Lilyblad Site Remedial Action Quality Assurance Project Plan

Prepared for

Department of Ecology

June 2009

CH2MHILL
CH2M HILL
1100 112th Avenue NE
Suite 400
Bellevue, WA 98004-4504

Quality Assurance Project Plan

Approvals

Approved by:

CH2M HILL Project Manager	Date
CH2M HILL Data Quality Assurance Manager	Date
Washington Department of Ecology Project Manager	Date

Distribution List

_________________ Washington Department of Ecology Project Manager

_________________ CH2M HILL Project Manager

_________________ CH2M HILL Task Leaders

_________________ CH2M HILL Data Quality Assurance Manager

1 Introduction

The purpose of this Quality Assurance Project Plan (QAPP) is to specify the policies, organization, objectives, functional activities, and quality assurance (QA) and quality control (QC) activities associated with generating data, including the collection and analysis of environmental samples in accordance with the Lilyblad Site Remedial Action Work Plan (Work Plan), 2008. This work is being conducted for the Washington State Department of Ecology (Ecology).

The Field Sampling Plan (FSP), presented in Attachment A, has been prepared to provide a detailed description of the field sampling program for the Lilyblad Site remedial action. The FSP includes a description of the QA/QC activities associated with collecting, packaging, and shipping environmental samples from the remedial investigation. A Health and Safety Plan (HSP) was prepared that describes potential hazards and personal protective and monitoring equipment that will be needed for the remedial action sampling.

For consistency and comparability of the data with the preceding remedial investigation data at this site (2003), this QAPP follows the same guidance and procedures as the preceding one, as per project specific guidance from Ecology (EPA, 1998 and Ecology, 2001).

2 Project Organization and Schedule

The project organization is shown in Figure 1. The Project Manager will have the overall responsibility for implementing the project. The Project Manager will be responsible for defining work scopes, project schedule, and financial status; administering staff; and providing overall quality review of project deliverables.

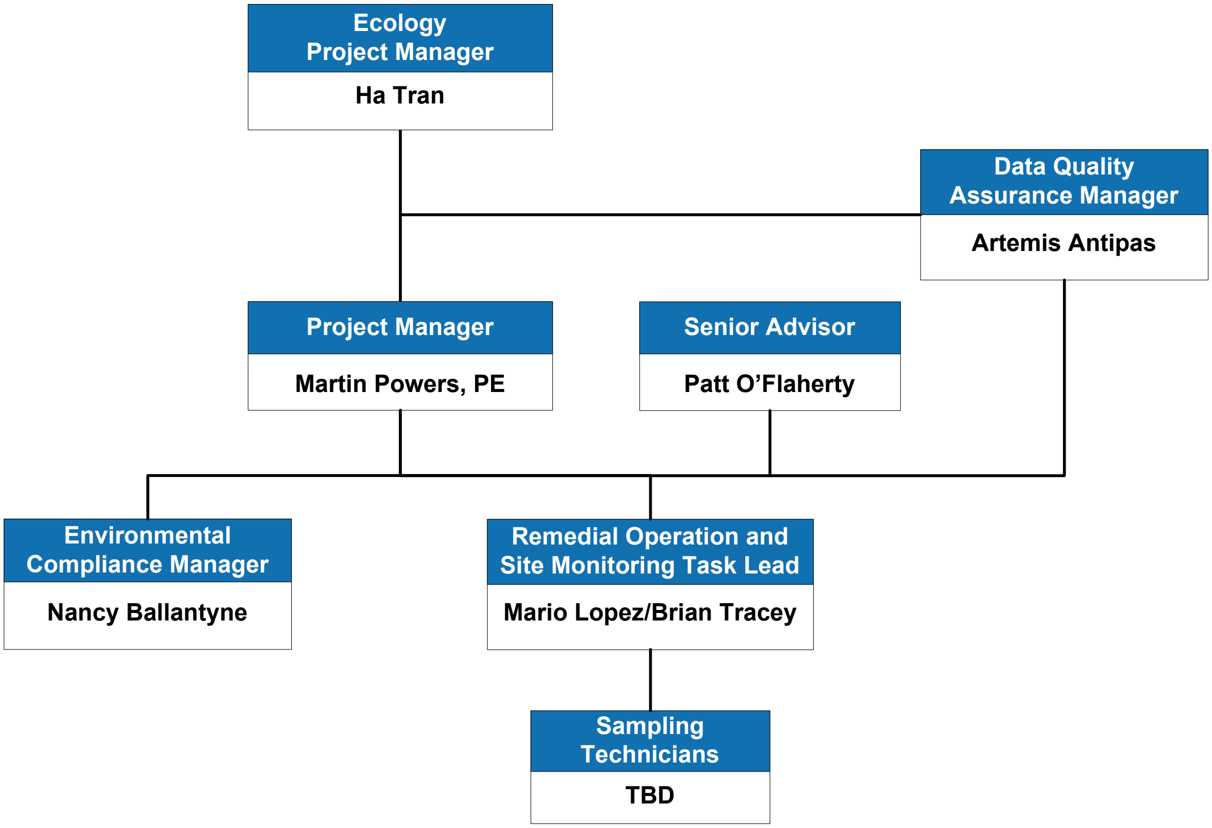
Independent technical review will be provided by the senior reviewers for project deliverables. When data QA problems or deficiencies requiring special action are identified, the Data QA Manager will identify the appropriate corrective action to be initiated by the Project Manager.

The Health and Safety Manager will be responsible for the project's health and safety planning and work practices. The Health and Safety Manager will coordinate directly with the remedial action sampling field team leaders.

The remedial action sampling field team leaders will be responsible for staffing, scheduling subcontract work, and maintaining the quality of all activities conducted in the field. The field team leaders will work closely with the Health and Safety Manager to create and maintain a safe working environment under all conditions at the Lilyblad Site.

Soil, groundwater and vapor sampling and analyses are expected to be carried out from April 2009 through June 2015**.** The project schedule is presented in the Remedial Action Work Plan.

FIGURE 1.
Lilyblad Quality Assurance Project Organization Chart
Lilyblad Site Remedial Action, Tacoma, WA



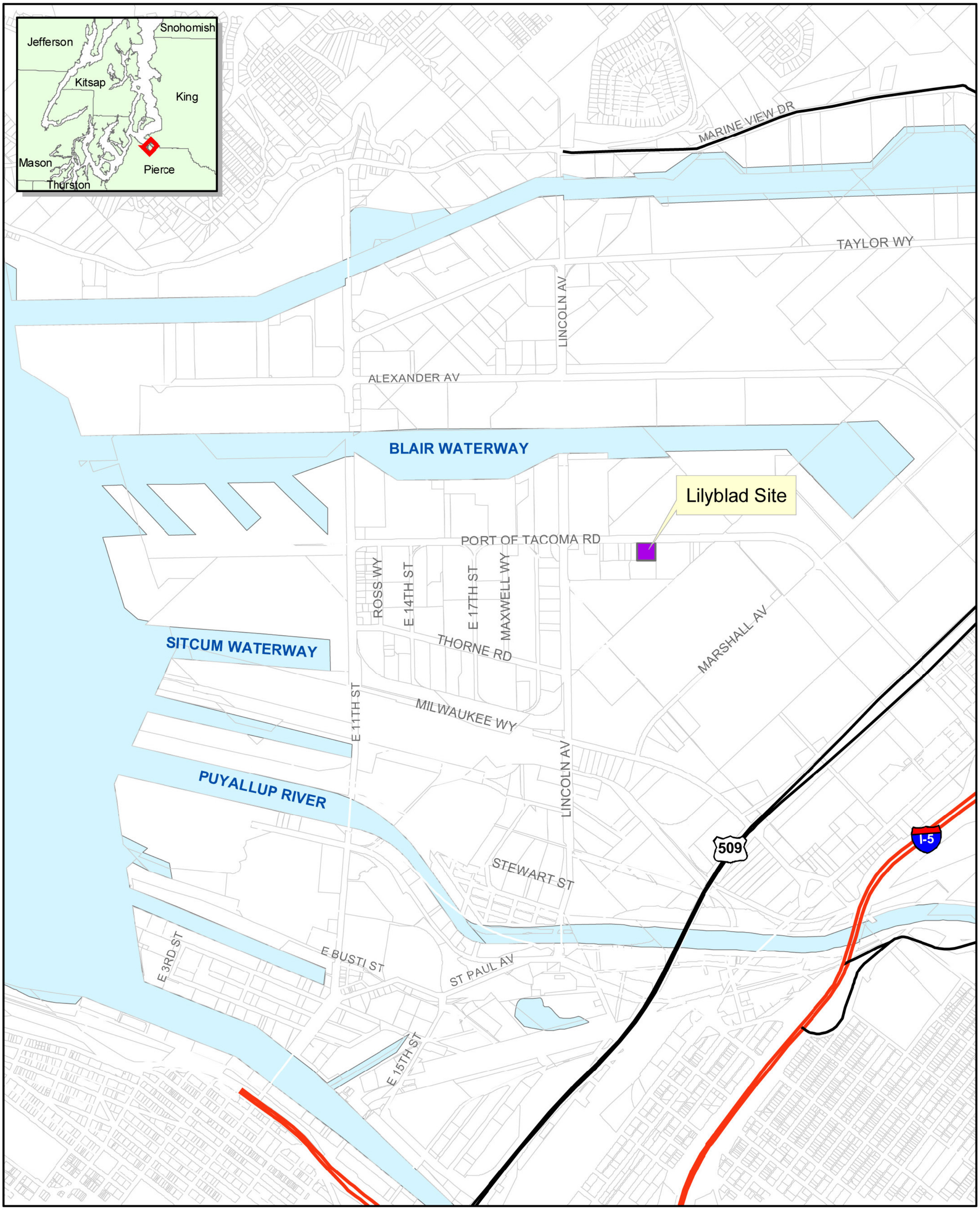
3 Background

3.1 Operational History

The Lilyblad Site (Figure 2) is located in the Tacoma Tide Flats industrial area. Prior to development, the area was part of the Puyallup River delta, which consisted of a series of braided channels, marshes, and lowlands. Lilyblad Petroleum Inc. (Lilyblad) began operation at the site in 1972 as a distributor of gasoline, diesel, solvents, and packaged petroleum products. Lilyblad was involved in various solvent mixing and recycling operations between 1972 and 2003. In 2003, Pacific Functional Fluids (PFF) purchased Lilyblad's assets, and continued operations to store, blend, repackage and distribute chemical and petroleum products. Lilyblad Petroleum Inc. is no longer in business. M&G Holdings currently owns the property that was previously owned by Lilyblad.

3.2 Regulatory History

The regulatory boundary of the Lilyblad Site extends over the portion of the former Lilyblad property (currently leased by PFF) and portions of adjacent parcels - including the Nelson Property, Port of Tacoma Road, the JM Eagle (formerly PW Eagle) Property, and the Saul Property (Figure 3). Lilyblad formerly operated the facility as an interim status dangerous



▭ Parcel Boundaries

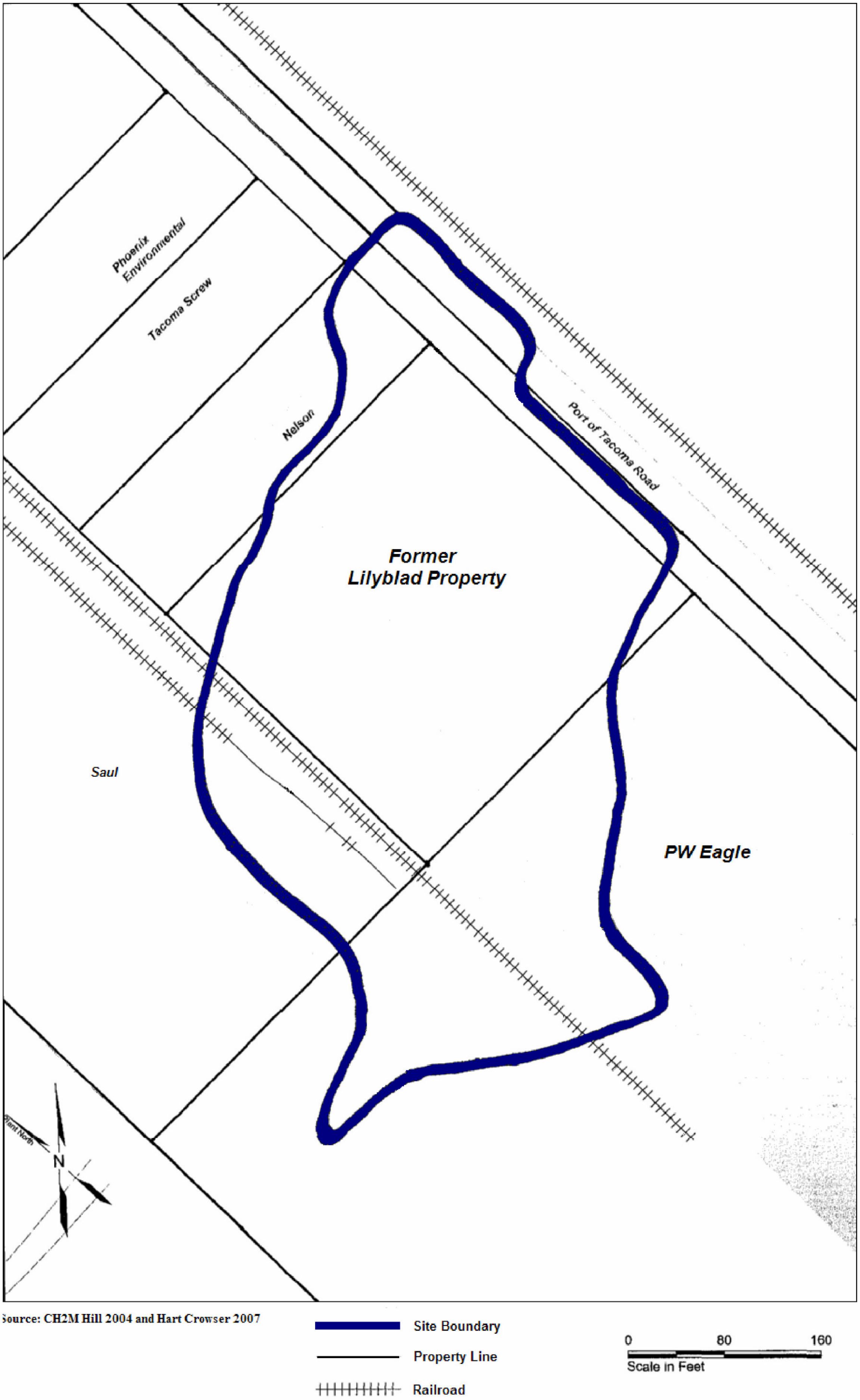
🟦 Waterbodies

Figure 2 Site Vicinity Map

Supplemental Remedial Investigation Report

Lilyblad Petroleum, Tacoma, WA

File Path: P:\LilybladPetroleum\177582\GIS\MapDocuments\SupplementalRI\Site_Location_Fig1-1.mxd



Source: CH2M Hill 2004 and Hart Crowser 2007

Figure 3 Lilyblad Site Boundary

Source: DOE Cleanup Action Plan, 2007

waste treatment, storage, and disposal (TSD) facility regulated under Subtitle C of the Resource Conservation and Recovery Act (RCRA). Ecology issued enforcement actions pursuant to the Model Toxics Control Act (MTCA) and named both Lilyblad and Sol Pro as potentially liable parties (PLPs). On October 30, 1995, the PLPs and Ecology entered into Agreed Order DE 95HS-S292 requiring the PLPs to prepare the remedial investigation/feasibility study (RI/FS) and cleanup action plan (CAP). Ecology issued an amendment to the Agreed Order on October 10, 2000, which required Lilyblad to develop and implement an interim action work plan to remediate contaminated groundwater and soil at the site. Ecology amended the Agreed Order again on August 15, 2006 and took over the preparation of the FS and CAP.

Ecology directed regulatory actions affecting the site, including the implementation and termination of several interim remedial actions and pilot studies. The interim actions required by the October 2000 amendment to the Agreed Order were conducted as follows:

- In March 2001, Camp, Dresser, and McKee (CDM) installed a groundwater interception trench system on the north and south corners of the Lilyblad Property, installed and operated multi-phase extraction (MPE) wells on the west side of the PW Eagle manufacturing building, and added a treatment system to treat extracted groundwater and soil vapor from the trenches and MPE wells. CDM's remedial activities were not effective in removing contaminants and were discontinued by September 2003.
- Terra Vac began a pilot study of *in situ* treatment technology at the site in September 2003. The *in situ* treatment included dual vacuum extraction (DVE) wells and associated soil vapor and water treatment system. Terra Vac added chemicals to oxidize contaminants and nutrients to enhance biodegradation. They conducted the pilot study at the "hot spot," "dissolved plume," and the light non-aqueous phase liquid (LNAPL) areas on the Lilyblad property. Ecology approved Terra Vac's interim action, which included continuing treatment at the pilot study areas and additional treatment at the former MPE area. The interim action was discontinued in March 2006.

On May 26, 2006, Ecology issued Enforcement Order No. 3334 to Lilyblad. In response to the Enforcement Order, Lilyblad submitted a groundwater monitoring plan. The plan included semi-annual groundwater monitoring at the site and a hydraulic containment plan to prevent further spread of contamination through groundwater flow. The hydraulic containment plan has not been implemented.

3.3 Investigative History

Solvent recycling and petroleum handling practice at the facility resulted in releases of hazardous substances to the soil and groundwater. Releases and potential releases of hazardous substance have been documented at the Lilyblad Site since 1984. Site investigations are documented in the following reports:

- *Remedial Investigation Report, Lilyblad Petroleum/Sol Pro, Inc.* (EHM, October 1999)
- *PW Pipe Facility Interim Action Final Work Plan* (CDM, March 2001)
- *Draft Remedial Investigation Addendum No. 1, Lilyblad Petroleum* (CDM, April 2001)

- *Draft Remedial Investigation Addendum No. 2, Additional Evaluation of cPAH and B2EHP, Lilyblad Petroleum* (CDM, December 2001)
- *Draft Feasibility Study, Lilyblad Petroleum Inc.* (Terra Vac, January 2002)
- *Draft Remedial Investigation Addendum No. 3, Supplemental Investigation of PW Eagle* (CDM, March 2002)
- *Annual Groundwater Monitoring Report, Lilyblad Petroleum Inc.* (CH2M HILL, March 2003)
- *Preliminary Draft, Feasibility Study Amendment, Lilyblad Petroleum Inc.* (CH2M HILL, September 2004)
- *Supplemental Remedial Investigation Report, Lilyblad Petroleum Inc.* (CH2M HILL, October 2004)
- *Interim Soil and Groundwater Sampling Event: MPE Treatment Area, PW Eagle Property, Lilyblad Pilot Test Areas* (Terra Vac, January 2006)
- *Focused Feasibility Study: Lilyblad Site* (Hart Crowser, 2007)

Site investigations identified the constituents of concern (CoCs) as halogenated and non-halogenated volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), and total petroleum hydrocarbons (TPH), in the gasoline, diesel, and motor oil ranges. A Supplemental Remedial Investigation Report (CH2M HILL, 2004) defined revised extents of contamination for both the groundwater and soil plumes for the various CoCs. Terra Vac updated those findings in their Site-Wide Remedial Action Design Plan (August 2005) apparently based on results of their interim action clean-up efforts.

3.4 Site Characterization

3.4.1 Geology and Subsurface

The upper geologic layer of the site is dredge spoil from the construction of the Blair Waterway and includes deltaic silts and sands with marine shells. CH2M HILL identified the subsurface features in the site investigation. The subsurface features include the following layers (from the surface downward):

- Structural Fill – The structural fill consists of slightly silty, sandy gravel to sandy, gravelly silt. The layer is 1 to 4 feet thick at most of the site and 6 to 7 feet thick under the JM Eagle building. The structural fill contains the vadose zone. At the base of the vadose zone is the capillary fringe.
- Upper Sand – The upper sand was formed from dredge spoil fill and consists of brown to black, medium-dense to loose, clean to silty, fine to medium sand with some gravel and shell fragments. The layer becomes finer with depth and grades into silty fine sand over much of the site. The layer thickness is 2 to 8 feet. Groundwater occurs in this unit under water table conditions at depths of 3 to 5 feet below ground surface.
- Upper Silt or Aquitard – The aquitard consists of gray to brown soft, clayey silt to silty clay with abundant organic material. The unit has a thickness of 9 to 16 feet and is made up of low-permeability sediments from native tidal flat deposits.

- Second Sand – The second sand layer consists of black, clean to fine silty fine sand. Red and white grain and shells are present on northern parts of the site. The top of the unit is 19 to 21 feet below the ground surface. Groundwater occurs in this unit and is tidally influenced.

3.4.2 Hydrogeology

Site investigations show a shallow aquifer and a second aquifer present in the site subsurface. The aquitard layer is located between the aquifers. The aquifers are as follows:

- Shallow Aquifer – The shallow aquifer is not tidally-influenced, according to the 16-hour tidal study in 1993. Except during seasonal extremes in recharge areas, depth to water below the site ranges from about 3 to 8 feet below ground surface. Seasonal fluctuation in the water level is on the order of 1 to 2 feet (CH2M HILL, 2004). Historically, groundwater flow at the site is influenced by a groundwater divide near the center of the Lilyblad property. Groundwater north of the divide flows north-northeast toward buried storm drains to sewer lines located along the Port of Tacoma Road. Groundwater south of the divide flows south-southwest and enters a sewer trench beneath PW Eagle. The natural gradient was low, at approximately 0.006 to 0.008 foot/foot (EHM, 1999).
- Second Aquifer – The second aquifer is tidally influenced (EHM, 1999). A 24-hour tidal study indicated a net flow direction from the southeast to the northwest. The apparent gradient calculated during the 24-hour study was 0.001 foot/foot. The gradient ranges from 0.0005 to 0.0013 foot/foot (CH2M HILL, 2004).

There are artesian aquifers on the Tacoma tideflats that are substantially deeper than the shallow and second aquifers and are not affected by the contamination at the site.

4 Project Description

4.1 Project Objectives

This QAPP was developed to document the type and quality of data needed for environmental decisions and to describe the methods for collecting and assessing those data during the implementation of this Remedial Action.

As described in the CAP, the preferred cleanup action at the site is intended to protect human health and the environment. The proposed cleanup methods are intended to comply with state and federal laws and cleanup standards for the CoCs. The CAP defines the cleanup levels (CULs) for the site as presented in Table 1.

4.2 Project Data to Be Collected

The project data is to be used to monitor permit requirements and assess the effectiveness of the remedial actions as further detailed below. The data collection events are described in Table 2.

TABLE 1
Soil and Groundwater Cleanup Levels (CULs)
Lilyblad Site Remedial Action, Tacoma, WA

Constituent of Concern	Soil CUL (µg/kg)	Groundwater CUL (µg/L)
1,1,1-trichloroethane	1,144	227
1,1,2-tricholoroethane	54.1	16
1,1-dichloroethane	164,000	52,000
1,1-dichloroethene (DCE)	7.9	1.93
1,2,4-trimethylbenzene	10,350,000	26,000
1,2-dichloroethane	100.6	37
1,4-dichlorobenzene	64.6	4.86
Benzene	75	22.7
bis(2-ethylhexyl)phthalate	4,400	2.2
cis-1,2-dichloroethene(a) (DCE)	14,880	5,200
Ethylbenzene	41,130	6,910
m,p-xylene	58,400	26,000
Methylene chloride	1,332	590
Tetrachloroethene (PCE)	24.5	3.3
Toluene	71,340	15,000
Trichloroethene (TCE)	121.7	30
Vinyl chloride	7.91	2.4
Naphthalene	115,900	4,940
Pentachlorophenol	37.97	3
2-methylnaphthalene	-	22.5
Diesel range hydrocarbons	2,000,000	1,000
Gasoline range hydrocarbons	100,000	1,000
Motor oil	2,000,000	1,000

Notes:
(a) Erroneously listed as cis-1,2-dichlorobenzene in the CAP.

Ecology derived soil CULs for volatile organic compounds (VOCs) and semi-volatile organic compounds (SVOCs) using the three-phase partitioning model and groundwater cleanup numbers.

Ecology used Method A soil and groundwater CULs for total petroleum hydrocarbon (TPH) compounds.

Ecology derived groundwater CULs for protection of surface water and for VOCs and SVOCs applied the more restrictive of two standards: the ambient water quality toxics criteria and the Method B surface water cleanup standards.

TABLE 2
Site Monitoring Schedule
Lilyblad Site Remedial Action, Tacoma, WA

Frequency of Sampling	Media	Number of Samples Per Event	Number of Events	Total Number of Samples	Parameters
Monthly	Groundwater	5	48	240	Water elevation, DO, ORP, pH, Conductivity, VOCs, SVOCs, TPH-G, TPH-D, CO_2 (headspace), Nitrate, Iron, & Sulfate
Monthly	Vapor (Influent/Effluent)	8	72	576	VOCs, SVOCs, TPH-G, and as per PSCAA permit
Monthly	Water (Influent/Effluent)	4	72	288	BTEX, O&G, TSS, RCRA Metals, pH, and as per City of Tacoma permit
Quarterly (Three per year, plus Annual)	Groundwater	13	18	234	Water elevation, DO, ORP, pH, Conductivity, VOCs, SVOCs, TPH-G, TPH-D, CO_2 (headspace), Nitrate, Iron, & Sulfate
Annual	Soil	12	5	60	VOCs, SVOCs, TPH-G, TPH-D, CO_2 (headspace), TOC
Annual	Groundwater	35	5	175	Water elevation, DO, ORP, pH, Conductivity, VOCs, SVOCs, TPH-G, TPH-D, CO_2 (headspace), Nitrate, Iron, & Sulfate

Note: Frequency of sampling events and number of samples collected per event may be subject to change. Project Manager should be consulted before each sampling event.

5 Data Quality Objectives and Criteria for Measurement Data

5.1 Project Data Quality Objectives

Specific data quality objectives (DQOs) were considered independently through the DQO process identified in *EPA Guidance for the Data Quality Objective Process* (U.S. EPA, August 2000/2006) to meet the data user's needs for each activity. The DQO decisionmaking process for each aspect of the Lilyblad Site Remedial Action is presented in Attachment B of this QAPP. The MTCA cleanup levels established for the Lilyblad site determine the appropriate detection limits for samples collected during the remedial action; these levels for groundwater and soil are shown in Table 1. For influent/effluent soil vapor and water the standard practicable method reporting limits are known to meet the permit requirements that apply to the effluent for soil vapor and water. These methods and limits are presented in Tables 3 and 4.

5.2 Measurement Performance Criteria

The QA objective of this QAPP is to develop implementation procedures that will provide data of known and appropriate quality for the needs identified in the project quality objectives. Data quality is assessed by representativeness, comparability, accuracy, precision, and completeness. Definitions of these terms, the applicable procedures, and level of effort are described below. The applicable QC procedures, quantitative target limits, and level of effort for assessing data quality are dictated by the intended use of the data and the nature of the analytical methods. Chemical parameters, analytical methods, applicable detection levels, analytical precision, accuracy, and completeness in alignment with project needs are presented in Table 4.

Representativeness is a measure of how closely the results reflect the actual concentration or distribution of the chemical compounds in the soil and groundwater sampled. Sampling plan design, sampling techniques, and sample-handling protocols (for example, storage, preservation, and transportation) have been developed and are presented in the FSP. Documentation procedures described in the FSP will demonstrate that protocols were followed and sample identification (ID) and integrity were assured. Equipment and trip blanks will be used to assess field and transport contamination and method variation. Laboratory sample retrieval, storage, and handling procedures have also been developed and are discussed in subsequent sections of this plan. Laboratory method blanks will be run at the minimum frequency of 5 percent or a minimum of one-per-sampling event to assess laboratory contamination.

Comparability of the data will be maintained by using standard EPA-defined procedures where available. If EPA procedures are not available, the proposed procedures are defined or referenced in this document. Data comparability will be maintained through the use of consistent methods, consistent units, and well-defined detection limits. The analytical methods are listed in Table 3, and the detection limits for specific analytes and methods are provided in Table 4. Method detection limits (MDLs) are established using pure standards. During measurement of an actual sample, detection limits may be elevated because of interference from other components in the matrix. Matrix interferences cannot be predicted ahead of time but will be reported if they occur.

TABLE 3
Measurement Performance Criteria for Soil, Groundwater and Vapor Chemical Parameters
Lilyblad Site Remedial Action, Tacoma, WA

Parameter	Method[a]	Target Detection Limit	Analytical Accuracy (% Recovery)	Analytical Precision (Relative % Deviation)	Overall Completeness (%)
Soil					
TCL VOCs[b]	8260/ CLP	See Table 4	CLP	CLP	90
TCL SVOCs[b]	8270 / CLP	See Table 4	CLP	CLP	90
VOCs by SIM	8260 SIM / CLP	See Table 4	CLP	CLP	90
SVOC by SIM	8270 SIM / CLP	See Table 4	CLP	CLP	90
TPH	NWTPH-HCID[c]	See Table 4	75-125	±25	90
TPH-Gasoline	NWTPHG	See Table 4	75-125	±25	90
TPH-Diesel	NWTPHD	See Table 4	75-125	±25	90
Water					
TCL VOCs[b]	8260/ CLP	See Table 4	CLP	CLP	90
TCL SVOCs[b]	8270/ CLP	See Table 4	CLP	CLP	90
VOCs by SIM	8260 SIM /CLP	See Table 4	CLP	CLP	90
SVOC by SIM	8270 SIM / CLP	See Table 4	CLP	CLP	90
TPH	NWTPH-HCID[c]	See Table 4	75-125	±25	90
TPH-Gasoline	NWTPHG	See Table 4	75-125	±25	90
TPH-Diesel	NWTPHD	See Table 4	75-125	±25	90
Metals	6010/6020	CLP	CLP	CLP	90
Cyanide total	9010	50 ug/l	75-125	±25	90
Cyanide free	9012	50 ug/l	70-130	±30	90
Total suspended solids (TSS)	160.2	20 mg/l	NA	±30	90
Oil and grease	413	2mg/l	70-130	±30	90
Vapor					
VOCs	TO15 modified	See Table 4	70-130	±30	90
TPH- Gasoline	TO15 modified	See Table 4	70-130	±30	90
SVOCs	TO13 modified	See Table 4	50-150	±50	90
HCl	TBD lab specific				

[a] CLP indicates that quality control will be performed in accordance with minimum level of effort of the CLP protocols, latest version in effect (*Methods for Chemical Analysis of Water and Wastes*, EPA-600/4-79-020 [U.S. EPA, revised March 1983]; *Test Methods for Evaluating Solid Waste*, *Physical/Chemical Methods, SW846*, 3rd Edition [U.S. EPA, March 1986 and revisions]).

[b] Compound list for VOCs and SVOCs as listed in Table 4.

[c] *Analytical Methods for Petroleum Hydrocarbons* (Ecology, June 1997).

SIM = selected ion monitoring
SVOC = semivolatile organic compound
TCL = target compound list
TPH = total petroleum hydrocarbons
VOC = volatile organic compound

TABLE 4
Laboratory Reporting Limits for Soil, Water and Vapor Chemical Parameters
Lilyblad Site Remedial Action, Tacoma, WA

			Soil			Groundwater			Vapor	
Parameter	**CAS Number**	**Method[a]**	**Lab Reporting Limit**	**MTCA CUL[b]**	**Units**	**Lab Reporting Limit**	**MTCA CUL[c]**	**Units**	**Lab Reporting Limit[d]**	**Units**
Volatile Organic Compounds										
Cis-1,2-Dichlorothene	156-59-2	8260	1.00E+00	1.48E+04	µg/kg	2.00E-01	5.20E+03	µg/L		
1,2-Dichlorobenzene	95-50-1	8260	1.00E+00	5.90E+02	µg/kg	2.00E-01	6.00E+02	µg/L		
1,4-Dichlorobenzene[d]	106-46-7	8260	1.00E+00	6.46E+01	µg/kg	2.00E-01	4.86E+00	µg/L		
1,1,1-Trichloroethane	71-55-6	8260	1.00E+00	1.14E+03	µg/kg	2.00E-01	2.27E+02	µg/L		
1,1,2-Trichloroethane	79-00-5	8260	1.00E+00	**5.41E+01**	µg/kg	2.00E-01	1.6E+01	µg/L		
1,1-Dichloroethane	75-34-3	8260	1.00E+00	1.64E+05	µg/kg	2.00E-01	5.20E+04	µg/L		
1,1-Dichloroethene	75-35-4	8260	1.00E+00	**7.90E+00**	µg/kg	2.00E-01	**1.93E+00**	µg/L		
1,2-Dichloroethane	107-06-2	8260	1.00E+00	**1.00E+02**	µg/kg	2.00E-01	3.7E+01	µg/L		
2-Butanone	78-93-3	8260	5.00E+00	1.40E+03	µg/kg	1.00E+00	4.80E+03	µg/L		
4-Methyl-2-pentanone	108-10-1	8260	5.00E+00	1.90E+02	µg/kg	1.00E+00	6.40E+02	µg/L		
Acetone	67-64-1	8260	5.00E+00	2.30E+02	µg/kg	1.00E+00	8.00E+02	µg/L		
Benzene	71-43-2	8260	1.00E+00	**7.50E+01**	µg/kg	2.00E-01	2.27E+01	µg/L		
Methylene Chloride	75-09-2	8260	2.00E+00	**1.33E+03**	µg/kg	3.00E-01	5.90E+02	µg/L		
Tetrachloroethene	127-18-4	8260	1.00E+00	**2.45E+01**	µg/kg	2.00E-01	3.30E+00	µg/L		
Toluene	108-88-3	8260	1.00E+00	7.13E+04	µg/kg	2.00E-01	1.50E+04	µg/L		
Trichloroethene	79-01-6	8260	1.00E+00	1.21E+02	µg/kg	2.00E-01	3.00E+01	µg/L		
Vinyl Chloride	75-01-4	8260	1.00E+00	**7.91E+00**	µg/kg	2.00E-01	**2.40E+00**	µg/L		
Xylenes (total)	1330-20-7	8260	1.00E+00	7.18E+03	µg/kg	2.00E-01	1.00E+04	µg/L		

TABLE 4
Laboratory Reporting Limits for Soil, Water and Vapor Chemical Parameters
Lilyblad Site Remedial Action, Tacoma, WA

			Soil			Groundwater			Vapor	
Parameter	**CAS Number**	**Method[a]**	**Lab Reporting Limit**	**MTCA CUL[b]**	**Units**	**Lab Reporting Limit**	**MTCA CUL[c]**	**Units**	**Lab Reporting Limit[d]**	**Units**
Volatile Organic Compounds with SIM										
1,1-Dichloroethene	75-35-4	8260/SIM	1.00E-01	4.00E-01	µg/kg	2.00E-02	1.00E-01	µg/L		
1,1,2-Trichloroethane	79-00-5	8260/SIM	1.00E-01	4.00E-01	µg/kg	5.00E-02	7.68E-01	µg/L		
1,2-Dichloroethane	107-06-2	8260/SIM	1.00E-01	3.00E-01	µg/kg	5.00E-02	4.81E-01	µg/L		
Benzene	71-43-2	8260/SIM	1.00E-01	7.50E+01	µg/kg	1.00E-01	2.27E+01	µg/L		
Tetrachloroethylene	127-18-4	8260/SIM	1.00E-01	7.00E-01	µg/kg	5.00E-02	8.57E-01	µg/L		
Vinyl Chloride	75-01-4	8260/SIM	1.00E-01	3.00E-01	µg/kg	2.00E-02	5.00E-02	µg/L		
Methylene Chloride	75-09-2	8260/SIM	1.00E-01	1.50E+00	µg/kg	3.00E-01	5.00E+00	µg/L		
Semivolatile Organic Compounds										
2-Methylphenol	95-48-7	8270	6.70E+01	2.60E+02	µg/kg	1.00E+00	8.00E+02	µg/L		
4-Methylphenol	106-44-5	8270	6.70E+01	**3.04E+01**	µg/kg	1.00E+00	8.00E+01	µg/L		
Benzo(a)anthracene	56-55-3	8270	6.70E+01	1.37E+03	µg/kg	1.00E+00	NA	µg/L		
Benzo(a)pyrene	50-32-8	8270	6.70E+01	1.37E+02	µg/kg	1.00E+00	NA	µg/L		
Bis(2-Ethylhexyl)phthalate	117-81-7	8270	6.70E+01	4.40E+03	µg/kg	4.00E+00	2.20E+00	µg/L		
Chrysene	218-01-9	8270	6.70E+01	1.37E+04	µg/kg	1.00E+00	NA	µg/L		
Pentachlorophenol	87-86-5	8270	3.30E+02	**3.79E+01**	µg/kg	5.00E+00	**3.00E+00**	µg/L		
1,4-Dichlorobenzene	106-46-7	8270	6.70E+00	6.70E+00	µg/kg	1.00E+00	1.80E+00	µg/L		
1,2-Dichlorobenzene	95-50-1	8270	6.70E+00	5.90E+02	µg/kg	1.00E+00	6.00E+02	µg/L		

TABLE 4
Laboratory Reporting Limits for Soil, Water and Vapor Chemical Parameters
Lilyblad Site Remedial Action, Tacoma, WA

			Soil			Groundwater			Vapor	
Parameter	**CAS Number**	**Method[a]**	**Lab Reporting Limit**	**MTCA CUL[b]**	**Units**	**Lab Reporting Limit**	**MTCA CUL[c]**	**Units**	**Lab Reporting Limit[d]**	**Units**
Semivolatile Organic Compounds by SIM										
2-Methylphenol	95-48-7	8270/SIM	6.70E+00	3.04E+01	µg/kg	1.00E+00	8.00E+01	µg/L		
Pentachlorophenol	87-86-5	8270/SIM	3.30E+01	3.79E+01	µg/kg	1.00E-01	3.00E+00	µg/L		
Total Petroleum Hydrocarbons										
TPH, gasoline[e]	NA	NWTPH-GX	5.00E+00	1.00E+05	mg/kg	2.50E-01	1.00E+03	mg/L		
TPH, diesel range[e]	NA	NWTPH-DX	5.00E+00	2.00E+06	mg/kg	2.50E-01	1.00E+03	mg/L		
TPH, mineral oils[e]	NA	NWTPH-DX	1.00E+01	2.00E+03	mg/kg	5.00E-01	5.00E-01	mg/L		
Volatile Organic Compounds in Vapor										
Freon 12		TO15 modified							0.50	ppbv
Freon 114		TO15 modified							0.50	ppbv
Chloromethane		TO15 modified							2.0	ppbv
Vinyl Chloride		TO15 modified							0.50	ppbv
1,3-Butadiene		TO15 modified							0.50	ppbv
Bromomethane		TO15 modified							0.50	ppbv
Chloroethane		TO15 modified							0.50	ppbv
Freon 11		TO15 modified							0.50	ppbv
Ethanol		TO15 modified							2.0	ppbv
Freon 113		TO15 modified							0.50	ppbv
1,1-Dichloroethene		TO15 modified							0.50	ppbv

TABLE 4
Laboratory Reporting Limits for Soil, Water and Vapor Chemical Parameters
Lilyblad Site Remedial Action, Tacoma, WA

			Soil			Groundwater			Vapor	
Parameter	**CAS Number**	**Method[a]**	**Lab Reporting Limit**	**MTCA CUL[b]**	**Units**	**Lab Reporting Limit**	**MTCA CUL[c]**	**Units**	**Lab Reporting Limit[d]**	**Units**
Acetone		TO15 modified							2.0	ppbv
2-Propanol		TO15 modified							2.0	ppbv
Carbon Disulfide		TO15 modified							0.50	ppbv
3-Chloropropene		TO15 modified							2.0	ppbv
Methylene Chloride		TO15 modified							0.50	ppbv
Methyl tert-butyl ether		TO15 modified							0.50	ppbv
trans-1,2-Dichloroethene		TO15 modified							0.50	ppbv
Hexane		TO15 modified							0.50	ppbv
1,1-Dichloroethane		TO15 modified							0.50	ppbv
2-Butanone (Methyl Ethyl Ketone)		TO15 modified							0.50	ppbv
cis-1,2-Dichloroethene		TO15 modified							0.50	ppbv
Tetrahydrofuran		TO15 modified							0.50	ppbv
Chloroform		TO15 modified							0.50	ppbv
1,1,1-Trichloroethane		TO15 modified							0.50	ppbv
Cyclohexane		TO15 modified							0.50	ppbv
Carbon Tetrachloride		TO15 modified							0.50	ppbv
2,2,4-Trimethylpentane		TO15 modified							0.50	ppbv
Benzene		TO15 modified							0.50	ppbv
1,2-Dichloroethane		TO15 modified							0.50	ppbv

TABLE 4
Laboratory Reporting Limits for Soil, Water and Vapor Chemical Parameters
Lilyblad Site Remedial Action, Tacoma, WA

			Soil			Groundwater			Vapor	
Parameter	**CAS Number**	**Method[a]**	**Lab Reporting Limit**	**MTCA CUL[b]**	**Units**	**Lab Reporting Limit**	**MTCA CUL[c]**	**Units**	**Lab Reporting Limit[d]**	**Units**
Heptane		TO15 modified							0.50	ppbv
Trichloroethene		TO15 modified							0.50	ppbv
1,2-Dichloropropane		TO15 modified							0.50	ppbv
1,4-Dioxane		TO15 modified							2.0	ppbv
Bromodichloromethane		TO15 modified							0.50	ppbv
cis-1,3-Dichloropropene		TO15 modified							0.50	ppbv
4-Methyl-2-pentanone		TO15 modified							0.50	ppbv
Toluene		TO15 modified							0.50	ppbv
trans-1,3-Dichloropropene		TO15 modified							0.50	ppbv
1,1,2-Trichloroethane		TO15 modified							0.50	ppbv
Tetrachloroethene		TO15 modified							0.50	ppbv
2-Hexanone		TO15 modified							2.0	ppbv
Dibromochloromethane		TO15 modified							0.50	ppbv
1,2-Dibromoethane (EDB)		TO15 modified							0.50	ppbv
Chlorobenzene		TO15 modified							0.50	ppbv
Ethylbenzene		TO15 modified		4.11E+04			6.91E+03		0.50	ppbv
m,p-Xylene		TO15 modified		5.84E+04			2.60E+04		0.50	ppbv
o-Xylene		TO15 modified							0.50	ppbv
Styrene		TO15 modified							0.50	ppbv

TABLE 4
Laboratory Reporting Limits for Soil, Water and Vapor Chemical Parameters
Lilyblad Site Remedial Action, Tacoma, WA

			Soil			Groundwater			Vapor	
Parameter	**CAS Number**	**Method[a]**	**Lab Reporting Limit**	**MTCA CUL[b]**	**Units**	**Lab Reporting Limit**	**MTCA CUL[c]**	**Units**	**Lab Reporting Limit[d]**	**Units**
Bromoform		TO15 modified							0.50	ppbv
Cumene		TO15 modified							0.50	ppbv
1,1,2,2-Tetrachloroethane		TO15 modified							0.50	ppbv
Propylbenzene		TO15 modified							0.50	ppbv
4-Ethyltoluene		TO15 modified							0.50	ppbv
1,3,5-Trimethylbenzene		TO15 modified							0.50	ppbv
1,2,4-Trimethylbenzene		TO15 modified		1.03E+07			2.60E+04		0.50	ppbv
1,3-Dichlorobenzene		TO15 modified							0.50	ppbv
1,4-Dichlorobenzene		TO15 modified							0.50	ppbv
alpha-Chlorotoluene		TO15 modified							0.50	ppbv
1,2-Dichlorobenzene		TO15 modified							0.50	ppbv
1,2,4-Trichlorobenzene		TO15 modified							2.0	ppbv
Hexachlorobutadiene		TO15 modified							2.0	ppbv
TPH ref. to Gasoline (MW=100)		TO15 modified							10	ppbv
Semivolatile Organic Compounds in Vapor										
Phenol		TO13 modified							5.0	µg
bis(2-Chloroethyl) Ether		TO13 modified							1.0	µg
2-Chlorophenol		TO13 modified							5.0	µg
1,3-Dichlorobenzene		TO13 modified							1.0	µg

TABLE 4
Laboratory Reporting Limits for Soil, Water and Vapor Chemical Parameters
Lilyblad Site Remedial Action, Tacoma, WA

			Soil			Groundwater			Vapor	
Parameter	CAS Number	Method[a]	Lab Reporting Limit	MTCA CUL[b]	Units	Lab Reporting Limit	MTCA CUL[c]	Units	Lab Reporting Limit[d]	Units
1,4-Dichlorobenzene		TO13 modified							1.0	µg
1,2-Dichlorobenzene		TO13 modified							1.0	µg
2-Methylphenol (o-Cresol)		TO13 modified							5.0	µg
bis(2-Chloroisopropyl) Ether		TO13 modified							1.0	µg
N-Nitroso-di-n-propylamine		TO13 modified							1.0	µg
4-Methylphenol/3-Methylphenol		TO13 modified							5.0	µg
Hexachloroethane		TO13 modified							1.0	µg
Nitrobenzene		TO13 modified							1.0	µg
Isophorone		TO13 modified							1.0	µg
2-Nitrophenol		TO13 modified							5.0	µg
2,4-Dimethylphenol		TO13 modified							5.0	µg
Benzoic Acid		TO13 modified							30	µg
bis(2-Chloroethoxy) Methane		TO13 modified							1.0	µg
2,4-Dichlorophenol		TO13 modified							5.0	µg
1,2,4-Trichlorobenzene		TO13 modified							1.0	µg
Naphthalene		TO13 modified		1.15E+05			4.94E+03		1.0	µg
4-Chloroaniline		TO13 modified							10	µg
Hexachlorobutadiene		TO13 modified							1.0	µg
4-Chloro-3-methylphenol		TO13 modified							5.0	µg

TABLE 4
Laboratory Reporting Limits for Soil, Water and Vapor Chemical Parameters
Lilyblad Site Remedial Action, Tacoma, WA

			Soil			Groundwater			Vapor	
Parameter	CAS Number	Method[a]	Lab Reporting Limit	MTCA CUL[b]	Units	Lab Reporting Limit	MTCA CUL[c]	Units	Lab Reporting Limit[d]	Units
2-Methylnaphthalene		TO13 modified		-			2.25E+01		1.0	µg
Hexachlorocyclopentadiene		TO13 modified							20	µg
2,4,6-Trichlorophenol		TO13 modified							5.0	µg
2,4,5-Trichlorophenol		TO13 modified							5.0	µg
2-Chloronaphthalene		TO13 modified							1.0	µg
2-Nitroaniline		TO13 modified							10	µg
Dimethylphthalate		TO13 modified							5.0	µg
Acenaphthylene		TO13 modified							1.0	µg
2,6-Dinitrotoluene		TO13 modified							5.0	µg
3-Nitroaniline		TO13 modified							10	µg
Acenaphthene		TO13 modified							1.0	µg
2,4-Dinitrophenol		TO13 modified							20	µg
4-Nitrophenol		TO13 modified							20	µg
2,4-Dinitrotoluene		TO13 modified							5.0	µg
Dibenzofuran		TO13 modified							1.0	µg
Diethylphthalate		TO13 modified							5.0	µg
Fluorene		TO13 modified							1.0	µg
4-Chlorophenyl-phenyl Ether		TO13 modified							1.0	µg
4-Nitroaniline		TO13 modified							10	µg

TABLE 4
Laboratory Reporting Limits for Soil, Water and Vapor Chemical Parameters
Lilyblad Site Remedial Action, Tacoma, WA

			Soil			Groundwater			Vapor	
Parameter	**CAS Number**	**Method[a]**	**Lab Reporting Limit**	**MTCA CUL[b]**	**Units**	**Lab Reporting Limit**	**MTCA CUL[c]**	**Units**	**Lab Reporting Limit[d]**	**Units**
4,6-Dinitro-2-methylphenol		TO13 modified							10.	µg
N-Nitrosodiphenylamine		TO13 modified							10	µg
4-Bromophenyl-phenyl Ether		TO13 modified							1.0	µg
Hexachlorobenzene		TO13 modified							1.0	µg
Pentachlorophenol		TO13 modified							20	µg
Phenanthrene		TO13 modified							1.0	µg
Anthracene		TO13 modified							1.0	µg
di-n-Butylphthalate		TO13 modified							5.0	µg
Fluoranthene		TO13 modified							1.0	µg
Pyrene		TO13 modified							1.0	µg
Butylbenzylphthalate		TO13 modified							5.0	µg
3,3'-Dichlorobenzidine		TO13 modified							20	µg
Chrysene		TO13 modified							1.0	µg
Benzo(a)anthracene		TO13 modified							1.0	µg
bis(2-Ethylhexyl)phthalate		TO13 modified							5.0	µg
Di-n-Octylphthalate		TO13 modified							5.0	µg
Benzo(b)fluoranthene		TO13 modified							1.0	µg
Benzo(k)fluoranthene		TO13 modified							1.0	µg
Benzo(a)pyrene		TO13 modified							1.0	µg

TABLE 4
Laboratory Reporting Limits for Soil, Water and Vapor Chemical Parameters
Lilyblad Site Remedial Action, Tacoma, WA

			Soil			Groundwater			Vapor	
Parameter	CAS Number	Method[a]	Lab Reporting Limit	MTCA CUL[b]	Units	Lab Reporting Limit	MTCA CUL[c]	Units	Lab Reporting Limit[d]	Units
Indeno(1,2,3-c,d)pyrene		TO13 modified							1.0	µg
Dibenz(a,h)anthracene		TO13 modified							1.0	µg
Benzo(g,h,i)perylene		TO13 modified							1.0	µg

[a] U.S. EPA, *Methods for Chemical Analysis of Water and Wastes,* EPA-600/4-79-020, revised March 1983.

[b] As determined from tables in *Cleanup Levels and Risk Calculations under the Model Toxics Control Act Cleanup Regulation, Version 3.1 (*Ecology, November 2001) and calculated for Lilyblad site COCs in the Draft Feasibility Study
(CDM, January 2002).

[c] As determined from tables in Ecology (November 2001) for Lilyblad site COCs -- not apportioned.

[d] Reporting limits cited do not take into account sample dilution due to canister pressurization.

Note: Bold and highlighting indicates analytes with standard analysis reporting limit that is greater than the CUL; see reporting limit under SIM analysis.

CAS = Chemical Abstracts Service
COC = constituent of concern
CUL = cleanup level
µg = microgram
µg/kg = microgram per kilogram
µg/L = microgram per liter
mg/L = milligram per liter MTCA = Model Toxics Control Act
NA = not applicable
SIM = selected ion monitoring
TPH = total petroleum hydrocarbons
U.S. EPA = U.S. Environmental Protection Agency

Accuracy is an assessment of the closeness of the measured value to the true value. The accuracy of chemical test results is assessed by spiking samples with known standards and establishing the average recovery. In general, two types of recoveries are measured for VOCs: matrix spike recoveries and surrogate spike recoveries. For a matrix spike, known amounts of standard compounds identical to the compounds present in the sample of interest are added to the sample. For a surrogate spike, the standards are chemically similar but not identical to the compounds in the fraction being analyzed. The purpose of the surrogate spike is to provide QC on every sample by constantly monitoring for unusual matrix effects and gross sample processing errors. Accuracy measurements will be conducted in the laboratory at a minimum frequency of 1 in 20 samples.

Precision is a measure of the spread of the data when more than one measurement is taken on the same sample. For duplicate measurements, precision can be expressed as the relative percent difference (RPD). Precision measurements will be conducted in the laboratory at a minimum frequency of 1 in 20 samples.

Completeness is a measure of the amount of valid data obtained from the analytical measurement system. The target completeness objective will be 90 percent; the actual completeness may vary depending on the intrinsic nature of the samples. The completeness of the data will be assessed during QC reviews.

6 Sampling Design

Data collection events will be conducted to maintain compliance with applicable air discharge and water discharge permits and to prepare site remediation status reports. The data will also be used to assess the effectiveness of the remedial system operations and allow for decisions to be made on when and where to implement *in situ* remedial methods.

The sampling design is as follows:

- Monthly samples will be collected from the influent (untreated) and effluent (treated) vapors extracted by the dual-phase extraction (DPE) system to determine the amount of contaminant mass that is being removed in the vapor phase from the subsurface. Samples will also be collected in between air pollution control devices (e.g., catalytic oxidizer and granular activated carbon vessels) to evaluate effectiveness of various pieces of control equipment in removal of vapor phase contamination. The vapor sample analytes will be dictated by the air quality permit to be applied to the site; however, at a minimum, the concentration of gasoline-range total petroleum hydrocarbons (TPH-G), VOCs, and SVOCs will be determined by laboratory analysis of vapor samples.
- Monthly samples will be collected from the influent (untreated) and effluent (treated) water extracted by the DPE system to determine the amount of contaminant mass that is being removed in the liquid phase from the subsurface. Samples will also be collected in between water treatment devices (e.g., air stripper and granular activated carbon vessels) to evaluate effectiveness of various pieces of equipment in removal of dissolved-phase contamination. The water sample analytes will be dictated by the wastewater discharge permit to be applied to the site; however, at a minimum, the concentration of benzene, ethyl benzene, toluene, and xylene (BETX), oil and grease (O&G), total

suspended solids (TSS), and RCRA metals will be determined by laboratory analysis of water samples.

- Monthly groundwater samples will be collected from five groundwater monitoring wells located within the area of contamination and up gradient of the contaminant area to collect data related to contaminant plume behavior and subsurface biological conditions. The data to be collected from each of these wells will be as follows:
  - Prior to making any adjustments to the DPE system operation, the depth to groundwater will be measured at each of the groundwater monitoring wells. Following this measurement, the DPE system will be deactivated in the vicinity of the wells to be sampled.
  - Following deactivation of the DPE system in the vicinity of the groundwater wells to be sampled, a field meter will be used to measure the concentration of carbon dioxide (CO_2) in the headspace of the well. After the CO_2 measurement is collected, the depth to groundwater will be measured, and field instrumentation will be utilized to measure the following geochemical data in the groundwater: dissolved oxygen (DO), oxidation-reduction potential (ORP), pH, and conductivity.
  - After the geochemical data is collected, a groundwater sample will be collected from the monitoring wells for submission to a laboratory for analysis of VOCs, SVOCs, TPH-G, diesel-range total petroleum hydrocarbons (TPH-D), nitrate, iron, and sulfate.
- On a quarterly basis, a total of 13 groundwater monitoring wells will be sampled. These wells will include the five wells sampled on a monthly basis, as well as eight additional wells that will more fully represent conditions within the contaminant plume as well as areas up gradient and down gradient of the contaminant plume. The method of collection and type of data collected will be the same as the data collected from the five groundwater monitoring wells on a monthly basis.
- During the establishment of baseline conditions in June 2009 and on an annual basis, beginning in the 4th quarter of 2009, a total of 35 groundwater monitoring wells will be sampled. These wells will include the 13 wells sampled on a quarterly basis, as well as 22 additional wells. The method of collection and type of data collected will be the same as the data collected from the five groundwater monitoring wells on a monthly basis.
- On an annual basis, beginning in the 3rd quarter of 2009, 12 soil samples will be collected from the site. The soil samples will be submitted to a laboratory for analysis of VOCs, SVOCs, TPH-G, TPH-D, and total organic carbon (TOC). The soil samples will be collected on a grid as further detailed in the FSP.

7 Field Procedures

Data gathering and sample collection procedures for each aspect of the remedial action are described in the associated FSP presented in Attachment A of this QAPP.

8 Laboratory Procedures

Project analytes, methods and detection limits are listed in Tables 3 and 4.

Soil and water samples will be analyzed in accordance with EPA SW846 (8260 and 8270 methods) for volatiles and semivolatiles. Selective ion monitoring (SIM) will be used in conjunction with these methods where lower detection than standard method levels are needed. Petroleum hydrocarbon measurements will be per Ecology methodology.

QA/QC for the analyses will be at a level of effort equivalent to EPA Contract Laboratory Program (CLP) methods.

9 Quality Control Procedures

9.1 Field Quality Control Procedures

Field QC procedures will include collecting trip blanks, field duplicates, and equipment blanks. Specific requirements are discussed in the FSP.

9.2 Laboratory Quality Control Procedures

Laboratory QC procedures will include the following:

- Analytical methodology according to specific methods and with corresponding detection limits listed in Table 3.
- Calibrations and standards in accordance with method and, at a minimum, at a level of effort equivalent to CLP, where applicable.
- Laboratory blank measurements at a minimum of 5 percent or a minimum of one per sampling event if less than 20 samples are collected.
- Accuracy and precision measurements at a minimum of 5 percent or a minimum of one per sampling event if less than 20 samples are collected.
- Data reduction and reporting according to specific methods listed in Table 4.
- Laboratory documentation equivalent to the CLP statement of work (SOW).

10 Data Management Procedures

Data management can be defined as the functions of creating and accessing stored data, enforcing data storage conventions, and regulating data input and output. The stored data will include parameters measured in soil and groundwater at the Site.

For this project, data management will involve the use of a computerized data management system. The system will provide a centralized, secure location for data of known quality that can be shared and used for multiple purposes. The data management system will assist in the project's information flow by providing a means of cataloging, organizing, archiving, and accessing information.

The data management system will include three main elements:

1. **The database.** An organized and structured storehouse of data used for multiple purposes.
2. **Data management procedures.** The steps involved in the data management process.
3. **Personnel.** The project staff who develop, implement, and administer the database and procedures.

These elements are briefly described in the following subsections.

10.1 Database

All field and analytical data obtained during the Lilyblad Supplemental Remedial Investigation will be managed in a relational database, such as Microsoft Access.

10.2 Data Management Procedures

Data management procedures are a crucial part of the data management system. Established procedures are necessary to ensure consistency among data sets, internal database integrity, and a verified, usable data set. The tasks and procedures that will be performed for all project data before data entry include the following:

- **Data mapping.** The process by which the collected environmental data are selected, marked, and correctly named for entry into the database.
- **Electronic data interchange.** This is done to facilitate data interchange between the analytical laboratory and data user. Detailed specifications will be developed for both receipt and delivery of electronic data, including data importing and exporting.
- **Data entry and verification.** The process by which data are correctly entered into the database, including data preparation, data import and entry, and data verification.
- **Data presentation and analysis.** Data from the database will be presented in tabular formats as individual sample results (with listings of results sorted by station and sample ID) and as summary statistics (for example, frequency of detection, mean, minimum values, maximum values, standard deviation, and variance) for grouped sample results. In addition, field and analytical data for each sample will be geo-referenced so that the data can be displayed on geographic information system (GIS) maps.
- **Data administration.** Effective administration of the data management system will reduce the likelihood of errors and ensure the database's integrity. Data administration tasks include data redundancy control, database operation and maintenance, data management process documentation, and data management task closes out in both interim and final stages of completion.

10.3 Personnel

Successful implementation of a data management system requires a clear definition of responsibilities. The Project Data Coordinator and Database Technician will implement the data management system. The Project Data Coordinator has an overall view of the project; his/her responsibilities include database integrity, redundancy control, data sharing and version control, performance, security, and backup. The Database Technician has a comprehensive understanding of the database structure, software, and associated analysis tools; his/her responsibilities include data logging and tracking, data preparation, data entry and verification, data archiving, data requests, and report generation.

11 Audits and Reports

11.1 Audits

The Project Manager and the Data QA Manager will monitor and audit the performance of the QA procedures. When necessary, field and laboratory audits will be conducted.

Verification of computer models and software will be conducted periodically by the entry of known data sets or programs by a computer expert not assigned to the project. Electronic and paper-based data sets will be verified by double entry, cross checking, and range checking against the known programs and models to check for correctness, reasonableness, and user competence. Verification of model and software performance will be documented in the QA/QC portion of the specific reports.

If QC audits result in detection of unacceptable conditions or data, the Project Manager will be responsible for initiating corrective action. The Ecology Project Manager will be notified if nonconformance is of program significance or requires special expertise not normally available to the project team. Corrective actions may include the following:

- Reanalyzing samples if holding-time criteria permit
- Resampling and analyzing
- Evaluating and amending sampling and analytical procedures
- Accepting data while acknowledging level of uncertainty

11.2 Reporting

Following completion of the project's data collection and analysis, a final summary report will be prepared assessing overall measurement data accuracy, precision, and completeness for the data gathered during this investigation.

12 Data Review, Verification, and Validation

Data reviews will be performed at two levels: 1) at the laboratory and 2) outside the laboratory by independent chemists. The in-laboratory reviews will be conducted in accordance with the laboratory QAPP. Outside the laboratory, 100 percent of the data will be reviewed for all QC summary data (presented at a level equivalent to CLP), and 10 percent of data will be reviewed for raw data (algorithm, calculation, and transcription checks) on a task-specific basis. Data reviews outside the laboratory will be in accordance with EPA CLP *National Functional Guidelines for Data Review* (EPA, 1999).

Following receipt of validated data, the data will be input into the database (as described in Section 10) to facilitate database queries and report preparation.

13 Data Quality Assessment

Analytical data obtained will be reconciled with the requirements specified in Tables 3 and 4. Assessment of data for precision, accuracy, completeness and sensitivity will be performed in accordance with the quantitative definitions in the following subsections.

Precision

If calculated from duplicate measurements, use relative percent difference (RPD), as follows:

$$RPD = \frac{(C_1 - C_2) \times 100\%}{(C_1 + C_2) / 2} \qquad (1)$$

where:

RPD = relative percent difference
C_1 = larger of the two observed values
C_2 = smaller of the two observed values

If calculated from three or more replicates, use relative standard deviation (RSD) rather than RPD, as follows:

$$RSD = (s / \bar{y}) \times 100\% \qquad (2)$$

where:

RSD = relative standard deviation
s = standard deviation
$\bar{y}$ = mean of replicate analyses

Standard deviation, s, is defined as follows:

$$s = \sqrt{\sum_{i=1}^{n} \frac{(y_i / \bar{y})^2}{n - 1}} \qquad (3)$$

where:

s = standard deviation
y_i = measured value of the ith replicate
$\bar{y}$ = mean of replicate analyses
n = number of replicates

Accuracy

For measurements where matrix spikes are used, use the following equation:

$$\%R = 100\% \times \left[\frac{S - U}{C_{sa}} \right] \tag{4}$$

where:

%R = percent recovery
S = measured concentration in spiked aliquot
U = measured concentration in unspiked aliquot
C_{sa} = actual concentration of spike added

For situations where a standard reference material (SRM) is used instead of or in addition to matrix spikes, use the following equation:

$$\%R = 100\% \times \left[\frac{C_m}{C_{sm}} \right] \tag{5}$$

where:

%R = percent recovery
C_m = measured concentration of SRM
C_{sm} = actual concentration of SRM

Completeness (Statistical)

Completeness will be defined as follows for all measurements:

$$\%C = 100\% \times \left[\frac{V}{T} \right] \tag{6}$$

where:

%C = percent completeness
V = number of measurements judged valid
T = total number of measurements

Detection Limit

The MDL is defined as follows for nonradionuclide measurements:

$$MDL = t_{(n-1, l-a=0.99)} \times s \tag{7}$$

where:

MDL = method detection limit
s = standard deviation of the replicated analyses
t(n-1, 1-a=0.99) = students' t-level and a standard deviation estimate with n-1 degree of freedom

14 References

U.S. Environmental Protection Agency (EPA). August 2000 and 2006 Revision. *Guidance for the Data Quality Objectives Process*. Office of Environmental Information. EPA QA/G-4, EPA/600/R-96/055.

U.S. Environmental Protection Agency (EPA). 1999. *National Functional Guidelines for Data Review*.

U.S. Environmental Protection Agency (EPA). 1998. *Guidance for Quality Assurance Project Plans*.

U.S. Environmental Protection Agency (EPA). March 1986 and revisions. *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW846*. 3rd Edition.

U.S. Environmental Protection Agency (EPA). Revised March 1983. *Methods for Chemical Analysis of Water and Wastes*. EPA-600/4-79-020.

Washington Department of Ecology (Ecology). February 2001. *Guidelines for Preparing Quality Assurance Project Plans for Environmental Studies.* Revision of Publication No. 91-16.

Washington Department of Ecology (Ecology). June 1997. *Analytical Methods for Petroleum Hydrocarbons*.

Attachment A
Field Sampling Plan

1 Introduction

This Field Sampling Plan (FSP) describes the field investigation activities planned for the Lilyblad Site remedial action to be conducted at the Lilyblad site. The Lilyblad site consists of the Lilyblad property in Tacoma, Washington, and portions of adjacent properties and Port of Tacoma Road that have been affected by Lilyblad contaminants. This FSP and the QAPP address the site-specific data quality objectives (DQOs) to ensure that the data collected are of known and appropriate quality.

Field activities will be conducted in accordance with the associated Health and Safety Plan (HSP). Wastes generated during the project will be minimized to the extent possible and handled in accordance with waste management procedures identified in this FSP.

The subsequent sections of this FSP are organized as follows:

- **Section 2 Field Sampling Activities**, describes the overall field activities and sampling programs planned for each phase of the work.
- **Section 3 Quality Control Sampling**, describes the quality control (QC) sampling requirements for the field sampling.
- **Section 4, Sample Volumes, Container Types, Preservation Requirements, and Holding Times,** lists these requirements for the field sampling.
- **Section 5, Detailed Field Procedures,** describes specific field procedures that will be implemented during collection of field and analytical data throughout the work phases described in Section 2**.**
- **Section 6, Subcontractor Project Activities**, lists the investigation activities that will require the procurement of subcontractors.

2 Field Sampling Activities

This section presents the sampling locations, media, and analytical methods to be used for each phase of the remedial monitoring – as summarized in Table A-1. This section is organized to reflect the work sequence as presented in the project schedule in the Work Plan. Sampling locations are shown in Figures A-1 and A-2. A detailed description of field procedures associated with collection of field data and samples is provided in Section 5.

TABLE A-1
Site Monitoring Schedule
Lilyblad Site Remedial Action, Tacoma, WA

Frequency of Sampling	Media	Number of Samples Per Event	Number of Events	Total Number of Samples	Parameters
Monthly	Groundwater	5	48	240	Water elevation, DO, ORP, pH, Conductivity, VOCs, SVOCs, TPH-G, TPH-D, CO_2 (headspace), Nitrate, Iron, Sulfate,
Monthly	Vapor (Influent/Effluent)	8	72	576	VOCs, SVOCs, TPH-G, and as per PSCAA permit
Monthly	Water (Influent/Effluent)	4	72	288	BTEX, O&G, TSS, RCRA Metals, pH, and as per City of Tacoma permit
Quarterly (Three per year, plus Annual)	Groundwater	13	18	234	Water elevation, DO, ORP, pH, Conductivity, VOCs, SVOCs, TPH-G, TPH-D, CO_2 (headspace), Nitrate, Iron, Sulfate
Annual	Soil	12	5	60	VOCs, SVOCs, TPH-G, TPH-D, CO_2 (headspace), TOC
Annual	Groundwater	35	5	175	Water elevation, DO, ORP, pH, Conductivity, VOCs, SVOCs, TPH-G, TPH-D, CO_2 (headspace), Nitrate, Iron, Sulfate

Note: Frequency of sampling events and number of samples collected per sampling event may change in the future. Consult Project Manager before each sampling event.

3 Quality Control Sampling

The QC samples to be obtained for the field investigations include field duplicates, equipment blanks, matrix spike/matrix spike duplicates (MS/MSDs), and trip blanks. The frequency of collection for each QC sample type will be as follows:

- Field duplicates will be collected at a frequency of 10 percent for each matrix type, or a minimum of one per sampling event if less than 10 samples are collected.
- Equipment blanks will be collected at a frequency of 5 percent or a minimum of one per sampling event if less than 20 samples are collected. Equipment blanks will be collected during actual sampling activities to also account for potential contaminants introduced under ambient conditions.
- MS/MSD samples will be provided at a frequency of 5 percent for each matrix type.

4 Sample Volumes, Container Types, Preservation Requirements, and Holding Times

Sample volumes, container types, and preservation requirements for the analytical methods performed on the samples are listed in Table A-2 for soil and groundwater samples, respectively. Sample holding time tracking will begin with the collection of samples and continue until the analyses are complete.

TABLE A-2
Sample Volumes, Container Types, Preservation Types, and Holding Times for Soil and Groundwater
Lilyblad Site Remedial Action, Tacoma, WA

Analytical Suite	Analytical Method	Soil Container	Water Container	Minimum Preservation	Maximum Holding Time
Volatile Organic Compounds	8260B	One 2-ounce glass, Teflon-lined cap	Three 40-mL VOAs	4°C/HCl	14 days soil 7 days water
Volatile Organic Compounds, SIM	8260B SIM	One 2-ounce glass, Teflon-lined cap	Three 40-mL VOAs	4°C/HCl	14 days soil 7 days water
Semivolatile Organic Compounds	8270C	One 4-ounce glass, Teflon-lined cap	One 500-mL amber glass	4°C	14 days soil 7 days water
Semivolatile Organic Compounds, SIM	8270C SIM	One 4-ounce glass, Teflon-lined cap	One 500-mL amber glass	4°C	14 days soil 7 days water
Total Petroleum Hydrocarbons, Diesel	NWTPHD	One 4-ounce glass, Teflon-lined cap	One 500-mL amber glass	4°C	14 days soil 7 days water
Total Petroleum Hydrocarbons, Oil[a]	NWTPHD	One 4-ounce glass, Teflon-lined cap	One 500-mL amber glass[a]	4°C	14 days soil 7 days water
Total Petroleum Hydrocarbons, Gasoline	NWTPHG	One 4-ounce glass, Teflon-lined cap	One 500-mL amber glass	4°C	14 days soil 7 days water

[a] Oil analysis can come from same bottle as diesel analysis.

°C = degree Celsius

mL = milliliter

SIM = selected ion monitoring

VOA = volatile organic aromatic compound

5 Detailed Field Procedures

5.1 Groundwater Sampling at Monitoring Wells

The initial phase of field work consists of groundwater sampling at existing monitoring wells, as shown in Figure A-1 and listed in Table A-1. Prior to collection of samples, depth to water and light nonaqueous phase liquid (LNAPL) thickness measurements will be obtained from all wells. An electronic water level indicator will be used to determine depth to water to the nearest 0.01 foot in all wells where LNAPL has not previously been reported. LNAPL thickness will be measured using an interface probe (Solinist Model 122 or equivalent). Depth to water will be measured from the existing reference points at the top of the well casing to the static water level inside the well casing. The depth to water and LNAPL thickness measurements will be recorded in the field book. If LNAPL is determined to be present in a well, a groundwater sample will not be collected from that well during the sampling event.

Each monitoring well will be purged prior to sample collection in order to obtain samples that are representative of formation water. Wells will be purged using a peristaltic pump and single-use disposable tubing. Low-flow purging techniques will be used.

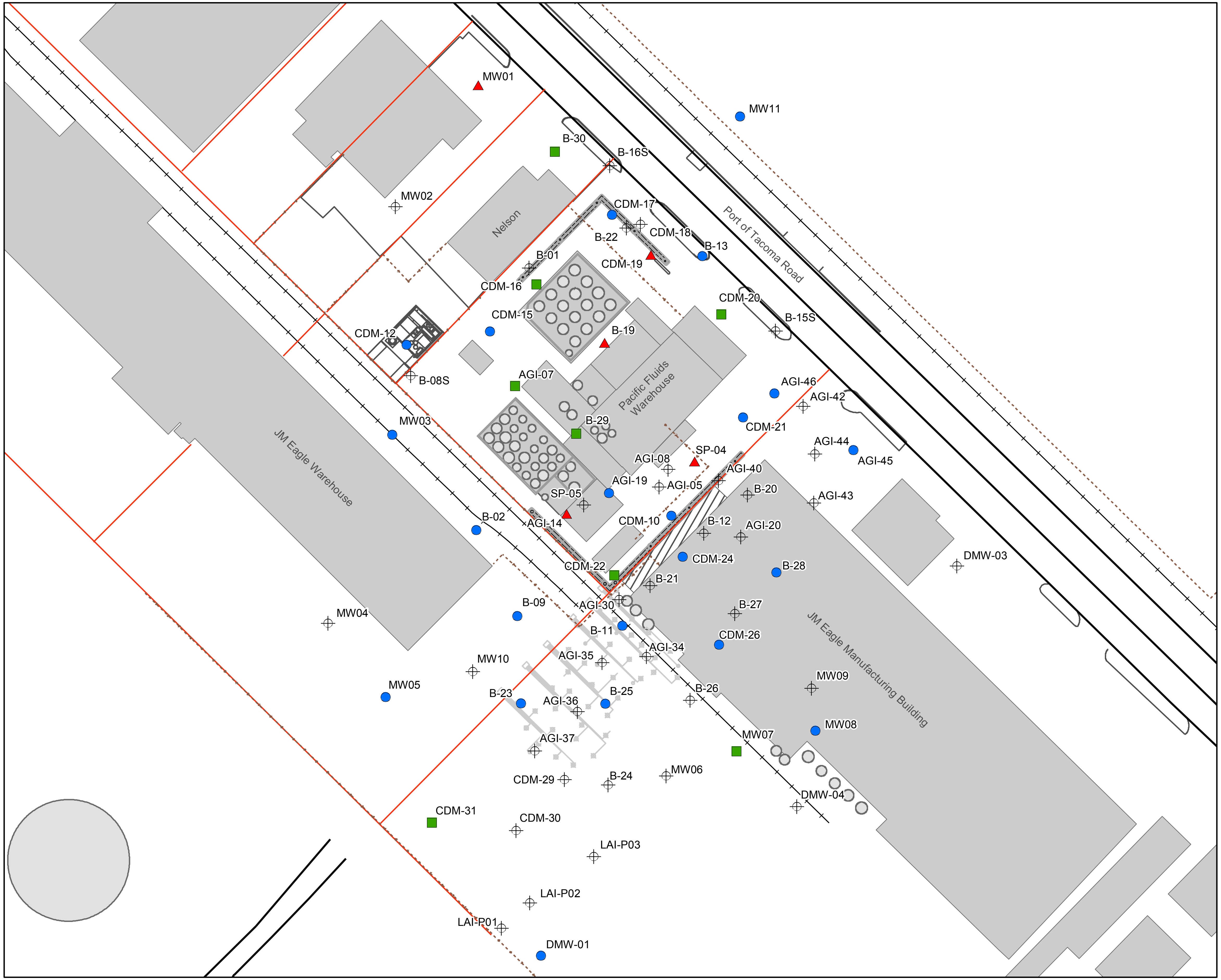
The following field parameters will be measured while purging and just prior to sample collection:

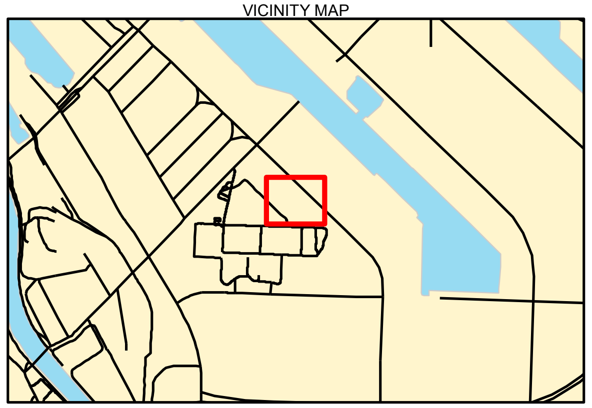
Parameter	Instrument
pH	Horiba U-10 or U-22, Orion SA250 (or equivalent)
Electrical conductivity	Horiba U-10 or U-22, YSI 33 (or equivalent)
Temperature	Horiba U-10 or U-22, Orion SA250 (or equivalent)
Dissolved oxygen	Horiba U-10 or U-22 (or equivalent)
Turbidity	Horiba U-10 or U-22 (or equivalent)

Purging will continue until field parameters stabilize. Field parameters stability will be established for three consecutive readings (that is, temperature of three consecutive readings within 10%, pH to be within +/- 0.2 units, conductivity to be within +/- 3%, dissolved oxygen [DO] to be within 10% or reading and oxidation-reduction potential [ORP] to be within +/- 20mV).

The probes used for these measurements will be rinsed with purge water between each measurement. Probes will be rinsed with distilled water between each well. If visible contamination is noted after rinsing, probes will be washed in a solution of Liquinox and distilled water followed by a distilled water rinse.

Groundwater samples will be collected from each well immediately after purging is completed, except in the case of wells that purge dry. In the case of dry wells, the well will be allowed to recover to a minimum of 80 percent of the pre-purging static water level before sampling is conducted, within 24 hours of purging dry.





LEGEND

Proposed Groundwater Sampling Wells

- ▲ Monthly
- 🟩 Quarterly (including monthly sampling)
- ● Annually (including monthly and quarterly sampling)
- ⌖ Water Well Locations
- ┄ Fence Line
- ═ Groundwater Interceptor Trench

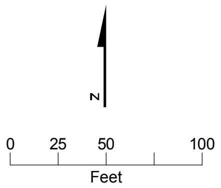


FIGURE A-1
Proposed Water Level Monitoring Location

Lilyblad Petroleum, Tacoma, WA

CH2MHILL

\\SIMBA\PROJ\WASTATEDEPTECOLOGY\380987\GIS\MAPFILES\PROPOSEDWATERLEVELLOCATIONS.MXD RGRABARE 3/17/2009

5.1.1 No Purge Sampling

“No-purge” Sampling is a relatively new method for obtaining groundwater samples that utilizes passive (that is, non-pumping) procedures. The no-purge sampling is based on the principal that groundwater flows through a horizontal well screen where the water in the well is in constant equilibrium. As such, representative groundwater samples can be collected without performing the costly and time-consuming well purging activities utilized in more conventional well sampling methods.

During the first year of groundwater sampling, a set of two to three wells will be selected to conduct no-purge sampling by installing passive diffusion bags (PDB) samplers. The PDB samplers will be filled with de-ionized water and will be suspended in the wells for approximately two weeks or until equilibrium conditions are established. The PDB samplers will be retrieved and the samples will be collected for laboratory analysis. The data from these samples will be compared to the rest of the samples collected at the site. If the results from the no-purge sampling come back similar to those collected by low purge sampling, permission may be requested from Ecology to convert a larger portion of the sampling program to using the no-purge sampling method.

5.2 Direct-Push Soil Sampling

Direct-push probing will be used to advance borings and collect soil samples. Sample locations are shown in Figure A-2. Borings used to collect samples for lateral extent delineation will be advanced to the top (that is, upper 0.5 foot) of the aquitard. A photoionization detector (PID) will be used at all times during the sampling event. Ecology will be notified of any changes in the sampling plan based on field observations.

The procedures for advancing direct push borings are as follows:

- Prior to implementation of the probe work, sampling locations will be adjusted in the field to avoid overhead utilities and surface obstructions that make them inaccessible to the probe rig. In addition, no soil samples will be collected from the interior of any tank farm containment walls. The public “One-Call” service will be contacted to locate and mark underground utilities prior to mobilizing the probe rig to the site. A subcontracted utility-locating company may also be contacted to locate and mark private underground utilities, such as the storm sewer line, on the site. Sample locations will be adjusted as needed to avoid underground utilities.

- The field geologist or engineer will be responsible for establishing probe location in the field, directing probe activities, logging the hydrostratigraphy observed at each probe hole, and selecting the appropriate intervals for sampling.

- Boring locations will be determined using the Global Positioning Satellite (GPS) system.

- All downhole tools, samplers, and other devices will be decontaminated by steam cleaning to the satisfaction of the field representative prior to use. Water generated by steam cleaning will be collected and treated onsite by Lilyblad.

- Each boring will be abandoned according to Washington State standards as set forth in Washington Administrative Code (WAC) 173-160, Minimum Standards for Construction and Maintenance Wells. All probe locations will be abandoned by installing bentonite chips and hydrating with potable water.

- Borings that penetrate asphalt will be finished at the surface using cold-patch asphalt or concrete with black dye added. Completions will be flush with the surrounding surface. Borings that penetrate concrete will be finished at the surface using concrete and will be flush with the surrounding surface.
- The field representative will keep a daily log of all activities performed and materials used. The daily log will be reconciled with the probe contractor at the end of each work day.

5.3 GPS Surveying

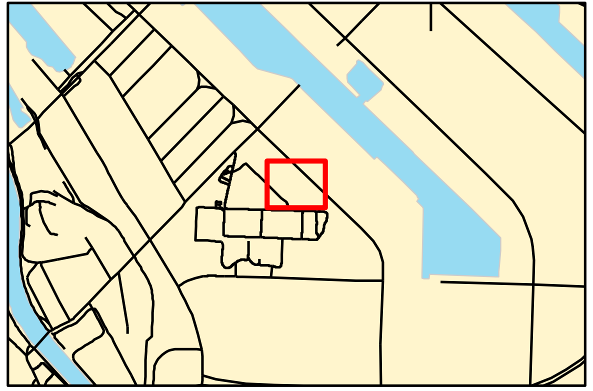
This section outlines the standard operating procedures for the use of mapping surveys that use global positioning system (GPS) instruments. These instruments will be used to collect positional (that is, horizontal survey) data, which can be in the form of individual features, the description of linear items, and the delineation of areas of interest. All items must be accompanied by a feature identification note, and, if necessary a detailed list of attributes of the feature.

For mapping or geographic information system (GIS) surveys, GPS receivers (with differential corrections applied either in real-time or in post-processing) must be rated at "sub-meter" (one meter or better) accuracy for horizontal surveying. The instrument may be set up in a backpack for surveys accessed by foot travel in typical ground terrain. Wherever possible, the GPS receivers will be used with a radio receiver linked to the GPS unit to receive the U.S. Coast Guard navigation beacon broadcast of GPS differential corrections. This enables the GPS system to generate final corrected positions in real time, allowing for positional checks during operation and for accurate navigation to predetermined or prerecorded positions, and obviates the post-processing required for differential corrections that must be applied when base station data are used. The navigation beacon is generally available in coastal areas. Dependent upon terrain conditions, it can be received as far as 100 to 200 miles inland as well. If the navigation beacon is not used, base station data for post-processing must be obtained from a reliable source. This can be from a project base station set up locally for the purpose, or a community base station, public or private, from which the appropriate data can be obtained.

Quality Assurance/Quality Control (QA/QC) procedures will include checks to known points during the course of the survey. To the extent practicable, known point positions will be recorded as they are encountered to verify positional surveys. Side trips to known points may be made to include selected known points in project records.

After the field work is complete, the data collector will be downloaded to a computer by using appropriate software. If the survey is performed in real-time mode with the differential corrections from the navigation beacon broadcast, the only steps required are to download the data, format it to an ASCII file or to an appropriate GIS data entry format, and output the data. If the survey is performed with a base station as the reference, the data are obtained and read into the software in the same way as for real-time mode except that the differential correction procedure will be performed prior to formatting and output.

VICINITY MAP

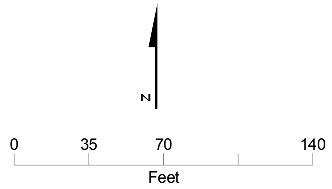


LEGEND

Proposed Soil Sample Location

Sample Year

● Sampled Annually
● Year 1
● Year 2
● Year 3
● Year 4
● Year 5
● Year 6
▭ Site Boundary
------- Fence Line
—— Approximate Property Line
▬ Groundwater Interceptor Trench
▨ Areas Excluded from Soil Sampling
▢ Building



1 inch = 90 feet

FIGURE A-2
Proposed Soil Sample Locations

Lilyblad Petroleum, Tacoma, WA

\\SIMBA\PROJ\WASTATEDEPTECOLOGY\380987\GIS\MAPFILES\QAPP\POTENTIALSOILSAMPLLOCATION.MXD DMORIN1 3/12/2009

CH2MHILL

5.4 Sampling Tool Decontamination

All equipment that may directly or indirectly contact samples will be decontaminated in a designated decontamination area. This includes casing, drill bits, auger flights, the portions of drill rigs that stand above boreholes, sampling devices, and instruments such as sounders. In addition, the contractor will take care to prevent samples from coming into contact with potentially contaminating substances, such as tape, oil, engine exhaust, corroded surfaces, and dirt. All steam cleaning rinsate will be collected and disposed of in the onsite groundwater treatment system.

The following procedure will be used to decontaminate large pieces of equipment such as casings, auger flights, pipe and rods, and those portions of the drill or direct-push rig that may stand directly over a boring or well location or that come into contact with casing, auger flights, pipe, or rods:

- Wash the external surfaces of equipment with high-pressure hot water and Alconox, or an equivalent laboratory-grade detergent, and
- If necessary, scrub until all visible dirt, grime, grease, oil, loose paint, and rust flakes have been removed.
- Rinse the equipment with potable water.

The inside surfaces of casing, drill rod, and auger flights will also be washed as described.

The following procedure will be used to decontaminate sampling and drilling devices such as split spoons, bailers, and augers that can be hand manipulated:

- Scrub the equipment with a solution of potable water and Alconox, or equivalent laboratory-grade detergent. Rinse the equipment with copious quantities of potable water followed by an ASTM Type II reagent-grade water (or deionized water with less than 15 microSiemens conductivity).
- Air-dry the equipment on a clean surface or rack, such as Teflon, stainless steel, or oil-free aluminum, elevated at least 2 feet above the ground.
- If the sampling device will not be used immediately after being decontaminated, it will be wrapped in oil-free aluminum foil or placed in a closed stainless steel, glass, or Teflon container.

5.5 Waste Handling

Waste can be classified as nonremedial activity-derived waste or remedial activity-derived waste (RADW), and will be managed accordingly, as follows:

- **Noninvestigation-derived waste**, such as litter and household garbage, will be collected on an as-needed basis to maintain each site in a clean and orderly condition. This waste will be containerized and transported to the designated sanitary landfill or collection bin. Acceptable containers will be sealed boxes or plastic garbage bags.
- **RADW** will be properly containerized and temporarily stored at each site or designated temporary storage area, prior to transportation. Depending on the constituents of

concern (CoCs), fencing or other special marking may be required. The number of containers will be estimated on an as-needed basis. Acceptable containers will be sealed, U.S. Department of Transportation (DOT)-approved steel 55-gallon drums or small dumping bins with lids. The containers will be transported in a manner that prevents spillage or particulate loss to the atmosphere. To facilitate handling, the containers will be no more than two-thirds full when moved. Purge water may be disposed of in the groundwater treatment intake, on the Nelson Property in the grate towards the northwest corner of the site.

The RADW will be segregated at the site according to matrix (solid or liquid) and how it was derived (for example, drill cuttings, drilling fluid, decontamination fluids, or purged groundwater). Each container will be properly labeled with the site identification, sampling point, collection depth, sampling matrix, CoCs, and other pertinent information for handling purposes. More detailed information regarding waste management is provided in the Waste Management Plan presented with the Remedial Action Work Plan prepared for the Lilyblad Site.

5.6 Documentation and Field Observations

5.6.1 Sample Identification and Labeling

Each sample will be designated by a unique identifier according to the following scheme. Sample labels will be completed using waterproof-ink pens and affixed to containers at the time of sampling. Soil sample designation numbers will contain, at a minimum, the following identifiers (example: LS-DPSB01a**)**:

- LS = Lilyblad Site
- DP = Station type, in this case direct-push probe location
- SB = Sample type, in this case subsurface soil (SB)
- 01 = Station ID number (two digits starting from 01)
- a = Sample interval, a for uppermost sample, b for the next deeper sample, and so on

Groundwater sample designation numbers will contain the following identifiers (example: LS-GW-24):

- LS = Lilyblad Site
- GW = Sample matrix (samples collected from direct-push locations will be designated DPGW)
- 24 = Well number or direct-push station number

Sample numbers will be recorded in the field logbook, on sample container labels, and chain-of-custody forms. Other information recorded on the sample container labels includes:

- Date and time the sample was collected
- Initials of sampler(s)
- Laboratory analyses to be performed
- Preservatives used, if any

5.6.2 Field Logbooks

The field representative will maintain a field logbook that contains all information pertinent to the FSP. The logbook will include at a minimum:

- Project name
- Project number
- Personnel
- Weather conditions
- Equipment calibration and decontamination
- Health and safety monitoring
- Photograph log (if photographs are taken)
- Sample data
- Location of sample
- Soil cover material (concrete, asphalt)
- Date of sample collection
- Time of sample collection
- Type of samples taken
- Sample identification numbers
- Sampling method
- Description of soil type (USCS)
- PID/FID headspace measurement
- Personnel decontamination procedures

All members of the field team will use the notebook, make entries in ink, then initial and date each page.

5.6.3 Corrections to Documentation

All entries in field and laboratory notebooks will be written in waterproof ink. No accountable serialized documents will be destroyed or thrown away, even when they are illegible or contain inaccuracies that require a replacement document. When an error is made on an accountable document, the person who made the error will make the correction by crossing a line through the error and entering the correct information. The erroneous information should not be obliterated. Any subsequent error discovered on an accountable document should be corrected by the person who made the entry. All corrections will be initialed and dated.

5.6.4 Sample Chain of Custody and Shipment

The management of samples collected in the field involves specific procedures that must be followed to ensure field sample integrity and custody. The possession of samples must be traceable from the time they are collected through the time they are analyzed by the contract laboratory.

The chain of custody of a sample is defined by the following criteria:

- The sample is in a person’s possession, or is in his/her view after being in his/her possession.

- The sample was in a person's possession and was locked up or transferred to a designated secure area by him/her.

Each time the samples change hands, both the sender and receiver will sign and date a chain-of-custody form and specify which item(s) has changed hands. When a sample shipment is sent to the laboratory, the top signature copy will be enclosed in plastic with the sample documentation and secured to the inside of the sample shipment containers. The second copy of the chain-of-custody form will be retained in the project files. A chain-of-custody record will be completed for each shipping container.

The following information is included on the chain-of-custody form:

- Sample number
- Signature of sampler
- Date and time of collection
- Project name and number
- Type of sample
- Number and type of container
- Inclusive dates of possession
- Signature of receiver

In addition to the labels, seals, and chain-of-custody form, other sample tracking components include the field logbook, sample request sheet, sample shipment receipt, and laboratory logbook. Before packaging samples, field personnel will make certain that the exterior of the sample container is clean and that the sample label is legible.

5.6.5 Sample Packing

The sample packaging and shipping containers will be assembled and packed to meet the following requirements:

- There will be no release of materials to the environment.

- Inner containers that are breakable must be packaged to prevent breakage and leakage. The cushioning and absorbent material used will not be reactive with the sample contents.

- The packaging procedures will be in compliance with all DOT and commercial carrier regulations. Only waterproof ice chests or coolers (supplied by the analytical laboratory) will be considered acceptable shipping containers.

Samples for shipment will be packed using the following procedures:

- Seal the drain plug in the cooler inside and outside with duct tape or equivalent.

- Pack, secure, or cushion sample bottles in a way that prevents breaking or leaking and that controls movement of the inner containers within the package during normal shipping conditions. Wrap glass bottles with bubble wrap or styrofoam wrapping; place them inside Ziploc-type plastic bags and then place them in the cooler.

- Add absorbent or cushioning material. Cushioning material will be used that does not react with or be deleteriously affected by the contents of the inner packages if the contents leak.
- Add ice in double-bagged Ziploc-type plastic bags.
- Place the shipping list chain-of-custody form in a plastic bag attached to the inside of the cooler lid.
- Attach two chain-of-custody seals (front and back of container) so that the seals must be broken if the cooler is opened.
- Place the name and address of the receiving laboratory in a position clearly visible on the outside of the cooler.
- Secure the lid with fiber tape.

All shipments for analysis will be transported directly to the laboratory or shipped to the laboratory via overnight courier. In either case, the laboratory will be notified immediately when samples are shipped.

6 Subcontractor Project Activities

The following field activities will be conducted by subcontractors working for CH2M HILL:

- Utility locating subcontractor
- Drilling subcontractor

Attachment B
Lilyblad Site Remediation Monitoring DQO

1. Problem Statements

Purpose:

- Clearly define the problem that requires new environmental data so that the focus of the study will be clear and unambiguous.

Outputs from This Step:

- A concise description of the problem.
- A list of the planning team members and identification of the decision maker.
- A summary of available resources and relevant deadlines for the study.

Problem

Remedial action based on the previous investigations and in the Cleanup Action Plan (CAP; Ecology, 2007). Remediation of the Lilyblad Petroleum Site (Site) consisting of most of the former Lilyblad Petroleum property, part of the Port of Tacoma Road, and adjacent portions of the MP Eagle property, Nelson property, and Saul property (Figure 3 of the QAPP). Historical releases of petroleum products and organic (for example, solvent) chemicals in the 1970s and 1980s resulted in contamination of subsurface soils and groundwater. The preferred remedial action is to apply dual phase (vacuum) extraction (DPE), potentially in combination with subsequent *in situ* treatment to treat both soil and groundwater contaminants. Data collection events will be conducted to maintain compliance with applicable air discharge and water discharge permits and to prepare site remediation status reports. The data will also be used to assess the effectiveness of the remedial system operations and allow for decisions to be made on when and where to implement *in situ* remedial methods. The data collection events needed are as follows.

1 – Treatment System Influent/Effluent Monitoring for Vapor and Water:

- Monthly samples will be collected from the influent (untreated) and effluent (treated) vapors extracted by the DPE system to determine the amount of contaminant mass that is being removed in the vapor phase from the subsurface. The vapor sample analytes will include gasoline-range total petroleum hydrocarbons (TPH-G), and volatile and semi-volatile organic compounds (VOCs and SVOCs). Additional analytes may be required if dictated by an air discharge permit.
- Monthly samples will be collected from the influent (untreated) and effluent (treated) water extracted by the DPE system to determine the amount of contaminant mass that is being removed in the liquid phase from the subsurface. The water sample analytes will be dictated by the wastewater discharge permit to be applied to the site; however, at a

minimum, the concentration of benzene, ethyl benzene, toluene, and xylene (BETX), oil and grease (O&G), total suspended solids (TSS), and metals [arsenic, cadmium, chromium (VI and total), copper, cyanide (free and total), lead, mercury, nickel, silver, and zinc] will be determined by laboratory analysis of water samples collected during the initial system operation. The list of metals to be analyzed may be modified based on the initial laboratory results and concurrence with the permitting agency (City of Tacoma); however, BETX, O&G, and TSS will continue to be analyzed in the system effluent on a monthly basis.

2 – Groundwater Monitoring

Monthly groundwater samples will be collected from five groundwater monitoring wells located within the area of contamination and up gradient of the contaminant area to collect data related to contaminant plume behavior and subsurface biological conditions. The data to be collected from each of these wells will be as follows:

- Prior to making any adjustments to the DPE system operation, the depth to groundwater will be measured at each of the groundwater monitoring wells. Following this measurement, the DPE system will be deactivated in the vicinity of the wells to be sampled.
- Following deactivation of the DPE system in the vicinity of the groundwater wells to be sampled, a field meter will be used to measure the concentration of carbon dioxide (CO_2) in the headspace of the well. After the CO_2 measurement is collected, the depth to groundwater will be measured, and field instrumentation will be utilized to measure the following geochemical data in the groundwater: dissolved oxygen (DO), oxidation-reduction potential (ORP), pH, and conductivity.
- After the geochemical data is collected, a groundwater sample will be collected from the monitoring wells for submission to a laboratory for analysis of VOCs, SVOCs, TPH-G, diesel-range total petroleum hydrocarbons (TPH-D), nitrate, iron, and sulfate.

On a quarterly basis, a total of 13 groundwater monitoring wells will be sampled. These wells will include the five wells sampled on a monthly basis, as well as eight additional wells that will more fully represent conditions within the contaminant plume as well as areas up and down gradient of the contaminant plume. The method of collection and type of data collected will be the same as the data collected from the five groundwater monitoring wells on a monthly basis.

On an annual basis, beginning in the fourth quarter of 2009 (the second quarter of DPE system operations), a total of 35 groundwater monitoring wells will be sampled. These wells will include the 13 wells sampled on a quarterly basis, as well as 22 additional wells. The method of collection and type of data collected will be the same as the data collected from the five groundwater monitoring wells on a monthly basis.

3 – Soil Monitoring

On an annual basis, beginning in the third quarter of 2009 (the first quarter of DPE system operations), 12 soil samples will be collected from the site. The soil samples will be submitted to a laboratory for analysis of VOCs, SVOCs, TPH-G, TPH-D, and total organic carbon (TOC).

Planning Team Members

Martin Powers (PM), Artemis Antipas (QAO), Mario Lopez (field leader), Tracy Brian

Limitations on Available Resources

Currently none

Relevant Deadlines

Per monitoring schedule identified above to start Summer 2009

2. Decision Statements

Purpose:

- Define the decision(s) that will be resolved using data to address the problem.

Approach:

- Identify the key question that the study attempts to address and alternative actions that may be taken, depending on the answer to the key study question.

Outputs from This Step:

- A statement of the decision that must be resolved using data in order to address or solve the problem.
- A list of possible actions or outcomes that would result from each resolution of the decision statement.

Note from EPA guidance on DQO: If the principal study question is not obvious and specific alternative actions cannot be identified, then the study may fall in the category of exploratory research, in which case, this particular step of the DQO Process may not be needed.

1 – Influent/Effluent from Treatment System:

Monthly Samples – influent and effluent vapor and water samples from the remediation system will be used to a) determine compliance with air and water discharge permits and b) develop contaminant mass removal calculations in the vapor and water phase.

Groundwater samples – evaluate the contaminant plume behavior and determine if the remedial system operations should be altered to focus remedial efforts on particular areas of the Site.

2 – Groundwater Monitoring:

Quarterly Groundwater Samples – evaluate the contaminant plume behavior and determine if remedial system operations should be altered to focus remedial efforts in particular areas of the Site; determine if there is progress toward meeting the Site’s groundwater cleanup levels (CULs); determine if in situ methods should be implemented to increase remedial effectiveness.

Annual Groundwater Samples – evaluate the contaminant plume behavior and determine if remedial system operations should be altered to focus remedial efforts in particular areas of the Site; determine if there is progress toward meeting the Site's groundwater CULs; determine if in situ methods should be implemented to increase remedial effectiveness.

3 – Soil Monitoring:

Annual Soil Samples – evaluate progress of the remediation system in achieving soil cleanup levels and to determine if in situ methods should be implemented to increase remedial effectiveness.

3. Input to the Decision

Purpose:

- The purpose of this step is to identify the data inputs that will be required to resolve the decision, and to determine which inputs require environmental measurements.

Activities:

- Identify the information that will be required to resolve the decision.
- Determine the sources for each item of information identified.
- Identify the information that is needed to establish the action level for the study.
- Confirm that appropriate field sampling techniques and analytical methods exist to provide the necessary data.

Outputs from This Step:

- A list of informational inputs (including sources and potential action levels) needed to resolve the decision.
- The list of environmental variables or characteristics that will be measured.

Required Information

1 – Treatment System Influent/Effluent

Influent/Effluent Vapor

Concentrations of TPH-G, VOCs, and SVOCs. and HCl will be determined. Specific VOC and SVOC analytes are per the CUL list shown below. These include air permit requirements (VOCs and HCl).

Influent/Effluent Water

The water sample analytes will be dictated by the wastewater discharge permit to be applied to the site; however, at a minimum, the concentration of BETX, O&G, TSS, and metals [arsenic, cadmium, chromium (VI and total), copper, cyanide (free and total), lead, mercury, nickel, silver, and zinc] will be determined by laboratory analysis of water samples collected during the initial system operation. The list of metals to be analyzed may be modified based on the initial laboratory results and concurrence with the permitting agency (City of Tacoma); however, BETX, O&G, and TSS will continue to be analyzed in the system effluent on a monthly basis.

2 – Groundwater Monitoring

- Monthly groundwater samples. Prior to making any adjustments to the DPE system operation, the depth to groundwater will be measured at each of the groundwater monitoring wells. Following this measurement, the DPE system will be deactivated in the vicinity of the wells to be sampled.
  - Following deactivation of the DPE system in the vicinity of the groundwater wells to be sampled, a field meter will be used to measure the concentration of CO_2 in the headspace of the well. After the CO_2 measurement is collected, the depth to groundwater will be measured, and field instrumentation will be utilized to measure the following geochemical data in the groundwater: DO, ORP, pH, and conductivity.
  - After the geochemical data is collected, a groundwater sample will be collected from the monitoring wells for submission to a laboratory for analysis of VOCs, SVOCs, TPH-G, diesel-range total petroleum hydrocarbons (TPH-D), nitrate, iron, and sulfate. VOC and SVOC lists are the same as the CUL lists below.
- On a quarterly basis, the type of data collected will be the same as the data collected from the five groundwater monitoring wells on a monthly basis.
- On an annual basis, type of data collected will be the same as the data collected from the five groundwater monitoring wells on a monthly basis.

3 – Soil Monitoring

- VOCs, SVOCs, TPH-G, TPH-D, and total organic carbon (TOC). VOC and SVOC lists are the same as the CUL lists below.

Data Sources:

1-Samples to be collected from the treatment system

2-Past RI/FS data as well as samples to be collected in the field

3-Past RI/FS data as well as samples to be collected in the field

Action Levels

1-Action levels will be dictated by the permits

2- Groundwater, and 3-soil- action levels as listed and referenced in Table B-1

Analytical Methods

Applicable methods are shown in the QAPP.

TABLE B-1
Soil & Groundwater Cleanup Levels (CULs)

Constituent of Concern	Soil CUL (µg/kg)	Groundwater CUL (µg/L)
1,1,1-trichloroethane	1,144	227
1,1,2-tricholoroethane	54.1	16
1,1-dichloroethane	164,000	52,000
1,1-dichloroethene (DCE)	7.9	1.93
1,2,4-trimethylbenzene	10,350,000	26,000
1,2-dichloroethane	100.6	37
1,4-dichlorobenzene	64.6	4.86
Benzene	75	22.7
bis(2-ethylhexyl)phthalate	4,400	2.2
cis-1,2-dichloroethene(a) (DCE)	14,880	5,200
Ethylbenzene	41,130	6,910
m,p-xylene	58,400	26,000
Methylene chloride	1,332	590
Tetrachloroethene (PCE)	24.5	3.3
Toluene	71,340	15,000
Trichloroethene (TCE)	121.7	30
Vinyl chloride	7.91	2.4
Naphthalene	115,900	4,940
Pentachlorophenol	37.97	3
2-methylnaphthalene	-	22.5
Diesel range hydrocarbons	2,000,000	1,000
Gasoline range hydrocarbons	100,000	1,000
Motor oil	2,000,000	1,000

Notes: (a) Erroneously listed as cis-1,2-dichlorobenzene in the CAP.

Ecology derived soil CULs for volatile organic compounds (VOCs) and semi-volatile organic compounds (SVOCs)using the three-phase partitioning model and groundwater cleanup numbers.

Ecology used Method A soil and groundwater CULs for total petroleum hydrocarbon (TPH) compounds.

Ecology derived groundwater CULs for protection of surface water and for VOCs and SVOCs applied the more restrictive of two standards: the ambient water quality toxics criteria and the Method B surface water cleanup standards.

4. Study Boundaries

Purpose:

- The purpose of this step is to identify the data inputs that will be required to resolve the decision, and to determine which inputs require environmental measurements.

Activities:

- Identify the information that will be required to resolve the decision.
- Determine the sources for each item of information identified.
- Identify the information that is needed to establish the action level for the study.
- Confirm that appropriate field sampling techniques and analytical methods exist to provide the necessary data.

Outputs from This Step:

- A list of informational inputs (including sources and potential action levels) needed to resolve the decision.
- The list of environmental variables or characteristics that will be measured.

Spatial Boundary

1- Influent/effluent decision boundaries are pre- and post-treatment streams.

2- Groundwater decision boundaries are shown in Figure A-1of the Field Sampling Plan (FSP) (Attachment A).

3- Soil boundaries are shown in Figure A-2 of the FSP.

Temporal Boundary

1- Decision will apply to time between monitoring events.

2- Decision will apply to time between monitoring events.

3- Decision will apply to time between monitoring events.

5. Decision Rules

Purpose:

- The purpose of this step is to integrate the outputs from previous steps into a single statement that describes the logical basis for choosing among alternative actions.

Activities:

- Specify the parameter that characterizes the population of interest.
- Specify the action level for the study.
- Combine the outputs of the previous DQO steps into an "if...then..." decision rule that defines the conditions that would cause the decision maker to choose among alternative actions.

Outputs from This Step:

- An "if...then..." statement that defines the conditions that would cause the decision maker to choose among alternative courses of action.
- Steps into a single statement that describes the logical basis for choosing among alternative actions.

1 – Treatment System Influent/Effluent

Treatment system/ effluent concentrations related decisions will be per vapor and water permits obtained for the site. Also individual sample point concentration differences between influent and effluent will be evaluated for system treatment effectiveness. If needed statistical analyses may be used to establish trends.

2 – Groundwater Monitoring

Groundwater individual sample concentrations will be plotted and tabulated for establishing trends to assess the effectiveness of the treatment. If needed statistical evaluations may be carried out. Also groundwater data will be assessed for implementation of other treatments (biostimulation and ISCO) as described below.

3 – Soil Monitoring

Soil individual sample concentrations will be plotted and tabulated for establishing trends to assess the effectiveness of the treatment. If needed statistical evaluations may be carried out. Soil data will also be assessed for implementation of other treatments (biostimulation and ISCO) as described below.

Biostimulation Implementation Decision Process

Injection of nutrients (for example, a mixture of nitrogen, phosphate, and potassium) will be implemented when there is prevailing evidence that the additional aerobic biodegradation rate influenced by the addition of nutrients will be beneficial as compared to contaminant reduction achieved during the operation of the DPE system without the injection of nutrients. Specifically, nutrient injection will be considered based on the following factors:

- Mass removal of CoCs through groundwater extraction has sufficiently diminished based on total CoC concentrations in the influent groundwater (as measured just prior to the air stripper) in the groundwater treatment system reaching levels of approximately 100 ppb or less.
- Mass removal of CoCs through vapor extraction has sufficiently diminished based on mass removal rates of the sum total of CoC analyzed falling below 10 pounds per month for three consecutive months in the influent vapor (as measured prior to the initial vapor treatment device – catox or granular activated carbon (GAC) adsorber).
- Groundwater analytical data indicating that the reduction in concentration of CoCs in the groundwater appear to be reaching steady-state conditions where the total volume of groundwater impacted by CoCs in excess of CULs appears to be diminishing by less than 10 percent over the course of two consecutive quarterly groundwater sampling events.

- Groundwater analytical data indicating that sufficient DO (typically determined to be greater than 1 ppm) is present in the groundwater within the contaminant plume to support aerobic biodegradation.
- Groundwater analytical data indicating that insufficient nitrogen is present in the groundwater to sustain aerobic biodegradation processes given the corresponding concentration of DO.
- CO_2 data collected from groundwater monitoring well headspace indicating that the concentration of CO_2 present within the contaminant plume is greater than that measured outside the contaminant plume area which indicates that the increased level of DO is causing an increased aerobic biodegradation rate within the plume.
- Review of geochemical data (pH, ORP, iron, nitrate, sulfate, and conductivity) indicates that conditions within the contaminant plume are more favorable for an increased aerobic biodegradation rate.
- Soil analytical data indicates that CoC concentrations within the soil (vadose and smear zone) are present at concentrations in excess of CULs.

Additional details related to the criteria to be considered when determining whether to begin nutrient injection into the groundwater will be presented within the Operation and Maintenance (O&M) Plan to be prepared for the project.

During the biostumulation phase, a nutrient solution will be injected through deactivated DPE extraction wells and the surrounding DPE extraction wells will remain in operation to promote the movement of the injected nutrients throughout the groundwater formation in the vicinity of the point of injection. Similar to the DPE system, the nutrient injection system will have flexibility so that nutrients can be injected into all of the DPE fields or focused on individual wells or areas where conditions appear to be more favorable for aerobic biodegradation.

ISCO Implementation Decision Process

Injection of chemical oxidants (such as potassium permanganate or a form of hydrogen peroxide) will be implemented when there is prevailing evidence that the aerobic biodegradation rates of CoC have sufficiently decreased due to the lack of a viable carbon source (that is, non-halogenated hydrocarbons) for continued aerobic biodegradation and ISCO methods could mineralize the remaining CoCs to meet CULs. Specifically, ISCO injection will be considered based on the following factors:

- Mass removal of CoCs through groundwater extraction has sufficiently diminished based on total CoC concentrations in the influent groundwater (as measured just prior to the air stripper) in the groundwater treatment system reaching levels of approximately 100 ppb or less.
- Mass removal of CoCs through vapor extraction has sufficiently diminished based on mass removal rates of the sum total of CoC analyzed falling below 10 pounds per month for three consecutive months in the influent vapor (as measured prior to the initial vapor treatment device – catox or GAC adsorber).

- Groundwater analytical data indicating that the reduction in concentration of halogenated CoCs in the groundwater appear to be reaching steady-state conditions where the total volume of groundwater impacted by halogenated CoCs in excess of CULs appears to be diminishing by less than 10 percent over the course of two consecutive quarterly groundwater sampling events.
- Review of geochemical data (pH, ORP, iron, nitrate, sulfate, and conductivity) indicates that conditions within the contaminant plume are favorable for the successful chemical oxidation of halogenated CoCs.
- Soil analytical data indicates that non-halogenated CoCs and TOC concentrations within the soil (vadose and smear zone) will not impede the mineralization of halogenated hydrocarbon CoCs by ISCO methods.

Additional details related to the criteria to be considered when determining whether to begin injection of chemical oxidants into the groundwater will be presented within the O&M Plan to be prepared for the project.

During the ISCO phase, chemical oxidants will be injected through deactivated DPE extraction wells and the surrounding DPE extraction wells will remain in operation to promote the movement of the injected nutrients throughout the groundwater formation in the vicinity of the point of injection. Similar to the DPE system, the ISCO injection system will have flexibility in that chemical oxidant can be injected into all of the DPE fields or focused on individual wells or areas where conditions appear to be more favorable for mineralization of halogenated CoCs.

6. Tolerable Limits on Decision Rules

Purpose:

- Specify the decision maker's acceptable limits on decision errors, which are used to establish appropriate performance goals for limiting uncertainty in the data.

Activities:

- Determine the possible range of the parameter of interest
- Define both types of decision errors and identify the potential consequences of each
- Specify a range of possible parameter values where the consequences of decision errors are relatively minor (gray region)
- Assign probability values to points above and below the action level that reflect the acceptable possibility for the occurrence of decision errors
- Check the limits on decision errors to ensure that they accurately reflect the decision maker's concern about the relative consequences for each type of decision error

Outputs from This Step:

- The decision maker’s acceptable decision error rates based on a consideration of the consequences of making an incorrect decision

1 – Treatment System Influent/Effluent Monitoring for Vapor and Water

For influent/effluent sampling, statistical design is not applicable; samples will be taken from pre-established locations, thus developing decision errors is not applicable.

2 – Groundwater Monitoring

For groundwater sampling, statistical design is not applicable; samples will be taken from pre-established groundwater wells. The well locations are per geophysical conditions and hydrologist professional judgment. Thus developing decision errors within the parameters prescribed here is not applicable.

3 – Soil Monitoring

Soil sampling design is based on systematic judgment as described in the next step, thus the parameters of this section are not applicable.

7. Optimization of the Sampling Design

Purpose:

- Identify the most resource-effective sampling and analysis design for generating data that are expected to satisfy the DQOs

Activities:

- Review the DQO outputs and existing environmental data
- Translate the information from the DQOs into a statistical hypothesis
- Develop general sampling and analysis design alternatives
- For each design alternative, formulate the mathematical expressions needed to solve the design problems
- For each design alternative, select the optimal sample size that satisfies the DQOs
- Select the most resource-effective design that satisfies all of the DQOs
- Document the operational details and theoretical assumptions of the selected design in the Sampling and Analysis Plan

Outputs from This Step:

- The most resource-effective design for the study that is expected to achieve the DQOs, selected from a group of alternative designs generated during this step

1 – Treatment System Influent/Effluent Monitoring for Vapor and Water

Monthly samples will be collected from the influent (untreated) and effluent (treated) vapors extracted by the DPE System to determine the amount of contaminant mass that is being removed in the vapor phase from the subsurface. The vapor sample analytes will include TPH-G, VOCs, and SVOCs. Additional analytes may be required if dictated by an air discharge permit.

Monthly samples will be collected from the influent (untreated) and effluent (treated) water extracted by the DPE system to determine the amount of contaminant mass that is being removed in the liquid phase from the subsurface. The water sample analytes will be dictated by the wastewater discharge permit to be applied to the site; however, at a minimum, the concentration of BETX, O&G, TSS, and metals [arsenic, cadmium, chromium (VI and total), copper, cyanide (free and total), lead, mercury, nickel, silver, and zinc] will be determined by laboratory analysis of water samples collected during the initial system operation. The list of metals to be analyzed may be modified based on the initial laboratory results and concurrence with the permitting agency (City of Tacoma); however, BETX, O&G, and TSS will continue to be analyzed in the system effluent on a monthly basis.

2 – Groundwater Monitoring

Monthly groundwater samples will be collected from five groundwater monitoring wells located within the area of contamination and up gradient of the contaminant area to collect data related to contaminant plume behavior and subsurface biological conditions. The data to be collected from each of these wells will be as follows:

- Prior to making any adjustments to the DPE system operation, the depth to groundwater will be measured at each of the groundwater monitoring wells. Following this measurement, the DPE system will be deactivated in the vicinity of the wells to be sampled.
- Following deactivation of the DPE system in the vicinity of the groundwater wells to be sampled, a field meter will be used to measure the concentration of CO_2 in the headspace of the well. After the CO_2 measurement is collected, the depth to groundwater will be measured, and field instrumentation will be utilized to measure the following geochemical data in the groundwater: DO, ORP, pH, and conductivity.
- After the geochemical data is collected, a groundwater sample will be collected from the monitoring wells for submission to a laboratory for analysis of VOCs, SVOCs, TPH-G, TPH-D, nitrate, iron, and sulfate.

On a quarterly basis, a total of 13 groundwater monitoring wells will be sampled. These wells will include the five wells sampled on a monthly basis, as well as eight additional wells that will more fully represent conditions within the contaminant plume as well as areas up and down gradient of the contaminant plume. The method of collection and type of data collected will be the same as the data collected from the five groundwater monitoring wells on a monthly basis.

On an annual basis, beginning in the fourth quarter of 2009 (the second quarter of DPE system operations), a total of 35 groundwater monitoring wells will be sampled. These wells will include the 13 wells sampled on a quarterly basis, as well as 22 additional wells. The method of collection and type of data collected will be the same as the data collected from the five groundwater monitoring wells on a monthly basis.

The water sampling locations are shown in Figure A-1 of the FSP.

3 – Soil Monitoring

On an annual basis, beginning in the third quarter of 2009 (the first quarter of DPE system operations), 12 soil samples will be collected from the site. The soil samples will be submitted to a laboratory for analysis of VOCs, SVOCs, TPH-G, TPH-D, and TOC.

Figure A-2 of the FSP shows the soil sample locations.

Soil sampling design rationale is as follows:

Strategy

Soil sampling within the site will be conducted over the 6 years of clean up actions to evaluate if soil concentrations are meeting clean-up levels. Soil monitoring will consist of collection of 12 soils samples from the site, annually, beginning in the third quarter of 2009. Samples will be submitted to a laboratory for analysis of VOCs, SVOCs, TPH-G, TPH-D, and TOC. This results in 72 primary samples collected over the 6-year period. Three locations on the site will be sampled yearly, resulting in a total of 87 samples over the 6-year period.

Implementation

Figure A-2 of the FSP shows proposed sampling locations. Site extent, outlined in green, has been defined by previous site investigations, coinciding with the extent of soil contamination overlying the groundwater plume, representing ~ 4.2-acre surface area. Buildings within the site extent have been excluded from potential sampling (~57,400 square feet), resulting in an area of 126,420 square feet (2.9 acres) requiring soil monitoring over the period of remedial action. Samples have been positioned on a 41.5-foot grid, randomly oriented from a random start point. The 72 primary sample locations are color-coded to indicate years 1 through 6 of the remedial action. Location allocation per year has been established to ensure that the site is spatially covered each year. The three locations to be sampled each of the 6 years, to examine change over the period of remediation, are asterisked.

Rationale

The rationale for the sampling strategy, including sample size, grid spacing and orientation, vertical profile, replicated locations and field duplicates is summarized in the following bullets:

- Annual sample size allocation is 12 primary locations per year. Conservatively assuming a homogeneous population, a sample size of 12 is sufficient to estimate the 85th percentile of a population with 85-percent confidence.
- Grid spacing derives from the total surface area of exposed soils, divided by the total number of sample locations. Positioning of the grid was established from a random start point and oriented in a random direction to ensure that the samples collected have been randomly located. Randomization is a major assumption of the statistics that will be used to compare soil sample results to criteria.
- The actual location of the 12 primary samples per year has been systematically assigned so that the entire site extent is covered during each year of sampling. This strategy

intends to ensure comparable spatial coverage from the period of expected highest soils concentration through the gradient to reduced soils concentrations resulting from the remedial action.

- The three locations that will be sampled every year will provide data which can be used to test for trend in concentration changes at the same location over the period of remediation. Testing for trend requires a minimum of four events, which is met by the six sequential samples at these three locations. The specific locations targeted for annual sampling (SS05, SS34 and SS68) have been selected to cover the center of the plume and locations approaching the northern and southern boundaries of plume extent. Given the year assigned to these locations, years 1, 2 and 4 will include 15 samples (the originally assigned 12 samples plus the 3 temporal replicates) and years 3, 5 and 6 will include 14 samples (the originally assigned 12 plus the 2 additional temporal replicates).
- Field duplicate sample allocation is to be the usual 10 percent of samples collected (rounding up to the next integer) and will be coupled to the three locations that are sampled annually. The resulting two field duplicates will be randomly assigned to one of the two additional locations per year.
- The current soil monitoring plan assumes surface sampling. If, over the course of the remedial activities, subsurface sampling is desired, an optimal approach would be to extend the collection device at the same locations as the proposed surface characterization.

Data Evaluation

Resulting soil data will be evaluated on an annual basis and at the end of the 6-year remediation. Annual evaluations will include comparison of soil concentrations to clean up levels and, following year 1, comparison of site-wide results from successive years. At the end of the remediation period, results from the temporal replicate locations will be tested for statistically significant changes. Specific statistical methods per evaluation are summarized in the following bullets.

- Comparison to applicable criteria will include conventional distribution goodness-of-fit testing and 95-percent confidence intervals using the 14 to 15 primary and temporal replicates per year for each analyte with applicable criteria. If the 95 UCL is less than the criterion, it will be concluded that the analyte-specific clean up standard has been achieved. If the 95 UCL is greater than the criterion, it will be concluded that the analyte-specific clean up standard has not been achieved and individual sample results will be used to identify locations of exceedances over the site.
- Inter-annual comparisons will consist of t-tests or the nonparametric analogue, the Mann-Whitney test for year 2. Subsequent years where 3 or more years results are available will be compared using either a parametric or non-parametric test.
- Trend tests will rely upon the Mann-Kendall test for trend to identify the existence and direction of trend over time for target analytes.

Procedural details for the sampling are provided in the project’s FSP (Attachment A).