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SENT VIA E-MAIL

August 28, 2020

Mohsen Kourehdar, PE
Department of Ecology
Southwest Regional Office
PO Box 47775
Olympia, WA 98504-7775

Dear Mohsen:

SUBJECT: Agreed Order No. DE 13797 – The City of Olympia (Former West Olympia Landfill) Feasibility Study Report

This letter transmits the City of Olympia's Feasibility Study (FS) report for the City's former West Olympia Landfill Site. The report, titled "*Feasibility Study Report, West Olympia Commercial Property*" (Landau Associates, August 28, 2020), is submitted under Agreed Order No. DE 13797. This report is a final version of the draft report submitted to the Washington State Department of Ecology (Ecology) on May 18, 2020. The revisions address Ecology's July 27, 2020 comments which included a request for the use of a groundwater conditional point of compliance (CPOC) at the property boundary and revisions to Figure 3-2. The City requested clarification of the comments and Ecology provided clarification via email communications on August 11, 2020. This final FS report includes minor text revisions and updates to Table 4-2, Table 5-1, and Figure 3-2.

The feasibility study evaluation of remedial alternatives was completed in accordance with the Model Toxics Control Act regulation (Chapter 173-340 of the Washington Administrative Code). To assist with Ecology's review of the Feasibility Study Report, Attachment 1 to this letter shows those sections of the FS report that address the FS requirements identified in Ecology's Feasibility Study Checklist.[1]

We look forward to receiving your approval of the Feasibility Study Report for the Former West Olympia Landfill Site. I can be reached at dbuxton@ci.olympia.wa.us or (360) 753-8793 if you have any questions.

Sincerely,

Donna Buxton

DONNA BUXTON, LHG
Groundwater Protection Program Manager
Public Works Department

Attachment 1

\\Calvin\pw water resources\DW Planning & Implementation\Donna Buxton\2-WOLF\2 Ecology\Feasibility Study\FS Rpt transmittal ltr 08-28-2020.docx

[1] FS Checklist, Ecology Publication No. 16-09-007, May 2016.

Feasibility Study Checklist
West Olympia Commercial Property
Olympia, Washington

Feasibility Study (FS) Checklist Guidance, Washington State Department of Ecology (Ecology) Publication No. 16-09-007				Location in Text
FEASIBILITY STUDY REPORT BODY				
I.			**COVER LETTER**	Included
II.			**INTRODUCTION**	
	a.		Site background, site investigations, interim actions (if any)	Site Background (Section 1.3) and Site Investigations (Section 1.3 [references Remedial Investigation [RI] Report and Addendum])
	b.		Results of any additional investigations conducted since completion of the RI	No additional investigations completed since submittal of the Final RI Report
	c.		Conceptual site model (CSM)	Section 3.0
	d.		Preliminary cleanup levels for indicator hazardous substances in each medium	Section 2.2
	e.		Proposed point of compliance for each affected medium, if different from the standard	Section 2.3
	f.		Applicable local, state, and federal laws	Section 2.1
III.			**ALTERNATIVES**	
	a.		Identify remedial action objectives. Describe the cleanup objectives and their compliance with Model Toxics Control Act.	Section 1.2
	b.		Identify a reasonable number and type of alternatives, including a brief description of each alternative.	Section 4.3
IV.			**DETAILED EVALUATION AND SELECTION OF ALTERNATIVES**	
	a.		Threshold and other requirements	Section 5.0 (Description of threshold and other requirements provided in Section 5.1.)
		i.	Protect human health and the environment.	Section 5.2.1; Table 5-1
		ii.	Comply with cleanup standards.	Section 5.2.1; Table 5-1
		iii.	Comply with applicable state and federal laws.	Section 5.2.1; Table 5-1
		iv.	Provide for compliance monitoring.	Section 5.2.1; Table 5-1
		v.	Reasonable restoration time frame.	Section 5.2.4; Table 5-1
	b.		Disproportionate cost analysis (DCA) ranking criteria	Section 5.0 (Description of DCA ranking criteria provided in Section 5.2.2.) Conclusion of DCA provided in Section 5.2.3 and Tables 5-2 and 5-3.
		i.	Protectiveness	Sections 5.2.2 and 5.2.3; Tables 5-2 and 5-3
		ii.	Permanence	Sections 5.2.2 and 5.2.3; Tables 5-2 and 5-3
		iii.	Cost	Sections 5.2.2 and 5.2.3; Tables 5-2, 5-3, 5-4, 5-5, 5-6, and 5-7
		iv.	Effectiveness over the long-term	Sections 5.2.2 and 5.2.3; Tables 5-2 and 5-3
		v.	Management of short-term risks	Sections 5.2.2 and 5.2.3; Tables 5-2 and 5-3
		vi.	Technical and administrative implementability	Sections 5.2.2 and 5.2.3; Tables 5-2 and 5-3
		vii.	Consideration of public concerns	Sections 5.2.2 and 5.2.3; Tables 5-2 and 5-3
V.			**REMEDY SELECTION**	Section 6.0

Feasibility Study Checklist
West Olympia Commercial Property
Olympia, Washington

Feasibility Study (FS) Checklist Guidance, Washington State Department of Ecology (Ecology) Publication No. 16-09-007			Location in Text
FS FIGURES			
I.		**VICINITY MAP(S)**	
	a.	Show property in relation to surrounding region.	Figure 1-1
	b.	Other applicable items: surface topography, natural areas, land use, groundwater supply, and monitoring wells.	These items are provided in the RI Report; the RI report is referenced in the FS Report.
II.		**SITE MAP(S)**	
	a.	Overall site layout with existing wells, borings, and sample locations labeled.	Figure 1-2
	b.	Contaminant of concern locations, concentrations, and estimated vertical and horizontal extent of contamination.	Figures 3-2, 3-3, 3-4, and 3-5
	c.	Geologic/hydrogeologic information, including soil types, wells, screened intervals, and water levels (cross sections). Show groundwater flow direction and gradient.	Figures 1-3, 1-4a, and 1-4b
	d.	Other relevant information: site and property boundaries, buildings, facilities, etc.	Figure 1-2
III.		**CONCEPTUAL SITE MODEL**	Figure 3-1
FS TABLES			
I.		**APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENT**	Table 2-1
II.		**EVALUATION OF REMEDIAL ALTERNATIVES**	Tables 5-1 and 5-2
III.		**COST/QUANTITY SUMMARY**	Table 5-3
IV.		**COST DETAIL FOR ALTERNATIVES**	Tables 5-4, 5-5, 5-6, and 5-7
V.		**Additional site investigations conducted after completion of the RI**	No additional site investigations conducted after completion of the RI.
FS APPENDICES			
VI.		**Contractor bids or other documents showing how quantity and/or cost estimates were made**	Tables 5-4, 5-5, 5-6, and 5-7
VII.		**Documentation related to additional site investigations conducted after completion of the RI**	No additional site investigations conducted after completion of the RI.
VIII.		**Limitations that apply to work**	Section 7.0
IX.		**Additional context or contribution to the understanding of the site or remedial alternatives**	Appendix A; Interim Action Plan
MISCELLANEOUS ITEMS			
X.		**CERTIFICATION (LICENSED PROFESSIONAL STAMP)**	Will be added to the final version of the report.
XI.		**ENVIRONMENTAL INFORMATION MANAGEMENT (EIM)**	EIM submittals have been completed, and are up to date through December 2019.
XII.		**Additional information requested by Ecology to fully assess remedial alternatives**	No additional information requested.
XIII.		**SUBMITTAL REQUIREMENTS**	LAI will provide required hard copies of the final report as requested by Ecology.

Feasibility Study Report
West Olympia Commercial Property
1305 Cooper Point Road Southwest
Olympia, Washington

August 28, 2020

Prepared for

City of Olympia
P.O. Box 1967
Olympia, Washington 98507

LANDAU ASSOCIATES

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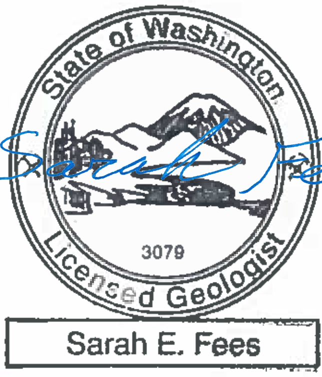
Feasibility Study Report
West Olympia Commercial Property
1305 Cooper Point Road Southwest
Olympia, Washington

This document was prepared by, or under the direct supervision of, the undersigned, whose seal is affixed below.

Name: Sarah Fees, LG
Washington/No. 3079

Date: August 28, 2020



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Project Coordinator:	MCS

Landau Associates

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LIST OF ABBREVIATIONS AND ACRONYMS

1,4-DCB	1,4-dichlorobenzene
ARAR	applicable or relevant and appropriate requirement
bgs	below ground surface
CAP	cleanup action plan
cDCE	cis-1,2-dichloroethene
City	City of Olympia
COC	contaminant of concern
CPOC	conditional point of compliance
CSM	conceptual site model
CUL	cleanup level
CVOC	chlorinated volatile organic compound
DCA	disproportionate cost analysis
Ecology	Washington State Department of Ecology
EISB	enhanced *in situ* bioremediation
FS	feasibility study
ft	foot/feet
GETS	groundwater extraction and treatment system
ID	identification
IHS	indicator hazardous substances
IWAS	in-well air stripping
LFG	landfill gas
MNA	monitored natural attenuation
MTCA	Model Toxics Control Act
No	number
PCE	tetrachloroethene
pCUL	proposed cleanup level
POC	point of compliance
redox	reduction-oxidation
RI	remedial investigation
SVE	soil vapor extraction
TCE	trichloroethene
TEE	Terrestrial Ecological Evaluation
TOC	total organic carbon
VC	vinyl chloride
VOC	volatile organic compound
WAC	Washington Administrative Code
WARM	Washington Ranking Method
WOCP	West Olympia Commercial Property

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1.0 INTRODUCTION

This report presents the results of a feasibility study (FS) conducted by Landau Associates, Inc. (LAI) for cleanup of groundwater impacted by contaminant releases from the City of Olympia's (City's) former West Olympia landfill (Site). The Site is located at 1305 Cooper Point Road Southwest in Olympia, Washington (Washington State Department of Ecology [Ecology] Facility/Site Identification [ID] Number [No.] 1425; Ecology Cleanup Site ID No. 4807). A Site vicinity map is shown on Figure 1-1. The City intends to sell its real property for private development and refers to the property as the West Olympia Commercial Property (WOCP), the term hereafter used in this report.

The City has conducted investigations at the Site to characterize the environmental conditions documented in the remedial investigation (RI) report (GEI/LAI 2019a) and RI addendum (GEI/LAI 2019b). The RI was performed to identify the extent of contamination associated with the WOCP. Investigation and cleanup activities are being implemented under Agreed Order No. DE 13797, established between the City and Ecology on October 2, 2017.

This FS develops and evaluates remedial action alternatives and identifies the preferred alternative for addressing groundwater impacted by releases from the WOCP. The planned remedial action for cleanup of soil and soil gas is identified in the interim action plan (LAI 2019), provided in Appendix A and briefly described in Section 4.1 of this report. This FS also develops soil and groundwater cleanup levels (CULs) and identifies proposed points of compliance (POCs). This FS was performed in accordance with Ecology's Model Toxics Control Act (MTCA) cleanup regulation (Washington Administrative Code [WAC] 173-340).

1.1 Site Description

The Site comprises the WOCP, inclusive of the former West Olympia landfill, and contiguous property affected by releases of hazardous substances that are confirmed or suspected to have originated at the landfill. The current Site and associated off-property monitoring locations are shown on Figure 1-2. The Site boundary may change over time as additional data are gathered and/or areas are remediated.

The WOCP is located within city limits and consists of a 12.3-acre parcel (Thurston County Parcel No. 12821240103). The City acquired a number of parcels that included the WOCP in two separate purchases in 1939 and 1942 (GEI/LAI 2019a). Over time, portions of the original 27.5-acre property were subdivided by the City and sold, leaving only the current 12.3-acre landfill property in the City's possession.

Before it was acquired by the City, the WOCP was used as a dumping site by local residents. After acquisition, the City operated the WOCP as a municipal solid waste landfill for residential and industrial waste. Waste was routinely burned and buried at the WOCP during landfill operations. When landfill operations ceased in about 1968, the City used the WOCP to store construction debris, power poles, concrete pipe, and other non-hazardous materials. Stored materials have since been removed. Based on the investigations completed, the 12.3-acre landfill property encompasses the full extent of the historical dumping and landfill operation.

Currently, the Site is vacant, and is not actively used by the City. The City plans to sell the WOCP for private development. The undeveloped landfill property currently attracts nuisance activities (illegal dumping and transient encampments). When developed, the Site will become a community amenity.

1.2 Objectives

The objective of this FS is to select a cleanup action or actions to remediate groundwater contaminant concentrations exceeding the CULs. Groundwater contamination appears to be the result of releases from former landfill activities. Other environmental media (soil and soil gas) are addressed in the interim action plan (Appendix A), hereafter incorporated by reference into this FS.

1.3 Site Background

The Site has been subject to environmental monitoring and investigations from 1984 to 2019, with several environmental conditions and contaminants of concern (COCs) identified in soil, soil gas, and groundwater. Buried landfill waste within the WOCP boundaries ranges from 0 to approximately 17.5 feet (ft) thick.

Primary COCs, receptors, and exposure pathways include:

- **Soil/Buried Waste:** Localized impacts from elevated concentrations of chromium and lead are present in shallow Site soils and buried waste. The primary pathway of concern for the localized chromium and lead impacts is direct contact by human and ecological receptors.
- **Soil/Landfill Gas:** Elevated concentrations of trichloroethene (TCE), tetrachloroethene (PCE), 1,4-dichlorobenzene (1,4-DCB), and methane have been identified in localized areas of Site soil gas. If structures are built in an area where vapors could migrate and accumulate, vapor intrusion and inhalation by human receptors are potential pathways of concern for TCE, PCE, and 1,4-DCB. Given its flammable and potentially explosive nature, methane is also a COC that requires unique health and safety/hazardous condition controls.
- **Groundwater:** Elevated concentrations of TCE have been identified in shallow groundwater at, and downgradient of, the WOCP. If groundwater from this area is used as a source of drinking water, ingestion by human receptors is the primary pathway of concern.

A summary of investigation activities and environmental conditions is presented in the RI report and addendum (GEI/LAI 2019a,b). Site monitoring wells, soil borings, test pits, and temporary and permanent soil gas monitoring locations are shown on Figure 1-2.

The Site was evaluated using the Washington Ranking Method (WARM), developed by Ecology and the Science Advisory Board. WARM uses data gathered during a site hazard assessment to estimate a site's potential threat to human health and the environment, with rankings made on a scale of one to five. A score of one represents the highest relative level of concern, and a score of five the lowest.

Ecology ranked the site a four, indicating that the landfill does not pose an imminent threat to human health or the environment.

1.4 Site Geology and Hydrogeology

Site geology and hydrogeology are described in the RI report (GEI/LAI 2019a) and summarized below.

1.4.1 Geology

Regional geology identified near the Site consists of a sequence of unconsolidated sediments above tertiary bedrock (Golder Associates 2008). Borings completed at the WOCP show that landfill waste and ash fill extend from ground surface to a maximum depth of approximately 17.5 ft. Generally, the landfill waste unit is thicker in the middle of the Site and thinner at the edges. The landfill waste includes a mixture of fill dirt, burned garbage, wood, glass, scrap metal, and brick and concrete fragments. The underlying material consists of a stratigraphic sequence of Vashon and pre-Vashon deposits. A thin (up to 5 ft thick), discontinuous layer of Vashon Recessional Outwash (Qgo; typically consists of permeable sand and gravel that make up the unconfined water table aquifer that is often on top of the underlying till) is present beneath the landfill waste. The Vashon Till (Qgt; typically consists of sand and gravel in a generally dense matrix of silt and clay) underlying the Qgo ranges from approximately 5 to 40 ft thick. The Qgt is a low-permeability aquitard that separates the Qgo aquifer from Vashon Advance Outwash aquifer (Qga; consists of permeable sand and gravel). Qga sand and gravel were encountered beneath the till (95 ft thick in boring LAI-5d) and were underlain by Pre-Vashon Glaciolacustrine Deposits (Qpf; consists of clay and silt that form an aquitard). The Qpf is 17 ft thick at monitoring well LAI-5d, and separates the Qga aquifer from Pre-Vashon Gravel (Qpg; consists of coarse sand and gravel; a significant aquifer unit regionally, but a thin to absent aquifer locally) and lower Undifferentiated Quaternary and Tertiary Deposits (TQu; consists of unconsolidated sediments, including aquifers and aquitards, that extend to the bedrock below). Monitoring well LAI-5d was advanced approximately 14 ft into the Qpg unit. A cross section of the geology in the vicinity of the Site is shown on Figure 1-3.

1.4.2 Hydrogeology

Groundwater aquifers at the Site consist of: the Qgo, which appears to be a relatively thin, discontinuous perched aquifer; the Qga, which is an unconfined aquifer; and the Qpg, which is a confined aquifer. Monitoring wells at the Site are primarily screened in the Qga with depths-to-water of approximately 40 to 70 ft below ground surface (bgs). One monitoring well (LAI-5d) has a screened interval in the Qpg aquifer, and depth-to-water is approximately 50 to 60 ft bgs. Indications of groundwater contamination are evident only in the Qga aquifer. Contaminant transport from the Qga aquifer to the deeper Qpg aquifer beneath the Site is unlikely, given the vertical separation; the presence of the Qpf aquitard; and the slight downward vertical gradient (0.01245 to 0.02660 foot per foot), based on water levels measured at the Site (GEI/LAI 2019a).

Water level elevations are generally higher in the spring and lower in the fall, and recharge occurs primarily from rainfall infiltration. Groundwater flow in the Qga aquifer is generally to the northwest, although groundwater level contours suggest the presence of a local groundwater divide at the Site, near monitoring well LAI-1 (Figures 1-4a, b). Groundwater velocities in the Qga aquifer range from 0.65 to 1.1 ft per day (GEI/LAI 2019a).

2.0 PROPOSED CLEANUP STANDARDS

Cleanup standards consist of three distinct components: 1) regulatory requirements that apply to the Site (applicable state and federal laws; WAC 173-340-700); 2) CULs for hazardous substances at the Site; and 3) the location where the CULs must be met (i.e., the POCs). This section discusses the process for developing cleanup standards for the Site as well as the proposed cleanup standards, including proposed CULs (pCULs) and POCs. The proposed cleanup standards were used in development and evaluation of cleanup alternatives presented in this report.

2.1 Regulatory Considerations

In accordance with MTCA, all cleanup actions must comply with applicable state and federal laws (WAC 173-340-710[1]). MTCA defines applicable state and federal laws as including applicable or relevant and appropriate requirements (ARARs). The MTCA cleanup regulation (WAC 173-340) outlines requirements for the development of cleanup standards and procedures for development and implementation of a cleanup. MTCA and other ARARs that may be applicable to the development of cleanup standards or the implementation of cleanup actions are presented in Table 2-1. For the purpose of developing pCULs, the following ARARs were considered in addition to MTCA:

- Washington State Maximum Contaminant Levels in Drinking Water.
- National Primary Drinking Water Regulations.

2.2 Proposed Cleanup Levels

The screening levels presented in the RI report were based on conservative values protective of human health and the environment, and were developed for all constituents detected in soil and groundwater. Development of the screening levels is discussed in Section 3.0 of the RI report. The pCULs presented in this FS report are for the indicator hazardous substances (IHS) identified in the RI report. The pCULs for affected media, developed under MTCA, represent the concentration of constituents that are protective of human health and the environment for identified potential exposure pathways, based on the highest beneficial use and the reasonable maximum exposure for each affected media. Per the regulatory requirements in WAC 173-340-704 and -720, MTCA Method A CULs are adequately protective for the Site. The pCULs for the Site are presented in Table 2-2.

2.2.1 Soil Proposed Cleanup Levels

The highest beneficial use of soil for current and future land use is considered unrestricted land use. Soil remediation is evaluated in the FS report in the context of protecting the direct-contact and leaching-to-groundwater pathways. Because they are considered protective of groundwater, the MTCA Method A CULs will be used as pCULs for soil. The IHS in Site soil, identified in the RI report, include lead and chromium (GEI/LAI 2019a). The pCULs for lead and chromium in soil are presented in Table 2-2.

In accordance with MTCA, the Site was evaluated for Terrestrial Ecological Evaluation (TEE) requirements during the RI (Appendix D of the RI report), and was determined not to qualify for any of the automatic exemptions “related to or connected to undeveloped land on the site…” (WAC 173-340-7491(1)(c)). However, based on the common soil remedy components found in all the remedial alternatives proposed in this FS, the Site qualifies for an exclusion from a TEE under WAC 173-340-7491(1)(b). All soil contaminated with hazardous substances will be covered by buildings, pavement, or other physical barriers once future redevelopment of the WOCP is completed, and institutional controls are placed on the property. Future redevelopment activities are outlined in the interim action plan (Appendix A) and summarized herein. Redevelopment activities are anticipated to occur within 3 years of completing the sale to a property developer. Based on the TEE exclusion, use of Method A soil CULs is applicable for the Site.

2.2.2 Groundwater Proposed Cleanup Levels

The highest beneficial use of groundwater is considered drinking water. The MTCA Method A CULs for groundwater are considered applicable and are used as pCULs. MTCA regulations (WAC 173-340-704) indicate that “Method A may be used to establish CULs at sites that have few hazardous substances and . . . sites where numerical standards are available in this chapter for applicable state and federal laws for all indicator hazardous substances in the media for which the Method A CUL is being used.” The IHS in groundwater is TCE. Although TCE can break down naturally through reductive dechlorination, transforming into other groundwater contaminants (e.g., cis-1,2-dichloroethene [cDCE] and vinyl chloride [VC]), none of these breakdown products were identified above screening levels during the RI. Monitoring for these breakdown products will be conducted during implementation of the final remedy; however, they are not identified COCs, and do not require pCULs.[1] Groundwater pCULs are presented in Table 2-2.

2.3 Points of Compliance

This section discusses POCs where the pCULs described above must be met. Both standard POCs and conditional POCs (CPOCs) may need to be included under various remedial alternatives; both types of POCs are discussed in this section.

2.3.1 Soil Point of Compliance

The standard soil POCs are as follows:

- Where soil CULs protective of groundwater must be met, the POC shall be throughout the site (WAC 173-340-740(6)(b)).
- Where soil CULs protective of vapors must be met, the POC shall be throughout the site from the ground surface to the uppermost groundwater table (WAC 173-340-140(6)(c)).

[1] Concentrations of TCE breakdown products will be compared against ARARs as needed for performance monitoring, and to ensure that the final remedy is adequately protective of human health and the environment. ARARs/performance monitoring criteria will be identified in the compliance monitoring plan, per WAC 173-340-400(4)(c) and -410(b).

- Where soil CULs protective of direct contact must be met, the POC shall be throughout the site from ground surface to 15 ft bgs (WAC 173-340-740(6)(d)).

Because a containment remedy for soil has been identified as the preferred remedial action (see the interim action plan and Section 6.0 of this FS report), the soil pCULs may not be met at the standard POCs. The cleanup action (site capping and institutional controls) will still comply with cleanup standards, because the regulatory conditions identified in WAC 173-340-740(6)(f)(i-vi) will be met. Specifically, the selected remedial alternative will comply with the following soil cleanup standards:

- Permanent to the maximum extent practicable (see Section 5.2.3).
- Protective of human health (see Section 5.2.1).
- Protective of terrestrial ecological receptors (see Section 2.2.1).
- Institutional controls to prohibit or limit activity that could interfere with the cap (see Section 4.1).
- Compliance monitoring (see Sections 4.1 and 4.2.1).
- The draft CAP will specify the hazardous substances that remain onsite and will include recommended measures for preventing migration of and contact with those substances.

2.3.2 Groundwater Point of Compliance

The standard POC for groundwater is throughout groundwater at the Site, in accordance with WAC 173-340-720(8)(b). A CPOC is a point or points as close to the source of contamination as reasonably possible, but not exceeding the property boundary. A CPOC may be used for a site (in accordance with WAC 173-340-720(8)(c)) if it can be demonstrated that it is not practicable to meet the CULs throughout the site in a reasonable restoration time frame, and that all practicable methods of treatment are to be used in the site cleanup. Ecology has requested that a CPOC is included at the property boundary (Ecology 2020a). Ecology has indicated that it is uncertain whether CULs within the property boundary can be met in the estimated 30-year restoration time frame under any of the remedial alternatives evaluated herein (Ecology 2020b). The preferred remedy is the most practicable method of treatment, as defined in Section 5.2. Therefore, a CPOC is permitted at the property boundary, per WAC 173-340-720(8)(c).

3.0 NATURE AND EXTENT OF CONTAMINATION

The nature and extent of contamination were characterized during the RI and are described in detail in Section 4.0 of the RI report (GEI/LAI 2019a). This section summarizes the general extent of Site soil and groundwater contamination as compared with Site pCULs (identified in Section 2.0). The COCs discussed in this section were identified by re-screening soil and groundwater sampling data against pCULs.

A conceptual site model (CSM; Figure 3-1) has been developed for the Site based on historical data, data collected during the RI, and the geology and hydrogeology summarized in Section 1.4. The primary sources of contamination at the Site are the landfill waste and fill from undocumented sources (GEI 2019). Soil, soil gas, and groundwater at the Site have been contaminated by these primary sources and are now secondary sources of IHS. Transport pathways have been identified for each media:

- **Soil:** Transport from buried waste to groundwater via leaching and transport from soil to soil gas and ambient air via volatilization, advection, and diffusion.
- **Soil Gas:** Transport from soil to ambient air via volatilization and soil gas migration.
- **Groundwater:** Transport from groundwater to air via volatilization, diffusion, and advection and transport from shallow groundwater to deeper groundwater via advection and diffusion.

Note that while soil gas was identified as a media of concern in the RI report, soil gas is not a regulated media, and there are no concerns for indoor air concentrations beyond the property boundary for the WOCP (see soil vapor intrusion analysis in the RI addendum; LAI 2019b). There are no structures currently on the WOCP; therefore, there are currently no indoor air concerns. Future indoor air concerns from vapor intrusion will be addressed as part of the site redevelopment described in the interim action plan (Appendix A), and by implementing institutional and engineering controls.

3.1 Soil Quality

Based on the findings of the RI, chromium and lead were identified as COCs at the Site in soil and in buried waste in soil. Concentrations of chromium in Site soil do not exceed the pCUL; chromium concentrations in buried waste exceed the pCUL at one location. Lead concentrations in Site soil exceed the pCUL at two locations; lead concentrations in buried waste exceed the pCUL at ten additional locations. Chromium and lead concentrations, as presented in the RI report, are provided in Table 3-1.[2] Locations where chromium and lead concentrations exceed the pCULs are shown on Figure 3-2.

Chromium and lead are not identified as COCs in groundwater; therefore, transport of these constituents from soil to groundwater is not a concern. The only exposure pathway for soil

[2] As stated in the RI report, the soil and waste data used for site characterization were collected from 2000 to present.

contaminants is human or ecological direct contact. As part of the interim action plan, site redevelopment plans will require that the buried waste and areas with contaminated soil are fully capped by buildings or pavement, which would prevent plants or wildlife from being exposed to soil contamination. No TEE is required for the Site, due to planned soil capping. Once Site redevelopment is complete, humans would be the only potential receptors for soil contaminants if future construction or maintenance/repair activities disturb, or extend beneath, the soil cap. Contact would likely occur during Site construction or maintenance activities that involve earthwork. Therefore, direct contact exposure pathways are considered in the evaluation of cleanup alternatives and the development of pCULs.

Although TCE has not been identified directly in Site soil through soil sampling, the presence of TCE in soil gas suggests that residual TCE could be present in the shallow soil in the northwestern portion of the WOCP.

3.2 Groundwater Quality

Based on the findings of the RI, TCE is the only COC identified in groundwater at the Site. TCE was detected in the Qga aquifer in the northwest portion of the Site (monitoring wells LAI-1 and LAI-MW-2) and in the downgradient portion of the Site (monitoring wells OLY-2 and OLY-1). TCE concentrations in monitoring wells LAI-1 and LAI-MW-2 have consistently exceeded the pCUL. In the downgradient portion of the Site, TCE concentrations exceeded the pCUL in monitoring well OLY-2 (once) during a 2015 sampling event. Groundwater TCE results are presented in Table 3-2.[3] Locations where TCE groundwater concentrations exceed the pCUL are shown on Figure 3-3.

Groundwater in the Qga aquifer at the Site is not used for drinking water, and it is unlikely that groundwater at the WOCP would be used for drinking water in the future, as drinking water would be supplied by the City. Per Olympia Municipal Code, new development at the Site would be required to connect to the City's public water supply (OMC 13.04.335). However, as required in MTCA, pCULs developed for the Site are protective of drinking water.

3.3 Groundwater Contaminant Fate and Transport

The primary sources of groundwater contamination at the Site include historical landfill waste and fill from undocumented sources that were historically placed at the Site. Leaching from these materials appears to have contaminated the underlying groundwater with TCE. An understanding of the groundwater contamination and fate and transport processes is important for evaluating possible cleanup alternatives. TCE contaminant fate and transport processes in groundwater include advection, sorption, dispersion, diffusion, and degradation. This section describes the characteristics of Site groundwater contamination and evaluates TCE degradation mechanisms.

[3] As stated in the RI report, the groundwater data used for site characterization were collected in 2014, 2015, and 2019.

3.3.1 Contamination Characteristics

The source of TCE in the Qga aquifer is likely historical landfill waste material that leached into groundwater, driven primarily by precipitation recharge (GEI/LAI 2019b). Data indicate that groundwater at the Site is not a source of volatile organic compounds (VOCs) in soil vapor. Groundwater in the Qga aquifer is located approximately 50 ft bgs and is below the Vashon till (Qgt) aquitard, a low-permeability soil unit that impedes movement of groundwater and vapor. TCE has been detected in Site groundwater in the Qga; however, the locations of elevated concentrations of TCE in groundwater do not correlate with the locations of elevated soil gas concentrations. For example, recent groundwater TCE concentrations are highest near the northwestern edge of the landfill property (23 micrograms per liter [µg/L] at monitoring well LAI-1 in March 2019); however, TCE has not been detected at adjacent soil gas sampling locations (GP-11, GP-1, and GP-23). Given this lack of co-occurrence of TCE, these data do not indicate that groundwater is the source of the VOCs detected in soil gas. Rather, the presence of VOCs in shallow soil gas is attributed to volatilization of residual VOC contamination in the waste material and associated unsaturated soil.

3.3.2 CVOC Degradation

Chlorinated volatile organic compound (CVOC) degradation is also a factor in the attenuation of TCE in groundwater. Degradation causes overall reduction in dissolved CVOC mass through chemical and biological processes. TCE can degrade through either biotic (biological) or abiotic (chemical) mechanisms; aquifer conditions are the primary factor in determining what mechanisms are active. Anaerobic aquifer conditions are generally required for biotic reductive dechlorination and for abiotic degradation of TCE, while TCE breakdown products, such as cDCE and VC, can be degraded under both anaerobic and aerobic conditions. TCE, cDCE, and VC can also be degraded co-metabolically under aerobic conditions. Aerobic and anaerobic conditions (called reduction-oxidation [redox] state) are characterized by sequential redox reactions whereby aquifer micro-organisms obtain energy. These redox reactions require an electron donor (i.e., a source of organic carbon) and an electron acceptor (e.g., oxygen, nitrate, iron). The redox reactions can be compared to the process whereby humans obtain energy through consumption of food (electron donor) and oxygen (electron acceptor). When oxygen is depleted in an aquifer, anaerobic bacteria use the less-oxidized electron acceptors in sequential order: nitrate, manganese (IV), iron (III), sulfate, and carbon dioxide. Indicators of TCE degradation at the Site include evaluation of aquifer redox parameters, evidence of natural electron donor indicators (total organic carbon [TOC]), and evaluation of historical TCE concentration trends.

3.3.2.1 Aquifer Redox Conditions and Presence of Electron Donor

Evaluation of the aquifer redox conditions and the presence of an electron donor (indicated by the presence/levels of TOC) at the Site was initially presented in Section 2.3.4 of the RI report (GEI/LAI 2019a). The evaluation presented in the RI report included an analysis of natural attenuation parameters from samples collected at monitoring wells LAI-MW-2 and OLY-02 in March 2019. The natural attenuation analysis was completed to evaluate the redox state of the shallow aquifer (Qga aquifer) and the potential for *in situ* degradation of CVOCs, primarily TCE. In this FS report, the natural attenuation analysis has been updated to include data collected at five monitoring wells in September 2019. Aquifer redox conditions for March and September 2019 are presented in Table 3-3.

Electron donor indicator, TOC, is present at low levels at monitoring wells LAI-1 and LAI-MW-4, but is generally not present at measurable concentrations at the Site. The available data indicate primarily aerobic conditions prevail at the Site. However, the TCE degradation product cDCE is present at monitoring wells LAI-1 and LAI-MW-2, suggesting that reducing conditions may be present in localized areas beneath the landfill. Although aquifer conditions are primarily aerobic, abiotic degradation mechanisms may still be occurring at the Site.

3.3.2.2 Contaminant Concentration Trends

The highest concentrations of TCE at the Site were found at monitoring wells LAI-1 (maximum detected TCE concentration of 40 µg/L [October 2006] and most recently detected concentration of 13 µg/L [September 2019]) and LAI-MW-2 (maximum detected concentration of 68 µg/L [July 2006] and most recently detected concentration of 15 µg/L [September 2019]). Concentrations of the reductive dechlorination breakdown product cDCE are consistently detected at monitoring wells LAI-1 and LAI-MW-2, indicating that reductive dechlorination is a mechanism for degradation of TCE at the Site. Concentrations of cDCE can be reduced under aerobic conditions; the aerobic conditions at the Site are likely the reason that concentrations of cDCE are low, and that the breakdown product VC is not present. Concentration time series plots for TCE and cDCE at monitoring wells LAI-1 and LAI-MW-2 are shown on Figures 3-4 and 3-5.[4]

A Mann-Kendall statistical analysis was conducted to assess TCE concentration trends over time at individual wells. The trend at monitoring well LAI-1 is considered probably decreasing, and the trend at monitoring well LAI-MW-2 is considered stable. The results of the Mann-Kendall statistical analysis are presented in Appendix B.

[4] Though only data from 2014, 2015, and 2019 were used for site characterization, a data set that included all available VOC groundwater data was used to evaluate contaminant concentration trends over time.

4.0 DEVELOPMENT OF CLEANUP ACTION ALTERNATIVES

Cleanup action alternatives were developed to address TCE-contaminated groundwater. An interim action plan was developed to address cleanup of other environmental media (landfill waste and soil). The interim action plan includes capping of WOCP soil and buried waste during future redevelopment and is considered part of each groundwater cleanup action alternative evaluated. This section includes a description of the interim action plan, an explanation of screening of remedial technologies for groundwater, and a summary of the cleanup action alternatives developed for evaluation under this FS.

4.1 Interim Action Plan

An interim action plan for the Site (LAI 2019) was prepared for the City and approved by Ecology. The purpose of the interim action is to use remedial action to address the landfill waste and contaminated soil and soil gas at the Site, and to allow for property sale and redevelopment prior to completion of the RI/FS and cleanup action plan (CAP). The interim action plan was written to be consistent with, and incorporated into, the final Site remedy and CAP.

WAC 173-340-430 defines an interim action as "a remedial action that is technically necessary to reduce a threat to human health or the environment by eliminating or substantially reducing one or more pathways for exposure to a hazardous substance at a facility." By requiring capping of the former landfill area during redevelopment, the interim action will reduce the threat to human health and the environment by eliminating or substantially reducing the human and ecological direct contact pathways for exposure to contaminants in Site soil, as described in WAC 173-340-430(1)(a). The interim action will help the City achieve partial Site cleanup, as described in WAC 173-340-430(2), by limiting exposure to COCs with a landfill cap, controlling soil gas emissions via installation of landfill gas (LFG)-collection and -venting systems, and establishing surface water controls and reducing contact between infiltrated stormwater and landfill waste.

Three alternatives were evaluated as part of the interim action plan:

- Alternative 1: No action.
- Alternative 2: Excavation and offsite disposal of solid waste.
- Alternative 3: Landfill cap, LFG control system, surface water controls, institutional controls, and compliance monitoring.

After being evaluated for permanence, protection of human health and the environment, compliance with cleanup standards and other ARARs, and public concerns, Alternative 3 was selected as the preferred interim action remedy for the following reasons:

- Most practicable permanent solution.

- Provides long-term protection of human health and the environment by limiting the potential for direct contact with contaminants, minimizes the potential for ongoing groundwater contamination, and controls LFG migration.
- Allows for monitoring programs to be implemented to confirm operational requirements have been satisfied for each media of concern.
- Poses substantially less short-term risk to human health than Alternative 2, which could expose workers to contaminated solid waste or soil during removal.
- Is consistent with MTCA and Comprehensive Environmental Response, Compensation, and Liability Act of 1980 preferred and presumptive remedies for landfill containment and cleanup.
- Will address public concerns through public comment periods.

Additional details about the selected alternative and the construction of a landfill cap, LFG control system, and surface water controls; implementation of institutional controls; and compliance monitoring are presented in the interim action plan (LAI 2019; Appendix A).

4.2 Identification and Screening of Groundwater Remedial Technologies

Per WAC 173-340-350(8)(b), an initial screening of remedial technologies and alternatives may be performed to reduce the number of alternatives for the final detailed evaluation of remedial alternatives. Technologies were evaluated based on their applicability and suitability, their presumed effectiveness for Site conditions, location constraints, and relative costs. Applicable technologies, screening, and decision criteria to address groundwater contamination at the Site are presented in Table 4-1.

4.3 Description of Cleanup Action Alternatives

Four cleanup action alternatives that meet regulatory requirements were evaluated to address contaminated groundwater at the Site. Each alternative also includes capping to address buried waste and soil at the Site, as described in the interim action plan. Depending on final redevelopment plans, some or all of the waste material may be removed from the WOCP; however, capping would most likely be conducted to contain residual soil contamination and as part of redevelopment activities.

The four alternatives incorporate the most viable cleanup action technologies within the general response action categories of hydraulic containment, *in situ* biological treatment, *in situ* physical treatment, and institutional controls. The four alternatives are:

- Alternative 1: Containment via capping and monitored natural attenuation (MNA) of groundwater.
- Alternative 2: Containment via capping and enhanced *in situ* bioremediation (EISB) of groundwater.

- Alternative 3: Containment via capping and hydraulic containment via groundwater extraction.
- Alternative 4: Containment via capping and in-well air stripping (IWAS) for groundwater.

A summary of each cleanup action alternative is included in Table 4-2. A detailed description of each alternative is presented below.

4.3.1 Alternative 1. Containment via Capping and Monitored Natural Attenuation of Groundwater

This alternative includes containment of landfill waste material via capping and MNA for cleanup of TCE-contaminated groundwater. MNA would include routine monitoring of groundwater contamination and ongoing evaluation of the attenuation processes (microbial, chemical, and/or physical). This alternative includes continued monitoring of seven of the existing Site monitoring wells (LAI-1, LAI-MW-2, LAI-2, LAI-MW-4, PGG-1, OLY-1, and OLY-2) and installation and monitoring of up to two additional downgradient wells. It is estimated that natural attenuation of groundwater would take approximately 30 years to reach the pCUL for TCE, Site-wide. The locations of the existing groundwater monitoring wells and the approximate locations of proposed downgradient wells are presented on Figure 4-1.

4.3.2 Alternative 2. Containment via Capping and Enhanced *In Situ* Bioremediation of Groundwater

This alternative includes creating a treatment zone using EISB at the landfill property boundary to minimize off-property migration of TCE-contaminated groundwater. EISB would rely on reductive dechlorination to transform the target VOC, TCE, into the non-toxic end products ethene and ethane. Reductive dechlorination would be stimulated by injecting an emulsion of fermentable electron donor substrates into the saturated zone via permanent injection wells. The injection wells would be evenly spaced along a row situated along the northern edge of the former landfill boundary, treating TCE in groundwater as it migrates north. It is estimated that the treatment zone would need to be maintained for 30 years, until treatment and natural attenuation of groundwater beneath the WOCP reach the TCE pCUL. The conceptual layout for the row of injection wells is presented on Figure 4-2.

4.3.3 Alternative 3. Containment via Capping and Hydraulic Containment via Groundwater Extraction

This alternative would use a groundwater extraction and treatment system (GETS) to create a hydraulic containment zone at the landfill property boundary, minimizing off-property migration of TCE-contaminated groundwater and increasing groundwater flushing beneath the WOCP. Extracted TCE-contaminated groundwater would be treated *ex situ* and/or discharged to the sanitary sewer. Groundwater extraction wells would be installed along the northern property boundary to capture groundwater before it moves downgradient. The approximately 400-ft-long conceptual capture area would be located immediately south of monitoring wells LAI-1, LAI-MW-2, and LAI-2, as shown on Figure 4-3.

Extracted groundwater would be conveyed to a central treatment building via underground piping. For the purposes of this FS, it is assumed that water treatment could be achieved with air stripping. Air stripping would be used to remove TCE from extracted groundwater to meet the limit for discharge to a sanitary sewer. The GETS would need to be operated for an estimated 30 years until treatment and natural attenuation of groundwater beneath the WOCP reach the TCE pCUL.[5] Re-injection of treated groundwater upgradient of the TCE plume could be a less-expensive alternative to sewer discharge; however, operation of the injection well may become cost-prohibitive if well-fouling occurs. The potential for fouling at injection wells is typically greater than at extraction wells, because oxygen-rich groundwater enhances microbial growth. Therefore, re-injection was not assumed.

4.3.4 Alternative 4. Containment via Capping and In-well Air Stripping for Groundwater

This alternative would use IWAS technology to remove TCE from groundwater along the northern WOCP boundary and minimize off-property migration of TCE-contaminated groundwater. IWAS is a physical treatment method used primarily to remove or degrade volatile contaminants from groundwater. IWAS combines several treatment technologies within a single well casing, including groundwater recirculation, air sparging, soil vapor extraction (SVE), and air stripping. Each IWAS well is constructed with a screen that extends above the saturated zone, so water can be recirculated through the vadose and saturated zones. Air sparging is achieved in each well by injecting air into the bottom of the well. Air injection at the bottom of the well decreases the density of the water column within the well casing, causing it to rise inside the well; this is known as airlift pumping. Airlift causes groundwater to be drawn into the well from the lower portion of the screen, and creates mounding at the water table, which pushes water out of the screen into the vadose zone. A vacuum is applied to each IWAS well through an SVE extraction system to remove TCE that has been volatilized in the well from air sparging or air stripping. Air stripping is simulated in the well with a submersible pump that pumps groundwater from the bottom of the well to the top of the casing. Water at the top of the casing is released through a nozzle to create a spray—a process similar to an air-stripping tower. Water continuously circulates through this cycle, enhancing removal of TCE with each cycle.

The IWAS system would be operated, maintained, and monitored for an estimated 30 years, until treatment and natural attenuation of groundwater beneath the WOCP reach the TCE pCUL. For the purposes of this FS, it is assumed that five wells, spaced 75 ft apart, would be installed at the northern

[5] Note that 30 years is a rough estimate for each of the remedial alternatives. It is assumed that the restoration time frame for GETS would be less than the time frames for the other alternatives, due to the enhanced flushing that would occur as a result of groundwater extraction. Detailed groundwater flow and/or fate and transport modeling would be necessary to provide more accurate restoration time frame estimates for each alternative.

property boundary to treat groundwater before it leaves the property, as shown on Figure 4-4. Prior to full implementation, a pilot study would be completed to evaluate the adequacy of well-spacing.

5.0 ANALYSIS OF CLEANUP ACTION ALTERNATIVES

This section evaluates each of the cleanup action alternatives developed in Section 4.0, using applicable MTCA evaluation criteria. A preferred alternative has been selected based on the evaluation and comparison of the alternatives. This section includes:

- An explanation of the minimum threshold and other requirements for cleanup actions (WAC 173-340-360(2)).
- A comparison of cleanup action alternatives using criteria in WAC 173-340-360(3)(f).
- An evaluation of the costs associated with each cleanup action alternative and a relative cost-benefit analysis to determine whether the cleanup action is permanent to the maximum extent practicable using criteria in WAC 173-340-360(3).
- An evaluation to determine if the cleanup action provides for a reasonable restoration time frame using criteria in WAC 173-340-360(4).

5.1 Minimum Requirements for Cleanup Action

MTCA regulations require that cleanup action alternatives meet certain minimum requirements, as provided in WAC 173-340-360(2). Cleanup alternatives must also be compared to evaluate their benefits relative to their costs, as provided in WAC 173-340-360(3). Consistent with MTCA, the alternatives described in Section 4.0 were evaluated with respect to threshold requirements and other requirements (using permanent solutions to the maximum extent practicable, restoration time frame, and consideration of public concerns). The following sections summarize the MTCA threshold and other requirements that must be met by the alternatives under consideration.

5.1.1 Threshold Requirements

WAC 173-340-360(2) requires first that all alternatives evaluated meet the following four threshold requirements:

- "Protect human health and the environment."
- "Comply with cleanup standards (see WAC 173-340-700 through WAC 173-340-760)."
- "Comply with applicable state and federal laws (see WAC 173-340-710)."
- "Provide for compliance monitoring (see WAC 173-340-410 and WAC 173-340-720 through WAC 173-340-760)."

5.1.2 Other Requirements

In addition to the threshold requirements described in Section 5.1.1, WAC 173-340-360(2)(b) requires that cleanup actions meet certain other requirements:

- "Use permanent solutions to the maximum extent practicable…"
- "Provide for a reasonable restoration time frame…"
- "Consider public concerns (see WAC 173-340-600)."

5.1.2.1 Requirements for a Permanent Solution to the Maximum Extent Practicable

Steps to determining whether a cleanup action uses permanent solutions to the maximum extent practicable are provided in WAC 173-340-360(3). WAC 173-340-200 defines a permanent solution as one in which cleanup standards "can be met without further action being required at the site being cleaned up or any other site involved with the cleanup action, other than the approved disposal site of any residue from the treatment of hazardous substances." MTCA recognizes that permanent solutions may not be practicable for all sites, and provides a procedure referred to as a disproportionate cost analysis (DCA; WAC 173-340-360(3)(e)) to determine whether a cleanup action is permanent to the maximum extent practicable.

The DCA is performed to determine whether the incremental increase in costs of a cleanup alternative over that of a lower cost alternative is justified by providing a corresponding incremental increase in human health and environmental benefits (WAC 173-340-360(3)(e)(i)). The relative benefits of a cleanup alternative are based on evaluation criteria provided in WAC 173-340-360(3)(f). These criteria are:

- ***Protectiveness.*** Overall protectiveness of human health and the environment, including the degree to which site risks are reduced, time required to reduce risk at the facility and attain cleanup standards, risks during implementation, and improvement of overall environmental quality.
- ***Permanence.*** The degree of reduction in toxicity, mobility, and volume of hazardous substances, including the reduction or elimination of hazardous substance releases and sources of releases.
- ***Cost.*** The cost to implement the remedy, including capital costs and operation and maintenance costs.
- ***Effectiveness over the long term.*** Long-term effectiveness, including the degree of certainty that the alternative would be successful, long-term reliability, the magnitude of residual risk, and the effectiveness of controls required to manage treatment residues and remaining waste. The following types of cleanup action components may be used as a guide to assess the relative degree of long-term effectiveness, in descending order: reuse or recycling; destruction or detoxification; immobilization or solidification; onsite or offsite disposal in an engineered, lined, and monitored facility; onsite isolation or containment with attendant engineering controls; and institutional controls and monitoring.

- ***Management of short-term risks.*** The risk to human health and the environment during construction and implementation and the effectiveness of measures to manage the risk.
- ***Technical and administrative implementability.*** Implementability, including consideration of whether the alternative is technically possible; the availability of necessary offsite facilities, services, and materials; administrative and regulatory requirements; scheduling, size, and complexity of construction; monitoring requirements; access for construction, operations, and monitoring; and integration with existing facility operations.
- ***Consideration of public concerns.*** Whether the community has concerns and the extent to which those concerns are addressed.

If the incremental increase in costs is determined to be disproportionate to the benefits, the more expensive alternative is considered impracticable, and the lower cost alternative is determined to be permanent to the maximum extent practicable (WAC 173-340-360(3)). This process provides a mechanism for balancing the permanence of the cleanup action with its costs, while ensuring that human health and the environment are adequately protected. If alternatives are equal in benefits, the less costly alternative is selected (WAC 173-340-360(3)(e)(ii)(C)).

5.1.2.2 Requirements for a Reasonable Restoration Time Frame

WAC 173-340-360(4)(b) specifies that the following factors be considered when determining whether a cleanup action provides for a reasonable restoration time frame:

- Potential risks to human health and the environment.
- Practicability of achieving a shorter restoration time frame.
- Current and potential future use 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 hazardous substances from the Site.
- Toxicity of hazardous substances at the Site.
- Natural processes that reduce concentrations of hazardous substances and have been documented to occur at the Site or under similar Site conditions.

5.1.2.3 Requirement for Consideration of Public Concerns

Consideration of public concerns is an inherent part of the cleanup process under MTCA (WAC 173-340-600). A public comment period will also occur for the RI/FS/CAP, prior to selection of the final cleanup action, as specified in WAC 173-340-380. Public concerns will be considered when finalizing cleanup alternatives and the CAP, as applicable. Further discussion of public concerns is incorporated into the disproportionate cost analysis section (Section 5.2.2), as required under WAC 173-340-360(3)(e)(ii)(C)(vii).

5.2 Evaluation and Comparison of Alternatives

This section evaluates and compares the adequacy of each alternative relative to the criteria discussed in Section 5.1. The comparative analysis of the alternatives is organized by comparison to threshold requirements in Section 5.2.1 and other requirements in Sections 5.2.2, 5.2.3, and 5.2.4.

5.2.1 Threshold Requirements

For an alternative to achieve the threshold requirements, it must adequately protect human health and the environment, comply with cleanup standards, comply with state and federal laws, and provide for compliance monitoring. Threshold requirements are evaluated for Cleanup Alternatives 1 through 4 in Table 5-1 and below:

- Protection of human health and the environment: Each of the remedial alternatives is protective of human health and the environment by reducing Site risks, addressing potential future exposure pathways, protecting human and ecological receptors, and improving overall environmental quality.
- Compliance with cleanup standards: Each of the remedial alternatives is protective of human health and the environment by reducing concentrations of IHS below pCULs after the cleanup remedy is complete.
- Compliance with applicable state and federal laws: Each of the remedial alternatives complies with the applicable state and federal laws described in Section 2.1 or as otherwise applicable through proper development of cleanup levels (Section 2.0) and compliance with applicable requirements specific to the construction and operation of the alternative.
- Provisions for compliance monitoring: Each of the remedial alternatives includes compliance monitoring (protection monitoring, performance monitoring, and confirmation monitoring), as required under WAC 173-340-410, as well as compliance monitoring required by cleanup standards (WAC 173-340-720 through -760).

All four cleanup alternatives meet the MTCA threshold requirements and are viable and appropriate cleanup alternatives under MTCA.

5.2.2 Permanent to the Maximum Extent Practicable

As described in Section 5.1.2.1, a DCA is performed to determine whether a cleanup alternative is permanent to the maximum extent practicable. The purpose of a DCA is to determine if the costs of a cleanup alternative are disproportionate to the human health and environmental benefits achieved by the cleanup action, thus rendering the alternative impracticable. Each of the remedial alternatives was evaluated using the DCA criteria, and the results of the evaluation are summarized in Tables 5-2 and 5-3 and on Figure 5-1. A breakdown of the costs is presented in Tables 5-4 to 5-7. Costs are further evaluated against the relative environmental benefits described in Section 5.2.4.

The following summarizes the rankings for each alternative when scored with qualitative DCA criteria. The summary is intended to be used in conjunction with Table 5-2, which provides a complete accounting of the rankings and considerations for each criteria and alternative.

- ***Protectiveness.*** All alternatives received relatively high benefit scores, because each alternative will minimize human and ecological direct contact risks, reduce the risk of soil contaminants leaching to groundwater, and reduce the risk for groundwater consumption by remediating groundwater to achieve cleanup standards.
- ***Permanence.*** All alternatives received a relatively high benefit ranking for permanence criteria, because they are each assumed to permanently treat groundwater contamination after implementation. Although soil capping would reduce the risk of direct contact with contaminants, it will not permanently eliminate or remove soil contamination from the Site.
- ***Effectiveness over the long term***. Alternative 2 received the highest benefit ranking for long-term effectiveness criteria, as its success at achieving cleanup standards has the highest degree of certainty. Additionally, Alternative 2 would provide adequate protection in the near term, while contaminant concentrations exceed pCULs. Alternatives 1, 3, and 4 have the same ranking, given the uncertainty of their successful implementation.
- ***Management of short-term risks.*** Alternative 1 received the highest benefit ranking for the management of short-term risks (risks incurred during construction or implementation) criteria, because it includes minimal construction activities, thereby limiting the potential for workers to be exposed to contaminated media. Alternatives 2, 3, and 4 have the same benefit ranking, because their installation involves similar short-term risks for construction and implementation of cleanup activities.
- ***Technical and administrative implementability.*** Alternative 1 received the highest benefit ranking for technical and administrative implementability criteria, because it includes minimal additional construction and negligible implementation, permitting, or other administrative challenges. Alternative 4 received the lowest benefit ranking, because it includes implementation of a less common treatment system, and a pilot study will be required to determine final design criteria.
- ***Consideration of public concerns.*** All alternatives ranked equally for consideration of public concerns criteria. Each of these alternatives is protective of human health and the environment. Public concerns related to the alternatives will be considered and addressed in the same manner by responding to comments received during the public comment period for the RI/FS/CAP, as required under MTCA.

Based on the benefit rankings for each criteria and the assigned weighting factors,[6] the overall weighted benefit score for each alternative is as follows (from highest to lowest):

- Alternative 1: 7.7.
- Alternative 2: 7.4.
- Alternative 3: 7.1.
- Alternative 4: 7.0.

[6] Note that the use of weighting factors is not specifically included under MTCA; however, it is a widely used and accepted practice of the regulated community and Ecology to assign weighting to DCA criteria (for example see Whatcom County Superior Court 2007 and Ecology 2008). The weighting factors identified herein are typical of FS DCA evaluations performed under MTCA; protectiveness, permanence, and long-term effectiveness criteria are typically weighted more heavily "since they are core to protecting human health and the environment" (Ecology 2017). Ecology guidance accepts and authorizes the use of alternative ranking and DCA criteria weighting.

The final DCA criterion to be evaluated is the cost of each alternative:

- Cost: Alternative 1 is the least expensive alternative, and Alternative 2 is the most expensive, as summarized below with present value costs (assuming a 0.4 percent discount rate).[7] Present values and undiscounted costs are presented in Tables 5-4 to 5-7.

Alternative	Cost Summary
Alternative 1	$490,000
Alternative 2	$6,200,000
Alternative 3	$4,640,000
Alternative 4	$2,850,000

5.2.3 Conclusion of Disproportionate Cost Analysis

To provide a direct quantitative metric for comparison of the costs and benefits of each alternative (WAC 173-340-360(3)(e)(i)(C)), a benefit-to-cost ratio was calculated for each. The overall benefit score for each alternative was divided by the overall cost, then multiplied by the cost of the lowest cost alternative to normalize and scale the data to fit on the chart shown on Figure 5-1. This benefit-to-cost ratio provides a metric to evaluate whether the cost of each alternative is commensurate with its benefits. The most permanent alternative is considered "permanent to the maximum extent practicable" so long as its benefits are not disproportionate to its costs, as determined by comparison to other alternatives with higher benefit-to-cost ratios.

Using this methodology, the benefit-to-cost ratio for each of the alternatives was calculated to be:

- Alternative 1: 7.7.
- Alternative 4: 1.2.
- Alternative 3: 0.7.
- Alternative 2: 0.6.

The alternatives are all considered the most permanent alternative (received the same permanence score) developed in this FS (WAC 173-340-360(3)(e)(ii)(B)) and are equally protective. Therefore, the other criteria must be used to differentiate which alternative is permanent to the maximum extent practicable. Alternative 2 is likely to be the most effective remedy in the long term, but the DCA shows that the cost of Alternative 2 is significantly disproportionate to its benefits. The results of the relative cost-benefit analysis are provided in graphical format on Figure 5-1. Alternative 1 has both the highest overall benefits score and the highest benefit-to-cost ratio over higher cost alternatives (as shown on Figure 5-1, which illustrates the significant difference between the Alternative 1 benefit-to-cost ratio and the ratios of the other alternatives). This benefit-to-cost ratio indicates that more

[7] Present value costs must be used for cost estimates, per WAC 173-340-360(3)(f)(iii).

expensive alternatives are disproportionately costly compared to their incremental increase in benefits. Therefore, based on the DCA, Alternative 1 (containment via capping and MNA of groundwater) is permanent to the maximum extent practicable.

5.2.4 Restoration Time Frame

This section evaluates and compares the restoration time frame associated with each of the remedial alternatives. The restoration time frame is defined in MTCA as “the period of time needed to achieve the required cleanup levels at the points of compliance established for the site” (WAC 173-340-200). Per WAC 173-340-360(4)(b), the selected alternative must meet the cleanup levels within a reasonable time frame, as determined based on the eight factors identified in Section 5.1.2.2 (WAC 173-340-360(4)(b)(i) through (ix)). A summary of the estimated restoration time frames for each remedial alternative and a brief explanation of how each of the associated factors relates to “reasonableness” are provided in Table 5-1.

Because the long-term effects of capping on contaminant concentrations are unknown, the restoration time frame for Alternatives 1 through 4 is estimated to be 30 years or more. These are rough estimates for each alternative; however, it is estimated that the restoration time frame for Alternative 3 would be shorter than the time frames for the other alternatives, due to the assumption that enhanced groundwater flushing will reduce the overall restoration period. Detailed groundwater flow and/or fate and transport modeling would be required to determine more accurate restoration time frames for the alternatives. The implementation of each alternative includes capping, which is assumed to decrease contaminant leaching to groundwater through stormwater management/control. Alternatives 2 through 4 include treatment at the property boundary, as a point source of TCE contamination has not been identified within the landfill. It is assumed that concentrations will abate within 30 years, even with active treatments at the property boundary. A 30-year restoration time frame for each remedial alternative is considered reasonable (see Table 5-1). However, Ecology has indicated that Site-wide cleanup of groundwater (at the standard POC) may not be achievable in the estimated restoration time frame under any of the remedial alternatives (Ecology 2020a, 2020b). Therefore, a CPOC for Site groundwater is established at the property boundary (see Section 2.3.2), as provided for in WAC 173-340-720(8)(c).

6.0 RECOMMENDATION OF PREFERRED CLEANUP ACTION ALTERNATIVE

Based on this FS, including the DCA discussed in Section 5.2.3, Alternative 1 is the preferred remedial action alternative for the Site. Alternative 1 consists of containment via capping[8] (to minimize the risk of human and ecological direct contact with contaminated soil and to limit stormwater infiltration and contaminant leaching to groundwater) and MNA (to monitor TCE concentrations in groundwater throughout the Site). Selection of this alternative over Alternatives 2, 3, and 4 is based primarily on the following:

- Alternative 1 has the highest overall benefit score, is the most cost-effective alternative (has the lowest cost to benefit ratio), and is permanent to the maximum extent practicable, as discussed in Section 5.2.3. Alternative 1 also achieves each of the threshold requirements, and provides for a reasonable restoration time frame, as described in Section 5.2.4.
- Alternatives 2, 3, and 4 would require significant upfront costs to construct and implement and would increase the potential for workers to be exposed to health and safety concerns, including contaminated media. Alternative 4 would also require a pilot test to determine appropriate design criteria.

[8] Based on the final property redevelopment design, some or all of the buried waste material may be removed. However, site capping will still occur as part of site redevelopment activities.

7.0 USE OF THIS REPORT

This feasibility study has been prepared for the exclusive use of the City of Olympia and applicable regulatory agencies for specific application to the West Olympia Commercial Property (also called the Former West Olympia Landfill) Site. No other party is entitled to rely on the information, conclusions, and recommendations included in this document without the express written consent of Landau Associates. Further, the reuse of information, conclusions, and recommendations provided herein for extensions of the project or for any other project, without review and authorization by Landau Associates, shall be at the user's sole risk. Landau Associates warrants that within the limitations of scope, schedule, and budget, its services have been provided in a manner consistent with that level of care and skill ordinarily exercised by members of the profession currently practicing in the same locality under similar conditions as this project. Landau Associates makes no other warranty, either express or implied.

8.0 REFERENCES

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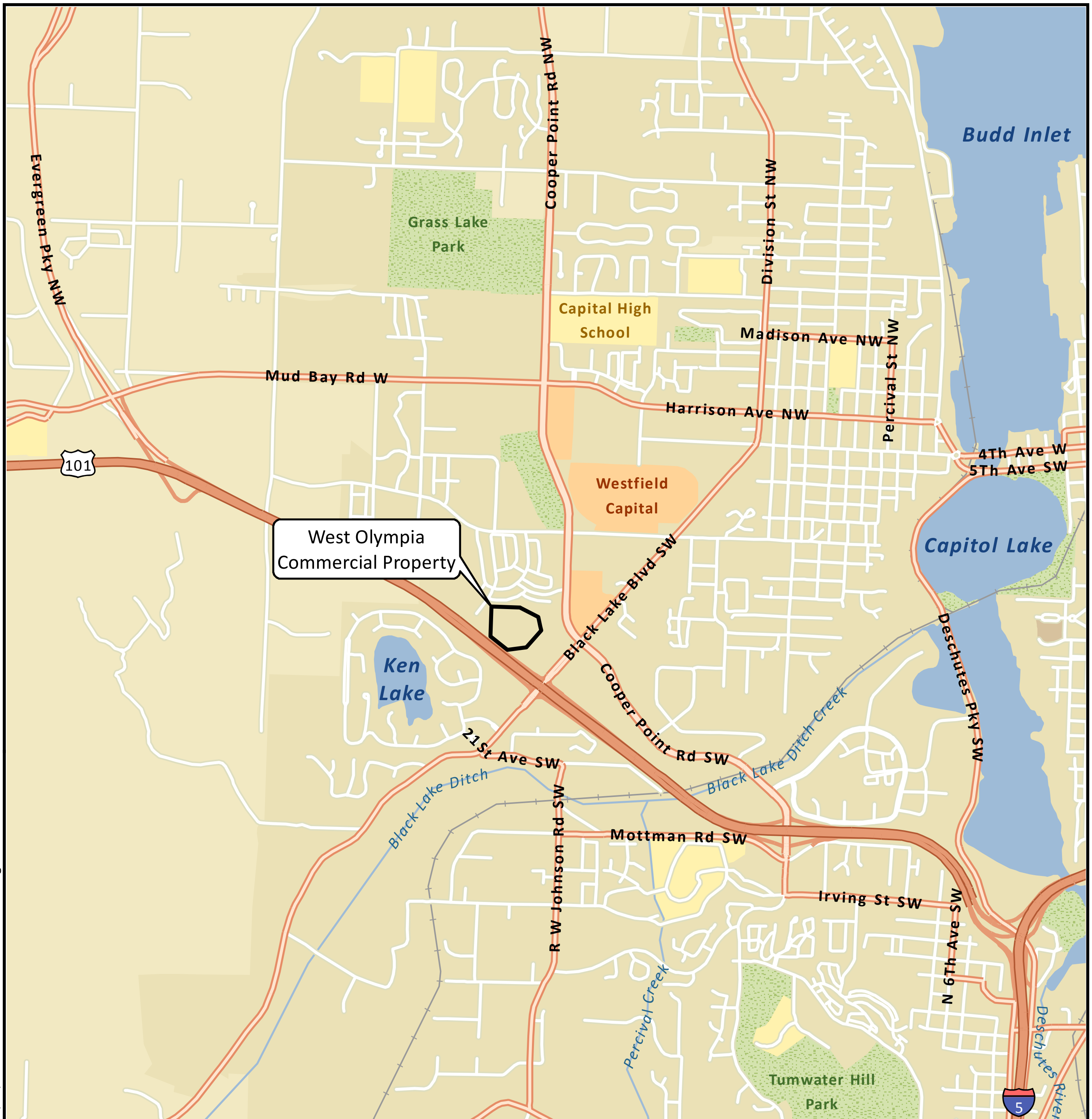

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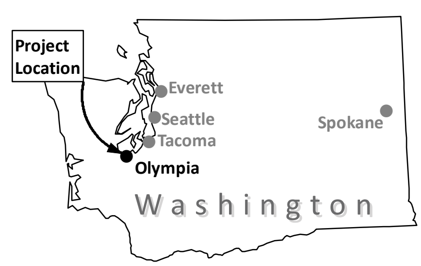

Data Source: Esri 2012

G:\Projects\258\052\030\034\FS\F1-1VicMap.mxd 5/15/2020 NAD 1983 StatePlane Washington South FIPS 4602 Feet

Landau Associates

West Olympia Commercial Property Feasibility Study Olympia, Washington	**Vicinity Map**	Figure 1-1

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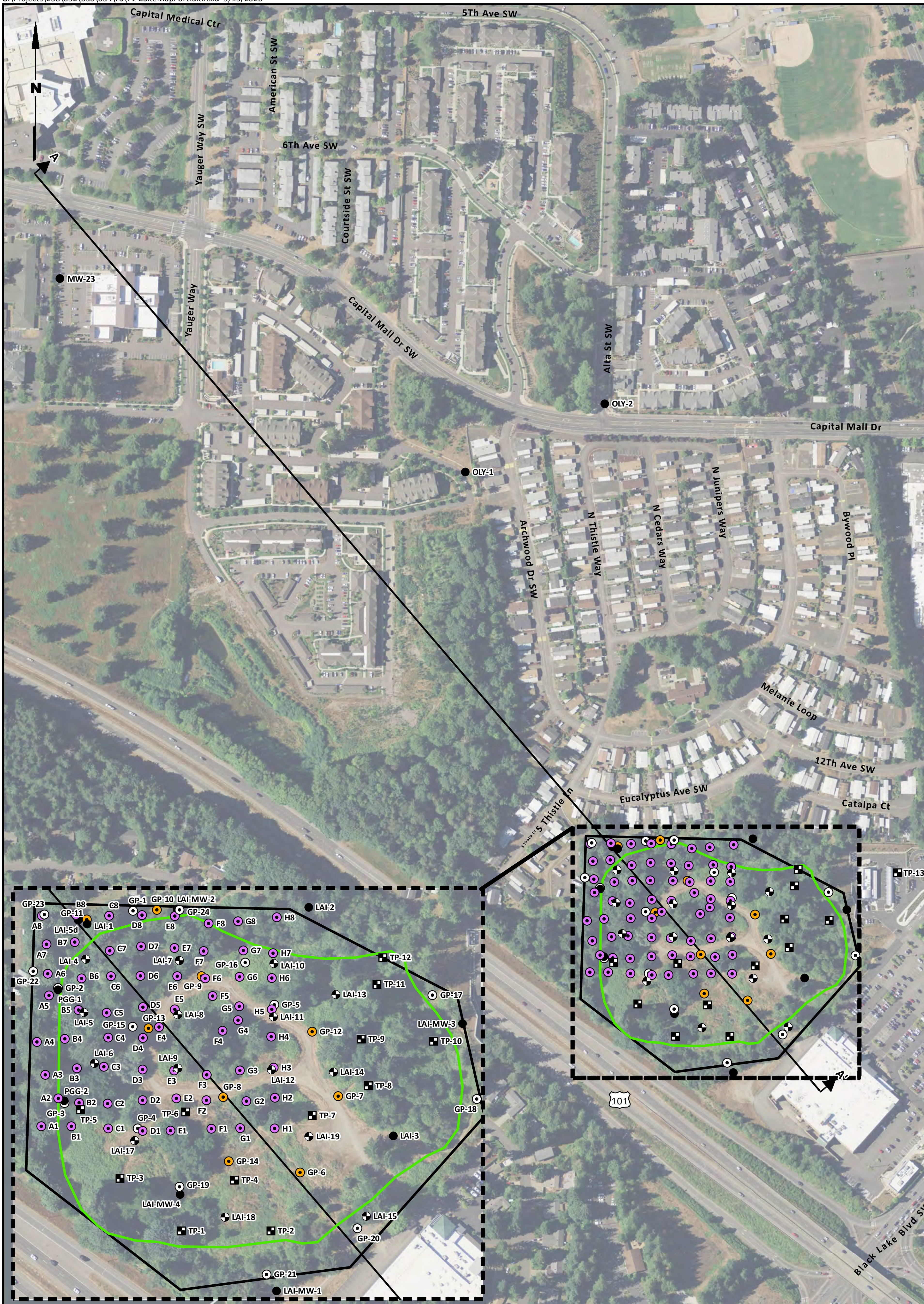

Legend

- Existing Groundwater Monitoring Well Location
- Soil Boring
- Test Pit
- Permanent Soil Gas Sample Location
- Temporary Active Soil Gas Sample Location
- Temporary Passive Soil Gas Sample Location
- Approximate Extent of Waste
- Subject Property

Note

1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Data Source: Thurston County GIS.

0 300 600

Scale in Feet

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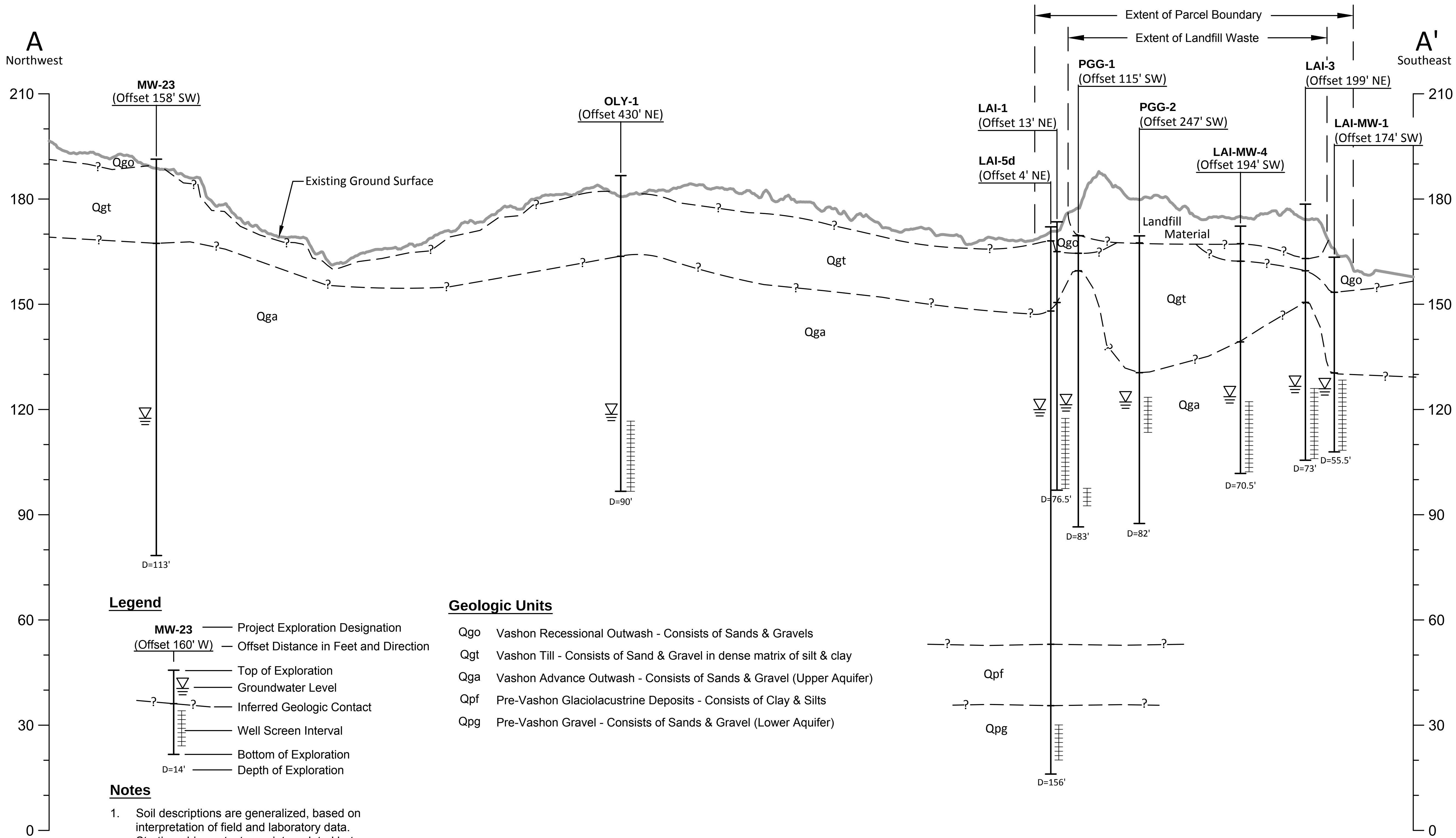
West Olympia Commercial Property Feasibility Study Olympia, Washington	**Site Map**	Figure 1-2



Notes

1. Soil descriptions are generalized, based on interpretation of field and laboratory data. Stratigraphic contacts are interpolated between borings and based on topographic features; actual conditions may vary.
2. See report text for descriptions of geologic units.
3. For cross-section location, see Figure 1-2.

Geologic Profile A-A'

Horizontal Scale in Feet: 1"=300'
Vertical Scale in Feet: 1"=30'
Vertical Datum: NGVD29

0 300 600
Scale in Feet

Source: PSLC Lidar Data

West Olympia Commercial Property Feasibility Study Olympia, Washington	**Conceptual Regional Geologic Cross-Section A-A'**	Figure 1-3

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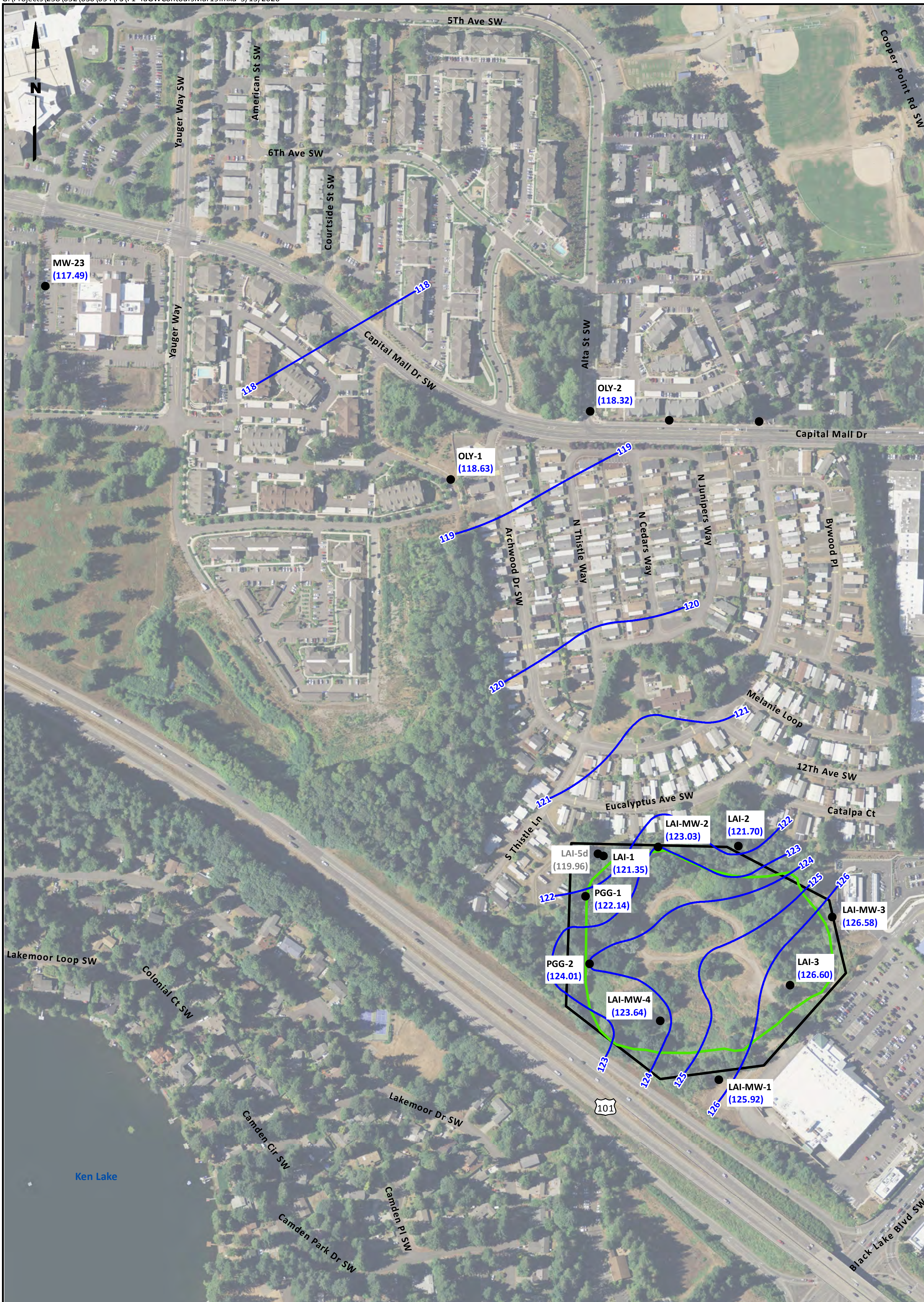

Legend

- Monitoring Well Location (Groundwater Elevation; ft MSL)
- Groundwater Elevation Contours
- Approximate Extent of Waste
- Subject Property

0 300 600

Scale in Feet

Notes

1. Vertical datum = NGVD29.
2. LAI-5d is screened in the lower aquifer (Qpg) and is not used for these contours, but is shown for reference.
3. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Data Sources: Thurston County GIS.

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West Olympia Commercial Property
Feasibility Study
Olympia, Washington

Groundwater Elevation Contours
Upper Aquifer (Qga) - March 2019

Figure
1-4a

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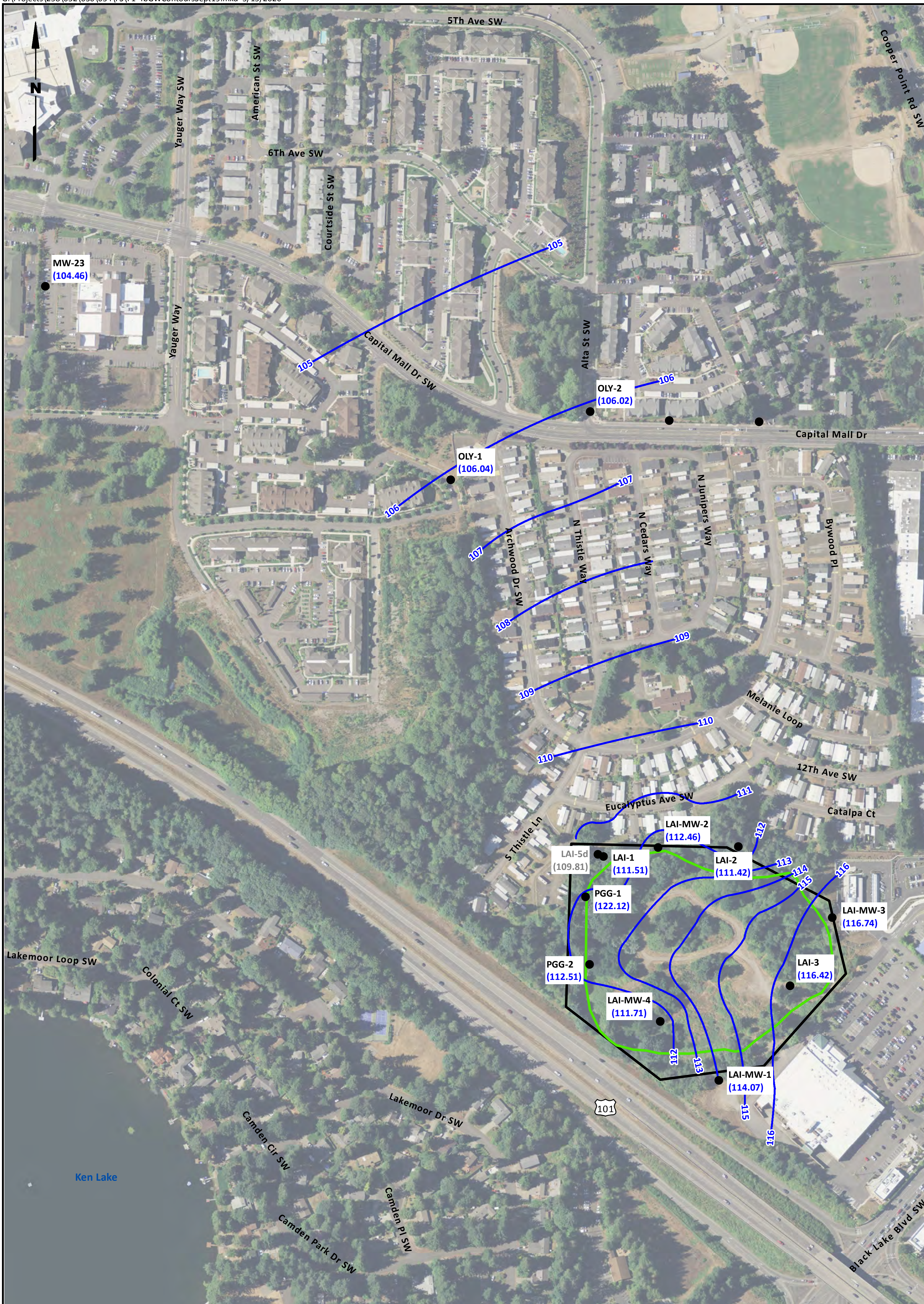


Legend

- Monitoring Well Location (Groundwater Elevation; ft MSL)
- Groundwater Elevation Contours
- Approximate Extent of Waste
- Subject Property

Notes

1. Vertical datum = NGVD29.
2. LAI-5d is screened in the lower aquifer (Qpg) and is not used for these contours, but is shown for reference.
3. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Data Sources: GeoEngineers RI Report Addendum; Thurston County GIS.

0 300 600

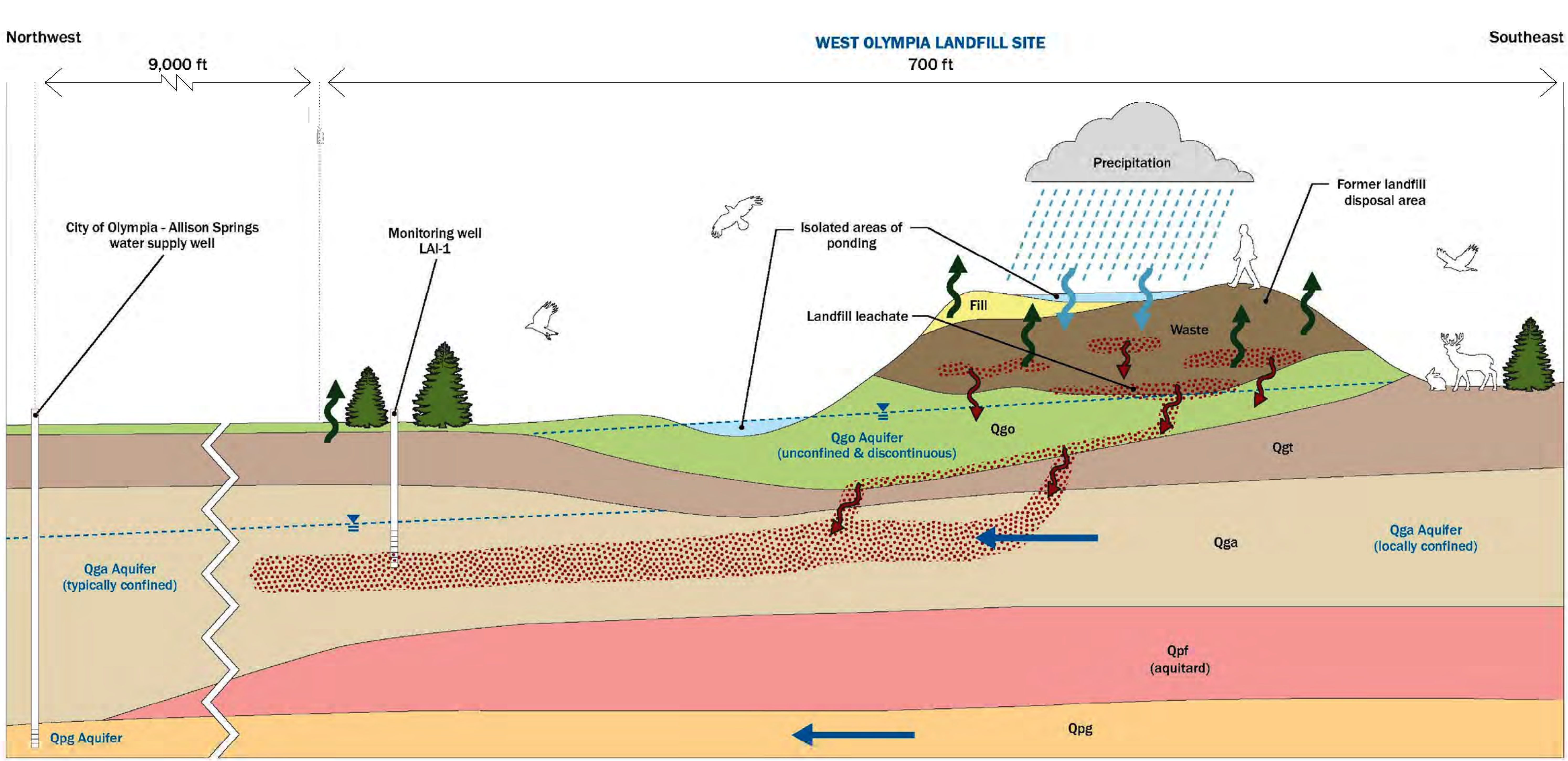
Scale in Feet

Landau Associates

West Olympia Commercial Property
Feasibility Study
Olympia, Washington

Groundwater Elevation Contours
Upper Aquifer (Qga) - September 2019

Figure
1-4b



Legend

- Qgo Vashon Recessional Outwash
- Qgt Vashon Till
- Qga Vashon Advance Outwash
- Qpf Pre-Vashon Glaciolacustrine Deposits
- Qpg Pre-Vashon Gravel
- Prevailing Groundwater Flow
- Groundwater
- Landfill Gases Irrigation Mechanism
- Precipitation/Infiltration Migration Mechanism
- Leachate Migration
- Dissolved Phase TCE

Data Source: GeoEngineers.

Notes
1. This figure is from the RI Report (GEI/LAI 2019a), and has been modified by Landau Associates for use in the FS Report.
2. Drawing not to scale.
3. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

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West Olympia Commercial Property Feasibility Study Olympia, Washington	**Conceptual Site Model**	Figure 3-1

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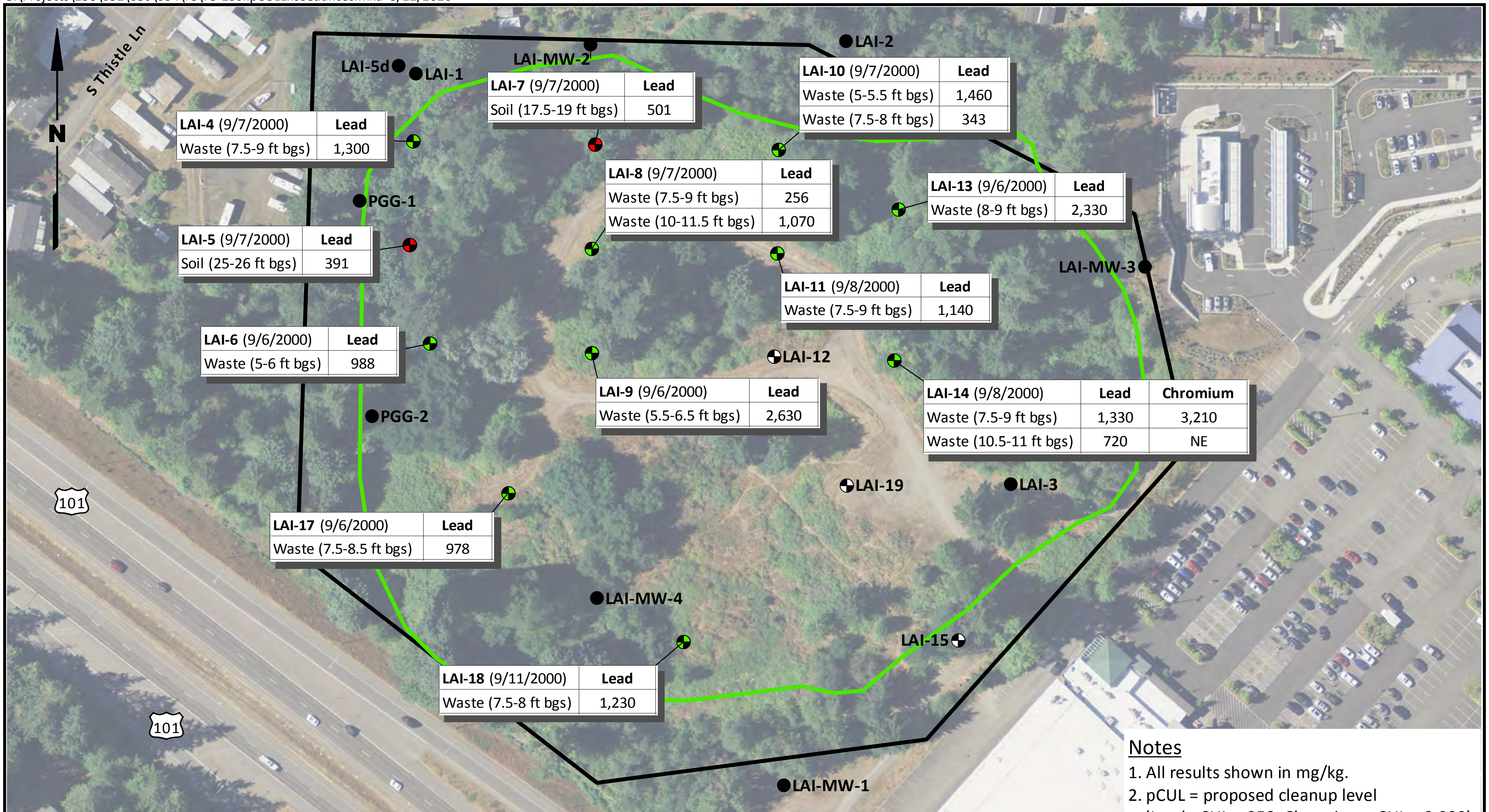

Notes

1. All results shown in mg/kg.
2. pCUL = proposed cleanup level (Lead pCUL = 250; Chromium pCUL = 2,000).
3. NE = No Exceedance of pCUL
   ft = feet
   bgs = below ground surface.
4. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Legend

- Existing Monitoring Well
- Soil Boring (Landau Associates 2000)
- Soil pCUL Exceedance in Buried Landfill Waste
- Soil pCUL Exceedance in Soil
- Subject Property
- Approximate Extent of Waste

0 150 300

Scale in Feet

Data Sources: Thurston County GIS; Esri World Imagery.

Landau Associates

West Olympia Commercial Property Feasibility Study Olympia, Washington	**Soil pCUL Exceedances**	Figure 3-2

OLY-2

Sample Date	TCE (µg/L)
3/2015	2.6
6/2015	2.8
9/2015	4.5
12/2015	6.1
3/2019	2.8
9/2019	4

OLY-1

Sample Date	TCE (µg/L)
3/2015	0.5 U
6/2015	0.5 U
9/2015	0.5 U
12/2015	0.11 J
3/2019	0.20 U
9/2019	0.20 U

LAI-1

Sample Date	TCE (µg/L)
1/2014	17
3/2015	27
6/2015	20
9/2015	19
12/2015	21
3/2019	23
9/2019	13

LAI-MW-2

Sample Date	TCE (µg/L)
1/2014	41
3/2015	22
6/2015	50
9/2015	19
12/2015	43
3/2019	22
9/2019	15

LAI-2

Sample Date	TCE (µg/L)
1/2014	1.1
3/2019	2.6
9/2019	0.58

PGG-1

Sample Date	TCE (µg/L)
1/2014	0.27 J
3/2019	0.29
9/2019	0.42

LAI-MW-4

Sample Date	TCE (µg/L)
3/2019	0.27
9/2019	0.20 U

Legend

- TCE Not Detected in Groundwater
- TCE Detected Below pCULs
- TCE Detected Above pCULs During One or More Sampling Event
- Approximate Extent of Waste
- Subject Property

0 300 600

Scale in Feet

Notes

1. TCE proposed cleanup level (pCUL) = 5.0 µg/L.
2. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Data Source: Thurston County GIS.

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West Olympia Commercial Property
Feasibility Study
Olympia, Washington

Groundwater pCUL Exceedances

Figure 3-3

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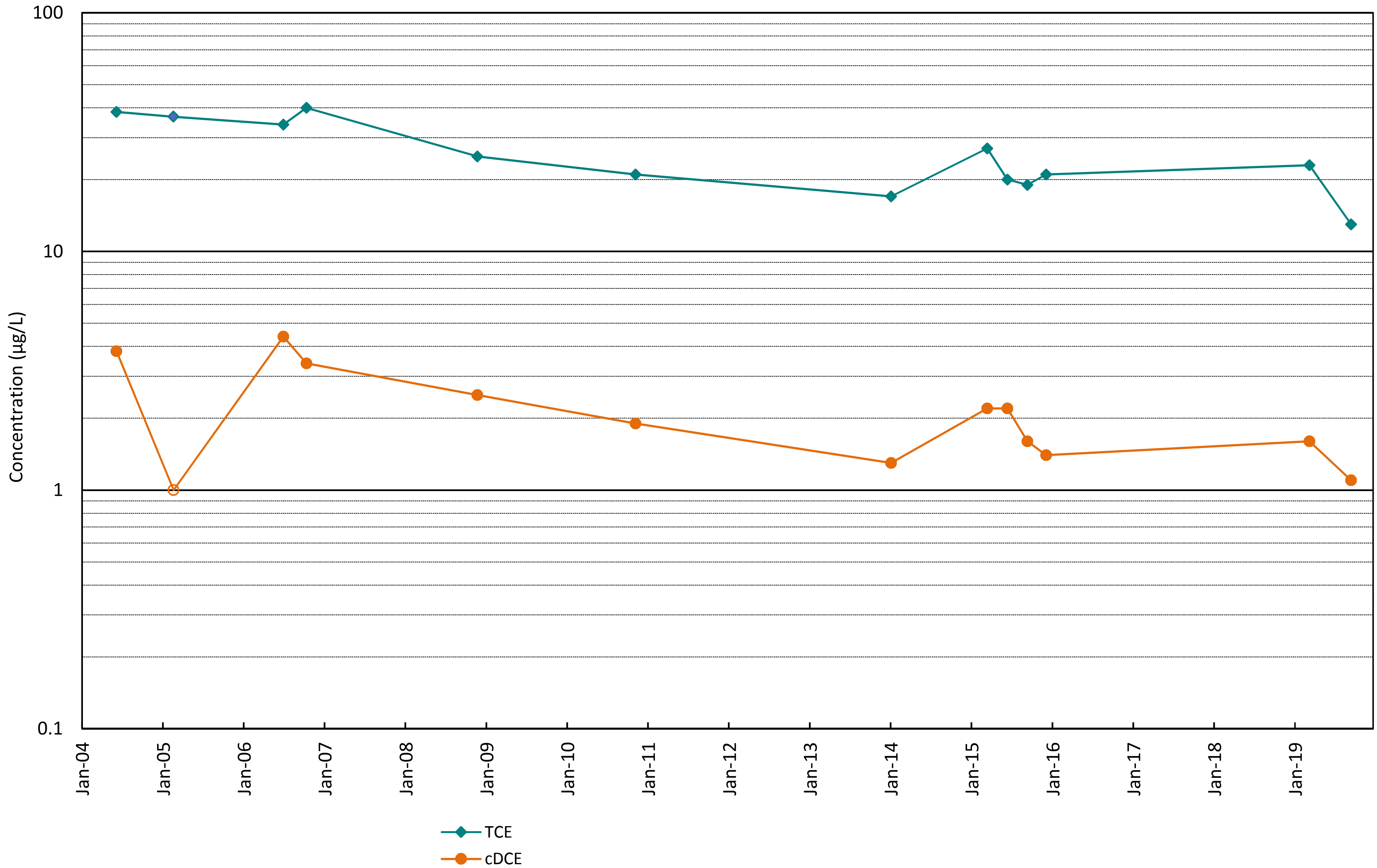

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West Olympia Commercial Property Feasibility Study Olympia, Washington	**LAI-1** **TCE and cDCE Concentrations**	Figure 3-4

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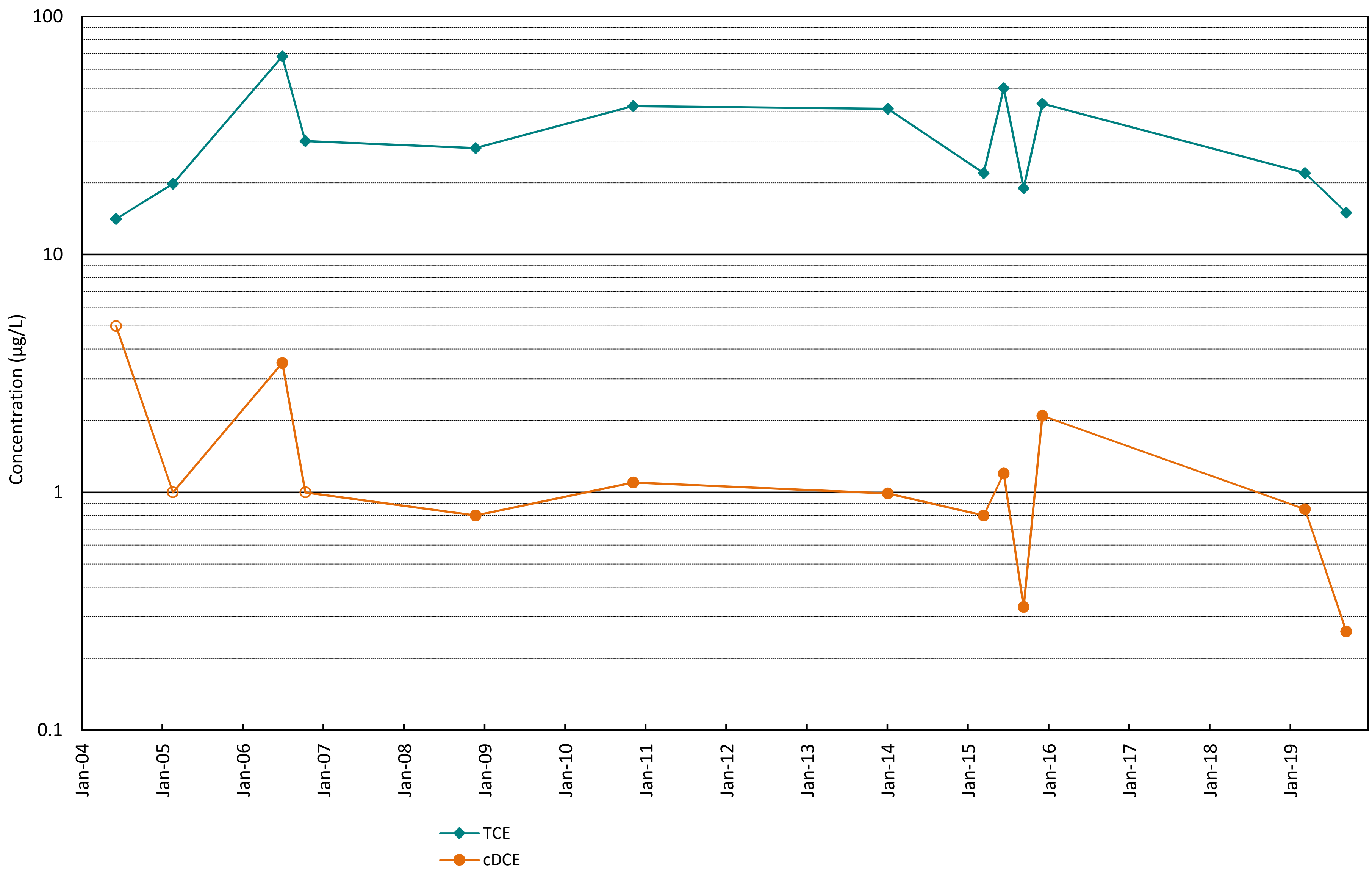

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West Olympia Commercial Property Feasibility Study Olympia, Washington	**LAI-MW-2** **TCE and cDCE Concentrations**	Figure 3-5

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Legend

- Proposed New Well Construction Location
- Existing Monitoring Well
- Off-Property Monitoring Well
- Groundwater pCUL Exceedance
- Well Selected for Continued Monitoring
- Approximate Extent of Waste
- Subject Property

0 200 400

Scale in Feet

Data Source: Thurston County GIS.

Notes

1. pCUL = proposed cleanup level.
2. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Landau Associates

West Olympia Commercial Property
Feasibility Study
Olympia, Washington

Conceptual Monitored Natural Attenuation Alternative (Alternative 1)

Figure
4-1

Legend

- Proposed New Well Construction Location
- Existing Monitoring Well
- Off-Property Monitoring Well
- Groundwater pCUL Exceedance
- Well Selected for Continued Monitoring
- Approximate Extent of Waste
- Subject Property
- EISB Injection Row

0 200 400

Scale in Feet

Data Source: Thurston County GIS.

Notes

1. pCUL = proposed cleanup level.
2. EISB = Enhanced *In Situ* Bioremediation.
3. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

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West Olympia Commercial Property
Feasibility Study
Olympia, Washington

Conceptual Enhanced *In Situ* Bioremediation Alternative (Alternative 2)

Figure 4-2

Legend

- Proposed New Well Construction Location
- Existing Monitoring Well
- Off-Property Monitoring Well
- Groundwater pCUL Exceedance
- Well Selected for Continued Monitoring
- Extraction Wells
- Pipeline, Electrical, and Communication Conduit Alignment
- Effluent Pipeline
- Treatment Building
- Approximate Extent of Waste
- Subject Property

Notes

1. pCUL = proposed cleanup level.
2. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

0 200 400

Scale in Feet

Data Source: Thurston County GIS.

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West Olympia Commercial Property
Feasibility Study
Olympia, Washington

Conceptual Groundwater Extraction Alternative (Alternative 3)

Figure 4-3

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Notes
1. pCUL = proposed cleanup level.
2. IWAS = In-Well Air Stripping
3. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Legend

- Proposed New Well Construction Location
- Existing Monitoring Well
- Off-Property Monitoring Well
- Groundwater pCUL Exceedance
- Well Selected for Continued Monitoring
- IWAS Wells
- Treatment Building
- Vapor Extraction Pipeline and Electrical Conduit Alignment
- Approximate Extent of Waste
- Subject Property

0 200 400
Scale in Feet

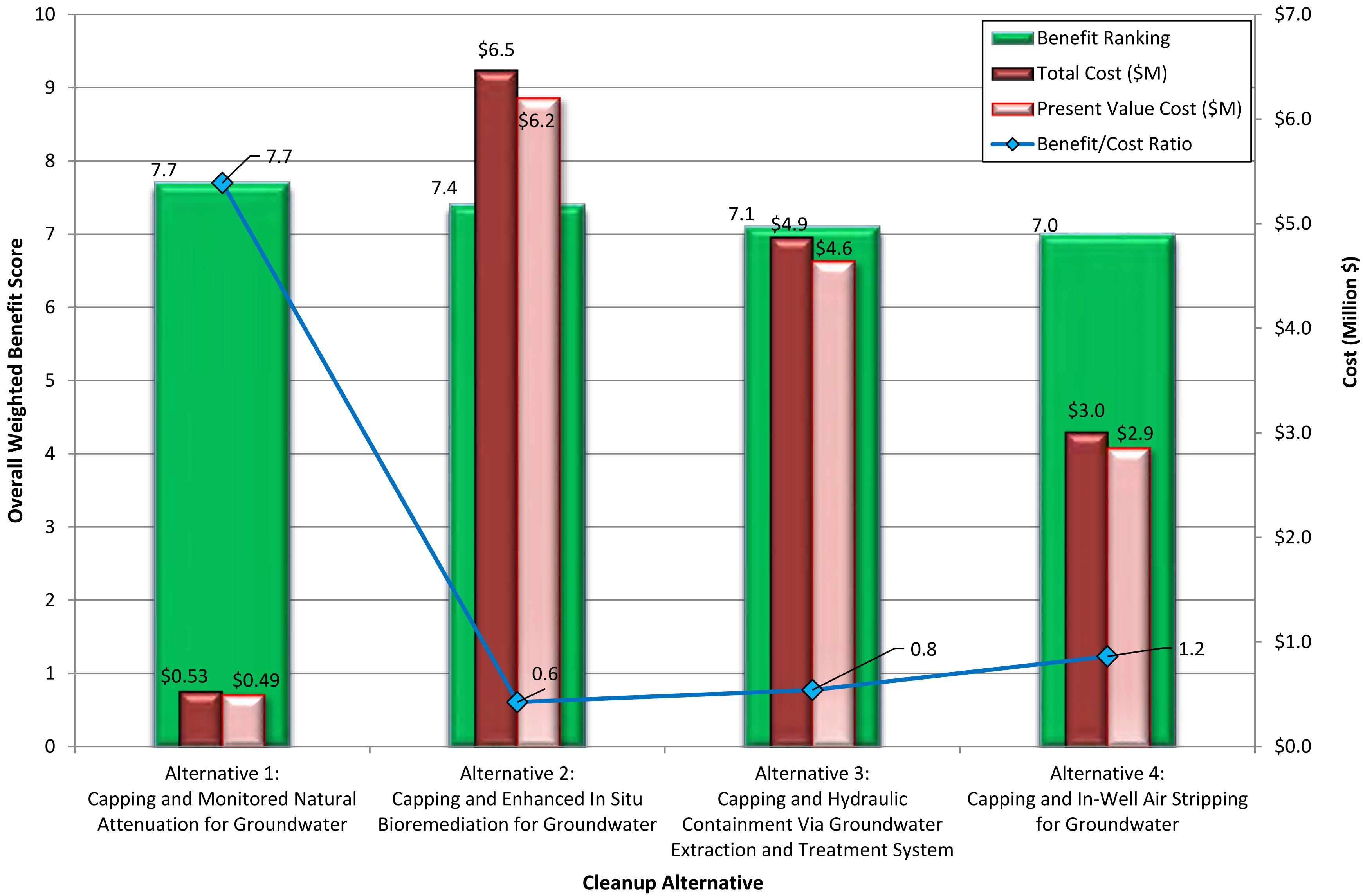
LANDAU ASSOCIATES

Data Source: Thurston County GIS.

West Olympia Commercial Property
Feasibility Study
Olympia, Washington

Conceptual In-Well Air Stripping (Alternative 4)

Figure 4-4



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West Olympia Commercial Property Feasibility Study Olympia, Washington	**Summary of MTCA Alternatives Relative Benefits Ranking**	Figure 5-1

Table 2-1
Applicable or Relevant and Appropriate Requirements
West Olympia Commercial Property
Feasibility Study
Olympia, Washington

ARARs for Development of Cleanup Levels	Source	Description/Rationale
Model Toxics Control Act	WAC 173-340	Establishes administrative processes and standards in Washington State to identify, investigate, and clean up facilities where hazardous substances have come to be located.
Washington State Maximum Contaminant Levels in Drinking Water	WAC 246-290-320	Establishes maximum contaminant levels allowed in public drinking water systems in Washington State.
National Primary Drinking Water Regulations	40 CFR 141	Establishes primary drinking water regulations pursuant to Section 1412 of the Public Health Service Act, as amended by the Safe Drinking Water Act (Pub. L. 93-523), and related regulations applicable to public water systems.
Potential Action-Specific ARARs	**Source**	**Description/Rationale**
Washington Hazardous Waste Management Act and its implementing regulation: Dangerous Waste Regulations	RCW 70.105; WAC 173-303	These regulations establish a comprehensive, statewide framework for the planning, regulation, control, and management of dangerous waste. The regulations designate those solid wastes that are dangerous or extremely hazardous to human health and the environment. The management of contaminated soil excavated from the Site would be conducted in accordance with these regulations to the extent that any dangerous wastes are discovered or generated during the cleanup action.
Washington Solid Waste Management Act and its implementing regulation: Criteria for Municipal Solid Waste Landfills	RCW 70.95; WAC 173-351	These regulations establish a comprehensive, statewide program for solid waste management, including proper handling and disposal. The management of any contaminated soil removed from the Site would be conducted in accordance with these regulations to the extent that this soil could be managed as solid waste instead of dangerous waste.
Hazardous Waste Operations	WAC 296-843	Establishes safety requirements for workers conducting investigation and cleanup operations at sites containing hazardous materials. These requirements would be applicable to onsite cleanup activities, and would be addressed in a Site-specific health and safety plan, prepared specifically for these activities.
State Construction Stormwater General Permit	WAC 173-220	An Ecology-issued Construction Stormwater General Permit is typically required for construction activities that would disturb 1 acre of land or more. A substantive requirement would be to prepare a SWPPP prior to earthwork activities. The SWPPP would document planned procedures designed to prevent stormwater pollution by controlling erosion of exposed soil and containing soil stockpiles and other materials that could contribute pollutants to stormwater.
State Environmental Policy Act	RCW 43.21.036; WAC 173-11-250 through 268	Under SEPA rules, MTCA and SEPA processes are to be combined to reduce duplication and improve public participation (WAC 97-11-250). Ecology is the lead agency for implementing the substantive requirements of SEPA as described in WAC 197-11-253. Ecology is likely to determine that it will act as the lead agency for implementing the requirements of SEPA for cleanup actions at the Site. A SEPA checklist will be completed and attached to the draft Cleanup Action Plan. A determination of non-significance is expected to be issued, as the alternatives evaluated in this FS are unlikely to have a significant adverse environmental impact.
Washington Minimum Standards for Construction and Decommissioning	WAC 173-160-381	Ecology, or its delegated authority, establishes requirements for the installation and decommissioning of monitoring wells.
Electrical Equipment Installations	RCW 19.28	Electrical wiring and equipment may be needed to power active controls and blower motors for GETS and IWAS treatments.
Underground Injection Control Program	WAC 173-218	UIC registration would be required for the injection of any materials below ground surface for the purposes of groundwater cleanup. This would include injection of reducing agents, such as electron donor substrates for bioremediation or reinjection of treated groundwater.
Uniform Environmental Covenants Act	RCW 64.70	Regulation that addresses recording environmental covenants on the West Olympia Commercial Property. Institutional controls; an environmental covenant will be a required element of the final remedy selected.
Right-of-Way Use and Construction	OlyMC Chapter 11.12.000	Requires a written permit for any proposed activities that use ROW, including construction activities and movement of equipment. Installation of additional wells may be required in ROWs.
Fire Hydrant Access	OlyMC Chapter 13.04.410	Specifies an application and approval process for connecting to the City of Olympia water supply system. Fire hydrant access may be needed for injections.
Environmentally Critical Areas	OlyMC Chapter 18.32.000	Specifies development standards for actions affecting environmentally critical areas, including wellhead protection areas, streams and riparian zones, wetlands, geological hazard areas, landslide areas, and erosion or seismic hazard areas.

Abbreviations and Acronyms:
ARAR = applicable or relevant and appropriate requirement
CFR = Code of Federal Regulations
Ecology = Washington State Department of Ecology
FS = feasibility study
GETS = groundwater extraction and treatment system
IWAS = in-well air stripping
MTCA = Model Toxics Control Act
OlyMC = City of Olympia Municipal Code
RCW = Revised Code of Washington
ROW = right-of-way
SEPA = State Environmental Policy Act
Site = West Olympia Commercial Property
SWPPP = stormwater pollution prevention plan
UIC = underground injection control
USC = United States Code
WAC = Washington Administrative Code

Table 2-2
Proposed Cleanup Levels
West Olympia Commercial Property
Feasibility Study
Olympia, Washington

Indicator Hazardous Substances – Soil	RI Soil SL (mg/kg)	Method A for Soil Unrestricted Land Use (mg/kg)	Soil pCUL (mg/kg)
Chromium III / Total	48	2,000	2,000
Lead	220	250	250

Indicator Hazardous Substances – Groundwater	RI Groundwater SL (µg/L)	Method A for Groundwater (µg/L)	Groundwater pCUL (µg/L)
Trichloroethene	0.54	5.0	5.0

Abbreviations and Acronyms:

µg/L = micrograms per liter
mg/kg = milligrams per kilogram
pCUL = proposed cleanup level
RI = remedial investigation
SL = screening level

Table 3-1
Soil Indicator Hazardous Substance Results
West Olympia Commercial Property
Feasibility Study
Olympia, Washington

Exploration Location	Sample Date	Media	Depth (ft bgs)	Metals (a) (mg/kg)	
				Chromium	Lead
LAI-4	9/7/2000	Waste	7.5–9	**50**	**1,300**
		Soil	15–15.5	**26.8**	**29**
LAI-5	9/7/2000	Soil	25–26	**50**	**391**
LAI-5d	9/26/2005	Soil	21–23	**18.9**	**2.04**
			31–33	**18.8**	**1.85**
			48–50	**27.5**	**1.77**
LAI-6	9/6/2000	Waste	5–6	**25.1**	**988**
LAI-7	9/7/2000	Soil	17.5–19	**88**	**501**
LAI-8	9/7/2000	Waste	7.5– 9	**51**	**256**
			10–11.5	**63**	**1,070**
LAI-9	9/6/2000	Waste	5.5–6.5	**79**	**2,630**
			7.5– 9	**30.5**	**78**
			10–11	**33.2**	**194**
LAI-10	9/7/2000	Waste	5–5.5	**66**	**1,460**
			7.5–8	**49**	**343**
LAI-11	9/8/2000	Waste	7.5–9	**62**	**1,140**
			10.5–11	**29.7**	**98**
		Soil	17.5–19	**26.1**	**4**
LAI-13	9/6/2000	Waste	8–9	**89**	**2,330**
LAI-14	9/8/2000	Waste	7.5–9	**3,210**	**1,330**
			10.5–11	**66**	**720**
LAI-15	9/8/2000	Waste	2.5–7.5	**29.9**	**22**
		Soil	22.5–24	**54.5**	**13**
LAI-17	9/6/2000	Waste	7.5–8.5	**58**	**978**
		Soil	16–16.5	**23.9**	**35**
LAI-18	9/11/2000	Waste	7.5–8	**90**	**1,230**
		Soil	13–14	**27.5**	**6**
LAI-19	9/8/2000	Waste	2.5–7.5	**30.4**	**60**
		Soil	20.5–25	**25.1**	**3**
			pCUL	2000	250

Notes:

(a) Total metals analyzed by EPA 6010.
Bold text indicates detected analyte.
Green shading indicates that analyte exceeds applicable soil pCUL.

Abbreviations and Acronyms:

bgs = below ground surface
EPA = U.S. Environmental Protection Agency
ft = feet
mg/kg = milligrams per kilogram
pCUL = proposed cleanup level

Table 3-2
Groundwater Indicator Hazardous Substances Results
West Olympia Commercial Property
Feasibility Study
Olympia, Washington

Exploration Location	Sample Date	TCE (µg/L)
LAI-1	1/15/2014	**17**
	3/25/2015	**27**
	6/24/2015	**20**
	9/23/2015	**19**
	12/16/2015	**21**
	3/20/2019	**23**
	9/24/2019	**13**
LAI-2	1/14/2014	**1.1**
	3/21/2019	**2.6**
	9/24/2019	**0.58**
LAI-3	1/13/2014	0.5 U
	3/22/2019	0.20 U
	9/23/2019	0.20 U
LAI-5d	1/15/2014	0.5 U
	3/28/2019	0.20 U
	9/25/2019	0.20 U
LAI-MW-1	1/13/2014	0.5 U
	3/22/2019	0.20 U
	9/24/2019	0.20 U
LAI-MW-2	1/15/2014	**41**
	3/26/2015	**22**
	6/24/2015	**50**
	9/23/2015	**19**
	12/16/2015	**43**
	3/21/2019	**22**
	9/24/2019	**15**
LAI-MW-3	1/14/2014	0.5 U
	3/22/2019	0.20 U
	9/23/2019	0.20 U
LAI-MW-4	1/13/2014	0.5 U
	3/21/2019	**0.27**
	9/24/2019	0.20 U
MW-23	1/23/2014	0.5 U
	3/19/2019	0.20 U
	9/23/2019	0.20 U
OLY-01	3/25/2015	0.5 U
	6/24/2015	0.5 U
	9/23/2015	0.5 U
	12/16/2015	**0.11 J**
	3/21/2019	0.20 U
	9/23/2019	0.20 U

Table 3-2
Groundwater Indicator Hazardous Substances Results
West Olympia Commercial Property
Feasibility Study
Olympia, Washington

Exploration Location	Sample Date	TCE (µg/L)
OLY-02	3/25/2015	**2.6**
	6/24/2015	**2.8**
	9/23/2015	**4.5**
	12/17/2015	**6.1**
	3/21/2019	**2.8**
	9/25/2019	**4**
PGG-1	1/14/2014	**0.27 J**
	3/20/2019	**0.29**
	9/25/2019	**0.42**
PGG-2 (a)	1/14/2014	0.5 U
	3/21/2019	0.20 U
	pCUL	5

Notes:
(a) A sample was not collected from PGG-2 in September 2019, because the well ran dry.
Bold text indicates detected analyte.
Green shading indicates that detected analyte exceeds applicable pCUL.
J = The result is an estimated quantity. The associated numerical value is the approximate concentration of the analyte in the sample.
U = The analyte was analyzed for, but was not detected above the level of the reported sample quantitation limit.

Abbreviations and Acronyms:
µg/L = micrograms per liter
pCUL = proposed cleanup levels
TCE = trichloroethene

Table 3-3
Natural Attenuation Assessment Results
West Olympia Commercial Property
Feasibility Study
Olympia, Washington

Sample Location	**Sample Date**	**Volatile Organic Compounds (µg/L)**									**Aquifer Redox Conditions**							**Electron Donor Indicator**
		PCE (µg/L)	TCE (µg/L)	cDCE (µg/L)	tDCE (µg/L)	1,1-DCE (µg/L)	VC (µg/L)	Ethene (µg/L)	Ethane (µg/L)	Acetylene (µg/L)	DO (mg/L)	ORP (mV)	Nitrate (mg/L as N)	Iron II (mg/L)	Sulfate (mg/L)	Methane (µg/L)	Aquifer Redox State	TOC (mg/L)
LAI-1	9/24/2019	<0.20	**13**	**1.1**	<0.20	<0.20	<0.20	<1.14	<1.23	<1.06	6.88	-40.5	2.3	0	71	<0.65	Aerobic	1.6
LAI-2	9/24/2019	<0.20	**0.58**	<0.20	<0.20	<0.20	<0.20	<1.14	<1.23	<1.06	9.58	-41.3	0.81	0	19	<0.65	Aerobic	<1.0
LAI-MW-2	3/21/2019	<0.20	**22**	**0.85**	<0.20	<0.20	<0.20	<0.50	<0.50	--	5.1	230.1	2.0	--	55	<1.0	Aerobic	<1.0
LAI-MW-2	9/24/2019	<0.20	**15**	**0.26**	<0.20	<0.20	<0.20	<1.14	<1.23	<1.06	5.58	-35.9	2.5	0	32	<0.65	Aerobic	<1.0
LAI-MW-4	9/24/2019	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<1.14	<1.23	<1.06	3.58	-45.4	2.0	0	66	<0.65	Aerobic	1.8
OLY-02	3/21/2019	<0.20	**2.8**	<0.20	<0.20	<0.20	<0.20	<0.50	<0.50	--	5.09	217.4	1.7	--	12	<1.0	Aerobic	<1.0
OLY-02	9/25/2019	<0.20	**4**	<0.20	<0.20	<0.20	<0.20	<1.14	<1.23	<1.06	7.93	-40.2	1.5	0	25	<0.65	Aerobic	<1.0

Notes:
-- = Not analyzed
Bold text indicates detected analyte.

Abbreviations and Acronyms:
1,1-DCE = 1,1-dichloroethene
cDCE = cis-1,2-dichloroethene
DO = dissolved oxygen
µg/L = micrograms per liter
mg/L = milligrams per liter
mV = millivolt
ORP = oxidation reduction potential
PCE = tetrachloroethene
TCE = trichloroethene
tDCE = trans-1,2-dichloroethene
TOC = total organic carbon
VC = vinyl chloride

Table 4-1
Groundwater Technology Screening
West Olympia Commercial Property
Feasibility Study
Olympia, Washington

Please see Notes and Abbreviations/Acronyms at the end of the table.

General Response Actions	Technology Option	Technology Description	General Benefits/Limitations	Likely Effectiveness	Implementability at Site	Relative Cost	Screening Result Retain/Reject
Institutional Controls	Restrictive environmental covenant, signage, access agreements	Limits use/access to groundwater.	**Benefits**: Restrict use of/exposure to contaminated groundwater. Require engineering controls or signage. **Limitations:** Not a standalone remedy. Does not provide treatment. Access to downgradient properties for groundwater monitoring would be required until groundwater is restored to cleanup levels. May require agreement from third parties for off-property groundwater monitoring.	**Moderate** Effective for limiting exposure to contaminated media. Not effective as a standalone solution for this Site, but can be combined with other technologies to make more protective.	**Easy** Restrictive environmental covenant will already be implemented for soil as part of the Interim Action Plan; can add groundwater use limitations. Would require Ecology approval to add a groundwater conditional point of compliance.	**Direct: Low** **Long Term - OMM: Low** **Overall: Low**	**Retain (included with other technologies)**
Containment (hydraulic)	Contaminated groundwater capture/control	Interceptor trench or extraction wells along downgradient property line to control/minimize migration of contaminated groundwater off property.	**Benefits:** Reliably minimize further migration of contamination beyond Site boundaries. Extracted groundwater may be discharged to sanitary sewer if approved by local POTW (may require pre-treatment), or treated and reinjected to enhance containment and/or groundwater flushing. **Limitations:** *Ex situ* treatment may be needed; does not treat downgradient plume. Engineering constraints limit the depth of treatment. Potential to cause ground/waste settlement and damage to nearby buildings, utilities, and other infrastructure in areas with poor soils and high water tables. In reduced aquifers, potential for biofouling; high extraction rates needed in aquifers with relatively high hydraulic conductivity; need for discharge permits to discharge large volume of water to sewer or surface water; larger treatment system footprint than *in situ* technologies. To address all applicable migration pathways and receptors, would be required to be performed with interim action capping and soil vapor control.	**Moderate to Low** Can be very effective at containing groundwater contaminant migration, but not effective in achieving groundwater cleanup levels. Limited ability to affect deeper portions of the aquifer.	**Difficult** Depth of treatment needed is not conducive for interceptor trenches. Excessive pumping/discharge rates needed to capture groundwater due to high seepage velocity and aquifer thickness. Buildings, utilities, and other infrastructure may limit or prohibit extraction in "ideal" locations.	**Direct: High** **Long Term - OMM: Low** **Overall: High**	**Retain**
In Situ Biological Treatment	Enhanced Bioremediation	Injection of electron donor in linear series of injection wells along property boundary for biologically mediated reductive dechlorination.	**Benefits:** Treat groundwater at multiple depths; can use injection locations to create overlap between wells (overlapping treatment zones form a treatment barrier). **Limitations:** Limited downgradient treatment zone. Potential to increase VC concentrations downgradient. (VC is a more toxic byproduct of TCE degradation.) Possible recontamination from upgradient source areas. To address all applicable migration pathways and receptors, would be required to be performed with interim action capping and soil vapor control.	**Moderate to Low** Effectiveness is dependent on ability to inject and distribute electron donor into impacted groundwater zones. Treatment of cVOCs in Qga aquifer likely to be very effective; treatment of discontinuous/perched groundwater zones likely to be less effective.	**Moderate** Requires engineering; well installation; injection fluid, labor, and equipment for multiple injections. Ability to treat all impacted perched groundwater zones not likely to be feasible. Long-term groundwater monitoring required.	**Direct: High** **Long Term - OMM: Low** **Overall: Moderate to High**	**Retain**
	MNA with site capping	Natural processes attenuate VOC contamination in groundwater. Monitored through periodic groundwater sampling.	**Benefits:** Natural treatment of entire plume (both vertical and horizontal); eventual *in situ* destruction of contaminants. Can be combined with other technologies. Low cost of implementation. **Limitations:** Variable degradation rates; longer restoration time frame than more active alternatives. To address all applicable migration pathways and receptors, would be required to be performed with interim action capping and soil vapor control.	**Low** Effectiveness of MNA is dependent on redox conditions. Site data indicate that the local aquifer is primarily aerobic, which is generally not conducive for cleanup of cVOCs; however, the presence of cDCE suggests that some natural attenuation is occurring at the Site.	**Easy** Groundwater cVOC and MNA parameters can easily be monitored in Site monitoring wells.	**Direct: Low** **Long Term - OMM: Low** **Overall: Low**	**Retain**
In Situ Physical/Chemical Treatment	In-Well Air Stripping	Air stripping of recirculated groundwater within well causing localized groundwater treatment through a series of wells along the property boundary.	**Benefits:** Provides active in-place treatment; requires minimal *ex situ* infrastructure and no discharge/disposal of treated water. Can be used for barrier to minimize migration or to treat large portions of contaminant plume. **Limitations:** Does not treat downgradient plume; unlikely to be feasible for shallow perched groundwater zones; limited by radius of influence of each individual treatment well.	**Moderate to Low** Can be very effective at minimizing groundwater contaminant migration and localized treatment, but not effective if achieving Site-wide groundwater cleanup levels.	**Moderate to Difficult** Could be moderately easy if used as barrier technology on downgradient property line. Unlikely to work well for discontinuous/perched groundwater zones. Much more difficult to implement for large- scale plume treatment.	**Direct: Moderate** **Long Term - OMM: Moderate** **Overall: Moderate**	**Retain**
In Situ Physical/Chemical Treatment (continued)	AS with overlying SVE in vadose zone (AS/SVE)	Injecting air directly into groundwater and extracting air/contaminant vapor in the vadose zone to remove VOCs.	**Benefits:** Technology is well-documented for treating VOCs. Permanently removes volatile contaminants from soil and groundwater. Removal rates are relatively fast. Addresses soil vapor concerns. **Limitations:** May reduce existing potential for natural reductive dechlorination in zones treated. Depth limited by engineering/technology constraints. Preferential flow paths may limit complete cleanup of impacted soil/groundwater in lower permeability zones.	**Moderate to Low** Effectiveness is dependent on ability to inject air into impacted groundwater zones. Treatment of cVOCs in Qga aquifer likely to be reasonably effective; treatment of discontinuous/perched groundwater zones likely to be much less effective. SVE can treat soil, but highly susceptible to short circuiting in heterogeneous waste deposits.	**Difficult** Depth of treatment required at property boundary is not conducive to AS/SVE. Would require downgradient monitoring and extraction of soil vapor; access to adjacent property has not been gained. Ensuring vapors captured before reaching adjacent residences difficult.	**Direct: High** **Long Term - OMM: Moderate** **Overall: Moderate to High**	Reject

Table 4-1
Groundwater Technology Screening
West Olympia Commercial Property
Feasibility Study
Olympia, Washington

General Response Actions	Technology Option	Technology Description	General Benefits/Limitations	Likely Effectiveness	Implementability at Site	Relative Cost	Screening Result Retain/Reject
In Situ Physical/Chemical Treatment (continued)	Chemical reductive treatment PRB via injected media (reductants; e.g., zero valent iron)	*In situ* emplacement of reactive reducing materials through which dissolved contaminant plume travels.	**Benefits:** Passive treatment requiring little maintenance; can treat groundwater at multiple depths; can target wide range of contaminants. **Limitations:** Temporary treatment—typically requires refreshing barrier periodically; fast seepage velocities increase the width of required treatment, and may reduce the duration of effective treatment; potential for biofouling, clogging of aquifer matrix.	**Moderate to Low** Effectiveness is dependent on ability to inject oxidants in treatment zone. Does not treat source of contamination, but is periodically reinjected until contamination is no longer detected.	**Difficult** Depth and discontinuous nature of groundwater contamination is not conducive to injected PRB application, especially with no source treatment occurring.	**Direct: High** **Long Term - OMM: Low** **Overall: Moderate to High**	Reject
	Chemical oxidative treatment PRB via injected media (oxidants; e.g., persulfate or permanganate)	*In situ* emplacement of reactive oxidizing materials through which dissolved contaminant plume travels.	**Benefits:** Smaller construction footprint for installation than an emplaced PRB; can target multiple depths; ability to vary reagent. **Limitations:** Mass loading may be excessive in reduced or organic carbon-rich aquifers with high seepage velocity, and will reduce longevity and effectiveness; oxidative potential generally inverse to longevity of treatment; typically requires repeated injections. Oxidants typically have shorter life span than reductants.	**Moderate to Low** Effectiveness is dependent on ability to inject oxidants in treatment zone. Does not treat source of contamination, but is periodically reinjected until contamination is no longer detected.	**Difficult** Depth and discontinuous nature of groundwater contamination is not conducive to injected PRB application, especially with no source treatment occurring.	**Direct: High** **Long Term - OMM: Low** **Overall: Moderate to High**	Reject
	ISCO or ISCR	Placing chemicals *in situ* to either oxidize or reduce contaminants in groundwater.	**Benefits:** Active treatment of contaminants in place; can treat groundwater at multiple depths; can target wide range of contaminants. **Limitations:** Mass loading for oxidants may be excessive in reduced or organic carbon-rich aquifers with high seepage velocity, and will reduce longevity and effectiveness; oxidative potential generally inverse to longevity of treatment; typically requires repeated injections. Treatment only occurs with direct contact to contaminant.	**Moderate to Low** Effectiveness is dependent on ability to inject and distribute chemical oxidants/reductants into impacted groundwater zones. Treatment generally limited to areas immediately around injection sites. Treatment of cVOCs in Qga aquifer likely to be minimally effective around injection sites; treatment of discontinuous/perched groundwater zones likely to be negligible.	**Difficult** Depth and discontinuous nature of contaminants requiring treatment, with poorly defined boundaries, not conducive to ISCO or ISCR.	**Direct: High** **Long Term - OMM: Low** **Overall: Moderate to High**	Reject
	Thermal treatment	Using various methods to heat soil and shallow groundwater to high temperatures. Heat vaporizes chemicals, which are captured and removed for *ex situ* treatment.	**Benefits:** Removal of contaminants through volatilization and abiotic transformation; does not directly influence redox conditions. Treatment effectiveness not limited by low permeability zones. Can achieve low cleanup levels. Residual heat can temporarily enhance natural attenuation/bioremediation. Can address groundwater, soil, and soil vapor concerns. **Limitations:** Energy-intensive, requires extensive aboveground infrastructure, typically most effective in source zones only. Infeasible for treatment of downgradient plume.	**Low** Effectiveness is dependent on ability to transfer enough heat to groundwater to vaporize COCs. Due to historical diffuse source, may not be effective at downgradient part of the landfill.	**Difficult** Depth of treatment required at property boundary and downgradient areas, combined with relatively low contaminant concentrations, are not conducive to thermal treatment; energy demands would be excessive due to high seepage velocity and aquifer thickness; potential to damage adjacent utilities.	**Direct: Very High** **Long Term - OMM: Low** **Overall: High**	Reject
Ex Situ Physical/Chemical Treatment	Pump and treat (various *ex situ* treatment options)	Groundwater is pumped from wells throughout plume or source area to an aboveground treatment system that removes contaminants.	**Benefits:** Partial capture and minimization of migration of contamination beyond Site boundaries. Complete treatment of extracted groundwater. Moderately enhances groundwater flushing. **Limitations:** *Ex situ* treatment needed; can only treat portions of plume where extraction wells can be installed. Potential to cause ground/waste settlement and damage to nearby buildings, utilities, and other infrastructure in areas with poor soils and high water tables. In reduced aquifers, potential for biofouling; high extraction rates needed in aquifers with relatively high hydraulic conductivity; need for discharge permits to discharge large volume of water to sewer or surface water; larger treatment system footprint than *in situ* technologies. To address all applicable migration pathways and receptors, would be required to be performed with interim action capping and soil vapor control.	**Moderate to Low** Can be very effective at containing groundwater contaminant migration, and reducing contaminant concentrations, but not effective for achieving low groundwater cleanup levels.	**Difficult** Depth of treatment required and relatively high hydraulic conductivity will result in high number of wells, extraction and treatment rates, and disposal/discharge rates. Will likely require operation for many decades.	**Direct: High** **Long Term - OMM: Moderate** **Overall: High**	Reject
Ex Situ Physical/Chemical Treatment (continued)	Excavation	Offsite disposal of landfill material at permitted/engineered landfill.	**Benefits:** Permanently removes waste and sources of ongoing groundwater and soil gas contamination. No long-term O&M. **Limitations:** Very large and disruptive construction project. Likely prohibitively costly. Does not directly address groundwater impacts.	**High** Permanently removes wastes and contaminant sources. Will likely speed up groundwater restoration.	**Difficult** Requires large-scale excavation in residential neighborhood; health and safety concerns with landfill gas; odor control issues; requires approval for disposal at permitted landfill; large-scale hauling operations.	**Direct: Very High** **Long Term - OMM: Low** **Overall: High**	Reject

Table 4-1
Groundwater Technology Screening
West Olympia Commercial Property
Feasibility Study
Olympia, Washington

General Response Actions	Technology Option	Technology Description	General Benefits/Limitations	Likely Effectiveness	Implementability at Site	Relative Cost	Screening Result Retain/Reject
Enhanced Groundwater Flushing	Dynamic groundwater recirculation	Groundwater extraction and reinjection at multiple locations across the Site to enhance groundwater flushing and contaminant removal across multiple flow channels.	**Benefits:** Complete treatment of extracted groundwater. Potential to vary groundwater flow paths and remove contaminants from zones of lower hydraulic conductivity. Faster restoration time than pump-and-treat. Likely to be able to fully restore groundwater in treatment zone. **Limitations:** Would require aboveground treatment before reinjection; potential to cause ground/waste settlement and damage to nearby buildings, utilities, and other infrastructure in areas with poor soils and high water tables. In reduced aquifers, potential for biofouling increases OMM cost; larger treatment system footprint than *in situ* technologies. Does not treat downgradient plume or address soil and soil vapor concerns.	**Moderate to Low** Effectiveness in highly transmissive aquifers may be difficult due to large volumes of water that must be extracted and injected to achieve significant changes in groundwater flow paths. More effective than pump-and-treat.	**Difficult** For highly transmissive aquifers, volumes of water that must be extracted, treated, and injected to achieve changes in flow directions necessary to fully flush aquifer may require high density of wells and multiple screened intervals to effectively achieve treatment goals.	**Direct: High** **Long Term - OMM: High** (but potentially shorter life span than pump-and-treat) **Overall: High**	Reject
Containment (physical)	Slurry walls, low-permeability barrier walls, or sheet pile walls	Isolates contamination by emplacing barriers around contaminated areas.	**Benefits:** Contains or slows contaminated groundwater from moving off site. **Limitations:** Does not provide treatment; not a permanent remedy. Typically has low effectiveness in aquifers with high seepage velocities. Engineering constraints limit depth of barrier. May require hydraulic capture element to supplement barrier.	**Low** Not effective to contain contaminant plume with a physical barrier alone due to seepage velocities and aquifer thickness.	**Difficult** Not feasible to contain contaminant plume with a physical barrier alone due to seepage velocities and aquifer thickness.	**Direct: High** **Long Term - OMM: Low** **Overall: High**	Reject

Notes:

Shaded cells indicate retained technology.

Abbreviations and Acronyms:

AS = air sparge
cDCE = cis-1,2-dichloroethene
COC = constituent of concern
cVOC = chlorinated volatile organic compound
Ecology = Washington State Department of Ecology
ISCO = *in situ* chemical oxidation
ISCR = *in situ* chemical reduction
MNA = monitored natural attenuation
O&M = operations and maintenance
OMM = operations, maintenance, and monitoring
POTW = publicly owned treatment works
PRB = permeable reactive barrier
SVE = soil vapor extraction
TCE = trichloroethene
VC = vinyl chloride
VOC = volatile organic compound

Table 4-2
Remedial Action Alternatives
West Olympia Commercial Property
Feasibility Study
Olympia, Washington

Alternative Number:	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Alternative Name:	Capping and MNA	Capping and Enhanced *In Situ* Bioremediation	Capping and Hydraulic Control via Groundwater Extraction	Capping and In-Well Air Stripping
Alternative Description:	Containment of soil and soil gas via capping and MNA of groundwater, including: • Containment of contaminated soil by installing the asphalt/concrete as part of property development as described in the Interim Action Plan. Routine inspection and reporting of containment. • Remediation of groundwater through naturally occurring biotic and abiotic degradation and other attenuation processes (MNA). Continued monitoring with routine groundwater sampling. • Institutional controls consisting of an environmental covenant to limit activities that could result in exposure to soil. The covenant would outline the required continued maintenance for the cap over soil concentrations exceeding CULs protective of groundwater.	Containment of soil and *in situ* groundwater treatment by creating a PRB at the landfill property boundary, including: • Containment of contaminated soil by installing the asphalt/concrete as part of property development as described in the Interim Action Plan. Routine inspection and reporting of containment. • *In situ* groundwater treatment along the northern landfill boundary using an EISB PRB installed via injection (*conceptual design: 400-foot-long injection row with 17 injection well pairs [wells screened from 60 to 80 ft bgs and from 90 to 110 bgs to span the 60-ft-thick, saturated aquifer] for a total of 34 injection wells, will consist of 12 injection events performed every year for the first 3 years, every other year for the next 6 years, and then every 3 years to provide a permeable reactive barrier to last 30 years).* • Institutional controls consisting of an environmental covenant to limit activities that could result in exposure to soil. The covenant would outline the required continued maintenance for the cap over soil concentrations exceeding CULs protective of groundwater.	Containment of landfill waste and soil via capping and hydraulic control of contaminated groundwater using a groundwater extraction and treatment system, including: • Containment of contaminated soil by installing the asphalt/concrete as part of property development as described in the Interim Action Plan. Routine inspection and reporting of containment. • Groundwater extraction and treatment to contain and treat TCE-contaminated groundwater (*conceptual design: 400-ft-long capture area with 5 extraction wells and groundwater treatment achieved via diffused aeration to operate for 30 years*). • Institutional controls consisting of an environmental covenant to limit activities that could result in exposure to soil. The covenant would outline the required continued maintenance for the cap over soil concentrations exceeding CULs protective of groundwater.	Containment of landfill waste and soil via capping and treatment of TCE in groundwater using in-well air stripping technology, including: • Containment of contaminated soil by installing the asphalt/concrete as part of property development as described in the Interim Action Plan. Routine inspection and reporting of containment. • In-well air stripping to provide *in situ* treatment of TCE- contaminated groundwater at the property boundary (*conceptual design: 5 wells spaced 75 ft apart, OMM for 30 years*). • Institutional controls consisting of an environmental covenant to limit activities that could result in exposure to soil. The covenant would outline the required continued maintenance for the cap over soil concentrations exceeding CULs protective of groundwater.
Point of Compliance - Soil:	Standard; Site-wide (with institutional controls for residual soil contamination)	Standard; Site-wide (with institutional controls for residual soil contamination)	Standard; Site-wide (with institutional controls for residual soil contamination)	Standard; Site-wide (with institutional controls for residual soil contamination)
Point of Compliance - Groundwater:	Conditional Point of Compliance at the Property Boundary	Conditional Point of Compliance at the Property Boundary	Conditional Point of Compliance at the Property Boundary	Conditional Point of Compliance at the Property Boundary

Abbreviations and Acronyms:
bgs = below ground surface
CUL = cleanup level (specifically referencing general MTCA cleanup levels rather than proposed cleanup levels developed as part of the feasibility study)
EISB = enhanced *in situ* bioremediation
ft = feet
MNA = monitored natural attenuation
MTCA = Model Toxics Control Act
OMM = operations, maintenance, and monitoring
pCUL = proposed cleanup level
PRB = permeable reactive barrier
TCE = trichloroethene

Table 5-1
Summary of Remedial Alternatives Compliance with MTCA Threshold Requirements
West Olympia Commercial Property
Feasibility Study
Olympia, Washington

Alternative Number:	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Description:	Capping and MNA of Groundwater	Capping and EISB of Groundwater	Capping and Hydraulic Control via GETS	Capping and IWAS for Groundwater
Compliance with MTCA Threshold Criteria (WAC 173-340-360[2][a])				
Protect human health and the environment.	**Yes** - Alternative will protect human health and the environment through remediation of contaminated groundwater.	**Yes** - Alternative will protect human health and the environment through treatment and remediation of contaminated groundwater.	**Yes** - Alternative will protect human health and the environment through containment, treatment, and remediation of contaminated groundwater.	**Yes** - Alternative will protect human health and the environment through treatment and remediation of contaminated groundwater.
Comply with cleanup standards (WAC 173-360-700 through 760).	**Yes** - Groundwater complies with pCULs after cleanup remedy is completed.			
Comply with applicable state/federal laws (WAC 173-360-710).	**Yes** - Alternative complies with applicable laws (see FS Report Section 3.0).			
Provide for compliance monitoring (WAC 173-360-410).	**Yes** - Alternative includes provisions for compliance monitoring (i.e., long-term routine groundwater monitoring).	**Yes** - Alternative includes provisions for compliance monitoring (H&S monitoring during construction/O&M, groundwater confirmation monitoring).	**Yes** - Alternative includes provisions for compliance monitoring (H&S monitoring during construction, and groundwater confirmation monitoring).	**Yes** - Alternative includes provisions for compliance monitoring (H&S monitoring during construction, and groundwater confirmation monitoring).
Compliance with other requirements (WAC 173-340-360[2][b])				
Permanent Solutions to the Maximum Extent Practicable (WAC 173-340-360[3])				
Permanent to the maximum extent practicable.	**Yes** - See Disproportionate Cost Analysis (Table 5-2 of this FS Report).			
Reasonable Restoration Time Frame (WAC 173-340-360[4][b])				
Provide for a reasonable restoration time frame.	**No** - Estimated restoration time frame for TCE in groundwater is approximately **30 years.** Although 30 years could be considered reasonable (see factors below), Ecology has indicated that it is uncertain that the cleanup levels can be achieved in this time frame under this alternative.	**No** - Estimated restoration time frame for TCE in groundwater is approximately **30 years** for design construction, implementation, and monitoring. Although 30 years could be considered reasonable (see factors below), Ecology has indicated that it is uncertain that the cleanup levels can be achieved in this time frame under this alternative.	**No** - Estimated restoration time frame for TCE in groundwater is approximately **30 years** for design construction, implementation, and monitoring. Although 30 years could be considered reasonable (see factors below), Ecology has indicated that it is uncertain that the cleanup levels can be achieved in this time frame under this alternative.	**No** - Estimated restoration time frame for TCE in groundwater is approximately **30 years** for design construction, implementation, and monitoring. Although 30 years could be considered reasonable (see factors below), Ecology has indicated that it is uncertain that the cleanup levels can be achieved in this time frame under this alternative.
Potential risk to human health and environment (a).	**Low** - Contaminated groundwater is not being used as drinking water. Soil and waste material will be capped to prevent risks to human health and the environment.			
Practicability of achieving shorter restoration time frame.	See Disproportionate Cost Analysis (Table 5-2 of this FS Report).			
Current use of Site, surrounding area, and associated resources that are, or may be, affected by releases from the Site.	Onsite: Vacant, Former landfill Surrounding areas: Residential, commercial Resources: None			
Potential future use of Site, surrounding area, and resources that are, or may be, affected by releases from the Site.	Onsite: Commercial Surrounding areas: Residential, commercial Resources: Drinking water			

Table 5-1
Summary of Remedial Alternatives Compliance with MTCA Threshold Requirements
West Olympia Commercial Property
Feasibility Study
Olympia, Washington

Alternative Number:	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Description:	Capping and MNA of Groundwater	Capping and EISB of Groundwater	Capping and Hydraulic Control via GETS	Capping and IWAS for Groundwater
Availability of alternative water supplies.	**Yes -** The Site is located within the Olympia water service area, which is supplied with municipal water.			
Likely effectiveness/reliability of institutional controls. (a)	**High.** Institutional controls will be required as part of the capping activities during future property development as described in the Interim Action Plan.			
Ability to monitor migration of hazardous substances. (a)	**High.** Appropriate groundwater monitoring network is present and will be supplemented, as necessary, to monitor groundwater after implementation.			
Toxicity of hazardous substances at the site. (a)	Contaminant and media dependent: Soil and waste material: **low to moderate** Water (drinking water beneficial uses): **low to moderate**			
Natural processes that reduce concentrations of hazardous substances, and have been documented at the Site or under similar conditions.	**Moderate to High.** Natural attenuation is likely an active process that reduces concentrations of TCE in groundwater. The reductive dechlorination breakdown product cDCE has been detected in groundwater at the Site; however, aerobic conditions have been identified at the Site.			
Consider Public Concerns (WAC 173-340-600[13])				
Consider public concerns.	**Yes** - Public notice and public comment period will be provided for review of the FS/CAP. No comments from public with concerns about cleanup alternatives that would occur at the Site have been received to date.			

Notes:
(a) Ratings used: Low, Moderate, or High.

Abbreviations and Acronyms:
CAP = cleanup action plan
cDCE = cis-1,2-dichloroethene
CULs = cleanup levels (specifically, general MTCA CULs rather than the pCULs developed as part of the FS)
EISB = enhanced *in situ* bioremediation
FS = feasibility study
GETS = groundwater extraction and treatment system
H&S = health and safety
ICs = institutional controls
IWAS = in-well air stripping
MNA = monitored natural attenuation
MTCA = Model Toxics Control Act
O&M = operations and maintenance
pCUL = proposed cleanup level
TCE = trichloroethene
WAC = Washington Administrative Code

Table 5-2
Disproportionate Cost Analysis Relative Benefits Ranking Considerations
West Olympia Commercial Property
Feasibility Study
Olympia, Washington

Alternative Number:			Alternative 1		Alternative 2		Alternative 3		Alternative 4
Alternative Name			Capping and MNA of Groundwater		Capping and EISB of Groundwater		Capping and Hydraulic Control Via GETS		Capping and IWAS of Groundwater
Relative Benefits Ranking for DCA									
Evaluation Criteria: WAC 173-340-360(3)(f)	**Weighting Factor**	**Benefit Score**	**Ranking Considerations (a)**	**Benefit Score**	**Ranking Considerations (a)**	**Benefit Score**	**Ranking Considerations (a)**	**Benefit Score**	**Ranking Considerations (a)**
Overall Protectiveness *(subsection [i])*	**30%**	**8**	**Excellent** • Cap to minimize human and ecological direct contact risk and mitigate risk of stormwater infiltration and contaminant leaching to groundwater. • Continued routine groundwater monitoring to confirm that groundwater contaminants are not migrating.	**8**	**Excellent** • Cap to minimize human and ecological direct contact risk and mitigate risk of stormwater infiltration and contaminant leaching to groundwater. • *In situ* groundwater chemical treatment provides long-term treatment of contaminated groundwater.	**8**	**Excellent** • Cap to minimize human and ecological direct contact risk and mitigate risk of stormwater infiltration and contaminant leaching to groundwater. • GETS provides long-term hydraulic containment and treatment of contaminated groundwater migrating off property.	**8**	**Excellent** • Cap to minimize human and ecological direct contact risk and mitigate risk of stormwater infiltration and contaminant leaching to groundwater. • IWAS groundwater treatment provides long-term treatment of contaminated groundwater migrating off property.
Permanence *(subsection [ii])*	**20%**	**7**	**Excellent** • Groundwater cleanup anticipated to be permanent as result of remedial action. • Provides *in situ* natural attenuation of groundwater contaminants. • Soil capping does not permanently eliminate or remove soil contamination from the Site.	**7**	**Excellent** • Groundwater cleanup anticipated to be permanent as result of remedial action. • Provides *in situ* biological destruction of groundwater contaminants. • Soil capping does not permanently eliminate or remove soil contamination from the Site.	**7**	**Excellent** • Groundwater cleanup anticipated to be permanent as result of remedial action. • Provides hydraulic containment and *ex situ* treatment of groundwater contaminants migrating off property. • Soil capping does not permanently eliminate or remove soil contamination from the Site.	**7**	**Excellent** • Groundwater cleanup anticipated to be permanent as result of remedial action. • Provides *in situ* treatment of groundwater contaminants migrating off property. • Soil capping does not permanently eliminate or remove soil contamination from the Site.
Long-Term Effectiveness *(subsection [iv])*	**20%**	**6**	**Good** • Exposure and risk are mitigated by capping and by low concentrations of contaminated groundwater. • Long-term effectiveness relies on naturally occurring attenuation processes. Contaminant concentrations currently appear to be stable or probably decreasing (via Mann-Kendall statistical analysis), but it is assumed that after the cap is installed, contaminant leaching to groundwater will decrease, and contaminant concentrations will decrease at a more consistent rate.	**7**	**Excellent** • Exposure and risk are mitigated by capping and by low concentrations of contaminated groundwater. • Long-term effectiveness relies on monitoring. • Treatment of groundwater is intended to decrease contamination, and success of treatment is relatively certain. However, there is a possibility of producing vinyl chloride that has a higher relative toxicity than the TCE parent product.	**6**	**Good** • Exposure and risk are mitigated by capping and by low concentrations of contaminated groundwater. • Long-term effectiveness relies on monitoring operation of GETS. • Treatment and containment of groundwater is intended to decrease contamination; however, success of treatment is uncertain.	**6**	**Good** • Exposure and risk are mitigated by capping and by low concentrations of contaminated groundwater. • Long-term effectiveness relies on monitoring of IWAS systems. • Treatment of groundwater is intended to decrease contamination; however, success of treatment is uncertain.
Manageability of Short-Term Risk *(subsection [v])*	**10%**	**9**	**Superior** • Minimal worker health risk from contact with contaminated media during ongoing groundwater sampling.	**7**	**Excellent** • Minimal worker health risk from contact with contaminated media during drilling and installation of *in situ* groundwater treatment wells; wells will be installed by HAZWOPER-certified drillers and contractors. • Long-term O&M of injection wells and treatment system presents minor risks. • Minimal worker health risk from contact with contaminated media during ongoing groundwater sampling.	**7**	**Excellent** • Minimal worker health risk from contact with contaminated media during drilling and installation of GETs; wells will be installed by HAZWOPER-certified drillers and contractors. • Long-term O&M of extraction wells and treatment system present minor risks. • Minimal worker health risk from contact with contaminated media during ongoing groundwater sampling.	**7**	**Excellent** • Minimal worker health risk from contact with contaminated media during drilling and installation of IWAS groundwater treatment systems; wells will be installed by HAZWOPER-certified drillers and contractors. • Long-term O&M of air stripping wells presents minor risks. • Minimal worker health risk from contact with contaminated media during ongoing groundwater sampling.

Table 5-2
Disproportionate Cost Analysis Relative Benefits Ranking Considerations
West Olympia Commercial Property
Feasibility Study
Olympia, Washington

Alternative Number:			Alternative 1		Alternative 2		Alternative 3		Alternative 4
Alternative Name			**Capping and MNA of Groundwater**		**Capping and EISB of Groundwater**		**Capping and Hydraulic Control Via GETS**		**Capping and IWAS of Groundwater**
Relative Benefits Ranking for DCA									
Implementability *(subsection [vi])*	**10%**	**10**	**Superior** • Technical implementation uncomplicated; continued routine groundwater monitoring to confirm containment.	**7**	**Excellent** • Technical implementation challenges: - proper treatment of groundwater provides limited technical challenges (achieving adequate distribution and contact of injectate, difficulties to inject in low-permeability zones, and challenges with injection solution mounding and entering subsurface utilities, possibility of creating higher relative toxicity breakdown product vinyl chloride). - Long-term O&M of injection wells may present challenges, such as rehabilitation of injection/extraction wells and additional equipment required. • Administration implementation challenges include permitting for injection (UIC permit), fire hydrant water use.	**6**	**Good** • Technical implementation challenges: - proper treatment of groundwater provides technical challenges (achieving adequate extraction, difficulties to extract in low-permeability zones). - Long-term O&M of extraction wells and treatment system may present challenges, such as rehabilitation of extraction wells and additional equipment required. • Administration implementation challenges include permitting for discharge of treated air and groundwater (industrial sewer discharge or UIC permit).	**5**	**Good** • Technical implementation challenges: - proper treatment of groundwater provides technical challenges, and will require a pilot study to test the well-spacing interval. - Long-term O&M of air stripping wells and treatment system may present challenges, such as rehabilitation of wells and additional equipment required. • Administration implementation challenges include permitting for discharge of treated air.
Consideration of Public Concerns *(subsection [vii])*	**10%**	**8**	**Excellent (assumed equal for all alternatives)** • Protective of human health and the environment. • Provides at least the minimum level of protection under MTCA. • Public comments/concerns will be addressed during FS/CAP public comment period(s).	**8**	**Excellent (assumed equal for all alternatives)** • Protective of human health and the environment. • Provides at least the minimum level of protection under the MTCA. • Public comments/concerns will be addressed during FS/CAP public comment period(s).	**8**	**Excellent (assumed equal for all alternatives)** • Protective of human health and the environment. • Provides at least the minimum level of protection under MTCA. • Public comments/concerns will be addressed during FS/CAP public comment period(s).	**8**	**Excellent (assumed equal for all alternatives)** • Protective of human health and the environment. • Provides at least the minimum level of protection under MTCA. • Public comments/concerns will be addressed during FS/CAP public comment period(s).
Estimated Present Value Cost ($) *(subsection [iii])*			**$490,000**		**$6,200,000**		**$4,640,000**		**$2,850,000**
Overall Weighted Benefit Score		**7.7**	**Excellent**	**7.4**	**Excellent**	**7.1**	**Excellent**	**7.0**	**Excellent**
Comparative Overall Benefit/Cost (b)			**7.7**		**0.6**		**0.7**		**1.2**

Notes:
(a) Ratings used: Poor (1–2), Fair (3–4), Good (5–6), Excellent (7–8), and Superior (9–10).
(b) Benefit/cost ratio calculated by dividing the overall weighted benefit score by the estimated remedy cost and scaled (multiplied) by lowest cost alternative cost in order to compare ranges similar in scale to comparative overall benefit, as presented on Figure 5-1 of this FS report.

Abbreviations and Acronyms:
CAP = cleanup action plan
DCA = disproportionate cost analysis
EISB = enhanced in situ bioremediation
FS = feasibility study
GETS = groundwater extraction and treatment system
HAZWOPER = Hazardous Waste Operations and Emergency Response
IWAS = in-well air stripping
MNA = monitored natural attenuation
MTCA = Model Toxics Control Act
O&M = operations and maintenance
TCE = trichloroethene
UIC = underground injection control
WAC = Washington Administrative Code

Table 5-3
Summary of MTCA Alternatives Relative Benefits Ranking
West Olympia Commercial Property
Feasibility Study
Olympia, Washington

Alternative Number and Name	**Alternative 1**				**Alternative 2**				**Alternative 3**				**Alternative 4**			
	Capping and MNA of Groundwater				**Capping and EISB of Groundwater**				**Capping and Hydraulic Control Via GETS**				**Capping and IWAS for Groundwater**			
Relative Benefits Ranking for Disproportionate Cost Analysis (WAC 173-340-360[2][b][i] and WAC 173-340-36093[f])																
Comparative Overall Benefit **(a)**		Score	Weighting Factor	Weighted Score		Score	Weighting Factor	Weighted Score		Score	Weighting Factor	Weighted Score		Score	Weighting Factor	Weighted Score
Overall Protectiveness	Excellent	8	0.3	2.4	Excellent	8	0.3	2.4	Excellent	8	0.3	2.4	Excellent	8	0.3	2.4
Permanence	Excellent	7	0.2	1.4	Excellent	7	0.2	1.4	Excellent	7	0.2	1.4	Excellent	7	0.2	1.4
Long-Term Effectiveness	Good	6	0.2	1.2	Excellent	7	0.2	1.4	Good	6	0.2	1.2	Good	6	0.2	1.2
Manageability of Short-Term Risk	Superior	9	0.1	0.9	Excellent	7	0.1	0.7	Excellent	7	0.1	0.7	Excellent	7	0.1	0.7
Implementability	Superior	10	0.1	1	Excellent	7	0.1	0.7	Good	6	0.1	0.6	Good	5	0.1	0.5
Consideration of Public Concerns	Excellent	8	0.1	0.8	Excellent	8	0.1	0.8	Excellent	8	0.1	0.8	Excellent	8	0.1	0.8
Overall Weighted Benefit Score				**7.7**				**7.4**				**7.1**				**7.0**

Disproportionate Cost Analysis – Quantitative Evaluation

	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Overall Weighted Benefit Score	7.7	7.4	7.1	7.0
Estimated Remedy Present Value Cost	$490,000	$6,200,000	$4,640,000	$2,850,000
Estimated Remedy Total Cost (Undiscounted)	$530,000	$6,460,000	$4,870,000	$3,010,000
Relative Benefit/Cost Ratio (b)	7.7	0.6	0.7	1.2
Most Permanent Solution	**Yes**	**Yes**	**Yes**	**Yes**
Lowest Cost Alternative	**Yes**	No	No	No
Costs Disproportionate to Incremental Benefits	No	**Yes**	**Yes**	**Yes**
Remedy Permanent to the Maximum Extent Practicable?	**Yes**	**Yes**	**Yes**	**Yes**
Preferred Alternative	**Yes**	**No**	**No**	**No**

Cost of Lowest Present Value Cost Alternative	**$490,000**
Benefit Score of Highest Ranked Alternative	**7.7**
Cost of Highest Present Value Cost Alternative	**$6,200,000**

Notes:
(a) Ratings used: Poor (1–2), Fair (3–4), Good (5–6), Excellent (7–8), and Superior (9–10).
(b) Benefit/cost ratio calculated by dividing the overall weighted benefit score by the estimated remedy cost and scaled (multiplied) by lowest cost alternative to compare ranges similar in scale to comparative overall benefit, as presented on Figure 5-1 of this FS report.

Abbreviations and Acronyms:
EISB = enhanced *in situ* bioremediation
FS = feasibility study
GETS = groundwater extraction and treatment system
IWAS = in-well air stripping
MNA = monitored natural attenuation
MTCA = Model Toxics Control Act
WAC = Washington Administrative Code

Table 5-4
Alternative 1 Detailed Cost Estimate
West Olympia Commercial Property
Feasibility Study
Olympia, Washington

Alternative 1: Containment Via Capping and Monitoring Natural Attenuation for Groundwater

General Description: MNA for TCE groundwater contamination. Thirty years of monitoring at seven existing wells and installation and sampling of two new wells.

ITEM	QUANTITY	UNIT	UNIT COST	TOTAL COST	COMMENTS
Work Plans/Design/Reporting/Other					
Cleanup Action Plan	1	LS	$ 20,000	$ 20,000	
Engineering Design Report	1	LS	$ 10,000	$ 10,000	
Permits and Plans	1	each	$ 3,000	$ 3,000	Right-of-way permit and TCP for downgradient monitoring well installation
Construction Contract Documents and Contractor Procurement	0	LS	$ -	$ -	
Cleanup Action Report	1	LS	$ 20,000	$ 20,000	
Project Management	8%	of total	$ 451,380	$ 36,110	Assumes ~8% of project costs (EPA Guide to FS Cost Estimates; EPA 540-R-00-002, July 2000)
Ecology Oversight	2%	of total	$ 451,380	$ 9,027.60	Assumes ~2% of project costs
Task Subtotal				*$ 98,138*	
New Downgradient Monitoring Well Installation					
Utility Locate/Clearing	1	LS	$ 900	$ 900	Private utility locate for injection wells (includes cost for private utility contractor and LAI labor)
Drilling	2	wells	$ 10,000	$ 20,000	Monitoring wells installed with screens in the Qga aquifer above the Qpf aquifer (approximate total depth of 110 ft bgs)
Traffic Control	3	days	$ 1,200	$ 3,600	Traffic control required for installation near Capital Mall Drive
IDW Transport and Disposal - Soil	3	tons	$ 225	$ 675	Soil cutting disposal; assumes 1.6 ton/yard^3 and IDW collected 5 drums; assumes treated as dangerous waste
IDW Transport and Disposal - Water	2	drums	$ 240	$ 480	Well development and decontamination water disposal. Assumes 1 drum per well; assumes treated as hazardous waste
Oversight Labor	3	days	$ 1,800	$ 5,400	Assumes 1-person crew overseeing drilling, installation, and development (12-hour days)
Task Subtotal				*$ 31,055*	
Long-Term Annual Groundwater Monitoring and Reporting					Assumes quarterly for 1st year, semiannual for 2nd & 3rd years; annual through year 10; every 2 years after first 10 years. Total of 25 events over 30 years
Groundwater Sampling Labor	24	days	$ 2,900	$ 69,600	Assumes 25 events, 1 day per event with 2 senior staff-level employees working 10-hour days
Groundwater Analysis	24	events	$ 3,000	$ 72,000	Assumes 10 samples per event (9 monitoring wells and 1 duplicate = 10 samples; $100 per well for VOC analysis, $200 per well for MNA analysis)
Reporting and Data Management	30	years	$ 8,000	$ 240,000	Annual reporting, data management, and EIM submittal
Task Subtotal				*$ 381,600*	
Confirmation Sampling and Monitoring					
Confirmation GW Sampling Laboratory Analysis	40	sample	$ 100	$ 4,000	4 quarters @ 9 wells/quarter for VOC analysis (plus duplicate)
Confirmation GW Sampling Labor	36	sample	$ 355	$ 12,780	4 quarters @ 9 wells/quarter
Task Subtotal				*$ 16,780*	
			Total Cost	$ 530,000	Undiscounted Total Project Costs
			Present Value Total Cost	$ 490,000	Present Value Project Costs for long-term monitoring costs (assumes 1.5% discount rate - real discount, 30-year note, per Office of Management and Budget, Circular A-94 Appendix C, Revised November 2018)
Appropriate Cost Range (-30% - +50%)			$ 340,000 to	$ 735,000	Applied to Present Value Total Cost

Table 5-4
Alternative 1 Detailed Cost Estimate
West Olympia Commercial Property
Feasibility Study
Olympia, Washington

Notes:
All costs presented in this FS are considered to have a relative accuracy within the range of -30 to +50 percent, as shown above, and should be used primarily as a basis for comparison of costs between alternatives. More reliable costs will be developed during the design and implementation phases of the cleanup.

Abbreviations and Acronyms:
bgs = below ground surface
EIM = Environmental Information Management
EPA = U.S. Environmental Protection Agency
FS = feasibility study
ft = feet
GW = groundwater
IDW = investigation-derived waste
LAI = Landau Associates, Inc.
LS = lump sum
MNA = monitored natural attenuation
TCE = tricholoroethene
TCP = traffic control plan
VOC = volatile organic compound

Table 5-5
Alternative 2 Detailed Cost Estimate
West Olympia Commercial Property
Feasibility Study
Olympia, Washington

Alternative 2: Containment Via Capping and Enhanced *In Situ* Bioremediation of Groundwater

General Description: Anaerobic bioremediation of VOC-contaminated groundwater on downgradient edge of Site. The EISB design consists of one, 400-ft-long injection row along the northern edge of the former landfill. The injection row will target the 60-ft-thick, saturated zone, and include 17 clusters of 2 wells (34 wells total) installed on 25-ft centers. The injection solution will include 5% vegetable oil to enhance reductive dechlorination. Injections will be performed approximately every year for the first 3 years, every other year for the next 6 years, and every 3 years for the remaining 18 years of injection (12 events anticipated). The monitoring well network will include 3 existing wells along the northern property boundary (LAI-1, LAI-MW-2, and LAI-2), downgradient monitoring well OLY-2, and 2 new downgradient monitoring wells near OLY-2, along Capital Mall Drive. Quarterly groundwater monitoring will be performed for the first 5 years of active treatment with a transition to semiannual monitoring for the remaining 22 years of active treatment. Annual monitoring will continue for 3 years after treatment ends.

ITEM	QUANTITY	UNIT	UNIT COST	TOTAL COST	COMMENTS
Work Plans, Design, Project Management					
Cleanup Action Plan	1	LS	$ 20,000	$ 20,000	
Permits	1	LS	$ 4,000	$ 4,000	Application for UIC permit; right-of-way permit and TCP for downgradient monitoring well installation
Engineering/Cleanup Design	8%	of capital	$ 3,859,263	$ 308,741	Assumes ~8% of capital costs (EPA Guide to FS Cost Estimates; EPA 540-R-00-002, July 2000)
Construction Management	0%	of capital	$ 3,859,263	$ -	Assumes labor-dominant cleanup approach; construction management/oversight percentage not applicable for estimating costs
Project Management	5%	of total	$ 5,846,963	$ 292,348	Assumes ~5% of project costs (EPA Guide to FS Cost Estimates; EPA 540-R-00-002, July 2000)
Ecology Oversight	1	LS	$ 15,000	$ 15,000	
Task Subtotal				*$ 640,089*	
Enhanced *In-Situ* Bioremediation (EISB)					
Injection Well Installation					
Utility Locate/Clearing	1	LS	$ 1,260	$ 1,260	Private utility locate for injection wells (includes cost for private utility contractor and LAI labor)
Drilling - Intermediate Injection Wells	34	wells	$ 8,000	$ 272,000	34 clusters of 1 intermediate and 1 deep injection well (assumes 25-ft well spacing for a 400-ft-long injection row), 2" wells, 80 ft deep (intermediate well); includes mobilization/demobilization, start card, well construction materials, development
Drilling - Deep Injection Wells	34	wells	$ 13,200	$ 448,800	34 clusters of 1 intermediate and 1 deep injection well (assumes 25-ft well spacing for a 400-ft-long injection row), 2" wells, 110 ft deep (deep well); includes mobilization/demobilization, start card, well construction materials, development
Well Completions	1	LS	$ 130	$ 130	Adapters and caps for all injection wells
IDW Transport and Disposal - Soil	89	tons	$ 225	$ 20,098	Soil cutting disposal; assumes 1.6 ton/yard^3 and IDW collected in rolloffs; assumes treated as dangerous waste
IDW Transport and Disposal - Water	68	drums	$ 240	$ 16,320	Well development and decontamination water disposal. Assumes 1 drum per well; assumes treated as hazardous waste
Oversight Labor	51	days	$ 3,500	$ 178,500	Assumes 2-person crew overseeing drilling, installation, and development (12-hour days); assumes 1 day per intermediate well and 2 days per deep well for installation and development
Task Subtotal				*$ 937,108*	
Injection of Electron Donor					
Electron Donor Substrate	12	events	$ 218,000	$ 2,616,000	Water and Newman Zone HRO™; assume 12 injection events over 30 years
Materials and Rentals for Injection Events	12	events	$ 35,000	$ 420,000	Injection kit rental, tanks, pumps, etc.
Injection Labor	288	days	$ 5,100	$ 1,468,800	Assumes 24 days per event (12-hour days), 3-person crew, 12 events total
Task Subtotal				*$ 4,504,800*	
Downgradient Monitoring Well Installation					
Utility Locate/Clearing	1	LS	$ 900	$ 900	Private utility locate for injection wells (includes cost for private utility contractor and LAI labor)
Drilling	2	wells	$ 10,000	$ 20,000	110-ft-deep monitoring well; includes mobilization/demobilization, start card, well construction materials, development
Traffic Control	3	days	$ 1,200	$ 3,600	Traffic control required for installation near Capital Mall Drive
IDW Transport and Disposal - Soil	3	tons	$ 225	$ 675	Soil cutting disposal; assumes 1.6 ton/yard^3 and IDW collected in rolloffs; assumes treated as dangerous waste
IDW Transport and Disposal - Water	2	drums	$ 240	$ 480	Well development and decontamination water disposal. Assumes 1 drum per well; assumes treated as hazardous waste.
Oversight Labor	3	days	$ 1,800	$ 5,400	Assumes 1-person crew overseeing drilling, installation, and development (12-hour days)
Task Subtotal				*$ 31,055*	

Table 5-5
Alternative 2 Detailed Cost Estimate
West Olympia Commercial Property
Feasibility Study
Olympia, Washington

Alternative 2: Containment Via Capping and Enhanced *In Situ* Bioremediation of Groundwater

General Description: Anaerobic bioremediation of VOC-contaminated groundwater on downgradient edge of Site. The EISB design consists of one, 400-ft-long injection row along the northern edge of the former landfill. The injection row will target the 60-ft-thick, saturated zone, and include 17 clusters of 2 wells (34 wells total) installed on 25-ft centers. The injection solution will include 5% vegetable oil to enhance reductive dechlorination. Injections will be performed approximately every year for the first 3 years, every other year for the next 6 years, and every 3 years for the remaining 18 years of injection (12 events anticipated). The monitoring well network will include 3 existing wells along the northern property boundary (LAI-1, LAI-MW-2, and LAI-2), downgradient monitoring well OLY-2, and 2 new downgradient monitoring wells near OLY-2, along Capital Mall Drive. Quarterly groundwater monitoring will be performed for the first 5 years of active treatment with a transition to semiannual monitoring for the remaining 22 years of active treatment. Annual monitoring will continue for 3 years after treatment ends.

ITEM	QUANTITY	UNIT	UNIT COST	TOTAL COST	COMMENTS
Performance Monitoring					
GW Sampling/Analysis	67	events	$ 2,100	$ 140,700	Quarterly monitoring for the first 5 years of injections, semiannual monitoring for remaining 22 years of injection; annual monitoring for 3 years after injections are complete; assumes 7 samples per event (6 x monitoring wells and 1 x duplicate = 7 samples); VOCs and MNA parameters
Sampling Labor	67	days	$ 2,900	$ 194,300	Assumes 67 events, 1 day per event with 2 senior staff-level employees working 10-hour days
Task Subtotal				*$ 335,000*	
Confirmation Sampling and Monitoring					
Confirmation GW Sampling Laboratory Analysis	40	sample	$ 100	$ 4,000	4 quarters @ 9 wells/quarter for VOC analysis (plus duplicate)
Confirmation GW sampling Labor	36	sample	$ 355	$ 12,780	4 quarters @ 9 wells/quarter
Task Subtotal				*$ 16,780*	
			Undiscounted Total Project Costs	$ 6,460,000	Undiscounted Total Project Costs
			Present Value Total Cost	**$ 6,200,000**	Present Value Project Costs for long-term operations, maintenance, and monitoring (assumes 1.5% discount rate - real discount, 30-year note, per Office of Management and Budget, Circular A-94 Appendix C, Revised November 2018)
Appropriate Cost Range on Present Value Total Cost (-30% - +50%)			**$ 4,340,000 to**	**$ 9,300,000**	Applied to Present Value Total Cost

Notes:
All costs presented in this FS are considered to have a relative accuracy within the range of -30 to +50 percent, as shown above, and should be used primarily as a basis for comparison of costs between alternatives. More reliable costs will be developed during the design and implementation phases of the cleanup.

Abbreviations and Acronyms:
bgs = below ground surface
EIM = Environmental Information Management
EPA = U.S. Environmental Protection Agency
FS = feasibility study
ft = feet
GW = groundwater
IDW = investigation-derived waste
LAI = Landau Associates, Inc.
LS =lump sum
MNA = monitored natural attenuation
TCE = tricholoroethene
TCP = traffic control plan
VOC = volatile organic compound

Table 5-6
Alternative 3 Detailed Cost Estimate
West Olympia Commercial Property
Feasibility Study
Olympia, Washington

Alternative 3: Containment Via Capping and Hydraulic Control via Groundwater Extraction

General Description: Groundwater extraction and treatment to contain and treat TCE-contaminated groundwater. Conceptual design includes a 400-ft-long capture area with 5 extraction wells and groundwater treatment via air stripping. The monitoring well network will include 3 existing wells along the northern property boundary (LAI-1, LAI-MW-2, and LAI-2), downgradient monitoring well OLY-2, and 2 new downgradient monitoring wells near OLY-2 along Capital Mall Drive.

ITEM	QUANTITY	UNIT	UNIT COST	TOTAL	COMMENTS
Work Plans, Design, Project Management					
Cleanup Action Plan	1	LS	$ 20,000	$ 20,000	
Permits	1	LS	$ 22,000	$ 22,000	Air discharge notification and construction permits; industrial sewer discharge permit
Engineering/Cleanup Design	8%	of capital	$ 799,818	$ 63,985	Assume 8% of total capital and planning costs (EPA Guide to FS Cost Estimates; EPA 540-R-00-002, July 2000)
Construction Management	6%	of capital	$ 799,818	$ 47,989	Assume 6% of capital and planning costs (EPA Guide to FS Cost Estimates; EPA 540-R-00-002, July 2000)
Project Management	5%	of total	$ 4,410,357	$ 220,518	Assume 5% of total project costs (EPA Guide to FS Cost Estimates; EPA 540-R-00-002, July 2000)
Ecology oversight	1	LS	$ 15,000	$ 15,000	
Task Subtotal (Indirect)				*$ 389,492*	
Downgradient Monitoring Well Installation					
Utility Locate/Clearing	1	LS	$ 900	$ 900	Private utility locate for injection wells (includes cost for private utility contractor and LAI labor)
Drilling	2	wells	$ 10,000	$ 20,000	Monitoring wells installed with screens in the Qga aquifer above the Qpf aquifer (approximate total depth of 110 ft bgs)
Traffic Control	3	days	$ 1,200	$ 3,600	Traffic control required for installation near Capital Mall Drive
IDW Transport and Disposal - Soil	3	tons	$ 225	$ 675	Soil cutting disposal; assumes 1.6 ton/yard^3 and IDW collected 5 drums; assumes treated as dangerous waste
IDW Transport and Disposal - Water	2	drums	$ 240	$ 480	Well development and decontamination water disposal. Assumes 1 drum per well; assumes treated as hazardous waste.
Oversight Labor	3	days	$ 1,800	$ 5,400	Assumes 1-person crew overseeing drilling, installation, and development (12-hour days)
Task Subtotal				*$ 31,055*	
Groundwater Extraction and Treatment System (GETS)					
Mobilization and Site Prep					
Mobilization	1	LS	$ 20,000	$ 20,000	Mobilize equipment and materials to site
Site Preparation	1	LS	$ 15,000	$ 15,000	Grubbing and clearing; construction entrance, and pad for treatment shed
Temporary Erosion and Sediment Control Measures	1	LS	$ 5,000	$ 5,000	
Task Subtotal (Direct)				*$ 40,000*	
Extraction Well Installation and Well Vaults					
Utility locate	1	LS	$ 1,500	$ 1,500	Private utility locate
Drilling - Extraction Well Installation	5	EA	$ 22,000	$ 110,000	Drilling, materials, and labor for installing 5 wells (6" stainless steel casings) to 120 ft bgs
Drilling - Piezometers	5	EA	$ 10,000	$ 50,000	Piezometers installed for monitoring drawdown in the vicinity of extraction wells.
IDW Transport and Disposal - Soil	10	tons	$ 225	$ 2,213	Soil cutting disposal; assumes 1.6 ton/yard^3 and IDW collected in rolloffs; assumes treated as dangerous waste
IDW Transport and Disposal - Water	35	drums	$ 240	$ 8,400	Well development and decontamination water disposal. Assumes 3.5 drum per well; assumes treated as hazardous waste.
Well vaults and installation	5	EA	$ 10,000	$ 50,000	6'x4'x4' concrete vaults w/lid
Well vaults instrumentation and controls	5	EA	$ 7,500	$ 37,500	Flow meters, pressure meters, level transducers, transmitters (includes materials and labor)
Submersible pumps	5	EA	$ 6,500	$ 32,500	
Wellhead fittings and valves	5	EA	$ 1,000	$ 5,000	Includes fittings, valves, well seals, etc.
Task Subtotal (Direct)				*$ 297,113*	
Groundwater Conveyance System from Extraction Wells					
Extraction line trenching, piping, and backfilling	400	LF	$ 40	$ 16,000	Includes trenching, bedding materials, piping, backfilling, and repaving as needed.
Cleanout vault and installation	1	EA	$ 3,000	$ 3,000	Vault, lid, fittings, valves, and pressure gauge
HDPE 3" water line, installed and welded	400	LF	$ 60	$ 24,000	HDPE SDR 11
Task Subtotal (Direct)				*$ 43,000*	

Table 5-6
Alternative 3 Detailed Cost Estimate
West Olympia Commercial Property
Feasibility Study
Olympia, Washington

Alternative 3: Containment Via Capping and Hydraulic Control via Groundwater Extraction

General Description: Groundwater extraction and treatment to contain and treat TCE-contaminated groundwater. Conceptual design includes a 400-ft-long capture area with 5 extraction wells and groundwater treatment via air stripping. The monitoring well network will include 3 existing wells along the northern property boundary (LAI-1, LAI-MW-2, and LAI-2), downgradient monitoring well OLY-2, and 2 new downgradient monitoring wells near OLY-2 along Capital Mall Drive.

ITEM	QUANTITY	UNIT	UNIT COST	TOTAL	COMMENTS
Treatment System					Treatment of combined flow of 75 **gpm** from **5** extraction wells
Treatment building or shed	1	LS	$ 25,000	$ 25,000	
Electrical drop and power	1	LS	$ 15,000	$ 15,000	1 electrical connection for treatment system
Security fence	150	LF	$ 50	$ 7,500	6' chain-link fence w/barbed wire, 150' total length w/personnel gate and double gate entrance
Tray-style air stripper	1	LS	$ 30,000	$ 30,000	4 to 6 tray air stripper; 75- to 100-gpm max flow
350 CFM TEFC, 8.5-HP blower	1	LS	$ 4,050	$ 4,050	
Discharge pump	1	LS	$ 3,500	$ 3,500	
Air discharge treatment	1	LS	$ 2,000	$ 2,000	Assume 2 x 55-gal GAC vessels
Monitoring and control equipment	1	LS	$ 6,000	$ 6,000	Flow meters, pressure gauges, etc.
System startup and testing	1	LS	$ 17,500	$ 17,500	Pressure-testing pipelines, baseline sampling, programming support for system controls, initial systems operations and testing
Task Subtotal (Direct)				*$ 110,550*	
Clean Water Discharge - to sanitary sewer					
Discharge line trenching, pipe bedding, and backfilling	800	LF	$ 40	$ 32,000	Includes trenching, bedding materials, backfilling, and repaving as needed.
HDPE 3" discharge line, installed, welded	800	LF	$ 60	$ 48,000	HDPE SDR 11
Side sewer connection	1	LS	$ 4,000	$ 4,000	
Discharge manhole	1	LS	$ 400	$ 400	
Discharge flow meter	1	LS	$ 1,200	$ 1,200	
Mechanical equipment	1	LS	$ 500	$ 500	Valves and fittings
Task Subtotal (Direct)				*$ 86,100*	
Electrical, Instrumentation, and Controls	1	LS	$ 150,000	$ 150,000	Based on cost of other typical projects
Task Subtotal (Direct)				*$ 150,000*	
Sales Tax (commercial equipment/services)		9.50%	$ 669,263	$ 63,580	Washington State sales tax
Direct and Indirect Costs Subtotal				$ 1,147,000	
Total Construction Cost (incl. tax)				*$ 1,210,580*	
Annual Operations, Monitoring, and Maintenance					Assumes 30-year operation
Sewer discharge rate	30	yrs	$ 66,620	$ 1,998,594	Discharge of 75 gpm for 30 years at a $1.69 per 1,000 gallons
Electrical Usage	30	yrs	$ 9,200	$ 276,000	Assume 8.5-hp blower, 5-hp discharge pump, 5 extraction pump VFDs, and instrumentation (assume 11-kW equivalent); 11 kw*24 hours/day*356/days/hour*$0.095/kWh
Operations and Maintenance	360	month	$ 1,500	$ 540,000	Assume 1 day O&M per month for 30 years, 1 person crew
Air stripper treatment effluent (vapor) sampling	110	events	$ 200	$ 22,000	Monthly vapor sample collected at air stripper treatment effluent for 5 years, semiannual for remaining 20 years
Well rehab for fouling	5	events	$ 125,000	$ 625,000	Assumes all extraction wells will need rehabilitation every 6 years because of fouling issues.
Task Subtotal				*$ 3,461,594*	
Performance Monitoring					
GW Sampling/Analysis	50	events	$ 700	$ 35,000	Quarterly monitoring for the first 5 years of extraction, semiannual monitoring for 5 years, and annual monitoring for another 20 years; assumes 7 samples per event (6 x monitoring wells and 1 x duplicate = 7 samples), VOCs only
Sampling Labor	50	days	$ 2,900	$ 145,000	Assumes 60 events, 1 day per event with 2 senior staff-level employees working 10-hour days
Task Subtotal				*$ 180,000*	
Confirmation Sampling and Monitoring					
Confirmation GW Sampling Laboratory Analysis	40	sample	$ 100	$ 4,000	4 quarters @ 9 wells/quarter for VOC analysis (plus duplicate)
Confirmation GW sampling Labor	36	sample	$ 355	$ 12,780	4 quarters @ 9 wells/quarter
Task Subtotal				*$ 16,780*	
			Undiscounted Total Project Costs	$ 4,870,000	
			Present Value Total Cost	**$ 4,640,000**	Present Value Project Costs for long-term operations, maintenance, and monitoring (assumes 0.4% discount rate - real discount, 30-year note, per Office of Management and Budget, Circular A-94 Appendix C, Revised Nov. 2019)
Appropriate Cost Range on Present Value Total Cost (-30% - +50%)			**$ 3,250,000 to**	**$ 6,960,000**	Applied to Present Value Total Cost

Table 5-6
Alternative 3 Detailed Cost Estimate
West Olympia Commercial Property
Feasibility Study
Olympia, Washington

Notes:

All costs presented in this FS are considered to have a relative accuracy within the range of -30 to +50 percent, as shown above, and should be used primarily as a basis for comparison of costs between alternatives. More reliable costs will be developed during the design and implementation phases of the cleanup.

Abbreviations and Acronyms:

bgs = below ground surface
CFM = cubic feet per minute
EA = each
EIM = Environmental Information Management
EPA = U.S. Environmental Protection Agency
FS = feasibility study
ft = feet
GAC = granular-activated carbon
Gal = gallon
GPM = gallons per minute
GW = groundwater
HDPE = high-density polyethylene
HP = horsepower
hr = hour
IDW = investigation-derived waste
kW = kilowatt
kWh = kilowatt-hour
LAI = Landau Associates, Inc.
LF = linear feet
LS = lump sum
MNA = monitored natural attenuation
O&M = operations and maintenance
SDR = standard dimension ratio
TCE = tricholoroethene
TCP = traffic control plan
TEFC = totally enclosed, fan-cooled
VFD = variable frequency drive
VOC = volatile organic compound

Table 5-7
Alternative 4 Detailed Cost Estimate
West Olympia Commercial Property
Feasibility Study
Olympia, Washington

Alternative 4: Containment Via Capping and In-Well Air Stripping for Groundwater

General Description: In-well air stripping at the property boundary to create "treatment barrier," assumes 75-ft well spacing. A pilot test would be completed prior to full-scale construction to determine final well spacing. The monitoring well network will include 3 existing wells along the northern property boundary (LAI-1, LAI-MW-2, and LAI-2), downgradient monitoring well OLY-2, and 2 new downgradient monitoring wells near OLY-2 along Capital Mall Drive.

ITEM	QUANTITY	UNIT	UNIT COST	TOTAL	COMMENTS
Work plans, Design, Project Management					
Cleanup Action Plan	1	LS	$ 20,000	$ 20,000	
Permits	1	LS	$ 10,000	$ 10,000	Air discharge notification and construction permits
Engineering/Cleanup Design	8%	of capital	$ 424,249	$ 33,940	Assume 8% of total of capital and planning costs (EPA Guide to FS Cost Estimates; EPA 540-R-00-002, July 2000)
Construction Management	6%	of capital	$ 424,249	$ 25,455	Assume 6% of capital and planning costs (EPA Guide to FS Cost Estimates; EPA 540-R-00-002, July 2000)
Project Management	5%	of total	$ 2,797,249	$ 139,862	Assume 5% of total project costs (EPA Guide to FS Cost Estimates; EPA 540-R-00-002, July 2000)
Ecology Oversight	1	LS	$ 15,000	$ 15,000	
Task Subtotal (Indirect)				*$ 244,257*	
In-Well Air Stripping (IWAS) Well System					
Mobilization and Site Preparation					
Mobilization	1	LS	$ 20,000	$ 20,000	Mobilize equipment and materials to site
Site Preparation	1	LS	$ 15,000	$ 15,000	Grubbing and clearing; construction entrance, and pad for treatment shed
Temporary Erosion and Sediment Control Measures	1	LS	$ 5,000	$ 5,000	
Task Subtotal (Direct)				*$ 40,000*	
IWAS Construction					
Utility Locate	1	LS	$ 1,500	$ 1,500	Private utility locate
Pilot Test	1	LS	$ 75,000	$ 75,000	Per quote + LAI oversight (assume installation costs included in final well costs)
Treatment Building or Shed	1	LS	$ 10,000	$ 10,000	For vapor treatment equipment and other controls/electrical
ASW Well Installation	5	wells	$ 21,924	$ 109,620	5 stainless steel wells; 120 ft deep, 6-inch diameter; includes mob/demob, start card, well construction materials
ASW Wellhead Installation	1	LS	$ 13,824	$ 13,824	Cost estimate for install and startup of IWAS system and wellhead equipment
Drilling - Piezometers	5	EA	$ 10,000	$ 50,000	Piezometers installed for monitoring drawdown in the vicinity of extraction wells.
Surface Completions	5	wells	$ 2,000	$ 10,000	Vaults and wellhead connections, valves, and fittings
IDW Disposal - Soil	10	tn	$ 225	$ 2,250	Soil cutting disposal; assume 1.5 ton/cubic yard; IDW collected in rolloffs
IDW Disposal - Water	35	drum	$ 240	$ 8,400	Well development and decontamination water disposal. Assumes 3.5 drum per well; assumes treated as hazardous waste
ASW Distribution Line Trenching, Piping, and Backfilling	400	LF	$ 40	$ 16,000	Includes trenching, bedding materials, piping, backfilling, and repaving as needed
Electrical Drop and Power	1	LS	$ 15,000	$ 15,000	1 electrical connection for treatment system
Air Discharge Treatment	1	LS	$ 2,000	$ 2,000	Assume 2 x 55-gal GAC vessels
Task Subtotal (Direct)				*$ 313,594*	

Table 5-7
Alternative 4 Detailed Cost Estimate
West Olympia Commercial Property
Feasibility Study
Olympia, Washington

Alternative 4: Containment Via Capping and In-Well Air Stripping for Groundwater

General Description: In-well air stripping at the property boundary to create "treatment barrier," assumes 75-ft well spacing. A pilot test would be completed prior to full-scale construction to determine final well spacing. The monitoring well network will include 3 existing wells along the northern property boundary (LAI-1, LAI-MW-2, and LAI-2), downgradient monitoring well OLY-2, and 2 new downgradient monitoring wells near OLY-2 along Capital Mall Drive.

ITEM	QUANTITY	UNIT	UNIT COST	TOTAL	COMMENTS
New Downgradient Monitoring Well Installation					
Utility Locate	1	LS	$ 900	$ 900	Private utility locate for injection wells (includes cost for private utility contractor and LAI labor)
Drilling - Monitoring Wells	2	wells	$ 10,000	$ 20,000	110-ft-deep monitoring wells; includes mobilization/demobilization, start card, well construction materials, development
Traffic Control	3	days	$ 1,200	$ 3,600	Traffic control required for installation near Capital Mall Drive
IDW Transport and Disposal - Soil	3	tons	$ 225	$ 675	Soil cutting disposal; assumes 1.6 ton/yard^3 and IDW collected in rolloffs; assumes treated as dangerous waste
IDW Transport and Disposal - Water	2	drums	$ 240	$ 480	Well development and decontamination water disposal. Assumes 1 drum per well; assumes treated as hazardous waste.
Oversight Labor	3	days	$ 1,800	$ 5,400	Assumes 1-person crew overseeing drilling, installation, and development (12-hour days)
Task Subtotal (Direct)				*$ 25,655*	
Sales Tax (commercial equipment/services)		9.50%	$ 379,249	$ 36,029	WSST
Direct and Indirect Costs Subtotal				$ 623,506	
Total Construction Cost (incl. tax)				*$ 659,534*	
Annual Operations, Maintenance, and Monitoring					
Performance Monitoring					Assumes 30 years of system operation
GWr Sampling Analytical	50	events	$ 700	$ 35,000	Quarterly monitoring for the first 5 years of system operations, semiannual monitoring for 5 years, and annually for another 20 years; annual monitoring for final 3 years; assumes 7 samples per event (6 x monitoring wells and 1 x duplicate = 7 samples), VOCs only
Sampling Labor	50	days	$ 2,900	$ 145,000	Assumes events, 1 day per event with 2 senior staff-level employees working 10-hour days
Task Subtotal				*$ 180,000*	
Operation and Maintenance					
GAC Disposal/Regeneration	30	each	$ 3,500	$ 105,000	Assumes changeout of one GAC vessel each year of operation
Electrical Usage	30	yrs	$ 9,200	$ 276,000	Assume 5-hp blower, and 10-hp compressors (11-kW equiv); 11-kw*24 hours/day*356/days/hour*$0.095/kwh
Operations and Maintenance	360	month	$ 1,500	$ 540,000	Assumes 1 day O&M per month, 1-person crew
SVE Treatment Effluent (Vapor) Sampling	110	events	$ 200	$ 22,000	Monthly vapor sample collected at SVE treatment effluent for 5 years, semiannual for remaining 25 years
Well Rehab for Fouling	10	events	$ 125,000	$ 1,250,000	Assumes all IWAS wells will need rehabilitation every 3 years because of fouling issues
Task Subtotal				*$ 2,193,000*	
Annual Operations, Maintenance, and Monitoring Subtotal				*$ 2,373,000*	
Confirmation Sampling and Monitoring					
Confirmation GW Sampling Laboratory Analysis	40	sample	$ 100	$ 4,000	4 quarters @ 9 wells/quarter for VOC analysis (plus duplicate)
Confirmation GW Sampling Labor	36	sample	$ 355	$ 12,780	4 quarters @ 9 wells/quarter
Task Subtotal				*$ 16,780*	
Undiscounted Total Project Costs				$ 3,010,000	
Present Value Total Cost				**$ 2,850,000**	Present Value Project Costs for long-term operations, maintenance, and monitoring (assumes 1.5% discount rate - real discount, 30-year note, per Office of Management and Budget, Circular A-94 Appendix C, Revised November 2018)
Appropriate Cost Range on Present Value Total Cost (-30% - +50%)			**$ 2,000,000 to**	**$ 4,280,000**	Applied to Present Value Total Cost

Table 5-7
Alternative 4 Detailed Cost Estimate
West Olympia Commercial Property
Feasibility Study
Olympia, Washington

Notes:
All costs presented in this FS are considered to have a relative accuracy within the range of -30 to +50 percent, as shown above, and should be used primarily as a basis for comparison of costs between alternatives.
More reliable costs will be developed during the design and implementation phases of the cleanup.

Abbreviations and Acronyms:
EA = each
EPA = U.S. Environmental Protection Agency
FS = feasibility study
ft = feet
GAC = granular-activated carbon
Gal = gallon
GW = groundwater
HP = horsepower
IDW = investigation-derived waste
IWAS = in-well air stripping
kW = kilowatt
kWh = kilowatt-hour
LAI = Landau Associates, Inc.
LF = linear feet
LS = lump sum
O&M = operations and maintenance
SVE = soil vapor extraction
tn = ton
VOC = volatile organic compound

APPENDIX A

Interim Action Plan

Interim Action Plan for Marketing the West Olympia Commercial Property 1305 Cooper Point Road Southwest Olympia, Washington

August 23, 2019

Prepared for

City of Olympia Public Works Department
PO Box 1967
Olympia, Washington 98507

LANDAU ASSOCIATES

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Interim Action Plan for Marketing the West Olympia Commercial Property 1305 Cooper Point Road Southwest Olympia, Washington

This document was prepared by, or under the direct supervision of, the technical professionals noted below.

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Quality Reviewer

Date: August 23, 2019
Project No.: 02585052.030
File path: U:\258\052\R\Interim Action Work Plan\Signature Page.docx
Project Coordinator: MCS

LANDAU ASSOCIATES

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ACRONYMS AND ABBREVIATIONS

1,4-DCB 1,4-dichlorobenzene
ARARs .... applicable or relevant and appropriate requirements
CAP .... corrective action plan
CERCLA .... Comprehensive Environmental Response, Compensation, and Liability Act
City .... City of Olympia
COC .... contaminant of concern
Ecology .... Washington State Department of Ecology
EPA .... U.S. Environmental Protection Agency
GEI .... GeoEngineers, Inc.
IA .... interim action
LAI .... Landau Associates, Inc.
LFG .... landfill gas
LLDPE .... linear low-density polyethylene
MARV .... minimum average roll value
MFS .... Minimum Functional Standards
MTCA .... Model Toxics Control Act
ORCAA .... Olympic Region Clean Air Agency
PCE .... tetrachloroethylene
PLP .... potentially liable party
RI/FS .... Remedial Investigation/Feasibility Study
TCE .... trichloroethylene
WAC .... Washington Administrative Code
WARM .... Washington Ranking Method
WOCP .... West Olympia Commercial Property

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1.0 INTRODUCTION

This document describes an interim action (IA) plan to be implemented at the City of Olympia's (City's) West Olympia Commercial Property (WOCP), located at 1305 Cooper Point Road Southwest in Olympia, Washington (Figure 1). The WOCP is an undeveloped property, inclusive of the former West Olympia landfill that was operated by the City between the 1940s and 1968. The IA plan provides an approach for actions that will allow development of the WOCP after purchase or lease from the City.

The WOCP and surrounding area (the West Olympia Landfill Site [Site[1]]) are undergoing a Remedial Investigation/Feasibility Study (RI/FS) in accordance with the Washington State Department of Ecology's (Ecology) Model Toxics Control Act (MTCA) cleanup regulation (Washington Administrative Code [WAC] 173-340). The City is preparing this IA plan as part of its cleanup effort to address contamination at the Site and return the WOCP to full active economic use for community benefit. The IA satisfies the requirements in Agreed Order No. DE 13797, established between the City and Ecology on October 2, 2017. The intent is for the IA to be consistent with and incorporated into the final Site remedy developed through the RI/FS process and outlined in the Cleanup Action Plan. With Ecology's support of this IA plan, the property will be sold and developed, incorporating the IA remedy outlined herein.

1.1 Site Description and Background

The WOCP is a 12.33-acre parcel (Thurston County parcel number 12821240103), located within city limits. The City acquired the parcels that included the WOCP in two separate purchases in 1939 and 1942 (GEI/LAI 2018). Over time, portions of the original 27.5-acre property were subdivided by the City and sold in 1987, resulting in the current 12.3-acre WOCP portion of the Site. Before it was acquired by the City, the WOCP was used as a dumping ground by local residents. After acquisition, the City operated the WOCP as a municipal solid waste landfill for residential and industrial waste until 1968. Waste was routinely burned and buried at the WOCP during landfill operations. When landfill operations ceased in about 1968, the City used the WOCP to store construction debris, power poles, concrete pipe, and other non-hazardous materials.

Because solid waste regulations were introduced after landfill operations ceased in 1968, the solid waste facility was not permitted, or subject to Ecology's closure and post-closure processes. The Site was evaluated using the Washington Ranking Method (WARM), developed by Ecology and the Science Advisory Board. WARM uses data gathered during a site hazard assessment to estimate a site's potential threat to human health and the environment, with rankings made on a scale of one to five. A score of one represents the highest relative level of concern, five the lowest. Ecology ranked the site a four. The landfill does not pose an imminent threat to human health or the environment.

[1] MTCA defines a Site as any place where contaminants have been stored, deposited, or otherwise come to be located (WAC 173-340). For the purposes of this report, the Site is defined as Thurston County parcel 12821240103, inclusive of the former landfill area, and all places where contaminants have come to be located.

The Site has been subject to environmental monitoring and investigations from 1984 to present, with several environmental conditions and contaminants of concern (COCs) identified in soil, soil gas, and groundwater. Buried landfill waste within the WOCP boundaries ranges from 0 to 17.5 feet thick.

Primary COCs and exposure pathways include:

- **Soil:** Localized chromium and lead are present in shallow soils. Direct contact is the primary pathway of concern for localized chromium and lead concentrations.
- **Soil/Landfill Gas:** Localized trichloroethene (TCE), tetrachloroethene (PCE), 1,4-dichlorobenzene (1,4-DCB), and methane are present in site soil gas. If structures are built in an area where vapors could collect, inhalation is a potential pathway of concern for TCE, PCE, and 1,4-DCB. Given its flammable and potentially explosive nature, methane is also a COC requiring unique hazardous condition controls.
- **Groundwater:** TCE is present in shallow groundwater at, and downgradient of, the WOCP. Ingestion is the primary pathway of concern.

A summary of investigation activities and environmental conditions is presented in the draft RI Report (GEI/LAI 2018).

1.2 Basis for Interim Action

The WOCP is the last large, undeveloped tract in West Olympia; its location at the intersection of US Highway 101 and two major City arterials (Black Lake Boulevard and Cooper Point Road) make it prime for development. The WOCP is zoned General Commercial. Adjacent properties and other properties in the area are zoned High-Density Corridor, Professional Office/Residential Multi-Family, Medical Service, Residential Multi-Family, Single-Family Residential, and Residential Low-Impact. The WOCP currently attracts nuisance activities, including illegal dumping and homeless encampments. When developed, the WOCP will be converted to beneficial use, providing value to the City and its citizens and protecting the environment.

Section 430, Chapter 173-340 WAC defines an IA as “a remedial action that is technically necessary to reduce a threat to human health or the environment by eliminating or substantially reducing one or more pathways for exposure to a hazardous substance at a facility.” The IA will reduce the threat to human health and the environment by eliminating or substantially reducing one or more pathways for exposure to a hazardous substance (WAC 173-340-430[1][a]). The IA will help the City achieve partial Site cleanup described in WAC 173-340-430(2) by:

- Limiting exposure to COCs with a landfill cap.
- Controlling soil gas emissions via installation of landfill gas (LFG)-collection and venting systems.
- Establishing surface water controls and reducing contact between infiltrated stormwater and landfill waste.

In accordance with MTCA requirements in WAC 173-340-430 (3)(b), the IA will “not foreclose reasonable alternatives for the cleanup action.” The IA will be designed to be consistent with the most likely final cleanup action. This IA is a partial cleanup because it will address direct exposure contamination at the landfill, but does not address any contamination (i.e., groundwater) emanating from the WOCP and extending to other nearby properties.

The intent is for the IA to be consistent with and incorporated into the final Site remedy cleanup action developed through the RI/FS process and outlined in the CAP. This IA plan outlines a preliminary conceptual design for actions that will support and facilitate cleanup and allow the WOCP to be leased or sold for development. Before development can be completed, additional plans, describing design, implementation, and monitoring of the IA, must be prepared and submitted for Ecology's review and approval. Plans should include:

- An Engineering Design Report for landfill cap, landfill gas control, and surface water control elements of the IA (WAC 173-340-400[4][a]).
- Construction plans and specifications for landfill cap, landfill gas control, and surface water control elements of the IA (WAC 173-340-400[4][b]).
- An Operation and Maintenance Plan for landfill cap and landfill gas collection elements of the IA (WAC 173-340-400[4][c]).
- Construction documentation, such as as-built plans (WAC 173-340-400[6]).
- A Compliance Monitoring Plan (WAC 173-340-410).
- A Sampling and Analysis Plan (WAC 173-340-820).
- A Quality Assurance Project Plan (WAC 173-340 and current Ecology guidelines).
- A Health and Safety Plan (WAC 173-340-810[2]).

1.3 Purpose of Interim Action

The purpose of this IA is to outline a remedial action that addresses the landfill waste and contaminated soil and soil gas at the Site, and allows for property development prior to completion of the RI/FS and CAP. The IA plan includes:

- A description of the IA and how it satisfies MTCA criteria identified in WAC 173-340-430(1), (2), and (3).
- A description of existing Site conditions and a summary of available data related to the IA.
- A description of the alternative IA approaches considered and a rationale for the selected approach.
- Information that supports applicable MTCA criteria for design and construction, identified in WAC 173-340-400(4), (6), and (8).

1.4 Report Organization

The IA plan has been developed in accordance with WAC 173-340-430 and consists of the following nine sections:

- **Section 1, Introduction** includes a description of WOCP features and a summary of environmental conditions, a regulatory framework, the basis for conducting the IA, and describes the purpose of the IA.
- **Section 2, Regulatory Considerations** includes a description of applicable or relevant and appropriate requirements (ARARs) (i.e., federal, state, and local requirements) that apply to the IA. This section also includes a list of regulatory agency guidance documents that should be considered, and the relationship of the IA to planned redevelopment of the property.
- **Section 3, Evaluation of Interim Action Alternatives** identifies the alternatives that were considered for the IA, and provides a basis for selection.
- **Section 4, Description of Interim Action** presents a summary of the IA work elements, including the impervious landfill cap, LFG control, and surface water control elements.
- **Section 5, Justification for Conceptual Design** presents the engineering justification used to select an IA alternative.
- **Section 6, Compliance Monitoring and Reporting** provides a summary of the compliance monitoring and reporting protocols for the IA.
- **Section 7, Limitations and Use of Report** presents Landau Associates, Inc.'s (LAI) standard limitations.
- **Section 8, References** lists documents cited in the IA plan.

2.0 REGULATORY CONSIDERATIONS

This section includes a description of regulatory considerations that apply to the IA, including ARARs (federal, state, and local requirements), agency guidance documents, and site development regulatory requirements.

2.1 Applicable or Relevant and Appropriate Requirements

Typically categorized as chemical-, location-, or action-specific requirements, ARARs are defined by statutes, regulations, and ordinances, and are used to develop cleanup actions. Chemical-specific requirements identify human health- or ecological-based cleanup levels for media of concern. Location-specific requirements apply to the geographical or physical position of the Site. Action-specific requirements refer to acceptable containment, treatment, storage, and disposal criteria and procedures as well as the permits and approvals required to implement the IA. Appendix A includes a list of known chemical-specific, location-specific, and action-specific ARARs for this IA.

Between 1940 and 1968, the WOCP was operated as a municipal solid waste landfill. Closure requirements for solid waste landfills were formally adopted in 1972, under WAC 173-301. The requirements were revised in 1985 as WAC 173-304 Minimum Functional Standards (MFS). Solid waste landfills operating after October 1991 are required to meet the landfill requirements in WAC 173-351, Criteria for Municipal Solid Waste Landfills. WAC 173-351 allows municipal landfills that stopped receiving solid waste prior to October 9, 1991 to use the closure and post-closure requirements in WAC 173-304. MFS are the minimum requirements for solid waste landfill closure under MTCA (WAC 173-340-710[7][c]). MFS will be the overarching regulatory ARARs for evaluation and selection of an appropriate IA alternative.

The U.S. Environmental Protection Agency (EPA) developed a "presumptive remedy" for CERCLA (Comprehensive Environmental Response, Compensation, and Liability Act) municipal landfill sites, intended to expedite RI/FS and closure processes (EPA 1991). Components of the EPA's presumptive remedy include:

- Landfill capping (including stormwater controls).
- Landfill gas collection and treatment.
- Institutional controls that supplement engineering controls.
- Source area groundwater treatment or control to contain potential offsite migration of contaminated groundwater, if necessary.

The EPA's guidance does not include remedial actions for groundwater located beyond the source area (the landfill boundary), or specific requirements for long-term groundwater monitoring. The IA has been developed to address the first three bullets above of the CERCLA presumptive remedy for landfills. Treatment of groundwater contamination (e.g., *in situ* source area groundwater treatment) will be addressed as part of the Feasibility Study.

Per MTCA, containment of hazardous substances is the preferred remedy for sites historically used as landfills; MTCA uses MFS as an ARAR. In WAC 173-340-740(6)(f), MTCA states that containment will satisfy cleanup standards, provided:

> *(i) The selected remedy is permanent to the maximum extent practicable using the procedures in WAC 173-340-360;*
>
> *(ii) The cleanup action is protective of human health. The department may require a site-specific human health risk assessment conforming to the requirements of this chapter to demonstrate that the cleanup action is protective of human health;*
>
> *(iii) The cleanup action is demonstrated to be protective of terrestrial ecological receptors under WAC 173-340-7490 through 173-340-7494;*
>
> *(iv) Institutional controls are put in place under WAC 173-340-440 that prohibit or limit activities that could interfere with the long-term integrity of the containment system;*
>
> *(v) Compliance monitoring under WAC 173-340-410 and periodic reviews under WAC 173-340-430 are designed to ensure the long-term integrity of the containment system; and*
>
> *(vi) The types, levels, and amount of hazardous substances remaining onsite and the measures that will be used to prevent migration and contact with those substances are specified in the draft cleanup action plan."*

The IA will comply with the ARARs identified in Appendix A and MTCA's preferred remedy approach.

Pursuant to Section 090, Chapter 70.105D of the Revised Code of Washington (RCW), PLPs conducting a remedial action under an agreed order with Ecology are exempt from some State-administered procedural requirements as well as the procedural requirements of local laws, requiring or authorizing local government permits or approvals for the remedial action. However, implementation of the IA will comply with the substantive requirements of state and local laws.

2.2 Guidance Documents

In addition to the ARARs, guidance documents - including criteria, advisories, and standards issued by federal or state governments - may be used to design and implement the IA. Guidance documents are not ARARs, and compliance with the documents is not mandatory. Rather, the guidance documents are intended to complement ARARs to the extent they are consistent with legal requirements.

2.3 Relationship to Site Development

The IA will be implemented in conjunction with third-party development of the WOCP. The following City permits and approvals will likely be required to develop the WOCP:

- Environmental review under the State Environmental Policy Act.
- Master use permit, including conditional use approval.
- Grading permit.
- Drainage control plan.
- Building permits.
- Street use permit with transportation concurrency.
- Approvals for water, sewer, and electrical connections.

3.0 EVALUATION OF INTERIM ACTION ALTERNATIVES

MTCA requires that IA plans include an evaluation of IA alternatives and a rationale for selection of the proposed IA (WAC 173-340-430[7][b][ii]). Five preliminary cleanup alternatives for the Site were evaluated by the EPA (E&E 2017). The five preliminary cleanup alternatives included:

- Option 1A: Cap and passively vent landfill gas.
- Option 1B: Cap and actively vent landfill gas.
- Option 2A: Excavate and dispose of waste off site: 50 percent as hazardous waste, 50 percent as non-hazardous waste.
- Option 2B: Excavate and dispose of waste off site: 10 percent as hazardous waste, 90 percent as non-hazardous waste.
- Option 2C: Excavate and dispose of waste off site: 1 percent as hazardous waste, 99 percent as non-hazardous waste.

Based on recent Site characterization data and the conceptual site model presented in the draft RI report (GEI/LAI 2018), three alternatives were evaluated as part of the IA plan:

- Alternative 1. No action.
- Alternative 2. Excavation and offsite disposal of solid waste.
- Alternative 3. Landfill capping, landfill gas control, surface water controls, institutional controls, and compliance monitoring.

Each of these alternatives is described below. IA alternatives were evaluated based on current site conditions and assumed development activities.

3.1 Alternative 1. No Action

A no-action alternative typically is included to provide a basis for comparing the efficacy of other alternatives. Inclusion of this alternative helps to ensure that the consequences of taking no action are fully understood.

With Alternative 1, no measures would be taken to meet the landfill-closure requirements in WAC 173-304 MFS. This IA alternative would not provide short- or long-term protection of human health or the environment. Workers at the Site could come into direct contact with contaminants, and contaminant migration could impact nearby groundwater, air, surface water, and soil. With Alternative 1, site cleanup processes would not be monitored for mitigation of risks to human health and the environment.

3.2 Alternative 2. Excavation and Offsite Disposal of Solid Waste

With Alternative 2, solid waste and contaminated Site soil would be excavated and disposed of at a permitted solid waste management facility. Solid waste in the center of the Site may be at least 17.5 feet thick. Following soil excavation and confirmation testing, clean fill would be placed and compacted to prepare the WOCP for development. After development, compliance groundwater monitoring would be performed to confirm the efficacy of the cleanup action.

3.3 Alternative 3. Landfill Cap, Landfill Gas Control, Surface Water Controls, Institutional Controls, and Compliance Monitoring

With Alternative 3, an impervious asphaltic concrete or membrane cap would be placed in areas where solid waste is present. This alternative also includes LFG control via a passive or active collection system, stormwater control, implementation of institutional controls, and compliance monitoring of IA effectiveness. Limited excavation of solid waste would likely be required to facilitate development activities, including grading, road and building construction, installation of the landfill cap, installation of the LFG control system, and installation of underground utilities. Solid waste and landfill cover material disturbed during IA activities would be interred below the landfill cap, or disposed of offsite in accordance with applicable regulations.

Surface water controls would be incorporated into the IA during development. As noted in the draft RI report, the shallowest aquifer (Qgo) provides a pathway, where soluble contaminants in fill and waste could come into contact with shallow groundwater (GEI/LAI 2018). Surface water controls would prohibit infiltration in areas of the Site where migration of contaminants is likely to occur. Where feasible, infiltration best management practices, or low-impact development techniques, are preferred.

Alternative 3 includes implementation of institutional controls that limit or prohibit activities that could interfere with the integrity of the IA, or that could result in exposure to hazardous substances. Institutional controls will be required if hazardous substances at the Site exceed applicable cleanup levels, or if a conditional point of compliance is established for site cleanup. The institutional controls may include fencing to limit site access, development and implementation of an Operation and Maintenance Plan for the landfill cap and LFG control system, and an environmental covenant on the property title restricting groundwater use and stipulating procedures if the landfill cap is penetrated. After installation of the landfill cap and LFG control system, compliance monitoring would be initiated to demonstrate efficacy of the IA.

3.4 Selection of the Preferred Alternative

Each of the alternatives were evaluated for the following criteria: permanency, capacity to protect human health and the environment, compliance with cleanup standards and other ARARs, and public concerns. Alternative 1 is not protective of human health and the environment, and was eliminated. Alternative 2 calls for waste to be removed from the site, and as such, is the most permanent remedy, but human health and the environment would be at risk during waste removal. Additionally, when compared with Alternative 3, the costs of Alternative 2 are disproportionate to the benefits. Costs in the 2017 site assessment report (E&E 2017) were based on excavation and offsite disposal of 160,000 bank cubic yards of contaminated material and site restoration with compacted clean material. Costs range from $42 million (assuming 1 percent of the excavation material is deemed RCRA hazardous waste, and 99 percent of the material will be disposed of at a Subtitle D facility) to $69 million (assuming 50 percent of the excavation material is deemed RCRA hazardous waste, and 50 percent of the material will be disposed of at a Subtitle D facility). The cost of Alternative 2 would exceed the value of the property, and inhibit cleanup through purchase and development.

Alternative 3 was selected as the preferred remedy for the following reasons:

- Provides long-term protection of human health and the environment by limiting the potential for direct contact with contaminants, minimizes the potential for ongoing groundwater contamination, and controls LFG migration.
- Allows for monitoring programs to be implemented to confirm operational requirements have been satisfied for each media of concern.
- Poses substantially less short-term risk to human health than Alternative 2, which could expose workers to contaminated solid waste or soil during removal.
- Is consistent with MTCA and CERCLA preferred and presumptive remedies for landfill containment and cleanup.

4.0 DESCRIPTION OF INTERIM ACTION

The WOCP will likely be developed with a parking area and one-story box store or series of stores based on the current zoning of the property as General Commercial. The IA as described herein is compatible with current zoning and similar commercial development approaches. Minor details in the containment and control approaches will vary based on actual development plans. These details will be documented in the Engineering Design Report, and further refined during preparation of construction plans and specifications by a third-party developer. Implementation of the IA plan and a cleanup schedule will depend on property lease or sale and development activities.

The selected IA alternative includes construction of a landfill cap and LFG control system, surface water controls, implementation of institutional controls, and compliance monitoring. Before the landfill cap is constructed, the WOCP will be graded as needed for redevelopment activities. The integrated cap and LFG control system will include vertical LFG wells for gas collection, an aggregate LFG-collection layer, piping for gas conveyance, and vents for gas dispersion. During site development, LFG control features will be incorporated into newly constructed buildings. A conceptual landfill cap and LFG control system layout is shown on Figure 2. Conceptual design details of the landfill cap and LFG control system are shown on Figures 3 through 7.

4.1 Landfill Cap

This section describes the design of the landfill cover systems that could be used throughout the WOCP. The layout of the cover systems will vary depending on the actual locations of buildings, parking lots, landscaping, etc. The landfill cover systems will be integrated to provide a continuous landfill cap where waste material is present. Conceptual landfill cap details are shown on Figure 3.

The following three cap designs are proposed:

- Asphaltic concrete cap over gently sloping areas, where pedestrian sidewalks, vehicle access, and parking will be installed.
- Geomembrane and soil cover cap in steep areas, landscaping areas, and/or areas where pedestrian walkways or vehicle access is not permitted.
- Low-permeability membrane cap (barrier) under building foundations to function as a methane-mitigation system and landfill cap.

The location of the landfill caps may change based on future site development plans.

4.1.1 Asphaltic Concrete Cap

The asphaltic concrete landfill cap is designed to address structural requirements, reduce stormwater infiltration, and mitigate risk to human health and the environment by preventing direct contact with solid waste. The cap will be constructed across a majority of the site, where final topography is approximately 6 percent or less. Sections of asphaltic concrete will likely be used in vehicle access and parking areas, and may be used for pedestrian walkways. The asphaltic concrete cap will be constructed on a mixture of imported fill and soil cover; design should include surface water controls to provide durability, flexibility, and operational compatibility with future-use requirements. To maintain imperviousness, a maintenance program consisting of periodic inspections, resealing, and restoration will be included.

The asphaltic concrete cap will be composed of at least three layers:

- The deepest layer will consist of at least 12 inches of compacted structural fill. Depending on the area, the fill may include existing cover soil.
- The second deepest layer will consist of at least 8 inches of crushed rock base.
- The shallowest layer will consist of at least 4 inches of asphalt cover Washington State Department of Transportation Class B or Modified Class B (commercial) with an asphalt-impregnated geotextile between 2-inch compacted lifts.

The asphaltic concrete cap will be designed to accommodate structural loading. Protective measures, including placement of reinforcing fabric and/or additional crushed rock, will be used to prevent cracking where yielding soils are encountered during construction.

4.1.2 Geomembrane and Soil Cover Cap

A geomembrane and soil cover cap will be installed in landscaped areas and areas that are too steep to pave, such as landscaped buffers, planter islands, and gravel road shoulders. The geomembrane and soil cover cap will act as a barrier to infiltrating stormwater, and will mitigate risk to human health and the environment by preventing direct contact with solid waste. The cap system design should include drainage controls.

The geomembrane and soil cover cap will be composed of at least four layers placed in the following order from base to surface:

- The first layer will consist of at least 12 inches of compacted structural fill. Depending on the area, the fill may include existing cover soil.
- The second layer will consist of at least a 40-millimeter-thick, linear low-density polyethylene (LLDPE) geomembrane.
- The third layer will consist of a non-woven geotextile cushion, weighing 16 ounces per square yard.
- The fourth or top layer will consist of:
  - at least 8 inches of rounded gravel below a 3-inch-thick concrete sidewalk, or
  - 8-inch-thick cover soil below at least 4 inches of topsoil in unpaved areas.

The geomembrane will serve as the primary infiltration barrier, and a solid waste boundary marker. The LLDPE geomembrane will be textured on both sides for cover soil and slopes greater than 10 horizontal to 1 vertical (10H:1V), and will be anchored at the top of slopes, depending on final site topography and grading plans.

The geomembrane will be seamed with heat fusion or extrusion welding, and all welds will be tested for leakage. To reduce the potential for erosion, the geomembrane liner will be covered by a protective geotextile cushion, granular drainage and vegetative soil layers, and a substrate for grass landscaping. Drainage within this layer will be routed to a perforated pipe at the base of the slope. Collected water that percolates through the upper cover layers will be conveyed and discharged to the surface water controls. Drainage design and surface water-engineering details will depend on the final development plan.

4.1.3 Low-permeability Membrane Cap (Barrier) under Building Foundations

A low-permeability membrane cap installed under all buildings will function as a methane mitigation system. Each building will be designed with a separate membrane barrier consisting of a sub-slab vapor retarder (membrane) with a methane permeance rating determined by ASTM International standard test method D1434, or other industry-accepted testing methods selected during the design process. Sand or equivalent geotextile material will cushion the membrane barrier and protect it from penetration. The membrane will be sealed at building foundations and footings, utility membrane penetrations, and membrane seams in accordance with the manufacturer's recommendations. After installation and before cover, the membrane should be smoke-tested for leaks; if observed, leaks should be repaired.

4.1.4 Landfill Cap Transitions

Cover system transitions will occur at waste boundaries, at building locations, and in select areas around parking lots. At buildings, cover system transitions will be implemented by extending building system membranes at least 3 feet beyond the building footprint, creating an overlap with the asphalt concrete or geomembrane soil cap systems. Design details for landfill cap transitions will be presented in the Engineering Design Report.

4.2 Landfill Gas Controls

Two different mechanisms for LFG control are recommended:

- To prevent LFG migration and fugitive emissions:
  - Perimeter LFG control system consisting of vertical LFG collection wells, conveyance piping, monitoring instrumentation and controls, and venting apparatuses.
- To protect indoor air quality:
  - Individual LFG control systems for occupied buildings, including below-grade, horizontal LFG collection, piping within gravel trenches, or geocomposite LFG collection vents, conveyance piping, monitoring instrumentation and controls, and venting apparatuses.

The LFG control systems will be designed to operate in passive or active conditions. Passive ventilation is intended to provide an unobstructed pathway for gases to ventilate to the atmosphere, and to allow ambient air into the subsurface through barometric pumping. Active extraction uses blower systems to remove gases from the subsurface. Hybrid systems, as proposed here, are designed to operate effectively under passive or active conditions. When designing the hybrid system, piping connections, materials, and perforation depths for passive and active conditions should be considered.

Passive extraction should be sufficient for the WOCP, and is likely to be preferred over active extraction following construction. However, active extraction should be included in the event more aggressive control is needed, given proximity to residences and at-grade buildings. Based on monitoring, the system may be converted to an active LFG control system, as described in Section 6.0. The location of each LFG control system may change based on future development plans.

4.2.1 Perimeter Landfill Gas Control System

To prevent offsite migration, a perimeter LFG control system will include a vertical LFG extraction well network, conveyance piping, monitoring instrumentation and controls, and ventilation apparatuses. The final positions of the vertical LFG collectors will be selected to protect the perimeter and avoid conflict with development features. The estimated extent, depth, and thickness of waste will influence the positions of the collectors. For preliminary planning purposes, 12 extraction wells are assumed, with an average spacing of 150 feet on center. A conceptual plan for the vertical extraction wells is presented on Figure 2.

Hollow-stem auger drilling or equivalent will be used to install the vertical LFG wells approximately 1 foot below the waste extents. Wells will be installed in 10-inch-diameter boreholes with 6-inch-diameter, high-density polyethylene (HDPE), perforated well casings. The waste depth will vary by location, but each well should be installed at approximately 15 feet below ground surface. Bentonite seals will be used to protect perforated well screens from the surface below the landfill cap. The conceptual vertical well collectors could have a 100-foot active radius of influence in deeper sections of the landfill, and a 60-foot active radius of influence in shallow waste areas.

Under passive operation, each vertical LFG well collector or well collector series will be surfaced with a wind vent apparatus that will ventilate accumulated LFG. LFG control vents likely will be directly discharged without emissions treatment. The ventilated LFG will be monitored as part of the compliance monitoring plan, and will meet the air quality requirements of the Olympic Region Clean Air Agency (ORCAA). A notice of construction will be filed with ORCAA, and if needed, emissions treatment will be added.

If additional collection and control are necessary, the system can be converted to an active collection system. An active manifold will be installed along the alignment of the passive perimeter LFG collection wells. To allow passive-to-active collection at discrete locations throughout the site, the manifold can be connected to a blower, and a vacuum can be used for LFG extraction. The vertical LFG collectors will be connected with piping and mains as necessary. The connector piping and LFG pipe mains will be designed to account for flow, condensate, drainage, and differential settlement. Figure 4 shows conceptual perimeter LFG control system details, and Figure 6 shows horizontal landfill gas control system collection trenches.

4.2.2 Building Landfill Gas Control System

Each occupied building at the WOCP will have a standalone LFG control system, independent of the site-wide perimeter LFG control system. Building LFG control systems will include below-grade features to capture LFG, and conveyance piping to allow discharge above the roofline. Building LFG control systems will need to be incorporated into the building foundation elements during construction. The final positions of the building LFG control systems will be selected based on development plans, including building interior and foundation designs. Additional building protection is provided by the barrier system described in Section 4.1.3.

The collection system beneath buildings will include horizontal LFG collection piping within gravel trenches or a geocomposite LFG collection vent system and conveyance piping. Vertical piping will convey gases to the roof, and will include monitoring instrumentation controls and LFG vents. The building LFG control systems are designed to operate passively, but can be converted to active operation if additional LFG control is necessary. The passive system will include a conveyance pipe manifold connected to an LFG blower and controls that can be used to vacuum beneath the building. Figure 5 shows the conceptual building LFG control system design details, and Figure 6 shows horizontal landfill gas control system collection trenches.

4.3 Surface Water Controls

Surface water controls will prevent exposure to, and mobilization of, contaminants associated with solid waste. Surface water controls should also:

- Capture and convey stormwater runoff before it makes contact with buried solid waste.
- Satisfy stormwater regulatory obligations, including conveyance, quantity, flow, and quality.

Drainage elements of the landfill cap systems should be designed based on the location and implementation of each cap type. Stormwater controls will be designed in accordance with City standards at the time of development.

4.4 Site Development Considerations

Site development activities will be completed as part of the IA. The site will be graded for construction of buildings, vehicle and pedestrian access, utilities, and landfill cap and LFG control systems. Site regrading will allow control of stormwater flow, and minimize exposure to waste, pre- and post-construction.

4.4.1 Existing Groundwater Monitoring Wells and Soil Gas Probes

A network of existing groundwater monitoring wells and soil gas probes is currently in use at the site. To facilitate site development, some wells and probes will be decommissioned in accordance with applicable state regulations. Nine existing perimeter gas probes will be used for compliance monitoring, and eight groundwater monitoring wells will be maintained during the IA. Wells and probes that will be decommissioned or retained are identified in Table 1 and presented on Figure 2.

4.4.2 Site Grading

Site grading will expose refuse and cover soil. Brush, vegetation, and trees should be removed from the construction area. Deleterious material, such as grass, roots, topsoil, surface debris, organic fill, ash, and soft or loose soil, should be stripped from areas that will be occupied by structures and pavements. Stripping of deleterious material should extend at least 10 feet beyond the building pad or other structures, and 5 feet beyond pavements. At most parts of the property, stripping depth is estimated to be approximately 12 inches. Deeper stripping or excavation may be needed to remove ash layers, large debris, or root zones near the surface.

Following regrading and before placement of structural fill, the exposed subgrade should be compacted to a dense, unyielding condition. The upper 12 inches of exposed subgrade should be compacted in accordance with the design specifications for structural fill.

Solid waste and soil excavated during implementation of the IA will likely be re-interred on site with Ecology’s approval. The proposed landfill cap will prevent human contact with reinterred solid waste or soil.

4.4.3 Ground Improvement

Long-term decay of organic material (putrescible material) and densification of the waste can lead to unacceptable total and differential settlements. Solid waste at the site contains smaller amounts of putrescible material than traditional municipal solid waste landfills; this is attributable to the age of the waste and reported, periodic burning of waste. Both short- and long-term settlement from densification and decay of putrescible material are estimated at 10 to 15 percent total waste thickness. The estimated total settlement is likely in the range of 12 to 18 inches, but differential settlement could be greater in transition areas between landfill waste and where dense native soil is present (LAI 2000).

Settlement could result in pavement distress, foundation settlement, and damage to utilities. To minimize the risk of settlement, ground improvement techniques will be required to support foundations. Selection of ground improvement techniques to facilitate development must specifically address concerns with long-term settlement at the WOCP due to the presence of waste fill.

4.4.4 Building Foundations

Different building foundation types will be required to address dynamic and static loads and will need to specifically address long-term settlement concerns due to the presence of waste fill. All building foundation systems will include a membrane barrier and passive subsurface gas collection system for LFG control. Conceptual development plans will be completed by a third-party developer. Under-slab design elements, including drainage and granular base course material, will be finalized in accordance with development plans. The final building foundation should be designed by geotechnical and structural engineers licensed in the State of Washington and possessing landfill and brownfield redevelopment experience. If deep foundations (e.g. piles, piers) are proposed, they must be designed to not penetrate contaminated soil and groundwater in a way that could potentially mobilize the pollutants downward and contaminate lower groundwater zones.

4.4.5 Retaining Walls

Retaining walls may be used for grade control along the edges of the WOCP. Walls should be founded on undisturbed native soil or compacted structural fill extending to such soil. Soft or loose soil or landfill waste should be removed from beneath the base of retaining walls. Retaining walls that cross transition areas between the landfill and dense native soil should be designed for differential settlement. Flexible wall systems, such as mechanically stabilized earth walls, are more suitable for transition zones than rigid systems, such as conventional concrete cantilever walls. A third-party developer will work with a geotechnical engineer to provide settlement information based on final development plans.

4.4.6 Utilities

There are no known utilities at the WOCP; if encountered during site grading or development, utilities or underground structures should be removed or abandoned. Abandoned utilities will be capped, and trenches will be filled with impermeable materials to eliminate potential migration pathways for LFG.

During development, water supply, sanitary sewer, storm drainage, electricity, natural gas, and communications utilities will be installed. Where practical, utilities will be routed beneath the asphaltic concrete cap and above the geomembrane cap in shared trenches. Settlement considerations will be incorporated into the utility design, and mitigation measures, such as soil compaction methods, will be implemented along utility trenches. Flexible couplings capable of accommodating settlement should be used in underground utilities. Utilities may be routed in pile-supported corridors to buildings. Utility corridors should be accessible with minimal disturbance to site operations. Conceptual utility corridor details are shown on Figure 7.

4.5 Institutional Controls

In accordance with MTCA (WAC 173-340-440), institutional controls will be implemented to limit or prohibit activities that may interfere with or diminish the integrity of the IA. Institutional controls may include fencing to limit access, and development and implementation of an operation and maintenance plan. Institutional controls will be documented in an environmental covenant recorded on the property deed (RCW 60.47).

5.0 JUSTIFICATION FOR CONCEPTUAL DESIGN

This section discusses the engineering justification for the conceptual IA landfill cap and LFG control design. A more thorough justification, including design criteria, will be presented in an engineering design report that conforms to the specifications outlined in this IA plan. The design will be completed by the third-party developer that leases or purchases the property.

Landfill Cap

The three IA landfill cap designs satisfy the two primary functions required under the MFS. MFS for solid waste handling requires that a landfill cap be installed upon closure, per WAC 173-304. Under MFS, a landfill cap is intended to perform two functions:

- Minimize infiltration of stormwater into the solid waste, thereby minimizing the production of additional leachate and
- Mitigate risk to human health and the environment by preventing direct contact exposure with solid waste.

To achieve these functions, two designs are prescribed for landfill caps in WAC 173-304-460:

- Placement of at least 2 feet of low-permeability soil (permeability of less the 10^{-6} centimeter per second [cm/sec]) or
- Use of a geomembrane layer with a 50-millimeter (50-thousandth of an inch) thickness.

The proposed landfill cap designs for the WOCP will not satisfy the presumptive cover in WAC 173-304-460 (3)(e) of 2 feet of low-permeability soil or a 50-millimeter-thick geomembrane layer. Therefore, Ecology's concurrence is requested to vary from the closure methods, per WAC 173-304-700 and WAC 173-340-710(5), which allow for variances, or waiver, of provisions included in other applicable regulations. Allowing the landfill cap to vary from the provisions of the MFS is appropriate for the WOCP considering the following:

- The geomembrane soil cap proposed includes a minimum average roll value (MARV) of 40-millimeter-thick LLDPE geomembrane in lieu of a stiffer MARV of 50-millimeter-thick HDPE indicated in the above regulations. LLDPE is designed for landfill closures, as it is flexible, conforms to subgrade, and can handle large strains caused by differential settlement.
- The under building barrier cap will allow the building itself to be the barrier for infiltration of rainwater, and the gas barrier membrane, collection and removal system will prevent buildup of landfill gas under the buildings.
- Although the asphaltic concrete cap does not provide a minimum of 2 feet of low-permeability soil of less than 1×10^{-6} centimeters per second or a geomembrane layer, per the MFS, the asphaltic cap system is an equivalent very low-permeability surface that provides erosion protection measures and minimizes infiltration of stormwater into the solid waste.
- Landfill operations ceased in 1968 in accordance with applicable regulations at the time.
- The three landfill caps will serve the two primary functions of a landfill cap, per the MFS: effectively minimize stormwater infiltration, and prevent direct exposure to solid waste and affected media.

Components of the CERCLA landfill closure presumptive remedy include:

- A landfill cap (including stormwater controls).
- Leachate collection and treatment.
- Landfill gas collection and treatment.
- Institutional controls to supplement engineering controls.

The proposed IA alternative will address all four of the CERCLA presumptive remedy components. Leachate generation will be eliminated through installation of the landfill cap.

Although the parcel ceased to be used as a landfill prior to adoption of the MSF, the IA is designed to comply with the MFS. The MFS ensures that a landfill is closed in a manner that:

- Minimizes the need for further maintenance;
- Controls, minimizes, or eliminates threats to human health and the environment from post-closure escape of municipal solid waste constituents, leachate, landfill gas, and contaminated rainfall or waste decomposition products to the ground, groundwater, surface water, and the atmosphere; and
- Prepares the site for the post-closure period, allowing for continued facility maintenance and monitoring of air, land, and water as long as is necessary for the facility to stabilize and protect human health and the environment.

WAC 173-340-710(4)(f) allows for variances or waiver provisions in other regulations to be included in MTCA process. A variance from the prescribed landfill cap alternatives is requested as part of this IA plan. The request for a landfill cap variance is based on the conditions under which the landfill operated, the timeframe of discontinued operations, current Site conditions, and the effectiveness of the proposed landfill cap in this IA plan.

LFG Control Systems

The LFG control system design satisfies the LFG migration criteria required under the MFS defined in WAC 173-304-460 and the Thurston County Board of Health Article 5 Regulations. The operational goal of the LFG control systems is to protect human health and the environment and maintain compliance with MFS criteria by preventing:

- LFG migration off the WOCP resulting in methane exceeding 5 percent by volume (lower explosive limit [LEL] for methane).
- LFG in onsite buildings exceeding 1.25 percent by volume, or 25 percent of the LEL.
- LFG in offsite buildings exceeding 100 parts per million volume (0.01 percent by volume and 0.2 percent of the LEL).
- LFG surface emissions that would create an explosion, fire hazard, or odors.

LFG control is necessary to manage LFG that would accumulate beneath the impermeable cover system, migrate offsite, or cause concerns of vapor intrusion if not properly vented.

Decomposition of organic waste at the WOCP produces LFG, primarily as methane and carbon dioxide. Due to the age of the landfill material and the fact that waste was burned prior to being buried, only a small amount of LFG is expected to be produced at the WOCP. The conceptual design for LFG collection and control systems is based on the potential for methane generation estimated using EPA's LandGEM LFG emissions modeling and data culled from the RI (GEI/LAI 2018). The estimate is generated based on waste age, type, quantity of buried waste, and subsurface environment. For 2018, the total LFG generation rate was estimated at 7.2 cubic feet per minute. Although this rate of generation is minor in comparison to larger active landfills, the LFG must be provided a ventilation pathway, or it could accumulate and cause unsafe conditions.

The LFG control system is expected to operate passively based on the estimated LFG generation rate modeled, the historical use of the site, historical and current waste practices, historical and current methane monitoring results, and experience with similar landfill sites and LFG control system designs. The requirement for contingent active LFG systems is based on the inherent uncertainty in estimating LFG generation once the site is capped. The passive systems can be converted to active systems if necessary.

6.0 COMPLIANCE MONITORING AND REPORTING

Compliance monitoring will be conducted in accordance with the requirements of WAC 173-340-410. There are four types of compliance monitoring that will be required to implement the IA:

- Protection monitoring.
- Construction quality control monitoring.
- Performance monitoring.
- Confirmation monitoring.

Details of the compliance monitoring will be described in the engineering design report. General requirements of the compliance monitoring are summarized below.

6.1 Protection Monitoring

Protection monitoring will be conducted to confirm that human health and the environment are adequately protected during construction, and during the operation and maintenance of the IA. Protection monitoring will be addressed through implementation of a site-specific health and safety plan developed by the construction contractor to meet WAC 173-340-810 Worker Safety and Health Requirements and WAC 296-62-General Occupational Health Standards.

6.2 Construction Quality Control Monitoring

Construction quality control monitoring will be conducted to document that the caps, LFG system, and stormwater systems are constructed consistent with this IA plan and the Ecology-approved plans and specifications. IA construction will be conducted under the oversight of a professional engineer registered in the State of Washington. Monitoring will include observation and documentation of the construction of the landfill cap and LFG control systems, including startup commissioning. LFG control system monitoring for methane will be conducted monthly at LFG control system vents and select individual vertical LFG gas control wells during landfill cover construction. The landfill cap and soils beneath the cap will be monitored as follows:

- Subgrade preparation and acceptance.
- Measurement and observation of base surface preparations.
- Review of aggregate and asphaltic concrete quality characteristics.
- Observation of subsurface utility construction with trench plugs to prevent migration of LFG.
- Observation of asphalt surface placement and review of surface finish quality.
- Seam and leak testing.
- Material certification.
- Observation of seam and seal applications so no cracks or weak seams transmit infiltrating stormwater or short circuit the LFG collection system, or expose pathways to the soil beneath.

6.3 Performance Monitoring

Performance monitoring will be conducted to confirm that the IA has attained cleanup standards and, if appropriate, remediation levels. The primary IA performance monitoring task will be demonstrating compliance with MFS LFG migration control criteria discussed in Section 4.2. A performance monitoring plan will be prepared to document the location, frequency, and methods of monitoring.

LFG control performance monitoring will include LFG control system emission baseline monitoring to ensure compliance with national ambient air quality and emission standards, ORCAA notice of construction requirements, and ORCAA emission standards for toxic air pollutants. LFG control performance monitoring will be conducted to empirically demonstrate performance with the LFG migration criteria and will be integrated into the site performance monitoring as outlined herein.

6.3.1 Site Monitoring

Following installation and startup of the LFG control systems, the perimeter monitoring probes will be monitored using a Landtec GEM™2000 plus or equivalent instrument. If methane concentrations in the LFG control vents or collection wells exceed 5 percent by volume, the perimeter gas monitoring probes will be monitored for methane, oxygen, carbon monoxide, carbon dioxide, hydrogen sulfide, and pressure. Perimeter gas probe monitoring will be scheduled to occur after falling barometric pressure conditions. If methane is detected in excess of the LEL at the perimeter gas monitoring probes, additional monitoring will be conducted within the existing gas probes; corrective actions will be initiated; and the potential for switching to an active LFG control system will be examined.

Once the LFG control system has been installed and the first round of baseline monitoring completed, monitoring will be conducted at the open LFG control system vents and perimeter gas monitoring probes in accordance with the following schedule:

- Monthly for 3 months.
- Quarterly for at least four quarters and integrating the long-term monitoring schedule finalized in the CAP.

If adjustments are made to the LFG control system, the schedule will restart with monthly monitoring.

6.3.2 Building Monitoring

The system will be designed to minimize the need for building monitoring. Buildings constructed during WOCP development will include independent, low-permeability geomembrane vapor barriers and LFG control vent systems. In addition, vent systems will be constructed to operate passively with the potential for conversion to an active systems. Conversion into an active LFG control system will occur as a corrective action if compliance monitoring detects methane consistently above the LEL within the LFG collection and control vents.

Onsite building monitoring will be triggered if LFG control system vents contain methane levels above the LEL. The system is being designed to prevent offsite migration of LFG. The need for offsite building monitoring will be triggered based on identification of methane exceeding 5 percent by volume in adjacent perimeter gas monitoring probes during routine monitoring. If required, onsite and offsite building monitoring will be described in the engineering design report.

6.4 Confirmation Monitoring

Confirmation monitoring will be conducted to confirm long-term effectiveness of the IA once cleanup standards and remediation levels have been achieved. Confirmation monitoring for the IA will involve periodic inspections conducted in accordance with the procedures described in an Ecology-approved Operation and Maintenance Plan, which will be developed following LFG control system startup and commissioning. Landfill cap integrity and LFG control system efficacy will be evaluated through visual assessment and use of field monitoring instruments. The Operation and Maintenance Plan will include record drawings, operational reference materials, monitoring equipment information, and monitoring procedures, and will specify requirements for recordkeeping and reporting.

6.5 Corrective Actions

During implementation of the IA, monitoring of the LFG control systems, perimeter gas monitoring probes, and ambient air in buildings will be performed in accordance with the monitoring summary outlined in Section 6.3.1. If exceedances occur, corrective actions may need to be initiated to comply with regulatory requirements at the landfill perimeter and at structures on and off the WOCP. If necessary, corrective actions will be initiated to address issues noted during monitoring or subsequent inspections, to ensure design controls are functional, and to determine whether the system can mitigate exposures or potentially explosive atmospheres associated with methane hazards. Corrective actions will require notifications to property owners and regulators, and may include targeted cover system or foundation sealing, penetration sealing, LFG control system adjustment, system augmentation, or conversion from passive LFG venting to active collection.

6.6 Reporting

Reporting for the IA compliance monitoring program will include preparation of an IA Construction Report, documentation of construction of IA elements, and annual monitoring reporting. Annual reporting will transition to a schedule developed for site-wide long-term reporting identified in the CAP.

7.0 LIMITATIONS AND USE OF THIS REPORT

This IA plan has been prepared for the exclusive use of the City of Olympia Public Works for specific application to the West Olympia Commercial Property in Olympia, Washington. No other party is entitled to rely on the information, conclusions, and recommendations included in this document without the express written consent of LAI. Further, the reuse of information, conclusions, and recommendations provided herein for extensions of the project or for any other project, without review and authorization by LAI, shall be at the user's sole risk. LAI warrants that within the limitations of scope, schedule, and budget, our services have been provided in a manner consistent with that level of care and skill ordinarily exercised by members of the profession currently practicing in the same locality under similar conditions as this project. We make no other warranty, either expressed or implied.

8.0 REFERENCES

ASTM. 2006. ASTM D2488-06: Standard Practice for Description and Identification of Soils (Visual-Manual Procedure). ASTM International. West Conshohocken, PA.

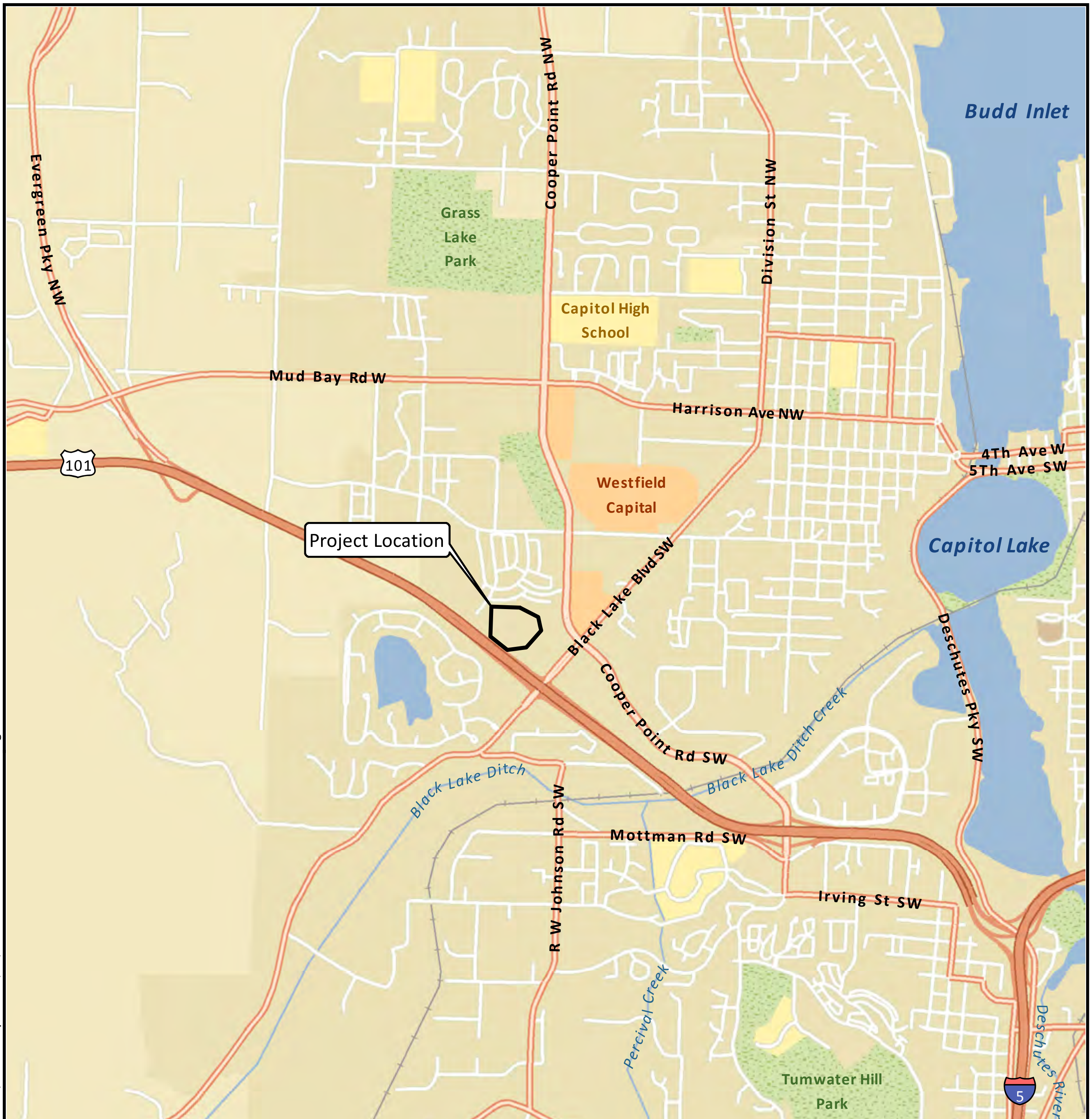
City of Olympia. 2016. *Drainage Design and Erosion Control Manual.* City of Olympia Public Works. December.

Ecology and Environment (E&E). 2017. West Olympia Landfill Site Targeted Brownfields Assessment, Olympia, Washington. Ecology and Environment, Inc. June.

EPA. 1991. Conducting Remedial Investigations/Feasibility Studies for CERCLA Municipal Landfill Sites. U.S. Environmental Protection Agency. February.

GEI and LAI. 2018. Draft Remedial Investigation Report: West Olympia Landfill Site, Olympia, Washington. Prepared by GeoEngineers, Inc. and Landau Associates, Inc. July 27.

LAI. 2000. Report: Environmental Investigations, Proposed Home Depot Store, Olympia, Washington. Landau Associates, Inc. December 21.



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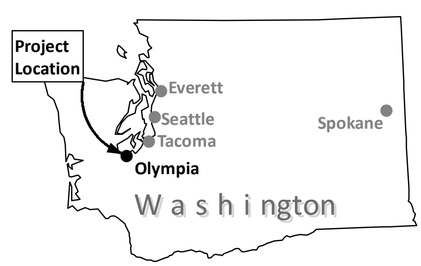


Data Source: Esri 2012

G:\Projects\258\052\030\033\Interim Action Work Plan\F01VicMap.mxd 3/25/2019 NAD 1983 StatePlane Washington South FIPS 4602 Feet

LANDAU ASSOCIATES

West Olympia Commercial Property Interim Action Work Plan Olympia, Washington	**Vicinity Map**	Figure 1

Legend

- Gas Monitoring Probe - Retained during Site Delpment
- Gas Monitoring Probe - Decommissioned during Site Development
- Monitoring Well - Retained during Site Development
- Monitoring Well - Decommissioned during Site Development
- Subject Property
- Approximate Extent of Waste

LFG Control System Legend

- Vertical LFG Collection Well
- LFG Collection Manifold
- Approximate Landfill Cap Extent

Notes

1. The locations of all features shown are approximate.
2. Projection: NAD 1983 StatePlane Washington South FIPS 4602 Feet
3. Data Sources: Thurston County GIS; Esri World Imagery.

LFG Control System Notes

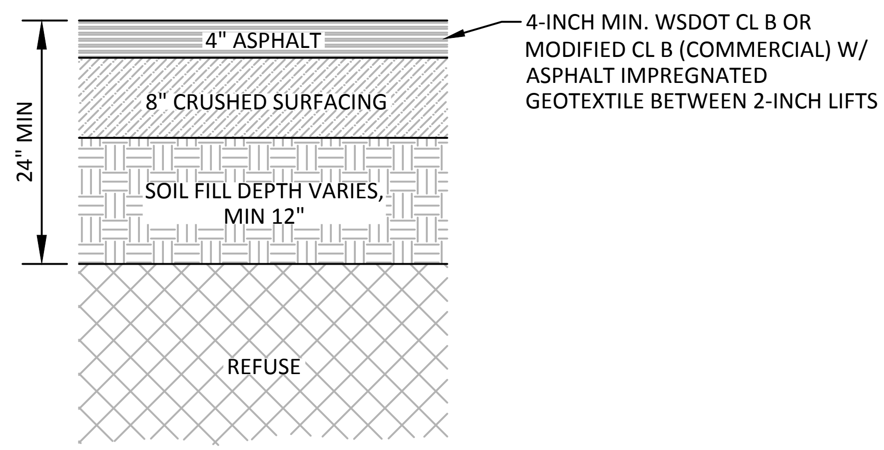
1. LFG Control system is conceptual only; The final LFG control system will be modified to accommodate the development plans for the WOCP.
3. Depending on final site development plans, other gas monitoring probes and/or groundwater monitoring wells may be retained or decommissioned for compliance monitoring.

0 140 280
Scale in Feet

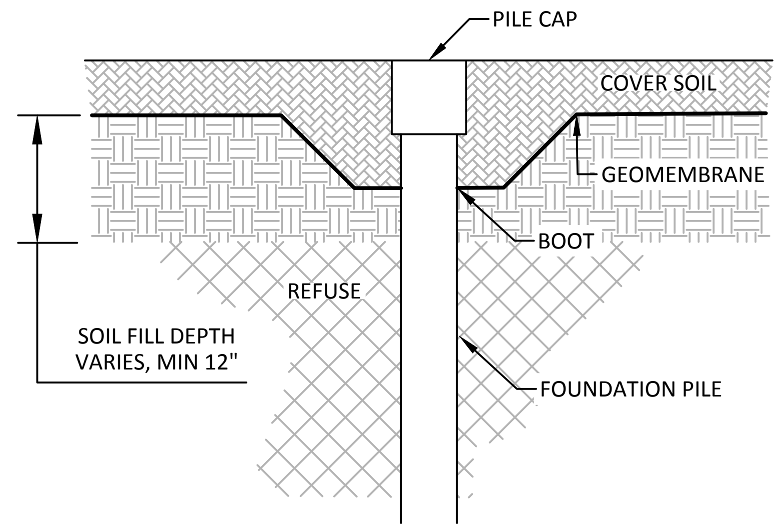
G:\Projects\258\052\030\033\Interim Action Work Plan\F02ConceptPlan.mxd 4/19/2019

LANDAU ASSOCIATES

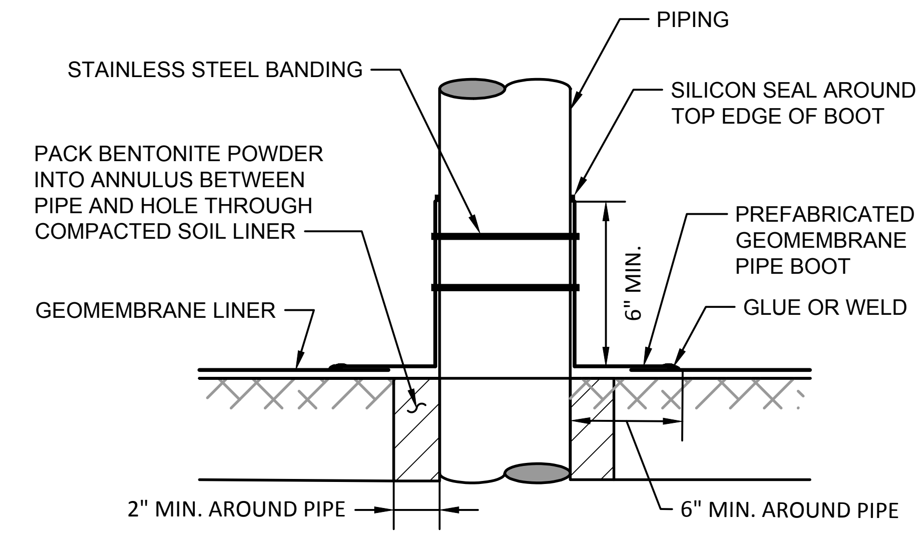
West Olympia Commercial Property Interim Action Work Plan Olympia, Washington	**Concept Landfill Cap and LFG Control System Layout**	Figure 2



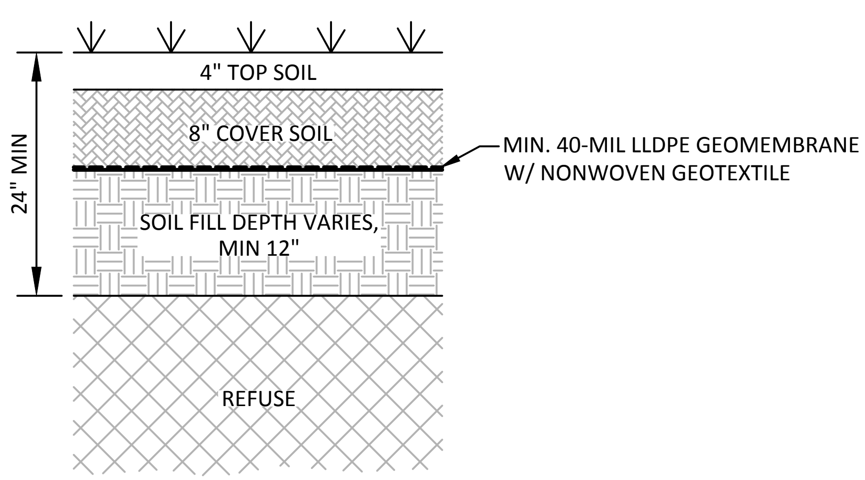
1 ASPHALTIC CONCRETE CAP



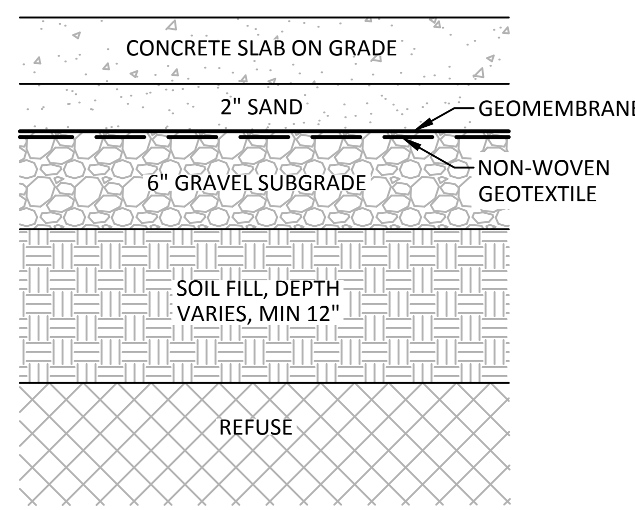
3 GEOMEMBRANE LINER UNDER PILE CAPS



5 LINER PENETRATION BOOT DETAIL



2 GEOMEMBRANE WITH SOIL COVER CAP

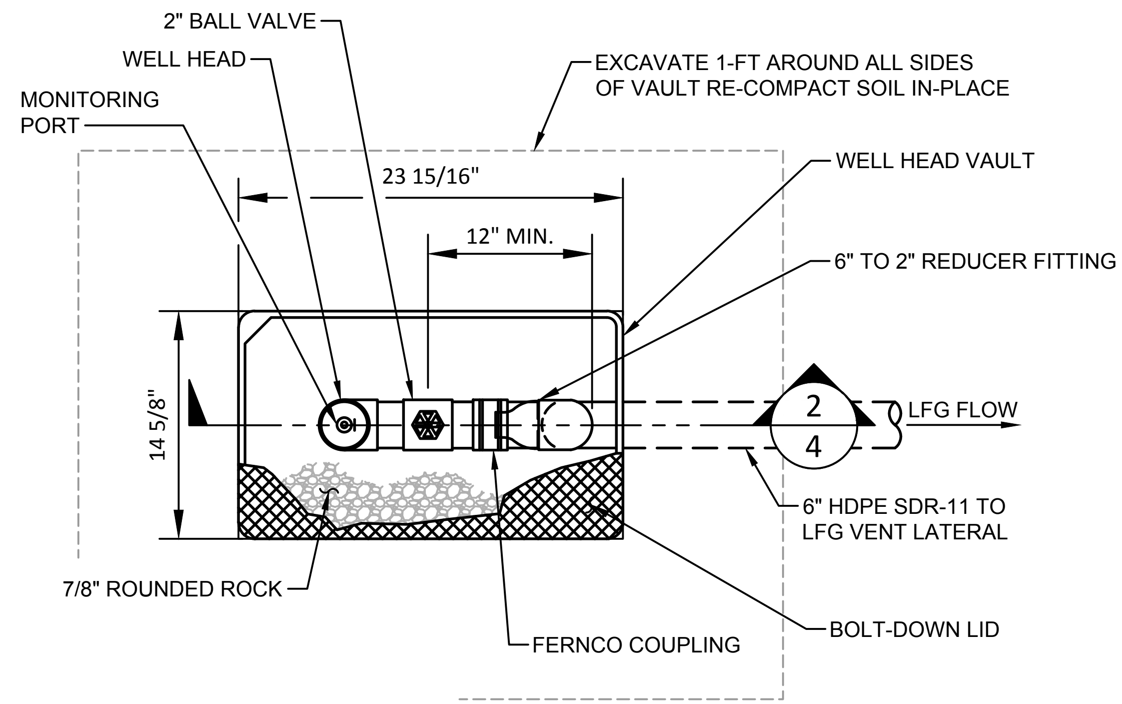


4 GEOMEMBRANE LINER UNDER SLAB ON GRADE

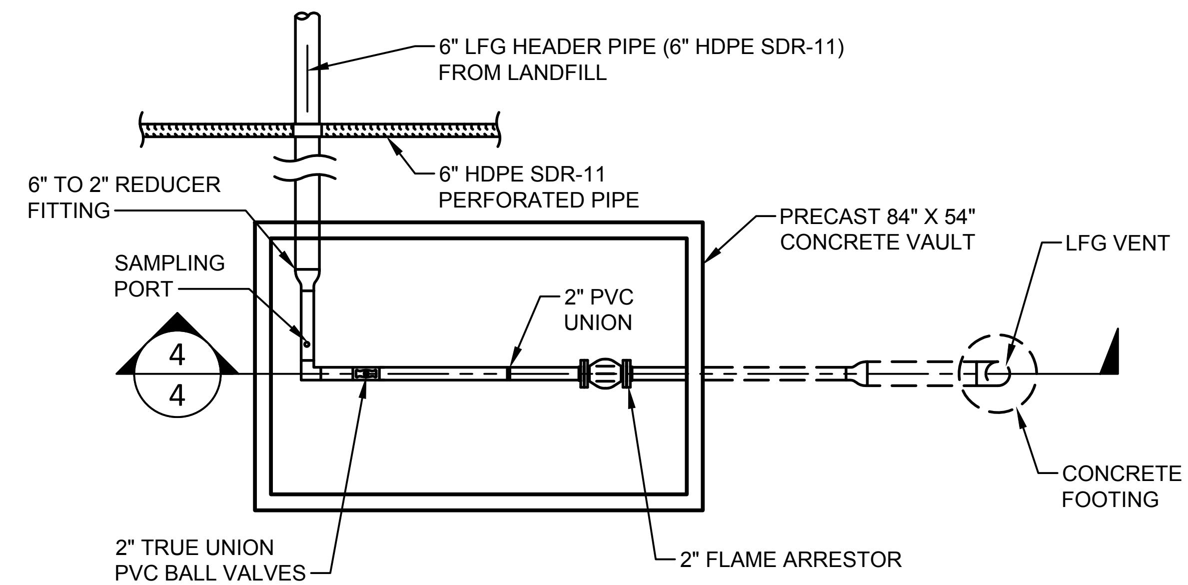
Notes
1. Landfill cap details are conceptual only. Final landfill cap design will be determined based on the development plan.
2. Drawing not to scale.

West Olympia Commercial Property Interim Action Work Plan Olympia, Washington	**Conceptual Landfill Cap Details**	Figure 3

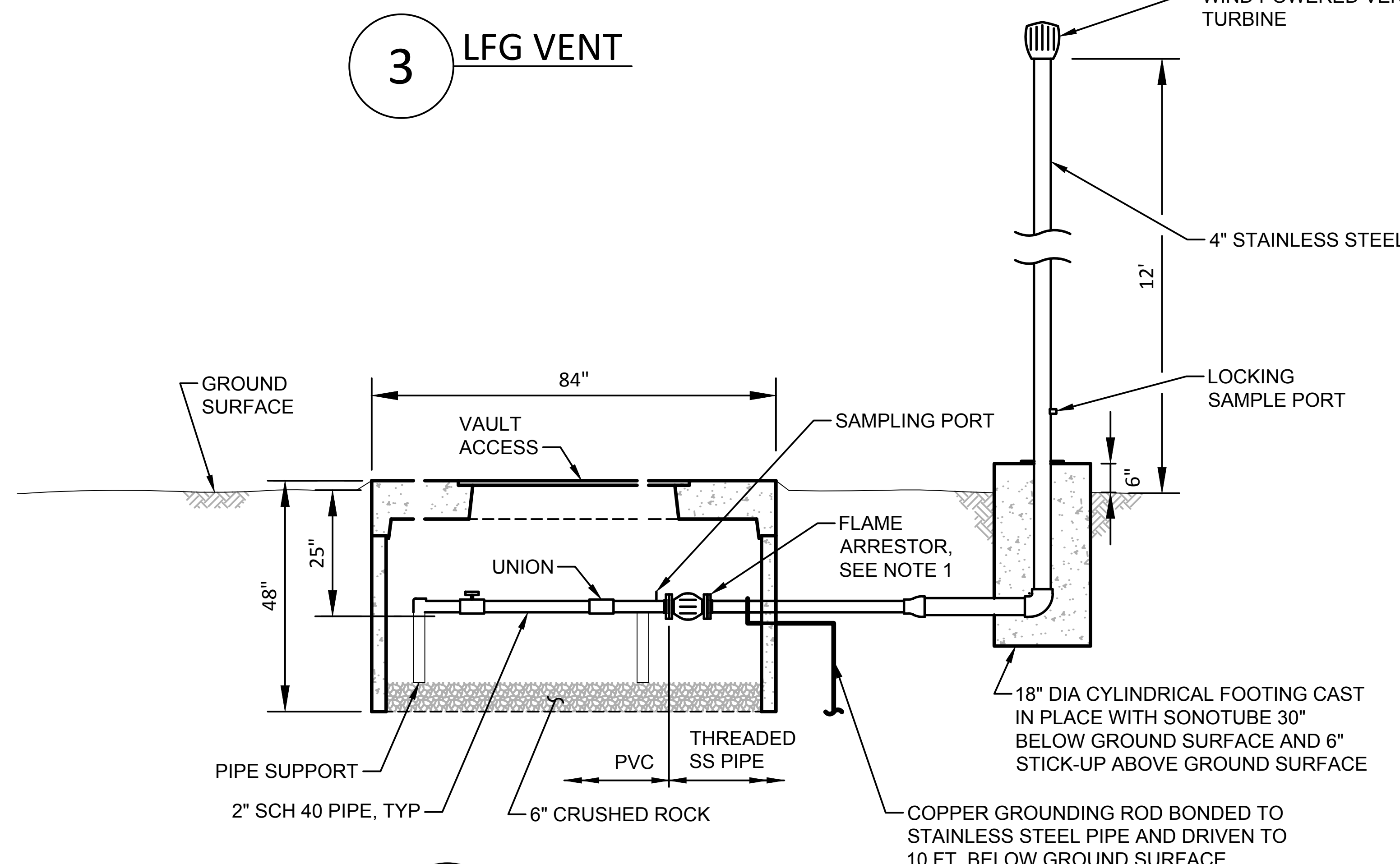
Landau Associates



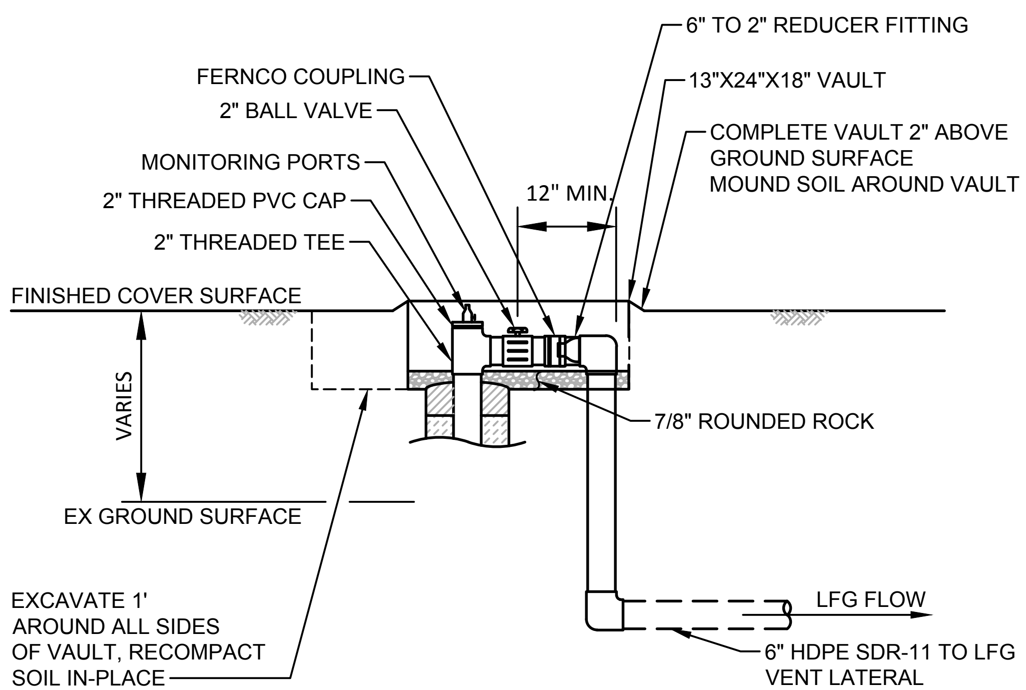
1 LFG PASSIVE COLLECTION WELL COMPLETION



3 LFG VENT



4 LFG VENT SECTION



2 LFG PASSIVE COLLECTION WELL COMPLETION SECTION

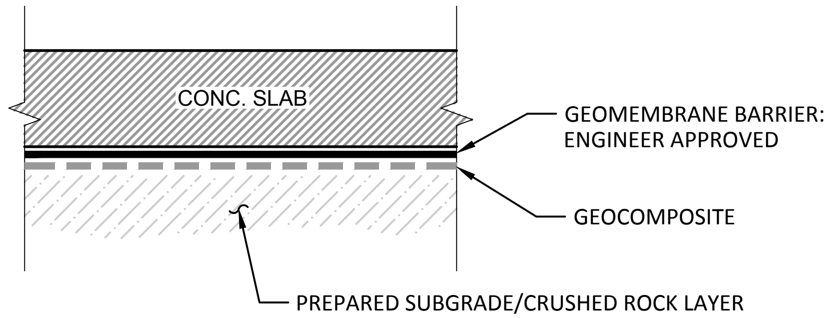
Notes
1. LFG control system details are conceptual only. Final LFG control system design will be determined based on the development plan.
2. Drawing not to scale.

Landau Associates

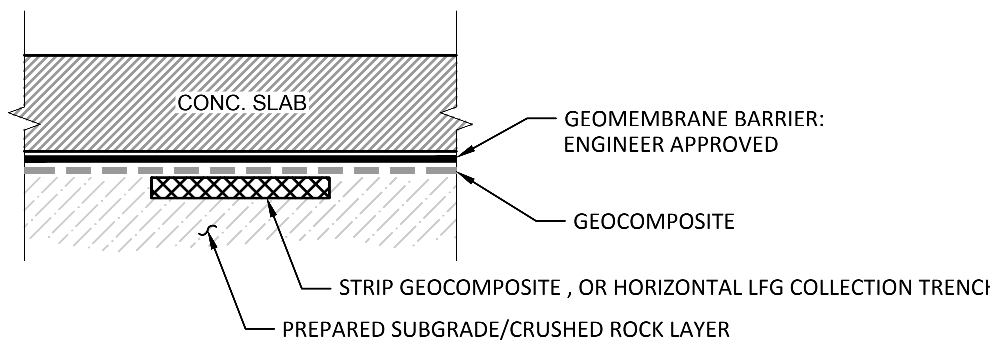
West Olympia
Commercial Property
Interim Action Work Plan
Olympia, Washington

Conceptual Perimeter
LFG Control System Details

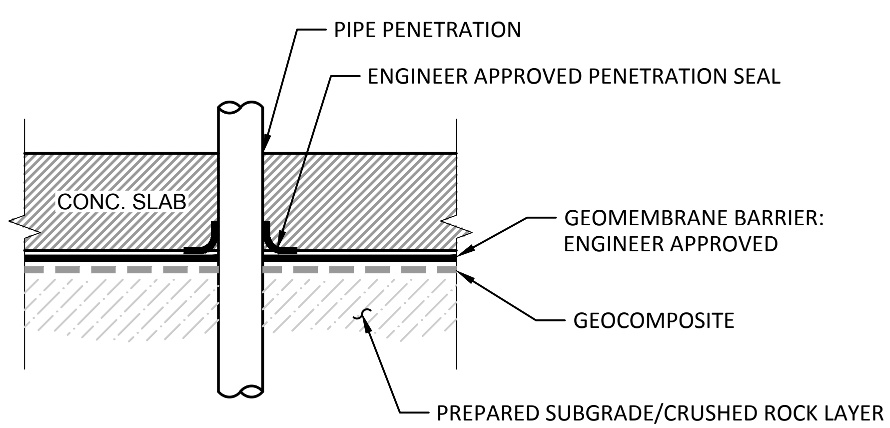
Figure 4



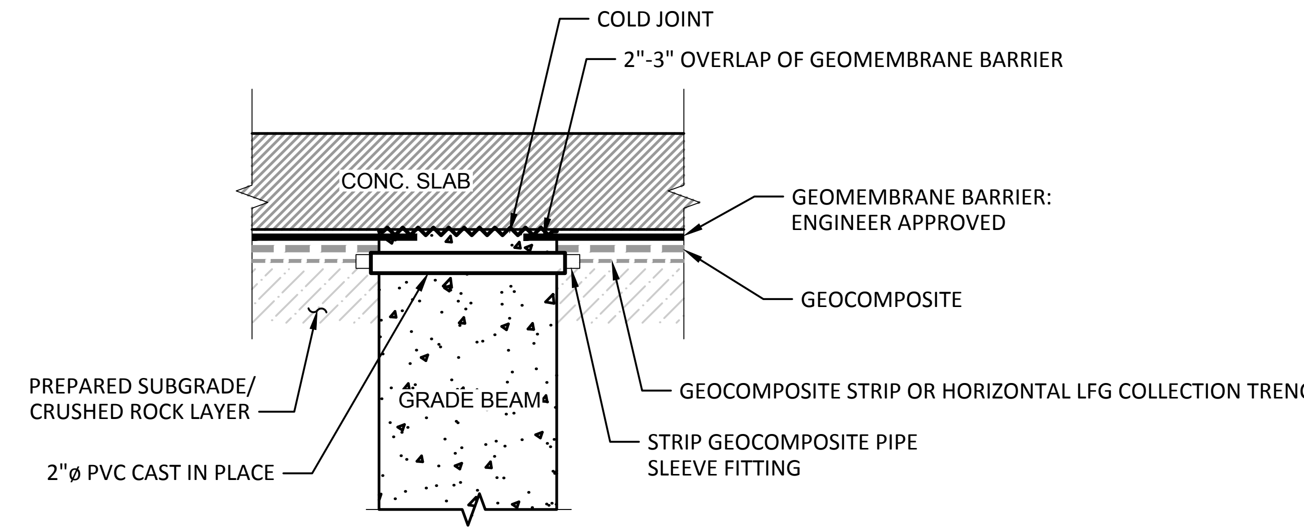
1 TYPICAL LFG VENTILATION LAYER AND BARRIER BELOW SLAB



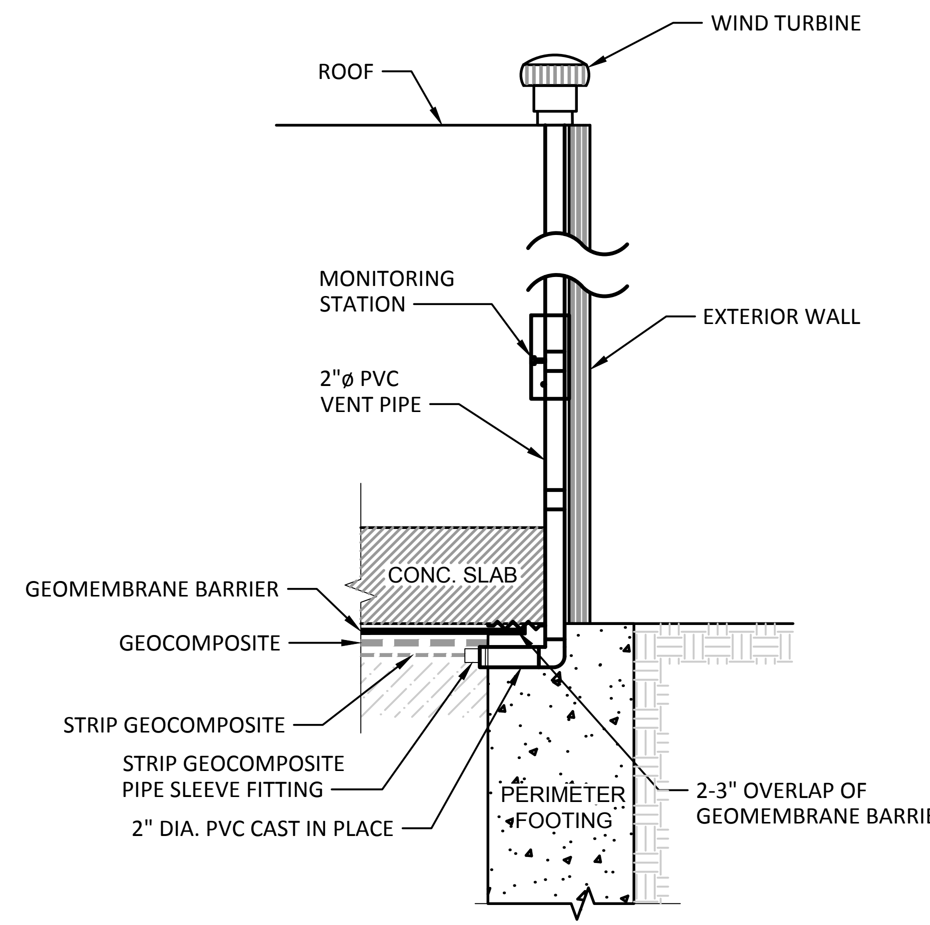
2 TYPICAL LFG VENTILATION AND BARRIER WITH STRIP GEOCOMPOSITE



3 TYPICAL VAPOR BARRIER PENETRATION



4 TYPICAL LFG CONDUIT PENETRATION AT GRADE BEAM

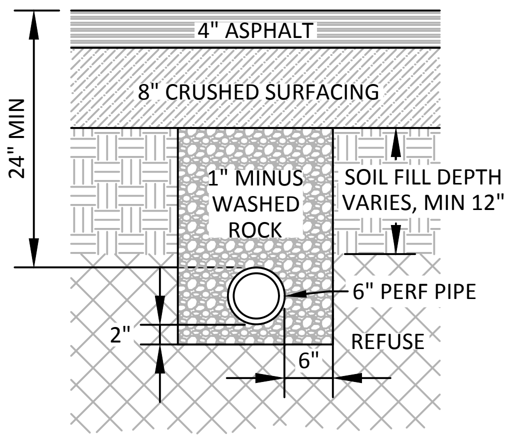


5 TYPICAL VENT PIPE PENETRATION

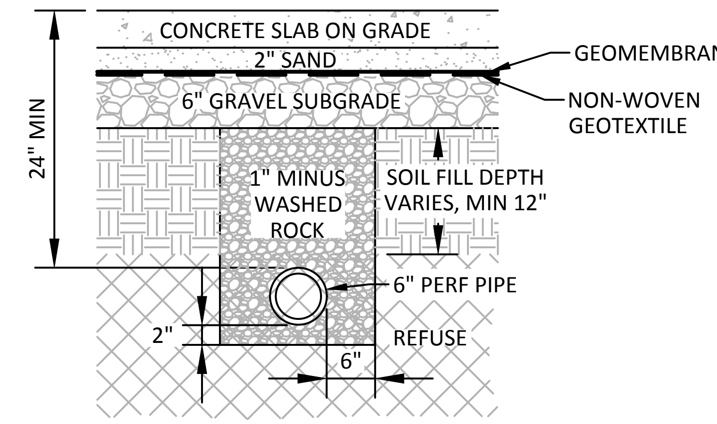
Notes
1. LFG control system details are conceptual only. Final LFG control system design will be determined based on the development plan.
2. Drawing not to scale.

Landau Associates

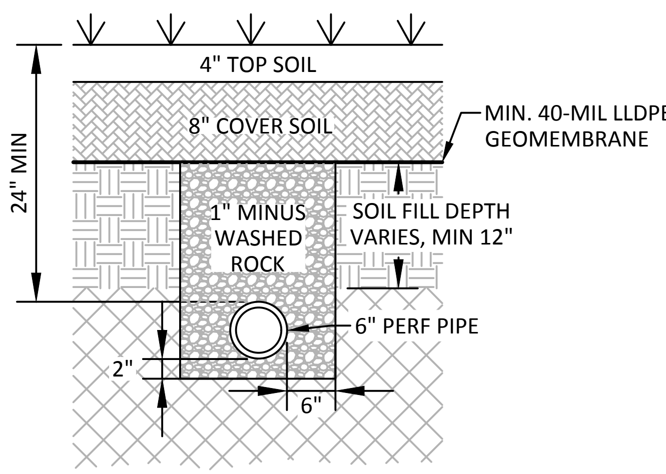
West Olympia Commercial Property Interim Action Work Plan Olympia, Washington	**Conceptual Building LFG Control System Details**	Figure 5



1 ASPHALT COVER WITH SHALLOW INTERNAL LFG TRENCH



3 BUILDING COVER WITH SHALLOW INTERNAL LFG TRENCH



2 MEMBRANE COVER WITH SHALLOW INTERNAL LFG TRENCH

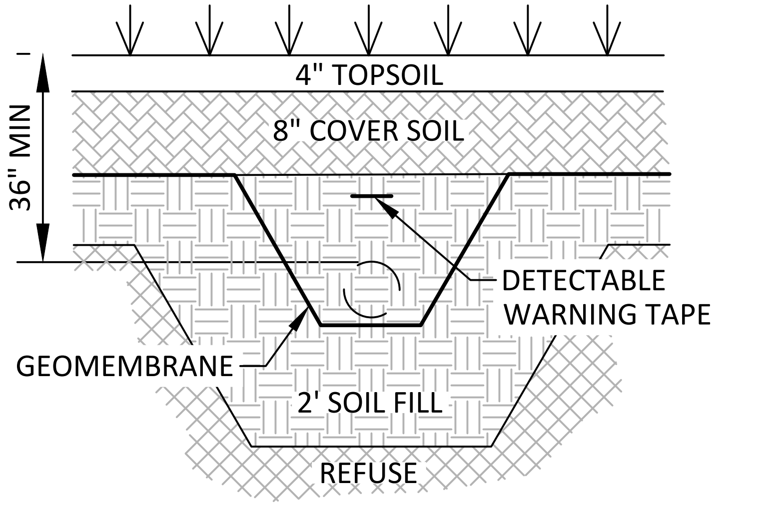
LANDAU ASSOCIATES

Notes
1. LFG control system details are conceptual only. Final LFG control system design will be finalized based on the development plan.
2. Drawing not to scale.

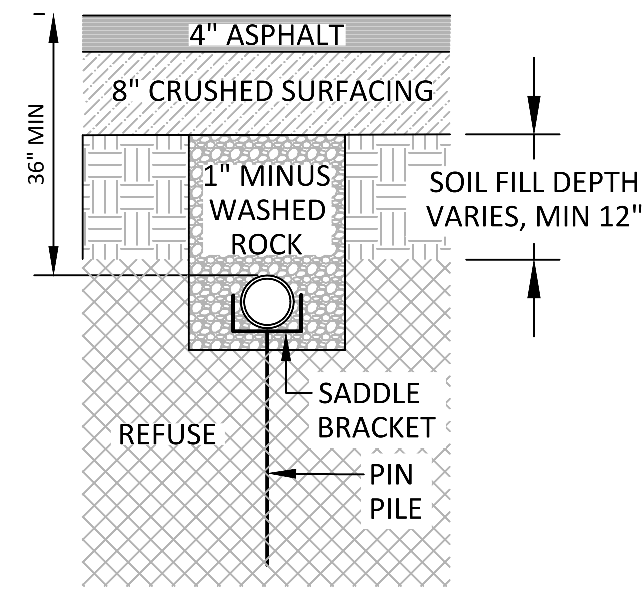
West Olympia
Commercial Property
Interim Action Work Plan
Olympia, Washington

Conceptual LFG Control System Details

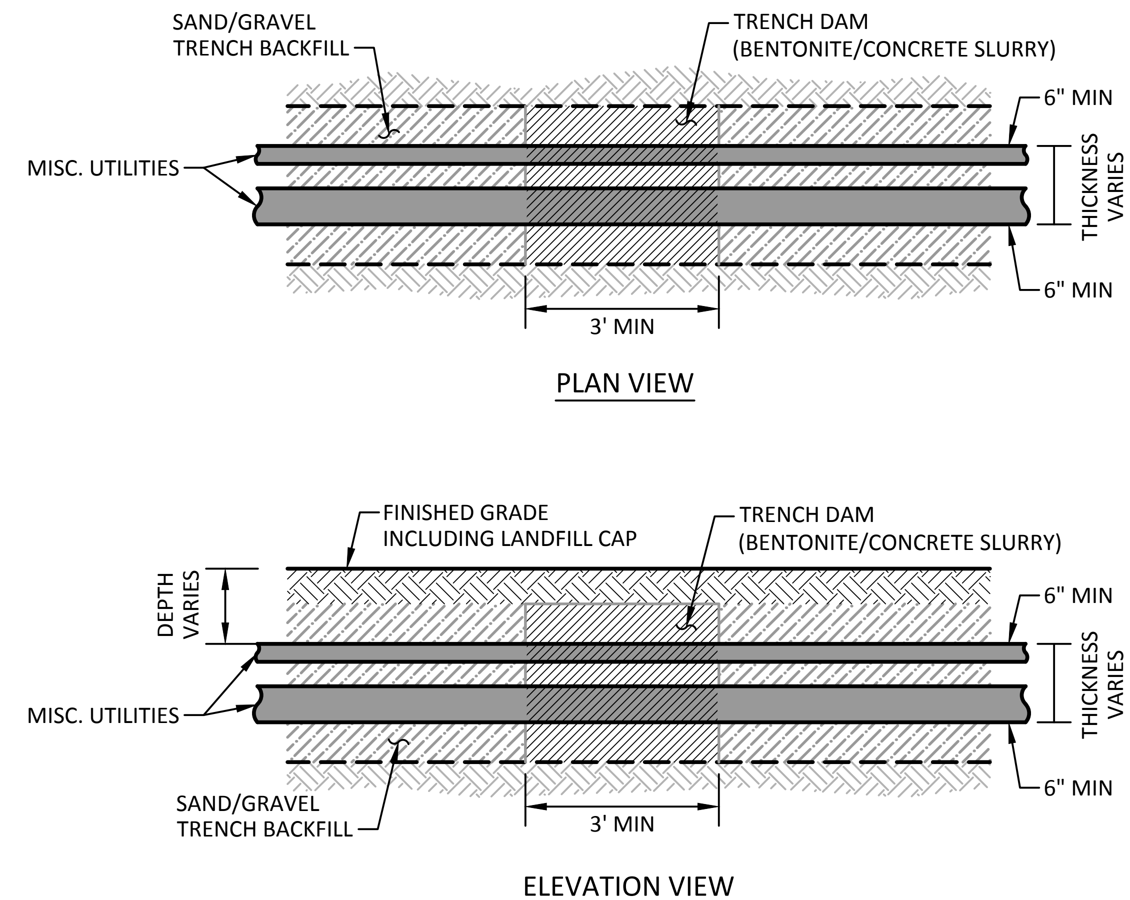
Figure
6



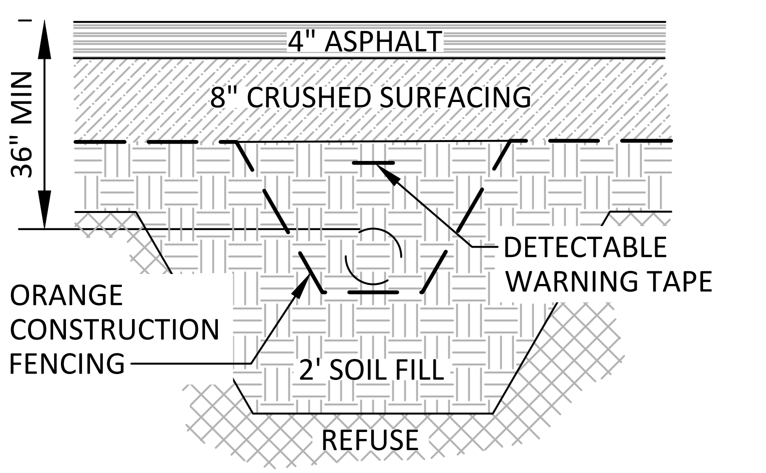
1 UTILITY CORRIDOR WITH SOIL COVER



3 PILE SUPPORTED UTILITIES



4 TRENCH DAM DETAIL



2 UTILITY CORRIDOR WITH ASPHALT COVER

Notes

1. Utility corridor details are conceptual only. Final utility corridor design will be determined based on the development plan.
2. Drawing not to scale.

West Olympia Commercial Property Interim Action Work Plan Olympia, Washington	**Conceptual Utility Corridor Details**	Figure 7

Table 1
Groundwater Monitoring Well and Soil Gas Probe Decommissioning Plan
West Olympia Commercial Property
Olympia, Washington

Exploration	Type of Exploration	Consultant	Completion Date	Exploration Depth (ft)	Retain/ Decommission
LAI-1	Monitoring Well	Landau Associates	7/20/2000	76.5	Retain
LAI-2	Monitoring Well	Landau Associates	7/20/2000	71.5	Retain
LAI-3	Monitoring Well	Landau Associates	7/19/2000	73.0	Decommission
LAI-MW-1	Monitoring Well	Landau Associates	6/7/2004	55.5	Retain
LAI-MW-2	Monitoring Well	Landau Associates	6/7/2004	65.4	Retain
LAI-MW-3	Monitoring Well	Landau Associates	6/8/2004	66.0	Retain
LAI-MW-4	Monitoring Well	Landau Associates	6/9/2004	70.5	Decommission
LAI-5d	Monitoring Well	Landau Associates	9/23/2005	156.0	Retain
PGG-1	Monitoring Well	Pacific Groundwater Group	6/21/2006	83	Retain
PGG-2	Monitoring Well	Pacific Groundwater Group	6/20/2006	82	Retain
GP-1	Gas Probe	Pacific Groundwater Group	6/19/2006	16	Retain
GP-2	Gas Probe	Pacific Groundwater Group	6/21/2006	13	Decommission
GP-3	Gas Probe	Pacific Groundwater Group	6/19/2006	14.5	Retain
GP-4	Gas Probe	Pacific Groundwater Group	6/20/2006	17	Decommission
GP-5	Gas Probe	Pacific Groundwater Group	6/20/2006	16	Decommission
GP-15	Gas Probe	Landau Associates	2/1/2018	7.0	Decommission
GP-16	Gas Probe	Landau Associates	2/1/2018	7.0	Decommission
GP-17	Gas Probe	Landau Associates	2/2/2018	7.0	Retain
GP-18	Gas Probe	Landau Associates	2/2/2018	7.0	Retain
GP-19	Gas Probe	Landau Associates	2/2/2018	7.0	Decommission
GP-20	Gas Probe	Landau Associates	2/2/2018	7.0	Retain
GP-21	Gas Probe	Landau Associates	5/17/2018	6.8	Retain
GP-22	Gas Probe	Landau Associates	5/17/2018	7.2	Retain
GP-23	Gas Probe	Landau Associates	5/17/2018	7.1	Retain
GP-24	Gas Probe	Landau Associates	5/17/2018	7.0	Retain

Abbreviations and Acronyms:
ft = feet

APPENDIX A

Applicable or Relevant and Appropriate Requirements, Interim Action West Olympia Commercial Property

West Olympia Commerical Property
Interim Action Work Plan
Applicable or Relevant and Appropriate Requirements

Comprehensive ARARs	Source	Description/Rationale
MTCA Cleanup Regulations	WAC 173-340	The overall ARAR applicable to the WOCP cleanup and interim action. Washington's hazardous waste cleanup law (MTCA) mandates site cleanups protect human health and the environment, and establishes regulatory requirements for the Interim Action at WOCP.
State Minimum Functional Standards for Solid Waste Handling	WAC 173-304-460	This regulation applies to facilities that dispose of solid waste in landfills, with the exception of inert, demolition, and wood waste landfills. It limits methane concentrations at the property boundary and in onsite and offsite structures, and requires compliance with ambient air quality standards and emission standards at the property boundary. This regulation applies only to solid waste landfills that operated after 1985, but it is a minimum requirement for solid waste landfill cleanups under MTCA.
State Environmental Policy Act	WAC 173-11-268	The interim action will have to comply with SEPA. SEPA mandates an environmental review of the project to prevent or eliminate damage to the environment. The SEPA review is typically integrated with MTCA requirements. The lead agency, either Ecology or the City of Olympia, will make a SEPA determination based on information in the IAWP, engineering design report, and required supplemental material (if any) to determine significant environmental impacts of the project.
Potential Chemical Specific ARARs[a]	**Source**	**Description/Rationale**
National Ambient Air Quality Standards	40 CFR 50	Specifies primary and secondary National Ambient Air Quality Standards, National Emission Standards for Hazardous Air Pollutants, and performance standards for new and existing stationary sources. National Ambient Air Quality Standards are applicable to those elements of the Interim Action pertaining to the collection and management of LFG.
State Dangerous Waste Regulations	WAC 173-303	Establishes regulatory requirements for the generation, handling, storage, transport, treatment, and disposal of dangerous wastes in the State of Washington under the provisions of the Washington State Hazardous Waste Management Act. These regulations apply to waste deemed dangerous or extremely hazardous to public health or the environment. The regulations would apply to material generated during the Interim Action that is found to be contaminated with dangerous waste, and requires treatment and offsite disposal.
Olympic Region Clean Air Agency (ORCAA) Notice of Construction	Regulation 6	ORCCA is the governing air emissions regulatory agency implementing the statues of the Washington State Clean Air Act and US EPA Clean Air Amendments. Requires a Notice of Construction and Application for Approval before constructing or modifying an air-contaminant source. This would apply to the Interim Action due to potential emissions of LFG.
ORCAA Emission Standards for Toxic Air Pollutants	Regulation 8	Implements at a regional level the National Emission Standards for Hazardous Air Pollutants. It requires best available control technology for sources of toxic air contaminants, and requires that toxic air contaminants be quantified and compared with acceptable source impact levels for each contaminant. ORCAA Emission Standards for Toxic Air Pollutants are applicable to air emissions from the LFG collection system.
Thurston County Board of Health Regulations	Article 5	The requirements established in this regulation govern solid waste handling and solid waste facilities and meet or exceed the requirements established by the Washington State Minimum Functional Standards for Solid Waste Handling.
Potential Location Specific ARARs[a]	**Source**	**Description/Rationale**
Federal Archeological Resource Preservation	RCW 27-53	This law addresses the discovery, identification, excavation, and study of archaeological resources, and the communication of information to state and federal agencies regarding the possible impact of construction activities on Washington State archaeological resources. The Interim Action Area has been extensively disturbed during operation of the landfill; this law could be applicable during implementation of the Interim Action.
State Permits for Archeological Excavation and Removal	WAC 25-48	Establishes application and review procedures for the issuance of archaeological excavation and removal permits, and for the issuance of civil penalties for violations. This law is potentially applicable in the event that archaeological resources are identified during implementation of the Interim Action.

West Olympia Commerical Property
Interim Action Work Plan
Applicable or Relevant and Appropriate Requirements

Potential Action Specific ARARs[a]	Source	Description/Rationale
City of Olympia Review (OMC title and chapter)		
Street/Right-of-Way Use	OMC Title 12/16	Requires a written permit for any proposed activities that use Olympia street ROW, including construction activities and movement of equipment. It will be necessary to conduct work in the ROW to implement the Interim Action. City of Olympia review requirements are applicable for elements of the interim action.
Water Connection	OMC Chapter 13.04	Specifies an application and approval process for connecting to the City of Olympia water supply system. Water connection is potentially needed for dust control during grading.
Sewer Connection	OMC Chapter 13.08	Requires connection of all sources of polluted water with the nearest accessible sanitary sewer. Sewer connection will potentially be needed for discharge of LFG condensate.
Electrical Service Connection	OMC Chapter 16.24	Specifies an application and approval process for obtaining electrical service from PSE and City inspection. Electrical service may be needed to power active LFG control elements, including LFG condensate controls and blower motors.
Building Codes	OMC Title 16/Title 18	Includes a number of requirements applicable to the Interim Action, including electrical, mechanical, fire, and energy codes and regulations for grading, stormwater, drainage, and erosion control.
Stormwater, Drainage, and Erosion Control	OMC Chapter 13.16	Specifies a drainage control review and approval process for projects that involve land-disturbing activities or new or replaced impervious surface. The Interim Action will require a Drainage Control Plan and a Construction Stormwater Control Plan.
Grading	OMC Chapter 16.48	Specifies a process for application and approval of a grading permit for earth-moving activities. Grading must preserve natural drainage patterns, and not create unstable slopes or contribute to increased turbidity or other forms of pollution in a watercourse.
Noise Control	OMC Chapter 8.32	Specifies maximum permissible noise levels for construction activities and facility operation in commercial zones, depending on the zoning designation of receiving properties.
Environmentally Critical Areas	OMC Chapter 18.32	Specifies development standards for actions affecting environmentally critical areas, including wellhead protection areas, streams and riparian zones, wetlands, geological hazard areas, landslide areas, and erosion or seismic hazard areas.
Monitoring and Maintenance		
Federal Occupational Safety and Health Standards	29 CFR 1910.120	Requires that employers develop and implement a written safety and health program for employees involved in hazardous waste operations. The program must be designed to identify, evaluate, and control safety and health hazards, and should provide emergency response for hazardous waste operations. This regulation is applicable to the implementation of the Interim Action.
State Occupational Health Standards	WAC 296-62	Establishes rules designed to protect the health of employees and to create a healthy work place. Requirements for chemical hazard communication programs, workplace lighting levels, and exposure records are in the safety and health core rules of this chapter. This regulation is applicable to the implementation of the Interim Action.
Well Construction Standards	WAC 173-160	Regulation defines minimum standards for the construction and decommissioning of the water resource protection and LFG control wells that will be installed or decommissioned as part of the Interim Action. The standards defined in this regulation are applicable to the Interim Action compliance monitoring program.
Groundwater Monitoring Plan	WAC 173- 304-490	This regulation addresses groundwater monitoring requirements for solid waste landfills, including provision for a minimum of one upgradient and two downgradient monitoring wells. The monitoring plan must specify procedures for sample collection, preservation and shipment, laboratory analysis and associated quality control protocols, and health and safety. Although this requirement applies only to landfills that operated after 1985, these monitoring requirements will be incorporated into the groundwater monitoring program that will be conducted as part of the RI/FS.
Accreditation of Environmental Laboratories	WAC 173-50	Regulation requiring persons submitting analytical data to use accredited environmental laboratories. Applies to all analytical data collected for the Interim Action and during the Interim Action compliance monitoring
Uniform Environmental Covenants Act	RCW 64.70	Regulation that addresses recording environmental covenants on the WOCP. The interim action strategy is containment, which will require the use of institutional controls and an environmental covenant on the WOCP as part of the Interim Action or future cleanup during the CAP.
Grading, Excavation, and Filling		
State Particulate Matter Standards	WAC 173-470	Establishes maximum acceptable levels for particulate matter in ambient air based on the criteria developed by the US Environmental Protection Agency. This regulation establishes requirements for monitoring, measuring, and reporting particulate matter data. It applies to dust-producing activities during implementation of the Interim Action, particularly excavation and site grading.
ORCAA Fugitive Dust Standards	Regulation 8	Establishes emission standards for fugitive dust. Applies to dust-producing activities, including construction and site grading.

West Olympia Commerical Property
Interim Action Work Plan
Applicable or Relevant and Appropriate Requirements

Potential Action Specific ARARs[(a)]	Source	Description/Rationale
Treatment, Discharge, and Disposal		
NPDES Permit	WAC 173-220	Establishes a state individual permit program, applicable to the discharge of pollutants and other wastes and materials to the surface waters of Washington State, operating under state law. Permits issued under this chapter are designed to satisfy the requirements for discharge permits under both the Federal Water Pollution Control Act and Washington State Water Pollution Control Act. This requirement is applicable to the control, collection, management, and discharge of stormwater runoff during and after construction of the Interim Action.
State Waste Discharge General Permit Program	WAC 173-226	Establishes a state general permit program, applicable to the discharge of pollutants, wastes, and other materials to waters of the state, including discharges to municipal sewerage systems. Permits issued under this regulation are designed to satisfy the requirements for discharge permits under the federal Water Pollution Control Act and the Washington State Water Pollution Control Act. Although this permit may not be required because of MTCA's permit exemption, it will be obtained as part of the Interim Action, because an NPDES permit is required, and Ecology typically issues a combined NPDES/state waste discharge permit.
Industrial Waste Discharge to LOTT Sewer System	LOTT Discharge and Industrial Pretreatment Regulations	Establishes rules and regulations applicable to water pollution-abatement activities, including the disposal of sewage or LFG condensate into the sewer system. Authorizes LOTT to develop and implement such procedures and to take any other actions necessary to ensure that local public sewers and private sewers discharging or proposing to discharge into the metropolitan sewer system are constructed and developed in accordance with applicable laws, regulations, and plans. This authorization may be required if LFG condensate requires discharge.
Thurston County Board of Health Regulations	Article 5	The requirements established in this regulation meet or exceed the requirements established by the Washington State Minimum Functional Standards for Solid Waste Handling, and are applicable to the Interim Action for compliance monitoring programs and as performance standards for the design of Landfill Cap and LFG control systems.

Notes:

(a) The above list of ARARs does not preclude subsequent identification of applicable federal, state, and local laws (WAC 173-340-360 (10)(a)(vii).

1. Pursuant to Section 090 of Chapter 70.105D of the Revised Code of Washington (RCW 70.105D.090), PLPs conducting a remedial action under an agreed order with Ecology are exempt from some state-administered procedural requirements and the procedural requirements of any local laws requiring or authorizing local government permits or approvals for the remedial action. However, the substantive requirements of state and local laws requiring permits or approvals shall be complied with.

2. Pursuant to WAC 173-340-710(9), the state agencies and local governments that have potential permits subject to the permit exemption have been consulted. The substantive requirements of the permits that are exempt, to the extent they are currently known, have been incorporated into this Interim Action Work Plan. Therefore, the substantive requirements of state and local laws subject to the permit exemption will be met during the Interim Action.

Abbreviations and Acronyms:

ARARs Applicable or relevant and appropriate requirements
CAP corrective action plan
CFR Code of Federal Regulations
IAWP Interim Action Work Plan
LFG landfill gas
MTCA Model Toxics Control Act Cleanup
NPDES National Pollutant Discharge Elimination System
OMC Olympia Municipal Code
ORCAA Olympic Region Clean Air Agency
PSE Puget Sound Energy
RCW Revised Code of Washington
RI/FS Remedial Investigation/Feasibility Study
ROW right-of-way
WAC Washington Administrative Code
WOCP West Olympia Commercial Property

APPENDIX B

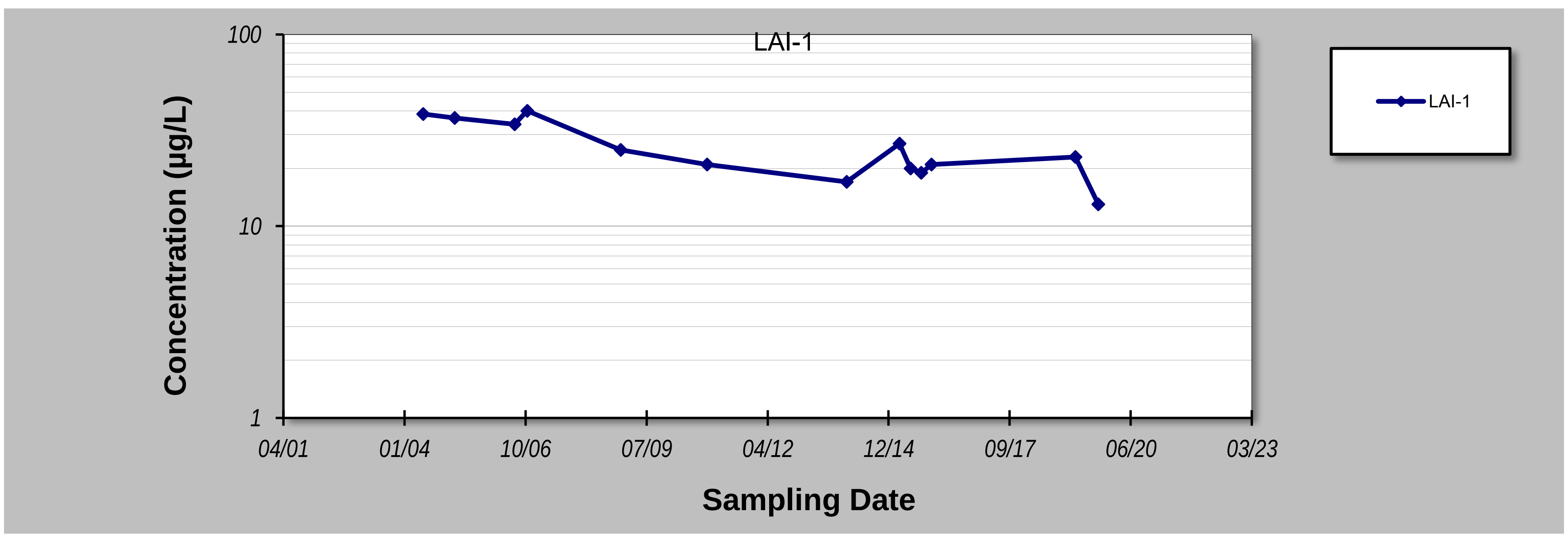
Mann-Kendall Analysis

GSI MANN-KENDALL TOOLKIT
for Constituent Trend Analysis

Evaluation Date:	26-Mar-20	Job ID:	0258052.030.034
Facility Name:	WOCP	Constituent:	TCE
Conducted By:	KMG	Concentration Units:	µg/L

Sampling Point ID: LAI-1

Sampling Event	Sampling Date	TCE CONCENTRATION (µg/L)						
		LAI-1						
1	18-Jun-04	38.4						
2	3-Mar-05	36.7						
3	11-Jul-06	34						
4	24-Oct-06	40						
5	3-Dec-08	25						
6	18-Nov-10	21						
7	15-Jan-14	17						
8	25-Mar-15	27						
9	24-Jun-15	20						
10	23-Sep-15	19						
11	16-Dec-15	21						
12	20-Mar-19	23						
13	24-Sep-19	13						
14								
15								
16								
17								
18								
19								
20								
Coefficient of Variation:		0.34						
Mann-Kendall Statistic (S):		-45						
Confidence Factor:		99.8%						
Concentration Trend:		Decreasing						



Notes:

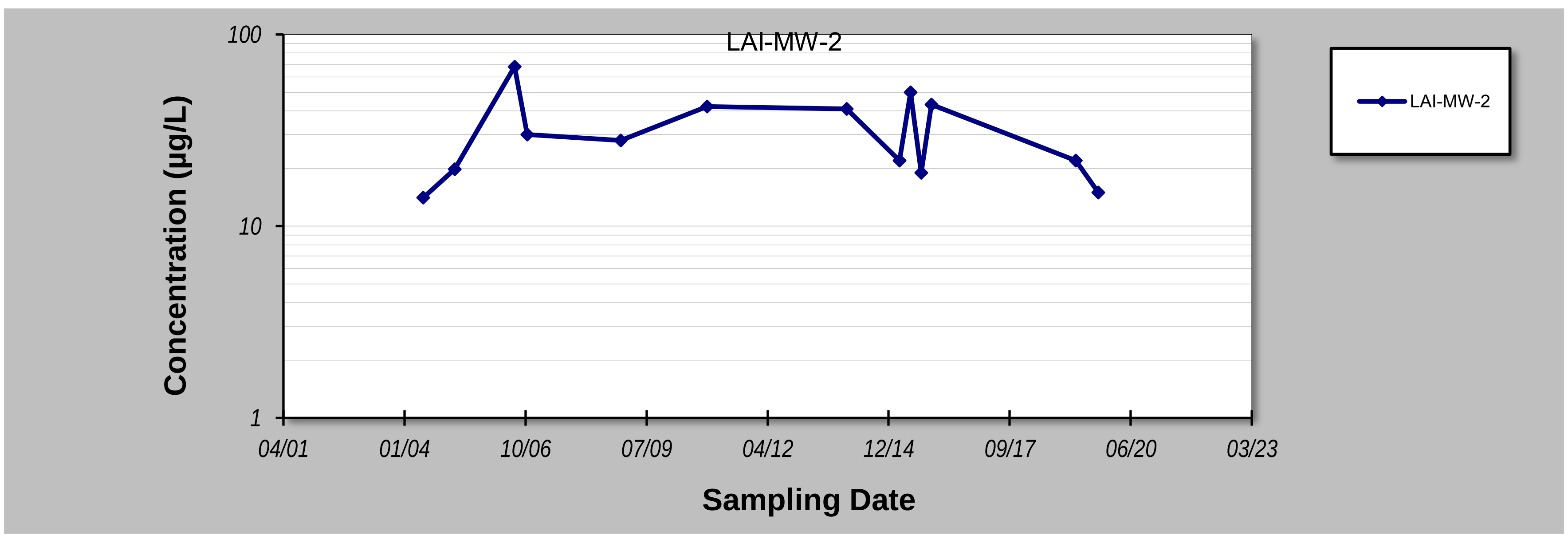
1. At least four independent sampling events per well are required for calculating the trend. *Methodology is valid for 4 to 40 samples.*
2. Confidence in Trend = Confidence (in percent) that constituent concentration is increasing (S>0) or decreasing (S<0): >95% = Increasing or Decreasing; ≥ 90% = Probably Increasing or Probably Decreasing; < 90% and S>0 = No Trend; < 90%, S≤0, and COV ≥ 1 = No Trend; < 90% and COV < 1 = Stable.
3. Methodology based on "MAROS: A Decision Support System for Optimizing Monitoring Plans", J.J. Aziz, M. Ling, H.S. Rifai, C.J. Newell, and J.R. Gonzales, *Ground Water* , 41(3):355-367, 2003.

GSI MANN-KENDALL TOOLKIT
for Constituent Trend Analysis

Evaluation Date:	**26-Mar-20**	Job ID:	**0258052.030.034**
Facility Name:	**WOCP**	Constituent:	**TCE**
Conducted By:	**KMG**	Concentration Units:	**µg/L**

Sampling Point ID: **LAI-MW-2**

Sampling Event	Sampling Date	TCE CONCENTRATION (µg/L)						
		LAI-MW-2						
1	18-Jun-04	14.1						
2	3-Mar-05	19.8						
3	11-Jul-06	68						
4	24-Oct-06	30						
5	3-Dec-08	28						
6	18-Nov-10	42						
7	15-Jan-14	41						
8	26-Mar-15	22						
9	24-Jun-15	50						
10	23-Sep-15	19						
11	16-Dec-15	43						
12	21-Mar-19	22						
13	24-Sep-19	15						
14								
15								
16								
17								
18								
19								
20								
Coefficient of Variation:		**0.50**						
Mann-Kendall Statistic (S):		**-3**						
Confidence Factor:		**54.8%**						
Concentration Trend:		Stable						



Notes:

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