DEPARTMENT OF
ECOLOGY
State of Washington

Interim Action Plan

L & L Exxon Site
1315 Lee Boulevard
Richland, Washington

Prepared by
Washington State Department of Ecology
October 6, 2014

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ACRONYMS AND ABBREVIATIONS

APN	Assessor Parcel Number
ARAR	Applicable or Relevant and Appropriate Requirement
AS	Air Sparge
bgs	below ground surface
COC	Contaminant(s) of Concern
CSID	Cleanup Site Identification
CUL	Cleanup Level
DRPH	Diesel-Range Petroleum Hydrocarbons
Ecology	Washington State Department of Ecology
EPA	US Environmental Protection Agency
FSID	Facility Site Identification
FS	Feasibility Study
GRPH	gasoline-range petroleum hydrocarbons
HASP	Health and Safety Plan
IA	Interim Action
IAP	Interim Action Plan
MCL	Maximum Contaminant Level
mg/L	milligrams per liter
mg/kg	milligrams per kilogram
MPE	Multi Phase Extraction
MTCA	Model Toxics Control Act
PCE	perchloroethylene
POC	Point of Compliance
QAPP	Quality Assurance Project Plan
RCRA	Resource Conservation and Recovery Act
RCW	Revised Code of Washington
RI	Remedial Investigation
SAP	Sampling and Analysis Plan
SEPA	State Environmental Policy Act
SVE	Soil Vapor Extraction
TEE	Terrestrial Ecological Evaluation
TESC	Temporary Facilities and Site Controls
µg/L	micrograms per liter
µg/kg	micrograms per kilogram
UST	Underground Storage Tank
VI	Vapor Intrusion
VOCs	Volatile Organic Compounds
WAC	Washington Administrative Code

INTERIM ACTION PLAN
L & L EXXON SITE

1.0 INTRODUCTION

This document provides a draft Interim Action Plan (IAP) for petroleum hydrocarbon remediation in soil and/or groundwater. The Washington State Department of Ecology (Ecology) is conducting an Interim Action (IA) for a petroleum release that occurred at the L & L Exxon Site (Site) located at 1315 Lee Boulevard in Richland, Washington.

1.1 Purpose

The IA is intended to reduce contamination in soil and groundwater at the Site impacted with gasoline- and diesel-range petroleum hydrocarbons (GRPH and DRPH, respectively), and associated Volatile Organic Compounds (VOCs). The selected IA for the Site as described in this IAP includes *in situ* soil and groundwater treatment through the installation of infiltration galleries and injection wells, application of a chemical oxidant, enhanced bioremediation, and multi-phase extraction of groundwater and vapors, institutional controls, and compliance monitoring. This IA is intended to be a final cleanup action for the L & L Exxon petroleum release. Co-mingled tetrachloroethylene (PCE)-related groundwater contamination likely from the New City Cleaners site will not be fully addressed.

1.2 Public Participation and Final Interim Action Plan

Ecology is providing public notice and opportunity for comment on this draft interim action plan as required in Washington Administrative Code (WAC) 173-340-600(14). After review and consideration of comments received, Ecology will issue a final interim action plan and publish its availability in the Site Register.

1.3 Interim Action Plan Content Requirements

This IAP was prepared by Ecology's Toxics Cleanup Program and developed in accordance with Ecology's Model Toxics Control Act Cleanup Regulation (MTCA), WAC 173-340-430 to present the selected IA for the L & L Exxon Site to be conducted by Ecology. The proposed interim action was selected in accordance with the MTCA criteria for the selection of cleanup actions in WAC 173-340-360.

The general requirements for IAP contents are specified in WAC 173-340-430 and include the following elements:

- A description of the planned IA
- How the IA meets the criteria of this plan (Sections 4.2 and 5.2)
- Information from the remedial investigation and feasibility study (RI/FS) including
    - Existing Site conditions
    - Summary of available data
    - Alternative interim actions considered
    - Rationale for selecting the proposed alternative
- Design and construction requirements
- Compliance monitoring plan
- Revised Sampling and Analysis Plan (SAP) with a Health and Safety Plan (HASP) and a Quality Assurance Project Plan (QAPP) included as appendices.

1.4 Interim Action Plan Organization

A description of subsequent sections of this IAP and the topics discussed are as follows:

- Section 2.0: Site Background, History, and Environmental Conditions; includes the Site location and description, geologic and hydrogeologic setting, historical operations and nature of contamination, previous environmental investigations and interim cleanup actions, summary of groundwater monitoring results, , and recent data gap investigation and results.
- Section 3.0: Cleanup Standards, Areas of Concern, and Points of Compliance; identifies cleanup levels established for the Site, areas of concern based on soil and groundwater contamination, and points of compliance for soil and groundwater at the Site.
- Section 4.0: Alternatives Development and Evaluation; presents a summary of the remedial action alternatives that were developed and evaluated in the Feasibility Study (FS), summary of the selected interim action and rationale for selection, and an updated evaluation of the selected interim action;
- Section 5.0: Selected Interim Action; presents a description of the selected interim action; how the selected interim action satisfies MTCA criteria, including the threshold requirements, use of permanent solutions to the maximum extent practicable, and providing a reasonable restoration time frame; compliance with applicable local, state, and federal laws; and completion of cleanup.
- Section 6.0: Interim Action Implementation Schedule; presents the implementation schedule for the interim action.
- Section 7.0: Ecology Periodic Reviews; describes the periodic reviews to be conducted by Ecology to ensure the selected interim action remains protective of human health and the environment.
- Section 8.0: References.

2.0 SITE BACKGROUND, HISTORY, ENVIRONMENTAL CONDITIONS, AND EXPOSURE PATHWAYS

Background project information including the Site location and description, geologic information, past Site operations, nature of contamination, previous environmental investigation activities and interim cleanup actions, groundwater monitoring and environmental conditions are described in the following subsections.

2.1 Site Location, Description, & Identifiers

- Site Address: 1315 Lee Boulevard in Richland, Yakima County, Washington (Vicinity Map, Figure 1).
- Location: Section 11, of Township 09 North, Range 28 East, of the Willamette Meridian
- Benton County Assessor's Parcel Number (APN): 111983020402002
- The assigned Ecology identification numbers for the Site are:
  - Facility Site Identification (FSID): 78835792
  - Cleanup Site Identification (CSID): 7128

The L & L Exxon property is 0.63 acres in size. The property is bounded on the north by Lee Boulevard, on the west and south by commercial properties, and on the east by Goethals Drive (Site Plan, Figure 2). A 4,540 square foot (sf) building is located at the approximate center of the Site. An automotive maintenance shop operates in the western portion of the building, and the eastern portion is currently used as a customer waiting area and for offices. The remainder of the Site is paved with asphalt concrete or gravel surfacing and is relatively level.

The Site is defined as the area located in the City of Richland where petroleum-related contaminants released at the L & L Exxon property have come to be located. For purposes of this IAP, the Site includes areas that may be affected by contaminants originating from the former L & L Exxon, including off-property parcels affected by on-property source areas.

2.3 Historical Operations and Nature of Contamination

The Site formerly consisted of a gasoline and service station, operated as L & L Exxon, from the 1950s until 1999. Historical use of the Site prior to the 1950s is unknown. Correspondence in the Site file indicates excavation, treatment, and disposal of contaminated soil was conducted in 1989. Five Underground Storage Tanks (USTs), fuel dispensers, and associated piping were removed at closure in 1999. At this time, petroleum hydrocarbon contamination was identified and a release from the UST system was confirmed.

The Site is co-mingled with an off-property PCE contaminant plume, likely migrating from the up-gradient New City Cleaners cleanup site (Address: 747 Stevens Dr., Richland, WA, Facility Site ID: 327). The soil and groundwater source area for PCE groundwater contamination from New City Cleaners is being addressed separately under an Agreed Order. This IA will only partially and temporarily address the down-gradient portion of the New City Cleaners PCE co-mingled groundwater plume. PCE groundwater contamination is expected to continue to migrate through the L & L Exxon property following cleanup of the L & L Exxon release.

Figure 2 provides the current Site layout and adjacent properties.

2.2 Geology and Hydrogeology

Soil encountered generally consisted of brown silty sand to a depth of 5 to 10 feet below ground surface (bgs), and brown poorly graded gravel and zones of cobbles and silt and silty sand to the completed depths of 25 feet bgs. Wood and metal (bolts) debris were observed in two test pits at depths of approximately 5 to 10 feet bgs.

Site groundwater elevations fluctuate minimally; approximately 0.5 foot during the last four monitoring events. The highest groundwater levels were observed in December 2013, but not enough data has been collected to draw conclusions regarding seasonal or irrigation recharge. The shallow groundwater table at the Site is typically present at approximately 15 and 18 feet bgs under unconfined conditions. Groundwater flow direction is generally toward the east and south- southeast. An apparent groundwater trough resulting in converging flows toward monitoring wells MW-1 and MW-5 was observed during the December 2013 and February 2014 groundwater monitoring events. Groundwater horizontal gradients at the Site are fairly shallow, ranging from 5×10^{-4} to 3.7×10^{-3} feet per foot. Vertical gradients and groundwater velocities have not been assessed.

2.4 Previous Environmental Investigations and Interim Cleanup Actions

Documentation of historical Site remediation work prior to 2012 is incomplete. Information obtained from historical reports, interviews, and observations indicate: excavation and land farming of contaminated soil, injection of microbes into the subsurface at the eastern side of the building on two occasions, installation of a blower at the injection points to supply air to aid biodegradation, and the installation of four groundwater monitoring wells. However, analytical results of soil samples collected during more recent soil investigation activities indicate petroleum contaminated soil and groundwater remain at the Site.

GeoEngineers performed subsurface assessment activities, beginning September 2012, by drilling six soil borings (B-1 through B-6) near the former UST and dispenser locations. Three additional borings were drilled to approximately 8 to 10 feet below the groundwater table and groundwater monitoring wells MW-1 through MW-3 were constructed.

Supplemental assessment activities were conducted in April 2013. Two additional downgradient monitoring wells (MW-4 and MW-5) were installed in Goethals Drive located east of the property and five test pits (TP-1 through TP-5) were excavated in the property to further define the extent of soil contamination. The test pits were backfilled and surfaced with crushed rock, and currently remain unpaved.

Groundwater samples have been collected from monitoring wells MW-1 through MW-3 since October 2012 and from monitoring wells MW-4 and MW-5 since May 2013. Groundwater monitoring is on-going and will continue throughout the IA remediation and post-remediation until the cleanup objectives have been attained.

Site features and monitoring well locations are depicted on Figure 2.

2.5 Summary of Groundwater Monitoring Results

The Site's monitoring well network currently consists of three on-property and two off-property wells (Figure 2). These wells are shallow wells installed at screen depths of approximately 15 to 25 feet bgs to monitor conditions in the shallow aquifer. Maximum concentrations of groundwater contaminants exceeding screening levels from recent (2012 through 2014) monitoring events are shown below in Table 1. See Appendix A for a summary of groundwater data.

Table 1. Maximum contaminant concentrations in shallow groundwater exceeding screening levels from recent (2012 through 2014) monitoring events.

Contaminant Name	Max Concentration in Groundwater (ug/L) [2]	Comparitive Screening Level [1] (ug/L) [2]	Monitoring Well Location
Benzene	1,620	5	MW-1
DRPH	10,700	500	MW-1
Ethylbenzene	2,750	700	MW-2
GRPH	98,400	800	MW-2
Manganese [3]	3.8 mg/L	0.01 mg/L [4]	MW-1
Naphthalenes [5]	724.3	160	MW-1
Nitrate-Nitrogen [3]	15.8 mg/L	2.2 mg/L [6]	MW-3
PCE [3]	12.2	5	MW-3
Toluene	15,700	1,000	MW-2
Xylenes [7]	13,480	1,000	MW-2

[1] The screening levels are MTCA Method A unless otherwise noted.
[2] Concentrations are reported as ug/L unless otherwise noted.
[3] These contaminants are not associated with a release of petroleum products originating from the Site. Refer to the discussion below for more information.
[4] MTCA Method B, non-carcinogenic.
[5] Includes naphthalene, 1-methylnaphthalene, & 2-methylnaphthalene
[6] EPA National Primary Drinking Water Regulation MCL
[7] Includes m-, o-, & p-xylenes

Site contaminants of concern (COCs) in groundwater related to the L & L Exxon petroleum release include: DRPH, GRPH, benzene, toluene, ethylbenzene, xylenes, and naphthalenes (naphthalene, 1-methylnaphthalene, and 2-methylnaphthalene).

PCE, manganese, and nitrates also exceed their respective MTCA Method A (PCE) and Method B (manganese and nitrate) cleanup levels (CULs). These contaminants are considered COCs; however, they are not associated with a release of contaminants originating from the Site. The PCE is likely associated with the identified New City Cleaners (Facility Site ID: 327) groundwater plume, and is being addressed as part of this separate cleanup site. The manganese and nitrates are second tier electron acceptors and likely indicative of anaerobic natural attenuation processes already occurring in the groundwater. Manganese and nitrates are measured to evaluate bioremediation potential or performance, and are anticipated to reduce in concentration as the cleanup progresses. These parameters will continue to be tracked, monitored, and evaluated as part of compliance monitoring.

2.6 Summary of Soil Investigation Results

The 2012 and 2013 subsurface investigations were conducted to assess remnant soil contaminant concentrations. Soil samples were collected from 16 explorations (five test pits to 11 to 13 ft bgs, six soil borings and five monitoring wells completed at 25 ft bgs). The maximum contaminant concentrations exceeding soil screening levels are listed below in Table 2. Soil contamination was observed at depths ranging between 5 to 16 ft bgs. See Tables 2 and 3 for a summary of soil data and Appendix A for more complete data summary tables representing the findings of the Site remedial investigations and groundwater monitoring events.

Table 2. Maximum contaminant concentrations in soil from the September 2012 and April 2013 investigations.

Contaminant Name	Max Concentration in Soil (mg/kg)	Comparitive Screening Level [1] (mg/kg)	Depth Below Ground Surface (ft)	Sample Location [2]
Benzene	0.03	0.03	15.5	MW-1
DRPH	1,480	2,000	15.5	MW-1
Ethylbenzene	45.4	6	16	B-5
GRPH	14,800	30	7.5	TP-3
Naphthalenes [3]	90.9	5	7.5	TP-3
Toluene	10.4	7	5	B-3
Xylenes [4]	289	9	16	B-5

[1] The screening levels are MTCA Method A unless otherwise noted.
[2] Refer to Figure 2, Site Plan, for location reference
[3] Includes naphthalene, 1-methylnaphthalene, & 2-methylnaphthalene
[4] Includes m-, o-, & p-xylenes

Site COCs in soil related to the L & L Exxon petroleum release, and detected above MTCA Method A cleanup levels include: GRPH, benzene, toluene, ethylbenzene, xylenes, and naphthalenes.

DRPH is a Site COC, but has not been detected above MTCA Method A cleanup levels.

2.7 Summary of Soil Vapor Intrusion Evaluation

Based on a review of contaminant concentrations and Site conditions, there is a potential for vapor intrusion (VI) at the L & L Exxon Site. Shallow groundwater gasoline range petroleum hydrocarbons (GRPH) concentrations exceed the Draft Ecology Vapor Intrusion Tier 1 groundwater screening levels.

Although this potential VI risk exists, the pending interim action scheduled for the fall/winter of 2014, is designed to significantly reduce petroleum concentrations and therefore reduce or eliminate the risk of vapor intrusion.

2.8 Terrestrial Ecological Evaluation

A Simplified Terrestrial Ecological Evaluation (TEE) was performed. The Site meets the TEE exclusion criteria and no further evaluation is required.

2.9 Extent of Contamination

The primary Site COCs include contaminants related to the L & L Exxon petroleum release. Based on the assessment results, soil contamination is present near the location of the former fuel dispensers and USTs. Soil samples with contaminant concentrations exceeding MTCA Method A cleanup levels were obtained from borings B-1, B-3 and B-5, monitoring wells MW-1 and MW-2, and test pits TP-3 and TP-5. Contaminated samples were obtained from depths ranging between 5 to 16 ft bgs. GRPH, DRPH and petroleum-related VOCs also have been detected in groundwater samples obtained from monitoring wells MW-1 and MW-2, located near the northeast corner of the Site, at concentrations greater than MTCA Method A cleanup levels during each monitoring event since October 2012. Petroleum-related contaminants of concern have not been detected at concentrations greater than MTCA Method A cleanup levels from downgradient monitoring wells MW-4 and MW-5 and upgradient monitoring well MW-3. Based on the locations of samples with contaminant concentrations greater than MTCA Method A cleanup levels, it is possible contaminated soil is located beneath the existing building, though this has not been confirmed.

Other COCs found at the Site exceeding screening levels include PCE, nitrate, and manganese. These are not considered COCs associated with an on-site release of petroleum products. PCE groundwater contamination extends from upgradient well MW-3 to the furthest downgradient Site wells, MW-4 and MW-5. Nitrate is found in upgradient well MW-3. Manganese is found at elevated concentrations in groundwater in MW-1 and MW-2, downgradient of the source area. See Figure 2.

2.10 Exposure Pathway Evaluation

Petroleum-contaminated soil is capped by the asphalt parking area. As a result, human and ecological direct contact with contaminants of concern is unlikely unless construction activities were to occur. Petroleum-contaminated groundwater has not been detected in downgradient monitoring wells MW-4 and MW-5. No production wells are present on the Site; human or ecological ingestion or direct contact with contaminated groundwater is unlikely. Vapor intrusion is a potential concern; however, the planned interim action will reduce and likely eliminate this exposure pathway.

3.0 CLEANUP STANDARDS AND POINTS OF COMPLIANCE

Cleanup standards, as defined in WAC 173-340-700, for the Site include establishing cleanup levels and points of compliance at which the cleanup levels will be attained for the Site. The cleanup standards have been established for the Site in accordance with MTCA (WAC 173-340-700 through 173-340-760) and are presented in the following sections.

3.1 Cleanup Levels

For the L & L Exxon Site, Ecology established the cleanup levels (CULs) for the contaminants of concern in indoor air, soil, and groundwater at the Site primarily based on MTCA Method A criteria.

Table 3. Cleanup levels for Site COCs in soil, groundwater, and air related to the L & L Exxon petroleum release. [1]

Contaminant Name	Soil (mg/kg)	Groundwater (ug/L)	Indoor Air[2] (ug/m^3)
Benzene	0.03	5	0.32
DRPH	2,000	500	Refer to notes [3]
Ethylbenzene	6	700	460
GRPH	30	800	Refer to notes [3]
Naphthalenes [4]	5	160	1.4
Toluene	7	1,000	2,200
Xylenes [5]	9	1,000	46 [6]

[1] The established cleanup levels are MTCA Method A unless otherwise noted.
[2] Indoor air CULs are calculated using Equations 750-1 (for non-carcinogens) or 750-2 (for carcinogens) as defined by MTCA.
[3] DRPH and GRPH must be quantified into individual fractions of volatile and air phase petroleum hydrocarbons to determine CULs
[4] Total concentration of naphthalene, 1-methylnaphthalene, & 2-methylnaphthalene
[5] Total concentration of m-, o-, & p-xylenes
[6] CUL for m- & o-xylenes individually

3.2 Screening Levels

Screening levels have been established for contaminants not directly related to the identified petroleum release at the Site. These parameters will continue to be tracked, monitored, and evaluated as part of compliance monitoring.

Table 4. Screening levels for Site COCs in groundwater and air related to the migrating off-site contaminant plume of PCE and natural attenuation processes.

Contaminant Name	Groundwater (ug/L)	Indoor Air (ug/m^3)
Manganese	2,240 [1, 2]	N/A [3]
Nitrate - Nitrogen	10 [4]	N/A [3]
PCE	5 [5]	0.42 [6]

[1] MTCA Method B, non-carcinogenic.
[2] Other screening levels may be applicable. See below.
- EPA National Secondary Drinking Water Regulation Secondary Maximum Contaminant Level (MCL)- 50 ug/L
- EPA Lifetime Exposure - 300 ug/L

[3] N/A=Not Applicable, these constituents are not VOCs
[4] EPA National Primary Drinking Water Regulation MCL
[5] MTCA Method A
[6] Calculated using Equations 750-2 for carcinogens as defined by MTCA

3.3 Points of Compliance

This IAP has established points of compliance for air, soil and groundwater at the Site. The point of compliance is the point (horizontal or vertical) where the established cleanup levels must be achieved. The standard soil and groundwater points of compliance will be observed for the remediation alternative selected.

The point of compliance for air is throughout the Site (WAC 173-340-750 (6)).

The soil point of compliance is all soils throughout the Site (WAC 173-340-740(6)). This cleanup point of compliance is based on the protection of groundwater.

The groundwater point of compliance is the standard point of compliance per WAC 173-340-720 (8)(a) & (b), which is established throughout the Site from the "… uppermost level of the saturated zone extending vertically to the lowest most depth which could potentially be affected by the site." The cleanup levels will be attained in all groundwater from the point of compliance to the outer boundary of the Site plume.

4.0 ALTERNATIVES DEVELOPMENT AND EVALUATION CRITERIA

Ecology completed a Focused Feasibility Study (FS) for the L & L Exxon Site in March 2014 for the purpose of developing and evaluating various cleanup action alternatives that would reduce or mitigate current and potential future risks to human health and the environment associated with soil and groundwater contamination at the Site (GeoEngineers, 2014). The FS identified a combination of chemical oxidant injections, enhanced bioremediation, and multi-phase extraction (alternative 5) as the selected cleanup action because it satisfied the minimum MTCA selection criteria, and was the most technically feasible and least-costly option for addressing the Site contamination. A summary of the remedial action alternatives developed in the FS, description of the evaluation of alternatives, summary of the selected interim action and the rationale for its selection and an evaluation of the selected interim action are provided in the following sections.

4.1 Summary of Remedial Alternatives

The following remedial alternatives were developed and evaluated in the FS based on direction from Ecology:

- Alternative 1: Contaminated soil excavation and enhanced bioremediation;
- Alternative 2: In situ treatment with a soil vapor extraction and air sparge (SVE/AS) system;
- Alternative 3: In situ treatment with a chemical oxidant and enhanced bioremediation - infiltration gallery and injection wells;
- Alternative 4: Multi-phase extraction (MPE); and
- Alternative 5: In situ treatment with chemical oxidant, enhanced bioremediation, and MPE (combination of alternatives 3 and 4).

The development of these alternatives included an initial step of identifying and screening potential remedial technologies for soil and groundwater. A broad range of technologies were initially identified, then screened based on technical practicability, effectiveness, and cost.

4.1.1 Alternative 1 – Contaminated soil excavation and enhanced bioremediation

This alternative involves excavation of gasoline-impacted soil from the northeast corner of the Site. A chemical oxidant product will be applied to the bottom of the excavation as an enhanced bioremediation amendment to remediate groundwater and remaining impacted soil.

4.1.2 Alternative 2 – In situ treatment with a soil vapor extraction and air sparge (SVE/AS) system

SVE extraction wells and AS injection wells will be installed to remediate the contaminated area following a pilot test to assess the radius of influence.

4.1.3 Alternative 3 – Use of Infiltration galleries and injection wells for in situ treatment with a chemical oxidant and enhanced bioremediation

This alternative involves installation of shallow infiltration galleries in the northeast corner of the Site and installation of injection wells. Infiltration galleries and injection wells will be used to dose soil and groundwater, respectively, with oxidants, surfactants and microbes to breakdown gasoline contamination.

4.1.4 Alternative 4 – Multi-phase extraction (MPE)

Extraction wells will be installed based on the results of a pilot test, and a vactor truck will be subcontracted to remove impacted water and vapors from the wells on a monthly basis.

4.1.5 Alternative 5 - In situ treatment with a chemical oxidant, enhanced bioremediation, and MPE (combination of alternatives 3 and 4)

This alternative combines the installation of infiltration galleries and injection wells, chemical oxidant and enhanced bioremediation amendment applications, in addition to MPE. The injection wells and infiltration galleries will be installed first and a dose of chemical oxidant will be applied to mobilize vadose zone contamination. After about 30 days, a vactor truck will be used to remove water, product, and vapors from the injection wells and existing monitoring wells MW-1 and MW-2. After the initial MPE event, enhanced bioremediation amendments (microbe, oxidant and surfactant dosing) will continue on a quarterly basis until contaminant concentrations have been reduced to less than CULs. MPE events will be repeated just prior to each subsequent oxidant and surfactant application. A pilot test is not needed to assess the MPE effectiveness because the existing monitoring wells and the proposed oxidant injection wells will be used for water and vapor extraction.

4.2 Criteria for Evaluation of Alternatives

The remedial alternatives were evaluated using the cleanup action selection criteria specified in MTCA regulation (WAC 173-340-360). The purpose of the evaluation was to identify the advantages and disadvantages of each alternative, and determine and select the alternative that most closely satisfies the MTCA criteria. The specific criteria are all considered important. These criteria are:

- Minimum Requirements for Cleanup Actions (WAC 173-340-360(2))
  - Threshold Requirements:
    - Protect human health and the environment
    - Comply with cleanup standards
    - Comply with applicable state and federal laws
    - Provide for compliance monitoring
  - Other Requirements:
    - Use a permanent solution to the maximum extent practicable. If a disproportional cost analysis is used, then evaluate:
      - Protectiveness
      - Permanence
      - Cost
      - Effectiveness over the long term
      - Management of short-term risks
      - Technical and administrative implementability
      - Consideration of public concerns
    - Provide for a reasonable restoration time frame
    - Consider public concerns
  - Groundwater Cleanup Actions:
    - Use a permanent groundwater cleanup action to achieve the cleanup levels for groundwater established in WAC 173-340-720 at the standard points of compliance
  - Use institutional controls when required by WAC 173-340-440
- Unrestricted Land Use Soil Cleanup Standards (WAC 173-340-740):
  - Use permanent soil cleanup action to achieve cleanup levels for soil at the standard points of compliance

An alternative must meet all of the threshold criteria to be eligible for selection as a Site remedy. If the alternative was considered to comply, the subsequent evaluation of the alternative was based on the remaining evaluation factors. The alternative that most closely satisfied all of these criteria was selected as the interim action for the Site.

4.3 Summary of Selected Interim Action and Rationale for Selection

Based on the evaluation of all of the alternatives, Alternative 5 was selected. Alternative 5 includes in situ chemical oxidation and enhanced bioremediation injections using infiltration galleries and injection wells combined with multi-phase extraction. Other components of the selected alternative include compliance monitoring and potentially institutional controls.

An evaluation and comparative analysis of cleanup action alternatives were developed for the Site. The alternatives were evaluated with respect to the MTCA evaluation criteria described above and then compared to each other relative to their expected performance under each criterion. In order to evaluate reasonableness of costs, planning level estimates were developed for each remedial alternative. While adequate for decision making purposes, final cost estimates will depend on the scope of the final remedial design. Refer to the Focused Feasibility Study (GeoEngineers, 2014) for more detailed information on the evaluation and rationale for selection of cleanup action alternatives.

Based on the Minimum Threshold, Other Criteria and Disproportionate Cost Analysis, remedial Alternative 5 is the preferred alternative. Alternatives 1 and 2 had the highest costs without a proportional increase in environmental benefits. Alternative 4 had the lowest costs, but was least protective of Alternatives 3 through 5. Alternative 5 also requires minimal maintenance (like Alternatives 3 and 4) because there is no active remediation system to operate and maintain. Alternative 5 had the highest total environmental benefit score (both including and excluding costs). In compliance with MTCA [WAC 173-340-360(3)(e)(ii)(c)], Alternative 5 should be the preferred remedial alternative.

Alternative 5 provides both soil and groundwater remediation through enhanced bioremediation. Like Alternative 3, oxidants, bacteria and surfactants are injected in wells and infiltration galleries to dose both the vadose zone and groundwater. Alternative 5 adds MPE to Alternative 3 to increase the effectiveness, particularly beneath the building. MPE will be conducted from the oxidant injection wells and existing monitoring wells. However, depending the frequency, duration, and effectiveness of MPE, contamination might remain beneath the building. Alternative 5 will also partially address the chlorinated solvents. This alternative provided the lowest cost alternative that was protective and satisfied the MTCA evaluation criteria described above.

5.0 SELECTED INTERIM ACTION

A description of the selected interim action components; how the selected interim action satisfies MTCA criteria; and the restoration timeframe for the completion of the cleanup are provided in the following sections.

5.1 Interim Action Description

The selected interim action, Alternative 5, includes a combined approach using in situ chemical oxidation, enhanced bioremediation, and MPE using infiltration galleries and injection wells. Other components of the selected alternative include compliance monitoring and institutional controls. These components are described below. The purpose of the proposed actions at the Site is to remediate soil and groundwater petroleum contamination at the Site. Some treatment of PCE in groundwater might occur; however, this will be temporary because the upgradient source has not been controlled. With respect to petroleum, soil and groundwater will be restored to toxicity-based cleanup levels protective of human health and the environment. The disturbed area will be restored to its current use as a paved parking lot.

5.1.1 Infiltration Gallery and Injection Well installation

The injection wells and infiltration galleries will be installed first. At the northern end of the property, in the former tank basin area, trenches will be excavated to install infiltration galleries. Suitability of imported fill and/or on-site soils for reuse as trench backfill will be determined by contaminant concentrations, soil properties, and Ecology's guidance on the reuse of petroleum-contaminated soils (Ecology, 2011). Excavated soil from trenches will be stockpiled and sampled for contaminants. Excess soil and/or petroleum contaminated soil will be disposed of at a permitted facility. Other tasks necessary to complete this work, but are not limited to, include temporary facilities and site controls (TESC), erosion and sediment controls, and protection of existing utilities.

Four injection wells will be installed in upgradient locations to apply oxidants and bioremediation amendments to groundwater. Injection well and infiltration gallery locations are depicted on Figure 3. Injection wells will be 2-inch diameter and advanced to about 20 feet bgs. Soil cuttings generated during drilling will be drummed, labeled and profiled for off-site disposal at a permitted facility.

The infiltration gallery risers and injection wells will be protected with flush-mounted, monitoring well monuments. The trench locations and the test pit locations, excavated during site assessment actions, will be repaved with hot-mix asphalt.

The infiltration gallery installation work will be completed by Ecology's Prime Contractor (GeoEngineers, Inc.) and under a Public Works contract as required by the Revised Code of Washington (RCW) 39.04.010.

5.1.2 Chemical Oxidation

Once the infiltration galleries and injection wells are installed, a chemical oxidant (NoviOx™) will be injected into the vadose zone and groundwater. The chemical oxidant injection is a one-time application intended to reduce vadose zone, smear zone, and groundwater contaminant concentrations by oxidizing contaminants into volatile fatty acids for consumption by microbes and improving permeability of the soil matrix. The chemical oxidation step reduces the contaminant load in the vadose zone and helps set the stage for enhanced bioremediation to occur more successfully in the smear zone and groundwater.

5.1.4 Enhanced Bioremediation

Approximately 1 month following the chemical oxidant injection, a suite of enhanced bioremediation products will be injected into the infiltration gallery and injection wells. The purpose of this application is to stimulate growth of naturally occurring and added bacteria that are capable of breaking down petroleum contamination into non-toxic compounds. Bioremediation product applications will include injection of oxygen releasing compounds, bio-augmentation product (additional bacteria), and surfactant into the infiltration gallery and wells. These bioremediation products will be injected on a quarterly basis for a minimum of 4 quarters.

5.1.5 Multi-Phase Extraction (MPE)

MPE events will be conducted just prior to each quarterly bioremediation product application. MPE events use a vactor truck to remove groundwater, product, and vapors from the injection wells and existing monitoring wells. Product and impacted water will be sampled for contaminants and disposed of at a permitted facility. A minimum of 4 quarters of MPE events are scheduled.

5.2 Satisfaction of MTCA Criteria

The selected interim action satisfies the MTCA criteria in WAC 173-340-360 for the selection of cleanup actions. Ecology has determined that the selected interim action is protective of human health and the environment, complies with cleanup standards, complies with federal and state requirements that are applicable or relevant and appropriate, and provides for compliance monitoring. Refer to the Focused Feasibility Study for a comprehensive discussion of how the selected interim action meets the specific MTCA minimum requirements.

5.2.1 Threshold Requirements

It has been determined through the FS evaluation that the selected interim action meets the threshold requirements of WAC 173-340-360(2)(a). Specifically, the selected interim action will:

- Protect human health and the environment
- Comply with cleanup standards
- Comply with applicable state and federal laws
- Provide for compliance monitoring

Compliance with Applicable Local, State, and Federal Laws

In accordance with WAC 173-340-710, local, state, and federal laws and requirements were identified as being applicable to the selected interim action. See Table 5 below for a summary of these requirements.

Compliance Monitoring

Compliance monitoring is a component of the selected interim action and is planned to be implemented in accordance with WAC 173-340-410. Compliance monitoring will include protection, performance, and confirmational monitoring as described below:

- <u>Protection Monitoring</u>: Protection monitoring will be performed to confirm that human health and the environment are adequately protected during the construction phase and operation and maintenance period of the interim action. A Sample and Analysis Plan will be prepared during the remedial design phase to address protection monitoring requirements.
- <u>Performance Monitoring</u>: To confirm that the interim action has attained cleanup standards and other performance standards performance monitoring will be performed. Performance monitoring of the bioremediation process is anticipated to be performed for one year (coinciding with the remediation activities) and will include collecting groundwater samples from the five existing monitoring wells. Groundwater samples will be analyzed for the contaminants of concern and natural attenuation parameters to evaluate the effective of the bioremediation processes. If warranted, quarterly groundwater sampling reports will provide a discussion and recommendations for contingency response actions, or rationale for terminating monitoring.
- <u>Confirmation Monitoring</u>: Confirmation monitoring will be performed to assess the long-term effectiveness of the interim action once performance standards have been attained. Post-treatment compliance monitoring will be implemented for a minimum period of one year following the treatment performance monitoring period to ensure treatment goals are being attained. Confirmation monitoring will include quarterly groundwater sampling from the five existing monitoring wells for the contaminants of concern and the natural attenuation parameters. Four consecutive quarters of contaminant concentrations less than the MTCA Method A cleanup level will be considered sufficient for Site closure. Additionally, confirmational soil samples will be collected to confirm the effectiveness of the cleanup.

Table 5. Summary of ARARS

ARAR	Regulated Activity	Evaluation
Richland City Codes		
Municipal Code 9.16	Public Nuisance - Noise	Construction actions will meet the requirements of this chapter.
Municipal Code 10.04	Public Nuisances	Protect open excavations from creating a hazard
Municipal Code 16.06	Stormwater Management Regulations	Construction stormwater requirements
Benton County		
Benton Clean Air Agency	Emissions	Notice of Construction required for new potential emission sources
Washington State		
Washington Administrative Code 173-201A	Water Quality Standards for Surface Waters	MTCA requires cleanup actions comply with applicable regulations.
Washington Administrative Code 173-218	Underground Injection Controls	UIC regulations apply to oxidant injection galleries and wells
Washington Administrative Code 173-340	Toxic Waste Cleanup (MTCA)	The remedial action will be conducted under MTCA. Remedial alternatives will comply with MTCA regulations.
Washington Administrative Code 197-11 and 173-802	State Environmental Policy Act	A SEPA review is required for projects with potential significant environmental impacts.
Federal Regulations		
Title 33 of United States Code, Chapter 26	Water Pollution Control (Clean Water Act)	MTCA requires cleanup actions comply with applicable regulations.
Title 40 Code of Federal Regulations 131	Water Quality Standards (National Toxics Rule)	MTCA requires cleanup actions comply with applicable regulations.
Title 40 Code of Federal Regulations 141	Drinking Water Regulations	MTCA requires cleanup actions comply with applicable regulations.
Title 40 Code of Federal Regulations 260-268	Hazardous Waste (RCRA)	MTCA requires cleanup actions comply with applicable regulations.

5.2.2 Other Requirements

Protectiveness

The selected cleanup action offers a high level of protection to human health and the environment. Soil and groundwater will be remediated by the application of oxidants and bioremediation products. The MPE will physically remove impacted water and increase oxygen flow for enhanced biological degradation. The interim action will likely extend beneath the building; reducing the likelihood of residual contamination and the need for institutional controls.

Permanent Solutions

The selected interim action also meets the regulatory requirements for a "permanent solution to the maximum extent practicable" per WAC 173 340-360 (2)(b)(i). Specifically, the proposed interim action includes the following components, which together meet this MTCA requirement: (1) removal or destruction of the source through in situ treatment; (2) minimization of the potential for human exposure through impacted soil in inaccessible areas through institutional controls; and (3) elimination of greater overall threat to human health and the environment by treatment of impacted soil and groundwater.

The determination of whether the interim action uses permanent solutions to the maximum extent practicable was completed during the FS in accordance with WAC 173-340-360(3). As part of the Disproportionate Cost Analysis, the selected interim action is considered to be a “permanent solution to the maximum extent practicable" because it (1) protects human health and the environment; (2) provides high degree of reduction of the contaminant mobility and volume; (3) provides for long-term and short-term remediation effectiveness; (4) manages short-term risks; (5) can be implemented with consideration given to the restrictions imposed by existing structures and subsurface conditions; and (6) considers public concerns. The selected alternative incorporates prevention or minimization of present or future releases by treating the contaminant source in soil and groundwater, and treating impacted groundwater.

Based on evaluation of these factors, and the specific subsurface soil and groundwater conditions existing at the Site, the in situ chemical oxidation, enhanced bioremediation, and MPE alternative, with compliance monitoring and potentially institutional controls, is considered to be the most permanent to the maximum extent practicable of the alternatives evaluated.

Cost

The estimated total cost of the selected cleanup action is $249,840. Refer to the Feasibility Study for a complete discussion of the disproportionate cost analysis.

Effectiveness over the Long Term

The selected cleanup action permanently remediates soil and groundwater to concentrations less than MTCA Method A cleanup levels. The MPE will likely extend beneath the building; reducing the likelihood of residual contamination and the need for institutional controls.

Management of Short-term Risks

The short-term risks associated with the installation of infiltration galleries and injection wells, and subcontracting vactor trucks for MPE are low.

Technical and Administrative Implementability

The selected cleanup is meets the requirements described in WAC 173-340-360(3)(f)(vi).

Restoration Time Frame

As required by WAC 173-340-360(2)(b)(ii), a cleanup action shall provide for a reasonable restoration time frame by considering the following factors specified in WAC 173-340-360(4)(b):

- Potential risks posed by the Site to human health and the environment
- Practicability of achieving a shorter restoration time frame
- Current uses of the Site, surrounding areas, and associated resources that are, or may be, affected by releases from the Site
- Potential future uses of the Site, surrounding areas, and associated resources that are, or may be, affected by releases from the Site
- Availability of alternative water supplies
- Likely effectiveness and reliability of institutional controls
- Ability to control and monitor migration of contamination
- Toxicity of the hazardous substances
- Natural processes which reduce concentrations of the hazardous substances

The proposed interim action takes into consideration the factors listed above. Institutional controls will be used to reduce the risk associated with groundwater ingestion during the reasonable restoration time frame, which is estimated to be 1 to 2 years. There is no practical remediation option which would result in a shorter time frame.

The expected performance of this alternative in attaining Site CULs within a reasonable time frame is high, based on experiences at other sites with similar geology and contaminant concentrations. Although in situ bioremediation is a proven technology, its overall performance with respect to the degree of cleanup and remediation time frame will be a function of the Site geology and the ability to distribute amendment throughout the treatment zone, and the presence of residual or unknown sources of contaminants.

Consideration of Public Concerns

This IAP and related documents will be made available for public review and comment. An evaluation of comments received will be conducted and a responsiveness summary will be prepared to determine the need for changes to this plan based on new information received.

Permanent Groundwater Cleanup Actions

The planned groundwater cleanup action is permanent and will achieve the cleanup levels for groundwater established in WAC 173-340-720 at the standard points of compliance. Refer to the section above titled “Permanent Solutions” for further discussion.

Use of Institutional Controls

One or more institutional controls may be required per WAC 173-340-440 to limit activities on the Site that might interfere with the integrity of the interim action or that might result in exposure to hazardous substances. In accordance with WAC 173-340-440, the cleanup goal is to remediate soil and groundwater to CULs. However, due to difficult accessibility, there is potential for leaving petroleum contamination underneath the L & L Exxon property building and Lee Boulevard, adjacent to the north. The effectiveness of the institutional controls, if used, will be evaluated every 5 years at a minimum. In this case, a long-term monitoring plan will be developed to monitor the migration of contamination and demonstrate the effectiveness of in situ bioremediation and natural attenuation for the off-Property groundwater plume attributed to the Site. The toxicity of petroleum contamination is well understood, in situ treatment processes are effective, and combined with monitored natural attenuation will be effective in reducing concentrations of petroleum constituents in soil and groundwater to attain the CULs.

If the only contamination left on site is related to the off-site release of PCE, a 5 year review for the L&L Exxon Site will not be appropriate. In this case, the review for this contaminant will be performed for the New City Cleaners Site (FSID: 327).

5.3 Completion of Interim Action

As previously described, chemical oxidation, enhanced bioremediation, and MPE treatments are estimated to be implemented for about 1 year, with performance monitoring occurring during this period. Confirmation monitoring will then be performed for about 1 year following performance monitoring to verify that CULs have been attained. It is assumed that treatment goals will be met and maintained within 1 years of treatment startup. Site closure will occur in 2 years and include final reporting, system decommissioning, and well decommissioning.

This interim action will be deemed complete when each component of the remedy, including any necessary institutional controls, are implemented and compliance with the CULs have been achieved with a minimum of 1 year of confirmation groundwater samples demonstrating attainment and maintenance of selected CULs at the points of compliance for both soil and groundwater.

Following completion of the interim action, Ecology shall provide public notice and an opportunity for public comment prior to removing the Site from the Hazardous Sites List in accordance with WAC 173-340-330 (4), unless Ecology becomes aware of circumstances at the Site that present a previously unknown threat to human health and the environment.

6.0 INTERIM ACTION IMPLEMENTATION SCHEDULE

This interim action will be implemented in accordance with WAC 173-340-400. After the public comment period and issuance of the final interim action plan, remedial action plans and specifications will be developed for the selected interim action. These plans and specifications will be included into bid documents for the Public Works bid process to select a construction contractor. After completion of the Public Works bid solicitation process and issuance of a contract to the selected contractor, the infiltration gallery construction will begin. The estimated schedule for the interim action design, construction, operation, and monitoring is summarized below:

Interim Action Plan Tasks		Estimated Timeline
▪	Public Comment Period for Interim Action Plan	October 2014 – November 2014
▪	Public Work Bid Solicitation and Contracting Process	November 2014 – January 2015
▪	Preparation of Performance Monitoring Plan	October – December 2014
▪	Infiltration Gallery Installation	Winter 2014/2015 or Spring 2015
▪	Injection Well Installation	Winter 2014/2015 or Spring 2015
▪	Treatment Startup	Winter 2014/2015 or Spring 2015
▪	Performance Monitoring	Winter 2014/2015 or Spring 2015 to Summer 2016
▪	Confirmation Monitoring (Groundwater & Soil)	Fall 2016

7.0 ECOLOGY PERIODIC REVIEWS

Due to difficult accessibility, there is potential for leaving petroleum contamination underneath the L & L Exxon property building and Lee Boulevard, adjacent to the north. In this scenario, Ecology will conduct periodic reviews to assess post-interim action Site conditions and monitoring data in accordance with requirements of WAC 173-340-420 to confirm that human health and the environment are adequately protected. Groundwater monitoring results and other inspection and monitoring data obtained pursuant to the OMMP and other activities will be reviewed at a minimum of every 5 years. The overall efficacy and progress of remediation might be assessed at more frequent intervals, such as subsequent to annual monitoring. Notice of periodic reviews for public comment will be provided as deemed necessary.

Several review criteria are listed under WAC 173-340-420 to evaluate overall remedy effectiveness including engineered and institutional controls, new scientific information regarding hazardous substances, and new legal and regulatory requirements. These review criteria further consider Site and resource use, availability and practicability of more permanent remedies, and new and improved analytical techniques.

These review findings will be used to assess the OMMP strategies, determine whether modifications are appropriate, and/or identify potential corrective actions. The scope and extent of revisions to the OMMP, and potentially to this IAP, will be determined based on results of the 5-year reviews.

8.0 REFERENCES

GeoEngineers, 2012. *File Review, Former L & L Exxon, 1315 Lee Boulevard, Richland, WA.* Prepared for the Washington State Department of Ecology. May 16.

GeoEngineers, 2013. *Soil and Groundwater Assessment, L & L Exxon, Richland, WA*. Prepared for the Washington State Department of Ecology. March 6.

GeoEngineers, 2013. *Supplemental Soil and Groundwater Assessment, L & L Exxon, Richland, WA*. Prepared for the Washington State Department of Ecology. August 20.

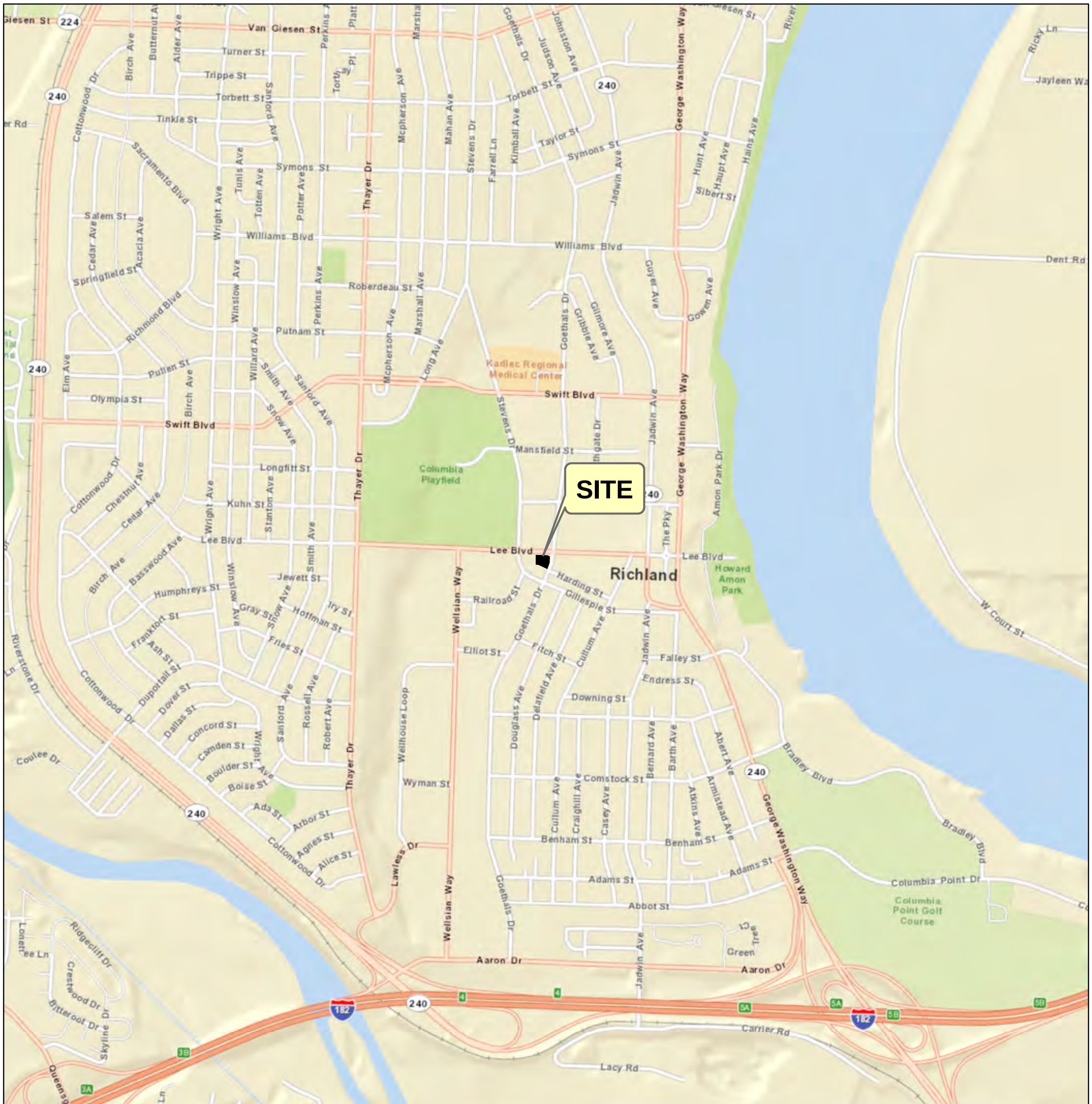
GeoEngineers, 2014. *Focused Feasibility Study, L & L Exxon, Richland, WA*. Prepared for the Washington State Department of Ecology. March 25.

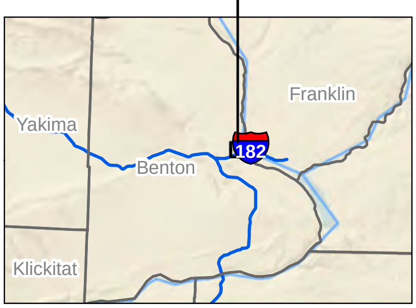
GeoEngineers, 2014. *Groundwater Monitoring Report, February 2014, Former L & L Exxon, Richland, WA*. May 12.

Ecology, 2013. *Model Toxics Control Act Regulation and Statute: MTCA Cleanup Regulation Chapter 173-340 WAC, MTCA Chapter 70.105D RCW, Uniform Environmental Covenants Act Chapter 64.70 RCW.* Washington State Department of Ecology, Publication No. 94-06, November.

Ecology, 2011. *Guidance for Remediation of Petroleum Contaminated Sites.* Washington State Department of Ecology, Publication No. 10-09-057, September.

FIGURES





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Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.
Data Sources: ESRI Data & Maps, Street Maps 2008.
Basemap streets base from ESRI Data Online.
Projection: NAD 1983, UTM Zone 11 North.

Vicinity Map

Former L&L Exxon
1315 Lee Boulevard
Richland, Washington

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Figure 1

Office: PORT Path: P:\0\0504081_SPOK_GIS\00\GIS\050408100_F1_VM.mxd Map Revised: 5/01/2012 CRC

Approximate Location of Remediation System

Approximate Location of Transformer

UST Number and Approximate Location

Approximate Location of Historic Excavation Area

Historical Fuel Dispenser and Approximate Location

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Notes:
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Projection: NAD 1983, UTM Zone 11 North.

Historic Site Features

Former L&L Exxon
1315 Lee Boulevard
Richland, Washington

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Figure 2

Office: PORT Path: P:\0\0504081\SPOK_GIS\00\GIS\050408101_F2_HSF.mxd Map Revised: 1/27/2014 CRC

TP-1 Test Pit Identification and Approximate Location

MW-1 Monitoring Well Number and Approximate Location

B-1 Soil Boring Identification and Approximate Location

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Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.
3. bgs = below ground surface

Data Sources: ESRI Data & Maps, Street Maps 2008.
Basemap streets base from ESRI Data Online.
Projection: NAD 1983, UTM Zone 11 North.

Approximate Soil Boring, Test Pit, and Monitoring Well Locations

Former L&L Exxon
1315 Lee Boulevard
Richland, Washington

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Figure 3

Office:PORT Path: P:\0\0504081_SPOK_GIS\00\GIS\050408101_SoilTestPitLocs_MW.mxd Map Revised: 27 January 2014 ccabrera

TP-1 Test Pit Identification and Approximate Location

MW-1 Monitoring Well Number and Approximate Location

B-1 Soil Boring Identification and Approximate Location

Soil Sample Locations with Contaminate Concentrations > MTCA Method A Cleanup Level

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Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.
3. bgs = below ground surface

Data Sources: ESRI Data & Maps, Street Maps 2008.
Basemap streets base from ESRI Data Online.
Projection: NAD 1983, UTM Zone 11 North.

Soil Chemical Analytical Results

Former L&L Exxon
1315 Lee Boulevard
Richland, Washington

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Figure 4

Office:PORT Path: P:\0\0504081_SPOK_GIS\00\GIS\050408101_SoilChemResults_F4.mxd Map Revised: 27 January 2014 ccabrera

TP-1 Test Pit Identification and Approximate Location

MW-1 Monitoring Well Number and Approximate Location

B-1 Soil Boring Identification and Approximate Location

Monitoring Wells with Chlorinated Solvent (PCE and/or TCE) Concentrations > MTCA Method A Cleanup Levels

Monitoring Wells with GRPH, DRPH and BTEXN Concentrations > MTCA Method A Cleanup Levels

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Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.
3. bgs = below ground surface

Data Sources: ESRI Data & Maps, Street Maps 2008.
Basemap streets base from ESRI Data Online.
Projection: NAD 1983, UTM Zone 11 North.

Groundwater Chemical Analytical Results

Former L&L Exxon
1315 Lee Boulevard
Richland, Washington

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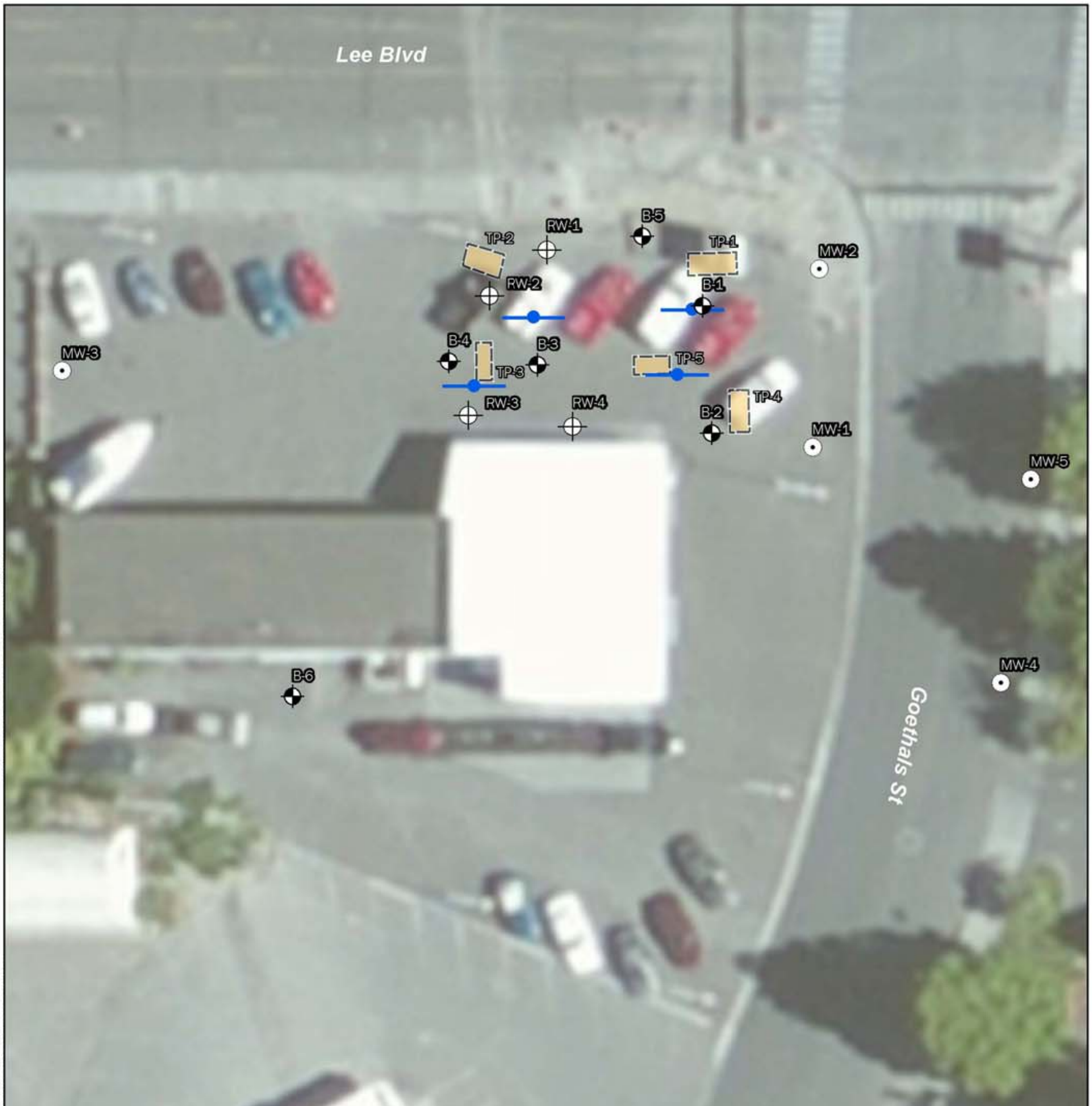
Figure 5

Office:PORT Path: P:\0\0504081_SPOK_GIS\00\GIS\050408101_GWChemResults_F5.mxd Map Revised: 27 January 2014 ccabrera



RW-1 Proposed Injection Well and Approximate Location

B-1 Soil Boring and Approximate Location (GeoEngineers 2012)

MW-1 Monitoring Well Number and Approximate Location (2012/2013)

Infiltration Gallery and Approximate Location

Test Pit and Approximate Location

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Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.
Data Sources: ESRI Data & Maps, Street Maps 2008.
Basemap streets base from ESRI Data Online.
Projection: NAD 1983, UTM Zone 11 North.

Proposed Infiltration Gallery and Injection Well Locations

Former L&L Exxon
1315 Lee Boulevard
Richland, Washington

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Figure 6

Office: PORT Path: \\pdx\projects\0\0504081_SPOK_GIS\01\MXD\050408101_F2_SP_Task300.mxd Map Revised: 24 June 2014 maugust

APPENDIX A

Table 2

Summary of Chemical Analytical Results - Soil Samples[1]

Former L&L Exxon, 1315 Lee Boulevard
Richland, Washington

Sample Number	TP-1	TP-2	TP-3	TP-4	TP-5	MW-4	MW-5	MTCA Method A Cleanup Levels[2]
Date Sampled	04/30/13	04/30/13	04/30/13	04/30/13	04/30/13	04/29/13	04/29/13	
Sample Depth (feet bgs)	8	9½	7½	13½	12	15	15	
GRPH[3] (mg/kg)	13.1	<7.46	**14,800**	<5.07	**1,770**	<6.50	<4.54	30/100
DRPH[4] (mg/kg)	<12.3	<10.6	1,480	<10.1	227	<10.4	10.4	2,000
ORPH[4] (mg/kg)	<30.7	<26.5	<607	<25.2	<25.6	<26.0	<25.9	2,000
Benzene[5] (mg/kg)	<0.00702	<0.00746	<0.0769	<0.00507	<0.00585	<0.00650	0.00454	0.03
Ethylbenzene[5] (mg/kg)	<0.140	<0.149	**19.3**	<0.101	1.80	<0.130	<0.0908	6
Toluene[5] (mg/kg)	<0.140	<0.149	<1.54	<0.101	1.37	<0.130	<0.0908	7
Total Xylenes[5] (mg/kg)	<2.11	<2.24	**120**	<1.52	**58.4**	<1.95	<1.36	9
Naphthalene[6]	<0.0119	<0.0106	**17.5**	<0.0118	**5.07**	<0.0102	<0.0101	5[7]
2-Methylnaphthalene[6]	<0.0119	<0.0106	**47.6**	<0.0118	**6.35**	<0.0102	<0.0101	
1-Methylnaphthalene[6]	<0.0119	<0.0106	**25.8**	<0.0118	**3.08**	<0.0102	<0.0101	
Hexane[5] (mg/kg)	<0.140	<0.149	<1.54	<0.101	<0.117	<0.130	<0.0908	NE

Notes:

[1]Samples analyzed by TestAmerica Laboratories, Inc. located in Spokane Valley, Washington.

[2]Washington State Model Toxics Control Act (MTCA) Method A Unrestricted Land Use cleanup levels.

[3]Gasoline-range petroleum hydrocarbons (GRPH) analyzed byNorthwest Method NWTPH-Gx. GRPH cleanup levels are 30 mg/kg when benzene is detected and 100 mg/kg when benzene is not detected.

[4]Diesel- and oil-range petroleum hydrocarbons (DRPH and ORPH, respectively) analyzed byNorthwest Method NWTPH-Dx.

[5]Volatile organic compounds (VOCs) analyzed by Environmental Protection Agency (EPA) Method 8260C. Total Xylenes include m,p and o-xylenes.

[6]Naphthalene, 2-Methylnaphthalene, and 1-Methylnaphthalene analyzed using EPA Method 8270C.

[7]Cleanup level for total naphthalenes (naphthalene, 1-methylnaphthalene, and 2-methylnaphthalene).

Bold indicates the analyte was detected at concentrations greater than MTCA Method A CULs.

mg/kg = milligrams per kilogram; µg/kg = micrograms per kilogram; bgs = below ground surface; NE = Not Established

https://projects.geoengineers.com/sites/0050408100/Draft/Supplemental Soil and GW Assessment/[LL Exxon GW ReportTables_June2013.xlsx]Table 2

Table 1

Summary of Groundwater Elevations and Natural Attenuation Parameters

Former L&L Exxon, 1315 Lee Boulevard

Richland, Washington

Well Number and Top of Casing Elevation[1] (feet)	Date Measured	Depth to Water (feet)	Groundwater Elevation[1] (feet)	pH (pH units)	Specific Conductivity (µS/cm)	Redox Potential (millivolts)	Dissolved Oxygen (mg/L)	Turbidity (NTU)	Temperature (degrees C)	Soluble Ferrous Iron[2] (mg/L)
MW-1 97.96	10/19/12	17.67	80.29	7.10	1096	-91	0.07	9.15	20.18	NM
	01/17/13	18.16	79.80	6.78	1206	-129	0.03	0.32	18.00	NM
	04/01/13	16.08	81.88	7.05	1400	-78.8	-0.04	NA	18.98	NM
	06/03/13	15.70	82.26	7.16	1072	-179	0.03	0.3728	18.50	NM
	12/16/13	15.60	82.36	7.09	1756	-181	0.07	5.376	19.46	2.5
	02/13/14	15.95	82.01	6.91	1261	-186	0.03	0.7333	18.31	2.0
	05/29/14	15.70	82.26	6.90	1338	-184	0.07	0.8673	19.15	2.0
MW-2 97.89	10/19/12	17.53	80.36	7.06	1295	-72	0.06	6.17	20.02	NM
	01/17/13	18.02	79.87	6.73	1216	-166	0.03	0.76	17.75	NM
	04/01/13	15.95	81.94	7.12	1200	-24	-0.03	NA	19.06	NM
	06/03/13	15.54	82.35	7.07	1059	-257	0.02	2.871	18.41	NM
	12/16/13	15.46	82.43	6.79	1239	-131	0.06	4.081	18.95	1.8
	02/13/14	15.82	82.07	7.09	895.7	-191	0.08	1.923	18.13	1.2
	05/29/14	15.54	82.35	6.97	1269	-229	0.05	6.273	19.1	2.0
MW-3 97.83	10/19/12	17.52	80.31	7.24	853	133	4.96	2.69	18.75	NM
	01/17/13	17.95	79.88	6.77	859	128	0.79	0.42	17.41	NM
	04/01/13	15.89	81.94	7.43	800	40.2	0.14	NA	18.79	NM
	06/03/13	15.51	82.32	7.34	742.9	360	0.33	0.6254	18.18	NM
	12/16/13	15.38	82.45	7.26	786.3	0	0.31	0.8251	18.29	< 0.2
	02/13/14	15.70	82.13	7.27	819.5	119	0.40	0	17.24	< 0.2
	05/29/14	15.51	82.32	7.37	827.3	183	0.85	0	19.80	< 0.2
MW-4 97.56	05/06/13	15.55	82.28	7.48	952.4	387	0.65	0.0581	17.66	NM
	06/03/13	15.16	82.40	7.42	979.2	396	0.64	-0.3368	19.54	NM
	12/16/13	15.08	82.48	7.39	1503	110	0.32	1.225	19.21	< 0.2
	02/13/14	15.42	82.14	7.19	1119	120	0.17	0	18.81	< 0.2
	05/29/14	15.17	82.39	7.31	1071	134	0.14	1	19.03	< 0.2

Well Number and Top of Casing Elevation[1] (feet)	Date Measured	Depth to Water (feet)	Groundwater Elevation[1] (feet)	pH (pH units)	Specific Conductivity (µS/cm)	Redox Potential (millivolts)	Dissolved Oxygen (mg/L)	Turbidity (NTU)	Temperature (degrees C)	Soluble Ferrous Iron[2] (mg/L)
MW-5 97.49	05/06/13	15.63	81.86	7.51	890.4	401	6.27	1.410	17.66	NM
	06/03/13	15.24	82.25	7.41	920.3	428	0.52	3.996	19.36	NM
	12/16/13	15.16	82.33	7.36	804.6	-11	0.07	1.226	19.51	< 0.2
	02/13/14	15.52	81.97	7.42	870.6	106	0.21	0.9834	17.67	< 0.2
	05/29/14	15.26	82.23	7.49	893.9	90	0.20	5.8430	20.32	< 0.2

Notes:

[1]Groundwater elevations were measured relative to a site-specific datum of 100.00 feet, established at the top of the elevated concrete base of the light pole near MW-1.

[2]Soluble ferrous iron concentrations are measured in the field using a Hach IR-18C color disc test kit and the 1,10 phenanthroline testing method.

Groundwater elevations were calculated through use of the following formula: Groundwater Elevation = Top of Casing Elevation - Depth to Water.

Dissolved oxygen, redox potential, specific conductivity, pH and temperature measurements in this table were recorded at the conclusion of well purging.

NTU = nephelometric turbidity units; mg/L = milligrams per liter; µS/cm = microSiemens per centimeter; NM = not measured

Table 2

Summary of Chemical Analytical Results - Groundwater[1]

Former L&L Exxon, 1315 Lee Boulevard

Richland, Washington

Monitoring Well ID	Date Sampled	Petroleum-Range Hydrocarbons: GRPH[3] (µg/L)	DRPH[4] (mg/L)	ORPH[4] (mg/L)	Volatile Organic Compounds[5] (µg/L): Benzene	Toluene	Ethylbenzene	m,p-Xylene	o-Xylene	Hexane	TCE[15]	PCE[16]	Naphthalenes[6] (ug/L): Naphthalene	1-Methyl-naphthalene	2- Methyl-naphthalene	Natural Attenuation Parameters (mg/L): Manganese[7]	Methane[8]	Nitrate-Nitrogen[9]	Sulfate[9]	Total Alkalinity[10]
MTCA CUL[2]		**800/1,000[11]**	**0.5**	**0.5**	**5**	**1,000**	**700**	**1,000[12]**		**480[13]**	**5**	**5**	160[14]			**2.2[7]**	**–**	**10[9]**	**250[9]**	**–**
MW-1	10/19/12	**3,740**	**2.40**	<0.299	**178**	100	16.5	334	139	4.53	NA	NA	**110**	**30.0**	**38.0**	NA	NA	NA	NA	NA
	01/17/13	**8,080**	**2.92**	<0.380	**628**	675	581	**1,290**	**365**	<1.00	NA	NA	87.4	19.4	18.4	NA	NA	NA	NA	NA
	04/01/13	**35,400**	**10.7**	<0.251	**1,620**	**1,330**	**1,440**	**4,930**	**1,220**	<20	NA	NA	**498**	**93.3**	**133**	NA	NA	NA	NA	NA
	06/03/13	**51,000**	**2.09**	<0.379	**<20.0**	**7,120**	**1,320**	**4,180**	**1,980**	<100	NA	NA	73.3	15.9	18.1	NA	NA	NA	NA	NA
	12/16/13	**27,200**	**6.91**	<0.390	**1,010**	990	**1,240**	**4,710**	**1,040**	<100	NA	NA	**335**	**61.3**	**94.8**	**3.76**	2.01	0.400	8.48	625
	02/13/14	**25,000**	**8.47**	<0.389	**925**	833	**1,000**	**4,520**	**875**	<100	<100	<100	**308**	**60.4**	**91.6**	**3.72**	5.86	0.300	7.42	625
	05/29/14	**21,100**	**8.21**	<0.386	**738**	971	**903**	**3,810**	**752**	<100	<100	<100	**266**	**45.3**	**72.1**	**4.11**	3.78	0.200	9.56	570
MW-2	10/19/12	**19,500**	**2.32**	<0.305	0.990	**2,400**	**834**	**2,720**	**982**	6.66	NA	NA	**170**	**37.0**	**49.0**	NA	NA	NA	NA	NA
	01/17/13	**98,400**	**3.35**	<0.381	3.23	**9,560**	**1,530**	**5,060**	**2,060**	21.8	NA	NA	**236**	**46.9**	**72.6**	NA	NA	NA	NA	NA
	04/01/13	**50,600**	**1.27**	<0.305	**<20.0**	**7,710**	**1,550**	**4,630**	**2,180**	<100	NA	NA	300	**55.8**	**84.9**	NA	NA	NA	NA	NA
	06/03/13	**10,200**	**2.91**	<0.382	**300**	159	316	**985**	**186**	<100	NA	NA	292	**58.2**	**87.5**	NA	NA	NA	NA	NA
	12/16/13	**95,300**	**3.87**	<0.398	**<20.0**	**15,700**	**2,750**	**9,360**	**4,120**	<100	NA	NA	**421**	**71.0**	**127**	**3.70**	3.02	0.260	11.6	460
	02/13/14	**44,100**	**3.03**	<0.392	**<40.0**	**8,050**	**1,570**	**5,690**	**2,390**	<200	<200	<200	**246**	**47.0**	**83.6**	2.19	3.75	0.610	28.3	335
	05/29/14	**60,100**	**6.72**	<0.390	**<40.0**	**13,900**	**2,430**	**8,360**	**3,690**	<200	<200	<200	**315**	**61.8**	**104**	**3.88**	2.61	0.430	19.9	490
MW-3	10/19/12	<90.0	<0.149	<0.298	<0.200	<0.500	<0.500	<0.500	<0.500	<1.00	NA	NA	0.160	<0.0095	<0.012	NA	NA	NA	NA	NA
	01/17/13	<90.0	<0.237	<0.379	<0.200	<0.500	<0.500	<0.500	<0.500	<1.00	NA	NA	<0.0951	<0.0951	<0.0951	NA	NA	NA	NA	NA
	04/01/13	<90.0	<0.187	<0.299	<0.200	<0.500	<0.500	<0.500	<0.500	<1.00	NA	NA	<0.262	<0.262	<0.262	NA	NA	NA	NA	NA
	06/03/13	<90.0	<0.237	<0.380	<0.200	<0.500	<0.500	<0.500	<0.500	<1.00	0.970	**9.25**	<0.190	<0.190	<0.190	NA	NA	NA	NA	NA
	12/16/13	<90.0	<0.437	<0.455	<0.200	<0.500	<0.500	<0.500	<0.500	<1.00	NA	NA	0.179	<0.0996	<0.0996	0.0105	0.0333	9.90	55.7	285
	02/13/14	<100	<0.233	<0.389	<0.200	<1.00	<1.00	<2.00	<1.00	<1.00	<1.00	**12.2**	<0.0950	<0.0950	<0.0950	0.0112	<0.00500	**15.8**	57.0	325
	05/29/14	<100	<0.237	<0.394	<0.200	<1.00	<1.00	<2.00	<1.00	<1.00	<1.00	**10.8**	0.128	<0.0986	<0.0986	0.0148	<0.00500	**12.3**	54.3	295
MW-4	05/06/13	<90.0	<0.238	<0.382	<0.200	<0.500	<0.500	<0.500	<0.500	<1.00	NA	NA	<0.191	<0.191	<0.191	NA	NA	NA	NA	NA
	06/03/13	<90.0	<0.236	<0.378	<0.200	<0.500	<0.500	<0.500	<0.500	<1.00	0.640	**4.12**	<0.190	<0.190	<0.190	NA	NA	NA	NA	NA
	12/16/13	<90.0	<0.235	<0.392	<0.200	<0.500	<0.500	<0.500	<0.500	<1.00	NA	NA	<0.0953	<0.0953	<0.0953	0.247	0.0719	0.520	55.3	405
	02/13/14	<100	0.259	<0.393	<0.200	<1.00	<1.00	<2.00	<1.00	<1.00	<1.00	<1.00	<0.0952	<0.0952	<0.0952	1.29	0.410	<0.200	55.6	455
	05/29/14	<100	<0.237	<0.395	<0.200	<1.00	<1.00	<2.00	<1.00	<1.00	<1.00	2.10	<0.101	<0.101	<0.101	0.970	0.148	0.560	44.7	415
MW-5	05/06/13	<90.0	<0.251	<0.402	<0.200	<0.500	<0.500	<0.500	<0.500	<1.00	NA	NA	<0.195	<0.195	<0.195	NA	NA	NA	NA	NA
	06/03/13	<90.0	<0.238	<0.381	<0.200	<0.500	<0.500	<0.500	<0.500	<1.00	1.05	**6.94**	<0.190	<0.190	<0.190	NA	NA	NA	NA	NA
	12/16/13	<90.0	<0.235	<0.391	<0.200	<0.500	<0.500	<0.500	<0.500	<1.00	NA	NA	<0.0965	<0.0965	<0.0965	0.532	<0.00500	7.50	77.9	360
	02/13/14	<100	<0.234	<0.390	<0.200	<1.00	<1.00	<2.00	<1.00	<1.00	<1.00	**8.05**	<0.0950	<0.0950	<0.0950	0.939	<0.00500	6.15	71.9	340
	05/29/14	<100	<0.241	<0.402	<0.200	<1.00	<1.00	<2.00	<1.00	<1.00	<1.00	**6.91**	<0.0960	<0.0960	<0.0960	0.549	0.0682	8.20	69.8	345

Monitoring Well ID	Date Sampled	Petroleum-Range Hydrocarbons			Volatile Organic Compounds[5] (µg/L)								Naphthalenes[6] (ug/L)			Natural Attenuation Parameters (mg/L)				
		GRPH[3] (µg/L)	DRPH[4] (mg/L)	ORPH[4] (mg/L)	Benzene	Toluene	Ethylbenzene	m,p-Xylene	o-Xylene	Hexane	TCE[15]	PCE[16]	Naphthalene	1-Methyl-naphthalene	2- Methyl-naphthalene	Manganese[7]	Methane[8]	Nitrate-Nitrogen[9]	Sulfate[9]	Total Alkalinity[10]
MTCA CUL[2]		**800/1,000[11]**	**0.5**	**0.5**	**5**	**1,000**	**700**	**1,000[12]**		**480[13]**	**5**	**5**	160[14]			**2.2 [7]**	**–**	**10 [9]**	**250 [9]**	**–**
Duplicate-1	10/19/12	**5,080**	**2.44**	<0.298	**261**	98	184	433	180	4.36	NA	NA	**120**	**31.0**	**41.0**	NA	NA	NA	NA	NA
	01/17/13	**9,890**	**2.63**	<0.380	**562**	628	529	**1,220**	**345**	<1.00	NA	NA	101	21.9	21.0	NA	NA	NA	NA	NA
	04/01/13	**32,400**	**11.3**	<0.258	**1,450**	**1,190**	**1,310**	**4,580**	**1,130**	<20	NA	NA	**278**	**49.9**	**72.1**	NA	NA	NA	NA	NA
	06/03/13	**<9,000**	**2.01**	<0.381	**289**	185	292	**971**	**189**	<100	NA	NA	105	26.2	26.6	NA	NA	NA	NA	NA
	12/16/13	**30,700**	**5.27**	<0.379	**1,010**	**1,300**	**1,360**	**5,170**	**1,110**	<100	NA	NA	**244**	**47.0**	**67.0**	**3.38**	3.30	2.77	14.3	560
	02/13/14	**21,900**	**9.10**	<0.385	**781**	707	**876**	**4,080**	**759**	<100	<100	<100	**293**	**57.6**	**87.2**	**3.79**	6.64	0.290	12.0	600
	05/29/14	**20,400**	**10.2**	<0.390	**803**	1,090	**981**	**3,990**	**813**	<100	<100	<100	**283**	**48.9**	**74.8**	**3.94**	4.69	0.260	10.1	555

Notes:

[1]Samples analyzed by TestAmerica Laboratories, Inc. located in Spokane Valley, Washington.

[2]Washington State Model Toxics Control Act (MTCA) Method A cleanup levels (CUL) for groundwater, unless otherwise footnoted.

[3]Gasoline-range petroleum hydrocarbons (GRPH) analyzed using Northwest Method NWTPH-Gx.

[4]Diesel- and oil-range petroleum hydrocarbons (DRPH and ORPH, respectively) analyzed using Northwest Method NWTPH-Dx.

[5]Volatile organic compounds analyzed using Environmental Protection Agency (EPA) Method 8260C.

[6]Naphthalenes analyzed using EPA Method 8270D.

[7]Dissolved manganese analyzed using EPA Method 200.7. The cleanup level is the standard formula value MTCA Method B in groundwater as calculated by Ecology;s Cleanup Levels and Risk Calculations (CLARC) database.

[8]Methane analyzed using method RSK-175.

[9]Nitrate-nitrogen and sulfate analyzed using EPA Method 300.0. The cleanup level refers to the Maximum Contaminant Level (MCL) for nitrate and the Secondary MCL for sulfate as recommended by the EPA.

[10]Alkalinity analyzed using Method SM 2320B.

[11]MTCA Method A cleanup level for gasoline-range petroleum hydrocarbons is 1,000 µg/l if benzene is not detected; otherwise the cleanup level is 800 µg/l.

[12]Cleanup level for total xylenes (m,p-xylene and o-xylene).

[13]MTCA Method B (non-carcinogen) cleanup level.

[14]Cleanup level for total naphthalenes (naphthalene, 1-methylnaphthalene, and 2-methylnaphthalene).

[15]TCE = Trichloroethene

[16]PCE = Tetrachloroethene

Bold indicates analyte was detected at a concentration greater than MTCA Method A cleanup level; NE= not established; µg/L = microgram per liter; mg/L = milligram per liter

APPENDIX B

Revised Sampling and Analysis Plan

L&L Exxon
Richland, Washington

for
Washington State Department of Ecology

June 18, 2014

GeoEngineers
Earth Science + Technology

Revised Sampling and Analysis Plan

L&L Exxon
Richland, Washington

for
Washington State Department of Ecology

June 18, 2014

GeoEngineers

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Spokane, Washington 99202
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Revised Sampling and Analysis Plan
L&L Exxon
Richland, Washington

File No. 0504-081-01

June 18, 2014

Prepared for:

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GeoEngineers

Table of Contents

ACRONYMS

ACGIH	American Conference of Governmental Industrial Hygienists
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene and xylenes
CFR	code of federal regulations
COC	chain of custody
COPC	contaminants of potential concern
CPR	cardiopulmonary resuscitation
dBA	Division of Occupational Safety and Health
DOT	Department of Transportation
DRPH	diesel-range petroleum hydrocarbons
Ecology	Washington State Department of Ecology
EDD	electronic data deliverable
EIM	Environmental Information Management
EPA	Environmental Protection Agency
GeoEngineers	GeoEngineers, Inc.
GRPH	gasoline-range petroleum hydrocarbons

ACRONYMS (CONTINUED)

HASP	Health and Safety Plan
HAZMAT	hazardous materials
HAZWOPER	Hazardous Waste Operations and Emergency Response Standard
HSM	Health and Safety Program Manager
IDL	instrument detection limit
IDLH	immediately dangerous to life or health
IDW	investigation derived waste
kV	kilovolt
LCS	laboratory control spikes
LCSD	laboratory control spike duplicates
MDL	method detection limit
mg/m^3	milligrams per cubic meter
MS	matrix spike
MSD	matrix spike duplicate
MTCA	Model Toxics Control Act
mV	millivolts
NIOSH	National Institute for Occupational Health and Safety
ORP	oxidation reduction potential
ORPH	oil-range petroleum hydrocarbons
OSHA	Occupational Safety and Health Administration
PCE	tetrachloroethane
PE	professional engineer
PEL	permissible exposure limits
PID	photo-ionization detector
PM	project manager
PPE	personal protective equipment
ppm	parts per million
PQL	practical quantitation limit
QAPP	Quality Assurance Project Plan
QC	quality control
RPD	relative percent difference
SAP	Sampling and Analysis Plan
SOP	standard operating procedures
SSO	Site Safety Officer
STEL	short-term exposure limit
SVOC	semi-volatile organic compounds
TCE	trichloroethane
TLV	threshold limit value
TRL	target reporting limits
TWA	time-weighted average
USTs	underground storage tanks

1.0 INTRODUCTION

This Revised Sampling and Analysis Plan (SAP) presents the proposed scope-of-work to conduct continued groundwater sampling at the Former L&L Exxon site (herein designated as the site) located at 1315 Lee Boulevard in Richland, Washington, approximately as shown in the attached Vicinity Map, Figure 1. This SAP is a revision from the SAP included in the Work Plan (GeoEngineers, 2012) created for the site assessment activities conducted at the site in 2012. The revisions in this SAP cover sampling during the remediation phase of the project, specifically, continued groundwater sampling from the five existing monitoring (MW-1 through MW-5). Groundwater monitoring will be used to assess the effectiveness of the remediation and to eventually confirm contaminant concentrations have decreased to less than MTCA Method A cleanup levels. When site closure seems feasible, soil closure samples will be obtained, likely from soil borings; this SAP will be amended as appropriate at that time to include the soil sampling procedures. Note: At this time, soil samples are not expected to be collected during installation of the remediation components (installing injection wells and excavating infiltration gallery trenches). If soil samples are collected from the injection well borings or the trenches, then we will follow the soil sampling guidelines contained in the original SAP.

The project Quality Assurance Project Plan (QAPP) is presented as Appendix B in the original SAP (GeoEngineers, 2012). Included in this SAP are general guidelines with the following sections:

- "Scope and Tasks - Section 2.0"
- "Assessment Procedures – Section 3.0"
- "Data Validation and Usability – Section 4.0"

2.0 SCOPE AND TASKS

The following describes the tasks associated with sample collection at the site. The scope items listed below are not a comprehensive list of the tasks that will be performed to conduct the remediation. The listed scope items address only the tasks associated with additional groundwater sampling. GeoEngineers will continue quarterly sampling the five groundwater monitoring wells to assess groundwater contaminant concentration trends during remediation. This task includes the following activities:

- Measure depth-to-groundwater during each monitoring event.
- Collect groundwater samples from each well using low-flow/low-stress sampling techniques, and measure water quality parameters during well purging activities.
- Submit groundwater samples to a qualified laboratory for chemical analysis. Samples will be analyzed for gasoline-range petroleum hydrocarbons (GRPH) using Northwest Method NWTPH-Gx; diesel- and oil-range petroleum hydrocarbons (DRPH and ORPH, respectively) using Northwest Method NWTPH-Dx, benzene, toluene, ethylbenzene and total xylenes (BTEX), trichloroethylene, perchloroethylene and n-hexane using Environmental Protection Agency (EPA) Method 8260B and naphthalenes (naphthalene, 1-methylnaphthalene and 2-methylnaphthalene) using EPA Method 8270-SIM. Additionally natural attenuation parameters (dissolved manganese, methane, nitrate-nitrogen, sulfate and total alkalinity) will be analyzed using their respective approved methods.

- Prepare a draft and final Groundwater Monitoring Report following each event.

3.0 SAMPLING PROCEDURES

This section contains standard procedures for field data collection that are anticipated during groundwater monitoring activities and include the following:

- Groundwater Elevation Measurement;
- Groundwater Sample Collection;
- Decontamination Procedures; and
- Handling of Investigation-Derived Waste (IDW).

3.1. Depth to Groundwater

Depth to groundwater in the wells will be measured and recorded in the field notes upon initially opening the well and after the water level has stabilized following well purging. Depth to groundwater relative to the notch or mark in the monitoring well casing rims will be measured to the nearest 0.01 foot using an electronic water level indicator and recorded in the field notes. Product thickness (if any) will be measured with an oil-water interface probe and recorded in the field notes. Groundwater elevation will be calculated by subtracting the depth-to-water measurement from the surveyed casing rim elevation. The electronic water level indicator will be decontaminated with Liquinox® solution wash and a distilled water rinse prior to use in each well.

3.2. Groundwater Sampling

Following depth to groundwater measurements, groundwater will be purged and groundwater samples will be collected from the installed monitoring wells consistent with the EPA's low-flow groundwater sampling procedure, as described in EPA (1996) and Puls and Barcelona (1996). Dedicated polyethylene tubing and a portable peristaltic pump will be used for groundwater purging and sampling. During purging activities, water quality parameters, including pH, temperature, conductivity, dissolved oxygen, oxidation reduction potential (ORP) and turbidity will be measured using a multi-parameter meter equipped with a flow-through cell. Groundwater samples will be collected after (1) water quality parameters stabilize; or (2) a maximum purge time of 60 minutes is achieved. During purging and sampling, drawdown will not be allowed to exceed 0.3 feet, if possible, and the purge rate will not be allowed to exceed 400 milliliters per minute. Water quality parameter stabilization criteria will include the following:

- Turbidity: ±10 percent for values greater than 5 nephelometric turbidity units (ntu);
- Conductivity: ±3 percent;
- pH: ±0.1 unit;
- Temperature: ±3 percent; and
- Dissolved oxygen: ± 10 percent.
- ORP: ± 10 percent or ± 10 millivolts (mV)

Samples will not be collected from the wells if they contain any measureable free product. Field water quality measurements and depth-to-water measurements will be recorded on a Well Purging-Field Water Quality Measurement Form. The groundwater samples will be transferred in the field to laboratory-prepared sample containers and kept cool during transport to the testing laboratory. Chain-of-custody procedures will be observed from the time of sample collection to delivery to the testing laboratory consistent with the QAPP.

3.3. Decontamination Procedures

The objective of the decontamination procedures described herein is to minimize the potential for cross-contamination between sample locations. Groundwater sampling equipment will be decontaminated in accordance with the following procedures before each sampling attempt or measurement.

1. Brush equipment with a nylon brush to remove large particulate matter.
2. Rinse with potable tap water.
3. Wash with non-phosphate detergent solution (Liquinox® and potable tap water).
4. Rinse with potable tap water.
5. Rinse with distilled water.

3.4. Handling of IDW

IDW, which consists of mainly purge water generated during groundwater sampling, typically will be placed in DOT-approved 55-gallon drums. Each drum will be labeled with the project name, exploration number, general contents and date. The drummed IDW will be stored onsite pending analysis and disposal.

Disposable items, such as sample tubing, disposable bailers, bailer line, gloves and protective overalls, paper towels, etc., will be placed in plastic bags after use and deposited in trash receptacles for disposal.

3.5. Sampling and Analytical Methods

Groundwater and soil field sampling methods, including quality control (QC) and maintenance of field instrumentation, will generally adhere to the requirements of the QAPP. Analytical method requirements also will adhere to the QAPP. During laboratory procurement and coordination, analytical method reporting limits for each proposed analysis will be compared to the reporting limits listed in the QAPP to ensure that data generated will be sufficient for assessment purposes.

3.6. Sample Handling and Custody Requirements

Samples will be handled in accordance with the QAPP. A complete discussion of the sample identification and custody procedures is provided in the QAPP.

3.7. Field Measurements and Observations Documentation

Field measurements and observations will be recorded in the project field notes. Daily logs will be dated, and pages will be consecutively numbered. Entries will be recorded directly and legibly in the daily log and signed and dated by the person conducting the work. If changes are made, the changes will not obscure the previous entry, and the changes will be signed and dated. At a minimum, the following data will be recorded in the log book:

- Purpose of activity
- Location of activity
- Description of sampling reference point(s)
- Date and time of activity
- Sample number identification
- Soil sample top and bottom depth (bgs)
- Sample number and volume
- Sample transporting procedures
- Field measurements and screening observations
- Calibration records for field instruments
- Visitors to site
- Relevant comments regarding field activities
- Signatures of responsible personnel

Sufficient information will be recorded in the log book so that field activities can be reconstructed without reliance on personnel memory.

3.8. Data Management And Documentation

Data logs and data report packages will be located in the project file system in GeoEngineers' Spokane, Washington office. Data reports will be available in both hard copy and electronic formats. Laboratory data reports will include internal laboratory quality control checks and sample results. Data logs and packages that are anticipated to be generated during the investigation include laboratory data report packages, boring logs, field sampling data sheets and chain-of-custody forms.

Analytical data will be supplied to GeoEngineers in both electronic data deliverable (EDD) format and hard copy format. The hard copy will serve as the official record of laboratory results. The EDDs will contain only data reported in the hard copy reports (e.g. only reportable results).

Upon receipt of the analytical data, the EDD will be uploaded to a project database and reduced into summary tables for each group of analytes and media. Upon completion of the summary tables, the accuracy of the data reduction will be verified using the hard copy of the data received from the laboratory. Any exceptions will be noted and corrections will be made. The EDD data will be submitted to Washington State Department of Ecology's (Ecology's) Environmental Information Management (EIM) system.

4.0 DATA VALIDATION AND USABILITY

Upon receipt of the sample data from the laboratory, the data will be validated and evaluated for usability in accordance with the existing QAPP.

5.0 REFERENCES

Puls, R.W. and Barcelona, M.J., Low-flow (minimal drawdown) ground-water sampling procedures: EPA Ground Water Issue, April 1996, p.1-9.

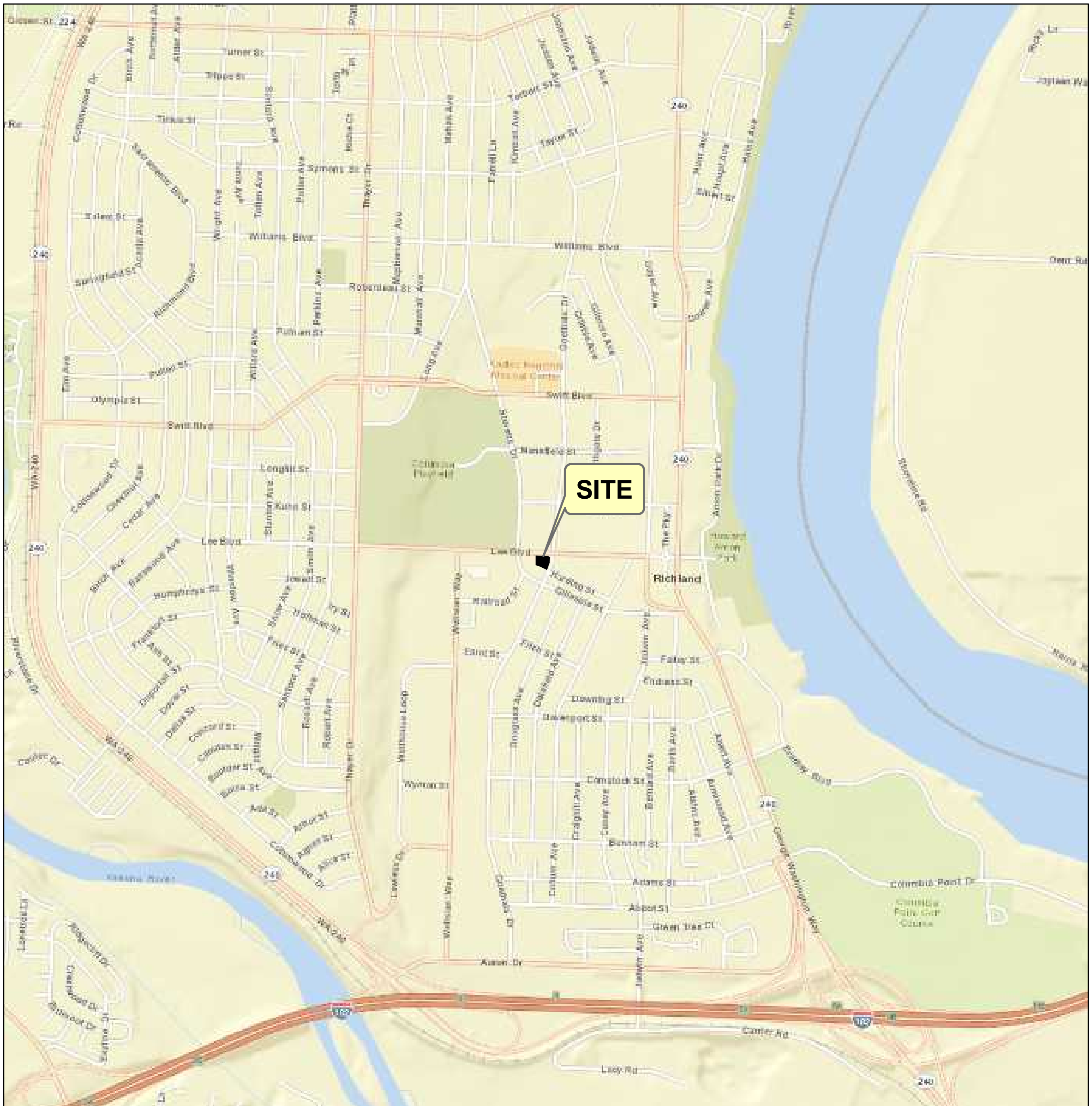
U.S. Environmental Protection Agency (EPA), Region 1, Low stress (low-flow) purging and sampling procedure for the collection of ground water samples from monitoring wells. EPA SOP No. GW 0001, Revision No. 2, July 30, 1996.

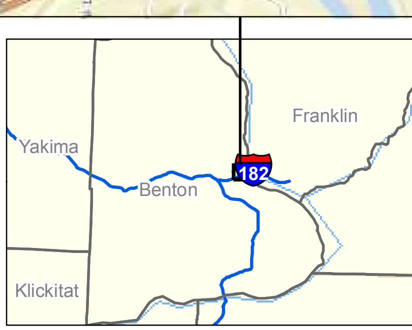
U.S. Environmental Protection Agency (EPA), "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods (SW-846)," Revision 5, April 1998.

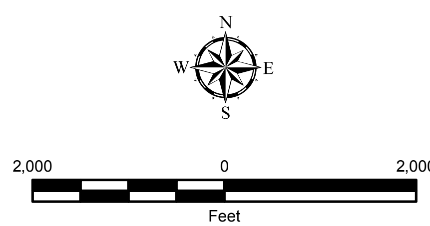
Washington State Department of Ecology, "Collecting and Preparing Soil Samples for VOC Analysis." 2004.

GeoEngineers, Inc. "Work Plan: Data Gap Investigation." June 6, 2012.

FIGURES







Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.
Data Sources: ESRI Data & Maps, Street Maps 2008.
Basemap streets base from ESRI Data Online.
Projection: NAD 1983, UTM Zone 11 North.

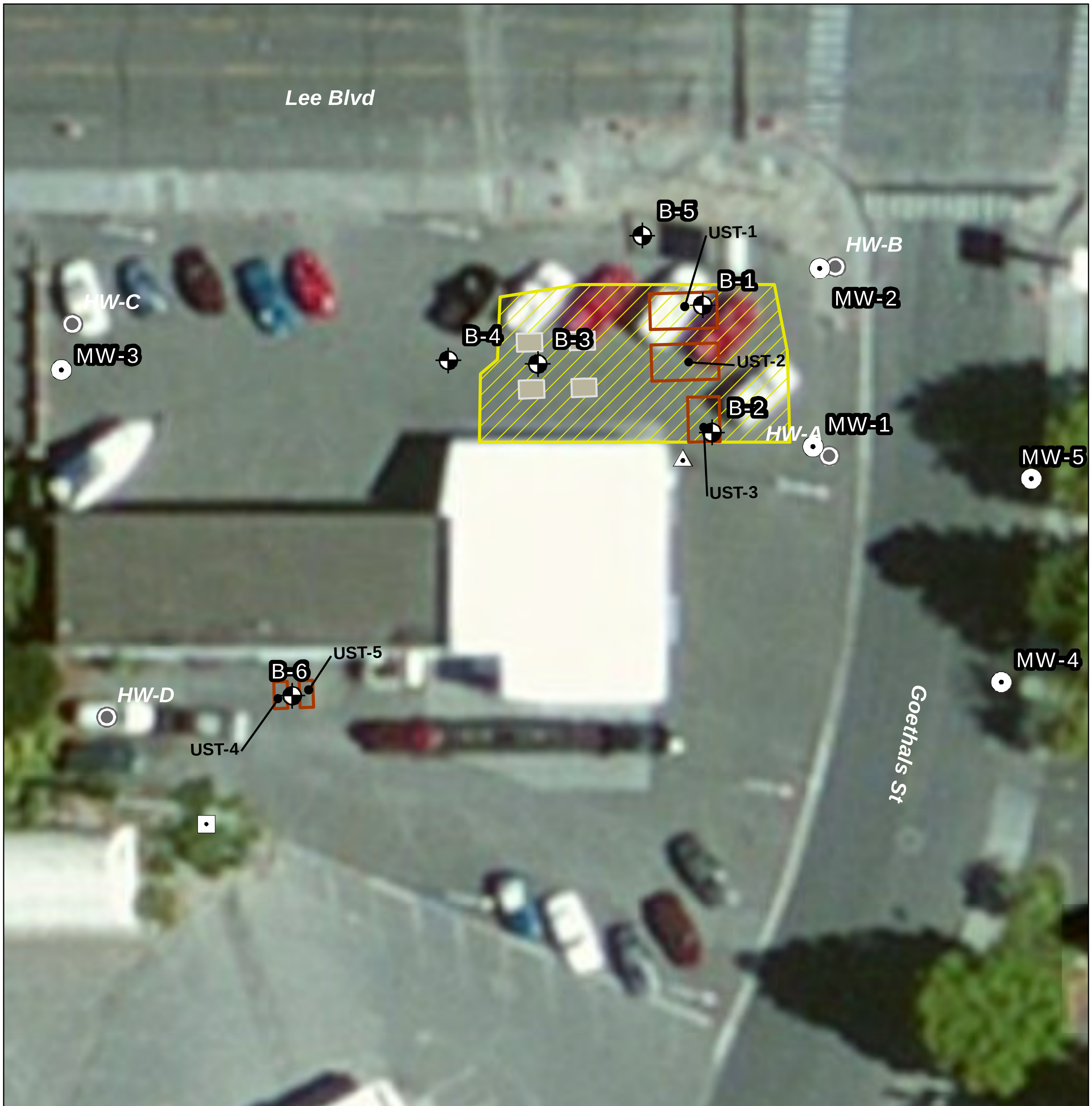
Vicinity Map

Former L&L Exxon
1315 Lee Boulevard
Richland, Washington

GeoEngineers

Figure 1

Office: PORT Path: P:\0\0504081_SPOK_GIS\01\MXD\0504081 01_F1_VM.mxd Map Revised: 2/18/2014 CRC



B-1 Previous Soil Boring Approximate Location

MW-1 Monitoring Well Number, Approximate Location

Approximate Location of Remediation System

Approximate Location of Transformer

Historical Monitoring Well Number and Approximate Location

UST Number and Approximate Location

Approximate Location of Excavation Area

Historical Fuel Dispenser and Approximate Location

N E S W

0 50
Feet

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.
Data Sources: ESRI Data & Maps, Street Maps 2008.
Basemap streets base from ESRI Data Online.
Projection: NAD 1983, UTM Zone 11 North.

Site Plan

Former L&L Exxon
1315 Lee Boulevard
Richland, Washington

GeoEngineers

Figure 2

Office: PORT Path: P:\0\0504081\SPOK_GIS\01\MXD\050408101_F2_SP_1Q.mxd Map Revised: 12 May 2014 ccabrera

APPENDICES

APPENDIX A
Health and Safety Plan

APPENDIX A
HEALTH AND SAFETY PLAN
FORMER L&L EXXON

This Health and Safety Plan (HASP) is to be used in conjunction with the GeoEngineers Safety Program Manual. Together, the written safety programs and this HASP constitute the site safety plan for this site. This plan is to be used by GeoEngineers personnel on this site and must be available on site. If the work entails potential exposures to other substances or unusual situations, additional safety and health information will be included and the plan will be approved by the GeoEngineers Health and Safety Manager. All plans are to be used in conjunction with current standards and policies outlined in the GeoEngineers Health and Safety Program Manual.

TABLE 1. GENERAL PROJECT INFORMATION

Project Name:	**L&L Exxon Assessment and Remediation**
Project Number:	00504-081-01
Type of Project:	Groundwater Monitoring and Site Remediation
Project Address:	1315 Lee Boulevard, Richland, Washington
Start/Completion:	June 2014 to June 2015
Subcontractors:	Environmental West

Liability Clause - This Site Safety Plan is intended for use by GeoEngineers Employees only. It does not extend to the other contractors or subcontractors working on this site. If requested by subcontractors, this site safety plan may be used as a minimum guideline for those entities to develop safety plans or procedures for their own staff to work under. In this case, Form 3 shall be signed by the subcontractor.

All personnel participating in this project must receive initial health and safety orientation (Form 1). Thereafter, brief tailgate safety meetings will be held as deemed necessary by the Site Safety and Health Supervisor.

The orientation and the tailgate safety meetings shall include a discussion of emergency response, site communications and site hazards.

TABLE 2. ORGANIZATION CHART

Chain of Command	**Title**	**Name**	**Telephone Numbers**
1	Project Manager	Scott Lathen	O: 509.363.3125 C: 509.251.5239
2	Hazardous Waste Operations and Emergency Response Standard (HAZWOPER) Supervisor	Bruce Williams	O: 509.363.3125 C: 509.954.6614

Chain of Command	Title	Name	Telephone Numbers
3	Field Engineer/Geologist	Scott Lathen Katie Hall Josh Lee	O: 509.363.3125 C: 509.251.5239 O: 509.363.3125 C: 509.768.3579 O: 509.363.3125 C: 406.239.7810
4	Site Safety and Health Supervisor (Site Safety Officer; [SSO])	Scott Lathen	See above
5	Client Assigned Site Supervisor	Bruce Williams	509.363.3125
6	Health and Safety Program Manager (HSM)	Wayne Adams	O: 253.722.2793 C: 253.350.4387

SITE SAFETY AND HEALTH SUPERVISOR

The individual present at a hazardous waste site responsible to the employer and who has the authority and knowledge necessary to establish the site-specific health and safety plan and verify compliance with applicable safety and health requirements.

GeoEngineers employees often do not have stop work authority on projects controlled by other contractors; however, any GeoEngineers employee, regardless of job title, working in the field will be responsible for contacting the Project Manager if they observe practices on the job site that are serious safety violations that are not under their control. They will document the unsafe practices and will contact the site supervisor as identified by the client. If no one is on site, the Project Manager, once notified, will contact the client. This action establishes GeoEngineers commitment to site health and safety on all job sites as our duty of care to the public, contractors, and clients.

TABLE 3. PERSONNEL TRAINING RECORDS

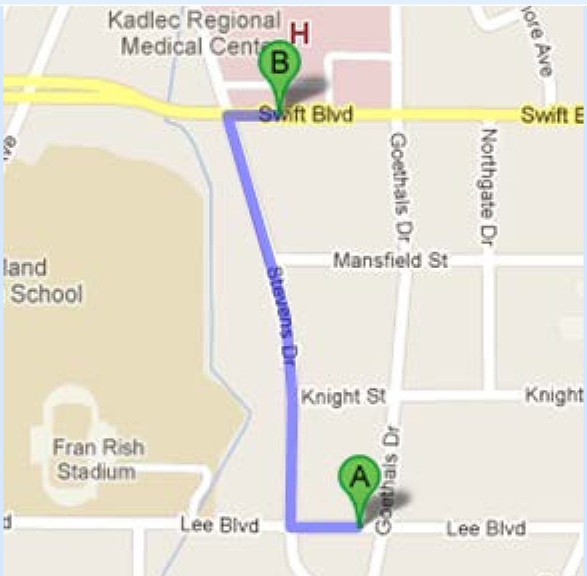
Name of Employee on Site	Level of HAZWOPER Training (24-/40-hr)	Date of 8-Hr Refresher Training	First Aid/ CPR	Date of Respirator Fit Test
Scott Lathen	5/21/2007	3/17/2014	2/25/2013	4/12/2013
Katie Hall	2/20/2012	2/26/2013	2/23/2011	3/12/2012
Josh Lee	11/29/2012	3/17/2014	5/2013	5/1/2013
Chelsea Voss	1/10/2014	NA	No record on file	3/7/2014

TABLE 4. EMERGENCY INFORMATION

Hospital Name and Address:	Kadlec Regional Medical Center 888 Swift Boulevard, Richland, WA 99352
Phone Numbers (Hospital ER):	509.946.4611
Distance:	0.5 miles

Route to Hospital:

1. Head west on Lee Boulevard toward Stevens Drive.
2. Turn right onto Stevens Drive.
3. Turn right onto Swift Boulevard.



Ambulance:	9.1.1
Poison Control:	800.222.1222
Police:	9.1.1
Fire:	9.1.1
Location of Nearest Telephone:	Cell phones are carried by field personnel.
Nearest Fire Extinguisher:	Located in the GeoEngineers' vehicle on site.
Nearest First-Aid Kit:	Located in the GeoEngineers' vehicle on site.

STANDARD EMERGENCY PROCEDURES

1. Get help
    a. send another worker to phone 911 (if necessary)
    b. as soon as feasible, notify GeoEngineers' project manager

2. Reduce risk to injured person
    a. turn off equipment
    b. move person from injury location (if possible)
    c. keep person warm
    d. perform CPR (if necessary)
3. Transport injured person to medical treatment facility (if necessary)
    a. by ambulance (if necessary) or GeoEngineers vehicle
    b. stay with person at medical facility
    c. keep GeoEngineers manager apprised of situation and notify human resources manager of situation

COMPREHENSIVE WORK PLAN

1. Contact the one-call utility locate service.
2. Observe installation of injection wells using air-rotary drilling techniques.
3. Observe infiltration gallery installation.
4. Observe chemical oxidant and other amendments injection.
5. Observe multi-phase extraction using a vactor truck.
6. Collect water level measurements at site monitoring wells.
7. Sample the monitoring wells using low-flow methods.
8. Groundwater samples will be submitted for laboratory analysis of the following: GRPH, DRPH, ORPH, BTEX, PCE, TCE and naphthalenes.

TABLE 5. LIST OF FIELD ACTIVITIES

Check the Activities to be Completed during the Project	
X	Site reconnaissance
	Exploratory borings
X	Construction monitoring
X	Surveying
	Test pit exploration
X	Monitor well installation
X	Monitor well development
	Soil sample collection
	Field screening of soil samples
	Soil Vapor measurements
	Soil Vapor sampling

Check the Activities to be Completed during the Project	
X	Groundwater sampling
X	Groundwater depth
	Product sample measurement (if any)
	Soil stockpile testing
	Remedial excavation
	Underground storage tank (UST) removal monitoring
X	Remediation system monitoring
	Recovery of free product

HAZARD ANALYSIS

Note: A hazard assessment will be completed at every site prior to beginning field activities. Updates will be included in the daily log. This list is a summary of hazards listed on the form.

TABLE 6. PHYSICAL HAZARDS

Physical Hazards	
X	Drill rigs
X	Overhead hazards/power lines
X	Tripping/puncture hazards
X	Snow, rain, ice, freezing temperatures
X	Heat/ Cold, Humidity
X	Utilities/ utility locate
X	Contaminated soil
X	Contaminated groundwater
X	Loud noise
X	Backhoe
X	Trackhoe
	Crane
X	Front End Loader
X	Excavations/trenching (1:1 slopes for Type B soil)
	Shored/braced excavation if greater than 4 feet of depth

1. Utility check list completed.
2. Lifting hazards: Use proper techniques, mechanical devices where appropriate.
3. Terrain obstacles: Work will be conducted in a parking lot, work areas will be marked off with cones to increase the safety of GeoEngineers' personnel and the public.

4. Personnel will wear high-visibility vests for increased visibility by vehicle and equipment operators.
5. Field personnel will be aware constantly of the location and motion of heavy equipment. A safe distance will be maintained between personnel and the equipment. Personnel will be visible to the operator at all times and will remain out of the swing and/or direction of the equipment apparatus. Personnel will approach operating heavy equipment only when they are certain the operator has indicated it is safe to do so.
6. Heavy equipment and/or vehicles used on this site will not work within 20 feet of overhead utility lines without first ensuring that the lines are not energized. This distance may be reduced to 10 feet depending on the client and the use of a safety watch.
7. Overhead Power Line Clearance Safety: Working equipment around overhead power lines requires distance and a spotter. Before a job begins, call the utility company and find out voltage in lines. Have the equipment de-energized if possible. Ensure that the equipment remains de-energized by using some type of lockout and tag procedure, and ensure that the electrician uses grounding lines when they are required.
8. Keep a safe distance from energized parts, which is a minimum of 10 feet for 50 kilovolt (kV) and under. The minimum distance will be more for higher voltages (above 50kV). The only exception is for trained and qualified electrical workers using insulated tools designed for high voltage lines.
9. Don't operate equipment around overhead power lines unless you are authorized and trained to do so. If an object (scaffolds, crane, etc.) must be moved in the area of overhead power lines, appoint a competent worker whose sole responsibility is to observe the clearance between the power lines and the object. Warn others if the minimum distance is not maintained.
10. Never touch an overhead line if it has been brought down by machinery or has fallen. Never assume lines are dead. When a machine is in contact with an overhead line, DO NOT allow anyone to come near or touch the machine. Stay away from the machine and summon outside assistance. Never touch a person who is in contact with a live power line.
11. If you are in a vehicle that is in contact with an overhead power line, DON'T LEAVE THE VEHICLE. As long as you stay inside and avoid touching metal on the vehicle, you may avoid an electrical hazard. If you need to get out to summon help or because of fire, jump out without touching any wires or the machine, keep your feet together, and hop to safety.
12. When mechanical equipment is being operated near overhead power lines, employees standing on the ground may not contact the equipment unless it is located so that the required clearance cannot be violated even at the maximum reach of the equipment.
13. When working near overhead power lines, the use of nonconductive wooden or fiberglass ladders is recommended. Aluminum ladders and metal scaffolds or frames are efficient conductors of electricity.
14. Avoid storing materials under or near overhead power lines.
15. Personnel will avoid tripping hazards, steep slopes, pit and other hazardous encumbrances. If it becomes necessary to work within 6 feet of the edge of a pit, slope, pier or other potentially hazardous area, appropriate fall protection measures will be implemented by the Site Safety and Health Supervisor in accordance with Occupational Safety and Health Administration (OSHA)/Division of Occupational Safety and Health (DOSH) regulations and the GeoEngineers Safety Program manual.

16. Heat stress control measures must be implemented according to the GeoEngineers, Inc. program with water provided on site. See Additional Programs at end of this HASP.

17. Excessive levels of noise (exceeding 85 decibels [dBA]) are anticipated. Personnel potentially exposed will wear ear plugs or muffs with a noise reduction rating of at least 25 dBA whenever it becomes difficult to carry on a conversation 6 feet away from a co-worker or whenever noise levels become bothersome. (Increasing the distance from the source will decrease the noise level noticeably.)

18. Work may be conducted in rain, freezing rain, snow, or icy conditions. Care will be taken to wear warm water proof clothing that limits exposure to cold.

TABLE 7. ENGINEERING CONTROLS

X	Trench shoring (1:1 slope for Type B Soils)
X	Locate work spaces upwind/wind direction monitoring
X	Other soil covers (as needed)
	Other (specify) _______________

TABLE 8. CHEMICAL HAZARDS (PRESENT AT SITE)

Petroleum Products and Volatile Organic Compounds	
Known	Aromatic hydrocarbons (benzene, ethylbenzene, toluene, xylenes [BTEX])
Known	GRPH, DRPH, ORPH
Known	Polycyclic aromatic hydrocarbons (naphthalenes)
Known	Chlorinated Solvents (PCE, TCE)

TABLE 9. SUMMARY OF CHEMICAL HAZARDS

Compound/ Description	Exposure Limits/Immediately Dangerous to Life or Health (IDLH)	Exposure Routes	Toxic Characteristics
Gasoline, Clear yellow brown combustible liquid; floats on water; distinct petroleum hydrocarbon odor	Permissible exposure limits (PEL) (none) Threshold limit value (TLV) 300 parts per million (ppm) Short-term exposure limit (STEL) 500 ppm	Ingestion, inhalation, skin absorption, skin and eye contact	Irritation of eyes, skin, respiratory tract; dizziness; headache; nausea; pulmonary edema (from aspiration of liquid); dry, red skin; irritant contact dermatitis; eye redness, pain; fatigue; memory loss; slurred speech; loss of coordination; confusion; seizures; vomiting; damage to kidneys; potential lung damage; suspected carcinogen.

Compound/ Description	Exposure Limits/Immediately Dangerous to Life or Health (IDLH)	Exposure Routes	Toxic Characteristics
Diesel Fuel	OSHA PEL (none) American conference of Governmental Industrial Hygienists (ACGIH) has adopted 100 milligrams per cubic meter (mg/m^3) for a time-weighted average (TWA) (as total hydrocarbons)	Ingestion, inhalation, skin absorption, skin and eye contact	Irritated eyes, skin, mucous membrane; fatigue; blurred vision; dizziness; slurred speech; confusion; convulsions; and headache; dermatitis.
Benzene	PEL 5 ppm Immediately dangerous to life or health (IDLH) 500 ppm	Inhalation, ingestion, skin absorption, and/or direct contact	Irritation of eyes, skin, nose, respiratory system; dizziness; headache; nausea; staggered gait; anorexia; exhaustion; dermatitis; bone marrow depression (leukemia).
Toluene	PEL 100 ppm IDLH 500 ppm	Inhalation, absorption, ingestion, direct contact	Irritation to eyes and nose, exhaustion; confusion; dizziness; headaches; dilated pupils; euphoria; anxiety; teary eyes; muscle fatigue; insomnia; paresthesia; dermatitis; liver and kidney damage.
Ethyl benzene	PEL 100 ppm IDLH 800 ppm	Inhalation, ingestion, direct contact	Irritation to eyes, skin, respiratory system; burning of skin; dermatitis.
Xylenes	PEL 100 ppm IDLH 900 ppm	Inhalation, skin absorption, ingestion, direct contact	Irritation to eyes, skin, nose, throat; dizziness; excitement; drowsiness; incoordination; staggering gait; corneal vacuolization; anorexia; nausea; vomiting; abdominal pain; dermatitis.
Tetrachloroethene (PCE), colorless liquid with a mild, chloroform-like odor	NIOSH = 100 ppm, C 200 ppm, IDLH 150 ppm TLV TWA = 25 ppm, STEL = 100 ppm OSHA = TWA 100 ppm, C 200 ppm	inhalation, skin absorption, ingestion, skin and/or eye contact	Irritation eyes, skin, nose, throat, respiratory system; nausea; flush face, neck; dizziness, incoordination; headache, drowsiness; skin erythema (skin redness); liver damage; (potential occupational carcinogen)
Trichloroethene (TCE), colorless liquid (unless dyed blue) with a chloroform-like odor	TLV TWA = 50 ppm, 269 mg/m^3 TWA; STEL = 100 ppm, 537 mg/m^3 OSHA = TWA 100 ppm, C 200 ppm	inhalation, skin absorption, ingestion, skin and/or eye contact	Irritation eyes, skin; headache, visual disturbance, lassitude (weakness, exhaustion), dizziness, tremor, drowsiness, nausea, vomiting; dermatitis; cardiac arrhythmias, paresthesia; liver injury; (potential occupational carcinogen)

Sample handling, packaging, and processing: skin contact with contaminated media and preservative acids. Wear modified Level D personal protection equipment (PPE).

Decontamination of equipment: Inhalation or eye contact or skin contact with airborne mists or vapors, or contaminated liquids. Wear safety glasses; decontaminate clothing and skin prior to eating, drinking or other hand to mouth contact.

Groundwater Sampling: Splash hazard associated with groundwater extraction and sample collection. Possible corrosion hazard associated with sample preservatives. Wear protective clothing and eye protection and chemical-resistant gloves are required when handling samples.

TABLE 10. BIOLOGICAL HAZARDS AND PROCEDURES

Y/N	Hazard	Procedures
N	Poison Ivy or other vegetation	
N	Insects or snakes	
	Others	

Site personnel shall avoid contact with or exposures to potential biological hazards encountered.

Additional Hazards (Update in Daily Log)

Include evaluation of:

1. Physical Hazards (equipment, traffic, tripping, heat stress, cold stress and others)
2. Chemical Hazards (odors, spills, free product, airborne particulates and others present)
3. Biological Hazards (snakes, spiders, other animals, poison ivy and others present)

Air Monitoring Plan

Work upwind if at all possible.

Check Instrumentation to be Used

_______ TLV Monitor (flammability only, for methane and petroleum vapors)

___X___ PID (Photoionization Detector)

_______ Other (i.e., detector tubes): ____

Check Monitoring Frequency/Locations: and Type (Specify: Work Space, Borehole, Breathing Zone)

_______ 15 minutes—Continuous during soil disturbance activities or handling samples

_______ 15 minutes

_______ 30 minutes

___X___ Hourly (in breathing zone during excavations, drilling, sampling)

SITE CONTROL PLAN

An up-to-date site control plan will be developed before field activities begin to minimize employee exposure to hazardous substances and including the following: a site map is included with the SAP. The hospital route map is included with this HASP.

Traffic or Vehicle Access Control Plans

Survey tape and traffic cones will be used to cordon off any areas on site where borings will be conducted in order to restrict public vehicular and pedestrian access. During infiltration gallery installation, the selected contractor will prepare and implement a site control plan. This will include establishing barriers to restrict site access.

Site Work Zones

Exclusion zones will be established within approximately 10 feet around each boring or well during drilling/sampling. Only persons with the appropriate training will enter this perimeter while work is being conducted there.

Method of Delineation / Excluding Non-Site Personnel	
X	Fence
X	Survey Tape
X	Traffic Cones
	Other Road Work Signs

Buddy System

Personnel on-site should use the buddy system (pairs), particularly whenever communication is restricted. If only one GeoEngineers employee is on-site, a buddy system can be arranged with subcontractor/contractor personnel.

Site Communication Plan

Positive communications (within sight and hearing distance or via radio) should be maintained between pairs on-site, with the pair remaining in proximity to assist each other in case of emergencies. The team should prearrange hand signals or other emergency signals for communication when voice communication becomes impaired (including cases of lack of radios or radio breakdown). In these instances, consider suspending work until communication can be restored; if not, the following are some examples for communication:

1. Hand gripping throat: Out of air, can't breathe.
2. Gripping partner's wrist or placing both hands around waist: Leave area immediately, no debate.
3. Hands on top of head: Need assistance.
4. Thumbs up: Okay, I'm all right; or, I understand.
5. Thumbs down: No, negative.

6. Extended fist: Stop.

Decontamination Procedures

All non-dedicated sampling equipment will be decontaminated with Liquinox™ soap and rinsed with distilled water prior to collecting any samples for analysis.

Personal decontamination consists of removing outer protective Tyvek clothing (if used), washing soiled boots, removing respirator (if used); hands and face will be washed in either a portable wash station or a bathroom facility in the support zone. Employees will perform decontamination procedures and wash prior to eating, drinking or leaving the site. All disposable personal protective clothing (i.e., nitrile gloves) will be bagged with other miscellaneous waste and discarded in the appropriate refuse receptacle in the contamination reduction zone.

PERSONAL PROTECTIVE EQUIPMENT

PPE will consist of standard Level D equipment. Disposable PPE (gloves) will be placed into plastic trash bags and disposed as solid waste. Minimum level of protective equipment for these sites is Level D. After the initial and/or daily hazard assessment has been completed, select the appropriate PPE to preserve worker safety. Task-specific levels of PPE shall be reviewed with field personnel during the pre-work briefing conducted prior to the start of site operations.

Check Applicable Personal Protection Equipment to be Used	
X	Hardhat
X	Steel-toed boots
X	Safety glasses
X	Hearing protection
X	Rubber boots (if wet conditions)
Gloves (specify)	
X	Nitrile
	Latex
	Liners
	Leather
	Other (specify) ______________________________
Protective clothing	
	Tyvek (if dry conditions are encountered, Tyvek is sufficient)
	Saranex (personnel shall use Saranex if liquids are handled or splash may be an issue)
X	Cotton
X	Rain gear (as needed)
X	Layered warm clothing (as needed)

Check Applicable Personal Protection Equipment to be Used	
Inhalation hazard protection	
X	Level D
	Level C (respirators with organic vapor filters/P100 filters)

Limitations of Protective Clothing

PPE clothing ensembles designated for use during site activities shall be selected to provide protection against known or anticipated hazards. However, no protective garment, glove, or boot is entirely chemical-resistant, nor does any PPE provide protection against all types of hazards. To obtain optimum performance from PPE, site personnel shall be trained in the proper use and inspection of PPE. This training shall include the following:

1. Inspect PPE before and during use for imperfect seams, non-uniform coatings, tears, poorly functioning closures or other defects. If the integrity of the PPE is compromised in any manner, proceed to the contamination reduction zone and replace the PPE.
2. Inspect PPE during use for visible signs of chemical permeation such as swelling, discoloration, stiffness, brittleness, cracks, tears or other signs of punctures. If the integrity of the PPE is compromised in any manner, proceed to the contamination reduction zone and replace the PPE.
3. Disposable PPE should not be reused after breaks unless it has been properly decontaminated.

Respirator Selection, Use and Maintenance

GeoEngineers has developed a written respiratory protection program in compliance with OSHA requirements contained in 29 code of federal regulations (CFR) 1910.134. Site personnel shall be trained on the proper use, maintenance and limitations of respirators. Site personnel that are required to wear respiratory protection shall be medically qualified to wear respiratory protection in accordance with 29 CFR 1910.134. Site personnel that will use a tight-fitting respirator must have passed a qualitative or quantitative fit test conducted in accordance with an OSHA-accepted fit test protocol. Fit testing must be repeated annually or whenever a new type of respirator is used. Respirators will be stored in a protective container.

Respirator Cartridges

If site personnel are required to wear air-purifying respirators, the appropriate cartridges shall be selected to protect personnel from known or anticipated site contaminants. The respirator/cartridge combination shall be certified and approved by National Institute for Occupational Health and Safety (NIOSH). A cartridge change-out schedule shall be developed based on known site contaminants, anticipated contaminant concentrations, and data supplied by the cartridge manufacturer related to the absorption capacity of the cartridge for specific contaminants. Site personnel shall be made aware of the cartridge change-out schedule prior to the initiation of site activities. Site personnel shall also be instructed to change respirator cartridges if they detect increased resistance during inhalation or detect vapor breakthrough by smell, taste or feel although breakthrough is not an acceptable method of determining the change-out schedule. At a minimum, cartridges should be changed a minimum of once daily.

Respirator Inspection and Cleaning

The Site Safety and Health Supervisor shall periodically (i.e., weekly) inspect respirators at the project site. Site personnel shall inspect respirators prior to each use in accordance with the manufacturer's instructions. In addition, site personnel wearing a tight-fitting respirator shall perform a positive and negative pressure user seal check each time the respirator is donned to ensure proper fit and function. User seal checks shall be performed in accordance with the GeoEngineers respiratory protection program or the respirator manufacturer's instructions.

Facial Hair and Corrective Lenses

Site personnel with facial hair that interferes with the sealing surface of a respirator shall not be permitted to wear respiratory protection or work in areas where respiratory protection is required. Normal eyeglasses cannot be worn under full-face respirators because the temple bars interfere with the sealing surface of the respirator. Site personnel requiring corrective lenses will be provided with spectacle inserts designed for use with full-face respirators. Contact lenses should not be worn with respiratory protection.

ADDITIONAL ELEMENTS

Heat Stress Prevention

Site specific procedures for preventing heat stress include: provide shade, water and frequent breaks.

The State of Washington and the State of California have regulations that provide specific requirements for handling employee exposure to heat stress. GeoEngineers' program complies with both sets of requirements and will be implemented in all areas where heat stress is identified as a potential health issue.

The Washington State requirements for preventing heat stress apply to outdoor work environments from May 1 through September 30, only when employees are exposed to outdoor heat at or above an applicable temperature listed in Table 11. To determine which temperature applies to each worksite, select the temperature associated with the general type of clothing or PPE each employee is required to wear.

TABLE 11. OUTDOOR TEMPERATURE ACTION LEVELS

All other clothing	89°
Double-layer woven clothes including coveralls, jackets and sweatshirts	77°
Non-breathing clothes including vapor barrier clothing or PPE such as chemical resistant suits	52°

Keeping workers hydrated in a hot outdoor environment requires more water be provided than at other times of the year. GeoEngineers is prepared to supply at least one quart of drinking water per employee per hour. When employee exposure is at or above an applicable temperature listed in Table 11, Project Managers will ensure that:

1. A sufficient quantity of drinking water is readily accessible to employees at all times; and

2. All employees have the opportunity to drink at least one quart of drinking water per hour.

Emergency Response

1. Personnel on-site should use the "buddy system" (pairs).
2. Visual contact should be maintained between "pairs" on-site, with the team remaining in proximity to assist each other in case of emergencies.
3. If any member of the field crew experiences any adverse exposure symptoms while on-site, the entire field crew should immediately halt work and act according to the instructions provided by the SSO.
4. Wind indicators visible to all on-site personnel should be provided by the SSO to indicate possible routes for upwind escape. Alternatively, the SSO may ask on-site personnel to observe the wind direction periodically during site activities.
5. The discovery of any condition that would suggest the existence of a situation more hazardous than anticipated should result in the evacuation of the field team, contact of the project manager, and reevaluation of the hazard and the level of protection required.
6. If an accident occurs, the SSO and the injured person are to complete, within 24 hours, an Accident Report for submittal to the project manager, the HSM and human resources. The project manager should ensure that follow-up action is taken to correct the situation that caused the accident or exposure.

A Sampling and Monitoring Plan for Drums and Containers

Drums containing IDW, which will consist of soil cuttings from the injection well installations and purge water from groundwater sampling, will be sampled as required by the disposal facility.

Site Control Measures

Listed above in Site Control Plan.

Spill Containment Plans (Drum and Container Handling)

IDW will be drummed and stored in a location approved by the property owners pending chemical analytical results. Drums will be labeled with applicable information and secured.

Standard Operating Procedures for Sampling, Managing, and Handling Drums and Containers

Drums and containers used during the cleanup shall meet the appropriate Department of Transportation (DOT), OSHA and EPA regulations for the waste that they contain. Site operations shall be organized to minimize the amount of drum or container movement. When practicable, drums and containers shall be inspected and their integrity shall be ensured before they are moved. Unlabeled drums and containers shall be considered to contain hazardous substances and handled accordingly until the contents are positively identified and labeled. Before drums or containers are moved, all employees involved in the transfer operation shall be warned of the potential hazards associated with the contents.

Drums or containers and suitable quantities of proper absorbent shall be kept available and used where spills, leaks or rupture may occur. Where major spills may occur, a spill containment program shall be implemented to contain and isolate the entire volume of the hazardous substance being transferred. Fire extinguishing equipment shall be on hand and ready for use to control incipient fires.

Entry Procedures for Tanks or Vaults (Confined Spaces)

N/A

Personnel Medical Surveillance

GeoEngineers' employees are not in a medical surveillance program as they do not fall into the category of "Employees Covered" in OSHA 1910.120(f)(2) which states a medical surveillance program is required for the following employees:

1. All employees who are or may be exposed to hazardous substances or health hazards at or above the permissible exposure limits or, if there is no permissible exposure limit, above the published exposure levels for these substances, without regard to the use of respirators, for 30 days or more a year;
2. All employees who wear a respirator for 30 days or more a year or as required by state and federal regulations;
3. All employees who are injured, become ill or develop signs or symptoms due to possible overexposure involving hazardous substances or health hazards from an emergency response or hazardous waste operation; and
4. Members of hazardous materials (HAZMAT) teams.

Sanitation

Field staff and subcontractors must go off site to access sanitation facilities. Multiple commercial buildings are located near the site with public access to restroom facilities.

Lighting

Fieldwork will be conducted during daylight hours.

Excavation, Trenching and Shoring

Trenches will be excavated to install the infiltration galleries. Trenches will be excavated to a maximum of 4 feet below ground surface. No shoring or other engineering controls will be required during trench excavation. Site personnel will establish visual contact with heavy equipment operators and receive a clear signal before approaching or working near heavy equipment.

Other Programs

None.

Documentation to Be Completed for HAZWOPER Projects

NOTE: The Field Log is to contain the following information:

1. Updates on hazard assessments, field decisions, conversations with subs, client or other parties.

2. Air monitoring/calibration results; personnel, locations monitored, activity at the time of monitoring (if performed).
3. Actions taken.
4. Action level for upgrading PPE and rationale.
5. Meteorological conditions (temperature, wind direction, wind speed, humidity, rain, snow, etc.).

Required forms:

1. Field Log.
2. Health and Safety Plan acknowledgment by GEI employees (Form 2).
3. Contractors Health and Safety Plan Disclaimer (Form 3).
4. Conditional forms available at GeoEngineers office: Accident Report.

APPROVALS

1.		______________________	______________
			Date
2.	Plan Approval	______________________	______________
		PM Signature	Date
3.	Health & Safety Officer	Wayne Adams	______________
		Health & Safety Program Manager	Date

FORM 1
HEALTH AND SAFETY PRE-ENTRY BRIEFING
L&L EXXON

Inform employees, contractors, and subcontractors or their representatives about:

1. The nature, level, and degree of exposure to hazardous substances they're likely to encounter, all site-related emergency response procedures, any identified potential fire, explosion, health, safety, or other hazards.
2. Conduct briefings for employees, contractors, and subcontractors, or their representatives as follows:
   a. A pre-entry briefing before any site activity is started.
   b. Additional briefings, as needed, to make sure that the site-specific HASP is followed.
   c. Make sure all employees working on the site are: Informed of any risks identified and trained on how to protect themselves and other workers against the site hazards and risks.
   d. Update all information to reflect current sight activities and hazards.
   e. All personnel participating in this project must receive initial health and safety orientation. Thereafter, daily brief tailgate safety meetings will be held or as deemed necessary by the Site Safety and Health Supervisor (such as a significant change in field conditions).
   f. The orientation and the tailgate safety meetings shall include a discussion of emergency response, site communications and site hazards.

Date	Topics	Attendee	Company Name	Employee Initials

FORM 2
SITE SAFETY PLAN – GEOENGINEERS' EMPLOYEE ACKNOWLEDGMENT
L&L EXXON

(All GeoEngineers' site workers complete this form, which should remain attached to the safety plan and filed with other project documentation).

I, ____, do hereby verify that a copy of the current Safety Plan has been provided by GeoEngineers, Inc., for my review and personal use. I have read the document completely and acknowledge a full understanding of the safety procedures and protocol for my responsibilities on site. I agree to comply with all required, specified safety regulations and procedures. I understand that I will be informed immediately of any changes that would affect site personnel safety.

Signed ______________________________ Date ______________________

Range of Dates From: ______________________________

To: ______________________________

Signed ______________________________ Date ______________________

Range of Dates From: ______________________________

To: ______________________________

Signed ______________________________ Date ______________________

Range of Dates From: ______________________________

To: ______________________________

Signed ______________________________ Date ______________________

FORM 3
SUBCONTRACTOR AND SITE VISITOR SITE SAFETY FORM
L&L EXXON

I, ____, verify that a copy of the current site Safety Plan has been provided by GeoEngineers, Inc. to inform me of the hazardous substances on site and to provide safety procedures and protocols that will be used by GeoEngineers' staff at the site. By signing below, I agree that the safety of my employees is the responsibility of the undersigned company.

Signed ______________________ Date ________________

Firm: ____

Signed ______________________ Date ________________

Firm: ____

Signed ______________________ Date ________________

Firm: ____

Signed ______________________ Date ________________

Firm: ____

Signed ______________________ Date ________________

Firm: ____

Signed ______________________ Date ________________

Firm: ____

APPENDIX B
Quality Assurance Project Plan

APPENDIX B
QUALITY ASSURANCE PROJECT PLAN

This Quality Assurance Project Plan (QAPP) was developed for groundwater sampling conducted during the interim action remediation at the Former L&L Exxon site (herein designated site) located at 1315 Lee Boulevard in Richland, Washington. Sampling procedures are outlined in the Sampling and Analysis Plan (SAP). The QAPP serves as the primary guide for the integration of quality assurance (QA) and quality control (QC) functions into assessment activities. The QAPP presents the objectives, procedures, organization, functional activities and specific QA and QC activities designed to achieve data quality goals established for the project. This QAPP is based on guidelines specified in Chapter 173-340-820 of the Washington Administrative Code (WAC) and the Environmental Protection Agency (EPA) Requirements for Quality Assurance Project Plans (EPA, 2004b).

Throughout the project, environmental measurements will be conducted to produce data that are scientifically valid, of known and acceptable quality, and meet established objectives. QA/QC procedures will be implemented so that precision, accuracy, representativeness, completeness and comparability of data generated meet the specified data quality objectives.

PROJECT ORGANIZATION AND RESPONSIBILITY

Descriptions of the responsibilities, lines of authority and communication for the key positions to QA/QC are provided below. This organization facilitates the efficient production of project work, allows for an independent quality review, and permits resolution of QA issues before submittal.

Project Leadership and Management

The Project Manager's (PM) duties consist of providing concise technical work statements for project tasks, selecting project team members, determining subcontractor participation, establishing budgets and schedules, adhering to budgets and schedules, providing technical oversight and providing overall production and review of project deliverables. Scott H. Lathen, Professional Engineer (PE) is the PM for activities at the sites. The Principal-in-Charge is responsible to Ecology for fulfilling contractual and administrative control of the project. Bruce D. Williams is the Principal-in Charge.

Field Coordinator

The Field Coordinator is responsible for the daily management of activities in the field. Specific responsibilities include the following:

- Provides technical direction to the field staff.
- Develops schedules and allocates resources for field tasks.
- Coordinates data collection activities to be consistent with information requirements.
- Supervises the compilation of field data and laboratory analytical results.
- Assures that data are correctly and completely reported.
- Implements and oversees field sampling in accordance with project plans.

- Supervises field personnel.
- Coordinates work with on-site subcontractors.
- Schedules sample shipment with the analytical laboratory.
- Monitors that appropriate sampling, testing and measurement procedures are followed.
- Coordinates the transfer of field data, sample tracking forms and log books to the PM for data reduction and validation.
- Participates in QA corrective actions as required.

The Field Coordinators for the interim remedial action activities at the site are Katie Hall, Josh Lee and/or Scott Lathen.

QA Leader

The GeoEngineers project QA Leader is under the direction of Scott Lathen and Bruce Williams, who are responsible for the project's overall QA. The Project QA Leader is responsible for coordinating QA/QC activities as they relate to the acquisition of field data. Mark Lybeer is the QA Leader. The QA Leader has the following responsibilities:

- Serves as the official contact for laboratory data QA concerns.
- Responds to laboratory data, QA needs, resolves issues and answers requests for guidance and assistance.
- Reviews the implementation of the QAPP and the adequacy of the data generated from a quality perspective.
- Maintains the authority to implement corrective actions as necessary.
- Reviews and approves the laboratory QA Plan.
- Evaluates the laboratory's final QA report for any condition that adversely impacts data generation.
- Ensures that appropriate sampling, testing and analysis procedures are followed and that correct QC checks are implemented.
- Monitors subcontractor compliance with data quality requirements.

Laboratory Management

The subcontracted laboratories conducting sample analyses for this project are required to obtain approval from the QA Leader before the initiation of sample analysis to assure that the laboratory QA plan complies with the project QA objectives. The Laboratory's QA Coordinator administers the Laboratory QA Plan and is responsible for QC. Specific responsibilities of this position include:

- Ensure implementation of the QA Plan.
- Serve as the laboratory point of contact.
- Activate corrective action for out-of-control events.
- Issue the final QA/QC report.

- Administer QA sample analysis.
- Comply with the specifications established in the project plans as related to laboratory services.
- Participate in QA audits and compliance inspections.

The chemical analytical laboratory QA Coordinator is Randee Arrington from TestAmerica Laboratories, Inc.

Health and Safety

A site-specific Health and Safety Plan (HASP) will be used for the interim action remediation activities. The Field Coordinator will be responsible for implementing the HASP during sampling and remediation activities. The PM will discuss health and safety issues with the Field Coordinator on a routine basis during the completion of field activities.

The Field Coordinator will conduct a tailgate safety meeting each morning before beginning daily field activities. The Field Coordinator will terminate any work activities that do not comply with the HASP. Companies providing services for this project on a subcontracted basis will be responsible for developing and implementing their own HASP. GeoEngineers will review subcontractor HASPs before commencement of their work at the site.

DATA QUALITY OBJECTIVES

The QA objective for technical data is to collect environmental monitoring data of known, acceptable and documentable quality. The QA objectives established for the project are:

- Implement the procedures outlined herein for field sampling, sample custody, equipment operation and calibration, laboratory analysis, and data reporting that will facilitate consistency and thoroughness of data generated.
- Achieve the acceptable level of confidence and quality required so that data generated are scientifically valid and of known and documented quality. This will be performed by establishing criteria for precision, accuracy, representativeness, completeness and comparability, and by testing data against these criteria.

The sampling design, field procedures, laboratory procedures and QC procedures are set up to provide high-quality data for use in this project. Specific data quality factors that may affect data usability include quantitative factors (precision, bias, accuracy, completeness and reporting limits) and qualitative factors (representativeness and comparability). The measurement quality objectives (MQO) associated with these data quality factors are summarized in Table B-1 and are discussed below.

Analytes and Matrices of Concern

Groundwater samples will continue to be collected during the interim action remediation. Table B-2 summarizes the analyses to be performed at the site for groundwater samples.

Detection Limits

Analytical methods have quantitative limitations at a given statistical level of confidence that are often expressed as the method detection limit (MDL). Individual instruments often can detect but not accurately quantify compounds at concentrations lower than the MDL, referred to as the instrument detection limit (IDL). Although results reported near the MDL or IDL provide insight to site conditions, QA dictates that analytical methods achieve a consistently reliable level of detection known as the practical quantitation limit (PQL). The contract laboratory will provide numerical results for all analytes and report them as detected above the PQL or undetected at the PQL.

Achieving a stated detection limit for a given analyte is helpful in providing statistically useful data. Intended data uses, such as comparison to numerical criteria or risk assessments, typically dictate specific project target reporting limits (TRLs) necessary to fulfill stated objectives. The PQL for site COPCs are presented in Table B-2 for groundwater samples. These reporting limits were obtained from an Ecology-certified laboratory (TestAmerica, Spokane, Washington). Other criteria include State of Washington (WAC 173-201) and federal Ambient Water Quality Criteria. The analytical methods and processes selected will provide PQLs less than the TRLs under ideal conditions. However, the reporting limits in Table B-2 are considered targets because several factors may influence final detection limits. For instance, analytical procedures may require sample dilutions or other practices to accurately quantify a particular analyte at concentrations above the range of the instrument. The effect is that other analytes could be reported as undetected but at a value much higher than a specified TRL. Data users must be aware that high non-detect values, although correctly reported, can bias statistical summaries and careful interpretation is required to correctly characterize site conditions.

Precision

Precision is the measure of mutual agreement among replicate or duplicate measurements of an analyte from the same sample and applies to field duplicate or split samples, replicate analyses and duplicate spiked environmental samples (matrix spike duplicates). The closer the measured values are to each other, the more precise the measurement process. Precision error may affect data usefulness. Good precision is indicative of relative consistency and comparability between different samples. Precision will be expressed as the relative percent difference (RPD) for spike sample comparisons of various matrices and field duplicate comparisons for water samples. This value is calculated by:

$$RPD(\%) = \frac{|D_1 - D_2|}{(D_1 + D_2)/2} X\ 100,$$

Where

D_1 = Concentration of analyte in sample.

D_2 = Concentration of analyte in duplicate sample.

The calculation applies to split samples, replicate analyses, duplicate spiked environmental samples (matrix spike duplicates) and laboratory control duplicates. The RPD will be calculated for samples and compared to the applicable criteria. Precision can also be expressed as the percent difference (%D) between replicate analyses. Persons performing the evaluation must review one or more pertinent documents (EPA, October 1999; EPA, October 2004a) that address criteria exceedances and courses of action. Relative percent difference goals for this effort are 30 percent in groundwater for all analyses, unless the duplicate sample values are within 5 times the reporting limit.

Accuracy

Accuracy is a measure of bias in the analytic process. The closer the measurement value is to the true value, the greater the accuracy. This measure is defined as the difference between the reported value versus the actual value and is often measured with the addition of a known compound to a sample. The amount of known compound reported in the sample, or percent recovery, assists in determining the performance of the analytical system in correctly quantifying the compounds of interest. Since most environmental data collected represent one point spatially and temporally rather than an average of values, accuracy plays a greater role than precision in assessing the results. In general, if the percent recovery is low, non-detect results may indicate that compounds of interest are not present when in fact these compounds are present. Detected compounds may be biased low or reported at a value less than actual environmental conditions. The reverse is true when recoveries are high. Non-detect values are considered accurate while detected results may be higher than the true value.

Accuracy will be expressed as the percent recovery of a surrogate compound (also known as "system monitoring compound"), a matrix spike (MS) result, or from a standard reference material where:

$$Recovery\,(\%) = \frac{Sample\ Result}{Spike\ Amount}\ X\ 100$$

Persons performing the evaluation must review one or more pertinent documents (EPA, October 1999; EPA, October 2004a) that address criteria exceedances and courses of action. Accuracy criteria for surrogate spikes, MS and laboratory control spikes (LCS) are found in Table B-1 of this QAPP.

Representativeness, Completeness and Comparability

Representativeness expresses the degree to which data accurately and precisely represent the actual site conditions. The determination of the representativeness of the data will be performed by completing the following:

- Comparing actual sampling procedures to those delineated within the SAP and this QAPP.
- Comparing analytical results of field duplicates to determine the variations in the analytical results.
- Invalidating non-representative data or identifying data to be classified as questionable or qualitative. Only representative data will be used in subsequent data reduction, validation and reporting activities.

Completeness establishes whether a sufficient amount of valid measurements were obtained to meet project objectives. The number of samples and results expected establishes the comparative basis for completeness. Completeness goals are 90 percent useable data for samples/analyses planned. If the completeness goal is not achieved an evaluation will be made to determine if the data are adequate to meet study objectives.

Comparability expresses the confidence with which one set of data can be compared to another. Although numeric goals do not exist for comparability, a statement on comparability will be prepared to determine overall usefulness of data sets, following the determination of both precision and accuracy.

Holding Times

Holding times are defined as the time between sample collection and extraction, sample collection and analysis, or sample extraction and analysis. Some analytical methods specify a holding time for analysis only. For many methods, holding times may be extended by sample preservation techniques in the field. If a sample exceeds a holding time, then the results may be biased low. For example, if the extraction holding time for volatile analysis of the sample is exceeded, then the possibility exists that some of the organic constituents have volatilized from the sample or degraded. Results for that analysis will be qualified as estimated to indicate that the reported results may be lower than actual site conditions. Holding times are presented in Table B-3.

Blanks

According to the *National Functional Guidelines for Organic Data Review* (EPA, 1999), "The purpose of laboratory (or field) blank analysis is to determine the existence and magnitude of contamination resulting from laboratory (or field) activities. The criteria for evaluation of blanks apply to any blank associated with the samples (e.g., method blanks, instrument blanks, trip blanks and equipment blanks)." Trip blanks are placed with samples during shipment; method blanks are created during sample preparation and follow samples throughout the analysis process.

Analytical results for blanks will be interpreted in general accordance with *National Functional Guidelines for Organic Data Review* and professional judgment.

SAMPLE COLLECTION, HANDLING AND CUSTODY

Sampling Equipment Decontamination

Sampling equipment decontamination procedures are described in "Section 3.3" of the SAP.

Sample Containers and Labeling

The Field Coordinator will establish field protocol to manage field sample collection, handling and documentation. Groundwater samples obtained during this study will be placed in appropriate laboratory-prepared containers. Sample containers and preservatives are listed in Table B-3.

Sample containers will be labeled with the following information at the time of collection:

- Project name and number;
- Sample name, which will include a reference to depth if appropriate; and
- Date and time of collection.

The sample collection activities will be noted in the field log books. The Field Coordinator will monitor consistency between the SAP, sample containers/labels, field log books and the chain-of-custody (COC).

Sample Storage

Samples will be placed in a cooler with "blue ice" or double-bagged "wet ice" immediately after they are collected. The objective of the cold storage will be to attain a sample temperature of 4 degrees Celsius. Holding times will be observed during sample storage. Holding times for the project analyses are summarized in Table B-3.

Sample Shipment

The samples will be transported and delivered to the analytical laboratory in the coolers. Field personnel will transport and hand-deliver samples that are being submitted to a local laboratory for analysis. Samples that are being submitted to an out-of-town laboratory for analysis will be transported by a commercial express mailing service on an overnight basis. The Field Coordinator will monitor that the shipping container (cooler) has been properly secured using clear plastic tape and custody seals.

Measures will be implemented to minimize the potential for sample breakage, which includes packaging materials and placing sample bottles in the cooler in a manner intended to minimize damage. Sample bottles will be appropriately wrapped with bubble wrap or other protective material before being place in coolers. Trip blanks will be included in coolers with groundwater samples.

COC Records

Field personnel are responsible for the security of samples from the time the samples are taken until the samples have been received by the shipper or laboratory. A COC form will be completed at the end of each field day for samples being shipped to the laboratory. Information to be included on the COC form includes:

- Project name and number.
- Sample identification number.
- Date and time of sampling.
- Sample matrix (water) and number of containers from each sampling point, including preservatives used.
- Analyses to be performed.
- Names of sampling personnel and transfer of custody acknowledgment spaces.
- Shipping information including shipping container number.

The original COC record will be signed by a member of the field team and bear a unique tracking number. Field personnel shall retain carbon copies and place the original and remaining copies in a plastic bag, placed within the cooler or taped to the inside lid of the cooler before sealing the container for shipment. This record will accompany the samples during transit by carrier to the laboratory.

Laboratory Custody Procedures

The laboratory will follow their standard operating procedures (SOPs) to document sample handling from time of receipt (sample log-in) to reporting. Documentation will include at a minimum, the analyst's name or initial, time and date.

Field Documentation

Field documentation provides important information about potential problems or special circumstances surrounding sample collection. Field personnel will maintain daily field logs while on-site. The field logs will be prepared on field report forms or in a bound logbook. Entries in the field logs and associated sample documentation forms will be made in waterproof ink, and corrections will consist of line-out deletions that are initialed and dated. Individual logbooks will become part of the project files at the conclusion of the site characterization field explorations.

At a minimum, the following information will be recorded during the collection of each sample:

- Sample location and description.
- Site or sampling area sketch showing sample location and measured distances.
- Sampler's name(s).
- Date and time of sample collection.
- Designation of sample as composite or discrete.
- Type of sample (water).
- Type of sampling equipment used.
- Field instrument readings.
- Field observations and details that are pertinent to the integrity/condition of the samples (e.g., weather conditions, performance of the sampling equipment, sample disturbance, etc.).
- Preliminary sample descriptions (e.g., noticeable odors, sheens, colors, field-screening results).
- Sample preservation.
- Shipping arrangements (overnight air bill number).
- Name of recipient laboratory.

In addition to the sampling information, the following specific information also will be recorded in the field log for each day of sampling:

- Team members and their responsibilities.
- Time of arrival/entry on Site and time of Site departure.
- Other personnel present at the site.
- Summary of pertinent meetings or discussions with regulatory agency or contractor personnel.
- Deviations from sampling plans, Site safety plans and QAPP procedures.
- Changes in personnel and responsibilities with reasons for the changes.
- Levels of safety protection.
- Calibration readings for any equipment used and equipment model and serial number.

The handling, use and maintenance of field log books are the field coordinator's responsibilities.

CALIBRATION PROCEDURES

Field Instrumentation

Equipment and instrumentation calibration facilitates accurate and reliable field measurements. Field and laboratory equipment used on the project will be calibrated and adjusted in general accordance with the manufacturer's recommendations. Methods and intervals of calibration and maintenance will be based on the type of equipment, stability characteristics, required accuracy, intended use and environmental conditions. The basic calibration frequencies are described below.

The photoionization detector (PID) used for vapor measurements will be calibrated daily, if required (based on the model used), for site safety monitoring purposes in general accordance with the manufacturer's specifications. If daily calibration is not required for a specific PID model, calibration of the PID will be checked to make sure it is up to date. The calibration results will be recorded in the field logbook.

The water quality measuring system will be calibrated prior to each monitoring event in general accordance with the manufacturer's specifications. The calibration results will be recorded in the field report.

Laboratory Instrumentation

For analytical chemistry, calibration procedures will be performed in general accordance with the methods cited and laboratory standard operating procedures. Calibration documentation will be retained at the laboratory and readily available for a period of 6 months.

DATA REPORTING AND LABORATORY DELIVERABLES

Laboratories will report data in formatted hardcopy and digital form. Analytical laboratory measurements will be recorded in standard formats that display, at a minimum, the field sample identification, the laboratory identification, reporting units, qualifiers, analytical method, analyte tested, analytical result, extraction and analysis dates, and detection limit (PQL only). Each sample delivery group will be accompanied by sample receipt forms and a case narrative identifying data quality issues. Laboratory EDD will be established by GeoEngineers, Inc., with the contract laboratory. Final results will be sent to the PM.

Chromatograms will be provided for samples analyzed by Northwest Methods NWTPH-Gx. The laboratory will assure that the full heights of all peaks appear on the chromatograms and that the same horizontal time scale is used to allow for comparisons to other chromatograms.

INTERNAL QC

Table B-4 summarizes the types and frequency of QC samples to be collected during the site characterization, including both field QC and Laboratory QC samples.

Field QC

Field QC samples serve as a control and check mechanism to monitor the consistency of sampling methods and the influence of off-site factors on environmental samples. Off-site factors include airborne volatile organic compounds and potable water used in drilling activities.

Field Duplicates

In addition to replicate analyses performed in the laboratory, field duplicates also serve as measures for precision. Under ideal field conditions, field duplicates (referred to as splits), are created when a volume of the sample matrix is thoroughly mixed, placed in separate containers and identified as different samples. This tests both the precision and consistency of laboratory analytical procedures and methods, and the consistency of the sampling techniques used by field personnel.

One field duplicate will be collected during each groundwater sampling event. The duplicate sample will be analyzed for the COPCs specified for the given sample location or well.

Trip Blanks

Trip blanks accompany groundwater sample containers used for VOC analyses during shipment and sampling periods. Trip blanks will be analyzed on a one per cooler basis.

Laboratory QC

Laboratory QC procedures will be evaluated through a formal data validation process. The analytical laboratory will follow standard method procedures that include specified QC monitoring requirements. These requirements will vary by method but generally include:

- method blanks
- internal standards
- calibrations
- MS/matrix spike duplicates (MSD)
- LCS/laboratory control spike duplicates (LCSD)
- laboratory replicates or duplicates
- surrogate spikes

Laboratory Blanks

Laboratory procedures employ the use of several types of blanks but the most commonly used blank for QA/QC assessments are method blanks. Method blanks typically are laboratory QC samples that consist of a high performance liquid chromatography (HPLC) water. Method blanks are extracted and analyzed with each batch of environmental samples undergoing analysis. Method blanks are particularly useful during volatiles analysis since VOCs can be transported in the laboratory through the vapor phase. If a substance is found in the method blank then one (or more) of the following occurred:

- Measurement apparatus or containers were not properly cleaned and contained contaminants.
- Reagents used in the process were contaminated with a substance(s) of interest.

- Contaminated analytical equipment was not properly cleaned.
- Volatile substances in the air with high solubility or affinities toward the sample matrix contaminated the samples during preparation or analysis.

It is difficult to determine which of the above scenarios took place if blank contamination occurs. However, it is assumed that the conditions that affected the blanks also likely affected the project samples. Given method blank results, validation rules assist in determining which substances in samples are considered "real," and which ones are attributable to the analytical process. Furthermore, the guidelines state, ". . . there may be instances where little or no contamination was present in the associated blank, but qualification of the sample is deemed necessary. Contamination introduced through dilution water is one example."

Calibrations

Several types of calibrations are used, depending on the method, to determine whether the methodology is 'in control' by verifying the linearity of the calibration curve and to assure that the sample results reflect accurate and precise measurements. The main calibrations used are initial calibrations, daily calibrations and continuing calibration verification.

MS/MSD

MS/MSD samples are used to assess influences or interferences caused by the physical or chemical properties of the sample itself. For example, extreme pH affects the results of semi-volatile organic compounds (SVOCs). Or, the presence of a particular compound may interfere with accurate quantitation of another analyte. MS/MSD data is reviewed in combination with other QC monitoring data to determine matrix effects. In some cases, matrix affects cannot be determined due to dilution and/or high levels of related substances in the sample. A MS is evaluated by spiking a known amount of one or more of the target analytes ideally at a concentration of 5 to 10 times higher than the sample result. A percent recovery is calculated by subtracting the sample result from the spike result, dividing by the spiked amount, and multiplying by 100.

The samples for the MS and MSD analyses should be collected from a sampling location that is believed to exhibit low-level contamination. A sample from an area of low-level contamination is needed because the objective of MS/MSD analyses is to determine the presence of matrix interferences, which can best be achieved with low levels of contaminants. Additional sample volume will be collected for these analyses. This MS/MSD sample will be a composite to achieve a level of representativeness and reproducibility in the data.

LCS/LCSD

Also known as blanks spikes, LCSs are similar to MSs in that a known amount of one or more of the target analytes are spiked into a prepared media and a percent recovery of the spiked substances are calculated. The primary difference between a MS and LCS is that the LCS media is considered "clean" or contaminant free. For example, HPLC water is typically used for LCS water analyses. The purpose of an LCS is to help assess the overall accuracy and precision of the analytical process including sample preparation, instrument performance, and analyst performance. LCS data must be reviewed in context with other controls to determine if out-of-control events occur.

Laboratory Replicates/Duplicates

Laboratories often utilize MS/MSDs, LCS/LCSDs, and/or replicates to assess precision. Replicates are a second analysis of a field collected environmental sample. Replicates can be split at varying stages of the sample preparation and analysis process, but most commonly occur as a second analysis on the extracted media.

Surrogate Spikes

The purposes of using a surrogate are to verify the accuracy of the instrument being used and extraction procedures. Surrogates are substances similar to, but not one of, the target analytes. A known concentration of surrogate is added to the sample and passed through the instrument, noting the surrogate recovery. Each surrogate used has an acceptable range of percent recovery. If a surrogate recovery is low, sample results may be biased low and depending on the recovery value, a possibility of false negatives may exist. Conversely, when recoveries are above the specified range of acceptance a possibility of false positives exist, although non-detected results are considered accurate.

DATA REDUCTION AND ASSESSMENT PROCEDURES

Data Reduction

Data reduction involves the conversion or transcription of field and analytical data to a useable format. The laboratory personnel will reduce the analytical data for review by the QA Leader and PM.

Field Measurement Evaluation

Field data will be reviewed at the end of each day by following the QC checks outlined below and procedures in the SAP. Field data documentation will be checked against the applicable criteria as follows:

- Sample collection information.
- Field instrumentation and calibration.
- Sample collection protocol.
- Sample containers, preservation and volume.
- Field QC samples collected at the frequency specified.
- Sample documentation and COC protocols.
- Sample shipment.

Cooler receipt forms and sample condition forms provided by the laboratory will be reviewed for out-of-control incidents. The final report will contain what effects, if any, an incident has on data quality. Sample collection information will be reviewed for correctness before inclusion in a final report.

Field QC Evaluation

A field QC evaluation will be conducted by reviewing field log books and daily reports, discussing field activities with staff and reviewing field QC samples (trip blanks and field duplicates). Trip blanks will be evaluated using the same criteria as method blanks.

Laboratory Data QC Evaluation

The laboratory data assessment will consist of a formal review of the following QC parameters:

- Holding times;
- Method blanks;
- MS/MSD;
- LCS/LCSD;
- Surrogate spikes; and
- Replicates.

In addition to these QC mechanisms, other documentation such as cooler receipt forms and case narratives will be reviewed to fully evaluate laboratory QA/QC.

REFERENCES

U.S. Environmental Protection Agency (EPA). 1999. Contract Laboratory Program National Functional Guidelines for Organic Data Review. 540/R-99/008.

U.S. Environmental Protection Agency (EPA). 2004a. Contract Laboratory Program National Functional Guidelines for Inorganic Data Review. 540/R-04/004.

U.S. Environmental Protection Agency (EPA). 2004b. EPA Guidelines for Preparing Quality Assurance Project Plans for Environmental Studies. EPA 04-03-030.

Table B-1

Measurement Quality Objectives

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Richland, Washington

		Surrogate Standards (SS) %R Limits [1,2,3]	Check Standard (LCS) %R Limits[2,4]	Matrix Spike (MS) %R Limits[4]	MSD Samples or Lab Duplicate (Dup) RPD Limits	Field Duplicate Samples RPD Limits[4]
Laboratory Analysis	**Reference Method**	**Water**	**Water**	**Water**	**Water**	**Water**
Gasoline-range Petroleum Hydrocarbons	Ecology NWTPH-Gx	37.9%-162% (water)	80%-120%	55.6%-126%	≤20% (MSD) ≤35% (Dup)	≤20%
Diesel- and Oil-range Petroleum Hydrocarbons	Ecology NWTPH-Dx	50%-150%	54.5%-136%	54.5%-136%	≤32.5%(MSD) ≤25% (Dup)	≤20%
Volatile Organic Compounds (VOC)	EPA 8260B	66.5%-145% (water)	47.1%-150%	44.3%-150%	≤15.7% (MSD) ≤20% (Dup)	≤20%
Napththalenes	EPA 8270	30%-150%	40%-130%	35%-125%	≤20%	≤20%
Nitrate	EPA 300.0	NA	90%-110%	80%-120%	≤12.1% (MSD) ≤13.1% (Dup)	≤20%
Sulfate	EPA 300.0	NA	90%-110%	80%-120%	≤10% (MSD) ≤15.7% (Dup)	≤20%
Methane	RSK-175	NA	75%-125%	52%-145%	≤20%	≤20%
Soluble Manganese	EPA 200.7	NA	85%-115%	75%-125%	≤20%	≤20%
Alkalinity	SM2320B	NA	90%-110%	80%-120%	≤20% (MSD) ≤10% (Dup)	≤20%

Notes:

[1] Individual surrogate recoveries are compound specific.

[2] Recovery Ranges are estimates. Actual ranges will be provided by the laboratory when contracted.

[3] Percent Recovery Limits are expressed as ranges based on laboratory control limits. Limits will vary for individual analytes.

[4] RPD control limits are only applicable if the concentration are greater than 5 times the method reporting limit (MRL). For results less than 5 times the MRL, the difference duplicate must be less than 1X the MRL for waters.

Method numbers refer to EPA SW-846 Analytical Methods or Washington State Department of Ecology (Ecology) recommended analytical methods.

VOCs = Volatile Organic Compounds: %R = percent recovery; LCS = Laboratory Control Sample; MS/MSD = Matrix Spike/Matrix Spike Duplicate; RPD = Relative Percent Difference

Table B-2

Methods of Analysis and Target Reporting Limits (Groundwater)

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Analyte	Analytical Method	Practical Quantitation Limit (µg/l)	MTCA Method A Cleanup Levels (µg/l)
Total Petroleum Hydrocarbons			
TPH-Gasoline Range	NWTPH-Gx	100	1,000/800[1]
TPH-Diesel Range	NWTPH-Dx	250	500
TPH-Oil Range	NWTPH-Dx	400	500
Volatile Organic Compounds			
Benzene	EPA 8260B	0.2	5
Toluene	EPA 8260B	0.5	1,000
Ethylbenzene	EPA 8260B	0.5	700
M+P Xylene	EPA 8260B	0.5	1,000[2]
O-Xylene	EPA 8260B	0.5	1,000[2]
n-hexane	EPA 8260B	1.0	NE
Trichloroethylene (TCE)	EPA 8260B	1.0	5
Perchloroethylene (PCE)	EPA 8260B	1.0	5
Semi-Volatile Organic Compounds			
Napthalene	EPA 8270 SIM	0.1	160[3]
1 & 2 Methyl Naphthalene	EPA 8270 SIM	0.1	160[3]
Natural Attenuation Parameters			
Nitrate	EPA 300.0	200	NE
Sulfate	EPA 300.0	500	NE
Methane	RSK 175	5	NE
Soluble Manganese	EPA 200.7	10	NE
Alkalinity	SM2320B	4000	NE

Notes:

[1]MTCA Method A cleanup level for gasoline-range petroleum hydrocarbons is 1,000 µg/l if benzene is not detected and the total concentrations of ethylbenzene, toluene and xylenes are less than 1 percent of the gasoline mixture; otherwise the cleanup level is 800 µg/l.

[2]Cleanup level for total xylenes

[3]Cleanup level refers to the sum of naphthalenes

Practical quantitation limist (PQLs) based on information provided by TestAmericaLaboratories.

µg/l = micrograms per liter; NE = not established

Table B-3

Test Methods, Sample Containers, Preservation and Holding Time[1]

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Analysis	Method	Groundwater			
		Minimum Sample Size	Sample Containers	Sample Preservation	Holding Times
Gasoline-Range Hydrocarbons[2]	NWTPH-Gx	80 mL	2 - 40 mL VOA Vials	Cool 4 C, HCl to pH < 2	14 days preserved 7 days unpreserved
Diesel- and Oil-Range Hydrocarbons	NWTPH-DX	1000 mL	1L Amber	Cool 4°C	14 days from collection to extraction. 40 days from extraction to analysis
VOCs[2, 3]	EPA 8260B	80 mL	2 - 40 mL VOA Vials	Cool 4 C, HCl to pH < 2	14 days preserved 7 days unpreserved
Naphthalenes	EPA 8270 SIM	1000 mL	1L Amber	Cool 4°C	7 days
Nitrate	EPA 300.0	50ml	250ml poly	Cool 4°C	48 hours
Sulfate	EPA 300.0	50ml	250ml poly	Cool 4°C	28 days
Methane	RSK-175	120ml	3 - 40ml Voa vial	Cool 4 C, HCl to pH < 2	14 days
Soluble Manganese	EPA 200.7	250ml	500ml poly	Field Filter; HNO3 to pH <2	180 days
Alkalinity	SM2320B	250ml	500ml poly	Cool 4°C	14 days

Notes:

[1] Holding Times are based on elapsed time from date of collection

[2] The gasoline range hydrocarbons and VOCs can be combined and do not require separate containers

[3] VOCs = Volatile organic compounds (to include bezene, toluene, ehtylbenzene, total xylenes, n-hexane, trichloroethylene (TCE) and perchloroethylene (PCE).

HCl = Hydrochloric Acid; HNO_s = Nitric Acid; VOA = volatile organic analyte; oz = ounce; mL = millilieter; L = liter; g = gram; NA = not applicable

Table B-4

Quality Control Samples Type and Frequency

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Parameter	Field QC		Laboratory QC			
	Field Duplicates	**Trip Blanks**	**Method Blanks**	**LCS**	**MS / MSD**	**Lab Duplicates**
Gasoline Range Hydrocarbons	1/10 samples analyzed	NA	1/batch	1/batch	1/batch	1/batch
Diesel-Range Hydrocarbons	1/10 samples analyzed	NA	1/batch	1/batch	1/batch	1/batch
Oil-Range Hydrocarbons	1/10 samples analyzed	NA	1/batch	1/batch	1/batch	1/batch
VOCs	1/10 samples analyzed	1/cooler	1/batch	1/batch	1 set/batch	NA
Naphthalenes	1/10 samples analyzed	NA	1/batch	1/batch	1/batch	NA
Natural Attenuation Parameters	1/10 samples analyzed	NA	1/batch	1/batch	1/batch	1/batch

Notes:

An analytical lot or batch is defined as a group of samples taken through a preparation procedure and sharing a method blank, LCS, and MS/ MSD (or MS and lab duplicate). No more than 20 field samples can be contained in one batch.

LCS = Laboratory control sample; MS = Matrix spike sample; MSD = Matrix spike dupblicate sample; VOCs = volatile organic compounds;

NA = Not applicable

Natural Attenuation Parameters = nitrate, soluble manganese, sulfate, methane and alkalinity

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