.071	0.079 U	0.070	0.080 U	0.071	0.081 U	0.072
4-Methylphenol	0.79 U	0.039	0.82 U	0.041	0.79 U	0.039	0.79 U	0.039	0.79 U	0.039	0.79 U	0.039	0.80 U	0.040	0.81 U	0.040
4-Nitroaniline	0.32 UJ	-	0.33 UJ	-	0.32 UJ	-	0.31 UJ	-	0.32 UJ	-	0.31 UJ	-	0.32 UJ	-	0.32 UJ	-
4-Nitrophenol	0.79 U	-	0.82 U	-	0.79 U	-	0.79 U	-	0.79 U	-	0.79 U	-	0.80 U	-	0.81 U	-
4-nonylphenol	0.32 U	0.032	0.33 U	0.033	0.32 U	0.032	0.31 U	0.031	0.32 U	0.032	0.31 U	0.031	0.32 U	0.032	0.32 U	0.032
Benzoic Acid	0.79 UJ	-	0.82 UJ	-	0.79 UJ	-	0.79 UJ	-	0.79 UJ	-	0.79 UJ	-	0.80 UJ	-	0.81 UJ	-
Benzyl Alcohol	0.79 UJ	0.028	0.82 UJ	0.029	0.79 UJ	0.028	0.79 UJ	0.028	0.79 UJ	0.028	0.79 UJ	0.028	0.80 UJ	0.028	0.81 UJ	0.028
Bis(2-chloro-1-methylethyl) ether	0.079 U	0.053	0.082 U	0.055	0.079 U	0.053	0.079 U	0.053	0.079 U	0.053	0.079 U	0.053	0.080 U	0.053	0.081 U	0.054
Bis(2-Chloroethoxy)Methane	0.079 U	0.066	0.082 U	0.068	0.079 U	0.066	0.079 U	0.065	0.079 U	0.066	0.079 U	0.065	0.080 U	0.066	0.081 U	0.067
Bis(2-Chloroethyl)Ether	0.16 U	0.046	0.16 U	0.047	0.16 U	0.046	0.16 U	0.045	0.16 U	0.045	0.16 U	0.045	0.16 U	0.046	0.16 U	0.046
Bis(2-Ethylhexyl) Phthalate	0.16 U	0.048	0.16 U	0.049	0.16 U	0.048	0.16 U	0.047	0.16 U	0.048	0.16 U	0.047	0.16 U	0.048	0.16 U	0.048
Bisphenol A	0.32 U	0.032	0.33 U	0.033	0.32 U	0.032	0.31 U	0.031	0.32 U	0.032	0.31 U	0.031	0.32 U	0.032	0.32 U	0.032
Butyl benzyl phthalate	0.32 UJ	0.037	0.33 UJ	0.038	0.32 UJ	0.037	0.31 UJ	0.037	0.32 UJ	0.037	0.31 UJ	0.037	0.32 UJ	0.037	0.32 UJ	0.038
Caffeine	0.16 U	0.062	0.16 U	0.064	0.16 U	0.062	0.16 U	0.061	0.16 U	0.061	0.16 U	0.061	0.16 U	0.062	0.16 U	0.063
Cholesterol	0.79 UJ	0.075	0.82 UJ	0.078	0.79 UJ	0.075	0.79 UJ	0.075	0.79 UJ	0.075	0.79 UJ	0.075	0.80 UJ	0.076	0.81 UJ	0.077

Table E-18, continued. January 2010 BNA Results for Marine Water Samples from Puget Sound Basin Sites.

Non-detect values are given at the reporting limit (RL). The method detection limit (MDL) is presented for comparison.

Parameter (µg/L)	Hood Canal				Whidbey Basin				Main Basin				South Sound			
	Surface		Deep		Surface		Deep		Surface		Deep		Surface		Deep	
	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL
Diethyl phthalate	0.16 U	0.078	0.16 U	0.081	0.16 U	0.078	0.16 U	0.078	0.16 U	0.078	0.16 U	0.078	0.16 U	0.079	0.16 U	0.080
Dimethyl phthalate	0.16 U	0.069	0.16 U	0.071	0.16 U	0.069	0.16 U	0.068	0.16 U	0.068	0.16 U	0.068	0.16 U	0.069	0.16 U	0.070
Di-N-Butylphthalate	0.11 UJ	0.058	0.19 UJ	0.060	0.13 UJ	0.058	0.15 UJ	0.058	0.23 UJ	0.058	0.21 UJ	0.058	0.17 UJ	0.058	0.25 UJ	0.059
Di-N-Octyl Phthalate	0.16 U	0.071	0.16 U	0.073	0.16 U	0.071	0.16 U	0.070	0.16 U	0.070	0.16 U	0.070	0.16 U	0.071	0.16 U	0.072
Ethanol, 2-Chloro-, Phosphate (3:1)	0.079 U	0.032	0.082 U	0.033	0.079 U	0.032	0.079 U	0.031	0.079 U	0.032	0.079 U	0.031	0.080 U	0.032	0.081 U	0.032
Hexachlorobenzene	0.079 U	0.039	0.082 U	0.040	0.079 U	0.039	0.079 U	0.039	0.079 U	0.039	0.079 U	0.039	0.080 U	0.039	0.081 U	0.040
Hexachlorobutadiene	0.079 UJ	0.012	0.082 UJ	0.012	0.079 U	0.012	0.079 U	0.012	0.079 UJ	0.012	0.079 UJ	0.012	0.080 UJ	0.012	0.081 UJ	0.012
Hexachlorocyclopentadiene	0.32 UJ	0.010	0.33 UJ	0.010	0.32 UJ	0.010	0.31 UJ	0.0099	0.32 UJ	0.0099	0.31 UJ	0.0099	0.32 UJ	0.010	0.32 UJ	0.010
Hexachloroethane	0.079 UJ	-	0.082 UJ	-	0.079 U	-	0.079 U	-	0.079 UJ	-	0.079 UJ	-	0.080 UJ	-	0.081 UJ	-
Isophorone	0.16 U	0.073	0.16 U	0.076	0.16 U	0.073	0.16 U	0.073	0.16 U	0.073	0.16 U	0.073	0.16 U	0.074	0.16 U	0.075
Nitrobenzene	0.079 U	0.066	0.082 U	0.068	0.079 U	0.066	0.079 U	0.065	0.079 U	0.065	0.079 U	0.065	0.080 U	0.066	0.081 U	0.067
N-Nitrosodi-n-propylamine	0.095 U	0.070	0.098 U	0.073	0.095 U	0.070	0.094 U	0.070	0.095 U	0.070	0.094 U	0.070	0.096 U	0.071	0.097 U	0.071
N-Nitrosodiphenylamine	0.16 U	0.033	0.16 U	0.034	0.16 U	0.033	0.16 U	0.033	0.16 U	0.033	0.16 U	0.033	0.16 U	0.033	0.16 U	0.034
Pentachlorophenol	0.079 UJ	-	0.082 UJ	-	0.079 UJ	-	0.079 UJ	-	0.079 UJ	-	0.079 UJ	-	0.080 UJ	-	0.081 UJ	-
Phenol	0.32 U	0.025	0.33 U	0.026	0.32 U	0.025	0.31 U	0.025	0.32 U	0.025	0.31 U	0.025	0.32 U	0.025	0.32 U	0.026
Triclosan	0.079 U	0.032	0.082 U	0.033	0.079 U	0.032	0.079 U	0.031	0.079 U	0.032	0.079 U	0.031	0.080 U	0.032	0.081 U	0.032
Triethyl citrate	0.32 U	0.032	0.33 U	0.033	0.32 U	0.032	0.31 U	0.031	0.32 U	0.032	0.31 U	0.031	0.32 U	0.032	0.32 U	0.032

Table E-19. January 2010 BNA Results for Marine Water Samples from Boundary Water Sites.

Non-detect values are given at the reporting limit (RL). The method detection limit (MDL) is presented for comparison.

Parameter (µg/L)	SJdF at Sill				SJdF North				Haro Strait			
	Surface		Deep		Surface		Deep		Surface		Deep	
	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL
1,2,4-Trichlorobenzene	0.082 U	0.020	0.087 U	0.021	0.083 U	0.020	0.084 U	0.021	0.081 U	0.020	0.082 U	0.020
1,2-Dichlorobenzene	0.082 U	0.019	0.087 U	0.021	0.083 U	0.020	0.084 U	0.020	0.081 U	0.019	0.082 U	0.019
1,2-Diphenylhydrazine	0.082 U	0.052	0.087 U	0.055	0.083 U	0.053	0.084 U	0.053	0.081 U	0.052	0.082 U	0.052
1,3-Dichlorobenzene	0.082 U	0.017	0.087 U	0.018	0.083 U	0.017	0.084 U	0.017	0.081 U	0.017	0.082 U	0.017
1,4-Dichlorobenzene	0.082 U	0.018	0.087 U	0.019	0.083 U	0.018	0.084 U	0.018	0.081 U	0.018	0.082 U	0.018
2,2'-Oxybis[1-chloropropane]	-	-	-	-	-	-	-	-	-	-	-	-
2,4,5-Trichlorophenol	0.33 U	0.065	0.35 U	0.069	0.33 U	0.066	0.33 U	0.066	0.32 U	0.064	0.33 U	0.065
2,4,6-Trichlorophenol	0.33 U	0.050	0.35 U	0.053	0.33 U	0.050	0.33 U	0.051	0.32 U	0.049	0.33 U	0.050
2,4-Dichlorophenol	0.82 U	0.043	0.87 U	0.045	0.83 U	0.043	0.84 U	0.044	0.81 U	0.042	0.82 U	0.043
2,4-Dimethylphenol	0.82 U	0.048	0.87 U	0.051	0.83 U	0.049	0.84 U	0.049	0.81 U	0.048	0.82 U	0.049
2,4-Dinitrophenol	0.82 U	-	0.87 U	-	0.83 U	-	0.84 U	-	0.81 U	-	0.82 U	-
2,4-Dinitrotoluene	0.33 U	0.046	0.35 U	0.049	0.33 U	0.047	0.33 U	0.047	0.32 U	0.046	0.33 U	0.046
2,6-Dinitrotoluene	0.33 U	0.056	0.35 U	0.059	0.33 U	0.057	0.33 U	0.057	0.32 U	0.055	0.33 U	0.056
2-Chlorophenol	0.33 U	0.043	0.35 U	0.045	0.33 U	0.043	0.33 U	0.044	0.32 U	0.042	0.33 U	0.043
2-Methylphenol	0.82 U	0.041	0.87 U	0.044	0.83 U	0.042	0.84 U	0.042	0.81 U	0.041	0.82 U	0.042
2-Nitroaniline	1.6 UJ	0.055	1.7 UJ	0.058	1.7 UJ	0.055	1.7 UJ	0.056	1.6 UJ	0.054	1.6 UJ	0.055
2-Nitrophenol	0.16 UJ	0.037	0.17 UJ	0.039	0.17 UJ	0.037	0.17 UJ	0.038	0.16 UJ	0.036	0.16 UJ	0.037
3,3'-Dichlorobenzidine	0.16 UJ	-	0.17 UJ	-	0.17 UJ	-	0.17 UJ	-	0.16 UJ	-	0.16 UJ	-
3B-Coprostanol	0.82 UJ	-	0.87 UJ	-	0.83 UJ	-	0.84 UJ	-	0.81 UJ	-	0.82 UJ	-
3-Nitroaniline	0.33 REJ	0.047	0.35 REJ	0.050	0.33 REJ	0.048	0.33 REJ	0.048	0.32 REJ	0.047	0.33 REJ	0.047
4,6-Dinitro-2-Methylphenol	1.6 U	0.55	1.7 U	0.58	1.7 U	0.55	1.7 U	0.56	1.6 U	0.54	1.6 U	0.55
4-Bromophenyl phenyl ether	0.16 U	0.074	0.17 U	0.078	0.17 U	0.075	0.17 U	0.075	0.16 U	0.073	0.16 U	0.074
4-Chloro-3-Methylphenol	0.82 UJ	0.065	0.87 UJ	0.069	0.83 UJ	0.066	0.84 UJ	0.066	0.81 UJ	0.064	0.82 UJ	0.065
4-Chloroaniline	3.3 REJ	0.13	3.5 REJ	0.14	3.3 REJ	0.13	3.3 REJ	0.13	3.2 REJ	0.13	3.3 REJ	0.13
4-Chlorophenyl-Phenylether	0.082 U	0.073	0.087 U	0.078	0.083 U	0.074	0.084 U	0.075	0.081 U	0.073	0.082 U	0.073
4-Methylphenol	0.82 U	0.041	0.87 U	0.043	0.83 U	0.041	0.84 U	0.041	0.81 U	0.040	0.82 U	0.041
4-Nitroaniline	0.33 UJ	-	0.35 UJ	-	0.33 UJ	-	0.33 UJ	-	0.32 UJ	-	0.33 UJ	-
4-Nitrophenol	0.82 U	-	0.87 U	-	0.83 U	-	0.84 U	-	0.81 U	-	0.82 U	-
4-nonylphenol	0.33 U	0.033	0.35 U	0.035	0.33 U	0.033	0.33 U	0.033	0.32 U	0.032	0.33 U	0.033
Benzoic Acid	0.82 UJ	-	0.87 UJ	-	0.83 UJ	-	0.84 UJ	-	0.81 UJ	-	0.82 UJ	-
Benzyl Alcohol	0.82 UJ	0.029	0.87 UJ	0.031	0.83 UJ	0.029	0.84 UJ	0.029	0.81 UJ	0.029	0.82 UJ	0.029
Bis(2-chloro-1-methylethyl) ether	0.082 U	0.055	0.087 U	0.058	0.083 U	0.055	0.084 U	0.056	0.081 U	0.054	0.082 U	0.055
Bis(2-Chloroethoxy)Methane	0.082 U	0.068	0.087 U	0.072	0.083 U	0.069	0.084 U	0.069	0.081 U	0.067	0.082 U	0.068
Bis(2-Chloroethyl)Ether	0.16 U	0.047	0.17 U	0.050	0.17 U	0.048	0.17 U	0.048	0.16 U	0.047	0.16 U	0.047
Bis(2-Ethylhexyl) Phthalate	0.16 U	0.049	0.17 U	0.052	0.17 U	0.050	0.17 U	0.050	0.16 U	0.049	0.16 U	0.049
Bisphenol A	0.33 U	0.033	0.35 U	0.035	0.33 U	0.033	0.33 U	0.033	0.32 U	0.032	0.33 U	0.033
Butyl benzyl phthalate	0.33 UJ	0.038	0.35 UJ	0.041	0.33 UJ	0.039	0.33 UJ	0.039	0.32 UJ	0.038	0.33 UJ	0.038
Caffeine	0.16 U	0.064	0.17 U	0.067	0.17 U	0.064	0.17 U	0.065	0.16 U	0.063	0.16 U	0.064
Cholesterol	0.82 UJ	0.078	0.87 UJ	0.083	0.83 UJ	0.079	0.84 UJ	0.079	0.81 UJ	0.077	0.82 UJ	0.078
Diethyl phthalate	0.16 U	0.081	0.17 U	0.086	0.17 U	0.082	0.17 U	0.082	0.16 U	0.080	0.16 U	0.081
Dimethyl phthalate	0.16 U	0.071	0.17 U	0.075	0.17 U	0.072	0.17 U	0.072	0.16 U	0.070	0.16 U	0.071
Di-N-Butylphthalate	0.29 UJ	0.060	0.26 UJ	0.064	0.21 UJ	0.061	0.24 UJ	0.061	0.30 UJ	0.059	0.28 UJ	0.060
Di-N-Octyl Phthalate	0.16 U	0.073	0.17 U	0.077	0.17 U	0.074	0.17 U	0.074	0.16 U	0.072	0.16 U	0.073
Ethanol, 2-Chloro-, Phosphate (3:1)	0.082 U	0.033	0.087 U	0.035	0.083 U	0.033	0.084 U	0.033	0.081 U	0.032	0.082 U	0.033
Hexachlorobenzene	0.082 U	0.040	0.087 U	0.043	0.083 U	0.041	0.084 U	0.041	0.081 U	0.040	0.082 U	0.041
Hexachlorobutadiene	0.082 U	0.012	0.087 U	0.013	0.083 U	0.013	0.084 U	0.013	0.081 U	0.012	0.082 U	0.012
Hexachlorocyclopentadiene	0.33 UJ	0.010	0.35 UJ	0.011	0.33 UJ	0.010	0.33 UJ	0.011	0.32 UJ	0.010	0.33 UJ	0.010
Hexachloroethane	0.082 UJ	-	0.087 UJ	-	0.083 UJ	-	0.084 UJ	-	0.081 UJ	-	0.082 UJ	-
Isophorone	0.16 U	0.076	0.17 U	0.080	0.17 U	0.077	0.17 U	0.077	0.16 U	0.075	0.16 U	0.076
Nitrobenzene	0.082 U	0.068	0.087 U	0.072	0.083 U	0.069	0.084 U	0.069	0.081 U	0.067	0.082 U	0.068
N-Nitrosodi-n-propylamine	0.098 U	0.073	0.10 U	0.077	0.10 U	0.074	0.10 U	0.074	0.097 U	0.072	0.099 U	0.073
N-Nitrosodiphenylamine	0.16 U	0.034	0.17 U	0.036	0.17 U	0.035	0.17 U	0.035	0.16 U	0.034	0.16 U	0.034
Pentachlorophenol	0.082 U	-	0.087 U	-	0.083 U	-	0.084 U	-	0.081 U	-	0.082 U	-
Phenol	0.33 U	0.026	0.35 U	0.028	0.33 U	0.026	0.33 U	0.027	0.32 U	0.026	0.33 U	0.026
Triclosan	0.082 U	0.033	0.087 U	0.035	0.083 U	0.033	0.084 U	0.033	0.081 U	0.032	0.082 U	0.033
Triethyl citrate	0.33 U	0.033	0.35 U	0.035	0.33 U	0.033	0.33 U	0.033	0.32 U	0.032	0.33 U	0.033

Table E-20. July 2009 Detected PCB Congeners for Marine Water Samples.

PCB Congener (pg/L)	Homolog	Hood Canal		SJdF at Sill		SJdF North		Haro Strait		Whidbey Basin		Main Basin		South Sound	
		Surface	Deep	Surface	Deep	Surface	Deep	Surface	Deep	Surface	Deep	Surface	Deep	Surface	Deep
PCB-001	mono-									3.07 NJ	1.3 NJ				
PCB-002	mono-										1.4 NJ				
PCB-003	mono-									3.19 NJ	1.82 NJ				
PCB-004	di-		3 J								2.27 J	1.72 J			2.9 J
PCB-008	di-		3.22 J					1.03 J			1.82 J	1.84 J	1.44 J		2.52 J
PCB-017	tri-		2.41 J								2.43 J				
PCB-018/030	tri-		2.69 NJ								2.44 J			2.12 J	
PCB-020/028	tri-		1.79 NJ											1.16 J	
PCB-031	tri-		1.78 NJ									1.96 J		1.06 J	
PCB-040/071	tetra-										0.731 J				
PCB-044/047/065	tetra-	5.82 J	10.8	6.68 J	4.99 J	6.63	4.66 J	5.02 J	7.58	6.81 N	6.5	5.94	6.29	6.09	13.6
PCB-049/069	tetra-		1.22 NJ								1.26 J	1.07 NJ	0.935 J	0.946 J	
PCB-051	tetra-	2.7 NJ	9.14 J	3.91 J	3.3 J	5.45	3.71 J	3.34 J	5.87	6.72	3.74 J	3.77 J	4.04 J	3.58 J	10.6
PCB-052	tetra-	2.6 J	4.02 J			1.23 NJ	1.15 J	0.838 J	1.17 J	2.01 J	2.51 J	2.63 J	1.95 J	2.06 J	2.52 J
PCB-061/070/074/076	tetra-		2.24 NJ			0.933 NJ	0.967 J				1.54 J			1 J	
PCB-066	tetra-										0.867 J				
PCB-068	tetra-		1.66 NJ			1.74 J	1.45 J	1.42 J	1.87 NJ	2.43 NJ	1.6 J		1.57 J	1.12 J	4.57 J
PCB-086/087/097/108/119/125	penta-		2.4 NJ								1.29 NJ	1.16 NJ			
PCB-090/101/113	penta-	2.29 NJ	4.37 J			0.91 J		1.02 J	1.04 NJ	2.03 NJ	3.01 J	2.34 J	1.59 J	2.04 J	2.48 J
PCB-095	penta-		4.55 J			0.864 NJ			1 NJ		2.35 J	1.97 NJ	1.18 NJ	2.01 J	1.55 NJ
PCB-099	penta-										0.974 NJ				0.883 NJ
PCB-105	penta-										0.932 J				
PCB-110	penta-	2.14 J	2.56 NJ			0.675 NJ	0.677 NJ	0.698 NJ	0.767 NJ		2.53 J	1.42 NJ	1.72 J	1.38 J	1.5 NJ
PCB-118	penta-	1.65 J	1.97 NJ			0.679 J		0.817 J			1.42 NJ	1.47 J	0.909 NJ	1.14 NJ	1.57 J
PCB-128/166	hexa-						0.532 J								
PCB-129/138/163	hexa-		2.13 J				1.74 J				2.98 J	1.52 J	1.51 NJ	1.04 J	
PCB-147/149	hexa-		1.53 NJ				0.539 NJ				1.94 J	1.03 NJ	1.29 NJ	0.944 J	1.49 J
PCB-153/168	hexa-		1.25 J								2.47 J	1.3 J	0.99 NJ	1.07 NJ	1.23 J
PCB-156/157	hexa-						0.715 NJ								
PCB-194	octa-								0.763 NJ						

Total PCBs														
…including N,NJ	17.2 J	64.73 J	10.59 J	8.29 J	19.111 J	16.14 J	14.183 J	20.06 J	26.26 J	52.124 J	31.14 J	25.414 J	28.76 J	47.413 J
…excluding N,NJ	12.21 J	44.89 J	10.59 J	8.29 J	15.409 J	14.209 J	13.485 J	14.62	8.73 J	43.92 J	24.49 J	19.535 J	26.55 J	43.48 J

Table E-21. September 2009 Detected PCB Congeners for Marine Water Samples.

PCB Congener (pg/L)	Homolog	Hood Canal		SJdF at Sill		SJdF North		Haro Strait		Whidbey Basin		Main Basin		South Sound	
		Surface	Deep	Surface	Deep	Surface	Deep	Surface	Deep	Surface	Deep	Surface	Deep	Surface	Deep
PCB-001	mono-	2.46 NJ	0.403 J		0.81 J	0.387 J	0.407 J		1.3 NJ	2.38 J					
PCB-002	mono-	0.336 NJ	1.21 J		0.498 J				0.958 J	7.17					
PCB-003	mono-	0.399 J	1.18 J		1.05 J	0.569 J	0.455 J		1.9 J	4.87 J					
PCB-004	di-	1.62 J	1.65 J	1.08 J	1.36 J	1.32 J	1.93 J	0.977 J	1.87 J	4.05 J	3.08 J	2.67 J	4.05 J	2.25 J	2.51 J
PCB-006	di-	0.397 J	0.386 J			0.404 J	0.411 J	0.299 J		0.826 J	5 U		1.37 J		
PCB-008	di-	1.41 J	1.16 J		1.03 J	0.857 J	1.28 J	0.78 J	1.36 J	2.43 J	1.44 J	1.19 J	1.75 J	1.34 J	1.48 J
PCB-015	di-		0.587 J												
PCB-016	tri-	0.503 J					0.475 J	0.301 NJ							
PCB-017	tri-	0.687 NJ	0.849 J	0.625 J	0.934 J	0.614 J	0.895 J	0.555 J	0.913 NJ	1.74 J	2.46 J	1.54 J	1.52 J	5 U	1.22 J
PCB-018/030	tri-	1.12 J	1.16 J	0.941 J	1.12 J	0.734 J	1.07 J	0.745 J	1.02 NJ	2.6 J	2.1 J	1.75 J	2.23 J	1.2 NJ	1.71 J
PCB-019	tri-	0.348 J					0.315 J	0.405 J		1.02 J					
PCB-020/028	tri-	1.06 J	0.993 J	0.723 J	0.676 NJ	0.656 J	0.757 J	0.506 NJ	0.709 J	1.1 J	1.14 NJ	0.995 NJ	1.16 J	5 U	0.976 J
PCB-021/033	tri-	0.595 J	0.563 J		0.579 J		0.478 NJ	0.348 J		0.963 J					
PCB-022	tri-	0.35 J													
PCB-031	tri-	0.822 J	0.868 J		0.713 NJ	0.535 J	0.685 J	0.519 NJ	0.758 J	1.37 J	1.06 NJ	0.891 J	1.11 J		
PCB-032	tri-	0.34 NJ	0.381 J				0.302 J			0.629 NJ	1.04 J	5 U			
PCB-039	tri-						0.308 J	0.199 NJ				5 U			
PCB-044/047/065	tetra-	5.48 J	6.12 J	5.93 J	12.6	5.73 J	9.7 J	4.94 J	9.55 J	14.5 J	17.1	6.76 J	13 J	6.32 J	8.25 J
PCB-049/069	tetra-	0.482 NJ	0.631 NJ		0.874 J		0.54 J	0.438 J		1.21 J	1.34 J	5 U		0.909 J	1.34 J
PCB-051	tetra-	4.01 J	4.2	3.54 J	9.76	4.1	6.71	3.33 J	8.62	11.7	12.4	4.84 J	10.4	4.44 J	6.61
PCB-052	tetra-	1.24 J	1.45 J	0.984 J	1.56 J	1.1 J	1.14 J	0.972 J	1.95 J	2.86 J	2.55 NJ	1.85 J	2.43 J	1.6 J	2.12 J
PCB-061/070/074/076	tetra-	1.05 J	1.07 J	0.656 J			0.837 J	0.728 J		1.58 NJ		1.41 NJ			
PCB-068	tetra-	0.96 J	1.43 J	1.11 J	2.79 J	1.07 J	2.16 J	0.93 J	2.29 J	2.45 J	6.26	1.78 NJ	2.77 J	1.13 NJ	2.45 J
PCB-086/087/097/108/119/125	penta-	0.903 J	1.28 J		1.14 J		0.808 J	0.723 J		2.1 J				2.4 J	
PCB-090/101/113	penta-	1.09 J	1.67 J	0.883 J		0.816 NJ	0.897 J	0.733 J	1.38 J	2.28 NJ	1.82 NJ	2.6 NJ	3.28 NJ		2.11 J
PCB-095	penta-	0.933 J	1.65 J	0.976 J		0.979 J	0.986 NJ	0.598 J	1.06 NJ	2.43 J	2.55 J	1.8 NJ	2.19 NJ	2.04 J	2.09 NJ
PCB-099	penta-						0.358 J								
PCB-105	penta-	0.371 NJ						0.413 NJ		0.935 NJ	1.31 NJ		1.06 NJ		
PCB-110	penta-	0.841 J	1.2 J	0.711 J	1.22 J	0.635 NJ	0.847 J	0.454 NJ	1.19 J	2.11 J	2.1 NJ	1.24 NJ	2.34 J	1.39 J	1.39 J
PCB-118	penta-	0.573 J	0.823 J	0.505 J	0.935 J		0.61 J	0.473 J		1.44 NJ	1.59 J	0.862 NJ	1.64 NJ	1.44 J	1.12 NJ
PCB-129/138/163	hexa-	0.609 J	1.3 J		1.14 J		0.44 J	0.473 J		1.04 NJ	1.44 J	1.75 J	2.01 J		1.9 J
PCB-147/149	hexa-	0.366 NJ	4.13 U				0.434 J	0.254 J		1.2 J	1.68 J	1.18 NJ	2.17 J	1.26 J	1.48 J
PCB-153/168	hexa-	0.383 J	0.542 NJ		0.732 NJ		0.366 J	0.302 J		1.02 J	1.29 NJ	0.865 J	1.86 J		1.26 J
PCB-169	hexa-	0.337 J													
PCB-177	hepta-												2.06 J		
PCB-187	hepta-									3.04 J	1.63 J				
PCB-194	octa-							0.287 J				1.27 J			1.53 NJ
Total PCBs															
…including N,NJ		32.075 J	34.756 J	18.664 J	41.521 J	20.506 J	36.882 J	21.682 J	36.828 J	83.043 J	68.83 J	37.243 J	60.4 J	27.719 J	41.546 J
…excluding N,NJ		27.033 J	33.583 J	18.664 J	39.4 J	19.055 J	35.418 J	19.29 J	32.535 J	75.139 J	57.56 J	25.376 J	52.23 J	25.389 J	36.806 J

Table E-22. January 2010 Detected PCB Congeners for Marine Water Samples.

PCB Congener (pg/L)	Homolog	Hood Canal		SJdF at Sill		SJdF North		Haro Strait		Whidbey Basin		Main Basin		South Sound	
		Surface	Deep	Surface	Deep	Surface	Deep	Surface	Deep	Surface	Deep	Surface	Deep	Surface	Deep
PCB-001	mono-				0.818 J								4.22		1.04 NJ
PCB-002	mono-												7.82	1.07 J	0.973 J
PCB-003	mono-				0.916 J								6.65	1.41 NJ	1.21 NJ
PCB-004	di-				1.67 J						2.15 J				
PCB-008	di-				1.28 J						0.858 J				
PCB-017	tri-				0.975 NJ						1.17 J			0.883 NJ	
PCB-018/030	tri-	1.14 J		0.939 J	0.808 NJ	1.03 NJ	1.39 J	1.11 J	0.958 NJ	1.22 NJ	1.5 J	1.68 NJ	1.26 NJ	1.42 NJ	1.22 J
PCB-020/028	tri-	0.629 NJ		0.62 J	0.67 J	0.855 J	0.908 J	0.644 J			1.05 J		1.24 J	1.24 J	
PCB-021/033	tri-			0.444 NJ	0.443 NJ										
PCB-031	tri-			0.53 NJ	0.521 NJ			0.587 NJ			0.883 NJ		1.11 J	1.11 NJ	
PCB-032	tri-										0.843 J				
PCB-040/071	tetra-										0.576 NJ				
PCB-044/047/065	tetra-	4.32 NJ	9.42 J	4.83 J	14.4	4.66 NJ	11.6 J	5.87 J	11.5 J	14.6	6.49 J	7.32 J	7.28 J	6.25 J	7.08 J
PCB-049/069	tetra-			0.714 NJ		1.04 NJ		0.569 NJ		1.36 J	1.09 J	1.58 J	1.35 J	0.982 NJ	
PCB-051	tetra-	3 NJ	6.82	3.3 J	9.99	3.61 J	8.36	3.78 J	8.01	8.69 NJ	3.9 J	4.36	4.65	2.53 NJ	4.93
PCB-052	tetra-	2.84 J	2.67 J	1.95 J	2.1 J	1.88 J	1.75 J	1.77 J	1.72 J	2.28 NJ	2.76 J	2.86 NJ	3.33 J	3.18 J	2.45 NJ
PCB-061/070/074/076	tetra-										1.35 NJ				
PCB-068	tetra-		1.27 NJ	0.696 NJ	2.89 J		2.4 J	0.983 J	2.36 J	2.71 NJ	0.923 J		0.916 NJ		0.856 J
PCB-084	penta-										0.818 J				
PCB-086/087/097/108/119/125	penta-										1.42 J				
PCB-090/101/113	penta-	2.11 J		1.42 J	1.12 J			0.944 J		2.43 J	2.81 J		1.95 NJ	2.86 J	2.57 J
PCB-095	penta-				1.44 NJ		1.4 NJ	1.3 J			2.76 NJ		1.82 NJ	1.84 NJ	2.65 J
PCB-099	penta-										0.969 J				
PCB-105	penta-				0.384 J						0.665 J				
PCB-110	penta-			1.15 J	0.935 J			0.803 NJ		1.52 NJ	2.13 J		1.29 NJ	2.07 J	1.47 NJ
PCB-118	penta-				0.649 J						1.56 NJ		1.33 J	1.37 J	
PCB-129/138/163	hexa-			0.595 NJ	0.872 J						2.68 J		1.6 NJ		2.48 J
PCB-132	hexa-										0.851 J				
PCB-135/151	hexa-										0.978 J				
PCB-147/149	hexa-	0.783 NJ						0.675 J			1.59 NJ		1.49 NJ	1.59 J	1.92 J
PCB-153/168	hexa-			0.545 NJ				0.582 J		1.11 NJ	1.83 J		1.04 NJ	1.54 NJ	1.63 J
PCB-169	hexa-				0.457 NJ										
PCB-180/193	hepta-										0.526 NJ				
PCB-187	hepta-										0.739 NJ				

Total PCBs														
…including N,NJ	14.822 J	20.18 J	17.733 J	43.338 J	13.075 J	27.808 J	19.617 J	24.548 J	35.92 J	47.869 J	17.8 J	50.346 J	31.345 J	32.479 J
…excluding N,NJ	6.09 J	18.91 J	14.209 J	38.694 J	6.345 J	26.408 J	17.658 J	23.59 J	18.39 J	37.885 J	13.26 J	38.98 J	19.63 J	26.309 J

Table E-23. PCB Homolog Totals for Marine Water Samples.

Results qualified as N or NJ were not included in homolog sums or Total PCB calculations.

Sampling Date	PCB Homolog (pg/L)	Hood Canal		SJdF at Sill		SJdF North		Haro Strait		Whidbey Basin		Main Basin		South Sound	
		Surface	Deep	Surface	Deep	Surface	Deep	Surface	Deep	Surface	Deep	Surface	Deep	Surface	Deep
July 2009	Mono-CBs	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Di-CBs	0	6.22 J	0	0	0	0	1.03 J	0	0	4.09 J	3.56 J	1.44 J	0	5.42 J
	Tri-CBs	0	2.41 J	0	0	0	0	0	0	0	4.87 J	1.96 J	0	4.34 J	0
	Tetra-CBs	8.42 J	23.96 J	10.59 J	8.29 J	13.82 J	11.937 J	10.618 J	14.62	8.73 J	18.748 J	12.34 J	14.785 J	14.796 J	31.29 J
	Penta-CBs	3.79 J	8.92 J	0	0	1.589 J	0	1.837 J	0	0	8.822 J	3.81 J	3.31 J	5.43 J	4.05 J
	Hexa-CBs	0	3.38 J	0	0	0	2.272 J	0	0	0	7.39 J	2.82 J	0	1.984 J	2.72 J
	Hepta-CBs	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Octa-CBs	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Nona-CBs	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	PCB-209	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total PCBs	12.21 J	44.89 J	10.59 J	8.29 J	15.409 J	14.209 J	13.485 J	14.62	8.73 J	43.92 J	24.49 J	19.535 J	26.55 J	43.48 J
September 2009	Mono-CBs	0.399 J	2.793 J	0	2.358 J	0.956 J	0.862 J	0	2.858 J	14.42 J	0	0	0	0	0
	Di-CBs	3.427 J	3.783 J	1.08 J	2.39 J	2.581 J	3.621 J	2.056 J	3.23 J	7.306 J	4.52 J	3.86 J	7.17 J	3.59 J	3.99 J
	Tri-CBs	4.798 J	4.814 J	2.289 J	2.633 J	2.539 J	4.807 J	2.053 J	1.467 J	8.793 J	7.05 J	4.181 J	6.02 J	0	3.906 J
	Tetra-CBs	12.74 J	14.27 J	12.22 J	27.584 J	12 J	21.368 J	11.338 J	22.41 J	32.72 J	37.1	13.45 J	28.6 J	13.269 J	20.77 J
	Penta-CBs	4.34 J	6.623 J	3.075 J	3.295 J	0.979 J	3.52 J	2.527 J	2.57 J	6.64 J	4.14 J	0	2.34 J	7.27 J	3.5 J
	Hexa-CBs	1.329 J	1.3 J	0	1.14 J	0	1.24 J	1.029 J	0	2.22 J	3.12 J	2.615 J	6.04 J	1.26 J	4.64 J
	Hepta-CBs	0	0	0	0	0	0	0	0	3.04 J	1.63 J	0	2.06 J	0	0
	Octa-CBs	0	0	0	0	0	0	0.287 J	0	0	0	1.27 J	0	0	0
	Nona-CBs	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	PCB-209	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total PCBs	27.033 J	33.583 J	18.664 J	39.4 J	19.055 J	35.418 J	19.29 J	32.535 J	75.139 J	57.56 J	25.376 J	52.23 J	25.389 J	36.806 J
January 2010	Mono-CBs	0	0	0	1.734 J	0	0	0	0	0	0	0	18.69	1.07 J	0.973 J
	Di-CBs	0	0	0	2.95 J	0	0	0	0	0	3.008 J	0	0	0	0
	Tri-CBs	1.14 J	0	1.559 J	0.67 J	0.855 J	2.298 J	1.754 J	0	0	4.563 J	0	2.35 J	1.24 J	1.22 J
	Tetra-CBs	2.84 J	18.91 J	10.08 J	29.38 J	5.49 J	24.11 J	12.403 J	23.59 J	15.96	15.163 J	13.26 J	16.61 J	9.43 J	12.866 J
	Penta-CBs	2.11 J	0	2.57 J	3.088 J	0	0	2.244 J	0	2.43 J	8.812 J	0	1.33 J	6.3 J	5.22 J
	Hexa-CBs	0	0	0	0.872 J	0	0	1.257 J	0	0	6.339 J	0	0	1.59 J	6.03 J
	Hepta-CBs	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Octa-CBs	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Nona-CBs	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	PCB-209	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total PCBs	6.09 J	18.91 J	14.209 J	38.694 J	6.345 J	26.408 J	17.658 J	23.59 J	18.39 J	37.885 J	13.26 J	38.98 J	19.63 J	26.309 J

Table E-24. Detected PBDE Congeners for Marine Water Samples.

Samples for which all congener results were nondetects (U- or UJ-qualified) were assigned a total PBDE value equal to the highest congener reporting limit (RL).

Sampling Date	PBDE Homolog [1]	PBDE Congener (pg/L)	Hood Canal		SJdF at Sill		SJdF North		Haro Strait		Whidbey Basin		Main Basin		South Sound	
			Surface	Deep	Surface	Deep	Surface	Deep	Surface	Deep	Surface	Deep	Surface	Deep	Surface	Deep
July 2009	Tetra-	PBDE-047				163 J										
	Penta-	PBDE-085				25.6										
	Penta-	PBDE-099				184										
	Penta-	PBDE-100				50 N										
	Total PBDEs															
	…including N, NJ		120.2 U	120.2 U	128.9 U	422.6 J	122.5 U	134.4 U	125 U	129.5 U	135.9 U	127.6 U	120.2 U	121.4 U	130.2 U	128.9 U
	…excluding N, NJ		120.2 U	120.2 U	128.9 U	372.6 J	122.5 U	134.4 U	125 U	129.5 U	135.9 U	127.6 U	120.2 U	121.4 U	130.2 U	128.9 U
September 2009	Tri-	PBDE-028													10.7 J	
	Tetra-	PBDE-047					87.5 J		556							
	Tetra-	PBDE-049							29.7							
	Penta-	PBDE-085							56.9				28.3		23 J	
	Penta-	PBDE-099					152	51 J	1080						424 J	
	Penta-	PBDE-100					26.4		238				63.2 J		74.3 J	
	Hexa-	PBDE-139							21.5 J				12.3 J			
	Hexa-	PBDE-153							115				32.6		33.1	
	Hexa-	PBDE-154							87.6				49.3		28	
	Octa-	PBDE-201							43 J							
	Deca-	PBDE-209							959							
	Total PBDEs															
	…including N, NJ		123 U	122.5 U	123.8 U	122.5 U	265.9 J	51 J	3186.7	134 U	121.4 U	120.2 U	185.7 J	121.4 U	593.1 J	127.6 U
	…excluding N, NJ		123 U	122.5 U	123.8 U	122.5 U	265.9 J	51 J	3186.7	134 U	121.4 U	120.2 U	185.7 J	121.4 U	593.1 J	127.6 U
January 2010	Tetra-	PBDE-066		12.8 NJ												
	Octa-	PBDE-196								40.8 J						
	Octa-	PBDE-201								50.3 J						
	Octa-	PBDE-203								108						
	Nona-	PBDE-206				80 J				822						
	Nona-	PBDE-207				166 J				1240						
	Nona-	PBDE-208				153 J				1270	101 NJ					
	Deca-	PBDE-209				2700				15200 J	1300 J				904	
	Total PBDEs															
	…including N, NJ		245 U	12.8 NJ	243 U	3099 J	253 U	253 U	255 U	18691 J	1401 J	245 U	240 U	245 U	904	238 U
	…excluding N, NJ		245 U	240 U	243 U	3099 J	253 U	253 U	255 U	18691 J	1300 J	245 U	240 U	245 U	904	238 U

[1] The following 36 congeners were measured (listed by homolog group):
Di-brominated congeners = PBDEs 007, 010, and 015; tri-brominated congeners = PBDEs 017, 028, and 030; tetra-brominated congeners = PBDEs 047, 049, 066, 071, and 077; penta-brominated congeners = PBDEs 085, 099, 100, 119, and 126; hexa-brominated congeners are PBDEs 138-140, 153, 154, and 156/169; hepta-brominated congeners are PBDEs 171, 180, 183, 184, and 191; octa-brominated congeners are PBDEs 196, 197/204, 201, 203, and 205; nona-brominated congeners are PBDEs 206-208; the deca-brominated congener is PBDE 209.

Appendix F. Analytical Results - Marine SPM

Table F-1. Summary of Results for Marine Particulate Samples.

All results for the Case+Carr Inlet sample were J-qualified due to analysis beyond holding time. PBDE results show only detected congeners.

Parameter	Hood Canal (Deep)	Case+Carr (Mid-water)
Conventional Parameters (%)		
TOC	2.75	n/a
Total Recoverable Metals (mg/Kg dry)		
Arsenic	7.53	5.72 J
Cadmium	0.87	1.04 J
Copper	82.0	18.5 J
Lead	9.13	8.78 J
Zinc	90.0	72.0 J
PBDE s (ng/Kg dry)		
BDE-017		28.6 J
BDE-028	10.2 J	40.1 J
BDE-047	120	438 J
BDE-049	17.8 J	59.6 J
BDE-099	104	184 J
BDE-100	27.1 J	84.8 J
BDE-139		10.4 J
BDE-153	29.6	18.2 J
BDE-154	14 J	29.8 J
BDE-183	54.1 J	41.2 J
BDE-197/204	36.7 J	28.4 J
BDE-203	20.6 J	
BDE-206		92.1 J
BDE-207	103 J	
BDE-208	167	
BDE-209	879	
Total PBDEs	1583.1 J	1055.2 J

Table F-2. Summary of Detected PCB Congeners in Marine Particulate Samples.
All detected results for the Case+Carr sample were J-qualified due to analysis beyond holding time.

PCB Congener (ng/Kg dry)	Hood Canal (Deep)	Case+Carr (Mid-water)
PCB-001		19 NJ
PCB-002		13.3 J
PCB-003		22 J
PCB-004		18.8 NJ
PCB-005/008	71.9	165 J
PCB-006		12.4 NJ
PCB-007	10.1 NJ	
PCB-011	305	571 J
PCB-012/013		58.5 N
PCB-015	52.5	104 J
PCB-016	13.5 NJ	60.7 J
PCB-017	22.9	61.5 J
PCB-018	42.6	143 J
PCB-020/033	34.9	172 J
PCB-022	26.4	111 J
PCB-025		28 J
PCB-026		34.5 J
PCB-027		11.7 J
PCB-028	56.6	381 J
PCB-031	52.5	243 J
PCB-032		47.1 J
PCB-037	44.2	57.5 N
PCB-042	20.5 J	21.4 NJ
PCB-043/049	43.7	150 J
PCB-044	53.1	97.8 J
PCB-045		15.8 NJ
PCB-046	31.8 N	
PCB-047/048	32.8	87.1J
PCB-050		
PCB-051		12.6 NJ
PCB-052/069		187 J
PCB-053		18.3 J
PCB-056	12.3 NJ	65.8 J
PCB-060		39.9 J
PCB-064/072	20.1 J	30 J
PCB-066	55.2	186 J
PCB-070	73	218 J
PCB-071	11.9 J	16.4 J
PCB-074	32.3	102 J
PCB-076		11.8 NJ
PCB-077		33.8 J
PCB-081	12.9 NJ	
PCB-082		32.1 N
PCB-083		19.1 NJ
PCB-084		75.7 J
PCB-085		72.5 J
PCB-086/097/117	54.1	86.3 J
PCB-087/115	50.6 N	103 J
PCB-090		15.8 J
PCB-091		50.2 J
PCB-092	39.7	72 J
PCB-093/095/098/102	134	283 J
PCB-099	124	214 J
PCB-101	171	365 J

PCB Congener (ng/Kg dry)	Hood Canal (Deep)	Case+Carr (Mid-water)
PCB-105	61.9	133 J
PCB-107/108		42.7 J
PCB-110	201	368 J
PCB-112/119		13.3 J
PCB-118	128	384 J
PCB-121	22 J	
PCB-123	12.5 J	11.7 J
PCB-124	11.5 NJ	
PCB-128	22.9 N	72.4 J
PCB-129		12.1 NJ
PCB-130		49.5 N
PCB-132	45.4	158 J
PCB-134		27.1 J
PCB-135	36	97.1 J
PCB-136	24.1 N	93.9 J
PCB-137		20 J
PCB-138	147	534 J
PCB-139/149	176	535 J
PCB-141		61.8 J
PCB-144		41.2 J
PCB-146	25 N	127 J
PCB-151	20.9 NJ	145 J
PCB-153	170	690 J
PCB-154		11.9 NJ
PCB-156	13.1 J	35.4 J
PCB-157		11.6 J
PCB-158	10.6 J	37.6 J
PCB-163/164	44.3	206 J
PCB-167		25.7 J
PCB-170	38.1	85 J
PCB-171		39.4 J
PCB-172		11.8 J
PCB-174	31.5 N	52.9 J
PCB-176		12 J
PCB-177	31.2	85.1 J
PCB-178		55.5 J
PCB-179	27.4	63.3 J
PCB-180	92.4	202 J
PCB-182/187	94.8	254 J
PCB-183	21.4 NJ	47.7 J
PCB-190		13.8 NJ
PCB-194		37.6 J
PCB-195		25.8 J
PCB-196		25.1 J
PCB-199	26.4 N	92.2 J
PCB-201		15.4 NJ
PCB-202		28.7 J
PCB-203	11.6 J	39.7 J
PCB-206	20.3 NJ	53.4 J
PCB-208	23.2 N	21.1 NJ
PCB-209	27.8	32.3 J
Total PCBs		
…including N,NJ	3324.4 J	10256.2 J
…excluding N,NJ	2966	9853.4 J

Appendix G. Analytical Results - Rivers

Table G-1. Conventionals and Metals Results for River Water Samples.

Non-detect values are given at the method detection limit (MDL).

Parameter	Nooksack			Skagit			Stillaguamish			Snohomish			Puyallup		
	July	Oct	Dec	July	Oct	Dec	July	Oct	Dec	July	Oct	Dec	July	Oct	Dec
Conventional Parameters (mg/L)															
TSS	10.9	3.7	76.3 J	7.2	6.4	60.8 J	2.6	41.3	3.7	4.7	13.6	54.5	233	38.7	11.9
TOC	0.6 J	0.8 J	2.8	0.6 J	0.6 J	1.7	0.8 J	3.3	1.1	0.6 J	2.1	2.1	0.5 J	1.1	1.3
DOC	0.8 J	1	2.9	0.6 J	0.9 J	1.6	0.9 J	4	1	0.7 J	2.2	2.1	0.8 J	1.4	1.2
Ammonia	0.002 U	0.002 U	0.022	0.002 U	0.046	0.002 U	0.011	0.039	0.007 J	0.002 U	0.079	0.008 J	0.01	0.162	0.027
Nitrate+Nitrite	0.087	0.344	0.544	0.045	0.084	0.126	0.088	0.341	0.301	0.077	0.281	0.276	0.11	0.309	0.301
Total Nitrogen	0.106	0.376	0.656	0.057	0.163	0.157	0.147	0.418	0.332	0.102	0.389	0.321	0.137	0.545	0.37
Total Phosphorus	0.0212	0.0257	0.0904	0.0073 J	0.0059	0.0855	0.0172	0.0718	0.0155	0.0092 J	0.0324	0.0532	0.25	0.0795	0.0437
Ortho-phosphate	0.0082 J	0.0209	0.0099	0.0042	0.0032	0.0045	0.0141	0.0112 J	0.0075	0.0047	0.0144	0.0041	0.0287	0.0478	0.0211
Hardness	38.1	62.0 J	38.5	21.8	29.9 J	27.6	31.9	19.2	29.9	17.4	15.7	13.2	27.7	40.8	33.2
Metals (µg/L)															
Arsenic, total	0.37	0.26	1.01	0.57	0.43	1.24	0.73	1.12	0.52	0.92	0.94	1.14	0.92	0.6	0.52
Arsenic, dissolved	0.31	0.37	0.3	0.5	0.47	0.5	0.75	0.51	0.48	0.86	0.71	0.52	0.46	0.62	0.5
Cadmium, total	0.005 J	0.005 J	0.04 J	0.009 J	0.006 J	0.02 J	0.005 J	0.02 J	0.007 J	0.005 J	0.01 J	0.03 J	0.01 J	0.006 J	0.005 J
Cadmium, dissolved	0.002 U	0.007 J	0.006 UJ	0.002 U	0.006 J	0.035	0.002 U	0.003 J	0.005 J	0.002 U	0.003 J	0.010 J	0.003 J	0.003 J	0.002 U
Copper, total	2.08	0.75 J	4.41	0.77	0.86	4.56	1.16	6.58	1.12	1.35	2.36	4.08	11.6	1.81	1.32
Copper, dissolved	0.38	0.41	2.09	0.52	0.35	1.04	1.22	1.69	0.68	1.71	1.17	1	4.19	0.91	0.63
Lead, total	0.10 J	0.05 J	0.82	0.11 J	0.05 J	0.78	0.03 UJ	0.79	0.37 J	0.09 J	0.3	0.63	1.42	0.2	0.11 UJ
Lead, dissolved	0.006 U	0.018 J	0.281	0.006 U	0.014 J	0.046	0.006 U	0.052	0.04	0.048	0.037	0.054	0.006 U	0.035	0.024
Zinc, total	5.1	3.2 J	9.7	2.4 J	2.4 J	10.6	4.0 J	17.7	5.2 J	2.5 J	3.3 J	8.3 J	11.6	3.7 J	2.7 UJ
Zinc, dissolved	1.4	1	3.4	1.5	0.7 J	0.9 J	2.2	0.7 J	3.2	4.4	3.7	0.9 J	2	1.2	1

Table G-2. Petroleum-Related Products Results for River Water Samples.

Non-detect values are given at the reporting limit (RL). The method detection limit (MDL) is presented for comparison.

Sampling Date	Parameter (mg/L)	Nooksack		Skagit		Stillaguamish		Snohomish		Puyallup	
		Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL
July 2009	Oil and Grease	1.4 J	0.5	1.4 J	0.5	1.4 J	0.5	2.8	0.5	0.9 J	0.5
	TPH-D #2 Diesel	0.05 U	0.002	0.05 U	0.002	0.05 U	0.002	0.05 U	0.002	0.05 U	0.002
	TPH-D Lube Oil	0.12 U	0.004	0.13 U	0.004	0.13 U	0.004	0.13 U	0.004	0.13 U	0.004
	TPH-G [1]	0.14 U	0.014	0.14 U	0.014	0.14 U	0.014	0.14 U	0.014	0.14 U	0.014
October 2009	Oil and Grease	1.8 U	0.5	1.9 U	0.5	1.8 U	0.5	1.8 U	0.5	1.8 U	0.5
	TPH-D #2 Diesel	0.05 U	0.002	0.05 U	0.002	0.05 U	0.002	0.05 U	0.002	0.05 U	0.002
	TPH-D Lube Oil	0.12 U	0.004	0.12 U	0.004	0.13 U	0.004	0.12 U	0.004	0.12 U	0.004
	TPH-G	0.14 U	0.014	0.14 U	0.014	0.14 U	0.014	0.14 U	0.014	0.14 U	0.014
December 2009	Oil and Grease	5.5 U	1.5	5.4 U	1.5	5.4 U	1.5	1.6 J	1.5	5.5 U	1.5
	TPH-D #2 Diesel	0.02 U	0.0005	0.02 U	0.0006	0.05 U	0.002	0.02 U	0.0006	0.02 U	0.0006
	TPH-D Lube Oil	0.04 U	0.001	0.04 U	0.001	0.12 U	0.004	0.04 U	0.001	0.04 U	0.004
	TPH-G	0.14 U	0.014	0.14 U	0.014	0.14 U	0.014	0.14 U	0.014	0.14 U	0.014

[1] TPH-G results for July represent the average of three quarter point samples (none were detected).

Table G-3. July 2009 Chlorinated Pesticides Results for River Water Samples.

Non-detect values are given at the reporting limit (RL). The method detection limit (MDL) is presented for comparison.

Parameter (ng/L)	Nooksack		Skagit		Stillaguamish		Snohomish		Puyallup	
	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL
2,4'-DDD	-	-	-	-	-	-	-	-	-	-
2,4'-DDE	-	-	-	-	-	-	-	-	-	-
2,4'-DDT	-	-	-	-	-	-	-	-	-	-
4,4'-DDD	0.20 U	0.17	0.21 U	0.18	0.21 U	0.18	0.20 U	0.17	0.21 UJ	0.18
4,4'-DDE	0.28 UJ	0.17	0.21 U	0.18	0.26 UJ	0.17	0.21 UJ	0.17	0.21 UJ	0.17
4,4'-DDT	0.20 U	-	0.21 U	-	0.21 U	-	0.20 U	-	0.21 UJ	-
Aldrin	0.20 UJ	0.061	0.21 UJ	0.065	0.21 UJ	0.062	0.20 UJ	0.061	0.21 UJ	0.063
Alpha-BHC	0.20 U	0.041	0.21 U	0.043	0.21 U	0.041	0.20 U	0.040	0.21 UJ	0.042
Beta-BHC	0.20 U	0.14	0.21 U	0.15	0.21 U	0.15	0.20 U	0.14	0.21 UJ	0.15
Chlorpyriphos	0.20 U	-	0.21 U	-	0.21 U	-	0.20 U	-	0.21 U	-
cis-Chlordane	0.20 U	0.090	0.21 U	0.096	0.21 U	0.092	0.20 U	0.090	0.21 UJ	0.093
Cis-Nonachlor	0.20 U	0.13	0.21 U	0.14	0.21 U	0.13	0.20 U	0.13	0.21 UJ	0.13
Dacthal (DCPA)	-	-	-	-	-	-	-	-	-	-
DDMU	-	-	-	-	-	-	-	-	-	-
Delta-BHC	0.20 UJ	0.040	0.21 UJ	0.043	0.21 UJ	0.041	0.20 UJ	0.040	0.21 UJ	0.041
Dieldrin	0.50 U	0.20	0.53 U	0.21	0.51 U	0.21	0.50 U	0.20	0.51 U	0.21
Endosulfan I	0.20 U	0.091	0.21 U	0.096	0.21 U	0.093	0.20 U	0.090	0.21 U	0.093
Endosulfan II	0.20 U	0.074	0.21 U	0.079	0.21 U	0.076	0.20 U	0.074	0.21 U	0.076
Endosulfan Sulfate	0.20 U	0.16	0.21 U	0.17	0.21 U	0.16	0.20 U	0.16	0.21 U	0.17
Endrin	0.50 U	0.22	0.53 U	0.23	0.51 U	0.22	0.50 U	0.21	0.51 U	0.22
Endrin Aldehyde	0.20 U	0.15	0.21 U	0.16	0.21 U	0.15	0.20 U	0.15	0.21 U	0.16
Endrin Ketone	0.75 U	0.61	0.80 U	0.64	0.77 U	0.62	0.75 U	0.60	0.77 U	0.62
Gamma-BHC (Lindane)	1.0 UJ	0.050	1.2 UJ	0.054	0.87 UJ	0.051	1.2 UJ	0.050	2.1 UJ	0.052
Heptachlor	0.20 UJ	0.088	0.21 UJ	0.093	0.21 UJ	0.090	0.20 UJ	0.087	0.21 UJ	0.090
Heptachlor Epoxide	0.20 U	0.12	0.21 U	0.13	0.21 U	0.13	0.20 U	0.12	0.21 U	0.13
Hexachlorobenzene	0.20 UJ	-	0.21 UJ	-	0.21 UJ	-	0.20 UJ	-	0.21 UJ	-
Methoxychlor	0.50 U	0.25	0.53 U	0.27	0.51 U	0.26	0.50 U	0.25	0.51 U	0.26
Mirex	-	-	-	-	-	-	-	-	-	-
Oxychlordane	0.20 U	0.073	0.21 U	0.078	0.21 U	0.075	0.20 U	0.073	0.21 UJ	0.075
Pentachloroanisole	-	-	-	-	-	-	-	-	-	-
Toxaphene	9.9 U	-	11 U	-	10 U	-	9.9 U	-	10 UJ	-
trans-Chlordane	0.20 U	0.15	0.21 U	0.16	0.21 U	0.15	0.20 U	0.15	0.21 UJ	0.15
Trans-Nonachlor	0.20 U	-	0.21 U	-	0.21 U	-	0.20 U	-	0.21 UJ	-

Table G-4. October 2009 Chlorinated Pesticides Results for River Water Samples.

Non-detect values are given at the reporting limit (RL). The method detection limit (MDL) is presented for comparison.

Parameter (ng/L)	Nooksack		Skagit		Stillaguamish		Snohomish		Puyallup	
	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL
2,4'-DDD	0.21 U	-	0.20 U	-	0.20 U	-	0.21 U	-	0.21 U	-
2,4'-DDE	0.21 U	-	0.20 U	-	0.20 U	-	0.21 U	-	0.21 U	-
2,4'-DDT	0.21 U	-	0.20 U	-	0.20 U	-	0.21 U	-	0.21 U	-
4,4'-DDD	0.21 U	0.18	0.20 U	0.17	0.20 U	0.17	0.21 U	0.18	0.21 U	0.18
4,4'-DDE	0.21 U	0.17	0.20 U	0.17	0.20 U	0.17	0.21 U	0.17	0.21 U	0.18
4,4'-DDT	0.21 U	-	0.20 U	-	0.20 U	-	0.21 U	-	0.21 U	-
Aldrin	0.21 UJ	0.062	0.20 UJ	0.062	0.20 UJ	0.061	0.21 UJ	0.063	0.21 UJ	0.063
Alpha-BHC	0.21 U	0.041	0.20 U	0.041	0.20 UJ	0.041	0.21 UJ	0.042	0.21 U	0.042
Beta-BHC	0.21 U	0.15	0.20 U	0.15	0.20 U	0.15	0.21 U	0.15	0.21 U	0.15
Chlorpyriphos	0.21 U	-	0.20 U	-	0.20 U	-	0.21 U	-	0.21 U	-
cis-Chlordane	0.21 U	0.092	0.20 U	0.091	0.20 U	0.091	0.21 U	0.093	0.21 U	0.093
Cis-Nonachlor	0.21 U	0.13	0.20 U	0.13	0.20 U	0.13	0.21 U	0.13	0.21 U	0.13
Dacthal (DCPA)	0.21 U	-	0.20 U	-	0.20 U	-	0.21 U	-	0.21 U	-
DDMU	0.21 U	-	0.20 U	-	0.20 U	-	0.21 U	-	0.21 U	-
Delta-BHC	0.21 U	0.041	0.20 U	0.040	0.20 U	0.040	0.21 U	0.041	0.21 U	0.041
Dieldrin	0.51 U	0.21	0.51 U	0.20	0.50 U	0.20	0.51 U	0.21	0.52 U	0.21
Endosulfan I	0.21 U	0.093	0.20 U	0.092	0.20 U	0.091	0.21 U	0.093	0.21 U	0.093
Endosulfan II	0.21 U	0.076	0.20 U	0.075	0.20 U	0.075	0.21 U	0.076	0.21 U	0.077
Endosulfan Sulfate	0.21 U	0.16	0.25 UJ	0.16	0.20 U	0.16	0.23 UJ	0.17	0.32 UJ	0.17
Endrin	0.51 U	0.22	0.51 U	0.22	0.50 U	0.22	0.51 U	0.22	0.52 U	0.22
Endrin Aldehyde	0.44 UJ	0.15	0.36 UJ	0.15	0.36 UJ	0.15	0.52 UJ	0.16	0.46 UJ	0.16
Endrin Ketone	0.77 U	0.62	0.76 U	0.61	0.75 U	0.61	0.77 U	0.62	0.77 U	0.62
Gamma-BHC (Lindane)	8.6 UJ	0.051	5.6 UJ	0.051	4.4 UJ	0.051	5.2 UJ	0.052	26 UJ	0.26
Heptachlor	0.21 U	0.090	0.20 U	0.089	0.20 U	0.088	0.21 U	0.090	0.21 U	0.090
Heptachlor Epoxide	0.21 U	0.13	0.20 U	0.12	0.20 U	0.12	0.21 U	0.13	0.21 U	0.13
Hexachlorobenzene	0.21 U	-	0.20 U	-	1.6	-	0.21 U	-	0.21 U	-
Methoxychlor	0.51 U	0.26	0.51 U	0.26	0.50 U	0.25	0.51 U	0.26	0.52 U	0.26
Mirex	0.21 U	-	0.20 U	-	0.20 U	-	0.21 U	-	0.21 U	-
Oxychlordane	0.21 U	0.075	0.20 U	0.074	0.20 U	0.073	0.21 U	0.075	0.21 U	0.075
Pentachloroanisole	0.21 U	-	0.20 U	-	0.20 U	-	0.21 U	-	0.21 U	-
Toxaphene	10 U	-	10 U	-	9.9 U	-	10 U	-	10 U	-
trans-Chlordane	0.21 U	0.15	0.20 U	0.15	0.20 U	0.15	0.21 U	0.15	0.21 U	0.15
Trans-Nonachlor	0.21 U	-	0.20 U	-	0.20 U	-	0.21 U	-	0.21 U	-

Table G-5. December 2009 Chlorinated Pesticides Results for River Water Samples.

Non-detect values are given at the reporting limit (RL). The method detection limit (MDL) is presented for comparison.

Parameter (ng/L)	Nooksack		Skagit		Stillaguamish		Snohomish		Puyallup	
	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL
2,4'-DDD	0.20 U	-	0.21 U	-	0.21 U	-	0.20 U	-	0.21 U	-
2,4'-DDE	0.20 U	-	0.21 U	-	0.21 U	-	0.20 U	-	0.21 U	-
2,4'-DDT	0.20 U	-	0.21 U	-	0.21 U	-	0.20 U	-	0.21 U	-
4,4'-DDD	0.20 U	0.17	0.21 U	0.18	0.21 U	0.18	0.20 U	0.17	0.21 U	0.18
4,4'-DDE	0.20 U	0.17	0.21 U	0.17	0.21 U	0.18	0.20 U	0.17	0.21 U	0.18
4,4'-DDT	0.20 U	-	0.21 U	-	0.21 U	-	0.20 U	-	0.21 U	-
Aldrin	0.20 U	0.061	0.21 UJ	0.062	0.21 U	0.065	0.20 U	0.061	0.21 UJ	0.064
Alpha-BHC	0.20 U	0.041	0.21 U	0.041	0.21 U	0.043	0.20 U	0.041	0.21 U	0.042
Beta-BHC	0.20 U	0.15	0.21 U	0.15	0.21 U	0.15	0.20 U	0.14	0.21 U	0.15
Chlorpyriphos	0.21 UJ	-	0.23 UJ	-	0.21 U	-	0.20 U	-	0.21 UJ	-
cis-Chlordane	0.20 U	0.091	0.21 U	0.092	0.21 U	0.096	0.20 U	0.090	0.21 U	0.094
Cis-Nonachlor	0.20 U	0.13	0.21 U	0.13	0.21 U	0.14	0.20 U	0.13	0.21 U	0.13
Dacthal (DCPA)	0.20 U	-	0.21 U	-	0.21 U	-	0.20 U	-	0.21 U	-
DDMU	0.20 U	-	0.21 U	-	0.21 U	-	0.20 U	-	0.21 U	-
Delta-BHC	0.20 U	0.040	0.21 U	0.041	0.21 U	0.043	0.20 U	0.040	0.21 U	0.042
Dieldrin	0.50 U	0.20	0.51 U	0.21	0.53 U	0.21	0.50 U	0.20	0.52 U	0.21
Endosulfan I	0.20 U	0.091	0.21 U	0.093	0.21 U	0.096	0.20 U	0.091	0.21 U	0.094
Endosulfan II	0.20 U	0.075	0.21 U	0.076	0.21 U	0.079	0.20 U	0.074	0.21 U	0.077
Endosulfan Sulfate	0.42	0.16	0.21 U	0.16	0.21 U	0.17	0.20 U	0.16	0.21 U	0.17
Endrin	0.50 U	0.22	0.51 U	0.22	0.53 U	0.23	0.50 U	0.22	0.52 U	0.22
Endrin Aldehyde	0.20 U	0.15	0.21 U	0.15	0.21 U	0.16	0.20 U	0.15	0.21 U	0.16
Endrin Ketone	0.75 U	0.61	0.77 U	0.62	0.80 U	0.64	0.75 U	0.61	0.78 U	0.63
Gamma-BHC (Lindane)	0.20 U	0.051	0.40 UJ	0.051	0.56 UJ	0.054	0.47 UJ	0.050	0.42 UJ	0.052
Heptachlor	0.20 U	0.088	0.21 U	0.090	0.21 U	0.093	0.20 U	0.088	0.21 U	0.091
Heptachlor Epoxide	0.20 U	0.12	0.21 U	0.13	0.21 U	0.13	0.20 U	0.12	0.21 U	0.13
Hexachlorobenzene	0.20 U	-	0.21 U	-	0.21 U	-	0.20 U	-	0.21 U	-
Methoxychlor	0.50 U	0.25	0.51 U	0.26	0.53 U	0.27	0.50 U	0.25	0.52 U	0.26
Mirex	0.20 U	-	0.21 U	-	0.21 U	-	0.20 U	-	0.21 U	-
Oxychlordane	0.20 U	0.073	0.21 U	0.075	0.21 U	0.078	0.20 U	0.073	0.21 U	0.076
Pentachloroanisole	0.20 U	-	0.21 U	-	0.21 U	-	0.20 U	-	0.21 U	-
Toxaphene	9.9 U	-	10 U	-	11 U	-	9.9 U	-	10 U	-
trans-Chlordane	0.20 U	0.15	0.21 U	0.15	0.21 U	0.16	0.20 U	0.15	0.21 U	0.15
Trans-Nonachlor	0.20 U	-	0.21 U	-	0.21 U	-	0.20 U	-	0.21 U	-

Table G-6. July 2009 PAH Results for River Water Samples.

Non-detect values are given at the reporting limit (RL). The method detection limit (MDL) is presented for comparison.

Parameter (µg/L)	Nooksack		Skagit		Stillaguamish		Snohomish		Puyallup	
	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL
1-Methylnaphthalene	0.011 U	0.011	0.011 U	0.011	0.0099 U	0.010	0.010 U	0.010	0.010 UJ	0.010
2-Chloronaphthalene	0.011 U	0.010	0.011 U	0.010	0.0099 U	0.0092	0.010 U	0.0094	0.010 UJ	0.0093
2-Methylnaphthalene	0.011 U	0.0095	0.011 U	0.0095	0.0099 U	0.0085	0.010 U	0.0087	0.010 UJ	0.0086
Acenaphthene	0.011 U	0.0095	0.011 U	0.0095	0.0099 U	0.0085	0.010 U	0.0087	0.010 UJ	0.0086
Acenaphthylene	0.011 U	0.0094	0.011 U	0.0094	0.0099 U	0.0084	0.010 U	0.0085	0.010 UJ	0.0084
Anthracene	0.011 U	0.0056	0.011 U	0.0056	0.0099 U	0.0051	0.010 U	0.0051	0.010 UJ	0.0051
Benzo(a)anthracene	0.018 UJ	0.0010	0.018 UJ	0.0010	0.016 UJ	0.0009	0.016 UJ	0.0009	0.016 UJ	0.0009
Benzo(a)pyrene	0.011 UJ	0.0018	0.011 UJ	0.0018	0.0099 UJ	0.0016	0.010 UJ	0.0016	0.010 UJ	0.0016
Benzo(b)fluoranthene	0.011 U	0.0011	0.011 U	0.0011	0.0099 U	0.0010	0.010 U	0.0010	0.010 UJ	0.0010
Benzo(ghi)perylene	0.011 UJ	0.0018	0.011 UJ	0.0018	0.0099 UJ	0.0016	0.010 UJ	0.0016	0.010 UJ	0.0016
Benzo(k)fluoranthene	0.011 U	0.0006	0.011 U	0.0006	0.0099 U	0.0005	0.010 U	0.0005	0.012 UJ	0.0005
Carbazole	0.011 U	0.0016	0.011 U	0.0016	0.0099 U	0.0015	0.010 U	0.0015	0.010 UJ	0.0015
Chrysene	0.011 UJ	0.0009	0.011 UJ	0.0009	0.0099 UJ	0.0008	0.010 UJ	0.0009	0.010 UJ	0.0009
Dibenzo(a,h)anthracene	0.011 U	0.0016	0.011 U	0.0016	0.0099 U	0.0014	0.010 U	0.0014	0.010 UJ	0.0014
Dibenzofuran	0.011 U	0.0087	0.011 U	0.0087	0.0099 U	0.0078	0.010 U	0.0079	0.010 UJ	0.0079
Fluoranthene	0.011 U	0.0017	0.011 U	0.0017	0.0099 U	0.0015	0.010 U	0.0016	0.010 UJ	0.0015
Fluorene	0.011 U	0.0082	0.011 U	0.0082	0.0099 U	0.0074	0.010 U	0.0075	0.010 UJ	0.0074
Indeno(1,2,3-cd)pyrene	0.011 U	0.0022	0.011 U	0.0022	0.0099 U	0.0020	0.010 U	0.0020	0.010 UJ	0.0020
Naphthalene	0.011 U	0.035	0.011 U	0.035	0.0099 U	0.031	0.010	0.032	0.010 UJ	0.031
Phenanthrene	0.011 U	0.0067	0.011 U	0.0067	0.0099 U	0.0060	0.010 U	0.0061	0.010 UJ	0.0061
Pyrene	0.011 U	0.0020	0.011 U	0.0020	0.0099 U	0.0018	0.010 U	0.0018	0.010 UJ	0.0018
Retene	0.011 U	0.0011	0.011 U	0.0011	0.0099 U	0.0009	0.010 U	0.0010	0.010 UJ	0.0010

Table G-7. October 2009 PAH Results for River Water Samples.

Non-detect values are given at the reporting limit (RL). The method detection limit (MDL) is presented for comparison.

Parameter (µg/L)	Nooksack		Skagit		Stillaguamish		Snohomish		Puyallup	
	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL
1-Methylnaphthalene	0.0039 J	0.0010	0.0049 J	0.0010	0.010 U	0.0010	0.0098 U	0.0010	0.010 U	0.0010
2-Chloronaphthalene	0.010 UJ	0.0093	0.010 U	0.0095	0.010 U	0.0093	0.0098 U	0.0091	0.010 U	0.0093
2-Methylnaphthalene	0.010 UJ	0.0086	0.0089 J	0.0087	0.010 U	0.0086	0.0098 U	0.0084	0.010 U	0.0086
Acenaphthene	0.010 UJ	0.0086	0.010 U	0.0087	0.010 U	0.0086	0.0098 U	0.0084	0.010 U	0.0086
Acenaphthylene	0.010 UJ	0.0085	0.010 U	0.0086	0.010 U	0.0085	0.0098 U	0.0083	0.010 U	0.0084
Anthracene	0.010 UJ	0.0051	0.010 U	0.0052	0.010 U	0.0051	0.0098 U	0.0050	0.010 U	0.0051
Benzo(a)anthracene	0.010 UJ	0.0009	0.010 U	0.0009	0.010 U	0.0009	0.0098 U	0.0009	0.010 U	0.0009
Benzo(a)pyrene	0.020 UJ	0.0016	0.020 UJ	0.0017	0.020 UJ	0.0016	0.020 UJ	0.0016	0.020 UJ	0.0016
Benzo(b)fluoranthene	0.010 UJ	0.0010	0.010 U	0.0010	0.010 U	0.0010	0.0098 U	0.0010	0.010 U	0.0010
Benzo(ghi)perylene	0.010 UJ	0.0016	0.010 U	0.0016	0.010 U	0.0016	0.0098 U	0.0016	0.010 U	0.0016
Benzo(k)fluoranthene	0.010 UJ	0.0005	0.010 U	0.0005	0.010 U	0.0005	0.0098 U	0.0005	0.010 U	0.0005
Carbazole	0.010 UJ	0.0015	0.010 U	0.0015	0.010 U	0.0015	0.0098 U	0.0014	0.010 U	0.0015
Chrysene	0.010 UJ	0.0009	0.010 U	0.0009	0.010 U	0.0009	0.0098 U	0.0008	0.010 U	0.0009
Dibenzo(a,h)anthracene	0.010 UJ	0.0014	0.010 U	0.0014	0.010 U	0.0014	0.0098 U	0.0014	0.010 U	0.0014
Dibenzofuran	0.010 UJ	0.0079	0.010 U	0.0080	0.010 U	0.0079	0.0098 U	0.0077	0.010 U	0.0079
Fluoranthene	0.010 UJ	0.0015	0.010 U	0.0016	0.010 U	0.0015	0.0098 U	0.0015	0.010 U	0.0015
Fluorene	0.010 UJ	0.0074	0.010 U	0.0075	0.010 U	0.0074	0.0098 U	0.0072	0.010 U	0.0074
Indeno(1,2,3-cd)pyrene	0.010 UJ	0.0020	0.010 U	0.0020	0.010 U	0.0020	0.0098 U	0.0019	0.010 U	0.0020
Naphthalene	0.012 UJ	0.0011	0.015 UJ	0.0011	0.010 U	0.0011	0.010 UJ	0.0011	0.012 UJ	0.0011
Phenanthrene	0.010 UJ	0.0061	0.010 U	0.0062	0.010 U	0.0061	0.0098 U	0.0060	0.010 U	0.0061
Pyrene	0.010 UJ	0.0018	0.010 U	0.0018	0.010 U	0.0018	0.0098 U	0.0017	0.010 U	0.0018
Retene	0.010 UJ	0.0010	0.010 U	0.0010	0.010 U	0.0010	0.0098 U	0.0009	0.010 U	0.0010

Table G-8. December 2009 PAH Results for River Water Samples.

Non-detect values are given at the reporting limit (RL). The method detection limit (MDL) is presented for comparison.

Parameter (µg/L)	Nooksack		Skagit		Stillaguamish		Snohomish		Puyallup	
	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL
1-Methylnaphthalene	0.010 U	0.010	0.010 U	0.011	0.010 U	0.0010	0.010 U	0.010	0.011 U	0.011
2-Chloronaphthalene	0.010 REJ	0.0094	0.010 REJ	0.0096	0.010 U	0.0010	0.010 REJ	0.0093	0.011 U	0.0098
2-Methylnaphthalene	0.010 U	0.0087	0.010 U	0.0089	0.010 U	0.0011	0.010 U	0.0086	0.011 U	0.0091
Acenaphthene	0.010 U	0.0087	0.010 U	0.0089	0.010 U	0.0011	0.010 U	0.0086	0.011 U	0.0091
Acenaphthylene	0.010 U	0.0086	0.010 U	0.0087	0.010 U	0.0018	0.010 U	0.0085	0.011 REJ	0.0089
Anthracene	0.010 U	0.0052	0.010 U	0.0053	0.010 U	0.0023	0.010 U	0.0051	0.011 U	0.0054
Benzo(a)anthracene	0.010 U	0.0009	0.010 U	0.0009	0.010 U	0.0010	0.0009 J	0.0009	0.011 U	0.0009
Benzo(a)pyrene	0.010 U	0.0016	0.010 U	0.0017	0.010 U	0.0018	0.010 U	0.0016	0.011 U	0.0017
Benzo(b)fluoranthene	0.010 U	0.0010	0.010 U	0.0011	0.010 U	0.0011	0.010 U	0.0010	0.011 U	0.0011
Benzo(ghi)perylene	0.010 U	0.0016	0.010 U	0.0017	0.010 U	0.0017	0.010 U	0.0016	0.011 U	0.0017
Benzo(k)fluoranthene	0.010 U	0.0005	0.010 U	0.0005	0.010 U	0.0006	0.010 U	0.0005	0.011 U	0.0006
Carbazole	0.010 U	0.0015	0.010 U	0.0015	0.010 U	0.0013	0.010 U	0.0015	0.011 U	0.0016
Chrysene	0.010 U	0.0009	0.010 U	0.0009	0.010 U	0.0009	0.010 U	0.0009	0.011 U	0.0009
Dibenzo(a,h)anthracene	0.010 UJ	0.0014	0.010 U	0.0015	0.010 UJ	0.0015	0.010 U	0.0014	0.011 UJ	0.0015
Dibenzofuran	0.010 U	0.0080	0.010 U	0.0081	0.010 U	0.0009	0.010 U	0.0079	0.011 U	0.0083
Fluoranthene	0.010 U	0.0016	0.010 U	0.0016	0.010 U	0.0010	0.010 U	0.0015	0.011 U	0.0016
Fluorene	0.010 U	0.0075	0.010 U	0.0077	0.010 U	0.0007	0.010 U	0.0074	0.011 U	0.0078
Indeno(1,2,3-cd)pyrene	0.010 U	0.0020	0.010 U	0.0020	0.010 U	0.0020	0.010 U	0.0020	0.011 U	0.0021
Naphthalene	0.010 U	0.0081	0.010 U	0.0082	0.010 U	0.0011	0.010 U	0.0080	0.024	0.0084
Phenanthrene	0.010 U	0.0062	0.010 U	0.0063	0.010 U	0.0024	0.010 U	0.0061	0.011 U	0.0064
Pyrene	0.010 U	0.0018	0.010 U	0.0018	0.010 U	0.0020	0.010 U	0.0018	0.011 U	0.0019
Retene	0.0097 J	0.0010	0.11	0.0010	0.010 U	0.0011	0.0030 J	0.0010	0.0015 J	0.0010

Table G-9. Total PAH and Total cPAH Results for River Water Samples.

Sampling Date	Parameter (µg/L)	Nooksack	Skagit	Stillaguamish	Snohomish	Puyallup
July 2009	Total PAHs					
	…ND at ½ RL	0.12 U	0.12 U	0.11 U	0.010	0.11 UJ
	…ND at MDL	0.13 U	0.13 U	0.12 U	0.010	0.12 UJ
	Total cPAHs					
	…ND at ½ RL	0.039 U	0.039 U	0.035 U	0.035 U	0.035 UJ
	…ND at MDL	0.0092 U	0.0092 U	0.0082 U	0.0083 U	0.0083 UJ
October 2009	Total PAHs					
	…ND at ½ RL	0.0039 J	0.014 J	0.12 U	0.11 U	0.12 U
	…ND at MDL	0.0039 J	0.014 J	0.079 U	0.077 U	0.079 U
	Total cPAHs					
	…ND at ½ RL	0.040 UJ	0.040 U	0.040 U	0.039 U	0.040 U
	…ND at MDL	0.0083 UJ	0.0084 U	0.0083 U	0.0081 U	0.0083 U
December 2009	Total PAHs					
	…ND at ½ RL	0.0097 J	0.11	0.11 U	0.0039 J	0.026
	…ND at MDL	0.0097 J	0.11	0.029 U	0.0039 J	0.026
	Total cPAHs					
	…ND at ½ RL	0.035 U	0.035 U	0.035 U	0.0009 J	0.039 U
	…ND at MDL	0.0083 U	0.0086 U	0.0089 U	0.0009 J	0.0088 U

Table G-10. Summary of July 2009 BNA Results for River Water Samples.

Non-detect values are given at the reporting limit (RL). The method detection limit (MDL) is presented for comparison.

Parameter (µg/L)	Nooksack		Skagit		Stillaguamish		Snohomish		Puyallup	
	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL
1,2,4-Trichlorobenzene	0.081 U	-	0.079 U	-	0.078 U	-	0.081 U	-	0.079 U	-
1,2-Dichlorobenzene	0.081 U	-	0.079 U	-	0.078 U	-	0.081 U	-	0.079 U	-
1,2-Diphenylhydrazine	0.081 U	-	0.079 U	-	0.078 U	-	0.081 U	-	0.079 U	-
1,3-Dichlorobenzene	0.081 U	-	0.079 U	-	0.078 U	-	0.081 U	-	0.079 U	-
1,4-Dichlorobenzene	0.081 U	-	0.079 U	-	0.078 U	-	0.081 U	-	0.079 U	-
2,4,5-Trichlorophenol	0.32 U	-	0.31 U	-	0.31 U	-	0.33 U	-	0.31 U	-
2,4,6-Trichlorophenol	0.32 UJ	-	0.31 UJ	-	0.31 UJ	-	0.33 UJ	-	0.31 UJ	-
2,4-Dichlorophenol	0.81 U	-	0.79 U	-	0.78 U	-	0.81 U	-	0.79 U	-
2,4-Dimethylphenol	0.81 U	-	0.79 U	-	0.78 U	-	0.81 U	-	0.79 U	-
2,4-Dinitrophenol	0.81 U	-	0.79 U	-	0.78 U	-	0.81 U	-	0.79 U	-
2,4-Dinitrotoluene	0.32 U	-	0.31 U	-	0.31 U	-	0.33 U	-	0.31 U	-
2,6-Dinitrotoluene	0.32 U	-	0.31 U	-	0.31 U	-	0.33 U	-	0.31 U	-
2-Chlorophenol	0.32 U	-	0.31 U	-	0.31 U	-	0.33 U	-	0.31 U	-
2-Methylphenol	0.81 U	-	0.79 U	-	0.78 U	-	0.81 U	-	0.0058 J	-
2-Nitroaniline	1.6 U	-	1.6 U	-	1.6 U	-	1.6 U	-	1.6 U	-
2-Nitrophenol	0.16 U	-	0.16 U	-	0.16 U	-	0.16 U	-	0.16 U	-
3,3'-Dichlorobenzidine	0.16 UJ	-	0.16 UJ	-	0.16 UJ	-	0.16 UJ	-	0.16 UJ	-
3B-Coprostanol	0.81 U	-	0.79 U	-	0.78 U	-	0.81 U	-	0.79 U	-
3-Nitroaniline	0.32 U	-	0.31 U	-	0.31 U	-	0.33 U	-	0.31 U	-
4,6-Dinitro-2-Methylphenol	0.32 U	-	0.31 U	-	0.31 U	-	0.33 U	-	0.31 U	-
4-Bromophenyl phenyl ether	0.16 U	-	0.16 U	-	0.16 U	-	0.16 U	-	0.16 U	-
4-Chloro-3-Methylphenol	0.81 U	-	0.79 U	-	0.78 U	-	0.81 U	-	0.79 U	-
4-Chloroaniline	3.2 REJ	-	3.1 REJ	-	3.1 REJ	-	3.3 REJ	-	3.1 REJ	-
4-Chlorophenyl-Phenylether	0.081 U	-	0.079 U	-	0.078 U	-	0.081 U	-	0.079 U	-
4-Methylphenol	0.81 U	-	0.79 U	-	0.78 U	-	0.81 U	-	0.79 U	-
4-Nitroaniline	0.32 UJ	-	0.31 UJ	-	0.31 UJ	-	0.33 UJ	-	0.31 UJ	-
4-Nitrophenol	0.81 U	-	0.79 U	-	0.78 U	-	0.81 U	-	0.79 U	-
4-nonylphenol	0.32 U	0.032	0.31 U	0.031	0.31 U	0.031	0.33 U	0.033	0.31 U	0.031
Benzoic Acid	0.81 UJ	-	0.79 UJ	-	0.78 UJ	-	0.81 UJ	-	0.79 UJ	-
Benzyl Alcohol	0.81 UJ	-	0.79 UJ	-	0.78 UJ	-	0.81 UJ	-	0.79 UJ	-
Bis(2-chloro-1-methylethyl) ether	0.081 U	-	0.079 U	-	0.078 U	-	0.081 U	-	0.079 U	-
Bis(2-Chloroethoxy)Methane	0.081 U	-	0.079 U	-	0.078 U	-	0.081 U	-	0.079 U	-
Bis(2-Chloroethyl)Ether	0.16 U	-	0.16 U	-	0.16 U	-	0.16 U	-	0.16 U	-
Bis(2-Ethylhexyl) Phthalate	0.16 U	-	0.16 U	-	0.16 U	-	0.16 U	-	0.16 U	-
Bisphenol A	0.32 U	0.032	0.31 U	0.031	0.31 U	0.031	0.33 U	0.033	0.31 U	0.031
Butyl benzyl phthalate	0.32 U	0.032	0.31 U	0.031	0.31 U	0.031	0.33 U	0.033	0.31 U	0.031
Caffeine	0.16 U	-	0.16 U	-	0.16 U	-	0.16 U	-	0.16 U	-
Cholesterol	0.81 U	-	0.79 U	-	0.78 U	-	0.81 U	-	0.79 U	-
Diethyl phthalate	0.16 U	0.032	0.16 U	0.031	0.16 U	0.031	0.16 U	0.033	0.16 U	0.031
Dimethyl phthalate	0.16 U	0.032	0.16 U	0.031	0.16 U	0.031	0.16 U	0.033	0.16 U	0.031
Di-N-Butylphthalate	0.12 UJ	-	0.18 UJ	-	0.19 UJ	-	0.16 UJ	-	0.17 UJ	-
Di-N-Octyl Phthalate	0.16 U	-	0.16 U	-	0.16 U	-	0.16 U	-	0.16 U	-
Ethanol, 2-Chloro-, Phosphate (3:1)	0.081 U	-	0.079 U	-	0.078 U	-	0.081 U	-	0.079 U	-
Hexachlorobenzene	0.081 U	-	0.079 U	-	0.078 U	-	0.081 U	-	0.079 U	-
Hexachlorobutadiene	0.081 U	-	0.079 U	-	0.078 U	-	0.081 U	-	0.079 U	-
Hexachlorocyclopentadiene	0.32 UJ	-	0.31 UJ	-	0.31 UJ	-	0.33 UJ	-	0.31 UJ	-
Hexachloroethane	0.081 U	-	0.079 U	-	0.078 U	-	0.081 U	-	0.079 U	-
Isophorone	0.16 U	-	0.16 U	-	0.16 U	-	0.16 U	-	0.16 U	-
Nitrobenzene	0.081 U	-	0.079 U	-	0.078 U	-	0.081 U	-	0.079 U	-
N-Nitrosodi-n-propylamine	0.097 U	-	0.094 U	-	0.094 U	-	0.098 U	-	0.094 U	-
N-Nitrosodiphenylamine	0.16 U	-	0.16 U	-	0.16 U	-	0.16 U	-	0.16 U	-
Pentachlorophenol	0.081 UJ	-	0.079 UJ	-	0.078 UJ	-	0.081 UJ	-	0.079 UJ	-
Phenol	0.32 U	-	0.31 U	-	0.31 U	-	0.33 U	-	0.31 U	-
Triclosan	0.081 U	-	0.079 U	-	0.078 U	-	0.081 U	-	0.079 U	-
Triethyl citrate	0.32 U	0.032	0.31 U	0.031	0.31 U	0.031	0.33 U	0.033	0.31 U	0.031

Table G-11. Summary of October 2009 BNA Results for River Water Samples.

Non-detect values are given at the reporting limit (RL). The method detection limit (MDL) is presented for comparison.

Parameter (µg/L)	Nooksack		Skagit		Stillaguamish		Snohomish		Puyallup	
	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL
1,2,4-Trichlorobenzene	0.079 U	0.020	0.080 U	0.020	0.079 U	0.019	0.083 U	0.020	0.080 U	0.020
1,2-Dichlorobenzene	0.079 U	0.019	0.080 U	0.019	0.079 U	0.019	0.083 U	0.020	0.080 U	0.019
1,2-Diphenylhydrazine	0.079 U	0.051	0.080 U	0.051	0.079 U	0.050	0.083 U	0.053	0.080 U	0.051
1,3-Dichlorobenzene	0.079 U	0.016	0.080 U	0.016	0.079 U	0.016	0.083 U	0.017	0.080 U	0.016
1,4-Dichlorobenzene	0.079 U	0.017	0.080 U	0.018	0.079 U	0.017	0.083 U	0.018	0.080 U	0.018
2,4,5-Trichlorophenol	-	-	-	-	-	-	-	-	-	-
2,4,6-Trichlorophenol	-	-	-	-	-	-	-	-	-	-
2,4-Dichlorophenol	0.79 U	0.042	0.80 U	0.042	0.79 U	0.041	0.83 U	0.043	0.80 U	0.042
2,4-Dimethylphenol	0.79 U	0.047	0.80 U	0.047	0.79 U	0.046	0.83 U	0.049	0.80 U	0.047
2,4-Dinitrophenol	0.79 U	-	0.80 U	-	0.79 U	-	0.83 U	-	0.80 U	-
2,4-Dinitrotoluene	0.32 U	0.045	0.32 U	0.045	0.31 U	0.044	0.33 U	0.047	0.32 U	0.045
2,6-Dinitrotoluene	0.32 U	0.054	0.32 U	0.054	0.31 U	0.054	0.33 U	0.056	0.32 U	0.054
2-Chlorophenol	0.32 U	0.041	0.32 U	0.042	0.31 U	0.041	0.33 U	0.043	0.32 U	0.042
2-Methylphenol	0.79 U	0.040	0.80 U	0.040	0.79 U	0.040	0.83 U	0.042	0.80 U	0.040
2-Nitroaniline	1.6 U	0.053	1.6 U	0.053	1.6 U	0.053	1.7 U	0.055	1.6 U	0.053
2-Nitrophenol	0.16 U	0.036	0.16 U	0.036	0.16 U	0.035	0.17 U	0.037	0.16 U	0.036
3,3'-Dichlorobenzidine	0.16 UJ	-	0.16 UJ	-	0.16 UJ	-	0.17 UJ	-	0.16 UJ	-
3B-Coprostanol	-	-	-	-	-	-	-	-	-	-
3-Nitroaniline	0.32 UJ	0.046	0.32 UJ	0.046	0.31 UJ	0.045	0.33 UJ	0.047	0.32 UJ	0.046
4,6-Dinitro-2-Methylphenol	1.6 U	0.53	1.6 U	0.53	1.6 U	0.53	1.7 U	0.55	1.6 U	0.53
4-Bromophenyl phenyl ether	0.16 U	0.071	0.16 U	0.072	0.16 U	0.071	0.17 U	0.074	0.16 U	0.072
4-Chloro-3-Methylphenol	0.79 U	0.063	0.80 U	0.063	0.79 U	0.062	0.83 U	0.065	0.80 U	0.063
4-Chloroaniline	3.2 U	0.13	3.2 U	0.13	3.1 UJ	0.13	3.3 UJ	0.13	3.2 U	0.13
4-Chlorophenyl-Phenylether	0.079 U	0.071	0.080 U	0.071	0.079 U	0.070	0.083 U	0.074	0.080 U	0.071
4-Methylphenol	0.79 U	0.039	0.80 U	0.040	0.050 J	0.039	0.093 J	0.041	0.80 U	0.040
4-Nitroaniline	0.32 U	-	0.32 U	-	0.31 U	-	0.33 U	-	0.32 U	-
4-Nitrophenol	-	-	-	-	-	-	-	-	-	-
4-nonylphenol	0.32 U	0.032	0.32 U	0.032	0.31 U	0.031	0.33 U	0.033	0.32 U	0.032
Benzoic Acid	-	-	-	-	-	-	-	-	-	-
Benzyl Alcohol	-	-	-	-	-	-	-	-	-	-
Bis(2-chloro-1-methylethyl) ether	-	-	-	-	-	-	-	-	-	-
Bis(2-Chloroethoxy)Methane	0.079 U	0.066	0.080 U	0.066	0.079 U	0.065	0.083 U	0.069	0.080 U	0.066
Bis(2-Chloroethyl)Ether	0.16 U	0.046	0.16 U	0.046	0.16 U	0.045	0.17 U	0.047	0.16 U	0.046
Bis(2-Ethylhexyl) Phthalate	0.16 U	0.048	0.16 U	0.048	0.16 U	0.047	0.17 U	0.050	0.16 U	0.048
Bisphenol A	0.32 U	0.032	0.32 U	0.032	0.072 J	0.031	0.33 U	0.033	0.32 U	0.032
Butyl benzyl phthalate	0.32 U	0.037	0.32 U	0.037	0.31 U	0.037	0.33 U	0.039	0.32 U	0.037
Caffeine	0.16 U	0.062	0.16 U	0.062	0.16 U	0.061	0.17 U	0.064	0.16 U	0.062
Cholesterol	0.13 NJ	0.075	0.63 J	0.076	0.49 J	0.075	0.73 J	0.078	1.4	0.076
Diethyl phthalate	0.16 U	0.078	0.16 U	0.079	0.16 U	0.078	0.17 U	0.081	0.16 U	0.079
Dimethyl phthalate	0.16 U	0.069	0.16 U	0.069	0.16 U	0.068	0.17 U	0.071	0.16 U	0.069
Di-N-Butylphthalate	0.13 UJ	0.058	0.12 UJ	0.058	0.079 U	0.058	0.083 U	0.060	0.14 UJ	0.058
Di-N-Octyl Phthalate	0.16 U	0.071	0.16 U	0.071	0.16 U	0.070	0.17 U	0.074	0.16 U	0.071
Ethanol, 2-Chloro-, Phosphate (3:1)	-	-	-	-	-	-	-	-	-	-
Hexachlorobenzene	0.079 U	0.039	0.080 U	0.039	0.079 U	0.039	0.083 U	0.041	0.080 U	0.039
Hexachlorobutadiene	0.079 U	0.012	0.080 U	0.012	0.079 UJ	0.012	0.083 UJ	0.013	0.080 U	0.012
Hexachlorocyclopentadiene	0.32 UJ	0.010	0.32 UJ	0.010	0.31 UJ	0.0099	0.33 UJ	0.010	0.32 UJ	0.010
Hexachloroethane	0.079 UJ	-	0.080 UJ	-	0.079 UJ	-	0.083 UJ	-	0.080 UJ	-
Isophorone	0.16 U	0.073	0.16 U	0.074	0.16 U	0.073	0.17 U	0.076	0.16 U	0.074
Nitrobenzene	0.079 U	0.066	0.080 U	0.066	-	-	0.083 U	0.068	0.080 U	0.066
N-Nitrosodi-n-propylamine	0.095 U	0.070	0.096 U	0.071	0.094 U	0.070	0.099 U	0.073	0.096 U	0.071
N-Nitrosodiphenylamine	0.16 UJ	0.033	0.16 UJ	0.034	0.16 UJ	0.033	0.17 UJ	0.035	0.16 UJ	0.034
Pentachlorophenol	0.079 U	-	0.080 U	-	0.079 U	-	0.083 U	-	0.083 NJ	-
Phenol	0.32 U	0.025	0.32 U	0.025	0.31 U	0.025	0.33 U	0.026	0.32 U	0.025
Triclosan	0.079 U	0.032	0.080 U	0.032	0.079 U	0.031	0.083 U	0.033	0.080 U	0.032
Triethyl citrate	0.060 J	0.032	0.058 J	0.032	0.31 U	0.031	0.33 U	0.033	0.32 U	0.032

Table G-12. Summary of December 2009 BNA Results for River Water Samples.

Non-detect values are given at the reporting limit (RL). The method detection limit (MDL) is presented for comparison.

Parameter (µg/L)	Nooksack		Skagit		Stillaguamish		Snohomish		Puyallup	
	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL
1,2,4-Trichlorobenzene	0.078 UJ	0.019	0.084 U	0.021	0.079 UJ	0.019	0.084 U	0.021	0.076 UJ	0.019
1,2-Dichlorobenzene	0.078 UJ	0.018	0.084 U	0.020	0.079 U	0.019	0.084 U	0.020	0.076 UJ	0.018
1,2-Diphenylhydrazine	0.078 U	0.049	0.084 U	0.053	0.079 U	0.050	0.084 U	0.053	0.076 U	0.049
1,3-Dichlorobenzene	0.078 UJ	0.016	0.084 U	0.017	0.079 UJ	0.016	0.084 U	0.017	0.076 UJ	0.016
1,4-Dichlorobenzene	0.078 UJ	0.017	0.084 U	0.018	0.079 UJ	0.017	0.084 U	0.018	0.076 UJ	0.017
2,4,5-Trichlorophenol	0.31 U	0.061	0.34 U	0.066	0.31 U	0.062	0.34 U	0.066	-	-
2,4,6-Trichlorophenol	0.31 UJ	0.047	0.34 UJ	0.051	0.31 UJ	0.048	0.34 UJ	0.051	-	-
2,4-Dichlorophenol	0.78 U	0.041	0.84 U	0.044	0.79 U	0.041	0.84 U	0.044	0.76 U	0.040
2,4-Dimethylphenol	-	-	0.84 U	0.049	0.79 U	0.046	0.84 U	0.049	0.76 U	0.045
2,4-Dinitrophenol	0.78 U	-	0.84 U	-	0.79 U	-	0.84 U	-	0.76 U	-
2,4-Dinitrotoluene	0.31 U	0.044	0.34 U	0.047	0.31 UJ	0.044	0.34 U	0.047	0.31 UJ	0.043
2,6-Dinitrotoluene	0.31 U	0.053	0.34 U	0.057	0.31 U	0.054	0.34 U	0.057	0.31 U	0.052
2-Chlorophenol	0.31 U	0.040	0.34 U	0.044	0.31 U	0.041	0.34 U	0.044	0.31 U	0.040
2-Methylphenol	0.78 U	0.039	0.84 U	0.042	0.79 U	0.040	0.84 U	0.042	0.76 U	0.039
2-Nitroaniline	1.6 UJ	0.052	1.7 UJ	0.056	1.6 UJ	0.053	1.7 UJ	0.056	1.5 UJ	0.051
2-Nitrophenol	0.16 U	0.035	0.17 U	0.038	0.16 UJ	0.035	0.17 UJ	0.038	0.15 UJ	0.034
3,3'-Dichlorobenzidine	0.16 UJ	-	0.17 UJ	-	0.16 UJ	-	0.17 UJ	-	0.15 UJ	-
3B-Coprostanol	0.78 UJ	-	0.84 UJ	-	0.79 UJ	-	0.84 UJ	-	0.76 UJ	-
3-Nitroaniline	0.31 REJ	0.045	0.34 REJ	0.048	0.31 REJ	0.045	0.34 REJ	0.048	0.31 REJ	0.044
4,6-Dinitro-2-Methylphenol	1.6 U	0.52	1.7 U	0.56	1.6 U	0.53	1.7 U	0.56	1.5 U	0.51
4-Bromophenyl phenyl ether	0.16 U	0.070	0.17 U	0.075	0.16 U	0.071	0.17 U	0.075	0.15 U	0.069
4-Chloro-3-Methylphenol	0.78 UJ	0.061	0.84 UJ	0.066	0.79 UJ	0.062	0.84 UJ	0.066	0.76 UJ	0.060
4-Chloroaniline	3.1 REJ	0.12	3.4 REJ	0.13	3.1 REJ	0.13	3.4 REJ	0.13	3.1 REJ	0.12
4-Chlorophenyl-Phenylether	0.078 U	0.069	0.084 U	0.075	0.079 U	0.070	0.084 U	0.075	0.076 U	0.068
4-Methylphenol	0.78 U	0.038	0.84 U	0.042	0.13 J	0.039	0.84 U	0.042	0.76 U	0.038
4-Nitroaniline	0.31 UJ	-	0.34 UJ	-	0.31 UJ	-	0.34 UJ	-	0.31 UJ	-
4-Nitrophenol	0.78 U	-	0.84 U	-	0.79 U	-	0.84 U	-	0.76 U	-
4-nonylphenol	0.31 U	0.031	0.052 J	0.034	0.31 U	0.031	0.34 U	0.034	0.31 U	0.031
Benzoic Acid	0.78 REJ	-	0.84 UJ	-	0.79 U	-	0.84 UJ	-	0.76 UJ	-
Benzyl Alcohol	0.78 UJ	0.027	0.84 UJ	0.030	0.79 UJ	0.028	0.84 UJ	0.030	0.76 UJ	0.027
Bis(2-chloro-1-methylethyl) ether	0.078 U	0.052	0.084 U	0.056	0.079 U	0.053	0.084 U	0.056	0.076 U	0.051
Bis(2-Chloroethoxy)Methane	0.078 U	0.064	0.084 U	0.070	0.079 U	0.065	0.084 U	0.070	0.076 U	0.063
Bis(2-Chloroethyl)Ether	0.16 U	0.044	0.17 U	0.048	0.16 U	0.045	0.17 U	0.048	0.15 U	0.044
Bis(2-Ethylhexyl) Phthalate	0.16 U	0.047	0.17 U	0.050	0.16 U	0.047	0.17 U	0.050	0.074 J	0.046
Bisphenol A	0.31 U	0.031	0.34 UJ	0.034	0.31 UJ	0.031	0.34 U	0.034	0.31 UJ	0.031
Butyl benzyl phthalate	0.31 U	0.036	0.34 UJ	0.039	0.31 UJ	0.037	0.34 UJ	0.039	0.31 U	0.036
Caffeine	0.16 U	0.060	0.17 U	0.065	0.16 U	0.061	0.17 U	0.065	0.15 U	0.059
Cholesterol	0.78 UJ	0.074	0.56 J	0.079	0.51 J	0.075	0.84 UJ	0.079	0.57 J	0.072
Diethyl phthalate	0.16 U	0.076	0.17 U	0.083	0.16 U	0.078	0.17 U	0.083	0.15 U	0.075
Dimethyl phthalate	0.16 U	0.067	0.17 U	0.072	0.16 U	0.068	0.17 U	0.072	0.15 U	0.066
Di-N-Butylphthalate	0.41 UJ	0.057	0.27 UJ	0.061	0.12 UJ	0.058	0.084 U	0.061	0.18 UJ	0.056
Di-N-Octyl Phthalate	0.16 U	0.069	0.17 U	0.075	0.16 U	0.070	0.17 U	0.075	0.15 U	0.068
Ethanol, 2-Chloro-, Phosphate (3:1)	0.078 U	0.031	0.084 U	0.034	0.079 U	0.031	0.084 U	0.034	0.076 U	0.031
Hexachlorobenzene	0.078 U	0.038	0.084 U	0.041	0.079 U	0.039	0.084 U	0.041	0.076 U	0.038
Hexachlorobutadiene	0.078 UJ	0.012	0.084 UJ	0.013	0.079 UJ	0.012	0.084 UJ	0.013	0.076 UJ	0.012
Hexachlorocyclopentadiene	0.31 UJ	0.0097	0.34 UJ	0.011	0.31 UJ	0.0099	0.34 UJ	0.011	0.31 UJ	0.0096
Hexachloroethane	0.078 UJ	-	0.084 UJ	-	0.079 UJ	-	0.084 UJ	-	0.076 UJ	-
Isophorone	0.16 U	0.072	0.17 U	0.077	0.16 U	0.073	0.17 U	0.077	0.15 U	0.071
Nitrobenzene	0.078 U	0.064	0.084 U	0.069	0.079 U	0.065	0.084 U	0.069	0.076 U	0.063
N-Nitrosodi-n-propylamine	0.093 U	0.069	0.10 U	0.074	0.094 U	0.070	0.10 U	0.074	0.092 U	0.068
N-Nitrosodiphenylamine	0.16 UJ	0.032	0.17 UJ	0.035	0.16 UJ	0.033	0.17 UJ	0.035	0.15 REJ	0.032
Pentachlorophenol	0.078 UJ	-	0.084 U	-	0.079 U	-	0.084 UJ	-	0.076 U	-
Phenol	0.31 U	0.025	0.34 U	0.027	0.31 U	0.025	0.34 U	0.027	0.31 U	0.024
Triclosan	0.078 UJ	0.031	0.084 U	0.034	0.079 U	0.031	0.084 U	0.034	0.076 U	0.031
Triethyl citrate	0.31 U	0.031	0.34 U	0.034	0.31 U	0.031	0.34 U	0.034	0.31 U	0.031

Table G-13. Detected PCB Congeners for River Water Samples.

PCB Congener (pg/L)	Nooksack			Skagit			Stillaguamish			Snohomish			Puyallup		
	July	Oct	Dec	July	Oct	Dec	July	Oct	Dec	July	Oct	Dec	July	Oct	Dec
PCB-001		0.861 NJ						0.86 NJ							0.976 J
PCB-002		1.46 NJ		1.71 J		0.595 NJ		1.26 NJ							1.73 NJ
PCB-003	11.4 NJ	2.14 J		10.5 NJ		0.677 NJ		1.75 J						1.8 J	1.75 J
PCB-006		0.391 J													
PCB-008	3.18 J	0.878 J		1.94 J		0.842 J	2.98 J	1.55 J		2.45 J				2.04 J	
PCB-015		0.513 J			0.709 J	0.532 J		0.948 J		3.69 J					
PCB-017					0.463 J	0.561 NJ									
PCB-018/030		0.742 J	0.688 NJ	2.17 J	0.902 J	1.16 J	3.17 J	1.28 J	1.11 J	2.84 J	1.02 NJ	0.801 J		1.69 J	1.49 J
PCB-020/028		0.666 NJ	0.756 NJ	1.51 J	1.04 J	0.988 J	2.19 J	1.59 J	0.625 J	2.54 J	1.29 J	0.5 NJ	10.3 NJ	1.77 J	1.04 NJ
PCB-021/033		0.286 J				0.496 J	1.63 J	0.651 NJ							0.897 J
PCB-022						0.297 J									
PCB-031	2.11 J	0.629 NJ			0.964 J	0.971 J	2.69 J	1.37 NJ		2.38 J	1.12 J		10.3 NJ	1.74 J	1.17 J
PCB-037		0.32 J													
PCB-039		0.255 NJ													
PCB-044/047/065		0.78 J	0.64 NJ		0.763 J	1.08 J		2.67 J	1.628 J	1.64 J		0.902 J			1.57 J
PCB-049/069		0.317 NJ	0.539 J			0.519 J		1.36 J				0.448 J		1.27 NJ	0.751 J
PCB-052		1.15 J			1.08 J		10.5 NJ	4.31 J			1.35 J		1.45 J	2.76 J	
PCB-056						0.217 J									
PCB-061/070/074/076		0.952 J	0.692 NJ		0.702 J	1.01 J		5.63 J				0.656 NJ		3.13 J	1.72 J
PCB-064						0.298 J		1.04 J							0.585 J
PCB-066						0.397 NJ		1.45 J							0.841 J
PCB-084								2.19 J							
PCB-085/116								0.806 NJ							
PCB-086/087/097/108/119/125		1.28 J			0.733 J	0.592 J		4.45 NJ							
PCB-090/101/113		1.39 J	1.39 NJ		0.847 J	0.974 J	1.87 J	7.03 J	0.821 J	11 NJ		1 NJ	10.3 NJ	3.04 J	1.76 J
PCB-095		1.11 J	0.685 NJ		0.688 NJ	0.848 NJ	1.18 J	5.87				1.19 J		3.37 J	1.4 J
PCB-099		0.39 J	0.382 NJ			0.355 J		2.32 J						1.63 J	0.497 J
PCB-105		0.566 J			0.469 NJ	0.294 J		2.45 NJ						1.86 J	
PCB-110	1.12 J	1 J	0.806 J		0.721 J	0.811 J	10.5 NJ	6.69		1.19 J		0.796 J	1.16 J	2.66 J	1.58 J
PCB-118		1.03 J	0.691 NJ		0.44 J	0.674 J	1.21 J	4.62 J				0.572 NJ		2.55 J	1.25 J
PCB-129/138/163		0.868 J	1.95 J		0.597 J	1.3 J	1.07 J	3.21 J	0.807 J	1.09 J	1.17 J	1.33 J		3.19 J	1.85 J
PCB-132						0.332 NJ		1.12 NJ							
PCB-135/151						0.55 J									
PCB-146						0.24 J									
PCB-147/149		0.69 J	0.979 J			0.656 NJ		2.03 NJ				0.829 J		2.43 J	1.41 J
PCB-153/168	11.4 NJ	0.704 J	1.52 J		0.405 NJ	0.974 J		2.33 J				0.997 J		3.01 J	1.17 NJ
PCB-169										0.961 J					
PCB-180/193						0.717 J						0.647 NJ			
PCB-187						0.523 NJ								1.51 J	
PCB-194						0.272 NJ	1.28 J	1.14 J							
PCB-198/199						0.292 NJ									
PCB-209						1.09 J									

Table G-14. Total PCBs for River Water Samples.

Total concentrations were calculated by summing the congener detects, as described in Appendix D.

Total PCBs (pg/L)	Nooksack			Skagit			Stillaguamish			Snohomish			Puyallup		
	July	Oct	Dec	July	Oct	Dec	July	Oct	Dec	July	Oct	Dec	July	Oct	Dec
…including N,NJ	29.21 J	21.37 J	11.72 J	17.83 J	11.52 J	22.13 J	40.27 J	73.98 J	4.99 J	29.78 J	5.95 J	10.67 J	35.31 J	41.45 J	25.44 J
…excluding N,NJ	6.41 J	17.18 J	5.79 J	7.33 J	9.96 J	16.98 J	19.27 J	58.98 J	4/99 J	18.78 J	4.93 J	7.29 J	2.61 J	40.18 J	21.5 J

Table G-15. PCB Homolog Totals for River Water Samples.

Results qualified as N or NJ were not included when summing homologs to calculate total PCBs.

PCB Homolog (pg/L)	Nooksack			Skagit			Stillaguamish			Snohomish			Puyallup		
	July	Oct	Dec	July	Oct	Dec	July	Oct	Dec	July	Oct	Dec	July	Oct	Dec
Mono-CBs	0	2.14 J	0	1.71 J	0	0	0	1.75 J	0	0	0	0	0	1.8 J	2.726 J
Di-CBs	3.18 J	1.782 J	0	1.94 J	0.709 J	1.374 J	2.98 J	2.498 J	0	6.14 J	0	0	0	2.04 J	0
Tri-CBs	2.11 J	1.348 J	0	3.68 J	3.369 J	3.912 J	9.68 J	2.87 J	1.735 J	7.76 J	2.41 J	0.801 J	0	5.2 J	3.557 J
Tetra-CBs	0	2.882 J	0.539 J	0	2.545 J	3.124 J	0	16.46 J	1.628 J	1.64 J	1.35 J	1.35 J	1.45 J	5.89 J	5.467 J
Penta-CBs	1.12 J	6.766 J	0.806 J	0	2.741 J	3.7 J	4.26 J	28.72 J	0.821 J	1.19 J	0	1.986 J	1.16 J	15.11 J	6.487 J
Hexa-CBs	0	2.262 J	4.449 J	0	0.597 J	3.064 J	1.07 J	5.54 J	0.807 J	2.051 J	1.17 J	3.156 J	0	8.63 J	3.26 J
Hepta-CBs	0	0	0	0	0	0.717 J	0	0	0	0	0	0	0	1.51 J	0
Octa-CBs	0	0	0	0	0	0	1.28 J	1.14 J	0	0	0	0	0	0	0
Nona-CBs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PCB-209	0	0	0	0	0	1.09 J	0	0	0	0	0	0	0	0	0
Total PCBs	6.41 J	17.18 J	5.794 J	7.33 J	9.961 J	16.98 J	19.27 J	58.98 J	4.991 J	18.78 J	4.93 J	7.293 J	2.61 J	40.18 J	21.50 J

Table G-16. Detected PBDE Congeners for River Water Samples.

Samples for which all congener results were nondetects (U- or UJ-qualified) were assigned a total PBDE value equal to the highest congener reporting limit (RL).

PBDE Congener (pg/L)	Nooksack			Skagit			Stillaguamish			Snohomish			Puyallup		
	July	Oct	Dec	July	Oct	Dec	July	Oct	Dec	July	Oct	Dec	July	Oct	Dec
BDE-017		5.19 J													
BDE-028		7.32 J		13.3 J			10.7 J			5.7 NJ				5.18 J	
BDE-030							5.2 NJ								
BDE-049		17 J													
BDE-100	34.2 J						11.6 J			13.7 J			10.9 J		
BDE-209														260	
Total PBDEs															
…including N, NJ	34.2 J	29.51 J	250 U	13.3 J	250 U	250 U	27.5 J	250 U	250 UJ	19.4 J	250 U	250 U	10.9 J	265.18	250 U
…excluding N,NJ	34.2 J	29.51 J	250 U	13.3 J	250 U	250 U	22.3 J	250 U	250 UJ	13.7 J	250 U	250 U	10.9 J	265.18	250 U

Appendix H. Analytical Results - River SPM

Table H-1. Results for Conventionals, Metals, and Petroleum-Related Products in River Particulate Samples.

All samples were collected in December 2009. Non-detect petroleum results are given at the reporting limit (RL).

Parameter	Nooksack	Skagit	Stillaguamish	Snohomish	Puyallup
Conventional Parameters (%)					
Percent Solids	69.0	60.6	43.9	56.7	73.3
TOC	0.96	1.46	1.88	1.49	0.36
Metals (mg/Kg dry)					
Arsenic	6.62	6.46	11.1	13.3	1.45
Cadmium	0.17	0.13	0.24	0.20	0.04 J
Copper	33.0	27.1	53.5	51.6	17.2
Lead	5.35	4.46	9.55	8.36	1.57
Zinc	77.4	53.8	106	86.0	20.3
Petroleum-Related Products (mg/Kg dry)					
TPH-D #2 Diesel	14 U	16 U	23 U	17 U	13 U
TPH-D Lube Oil	36 U	41 U	57 U	44 U	33 U

Table H-2. December 2009 Chlorinated Pesticides Results for River Particulate Samples.

Non-detect results are given at the reporting limit (RL). The method detection limit (MDL) is presented for comparison.

Parameter	Nooksack		Skagit		Stillaguamish		Snohomish		Puyallup	
(µg/Kg dry)	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL
2,4'-DDD	0.13 U	0.027	0.13 U	0.027	0.32 U	0.069	0.13 U	0.027	0.12 U	0.027
2,4'-DDE	0.13 U	0.068	0.13 U	0.068	0.32 U	0.17	0.13 U	0.069	0.12 U	0.067
2,4'-DDT	0.13 U	0.051	0.13 U	0.051	0.32 U	0.13	0.13 U	0.051	0.12 U	0.050
4,4'-DDD	0.13 U	0.032	0.13 U	0.032	0.32 U	0.082	0.13 U	0.032	0.12 U	0.032
4,4'-DDE	0.38	0.069	0.13 U	0.069	0.32 U	0.18	0.13 U	0.070	0.12 U	0.068
4,4'-DDT	0.39	0.053	0.13 U	0.054	0.32 U	0.14	0.13 U	0.054	0.12 U	0.053
Aldrin	0.13 U	0.057	0.13 U	0.057	0.32 U	0.15	0.13 U	0.058	0.12 U	0.056
Alpha-BHC	0.13 U	0.033	0.13 U	0.033	0.32 U	0.084	0.13 U	0.033	0.12 U	0.032
Beta-BHC	0.13 U	0.027	0.13 U	0.027	0.32 U	0.068	0.13 U	0.027	0.12 U	0.026
Chlordane, technical	1.3 U	-	1.3 U	-	3.2 U	-	1.3 U	-	1.2 U	-
Chlorpyriphos	0.13 U	0.029	0.13 U	0.029	0.32 U	0.073	0.13 U	0.029	0.12 U	0.028
cis-Chlordane	0.13 U	0.041	0.13 U	0.041	0.32 U	0.10	0.13 U	0.041	0.12 U	0.040
Cis-Nonachlor	0.13 U	0.046	0.13 U	0.046	0.32 U	0.12	0.13 U	0.047	0.12 U	0.045
Dacthal	0.13 U	0.021	0.13 U	0.021	0.32 U	0.053	0.13 U	0.021	0.12 U	0.020
DDMU	0.13 U	0.032	0.13 U	0.032	0.32 U	0.082	0.13 U	0.033	0.12 U	0.032
Delta-BHC	0.13 U	0.029	0.13 U	0.029	0.32 U	0.075	0.13 U	0.030	0.12 U	0.029
Dieldrin	0.13 U	0.0052	0.13 U	0.0052	0.32 U	0.013	0.13 U	0.0052	0.12 U	0.0051
Endosulfan I	0.13 U	0.056	0.13 U	0.056	0.32 U	0.14	0.13 U	0.057	0.12 U	0.055
Endosulfan II	0.13 U	0.010	0.13 U	0.010	0.32 U	0.026	0.13 U	0.010	0.12 U	0.0099
Endosulfan Sulfate	0.72 UJ	0.045	0.26 UJ	0.045	0.32 U	0.11	0.30 UJ	0.045	0.32 UJ	0.044
Endrin	0.13 U	0.0056	0.13 U	0.0056	0.32 U	0.014	0.13 U	0.0057	0.12 U	0.0055
Endrin Aldehyde	0.13 UJ	0.083	0.13 UJ	0.083	0.32 UJ	0.21	0.13 UJ	0.084	0.12 UJ	0.082
Endrin Ketone	0.13 U	0.029	0.13 U	0.029	0.32 U	0.074	0.13 U	0.029	0.12 U	0.029
Gamma-BHC	0.52 UJ	0.028	0.58 UJ	0.029	2.0 UJ	0.073	0.47 UJ	0.029	0.72 UJ	0.028
Heptachlor	0.13 U	0.034	0.13 U	0.034	0.32 U	0.086	0.13 U	0.034	0.12 U	0.033
Heptachlor Epoxide	0.13 U	0.060	0.13 U	0.061	0.32 U	0.15	0.13 U	0.061	0.12 U	0.060
Hexachlorobenzene	0.41	0.065	0.13 U	0.065	0.32 U	0.17	0.13 U	0.066	0.12 U	0.064
Methoxychlor	0.13 U	0.066	0.13 U	0.066	0.32 U	0.17	0.13 U	0.066	0.12 U	0.065
Mirex	0.13 U	0.067	0.13 U	0.067	0.32 U	0.17	0.13 U	0.068	0.12 U	0.066
Oxychlordane	0.13 U	0.037	0.13 U	0.037	0.32 U	0.095	0.13 U	0.037	0.12 U	0.037
Pentachloroanisole	0.17	0.120	0.13 U	0.12	0.32 U	0.31	0.13 U	0.12	0.12 U	0.12
Toxaphene	1.3 U	0.043	1.3 U	0.043	3.2 U	0.11	1.3 U	0.043	1.2 U	0.042
trans-Chlordane	0.13 U	0.037	0.13 U	0.037	0.32 U	0.095	0.13 U	0.037	0.12 U	0.037
Trans-Nonachlor	0.13 U	0.060	0.13 U	0.060	0.32 U	0.15	0.13 U	0.061	0.12 U	0.059

Table H-3. December 2009 PAH Results for River Particulate Samples.

Non-detect results are given at the reporting limit (RL). The method detection limit (MDL) is presented for comparison.

Parameter	Nooksack		Skagit		Stillaguamish		Snohomish		Puyallup	
(µg/Kg dry)	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL
1-Methylnaphthalene	13	0.81	3.6	0.93	18	3.2	6.4	0.99	5.3	0.77
2-Chloronaphthalene	3.6 U	2.4	4.1 U	2.7	14 U	9.3	4.4 U	2.9	3.4 U	2.3
2-Methylnaphthalene	21		6.1		30		11		7.8	
Acenaphthene	1.4 U	2.1	1.6 U	2.4	5.6 U	8.0	1.7 U	2.5	1.4 U	2.0
Acenaphthylene	1.4 U	0.74	1.6 U	0.85	5.6 U	2.9	1.7 U	0.90	1.4 U	0.70
Anthracene	1.5	1.4	1.6 U	1.6	6.6	5.3	2.6	1.7	1.5	1.3
Benzo(a)anthracene	3.6	0.80	1.6 U	0.92	6.9	3.1	4.6	0.97	1.6	0.76
Benzo(a)pyrene	2.8 J	1.6	3.3 U	1.8	6.9 J	6.1	3.7	1.9	2.7 U	1.5
Benzo(b)fluoranthene	8.0	1.9	1.6 U	2.2	14	7.3	11	2.3	2.0	1.8
Benzo(ghi)perylene	5.2 J	1.2	1.8 J	1.3	12 J	4.5	7.7 J	1.4	2.0 J	1.1
Benzo(k)fluoranthene	2.1	2.0	1.6 U	2.2	5.6 U	7.6	1.7	2.4	1.4 U	1.8
Carbazole	3.6 U	4.1	4.1 U	4.6	14 U	16	4.4 U	4.9	3.4 U	3.8
Chrysene	12	1.3	2.3	1.5	15	4.9	9.6	1.5	2.8	1.2
Dibenzo(a,h)anthracene	0.94 J	0.78	1.6 U	0.89	5.6 U	3.0	1.1 J	0.94	1.4 U	0.73
Dibenzofuran	4.3		1.4 J		8.8		3.2		1.6	
Fluoranthene	18	0.94	2.1	1.1	13	3.6	8.9	1.1	3.2	0.88
Fluorene	3.9 J	0.89	1.1 J	1.0	7.6	3.5	4.3	1.1	1.4 U	0.84
Indeno(1,2,3-cd)pyrene	3.1 J	0.73	0.92 J	0.84	7.5 J	2.8	5.0 J	0.89	1.3 J	0.69
Naphthalene	11	1.7	3.4	2.0	19	6.7	8.8	2.1	2.7	1.6
Phenanthrene	28	0.77	6.7	0.88	36	3.0	22	0.94	6.7	0.73
Pyrene	18	2.1	3.5	2.4	18	8.2	11	2.6	4.4	2.0
Retene	100	2.3	280 J	5.2	310	8.8	400 J	11	60	2.1
Total PAHs	260		310 J		530		520 J		100	
Total cPAHs*	33 J		3.2 J		50 J		37 J		7.7 J	

*The carcinogenic PAH compounds (cPAHs) are: benzo(a)pyrene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene.

Table H-4. December 2009 BNA Results for River Particulate Samples.

Non-detect results are given at the reporting limit (RL). The method detection limit (MDL) is presented for comparison.

Parameter (µg/Kg dry)	Nooksack		Skagit		Stillaguamish		Snohomish		Puyallup	
	Result	MDL	Result	MDL	Result	MDL	Result	MDL	Result	MDL
1,2,4-Trichlorobenzene	47 U	39	53 U	44	74 U	61	57 U	47	43 U	35
1,2-Dichlorobenzene	94 U	41	110 U	46	150 U	64	110 U	49	85 U	37
1,2-Diphenylhydrazine	23 U	17	27 U	20	37 U	27	28 U	21	21 U	16
1,3-Dichlorobenzene	94 U	39	110 U	45	150 U	62	110 U	48	85 U	36
1,4-Dichlorobenzene	94 U	39	110 U	44	150 U	61	110 U	47	85 U	35
2,4,5-Trichlorophenol	94 U	15	110 U	17	150 U	23	110 U	18	85 U	13
2,4,6-Trichlorophenol	94 U	11	110 U	13	150 U	17	110 U	13	85 U	10
2,4-Dichlorophenol	230 U	16	270 U	18	370 U	25	280 U	19	210 U	15
2,4-Dimethylphenol	230 U	16	270 U	18	370 U	25	280 U	19	210 U	15
2,4-Dinitrophenol	230 REJ		270 REJ		370 REJ		280 REJ		210 REJ	
2,4-Dinitrotoluene	94 UJ	8.9	110 UJ	10	150 UJ	14	110 UJ	11	85 UJ	8.0
2,6-Dinitrotoluene	94 U	8.5	110 U	9.7	150 U	13	110 U	10	85 U	7.7
2-Chlorophenol	94 U	19	110 U	21	150 U	29	110 U	23	85 U	17
2-Methylphenol	230 U	17	270 U	19	370 U	26	280 U	20	210 U	15
2-Nitroaniline	470 UJ	22	530 UJ	25	740 UJ	34	570 UJ	26	430 UJ	20
2-Nitrophenol	47 UJ	15	53 UJ	17	74 UJ	23	57 UJ	18	43 UJ	14
3,3'-Dichlorobenzidine	94 UJ	5.2	110 UJ	5.9	150 UJ	8.1	110 UJ	6.2	85 UJ	4.7
3B-Coprostanol	260 J	12	220 J	13	670 J	18	240 J	14	310 J	11
3-Nitroaniline	94 REJ	23	110 REJ	26	150 REJ	36	110 REJ	28	85 REJ	21
4,6-Dinitro-2-Methylphenol	94 REJ		110 REJ		150 REJ		110 REJ		85 REJ	
4-Bromophenyl phenyl ether	47 U	9.8	53 U	11	74 U	15	57 U	12	43 U	8.9
4-Chloro-3-Methylphenol	230 U	14	270 U	16	370 U	22	280 U	17	210 U	13
4-Chloroaniline	940 REJ	23	1100 REJ	27	1500 REJ	37	1100 REJ	28	850 REJ	21
4-Chlorophenyl-Phenylether	23 U	12	27 U	14	37 U	19	28 U	15	21 U	11
4-Methylphenol	230 U	30	78 J	34	52 J	47	43 J	36	210 U	27
4-Nitroaniline	94 UJ	9.1	110 UJ	10	150 UJ	14	110 UJ	11	85 UJ	8.2
4-Nitrophenol	230 UJ	9.0	270 UJ	10	370 UJ	14	280 UJ	11	210 UJ	8.2
4-nonylphenol	15 J	2.3	27 U	2.7	37 U	3.7	28 U	2.8	21 U	2.1
Benzoic Acid	230 UJ	9.1	270 UJ	10	370 UJ	14	310 J	11	210 UJ	8.3
Benzyl Alcohol	230 UJ	39	270 UJ	44	370 UJ	61	280 UJ	47	210 UJ	35
Bis(2-chloro-1-methylethyl) ether	23 U	21	27 U	24	37 U	33	28 U	25	21 U	19
Bis(2-Chloroethoxy)Methane	23 U	16	27 U	18	37 U	24	28 U	19	21 U	14
Bis(2-Chloroethyl)Ether	47 U	16	53 U	18	74 U	25	57 U	19	43 U	14
Bis(2-Ethylhexyl) Phthalate	540	5.9	510	6.7	230 J	9.2	170 J	7.1	1000	5.3
Bisphenol A	20 J	2.3	27 U	2.7	37 U	3.7	28 U	2.8	21 U	2.1
Butyl benzyl phthalate	47 UJ	4.4	53 UJ	5.0	74 UJ	7.0	57 UJ	5.4	43 UJ	4.0
Caffeine	47 UJ	24	53 UJ	27	74 UJ	38	57 UJ	29	43 UJ	22
Cholesterol	410 J	2.3	1100 J	2.7	8600 J	3.7	1300 J	2.8	1400 J	2.1
Diethyl phthalate	23 U	8.6	27 U	9.8	37 U	13	28 U	10	21 U	7.8
Dimethyl phthalate	23 U	11	27 U	12	37 U	17	28 U	13	21 U	9.7
Di-N-Butylphthalate	58 UJ	6.0	54 UJ	6.8	70 UJ	9.4	40 UJ	7.2	33 UJ	5.4
Di-N-Octyl Phthalate	47 U	3.8	53 U	4.3	74 U	6.0	57 U	4.6	43 U	3.5
Ethanol, 2-Chloro-, Phosphate (3:1)	23 U	2.3	27 U	2.7	37 U	3.7	28 U	2.8	21 U	2.1
Hexachlorobenzene	23 U	8.3	27 U	9.4	37 U	13	28 U	10	21 U	7.5
Hexachlorobutadiene	94 U	42	110 U	47	150 U	65	110 U	50	85 U	38
Hexachlorocyclopentadiene	94 UJ		110 UJ		150 UJ		110 UJ		85 UJ	
Hexachloroethane	23 U	15	27 U	17	37 U	23	28 U	18	21 U	14
Isophorone	47 U	13	53 U	15	74 U	21	57 U	16	43 U	12
Nitrobenzene	23 U	20	27 U	23	37 U	32	28 U	24	21 U	18
N-Nitrosodi-n-propylamine	23 U	15	27 U	17	37 U	24	28 U	18	21 U	14
N-Nitrosodiphenylamine	47 UJ	9.4	53 UJ	11	74 UJ	15	57 UJ	11	43 UJ	8.5
Pentachlorophenol	230 UJ	4.8	270 UJ	5.4	370 UJ	7.5	280 UJ	5.8	210 UJ	4.3
Phenol	94 U	20	26 NJ	23	150 U	32	110 U	25	26 J	18
Triclosan	23 UJ	2.3	27 UJ	2.7	37 UJ	3.7	28 UJ	2.8	21 UJ	2.1
Triethyl citrate	23 REJ	2.3	27 REJ	2.7	37 REJ	3.7	28 REJ	2.8	21 REJ	2.1

Table H-5. Detected PCB Congeners for River Particulate Samples Collected in December 2009.

PCB Congener (ng/Kg dry)	Nooksack	Skagit	Stillaguamish	Snohomish	Puyallup
PCB-003		3.52 J	5.34 J		
PCB-005/008	15.8	11.7	25.7	20.8	8.59
PCB-006			8.23		
PCB-007				5.96	
PCB-011	86.8	35.5	121	86.4	26.1
PCB-015	5.69	9.91	13.3	10.2	4.63
PCB-016	3.44 J		4.86 NJ		
PCB-017	5.6	4.06	5.54 J	5.02	
PCB-018	12.1	8.76	16.9	11.5	5.51
PCB-020/033	8.02	6.86	15.2	7.85	3.63 J
PCB-022	4.83	5.54	9.99	4.06 N	
PCB-028	11.3	10.9	18.6	11.3	6.56
PCB-031	9.56	8.32	18	10	4.15
PCB-037	4.76	7.95	15.7	6.6	4.63 N
PCB-042			5.63 J		
PCB-043/049	5.33		9.36	5.21	
PCB-044	5.7		13.1	3.97 NJ	
PCB-047/048	4.97		5.35 J	3.36 J	
PCB-052/069	8.56	4.64	18.4	10.2	3.93 J
PCB-056			3.81 J	3.33 J	
PCB-060			3.95 NJ		
PCB-064/072	3.1 J		5.22 J		
PCB-066	7.21	4.42	12.5	7.01	
PCB-070	11.6	4.36 N	19.5	10.4	5.58
PCB-074	4.38		7.67	4.78	
PCB-082			4.22 NJ		
PCB-084			3.79 J		
PCB-085		3.42 J	8.49		
PCB-086/097/117	4.57		13.6	5.95	3.08 J
PCB-087/115	6.43 N	3.75 J	19.3	6.07	6.16
PCB-092	5.16		6.18 N	3.07 J	
PCB-093/095/098/102	21.1	6.91 N	36.3	20.7	7.17
PCB-099	6.99		17.6	7.99	
PCB-101	16.9 N	7.05	39.2	19	8.03
PCB-105	5.22	5.49	15.4	5.74	3.43 J
PCB-110	22	12.7	45.3	22.4	12.3
PCB-118	10.1	11.1	33.4	13.2	7.84
PCB-128			7.15 N	4.37	
PCB-132			7 N	4.55 N	
PCB-135			6.48		
PCB-136	4.22		8.88	5.25	
PCB-138	9.8	8.7	34.6	20.4	6.96
PCB-139/149	18.1	10.5	37.7	24.3	9.74 N
PCB-141			7.13	3.26 NJ	
PCB-146			3.67 NJ	3.45 J	
PCB-151	6.66		14.6	6.57	
PCB-153	13.2	8.6	29.4	20.2	6.36
PCB-156			3.69 J		
PCB-158			3.2 J		
PCB-163/164			9.18 N	7.85	
PCB-170		4.91	10.8	3.58 NJ	
PCB-174	3.15 J		15.2	7.43	4.33
PCB-177			9.02	5.04	
PCB-179			3.37 NJ		

PCB Congener (ng/Kg dry)	Nooksack	Skagit	Stillaguamish	Snohomish	Puyallup
PCB-180	6.72	7.94	29.9	12.3	6.89
PCB-182/187	4.58	4.88	16	10.4	4.13
PCB-183			4.89 J		
PCB-190			3.67 J		
PCB-199		4.7	8.52	7.25	
PCB-203			7.05	3.42 J	
PCB-206			8.31 N	5.81 N	
PCB-209		5.12	7.46	4.32	
Total PCBs					
…including N,NJ	383.65	232.21	922.5 J	491.82	162.73 J
…excluding N,NJ	360.32	220.94	864.61	466.59	145.36

Table H-6. PCB Homolog Totals for River Particulate Samples Collected in December 2009.

Results qualified as N or NJ were not included in homolog sums or Total PCB calculations.

PCB Homolog (ng/Kg dry)	Nooksack	Skagit	Stillaguamish	Snohomish	Puyallup
Mono-CBs	0	3.52 J	5.34 J	0	0
Di-CBs	108.29	57.11	168.23	123.36	39.32
Tri-CBs	59.61	52.39	99.93	52.27	19.85 J
Tetra-CBs	50.85	9.06	100.54 J	44.29 J	9.51 J
Penta-CBs	75.14	43.51 J	232.38	104.12	48.01 J
Hexa-CBs	51.98	27.8	145.68	92.39	13.32
Hepta-CBs	14.45 J	17.73	89.48	35.17	15.35
Octa-CBs	0	4.7	15.57	10.67 J	0
Nona-CBs	0	0	0	0	0
Deca-CBs (PCB-209)	0	5.12	7.46	4.32	0
Total PCBs	360.32	220.94	864.61	466.59	145.36

Table H-7. Detected PBDE Congeners for River Particulate Samples Collected in December 2009.

PBDE Congener (ng/Kg dry)	Nooksack	Skagit	Stillaguamish	Snohomish	Puyallup
BDE-017	6.02		4.69 J		
BDE-028	5.62	3.51	18.9	2.28 J	4.08
BDE-047	126	18.9 J	442	53.4	77.5
BDE-049	24.8		24	4.94 J	5.96
BDE-066	6.15		25.3	3.09 J	3.57 J
BDE-071	2.2 J		5.01 J		
BDE-085	6.05		20.4	2.86 J	4.87
BDE-099	155	19	499	60	84.4
BDE-100	40.5		114	15.8	19.9
BDE-119			6.17 J		
BDE-138	3.73 J		3.19 J		
BDE-139	2.64 J		4.01 NJ		
BDE-140			3.62 J		
BDE-153	17.9		46.2	7.3	9.33
BDE-154	18.7	3.41 J	51.5	5.02 J	4.87
BDE-156/169			2.97 J		
BDE-183	5 J		9.74 J		
BDE-196	9.18	4.24 J	31.4		8.2 J
BDE-197/204	6.56 J		29.3 J		5.58 NJ
BDE-201	8.01 J	7.08 J	38.6	6.31 J	8.9 J
BDE-203	12.9	10.6	66.9	6.63 J	13.9
BDE-206	84	14.3 J	268	52.5	69.4
BDE-207	88.2	68.7	308	55.7	115
BDE-208	96.2	50.1	397	69.9	133
BDE-209	683	322	2280	375	470
Total PBDEs					
…including N,NJ	1408.36	521.84	4699.9	720.73	1038.46
…excluding N,NJ	1408.36	521.84	4695.89	720.73	1032.88

Table H-8. PBDE Homolog Totals for River Particulate Samples Collected in December 2009.

Results qualified as N or NJ were not included in homolog sums or total PBDE calculations.

PBDE Homolog (ng/Kg dry)	Nooksack	Skagit	Stillaguamish	Snohomish	Puyallup
Mono-BDEs	-	-	-	-	-
Di-BDEs	0	0	0	0	0
Tri-BDEs	11.64	3.51	23.59 J	2.28	4.08
Tetra-BDEs	159.2	18.9 J	496.3	61.43 J	87.03
Penta-BDEs	201.6	19	639.6	78.66	109.2
Hexa-BDEs	42.97 J	3.41 J	107.5 J	12.32 J	14.2
Hepta-BDEs	5 J	0	9.74 J	0	0
Octa-BDEs	36.65 J	21.92 J	166.2 J	12.94 J	31 J
Nona-BDEs	268.4	133.1 J	973	178.1	317.4
Deca-BDEs (PBDE-209)	683	322	2280	375	470
Total PBDEs	1408.36	521.84	4695.89	720.73	1032.88

Appendix I. 2009-2010 Results Compared to Historical Data

Table I-1. Marine water column results for conventional parameters compared to historical data.

Parameter (mg/L)	Number	Median	Mean	Stdev	Low	High	Data Source*
TSS	42	1.6	1.75	1.05	0.8	6.0	Present Study
	18	4.5	4.9	1.6	2	9	Johnson (2009)
	19185	~2.5	~3.0	~2.47	0.0	64.1	Pelletier and Mohamedali (2009)
POC	28	0.059	0.133	0.326	0.028	1.780	Present Study
	~472	~0.08	~0.11	~0.03	~0.01	~0.36	Johannessen et al. (2008)
	(calc'd)	~2.84	~5.12	-	-	-	Pelletier and Mohamedali (2009)
DOC	28	0.754	0.757	0.089	0.611	0.969	Present Study
	~472	~0.64	~0.66	~0.02	~0.44	~0.91	Johannessen et al. (2008)
	24	1.06	1.23	-	0.70	2.16	Pelletier and Mohamedali (2009)
TOC	28	0.807	0.891	0.379	0.660	2.749	Present Study
	~472	~0.71	~0.77	~0.03	~0.48	~1.2	Johannessen et al. (2008)
	348	4.00	~6.35	-	0.85	79.0	Pelletier and Mohamedali (2009)

* Data sources:
Johannessen et al. (2008) data from Straits of Juan de Fuca and Georgia, 2003.
Johnson (2009) data from Strait of Juan de Fuca, Guemes Channel, and Commencement Bay, 2008-2009.
Pelletier and Mohamedali (2009) summary of EIM data for various Box Model regions; POC calculated as the difference of TOC and DOC.

Table I-2. Marine water column results for PCBs and PBDEs compared to historical data.

Parameter (pg/L)	Number	Median	Mean	Stdev	Low	High	Data Source*
Total PCBs	42	24.0	26.3	14.9	6.09	75.1	Present Study
	~14	-	~42	-	40.3	43.5	Dangerfield (2007)
Total PBDEs	10	749	2865	5678	51	18691	Present Study
	~14	-	~19	-	14.8	23.4	Dangerfield (2007)

* Data source:
Dangerfield et al. (2007) data from Boundary Pass and Rosario Strait, Strait of Georgia.

Table I-3 (presented on the following page). Marine water column metals results compared to historical data.

* Data sources:
Crecelius (1998) data from Cherry Point, Strait of Georgia and from March Point, Strait of Juan de Fuca, 1997.
Johnson (2009) data from Strait of Juan de Fuca, Guemes Channel, and Commencement Bay, 2008-2009.
Johnson (2009) summary of KCDNR data from Strait of Juan de Fuca, 1997-2000 (King County, 2001).
Johnson (2009) summary of Johnson and Summers (1999) data from Commencement Bay, 1997-1998.
Serdar (2008) summary of KCDNR data from Puget Sound region, 1996-2002; summary of EIM data from Puget Sound, 1995-2007.

Table I-3. Marine water column metals results compared to historical data.

Parameter (µg/L)	Number	Median	Mean	Stdev	Low	High	Data Source
Arsenic Total	42	1.41	1.42	0.091	1.16	1.56	Present Study
	10	0.457	0.468	0.044	0.410	0.567	Crecelius (1998) – Cherry Point
	10	1.03	1.03	0.081	0.856	1.16	Crecelius (1998) – March Point
	1927	~1.1	-	-	-	-	Serdar (2008) – KCDNR
	~130	~1	-	-	0.5	2.0	Serdar (2008) – EIM
Arsenic Dissolved	42	1.42	1.42	0.089	1.26	1.70	Present Study
	10	0.444	0.464	0.057	0.417	0.579	Crecelius (1998) – Cherry Point
	10	1.06	1.06	0.682	0.965	1.18	Crecelius (1998) – March Point
	1927	~1.1	-	-	-	-	Serdar (2008) – KCDNR
	~125	~1	-	-	0.5	2.0	Serdar (2008) – EIM
Cadmium Total	42	0.084	0.085	0.0097	0.059	0.112	Present Study
	10	0.0455	0.0451	0.0026	0.040	0.0480	Crecelius (1998) – Cherry Point
	10	0.0713	0.0703	0.0041	0.0616	0.0746	Crecelius (1998) – March Point
	~2227	~0.06	-	-	-	-	Serdar (2008) – KCDNR & EIM
Cadmium Dissolved	42	0.081	0.083	0.0105	0.067	0.111	Present Study
	10	0.0373	0.0365	0.0033	0.0306	0.0408	Crecelius (1998) – Cherry Point
	10	0.0696	0.0694	0.0047	0.0626	0.0759	Crecelius (1998) – March Point
	~2227	~0.06	-	-	-	-	Serdar (2008) – KCDNR & EIM
Copper Total	42	0.38	0.41	0.212	0.19	1.37	Present Study
	10	0.673	0.666	0.051	0.556	0.733	Crecelius (1998) – Cherry Point
	10	0.508	0.500	0.029	0.444	0.535	Crecelius (1998) – March Point
	17	0.45	0.53	0.30	0.19	1.3	Johnson (2009) /King County (2001)
	3 to 5	-	0.45	-	-	-	Johnson (2009)/King County (2001)
	1935	0.55	-	-	-	-	Serdar (2008) – KCDNR
	340	0.8	-	-	-	-	Serdar (2008) – EIM
Copper Dissolved	42	0.30	0.31	0.079	0.16	0.51	Present Study
	10	0.606	0.594	0.034	0.525	0.637	Crecelius (1998) – Cherry Point
	10	0.425	0.425	0.022	0.387	0.451	Crecelius (1998) – March Point
	12	0.38	0.48	0.21	0.31	1.0	Johnson (2009) /King County (2001)
	3 to 5	-	0.37	-	-	-	Johnson (2009) /King County (2001)
	3	-	0.61	-	-	-	Johnson and Summers (1999)
	1935	~0.39	-	-	-	-	Serdar (2008) – KCDNR
Lead Total	37	0.070	0.085	0.0541	0.015	0.230	Present Study
	10	0.0146	0.0144	0.0025	0.0101	0.0189	Crecelius (1998) – Cherry Point
	10	0.0380	0.0389	0.0057	0.0309	0.0507	Crecelius (1998) – March Point
	18	0.039	0.034	0.021	< 0.006	0.069	Johnson (2009)
	7 to 14	-	0.015	-	-	-	Johnson (2009) /King County (2001)
	1953	~0.045	-	-	-	-	Serdar (2008) – KCDNR
	< 274	~0.08	-	-	-	-	Serdar (2008) – EIM
Lead Dissolved	39	0.048	0.056	0.0464	0.006	0.235	Present Study
	10	0.0061	0.0083	0.0070	0.0061	0.0281	Crecelius (1998) – Cherry Point
	10	0.0089	0.0096	0.0032	0.0061	0.0182	Crecelius (1998) – March Point
	16	< 0.006	< 0.008	0.007	< 0.006	0.033	Johnson (2009)
	7 to 14	-	< 0.005	-	-	-	Johnson (2009)/King County (2001)
	3	-	0.018	-	-	-	Johnson and Summers (1999)
	1953	~0.008	-	-	-	-	Serdar (2008) – KCDNR
	< 274	~0.03	-	-	-	-	Serdar (2008) – EIM
Zinc Total	42	0.69	0.86	1.060	0.41	7.44	Present Study
	10	0.832	0.846	0.194	0.574	1.30	Crecelius (1998) – Cherry Point
	10	0.336	0.447	0.218	0.336	1.01	Crecelius (1998) – March Point
	18	0.75	0.90	0.64	0.20	2.9	Johnson (2009)/King County (2001)
	7 to 24	-	0.42	-	-	-	Johnson (2009) – KCDNR
	1954	0.87	-	-	-	-	Serdar (2008) – KCDNR
Zinc Dissolved	39	0.65	0.71	0.388	0.36	2.30	Present Study
	10	0.500	0.552	0.150	0.336	0.836	Crecelius (1998) – Cherry Point
	10	0.336	0.581	0.776	0.336	2.79	Crecelius (1998) – March Point
	14	0.60	0.80	0.59	0.31	2.6	Johnson (2009)/King County (2001)
	3	-	2.0	-	-	-	Johnson and Summers (1999)
	1954	0.73	0.73	-	-	-	Serdar (2008) – KCDNR
	< 574	2	-	-	-	-	Serdar (2008) – EIM

Table I-4. Concentrations of conventional parameters and nutrients in major rivers discharging to Puget Sound compared to historical data.

River	Study/ Data Source	TSS	TOC	DOC	Total N	Nitrite/ Nitrate - N	Ammonia - N	Total P	Ortho-P
Skagit	Present Study Mean (n=3 except as noted) and Range	24.8 6.4 - 60.8	1.0 0.6-1.7	1.0 0.6-1.6	0.13 0.057-0.163	0.08 0.045-0.126	0.046 (1) --	0.033 0.006-0.086	0.004 0.003-0.005
	EIM Mean (n) and Range [1]	42.4 (401) 1.0-1230	2.1 (42) 0.5-7.0	--	0.140 (209) 0.033-0.48	0.097 (64) 0.020-0.200	0.041 (252) 0.010-2.65	0.032 (359) 0.003-0.737	0.007 (105) 0.001-0.030
	Wise et al., 2007 Range for annual mean [2]	13.6 - 78.5	--	--	0.13 - 0.17	--	--	0.02 -0.05	--
Snohomish	Present Study	24.3 4.7-54.5	1.6 0.6-2.1	1.7 0.7-2.2	0.271 0.102-0.389	0.211 0.077-0.281	0.044 0.008-0.079	0.032 0.009-0.053	0.008 0.004-0.014
	EIM	15.2 (392) 1.0-260	1.85 (21) 0.8-6.1	--	0.304 (205) 0.030-0.840	0.219 (21) 0.073-0.368	0.040 (306) 0.010-0.780	0.025 (429) 0.005-0.160	0.011 (207) 0.002-0.100
	Wise et al., 2007	9.7 - 42.4	--	--	0.32 - 0.34	--	--	0.02 - 0.03	--
Nooksack	Present Study	30.3 3.7-76.3	1.4 0.6-2.8	1.6 0.8-2.9	0.379 0.106-0.656	0.325 0.087-0.544	0.022 (1) --	0.046 0.021-0.090	0.013 0.009-0.021
	EIM	97.5 (382) 1.0-2600	--	--	0.437 (233) 0.097-1.22	0.331 (20) 0.076-0.684	0.057 (408) 0.010-0.510	0.066 (562) 0.009-0.132	0.013 (324) 0.004-0.121
	Embrey & Frans, 2003 [3] *Median* and range	70 8-2,890	2.2 0.7-6.8	--	--	0.35 0.13-0.94	0.03 <0.02-0.08	0.04 <0.01-.3	0.008 <0.01 - 0.02
	Wise et al., 2007	48 - 301	--	--	0.49 -0.55	--	--	0.05 - 0.20	--
Stillaguamish	Present Study	15.9 2.6-41.3	1.7 0.8-3.3	2.0 0.9-4.0	0.299 0.147-0.418	0.243 0.088-0.341	0.019 0.007-0.039	0.035 0.016-0.072	0.011 0.008-0.014
	EIM	73.1 (758) 0.1-2700	1.7 (2) 1.4-2.0	--	0.275 (389) 0.054-0.767	0.208 (410) 0.010-0.728	0.044 (500) 0.010-0.760	0.046 (615) 0.008-0.698	0.010 (393) 0.002-0.110
Puyallup	Present Study	94.5 11.9-233	1.0 0.5-1.3	1.1 0.8-1.4	0.351 0.137-0.545	0.240 0.110-0.309	0.066 0.010-0.162	0.124 0.044-0.250	0.033 0.021-0.048
	EIM	138 (483) 1.0-2890	3.0 (63) 0.9-9.1	1.7 (16) 1.1-3.2	0.305 (274) 0.074-0.826	0.225 (21) 0.056-0.399	0.064 (542) 0.004-0.580	0.104 (585) 0.010-1.66	0.018 (526) 0.007-0.120
	Wise et al., 2007	77.1 - 407	--	--	0.27 - 0.41	--	--	0.09 - 0.15	--

[1] Derived from EIM data representing similar locations in each river and equivalent and analytical methods.
[2] Flow-weighted annual mean concentrations for 1997, 2000, and 2001 based on LOADEST model annual loads and annual flows.
[3] Based on approximately 40 samples collected near Brennan, Washington, in 1996-1998.

Table I-5. Hardness and concentrations of metals in major rivers discharging to Puget Sound compared to historical data.

River	Study/ Data Source	Hardness	Total Arsenic	Total Cadmium	Total Copper	Total Lead	Total Zinc
		mg/L	μg/L				
Skagit	Present Study Mean (n=3 except as noted) and Range	26.4 21.8-29.9	0.75 0.43 - 1.24	0.012 0.006-0.020	2.06 0.77-4.56	0.31 0.05-0.78	5.1 2.4-10.6
	EIM Mean (n) and Range [1]	22.6 (218) 13-48	0.65 (12) 0.45-1.09	--	1.39 (19) 0.280-12.0	0.165 (9) 0.023-0.47	3.09 (8) 0.55-9.34
Snohomish	Present Study	15.4 13.2-17.4	1.00 0.92-1.14	0.015 0.005-0.030	2.60 1.35-4.08	0.34 0.09-0.63	4.7 2.5-8.3
	EIM	18.2 (368) 3.0-52.0	0.82 (23) 0.48-1.9	0.03 (1) --	1.06 (42) 0.39-5.9	0.271 (29) 0.020-1.50	5.49 (30) 0.61-33.9
Nooksack	Present Study	46.2 38.1-62.0	0.55 0.26-1.01	0.017 0.005-0.040	2.41 0.75-4.41	0.32 0.05-0.82	6.0 3.2-9.7
	EIM	39.8 (306) 10.0-71.0	0.725 (18) 0.23-5.22	--	2.03 (29) 0.27-21	0.368 (22) 0.020-3.86	5.0 (24) 0.34-35.3
Stillaguamish	Present Study	27.0 19.2-31.9	0.79 0.52-1.12	0.011 0.005-0.020	2.95 1.16-6.58	0.58 (2) 0.37-0.79	9.0 4.0-17.7
	EIM	22.3 (178) 11.0-43.0	0.90 (18) 0.37-2.65	0.102 (1) --	2.15 (18) 0.50-18.0	0.08 (12) 0.020-0.450	4.2 (10) 0.45-20
Puyallup	Present Study	33.9 27.7-40.8	0.68 0.52-0.92	0.007 0.005-0.010	4.91 1.32-11.6	0.81 (2) 0.20-1.42	7.7 (2) 3.7-11.6
	EIM	25.5 (273) 14.0-60.4	0.68 (38) 0.33-1.16	0.073 (22) 0.003-0.200	4.82 (73) 0.45-41.4	0.77 (45) 0.022-6.30	7.5 (57) 0.21-43.5
Green/Duwamish	King County (2007) [1,2] Mean (n) and range	--	0.71 (11) 0.34-2.4	--	13.1	--	21.3
Surface Runoff	PSTLA (Ecology, 2010) [3] Range for 5% - 95% probability of exceedance concentrations	--	0.2 -14.9	0.0002 - 9.2	0.1 - 110	0.02 - 309	0.28 - 527

[1] King County, personal communication, April 2009. Arsenic data from 2006-2008.
[2] Mean copper and zinc concentrations derived from 2003-2005 total annual loads and discharges listed in King County (2007), Table 5-9.
[3] Range of values from Ecology (2010), Table 2: Probability of exceedance concentrations applied to major land-use types and highways.

Table I-6. Comparison of concentration ranges for organic compounds measured for the present study and others.

River	Study/ Data Source	Oil and Grease		Total PAH	cPAH *	Total PCBs	Total PBDEs
		Including ND=MDL/2	Detects only	Including ND = MDL/2			
		µg/L				pg/L	
Skagit, Snohomish, Nooksack, Stillaguamish, and Puyallup	Present Study Mean (n) and Range	920 (15) 250-2800	1600 (6) 900-2800	0.032 (15) 0.012 - 0.055	0.011 (15) 0.009 - 0.014	16.1 (15) 2.6 - 59.0	55.6 (7) 10.9 - 265
Green/Duwamish	Williston (2009) [1] Mean (n) and Range	--		0.026 (11) 0.015 - 0.05	0.001 (18) <0.001 - 0.003	410 (22) 38 - 2360	--
	Gries and Sloan (2009) [2] Est. range for annual mean	--		--	1.2-14.3	140 - 1,600	--
Total Surface Runoff	PSTLA (Ecology 2010) [3] Concentration Range	3.7 - 26,400		0.001- 56.6	0.0002 - 11.8	16 - 810,000	0.30 - 810

* Carcinogenic PAH compounds (cPAH) include benzo(a)pyrene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-c,d)pyrene

[1] King County, personal communication, April 2009. PAH data from 2008.

[2] Estimated range for annual flow-weighted mean concentrations.

[3] Range of values from Ecology (2010), Table 2: Probability of exceedance concentrations applied to major land uses types and highways.

Appendix J. Statistical Results

Marine Water Column Statistics

Table J-1. Data distributions/outliers

Table J-2. Nonparametric analysis of variance (ANOVA) results

Table J-3. Spearman rank correlations

River Water Statistics

Table J-4. Data distributions/outliers

Table J-5. Nonparametric ANOVA results

Table J-6. Nonparametric ANOVA results, excluding summer 2009 Puyallup River results

Table J-7. Spearman rank correlations

Table J-1. Data distributions and potential outliers for marine water column sample results.

Parentheses indicate that some distributions change when outliers are removed from the data set.

Parameter	Normal Distribution	Log Normal Distribution	Gamma Distribution	Statistical Outliers
TSS	x (Y)	x (Y)	x (Y)	6.0, 5.5, 3.5
DOC	Y	Y	Y	--
POC	x (x)	x (Y)	x (Y)	1.78, 0.22, 0.18
Arsenic, Total	x	x	Y	--
Arsenic, Dissolved	x (Y)	x (Y)	Y	1.704
Cadmium, Total	x	x	Y	--
Cadmium, Dissolved	x	x	Y	--
Copper, Total	x (Y)	x (Y)	x (Y)	1.37, 1.03, 0.72
Copper, Dissolved	x	x	Y	--
Lead, Total	x	Y	Y	--
Lead, Dissolved	x (x)	Y	Y	0.235
Zinc, Total	x (Y)	x (Y)	x (Y)	7.44, 1.44
Zinc, Dissolved	x (x)	x (x)	x (Y)	2.3, 1.78, 1.42, 1.25, 1.06
Mono-chlorinated PCBs	x	Y	X	18.7, 0.399
Di-chlorinated PCBs	Y	Y	Y	7.31, 1.03
Tri-chlorinated PCBs	x	Y	Y	--
Tetra-chlorinated PCBs	x	x	Y	--
Penta-chlorinated PCBs	x	Y	Y	--
Hexa-chlorinated PCBs	x	Y	Y	7.39, 0.872
Total PCBs *	x (Y)	x	Y	75.1
Total PBDEs *	x	Y	Y	18700, 51

* Insufficient number of detected results (n<8) to evaluate distributions for PCB homologs with more than 6 chlorines or any PBDE homologs.

Table J-2. Results of nonparametric ANOVA (Kruskal Wallis Test and Test of Means) for all marine water column results.

Independent Categorical Variable → / Chemical Name ↓	Puget Sound (PS) Vs. Ocean Boundary (OB)	Summer, Fall, Winter: Kruskal Wallis Test & Test of Medians	Stations Kruskal Wallis Test & Test of Medians	Surface vs. Deep Layer Kruskal Wallis Test & Test of Medians
TSS		p<0.002, TSS lowest in Fall		
DOC	p<0.001, PS>OB	p<0.024*, Fall > Winter	p<0.014, greatest at Whidbey Basin & South Sound stations	
POC		p<0.004, Fall > Winter		
TOC	p<0.001, PS>OB	p<0.031, Fall > Winter	p<0.034, see DOC	
Arsenic, Total		p<0.020, lowest in Fall		p<0.031, Surface < Deep
Arsenic, Dissolved				p<0.001, Surface < Deep
Cadmium, Total	p<0.001, PS<OB		p<0.003, greatest at Juan de Fuca & Hood Canal stations	(p<0.13, Surface < Deep)
Cadmium, Dissolved	p<0.001, PS<OB		p<0.002, see total cadmium	
Copper, Total	p<0.005, PS>OB	p<0.003, lowest in Fall		
Copper, Dissolved	p<0.001, PS>OB	p<0.042, lowest in Fall	p<0.001, lowest at Juan de Fuca & Hood Canal stations	
Lead, Total				p<0.005, Surface < Deep
Di-chlorinated PCBs	p<0.001, PS>OB			
Tri-chlorinated PCBs		p<0.002, lowest in Winter		
Tetra-chlorinated PCBs				P<0.001, Surface < Deep
Penta-chlorinated PCBs	p<0.002, PS>OB		p<0.015, greatest at Haro Strait, Whidbey Basin, and South Sound stations	
Hexa-chlorinated PCBs			p<0.044, greatest at Main and Whidbey basin stations	
Total PCBs	p<0.027, PS>OB	p<0.020, greatest in fall		p<0.001, Surface < Deep
Total PBDEs		p<0.034*, greatest in winter		

* Identified as significant only by Test of Medians.

Table J-3. Spearman rank correlation coefficients between pairs of parameters measured in marine water column samples.

Units of measure are mg/L for conventionals, µ/L for metals, and pg/L for total PCBs and PBDEs.
Values in bold are significant at p<0.05. The 3 italicized values are significant only at p<0.10.

	TSS	DOC	POC	TOC	Arsenic , Total	Arsenic , Dissolved	Cadmium , Total	Cadmium , Dissolved	Copper , Total	Copper , Dissolved	Lead , Total	Lead , Dissolved	Zinc , Total	Zinc , Dissolved	Total PCBs	Total PBDEs
TSS	1.00															
DOC	**-0.67**	1.00														
POC	**-0.49**	*0.32*	1.00													
TOC	**-0.76**	**0.96**	*0.36*	1.00												
Arsenic, Total	0.20	**-0.57**	0.11	**-0.61**	1.00											
Arsenic, Dissolved	0.27	**-0.70**	0.02	**-0.76**	**0.88**	1.00										
Cadmium, Total	0.27	**-0.54**	-0.07	**-0.50**	**0.39**	**0.63**	1.00									
Cadmium, Dissolved	**0.45**	**-0.88**	-0.13	**-0.78**	**0.52**	**0.66**	**0.79**	1.00								
Copper, Total	0.16	**-0.46**	**0.36**	**-0.57**	**0.75**	**0.88**	**0.43**	**0.40**	1.00							
Copper, Dissolved	**-0.45**	**0.64**	**0.50**	**0.54**	0.14	-0.16	**-0.61**	**-0.72**	0.11	1.00						
Lead, Total	**0.83**	**-0.93**	**-0.39**	**-0.89**	**0.43**	**0.51**	**0.54**	**0.85**	0.25	**-0.68**	1.00					
Lead, Dissolved	**0.54**	**-0.88**	**-0.56**	**-0.78**	0.31	**0.39**	**0.36**	**0.78**	0.04	**-0.76**	**0.85**	1.00				
Zinc, Total	-0.02	0.25	0.21	0.04	**0.32**	0.20	**-0.46**	**-0.54**	**0.46**	**0.79**	**-0.36**	**-0.51**	1.00			
Zinc, Dissolved	**-0.99**	**0.61**	**0.46**	**0.71**	-0.18	-0.27	**-0.32**	**-0.41**	-0.18	**0.43**	**-0.79**	**-0.45**	0.00	1.00		
Total PCBs	**0.70**	**-0.54**	0.14	**-0.57**	0.04	0.16	0.11	**0.38**	**0.32**	**-0.32**	**0.61**	**0.31**	0.00	**-0.68**	1.00	
Total PBDEs	0.29	-0.07	-0.46	-0.11	0.14	-0.18	*-0.61*	-0.25	-0.32	0.29	0.14	0.25	0.32	-0.21	-0.07	1.00

Table J-4. Data distributions and potential outliers for river water sample results.

Chemical	Normal Distribution	Log Normal Distribution	Gamma Distribution	Statistical Outliers
TSS	x (x)	Y	Y	233
TOC	x	Y	Y	--
DOC	x (x)	Y	Y	0.56
Total Nitrogen	Y	Y	Y	--
Nitrate+Nitrite Nitrogen	x	Y	x	--
Ammonia Nitrogen	x (Y)	Y	Y	0.162
Total Phosphorus	x (Y)	Y	Y	0.250
Ortho-phosphate	x (Y)	Y	Y	0.0478
Hardness	Y	Y	Y	62
Arsenic, Total	Y	Y	Y	--
Arsenic, Dissolved	Y	Y	Y	--
Cadmium, Total	x	x	x (Y)	0.04
Cadmium, Dissolved	x (Y)	x (Y)	Y	0.035 *
Copper, Total	x (x)	Y	Y	11.6
Copper, Dissolved	x (x)	Y	Y	4.19
Lead, Total	x	Y	Y	--
Lead, Dissolved	x (Y)	Y	x (Y)	0.281
Zinc, Total	x	Y	Y	--
Zinc, Dissolved	x	Y	Y	--
Oil & Grease	Y	Y	Y	2.8
Mono-chlorinated PCBs	Y	Y	Y	--
Di-chlorinated PCBs	Y	Y	Y	6.14
Tri-chlorinated PCBs	Y	Y	Y	9.68
Tetra-chlorinated PCBs	x (x)	Y	Y	16.5
Penta-chlorinated PCBs	x (x)	Y	Y	28.7
Hexa-chlorinated PCBs	Y	Y	Y	--
Total PCBs	x (x)	Y	Y	59.0
Tri-brominated PBDEs	--	--	--	--
Penta-brominated PBDEs	--	--	--	34.2
Total PBDEs	x (Y)	x (Y)	x (Y)	265.2

* Outlier removed for analysis because dissolved cadmium >> total cadmium.

Table J-5. Results of nonparametric ANOVA (Kruskal Wallis Test and Test of Medians) for all river water results.

Independent Categorical Variable → / Chemical Name ↓	Season: Summer vs. Fall vs. Winter	River/Station	Flow Regime: Baseflow vs. Runoff Event
TSS	--	--	--
DOC	p<0.011; summer low	--	--
TOC	p<0.019; summer low	--	--
Total Nitrogen	p<0.008; summer low	--	--
Ammonia Nitrogen	p<0.038; fall high	--	--
Nitrate+Nitrite Nitrogen	p<0.026; summer low	--	--
Total Phosphorus	--	--	--
Ortho-phosphate	--	P<0.034; Skagit lowest, Puyallup highest	--
Hardness	--	P<0.026; Snohomish lowest, Nooksack/Puyallup highest	--
Arsenic, Total	--	--	--
Arsenic, Dissolved	--	P<0.041; Nooksack lowest	--
Cadmium, Total	--	--	--
Cadmium, Dissolved	--	--	--
Copper, Total	--	--	--
Copper, Dissolved	--	--	--
Lead, Total	p<0.034*; summer/fall low, winter high	--	--
Lead, Dissolved	--	--	--
Zinc, Total	p<0.050*; fall low, winter high	--	--
Zinc, Dissolved	--	--	--
Oil and Grease	--	--	--
Total PCBs	--	--	(p<0.094; baseflow higher)
Total PBDEs	--	--	--

* Identified as significant only by Test of Medians.

Table J-6. Results of nonparametric ANOVA (Kruskal Wallis Test and Test of Medians) excluding summer Puyallup River results.

Independent Categorical Variable → / Chemical Name ↓	Season: Summer vs. Fall vs. Winter	River/Station	Flow Regime: Baseflow vs. Runoff Event
TSS	p<0.050*; summer low, winter high	--	--
DOC	p<0.022; summer low, winter high	--	--
TOC	p<0.038; summer low, winter high	--	--
Total Nitrogen	p<0.015; summer low, fall high	--	--
Ammonia Nitrogen	p<0.050, fall high, winter low	--	--
Nitrate+Nitrite Nitrogen	p<0.039; summer low, fall high	--	--
Total Phosphorus	0.050*; summer low, winter high	--	--
Ortho-phosphate	--	--	--
Hardness	--	p<0.022, Nooksack/Puyallup high, Skagit/Snohomish low	--
Arsenic, Total	--	--	--
Arsenic, Dissolved	--	P<0.044, Nooksack/Skagit low, Snohomish high	--
Cadmium, Total	--	--	--
Cadmium, Dissolved	--	--	--
Copper, Total	--	--	--
Copper, Dissolved	--	--	--
Lead, Total	0.027*; summer low, winter high	--	--
Lead, Dissolved	--	--	--
Zinc, Total	p<0.050*; winter high, summer/fall low	--	--
Zinc, Dissolved	p<0.034*; summer high, fall low	--	--
Oil and Grease	--	--	--
Total PCBs	--	--	--
Total PBDEs	--	--	--

* Identified as significant only by Test of Medians.

Table J-7. Spearman rank correlation coefficients between paired parameters measured in river water samples.

Units of measure are mg/L for conventionals, nutrients, and hardness; µg/L for all metals; mg/L for oil and grease, and pg/L for PCBs. Values in bold are significant at p<0.05.

	Flow	TSS	TOC	DOC	Total Nitrogen (N)	Nitrate+Nitrite N	Ammonia N	Total Phosphorus	Ortho-phosphate	Hardness	Arsenic , Total	Arsenic , Dissolved	Cadmium , Total	Cadmium , Dissolved	Copper , Total	Copper , Dissolved	Lead , Total	Lead , Dissolved	Zinc , Total	Zinc , Dissolved
Flow (cfs)	1.00																			
TSS	0.50	1.00																		
TOC	0.28	0.39	1.00																	
DOC	0.22	0.50	**0.95**	1.00																
Total Nitrogen	-0.11	0.29	**0.76**	**0.85**	1.00															
Nitrate+Nitrite Nitrogen	-0.22	0.28	**0.71**	**0.78**	**0.92**	1.00														
Ammonia Nitrogen	-0.09	-0.04	0.14	0.31	0.49	0.17	1.00													
Total Phosphorus	0.09	**0.85**	0.47	**0.59**	0.49	**0.59**	0.02	1.00												
Ortho-phosphate	**-0.70**	0.13	0.05	0.17	0.44	0.52	0.36	0.50	1.00											
Hardness	**-0.64**	-0.02	-0.17	-0.08	0.29	0.30	0.30	0.25	0.50	1.00										
Arsenic, Total	**0.61**	**0.67**	**0.59**	**0.56**	0.17	0.13	-0.16	**0.58**	-0.14	**-0.52**	1.00									
Arsenic, Dissolved	0.00	-0.20	0.16	0.06	-0.08	-0.24	0.29	-0.18	0.02	-0.46	0.39	1.00								
Cadmium, Total	**0.74**	**0.76**	**0.59**	**0.62**	0.34	0.30	-0.21	**0.57**	-0.24	-0.32	**0.77**	-0.11	1.00							
Cadmium, Dissolved	0.51	0.01	0.01	-0.03	-0.33	-0.10	-0.47	-0.14	**-0.65**	-0.15	0.22	-0.31	0.19	1.00						
Copper, Total	0.33	**0.86**	0.41	0.50	0.20	0.22	-0.07	**0.81**	0.17	-0.16	**0.77**	0.01	**0.66**	-0.21	1.00					
Copper, Dissolved	0.15	0.48	0.28	0.28	0.13	0.18	-0.20	**0.57**	0.27	-0.20	**0.74**	0.30	0.46	-0.36	**0.69**	1.00				
Lead, Total	0.47	**0.86**	0.48	**0.53**	0.34	0.41	-0.35	**0.78**	0.11	-0.10	**0.67**	-0.21	**0.85**	-0.14	**0.81**	**0.57**	1.00			
Lead, Dissolved	0.56	**0.64**	**0.66**	0.58	0.12	0.11	-0.55	0.54	-0.28	-0.32	**0.81**	0.16	**0.74**	0.17	**0.77**	**0.85**	**0.83**	1.00		
Zinc, Total	0.10	**0.63**	0.45	0.52	0.28	0.43	-0.47	**0.76**	0.17	0.02	**0.60**	-0.19	**0.62**	-0.13	**0.82**	**0.57**	**0.78**	**0.70**	1.00	
Zinc, Dissolved	-0.13	-0.19	-0.17	-0.26	-0.14	-0.11	-0.13	-0.11	0.20	0.01	0.02	0.17	-0.13	-0.34	-0.04	0.44	-0.01	0.17	-0.12	1.00

Table J-7 (continued). Spearman rank correlation coefficients between paired parameters measured in river water samples.

Units of measure are mg/L for conventionals, nutrients, and hardness; µg/L for all metals; mg/L for oil and grease; pg/L for all summed PCBs. There were no significant correlations involving PBDE results for river water. Values in bold are significant at p<0.05.

	Oil & Grease	Mono-chlorinated PCBs	Di-chlorinated PCBs	Tri-chlorinated PCBs	Tetra-chlorinated PCBs	Penta-chlorinated PCBs	Hexa-chlorinated PCBs	Total PCBs
Flow	0.46	**-0.70**	-0.40	-0.15	-0.49	-0.35	0.04	-0.34
TSS	-0.40	-0.20	-0.20	-0.11	-0.24	-0.15	**0.67**	-0.24
TOC	0.55	0.30	-0.18	-0.28	-0.03	0.24	**0.60**	0.17
DOC	0.03	0.10	-0.34	-0.32	-0.02	0.31	**0.65**	0.12
Total Nitrogen (N)	-0.03	0.10	-0.35	-0.30	0.07	0.34	**0.63**	0.17
Nitrate+Nitrite N	-0.15	0.30	-0.18	-0.39	0.13	0.26	**0.61**	0.14
Ammonia N	-0.50	-0.50	**-0.80**	0.41	0.34	**0.67**	0.37	0.43
Total Phosphorus	-0.40	0.20	-0.05	-0.06	-0.07	0.06	**0.83**	-0.07
Ortho-phosphate	-0.70	**0.70**	0.33	0.12	0.26	0.39	0.43	0.17
Hardness	-0.64	**0.60**	-0.18	0.28	0.22	-0.11	0.37	0.14
Arsenic , Total	0.37	**-0.60**	0.15	0.25	-0.21	-0.03	0.40	-0.04
Arsenic , Dissolved	0.70	-0.31	0.45	**0.55**	0.16	0.46	-0.03	0.43
Cadmium , Total	-0.16	**-0.87**	-0.50	-0.29	-0.45	-0.24	0.34	-0.37
Cadmium , Dissolved	**1.00**	**0.87**	**-0.67**	-0.27	-0.12	-0.15	-0.20	0.14
Copper , Total	-0.21	-0.20	0.30	-0.02	-0.14	-0.12	**0.64**	-0.19
Copper , Dissolved	-0.09	-0.20	**0.53**	0.41	-0.39	-0.18	0.29	-0.10
Lead , Total	-0.40	-0.41	-0.05	-0.28	-0.30	-0.26	**0.54**	-0.37
Lead , Dissolved	**-1.00**	**-0.80**	**0.77**	-0.08	-0.39	-0.38	0.39	-0.14
Zinc , Total	-0.40	0.00	0.24	-0.27	-0.06	-0.14	0.46	-0.18
Zinc , Dissolved	0.09	-0.36	**0.70**	0.25	**-0.54**	**-0.60**	-0.17	-0.44
Oil & Grease	1.00	.	**0.78**	-0.11	0.50	0.31	0.50	0.52
1-Cl PCBs		1.00	-0.40	-0.30	-0.40	**-1.00**	**-0.60**	0.10
2-Cl PCBs			1.00	0.30	0.09	-0.29	0.07	0.23
3-Cl PCBs				1.00	0.45	0.21	0.03	**0.54**
4-Cl PCBs					1.00	**0.89**	0.40	**0.84**
5-Cl PCBs						1.00	0.44	**0.88**
6-Cl PCBs							1.00	0.51
Total PCBs								1.00