Quality Assurance Project Plan

Investigation of Petroleum Products in Black Lake Sediment and Surface Water from Underground Tanks

by
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April 2005

303(d) Listings Addressed in this Study: None

Waterbody Number: WA-23-9010

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Approvals

Approved By:	April 6, 2005
Panjini Balaraju, Southwest Regional Office	Date
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Rebecca Lawson, Section Manager, Southwest Regional Office	Date
Approved By:	May 31, 2005
Randy Coots, Project Manager, Watershed Ecology Section	Date
Approved By:	April 5, 2005
Dale Norton, Unit Supervisor, Toxic Studies Unit	Date
Approved By:	April 5, 2005
Will Kendra, Section Manager, Watershed Ecology Section	Date
Approved By:	April 6, 2005
Stuart Magoon, Director, Manchester Environmental Laboratory	Date
Approved By:	April 6, 2005
Cliff Kirchmer, Ecology Quality Assurance Officer	Date

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Abstract

Groundwater under Black Lake Grocery (near Tumwater, Washington) is known to be contaminated with petroleum products from leaking underground gasoline tanks. Although a remedial technology (treatment wall) has been developed and implemented in November 2004 for treating the contaminated groundwater, sediments and lake water down gradient of the tanks have never been evaluated for hydrocarbons or impacts to benthic communities. This project will determine if Black Lake sediments and surface water have been impacted by contaminated groundwater from the Black Lake Grocery site. Samples will be collected to determine the presence, or absence, of petroleum products in surface sediments and water down gradient of the remediation site. If sediment results show elevated levels of petroleum hydrocarbons, a follow-up sampling, using sediment bioassay, will be conducted to evaluate toxicity to aquatic life. Data from this study will be used to determine if remediation of Black Lake sediments is needed.

Background

Black Lake (in Thurston County just west of Tumwater, Washington) is 2.6 miles long and has a surface area of 570 acres (Figures 1 and 2). It is fed from the south by the Black River, drains to the north into Black Lake Ditch and Percival Creek, and ultimately ends up in Capitol Lake. The lake has a mean depth of 19 feet and a maximum depth of 29 feet. Geologic records indicate the area is underlain by recessional sand, glacial till, and advance outwash. Prior test borings completed by Summit Envirosolutions have confirmed that the site is underlain by fine-grained lacustrine deposits (silts and clays). In addition, "although the regional occurrence of shallow groundwater in the area is associated with unconsolidated glacial deposits, aquifer units capable of providing sufficient groundwater for domestic use in the vicinity of the project site are associated with the underlying volcanic rocks… It is likely that the shallow groundwater flow regime beneath the site is dominated by horizontal flow towards Black Lake" (Summit Envirosolutions, 2000).

Black Lake Grocery, located on the north end of the lake at 4409 Black Lake Boulevard SW, is currently a convenience store on a 5.2 acre parcel of land. The store is situated approximately 75 feet from the shore of the lake. The site is bounded on the east by Black Lake Boulevard, on the north by Goldsby Road, and on the south and west by residential property.

Contamination was detected in 1989 when petroleum levels in soil and groundwater were found to exceed the Model Toxics Control Act (MTCA) cleanup standards. A site hazard assessment was conducted by the Washington State Department of Ecology (Ecology) in 1992. That same year, two underground storage tanks were removed. Three more tanks, along with 1200 cubic yards of total petroleum hydrocarbons (TPH) contaminated soils, were excavated and the soil was bioremediated on site by 1995. Envirosolutions found that although a significant portion of source material was removed, results of chemical analyses indicate that petroleum hydrocarbons at concentrations exceeding cleanup levels existed at the limits of the excavation that was not accessible below the Goldsby Road. A residual smear zone may be contributing to petroleum concentrations in groundwater (Summit Envirosolutions, 2000). Additionally, lake sediments down gradient have never been evaluated for petroleum products or impacts to benthic communities.

Remedial technology (treatment wall) has been developed for treating the contaminated groundwater. A treatment wall was constructed at the site in November 2004. The treatment wall is an interceptor trench installed perpendicular to groundwater flow at the down gradient location of the plume. The treatment wall is approximately 120 feet long, 5 feet wide, and 12 feet deep (see Figure 2 and A1). The design of the trench required it to be filled with a material to treat contaminated groundwater as it passes through.

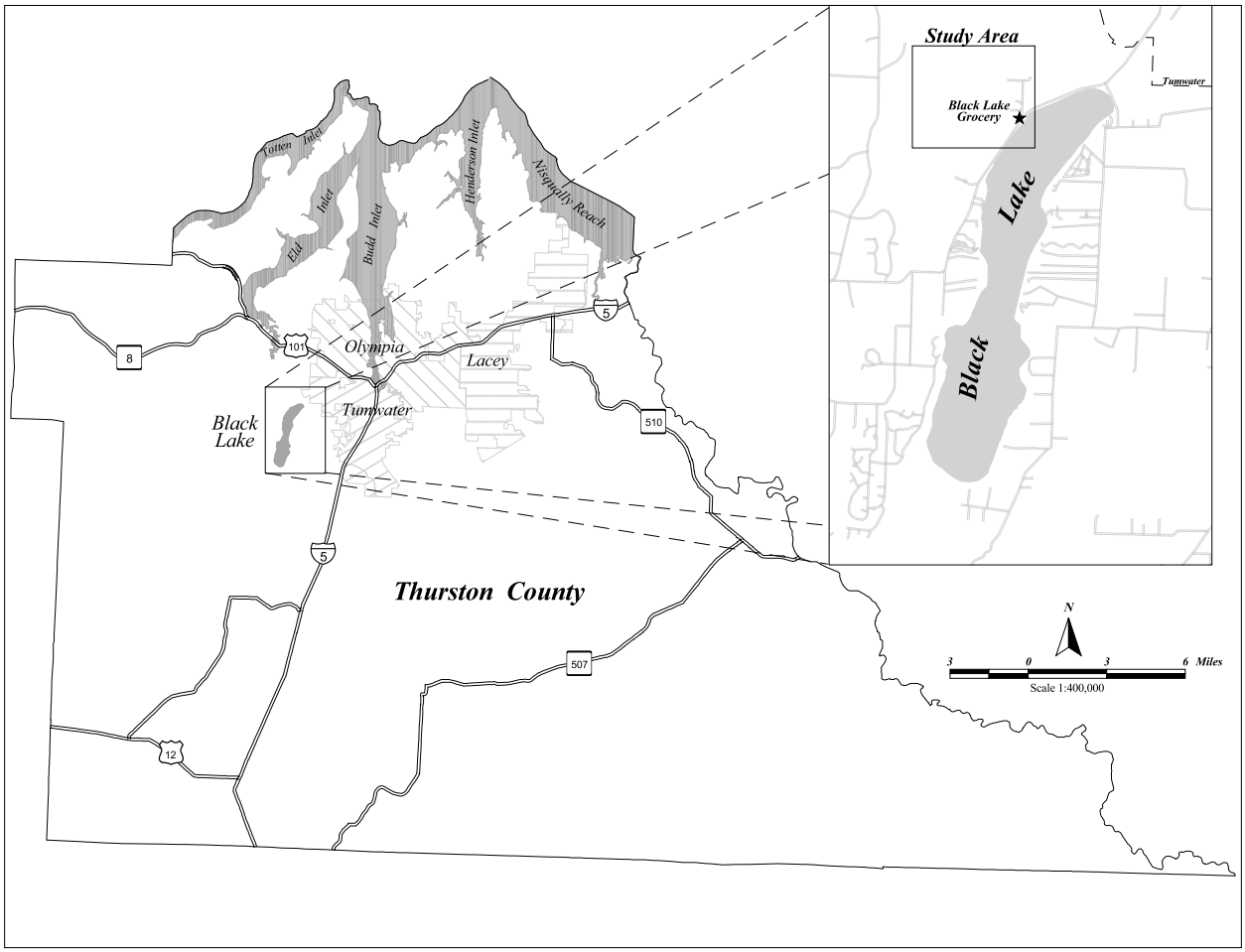

Figure 1. General Location of Black Lake and Black Lake Grocery.

Project Description

The goal of this project is to conduct an evaluation of lake sediments and surface water to determine whether or not they have been impacted by the petroleum products.

Near-shore sediments have never been evaluated for hydrocarbons or impacts to benthic communities. To determine whether petroleum products are moving with groundwater into the lake, sediment sample locations in Black Lake will be positioned to intersect groundwater flow from the site.

If Phase I study results show the lake sediments have been impacted by petroleum products, a second round of sediment sampling will be conducted to evaluate toxicity to aquatic life by use of sediment bioassay. To determine the need for bioassay, results from the initial survey will be compared to available freshwater sediment criteria. Numeric criteria for freshwater sediments are not available in the Washington State Sediment Management Standards (Chapter 173-402 WAC). Freshwater Sediment Quality Values (Cubbage, *et al.*, 1997 and Avocet Consulting, 2003) will be used as a screening tool. Sampling will be conducted near shore in Black Lake, selecting locations that are representative of groundwater movement from the Black Lake Grocery site.

Study results will be assessed by Ecology's Southwest Regional Office site manager to determine the need for remediation of contaminated lake sediments adjacent to the Black Lake Grocery.

The specific objectives of the study are to:

- Determine through near-shore sediment and surface water sampling (Phase I) if petroleum products have migrated from the Black Lake Grocery site into the lake.

- If results of Phase I sampling indicate that the lake sediments have been impacted by petroleum products, the Phase II study needs to be conducted to evaluate the toxicity of sediments and surface water through the use of bioassays.

Organization and Schedule

Responsibilities

The following individuals and organizations will be involved in the project:

Panjini Balaraju (Ecology): TCP Project Manager, client, and staff contact for the Southwest Regional Office. Responsible for reviewing the QA Project Plan and draft study report and coordination with site owners (360-407-6243).

Randy Coots (Ecology): Toxics Study Unit. Develops the project objectives, scope, and study design. Responsible for project management, preparation of the QA Project Plan, field sampling, and write-up of the study findings (360-407-6690).

Erika Wittmann (Ecology): Toxics Studies Unit. Responsible for assistance in preparation of the QA Project Plan and project support (360-407-6530).

Dale Norton (Ecology): Toxics Studies Unit Supervisor. Responsible for review of the QA Project Plan and draft study report (360-407-6765).

Will Kendra (Ecology): Section Manager, Watershed Ecology Section Manager. Responsible for review of the QA Project Plan and draft study report (360-407-6698).

Cliff Kirchmer (Ecology): Quality Assurance Officer. Responsible for review of the QA Project Plan and available for technical assistance on QA during implementation and assessment (360-407-6455).

Stuart Magoon and Manchester Environmental Laboratory Personnel (Ecology): Responsible for review of the QA Project Plan pertaining to laboratory analyses and the analysis/reporting of project data to the principal investigator (360-871-8801).

Carolyn Lee (Ecology): Toxics Studies Unit. Responsible for entering project data into the EIM database system (360-407-6430).

Schedule

Preparation and approval of QAPP	February 2005		
Field Sample Collection	March 2005	Phase II (if needed)	April 2005
Laboratory Analysis Complete	April 2005	Phase II (if needed)	May 2005
Draft Report	June 2005	Phase II (if conducted)	July 2005
Final Report	September 2005		
EIM Data Entry	September 2005		

Quality Objectives

Measurement Quality Objectives (MQO's) for accuracy (precision and bias) and required reporting limits for this investigation are shown in Table 1. The MQOs for this project are listed below in terms of maximum acceptable error and were taken from Ecology's guidance document to meet requirements of the Sediment Management Standards (Ecology, 2003).

Sampling bias should be low by use of standardized procedures for sampling, preservation, transportation, and storage.

Table 1. Measurement Quality Objectives for the Black Lake Sediment and Surface Water Investigation.

Analysis	Check Standards (LCS) and Surrogates[1]	Laboratory Replicates	Matrix Spikes	Matrix Spike Duplicates	
	% Recovery Limits	RPD[2]	% Recovery Limits	RPD	Lowest Concentration of Interest
Sediment					
NWTPH-Gx	35-150%[1]	50%	25-150%	35%	20 mg/Kg
BTEX	35-150%[1]	50%	25-150%	35%	50 *u*g/Kg
PAH	35-150%[1]	50%	25-150%	35%	230-11,000[4]
Lead	50-150%	20%	75-125%	30%[3]	0.10 mg/Kg
Ammonia	80-120%	50%	75-125%	30%[3]	100 *u*g/Kg
Total Sulfides	65-135%	50%	65-135%	30%[3]	10 mg/Kg
Percent Solids	NA	30%[3]	NA	NA	0.10%
Grain Size	NA	30%[3]	NA	NA	0.10% per fraction
TOC	80-120%	30%[3]	NA	NA	0.10%
Surface Water					
NWTPH-Gx	50-150%[1]	50%	50-150%	50%	0.12 mg/L
BTEX	50-150%[1]	50%	50-150%	50%	1 *u*g/L
Lead	75-125%	25%	50-150%	50%	0.10 *u*g/L
pH[5]	±0.2 pH units	±0.1 pH units	NA	NA	NA
Conductance[5]	±10 *u*mhos	10%	NA	NA	NA
Temperature[5]	NA	5%	NA	NA	NA

1 = Surrogates for NWTPH-Gx, BTEX, and PAHs as per MEL SOP.
2 = RPD is relative percent difference.
3 = Relative standard deviation (RSD) is used for parameters using triplicate analysis, the equivalent RPD is shown.
4 = See Table 5.
5 = pH, conductance, and temperature are measured in the field. Values are stated in terms of maximum allowable differences from the field check standards. Accuracy is ensured by pre- and post calibration and standard checks. Temperature will be verified by pre- and post sample event comparison to a reference thermometer.
NA = Not applicable.

Quality control requirements for freshwater bioassay tests proposed for Phase II of the study are included in the Sediment Sampling and Analysis Plan Appendix, Section 7 and Table 15 (Ecology, 2003). The laboratory procedures for these bioassays include positive and negative controls, and they establish quantitative criteria for control data for bioassay results to be considered valid (PSEP, 1995 and Ecology, 2003).

Sampling Design

This study will be implemented in two phases. Phase I will determine if petroleum contamination is present in Black Lake sediment and surface water. If Phase I results do not indicate contamination in lake sediments and surface water, the study will be concluded. If contamination is present, Phase II (bioassay testing) will be conducted to evaluate toxicity to benthic communities. Sediment and surface water samples for Phase I will be collected in March 2005. Phase II sampling will be conducted after results for the Phase I study have been received and evaluated, likely in late April.

Sediment sample locations for Phase I are positioned to identify any concentration gradient of petroleum products that may have migrated from the Black Lake Grocery site. Whole water samples will be collected from near-shore sediment sites to evaluate impacts to surface water. Sediment samples will be collected from seven near-shore sites down gradient of the Black Lake Grocery. Four samples will be collected parallel to the shoreline at three-to-four feet deep. Three deeper sites will be sampled at seven-to-eight feet deep (Figure 2). Results from the remedial investigation at Black Lake Grocery have shown monitoring well samples collected down gradient of the site near the shoreline contained petroleum products between two-to-fifteen feet deep. Black Lake sediment sites will be aligned where groundwater and runoff are known to transport contaminants. Placement of sample sites will begin just north of the Black Lake Grocery property at the discharge area of the unnamed tributary and proceed south just beyond the recently installed treatment wall. In addition, one reference site will be located at the southern end of Black Lake, the area most remote and least likely to be impacted by target analytes. Reference site sediments will be collected from three-to-four feet deep like near-shore study sites and analyzed for the same suite of parameters for comparison. If results from Phase I indicate a need for bioassay testing, sample locations for Phase II will be determined based on Phase I results.

Phase I sediment samples will be analyzed for Total Petroleum Hydrocarbons (TPH gas), Benzene Toluene Ethylbenzene Xylene (BTEX), Polynuclear Aromatic Hydrocarbons (PAHs), lead, percent solids, grain size, and Total Organic Carbon (TOC). Surface water samples will also be analyzed for TPH gas, BTEX, and lead but with the addition of pH, conductivity, and temperature field measurements. The lead analysis is being conducted as another means to identify historic petroleum discharges from the site. Lead was a gasoline additive prior to elimination in the early 1970s.

If Phase II (bioassay) sampling is conducted, three Ecology-approved (Ecology, 2003) freshwater sediment bioassays: 10 and 28-day amphipod (*Hyallela azteca*), 10 and 21-day midge (*Chironomus tentans*), and Microtox® will be used. In addition, companion sediment samples for percent solids, grain size, TOC, ammonia, and total sulfides will be collected and analyzed.

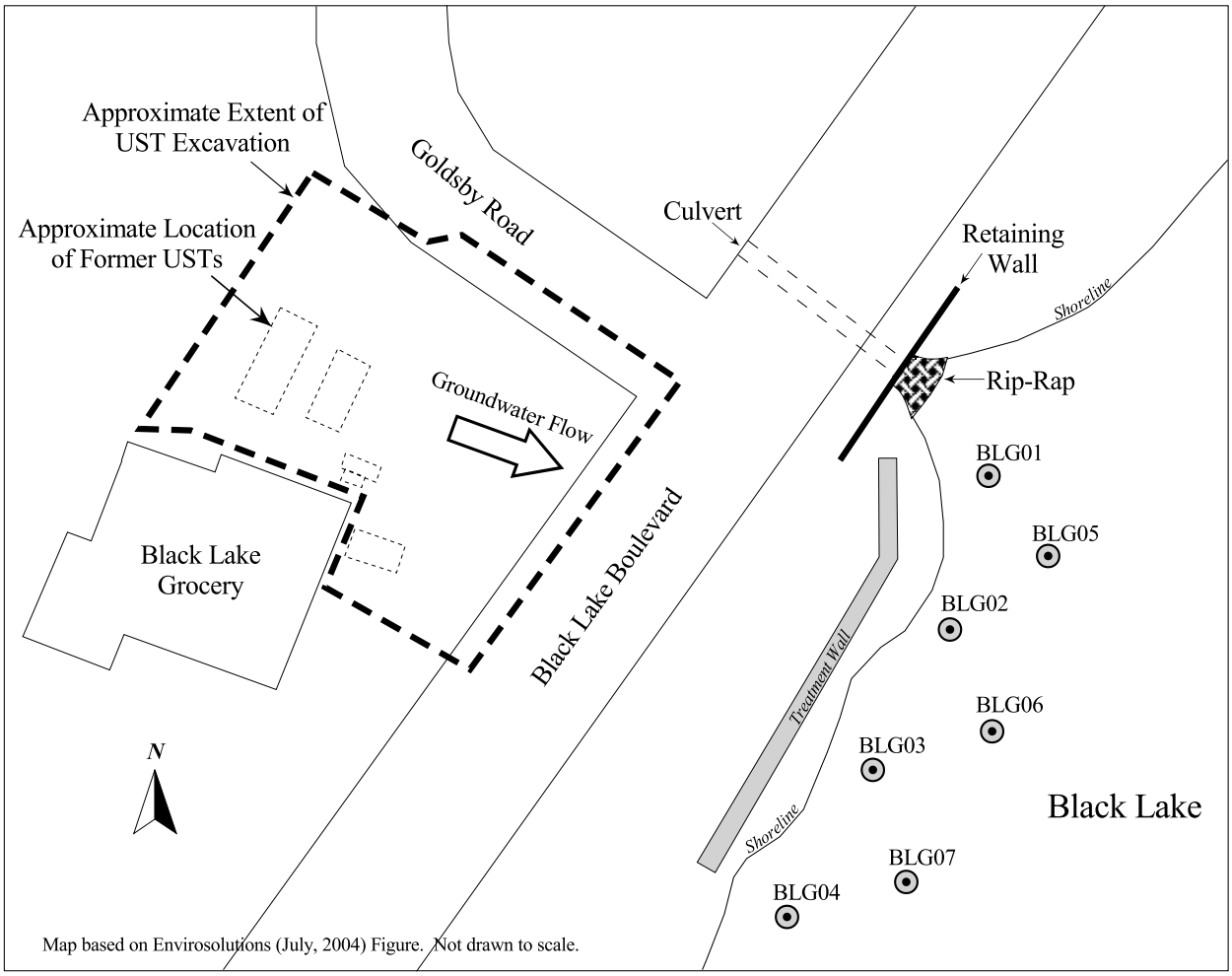

Figure 2. Proposed Sediment and Surface Water Sampling Stations.

Table 2. Coordinates of Proposed Sampling Stations in Decimal Degrees (NAD27).

Sampling Station	Latitude	Longitude
BLG01	47.0074	122.9743
BLG02	47.0072	122.9746
BLG03	47.0070	122.9748
BLG04	47.0068	122.9750
BLG05	47.0073	122.9741
BLG06	47.0070	122.9744
BLG07	47.0067	122.9747
Ref. Station*	46.9763	122.9825

*=Reference station not shown on Figure 2.

Field Sampling Procedures

Sediments

To the extent possible, sediment collection methods will follow PSEP (1996) protocols and requirements of Ecology's Sediment Management Standards (Chapter 173-204 WAC; Ecology, 2003).

Surface sediment samples will be collected from a 17 foot Boston Whaler or jet sled, using a 0.05 m^2 stainless steel Ponar grab. All sediment stations will be located by Differentially-corrected Global Positioning System (DGPS) and recorded in field logs.

Following collection of each sediment grab, an evaluation of acceptability will be made. Information about each grab will be recorded in the field sample log (example in Appendix B). A grab will be considered acceptable if it is not overfilled, overlaying water is present but is not overly turbid, the sediment surface appears intact, and the grab reached the desired sediment depth.

Overlaying water will be siphoned off prior to sub-sampling and stainless steel spoons and bowls will be used for manipulating sediments. Debris on the sediment surface or materials contacting the sides of the Ponar grab will not be retained for analysis.

Sediments will be collected once at seven stations and a reference site. To avoid volatilization of target analytes during sampling, a sediment syringe will be used to collect TPH and BTEX samples (Ecology, 2004b). Sediments to a depth of approximately 5 cm will be sealed in the syringe immediately following collection and transported intact to the laboratory for preservation. Two syringes of sediment will be collected at each site to ensure enough material is available for the required analysis and as back up in case of laboratory accident. For TOC and determination of grain size, the top 10 cm of sediment will be removed using stainless steel scoop, placed in a dedicated pre-cleaned mixing bowl, and homogenized. Subsamples of the homogenate will be placed in jars based on their respective analytical methods listed in Table 3.

If Phase II of the study is required, sediment subsamples for total sulfides and ammonia analyses should also be taken prior to homogenization. Disturbance of sediments during collection should be avoided to minimize losses of sulfide gases and volatilization. These subsamples will be collected immediately after a grab has been determined acceptable and prior to homogenization for other analyses.

Sample containers will be cleaned to EPA (1990) QA/QC specifications and certified for trace organic analyses. All stainless steel sampling equipment will be precleaned with Liquinox® detergent, rinsed with deionized water, 10% nitric acid solution, and pesticide-grade hexane. All equipment will be air dried and then wrapped completely in foil. To avoid cross-contamination, the grab will be thoroughly scrubbed and rinsed with site water between sample stations.

Surface Water

Surface water grab samples for NWTPH-Gx and BTEX analysis will be collected immediately above and without disturbance to the sediments once from station BLG01, BLG02, and BLG03 (Figure 2). Temperature, pH, and conductivity will also be measured at the time of sampling. Recommended collection containers, preservation, and holding times are listed in Table 3. Temperature and pH will be measured using an Orion Model 250 temperature-compensating pH meter. Electrical conductivity will be measured using a Beckman conductivity meter. Exact sample location coordinates will be determined in the field by using a DGPS.

Immediately after collection, samples from each station will be sealed in zip-lock plastic bags and placed in a cooler filled with ice. Samples will be transported to the Ecology Environmental Assessment (EA) Program Operations Center where they will be stored at 4° C. The following morning samples will be transported to the Ecology Manchester Environmental Laboratory (MEL). Analysis will be conducted within holding time requirements. Chain of custody will be maintained throughout the process, including archived samples.

Table 3. Sample Containers, Preservation, and Holding Time.

Parameter	Sample Container	Preservation	Holding Time[1]
SEDIMENT			
BTEX	5 gram EnCore® syringe	Cool to 4° C	14 days
NWTPH-Gx	5 gram EnCore® syringe	Cool to 4° C	14 days
PAH's	8 oz glass jar	Cool to 4° C	14 days
Lead	4 oz glass jar	Cool to 4° C	6 months
Ammonia	8 oz glass jar	Cool to 4° C - no head space	7 days[2]
Total Sulfides	8 oz glass jar	Cool to 4° C - no head space, 5 mL of 2 N zinc acetate	7 days[2]
% Solids	2 oz glass jar	Cool to 4° C	7 days
Grain Size	8 oz plastic jar	Cool to 4° C	6 months
TOC	2 oz glass jar	Cool to 4° C	14 days
SURFACE WATER			
BTEX	3 40 mL VOA vials w/ septum, per field station, plus 3 extra QC	1:1 HCl, Cool to 4° C	14 days if preserved with HCl
NWTPH-Gx	3 40 mL VOA vials w/ septum, per field station	1:1 HCl, Cool to 4° C	14 days
Lead	1 L HDPE bottle	HNO_3 to pH < 2 (by lab within 24 hours of arrival)	6 months
PHASE II BIOASSAY			
Hyallela azteca (amphipod bioassay)	1 gallon glass jar	Cool to 4° C, keep in dark	14 days
Chironomus tentans (midge bioassay)	1 gallon glass jar	Cool to 4° C, keep in dark	14 days
Microtox	1 liter glass jar	Cool to 4° C, keep in dark	14 days

1 = Holding time for BTEX, NWTPH-Gx, and PAH samples is until extraction.
2 = Ecology, 2003.

Measurement Procedures

All project samples will be analyzed at MEL or a contractor arranged by MEL. A summary of laboratory procedures for project samples appears below in Table 4.

Table 4. Analytical Methods and Detection Limits for the Black Lake Sediment and Surface Water Investigation.

Analytes	Preparation Method	Method	Reference	Detection Limit
SEDIMENT				
BTEX (volatile aromatics)		EPA SW-846 Method 8021B	EPA 1996	1-5 µg/Kg
TPH – Gasoline		NWTPH-Gx	Ecology 1997	20 mg/Kg
Lead	EPA 3050B	EPA 6020	EPA 1996	0.10 mg/Kg
PAH's	EPA 3540C	EPA 8270C	EPA 1989	77-1067 ug/Kg
Ammonia		Plumb 1981	EPA/CE81-1	100 ug/Kg
Total Sulfides		9030B	EPA 1986	10 mg/Kg
% Solids		EPA 160.3	EPA 1996	0.1%
Grain Size		Plumb 1981	EPA/CE81-1	1%
TOC		Combustion/ CO_2 Measurement @ 70 °C	PSEP 1997	0.1%
SURFACE WATER				
BTEX		EPA SW-846 Method 8021B	EPA 1996	1 µg/L
TPH – Gasoline		NWTPH-Gx	Ecology 1997	0.12 mg/L
Lead	EPA 200.8	EPA 200.8		0.1 ug/L
PHASE II BIOASSAY				
Hyallela azteca (amphipod) 10 day & 28 day		EPA 100.4	ASTM 2000	-
Chironomus tentans (midge) 10 day & 21 day		EPA 100.5	ASTM 2000	-
Microtox®		Microtox®	PSEP 1995	-

The EPA 8270C method for analysis of PAHs in sediments is a modification of the EPA 1625 method. The modification is an isotopic dilution procedure for quantitation. The SOP for the modified method is available from MEL. To ensure detection limits for PAHs are low enough to allow comparison to SQVs, Table 5 below lists SQVs for individual hydrocarbons and the level that detection limits must be below in order to meet project objectives. The SQVs included in the table below are from Cubbage et al. (1997) and Avocet Consulting (2003). If the laboratory fails to meet detection limits for comparison to SQVs, corrective action should be taken to notify the project manager and reanalyze the original extract with cleanup as required or reextract and reanalyze.

Table 5. Freshwater Sediment Quality Values for PAHs.

	Cubbage *et al.*		Avocet Consulting
Chemical	**LAET[1]**	**FSQV[2]**	**2003 LAET[3]**
PAH Units: *u*g/Kg Dry Weight			
Naphthalene	46,000	37,000	**529**
Acenaphthylene	2,200	1,900	**470**
Acenaphthene	4,100	3,500	**1,060**
Fluorene	4,200	3,600	**1,070**
Phenanthrene	15,000	**5,700**	6,100
Anthracene	2,800	2,100	**1,230**
Total LPAH	74,000	27,000	**6,590**
Fluoranthene	21,000	**11,000**	11,100
Pyrene	23,000	9,600	**8,790**
Benz(A)Anthracene	7,700	5,000	**4,260**
Chrysene	11,000	7,400	**5,940**
Total Benzofluoranthenes	16,000	**11,000**	**11,000**
Benzo(A)Pyrene	11,000	7,000	**3,300**
Indeno(1,2,3-CD)Pyrene	760	**730**	4,120
Dibenzo(A,H)Anthracene	**230**	**230**	800
Benzo(G,H,I)Perylene	1,400	**1,200**	4020
Total HPAH	91,000	36,000	**31,640**
Total PAH	170,000	**60,000**	**--**

LAET1 = Lowest AET between Microtox and Hyalella AET.
FSQV2 = Freshwater Sediment Quality Values: Organics derived from PAET Microtox and Metals from Marine SMS.
2003 LAET[3] = 2003 Apparent Effects Thresholds derived from four bioassay endpoints.
Bolded values are the maximum analytical detection level per analyte.

Budget Information

Price estimates include field QA samples and are based on a 50% discount rate for analysis at MEL. Estimates for the bioassay testing are from other recent projects.

Table 6. Estimated Costs for Analyzing Black Lake Sediment and Surface Water Samples.

PHASE I Sediment	Stations	QA Samples	Total	Cost per Unit	Contracting Fee	Total
BTEX + TPH (gas)	8	1	9	$140	-	$1,260
Lead	8	1	9	$35	-	$315
PAH's	8	3[1]	11	$304	-	$3,344
Percent Solids	8	1	9	$10	-	$90
Grain Size	8	1	9	$100	$225	$900
TOC	8	1	9	$39	-	$351
					Sediment Subtotal	$6,260

PHASE I Surface Water	Stations	QA Samples	Total	Cost per Unit	Contracting Fee	Total
BTEX + TPH (gas)	3	2[2]	5	$100	-	$500
Lead	3	1	4	$60	-	$240
pH	3	1	4	Field	-	-
Conductivity	3	1	4	Field	-	-
Temperature	3	1	4	Field	-	-
Phase I Analysis						$7,000
Phase I Analysis + 25% contracting fee					Subtotal	$7,225

[1] = Includes transport blank [2] = Includes Matrix spike, matrix spike duplicate

PHASE II Bioassay	Stations	QA Samples	Total	Cost per Unit	Contracting Fee	Total
Hyallela azteca (amphipod)	4	0	4	$750	$750	$3,000
Chironomus tentans (midge)	4	0	4	$900	$900	$3,600
Microtox®	4	0	4	$200	$200	$800
					Bioassay Subtotal	$7,400

PHASE II Sediment	Stations	QA Samples	Total	Cost per Unit	Contracting Fee	Total
Percent Solids	4	1	5	$10	-	$50
Grain Size	4	1	5	$100	$125	$500
TOC	4	1	5	$39	-	$195
Ammonia	4	1	5	$50	-	$250
Total Sulfides	4	1	5	$40	-	$200
Phase II Analysis						$8,595
Phase II Analysis + 25% contracting fee					Subtotal	$10,570

1 = Includes MS/MSD samples.
2 = Includes transport blank.

Phase I Subtotal:	$7,225
Phase II Subtotal:	$10,570
Project Total:	**$17,795**

Quality Control Procedures

Field Quality Control

Quality control field samples provide an estimate of the overall variability of each analysis. Field quality control will entail collection and analysis of replicate samples, and replicate meter measurements. Field replicates are defined as two or more samples collected at the same time and place. They are treated the same as other samples and provide an estimate of the total variability of analysis (laboratory plus field). A complete set of replicate samples for both sediment and surface water will be collected from one of the four shallow sites shown in Figure 2. Replicate samples will be collected by filling two sets of sample containers sequentially. Relative Percent Difference (RPD) will be calculated from the results of replicate pairs as an estimate of the overall variability of each analysis.

One transport blank supplied by MEL will be analyzed for BTEX in water. The blank will be taken to and from the field along with the other study sample containers but remain sealed through the sample day. The transport blank will be treated as other study samples. Results from the transport blank may indicate contamination from the sample containers or cross contamination during shipment, storage, or laboratory contamination (MEL, 2001).

Field meters will be calibrated at the start of the sample day according to the manufacturer's instructions. Replicate field measurements will be taken once during the sample day for temperature, pH, and conductivity to estimate precision. A check standard will also be measured once during the sample day for pH and conductivity to evaluate accuracy.

To help minimize variability from sample collection, field samplers will be familiar with and follow methods described in WAS (1993) and PSEP (1996). All sampling equipment will be cleaned prior to going into the field according to protocols (see Field Procedures). Precleaned, sampling equipment will be wrapped in aluminum foil until used

Laboratory Quality Control

Quality control procedures should conform to requirements provided by MEL (2001) and the Ecology Sediment Management Unit (Ecology, 2003). The laboratory uses blanks, matrix spikes, surrogates, and check standards (another name for laboratory control samples) for quality control samples (MEL, 2003).

Laboratory duplicate and triplicate analysis will be used to estimate analytical precision. Matrix spikes will be used as an indicator of bias due to matrix interference, while lab control samples will be used as an indicator of bias due to calibration. Laboratory blanks are analyzed to verify that the analytical system is free of significant contamination and that detection limits can be met. MEL's Quality Assurance Manual (MEL, 2001) provides discussion in more detail of the quality control samples and procedures.

Information on the quality control requirements to meet Sediment Management Standards (Chapter 173-204 WAC) for sediment bioassay and related conventional analyses can be found in Ecology (2003), Table 15 and Table 13, respectively. Guidance on control limits and performance standards are provided. The required quality control samples to meet Sediment Management Standards for conventional analyses and lead are listed below in Table 7.

Table 7. Quality Control Samples.

Parameter	Laboratory Blanks	Laboratory Duplicates	Lab Control Samples (LCS)	Matrix Spikes
Lead	1/batch	1/batch	-	1/batch
Percent Solids	-	1 triplicate	-	-
Grain Size	-	1 triplicate	-	-
TOC	1/batch	1 triplicate	-	-
Ammonia	1/batch	1 triplicate	1/batch	1/batch
Total Sulfides	1/batch	1 triplicate	1/batch	1/batch

Audits and Reports

MEL conducts performance and system audits for routine analytical procedures. Results of these audits can be obtained by request. MEL and any contracted laboratory conducting analysis for the project must be accredited by Ecology's Quality Assurance Unit. As part of the accreditation process performance and system audits are included.

A draft study report will be completed in June of 2005. If Phase II of the study is conducted the draft will be completed in July 2005. The draft report of study findings at a minimum will include the following:

- A study area map showing the sampling sites.
- Latitude and longitude and other information describing the sampling sites.
- Descriptions of field and laboratory methods.
- A data quality synopsis and discussion of the significance of any analytical problems.
- Summary tables of chemical and biological data.
- An evaluation of significant findings.
- A comparison to applicable environmental quality guidelines.

A final report will be prepared in September 2005. Following final review, project data will be entered into the Ecology EIM database system. As per requirements of Sediment Management Standards, all sediment data will be entered into SEDQUAL templates, following final review. Electronic versions of the study report or data will be available to the public through Ecology's internet site at: http:\\www.ecy.wa.gov.

Data Verification and Validation

MEL will review the Quality Assurance (QA) Project Plan and all of the sample and quality control data. MEL is responsible for verifying the data and providing a verification report, and the project lead is responsible for validating the data. Data validation involves detailed examination of the complete data package using professional judgment to determine whether the measurement quality objectives (MQOs) for precision, bias, and sensitivity have been met (Ecology, 2004a).

A data verification report will be sent to the project lead in the form of case narratives and will include an assessment of the laboratory's performance in meeting the conditions and requirements set forth in this sampling plan. On receipt of the data, the project lead will review the results for completeness, reasonableness, and usability. The results of bioassay analysis will also be validated by the project lead to ensure that the methods and test conditions were followed and that results on negative/positive controls and reference toxicants were acceptable.

Data Quality Assessment

After the project data has been reviewed, verified, and validated, the project lead will determine if the data is of sufficient quality to make decisions for which the study was designed. The data from the laboratory's quality control procedures and replicate field samples will provide information to determine if DQOs have been met. Laboratory and quality assurance staff familiar with assessment of data quality may be consulted. The projects final report will discuss data quality and whether the project objectives can be met. If limitations in the data are identified, they will be noted.

The study is designed in two phases. Phase I is a screening level study to determine the presence, or absence, of petroleum products in lake sediments or water. Results will be compared to available FSQVs. If petroleum is confirmed in the sediments or surface water, Phase II (bioassay testing) will be conducted. Placement of Phase II sample sites will be based on results from Phase I. Results of bioassay testing will be evaluated for compliance with sediment Management Standards. Study results will be presented in tables with reference to site maps for illustration. If petroleum is found in lake sediments, contouring software like Surfer® may be used for development of figures for presentation of contaminant levels.

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Appendices

Appendix A

Historical Results from Groundwater and Soil Monitoring at Black Lake Grocery

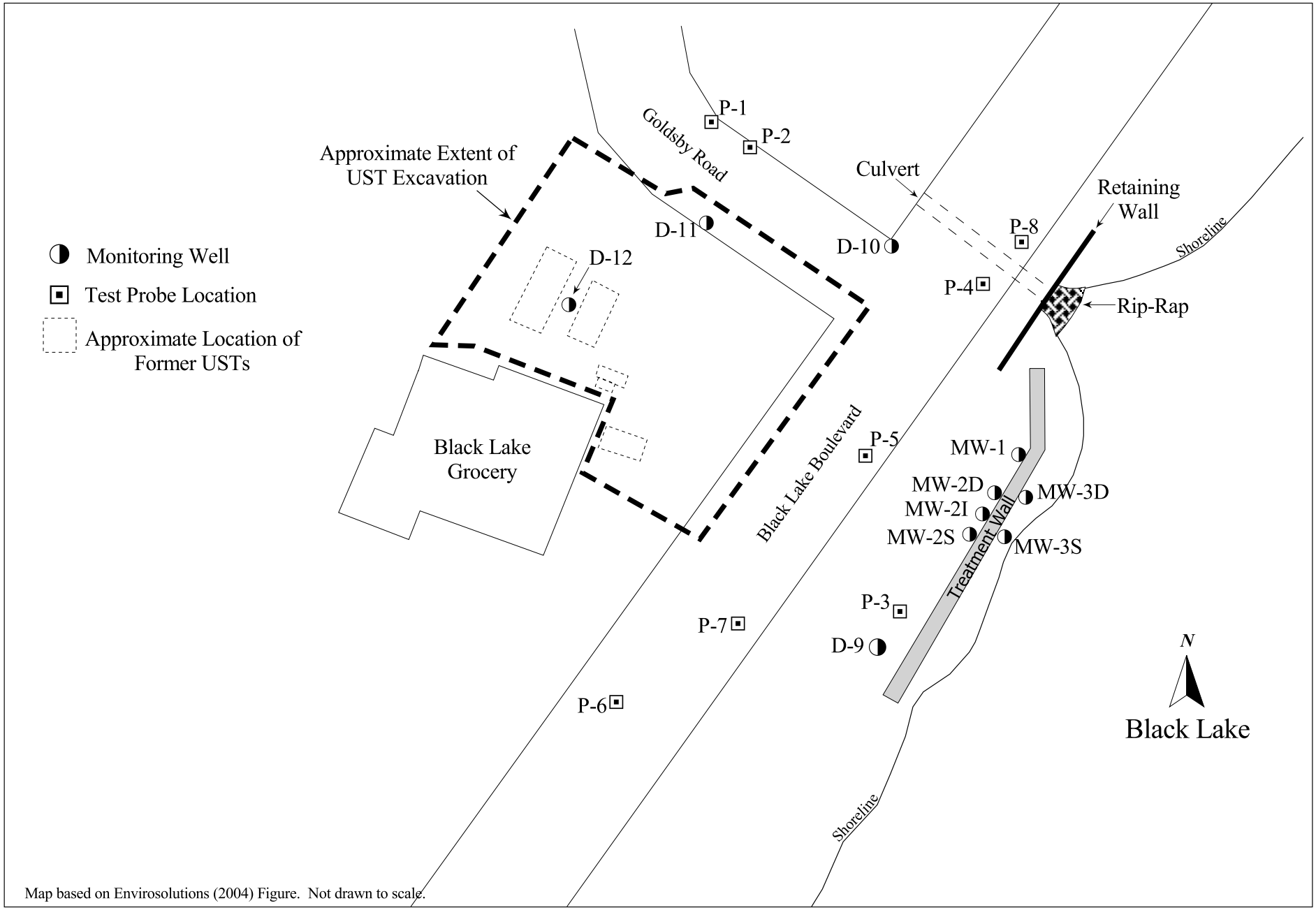

Figure A1. Historical Sample Locations for the Black Lake Grocery.

Table A1. Historical Data Reported by Summit Envirosolutions (2004) from Black Lake Grocery (units = *u*g/L).

Well	Sample Date	Contaminant				
		Benzene	Toluene	Ethylbenzene	Xylenes	TPH-G
D9	11/23/93	**909**	**3520**	**1720**	**6050**	**57570**
	4/14/95	**830**	**1500**	**1300**	**2600**	**28000**
	8/29/95	**570**	**680**	**510**	**1100**	**13000**
	12/17/96	**164**	**190**	**170**	**418**	**3300**
D10	11/23/93	**8450**	**8670**	**1450**	**5260**	**30680**
	12/17/96	**8150**	**4830**	**2190**	**9680**	**45400**
	5/11/00	**5580**	**931**	**1070**	**3660**	**40700**
D11	11/23/93	**1020**	**2670**	**838**	**4180**	**32750**
	4/14/95	**4700**	**4300**	**820**	**4000**	**24000**
	8/29/95	**3500**	**2500**	**1200**	**4500**	**32000**
	12/17/96	**3640**	**3950**	**1770**	**6740**	**49800**
	5/11/00	**2690**	**988**	**1570**	**4220**	**24500**
D12	8/29/95	0.51	0.5 U	0.67	1 U	50 U
	12/17/96	0.5 U	0.5 U	0.5 U	1 U	50 U
	5/11/00	0.5 U	0.5 U	0.5 U	1 U	50 U
MW-1	12/17/96	**10600**	**17400**	**3160**	**16000**	**10600**
MW-2S	1/12/00	**7360**	**16600**	**2960**	**16000**	**122000**
	5/11/00	**7930**	**14300**	**2780**	**16300**	**104000**
MW-2I	12/17/96	**8860**	**15200**	**2710**	**15500**	**110000**
	5/11/00	**8860**	**1640**	**1300**	**2040**	**18000**
MW-2D	12/17/96	**3040**	**7300**	**1830**	**10700**	**64000**
	5/11/00	**787**	28.9	**41.6**	13.4	425
MW-3S	12/17/96	**7860**	**11600**	**2730**	**13200**	**83600**
MW-3D	12/17/96	**132**	**138**	**20.8**	**1440**	**11600**
Sump	1/14/97	**7340**	**14500**	**2040**	**10200**	**82900**
Holding Tank	1/28/97	**2090**	**3620**	**86.8**	**2970**	**24200**

Bolded values exceed MTCA Method A Cleanup Levels.
U = Not detected at the detection limit shown.

Table A2. Historical Inorganic Analytical Data Reported by Summit Envirosolutions (2004) from the Black Lake Grocery Site.

Well	Date	pH (units)	Temp (°F)	Sp Cond (uS/cm)	Iron (mg/L)	CO_2	DO (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	Mn (mg/L)	Ammonia (mg/L)	TKN (mg/L)	Sulfide (mg/L)	Sulfate (mg/L)
D9	4/14/95	6.29	53	527	---	---	---	---	---	---	---	---	---	---
	8/29/95	6.68	74.5	0.01	9.6	120	4.5	< 0.1	---	---	---	---	---	---
	12/17/96	6.34	---	---	< 0.15	91.5	---	< 0.05	< 0.1	1.55	< 0.1	< 1	< 10	1.46
D10	12/17/96	5.61	---	---	5.67	97.2	---	< 0.05	< 0.5	3.12	0.28	11.1	< 10	0.543
D11	4/14/95	6.06	52.7	709	---	---	---	---	---	---	---	---	---	---
	8/29/95	6.59	72.3	0.02	17	230	6.5	< 0.1	---	---	---	---	---	---
	12/17/96	5.79	---	---	< 0.15	106	---	< 0.05	< 1	6.98	1.09	< 1	< 10	0.572
D12	8/29/95	6.18	74.2	0.026	23	34	7	0.76	---	---	---	---	---	---
	12/17/96	7.43	---	---	< 0.15	44.9	---	1.04	< 0.2	0.053	< 0.1	< 1	< 10	30.7
MW-1	12/17/96	6.29	---	---	< 0.15	65.1	---	1.3	< 10	2.12	< 0.1	7.92	<10	68.1
MW-2S	12/17/96	5.95	---	---	< 0.15	108	---	0.182	< 0.5	1.56	< 0.1	9.07	< 10	26.4
MW-2I	12/17/96	6.02	---	---	< 0.15	92.8	---	0.421	< 0.2	1.27	< 0.1	1.82	< 10	44
MW-2D	12/17/96	6.2	---	---	< 0.15	56.8	---	0.121	< 10	0.778	< 0.1	< 1	<10	26.7
MW-3S	12/17/96	5.82	---	---	< 0.15	85.4	---	1.31	< 2	2.2	< 0.1	4.2	< 10	88.1
MW-3D	12/17/96	6.14	---	---	< 0.15	72.2	---	< 0.05	<2	0.527	< 0.1	< 1	< 10	30.9

Table A3. On-site Groundwater Analytical Results. Test Probes Taken by Summit Envirosolutions, Inc. (2000) from Black Lake Grocery Site (units = *u*g/L).

Well	Date	Depth	Contaminant				
			Benzene	Toluene	Ethylbenzene	Xylenes	TPH-G
P1	6/29/95	15	4 U	4 U	4 U	4 U	NA
	8/7/95	20	2 U	2 U	2 U	2 U	100 U
P2	6/29/95	15	980	24	10	72	NA
	8/7/95	20	2 U	2 U	2 U	3	100 U
P3	6/29/95	6	7040	450	383	663	NA
	8/7/95	11	5	8	2 U	10	91
P4	6/29/95	15	20900	11500	1640	14800	NA
	8/7/95	20	2 U	2 U	2 U	2 U	100 U
	8/7/95	25	2 U	2 U	2 U	2 U	100 U
P5	6/29/95	15	2920	8460	7620	27800	NA
	8/7/95	20*	379	826	971	2250	21800
	8/7/95	25*	715	3180	36	48	14400
P6	6/29/95	15	4 U	4 U	4 U	4 U	NA
P7	6/29/95	15	2 U	2 U	2 U	2 U	100 U
P8	6/29/95	15	2 U	2 U	2 U	2 U	100 U

* = Sample integrity compromised during sampling, results questionable.
U = Not detected at the detection limit shown.
NA = Not analyzed.

Table A4. Historical On-Site Soil Analytical Results. Test Probes Taken by Summit Envirosolutions (2004) from Black Lake Grocery Site (units = *u*g/Kg).

Sample Location	Depth	Date Collected	Contaminant				
			TPH-G	Benzene	Toluene	Ethylbenzene	Xylenes
P1	14-16 ft	6/29/95	NA	< 4	< 4	< 4	< 4
P4	14-16 ft	6/29/95	NA	2490	664	98	192
P5	14-16 ft	6/29/95	NA	69	97	124	408
P6	14-16 ft	6/29/95	NA	< 4	< 4	< 4	< 4
P7	14-16 ft	6/29/95	< 100	< 2	< 2	< 2	< 2
P8	14-16 ft	6/29/95	< 100	<2	< 2	< 2	< 2

NA = Not analyzed.

Appendix B

Example
Field Log Sheet for Black Lake Sediment Sampling

Field Sample Log

Site: **Black Lake, Tumwater, WA**

Recorder: _____

	Station Coordinates	Station	Grab #	Depth (ft)	Date	Time	Penetration (cm)	pH		Conductivity	Sample Description (Texture, Color, Debris, Sheen, Odor)
								Surface	Bottom		
LAT LONG											
LAT LONG											
LAT LONG											
LAT LONG											
LAT LONG											
LAT LONG											
LAT LONG											
LAT LONG											
LAT LONG											
LAT LONG											