King County Department of Natural Resources and Parks

Solid Waste Division

Phase 1 – Vashon Island Closed Landfill

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Remedial Investigation Report

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Vashon Island Closed Landfill

Prepared for: King County Solid Waste Division

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Acronyms

amsl	above mean sea level
ARAR	applicable or relevant and appropriate requirement
Aspect	Aspect Consulting, LLC
CFR	Code of Federal Regulations
CO_2	carbon dioxide
COC	constituent of concern
CSM	conceptual site model
CWA	Clean Water Act
Ecology	Washington State Department of Ecology
EM	electromagnetic
EPA	United States Environmental Protection Agency
FS	Feasibility Study
GWAC	groundwater advisory committee
HDPE	high-density polyethylene
HEC	Herrera Environmental Consultants
KCSWD	King County Solid Waste Division
KCWLRD	King County Water and Land Resources Division
LFG	landfill gas
MCL	maximum contaminant level
MTCA	Model Toxics Control Act
NTR	National Toxics Rule
PCUL	preliminary cleanup level
POC	point of compliance
RCRA	Resource Conservation and Recovery Act
RDL	reporting detection limit
RI	Remedial Investigation
scfm	standard cubic feet per minute
SQER	small quantity emission rate

SWANA	Solid Waste Association of North America
TCE	trichloroethene
USC	United States Code
USGS	United States Geological Survey
VLF	Vashon Island Closed Landfill
VMI	Vashon-Maury Island
VOC	volatile organic compound
WAC	Washington Administrative Code

Executive Summary

This Remedial Investigation (RI) Report has been prepared to document the results of the RI at the Vashon Island Closed Landfill (VLF), located on Vashon Island, Washington (Figure 1.1). An RI is conducted to define the distribution of contaminants at a site and the associated potential threat to human health and the environment. For an RI conducted in accordance with the Washington State Model Toxics Control Act (MTCA; Washington Administrative Code [WAC] Chapter 173-340), data is gathered and analyzed to provide an understanding of the hydrogeologic site setting, nature and extent of contaminants, their fate and transport, and the receptors that may be impacted by the contaminants. This information is used to develop preliminary cleanup levels (PCULs) and constituents of concern (COC). PCULs address all detected constituents in all affected media for which promulgated screening criteria are available. Information collected for the RI enables preparation of a feasibility study (FS). PCULs are considered preliminary as the final cleanup levels are established by the Washington State Department of Ecology (Ecology) in a cleanup action plan, prepared following the approval of the RI and the FS.

King County Solid Waste Division (KCSWD) performs routine monitoring to meet the landfill's permit requirements. One of these requirements is groundwater detection monitoring. In response to a written request by KCSWD to modify the list of groundwater analytes it was required for detection monitor (King County, 2014), Ecology and Public Health – Seattle & King County (herein referred to collectively as the Agencies) stated that additional data and evaluation were needed before a reduction in the analyte list could be authorized (Ecology, 2014). This RI Report includes evaluation of data collected since implementation of the recommendations made in "Environmental Review, Investigation, and Evaluation Technical Memorandum – Vashon Island Closed Landfill" (Aspect et al., 2012a).

The following provides an overview of the RI findings.

Extent of Solid Waste and Landfill Closure

Solid waste disposal activities occurred at the VLF since the early 1900s. Based on review of historical topographic maps, solid waste was placed in a former valley. The northwest portion of the landfill, approximately 2.3 acres, was closed in 1988 in accordance with WAC 173-304 (Phase 1 Closure Area). During Phase 1 closure, a liner was placed across the central portion of the landfill. The landfill accepted refuse for placement in the lined portion of the landfill until 1999. Final landfill closure (or Phase 2 closure) was completed in 2001 in accordance with WAC 173-351. Site investigations suggest that unlined refuse extends approximately 300 feet south of the Phase 2 closure area, into the South Slope Area.

Landfill environmental controls include a permanent geomembrane cover system across Phase 1 and 2 closure areas, landfill gas (LFG) extraction and treatment, stormwater management, and leachate collection. The VLF facility includes a transfer and recycling station, LFG treatment facilities, and a scale house.

Hydrogeology

VLF geology is composed of glacially derived sediments, with surficial geology being primarily glacial till and advance outwash. The site stratigraphic model categorizes the subsurface into seven primary units, designated A through G, based on interpreted geologic origin. Groundwater in two underlying stratigraphic units (Unit C and Unit D) has been characterized for the nature and extent of COCs at the VLF.

Unit C is glacially derived, consisting of fine-grained soils (Cf) deposited in a low-energy glaciomarine or glaciolacustrine setting and coarser-grained soils (Cc) deposited in a higher-energy glaciofluvial deposit. Subunits Cc2 and Cc3 are considered to be the principal water-bearing layers of Unit C. Borings completed at the VLF indicate limited hydraulic interconnection between Cc units, which is consistent with the characteristics of their glacial depositional environment. The Cc units are separated from one another by fine grained soils (Cf).

Groundwater with concentrations of COCs exceeding PCULs is limited to Unit Cc2. Groundwater flow in Unit Cc2 is westerly and discharges from seeps located on the steep hillslope on the western side of the VLF property.

Unit D is a fluvial deposit exhibiting a wide range in texture consistent with varying energy in a fluvial environment, including sandy gravel channel deposits to fine-grained overbank deposits. In all deeper borings completed onsite, a fine-grained portion of Unit C was observed separating the water-bearing portions of Unit C from the Unit D aquifer. Groundwater COCs have not been detected above PCULs in Unit D, whether in on-property monitoring wells or off-property domestic drinking water wells monitored by KCSWD. Unit D is not considered to be impacted by landfilling processes.

Extent of Impact

The following presents the conclusions of the RI.

- Groundwater impacts are limited to Unit Cc2. Groundwater COCs include dissolved metals (arsenic and iron) and volatile organic compound (VOCs; vinyl chloride, benzene, 1,2-dichloropropane, and trichloroethene [TCE]).
- Surface water impacts at the VLF are limited to surface water locations downgradient of Unit Cc2 groundwater discharge points along the West Hillslope of the VLF property.
- LFG is the primary source of groundwater impact. Residual leachate impacts to groundwater have diminished overtime.
- Lateral control of LFG is maintained by active LFG collection infrastructure. No off-property migration of LFG has been observed since at least 1998.

MTCA defines “Site” or “Facility” as everywhere that contamination has come to be located. The VLF MTCA Site includes those areas delineated on Figure 8.1 where COCs exceed PCULs. More specifically, the VLF MTCA Site is bounded to the north by the edge of the Phase 2 final cover and by MW-4 and MW-36, and to the east by the estimated extent of unlined refuse and MW-20. To the south, COC concentrations at MW-21 are expected to continue to decline with the expansion of the LFG collection system within the South Slope Area. At the west property boundary, only vinyl chloride exceeds PCULs; however, downgradient of the VLF, concentrations of vinyl chloride do not exceed PCULs at a sampling location 1,600 feet west of the VLF in Robinwood Creek.

Exposure Pathways and Receptors

The following exposure pathways and receptors were identified as potentially complete for humans:

- Direct contact with groundwater. Direct contact of current and potential future on-property VLF staff and construction workers (above- and below-ground) is an exposure pathway mitigated by landfill safety procedures.
- Ingestion of groundwater. This is considered a potentially complete pathway for off-property for both current and potential future residents because the extent of impacted Unit Cc2 groundwater to the south of the VLF property is unknown.
- Direct contact with surface water. This exposure pathway is potentially complete for current and future off-property residents and off-property recreational users.
- Ingestion of aquatic organisms. Off-property, this exposure pathway is complete for current residents and recreational users and potentially complete for future residents and recreational users, driven by ingestion of aquatic organisms exposed to bioaccumulative compounds (i.e., vinyl chloride) originating from groundwater discharge to surface water.
- Direct contact with refuse. Potential exposure pathways for soil include direct contact with shallow refuse (on-property only).
- Inhalation of fugitive LFG. Human exposure to LFG is mitigated on-property by landfill safety procedures. There is no evidence of LFG migration off-property.
- Direct contact with fugitive leachate. Human exposure to leachate is mitigated on-property by landfill safety procedures. There is no evidence of leachate migration off-property.

While the pathway for ecological exposure to impacted surface water is complete on-property along the West Hillslope, no exceedances of dissolved metals are present at the VLF property boundary. No ecological-based PCULs are established for other COCs.

The exposure pathway of direct contact by terrestrial receptors is considered incomplete based on terrestrial ecological evaluation exclusion criteria. The exclusion to the ecological evaluation based on depth to refuse is an institutional control that would need to be captured in a restrictive covenant.

1 Introduction

This Remedial Investigation (RI) Report has been prepared to document the results of the RI at the Vashon Island Closed Landfill (VLF), located on Vashon Island, Washington (Figure 1.1). An RI is conducted to define the distribution of contaminants at a site and the associated potential threat to human health and the environment. For an RI conducted in accordance with the Washington State Model Toxics Control Act (MTCA; Washington Administrative Code [WAC] Chapter 173-340), data is gathered and analyzed to provide an understanding of the hydrogeologic site setting, nature and extent of contaminants, their fate and transport, and the receptors that may be impacted by the contaminants. This information is used to develop preliminary cleanup levels (PCULs) and constituents of concern (COC). PCULs address all detected constituents in all affected media for which promulgated screening criteria are available. Information collected for the RI enables preparation of a feasibility study (FS) and remedy selection to address contamination. PCULs are considered preliminary as the final cleanup levels are established by the Washington State Department of Ecology (Ecology) in a cleanup action plan, prepared following the approval of the RI and the FS.

King County Solid Waste Division (KCSWD) performs routine monitoring to meet the landfill's permit requirements. In response to a written request by KCSWD to modify the list of groundwater analytes it was required for detection monitor (King County, 2014), the Washington State Department of Ecology (Ecology) and Public Health – Seattle & King County (herein referred to collectively as the Agencies) stated that additional data and evaluation were needed before a reduction in the analyte list could be authorized (Ecology, 2014). This RI satisfies some of the additional data and evaluation requested by Ecology to support the demonstration. This RI Report includes evaluation of data collected since implementation of the recommendations made in "Environmental Review, Investigation, and Evaluation Technical Memorandum – Vashon Island Closed Landfill" (Aspect et al., 2012). These recommendations included updates to the hydrogeologic conceptual model; contaminant source evaluation; groundwater and surface water monitoring system improvements; leachate monitoring; and landfill gas (LFG) monitoring investigations.

1.1 Objectives and Purpose

The objective of this RI Report is to evaluate and document data by which to characterize the environmental conditions associated with the VLF. Ultimately, this RI will be used to prepare a FS to enable the selection of a cleanup action in compliance with MTCA regulations (WAC 173-340-350 through 173-340-390). Specifically, the RI objectives included:

- Provide an up-to-date summary of completed investigations conducted at the VLF since landfill closure.

- Update the existing hydrogeologic conceptual site model (CSM) with data through December 2017.
- Characterize the nature and extent of impacted media (i.e., groundwater and surface water) at the VLF and define the “Site” in accordance with MTCA.
- Identify the potential for vertical migration of LFG and the need for LFG controls beyond what is already in place.
- Identify the potential for migration of landfill leachate and the need for leachate controls beyond what is already in place.
- Identify PCULs for affected media that are not contained within the footprint of landfill refuse.

1.2 Report Organization

This RI includes 9 sections and 10 appendices. The main text is organized as follows:

- **Section 1 – Introduction** presents information regarding the objectives and approaches for the VLF RI.
- **Section 2 – Site Setting** provides information on VLF location, history, and closure.
- **Section 3 – Environmental Setting** summarizes environmental information relevant to the VLF RI, including topography, surface water features, climate, and hydrogeology.
- **Section 4 – Previous Investigations** describes the purpose and scope of earlier investigations conducted at the VLF.
- **Section 5 – Proposed Preliminary Cleanup Levels** are identified for the purposes of comparing chemical concentrations and identifying potential site-specific pathways by which human and ecological receptors. Chemical data are compared to potential screening levels to determine COCs.
- **Section 6 – Nature and Extent of Contamination** summarizes data on the chemical quality of groundwater, surface water, LFG, and leachate and compares the concentrations to PCULs.
- **Section 7 – Conceptual Site Model** provides a discussion of fate, transport, and attenuation processes. It describes the mechanisms of contaminant transport through groundwater, discusses the processes of chemical attenuation, and evaluates potential exposure pathways.
- **Section 8 – Remedial Investigation Conclusions** summarizes the main conclusions presented in the RI, presents the MTCA “Site” boundary, identifies ongoing interim actions, and discusses potential data gaps resulting from the RI.
- **Section 9 – References** are provided at the end of the main report text.

The RI includes multiple appendices, as presented in the Table of Contents, that support the analyses and discussions in the main body of the text and tables.

2 Site Setting

This section provides descriptions of the Site location and surrounding area, and a summary of the Site history including historical operations, and phased landfill closure.

2.1 Site Location and Surrounding Area Description

The VLF property encompasses 52.5 acres of land within the west-central portion of Vashon Island, King County, Washington (Figure 2.1). Westside Highway SW runs through the landfill, dividing it into two unequal parts. The 37.2-acre area east of the highway is primarily unwooded open space and consists of 10.3 acres of municipal solid waste and 28.7 acres of landfill facilities. This eastern portion is currently secured with perimeter fencing and locked access gates. The 15.3-acre area west of the highway is steep, undeveloped, forested land, commonly referred to as the West Hillslope. The VLF property is bounded by Westside Highway SW and rural residential land to the northwest, by Southwest 184th Street to the north, by forested land and rural residential land to the east, and by rural residential land to the south. Figure 2.2 presents the land use and parcel map for the landfill and surrounding properties.

The VLF property is zoned RA-5 (Rural Area, one dwelling unit per 5 acres). Adjacent land to the north, south, and east are also zoned RA-2.5 and RA-5 (Rural Area, one dwelling unit per 5 acres). The Island Center Forest, a King County park, adjoins the landfill along parts of its east and north borders.

Facilities at the VLF include a transfer and recycling station, LFG treatment facilities, a scale house, a perimeter road, perimeter stormwater ditches, a leachate lagoon, a south siltation pond, a south detention pond, an east pond, transfer station storm ponds, and a borrow area with associated pond. These facilities are shown on Figure 2.3.

2.2 Site History

The following section provides a history of site use as a landfill, extent of solid waste and details about landfill closure activities in 1988 and 2001.

2.2.1 Historical Operations

Solid waste disposal activities have occurred at the VLF since the early 1900s. KCSWD assumed operations during the late 1950s (R.W. Beck and Associates, 1983), at which time routine record-keeping practices were initiated. The northwest portion of the landfill east of Westside Highway SW was closed in 1988 and a liner was placed across the central portion of the landfill. A summary of closure activities including liner placement are detailed in Section 2.2.2. The facility accepted refuse for placement in the landfill until 1999 (King County, 2011b), when the transfer and recycling station was completed. Since then, waste generated on the island has been trucked off-island to the Cedar Hills Regional Landfill (Berryman & Henigar and UES, 2006a).

2.2.1.1 Depth and Extent of Solid Waste

None of the subsurface explorations at the VLF have encountered the bottom of the solid waste in the central portion of the landfill, outlined as 1988 and 2001 final cover areas on

Figure 2.3, and a high-resolution pre-landfill topographic map is not available. However, given the general site setting, it is suspected solid waste was placed in a former valley running approximately north-south, the southern extent of which can be seen at the South Slope Area located at the south end of the landfill, east of the Leachate Lagoon. Based on review of historical topographic maps, it is suspected that the solid waste reaches a maximum thickness of 20 to 40 feet near the center of the former valley and thins towards the outer margins of the landfill (Golder Associates, 1986). While a high-resolution pre-landfill topographic map is not available, pre-landfill closure maps from 1979 and 1986 are provided in Appendix A.

The horizontal extent of solid waste, including areas without a bottom liner located within the northwest corner of the landfill closed in 1988 and the South Slope Area, is shown on Figure 2.4. The extent of unlined refuse (enclosed by dotted red line in Figure 2.4) is based on multiple lines of evidence: visual observations in 1987 (Golder Associates, 1987), geophysical investigations (Aspect and Duoos, 2018), subsurface explorations, and LFG occurrence. Figure 2.4 also depicts the landfill closure areas and the portions of the unlined refuse areas at the south end of the landfill where a geotextile cover was placed. The leachate lagoon, also located at the south end of the landfill, was constructed with a geomembrane liner and it is unknown if solid waste underlies this feature.

2.2.2 Landfill Closure

The VLF was closed in two phases: a partial closure in 1988 in accordance with WAC 173-304 (herein referred to as Phase 1) and a final closure in 2001 in accordance with WAC 173-351 (herein referred to as Phase 2). The following subsections summarize specific activities performed during the two closure phases.

2.2.2.1 Phase 1 Closure Activities

In 1988, the northwest portion of the landfill area (approximately 2.3 acres) was closed in accordance with then-applicable regulations, Minimum Functional Standards for Solid Waste Handling (WAC 173-304). The closure included installation of cover, a liner below the lateral expansion area, surface water management, leachate collection, and LFG collection systems.

Cover System Installation

The cover system installed in 1988 spanned the existing waste as well as locations planned for lateral expansion east and south sides of the existing refuse mounds (referred to as the “lateral expansion area”). The composite lining system consists of the following components, listed from top to bottom.

- Seed
- Topsoil (6 inches)
- Vegetative soil (6 inches)
- Drain sand (12 inches)

- Strip drain
- High-density polyethylene (HDPE) geomembrane (80 mil [0.08 inches] thick)
- Low-permeability soil (24 inches)
- Geotexile
- Foundation material/natural soil liner (6 inches)
- Gas collection gravel (12 inches)—existing refuse mound only, not placed in lateral expansion area

Refuse placed in the ravine between the south toe of the lined area and the south stormwater facilities (also referred to as the “South Slope Area”) was stabilized using geotextile and a native soil cover as depicted in Figure 2.4 (Berryman & Henigar and UES, 2006a).

Approximately 10 acres were covered or lined (Berryman & Henigar and UES, 2006a). Figure 2.3 depicts the northwest refuse area covered in 1988 and the lateral expansion area where the bottom liner was placed in preparation for future refuse placement (identified as the “Phase 2 - 2001 Final Cover” area).

Surface Water Management System Installation

The initial surface water collection and conveyance system was installed from 1986 to 1990 during closure of the northwest corner of the landfill (King County, 2018). The surface water management systems installed at that time included ditches, culverts, and siltation and detention ponds. Surface water collection features are illustrated on Figure 2.5.

Leachate Collection System Installation

To bring the VLF into compliance with state and local solid waste regulations, a leachate collection system was installed in 1988 after placement of the cover system. Leachate collection features are illustrated on Figure 2.6. The process of installing the collection system included:

- Installation of a gravity leachate collection system within the landfill footprint.
- Construction of a lined, aerated, pretreatment and storage lagoon (“Leachate Lagoon” on Figure 2.6).
- Construction of discharge pump station and leachate tank truck loading station.
- Installation of a perforated toe collector and pump station at the base of the South Slope Area of the VLF that discharges to the leachate conveyance system.

LFG Collection System Installation

The information summarized in this section regarding the initial 1988 and expanded 1996 LFG collection system installation is based on Harper-Owes et al. (1988), CH2M HILL (1997a, 1997b), and Berryman & Henigar and UES (2006a). A detailed description of these activities is provided in “Vashon Island Closed Landfill Environmental Evaluation” (henceforth the Environmental Evaluation Report) (Berryman & Henigar and UES, 2006a). The existing LFG collection system is illustrated on Figure 2.7.

In 1988, KCSWD installed a passive LFG collection system using horizontal perforated piping connected to independent elevated flares (including EF-1, EF-2, EF-3, and EF-4), in addition to the gas collection gravel placed beneath the 1988 closure cover system. This system was designed to control LFG along the edges of waste (EF-1, EF-2, and EF-3), and within the covered waste area (EF-4).

In 1996, KCSWD converted the passive LFG collection system to an active system by installing a blower and treatment system, connecting EF-1 through EF-4 to a gas conveyance pipe header, and decommissioning the elevated flares. The collected LFG was not flammable, and LFG was treated using granular activated carbon. Condensate from LFG conveyance piping was pumped or drained into leachate pipes for conveyance to the lined Leachate Lagoon.

KCSWD also expanded the LFG collection infrastructure in 1996 by installing:

- Vertical gas wells GW-1 through GW-8 across the bottom two-thirds of refuse thickness in the 1988 closure area (CH2M HILL, 1997b).
- Horizontal trench collectors T-1 and T-5 along the northern and western edge of unlined waste in the gas collection gravel placed above the refuse and beneath the 1988 closure cover system.
- Horizontal trench collector T-2 along the eastern edge of unlined waste in reworked "natural soil material" beneath the 1988 bottom liner geomembrane (no waste had yet been placed above the liner in this area).
- Horizontal trench collectors T-3 and T-4 in what was then uncovered refuse above the bottom liner at the south end of the landfill, within the Phase 2 landfill area.

2.2.2.2 Phase 2 - Final Closure Activities

The placement of material in the "lateral expansion area" was discontinued in August 1999 and a temporary plastic cover was placed over the refuse. Final closure in accordance with WAC 173-351, Criteria for Municipal Solid Waste Landfills, was completed between 1999 and 2001. Closure activities began with expansion of the existing surface water management infrastructure and improvements to accommodate flows following installation of the final cover system. The second stage of closure involved installation of an impermeable cap over the refuse, and upgrades to the other environmental control systems. The combined Phase 1 and Phase 2 landfill closure area is approximately 10.3 acres. Final closure record drawings were presented by Berryman & Henigar et al. (2001).

Surface Water Management System Installation

Surface water drainage features are illustrated on Figure 2.5. During the late 1999 upgrades to the surface water management system, a detention pond (the "East Pond") was installed at the southeast corner of the property and an underground drain system including the North Landfill Drain was installed along the landfill perimeter (King County, 2010). The North Landfill Drain is a 12-inch diameter storm drain system that extends along the east side of the landfill along the perimeter road between the two east-side catch basins, and ultimately discharges to the East Pond. During the final closure phase in 2001, surface water control features within the landfill perimeter were further modified; these modifications included installation of the West Landfill Drain and the South Landfill Underdrain at the south toe of the landfill (Berryman & Henigar and UES, 2006a). The South Landfill Underdrain was installed below and parallel to the ditch along the south face of the landfill. Ultimately, stormwater from the VLF is discharged via an outfall from the South Detention Pond into an unnamed, natural, ephemeral drainage course tributary to Judd Creek.

After final landfill closure, the surface water management system included the following features:

- Vegetated, rock, and asphalt ditches
- Drainage structures and piping
- South Siltation Pond
- Borrow Area Pond
- East Pond
- South Detention Pond
- Transfer Station Storm Ponds

A detailed description of the VLF surface water management system is provided by Berryman & Henigar and UES (2006a).

Final Cover System Installation

The final cover system installed in 2001, designed and constructed in accordance with WAC 173-351, consisted of the following components from top to bottom:

- Seed
- Vegetative Soil (6 inches)
- Topsoil (6 inches)
- Granular drain material (18 inches)
- 60-mil HDPE geomembrane
- Natural low-permeability soil liner (24 inches)
- Geotexile
- Gas collection gravel drainage layer (1 inch)

The topsoil, vegetative soil, and low-permeability soil were all obtained from source onsite at the borrow area (Berryman & Henigar and UES, 2006a).

Leachate Collection System Installation

Leachate collection features are illustrated on Figure 2.6. The leachate collection and conveyance system were expanded before cap placement during the Phase 2 closure, and the Leachate Lagoon was constructed. At landfill closure, the VLF leachate control system consisted of drainage material placed above the bottom liner of the landfill, a network of collection and transmission pipes, two pump stations, and the Leachate Lagoon (Berryman & Henigar and UES, 2006a). Leachate either flows by gravity or is pumped by Pump Station 2 to the flow control vault, and then to Manhole 3. From Manhole 3, leachate flows by gravity to the Leachate Lagoon for pretreatment by aeration. Pump Station 1 pumps the treated leachate from the lagoon to tanker trucks for discharge off-site at a King County wastewater treatment plant.

The sanitary sewer and leachate flows from the tipping floor of the transfer station are conveyed to the VLF leachate system for pretreatment. A detailed description of the leachate system is provided by Berryman & Henigar and UES (2006a).

LFG Collection System Installation

This section summarizes the LFG collection system installation after 1996, and prior to final Phase 2 closure in 2001. A more detailed description is provided in the Environmental Evaluation Report (Berryman & Henigar and UES, 2006a). Figure 2.7 maps the existing LFG collection system.

During landfilling activities after 1996 and before 1999, horizontal trench collectors FT-1 through FT-4 were installed between refuse lifts and connected to the existing active LFG collection system. In 2001, horizontal trench collectors FT-5 and FT-6 were installed just below the 2001 closure cover system and connected to the existing active LFG collection system.

3 Environmental Setting

This section describes the topography, climate, and geology/hydrogeology conditions of the landfill. In addition, a summary of LFG generation and components is provided.

3.1 Topography and Surface Drainage

The topography at the VLF property is gently rolling at elevations ranging from 300 to 400 feet above mean sea level (amsl). The VLF is located within the Judd Creek drainage area. Surface water from the VLF generally drains toward the south into a tributary of Judd Creek; however, the undeveloped West Hillslope portion of the property drains westward into an unnamed tributary of Robinwood Creek and eventually into Colvos Passage. Robinwood Creek is a fish-bearing waterbody. Judd Creek flows approximately 3 miles to the southeast and discharges into Quartermaster Harbor (King County, 2018). Streams near the VLF are identified on Figure 2.1.

3.2 Climate

King County has a mild climate tempered by southwesterly winds. Summers are cool and dry, and winters are moist and mild. KCSWD has maintained a weather station—the West Judd Creek Rain Gage (28Y)— at the VLF since October 2004. Routine monitoring (to the quarter hour) has occurred since 2004 for precipitation, since 2007 for air temperature, since 2010 for barometric pressure, and since 2011 for solar radiation. The data for the West Judd Creek Rain Gage were provided by King County's Hydrologic Information Center (http://green2.kingcounty.gov/hydrology/DataDownload.aspx).

The monthly average precipitation ranges from 0.5 inches in July to 7.7 inches in November. The annual total precipitation received ranged from 30.9 inches in 2013 to 56.5 inches received in 2006. The single rainiest month on record was November 2006, with 18.2 inches of rain recorded.

The daily average temperature for the period of record (2007-2014) ranged from 48 to 54 degrees Fahrenheit, while the daily maximum temperature ranged from 68 to 84 degrees Fahrenheit, and the daily minimum temperature range from 19 to 32 degrees Fahrenheit.

3.3 Regional Geology and Hydrogeology

This section provides a detailed summary of the regional geology and hydrogeology to provide broader context and scale for relevant VLF stratigraphy and contaminant extent discussed in Section 3.4.

3.3.1 Geologic Setting

Vashon Island geology is composed of glacially derived sediments deposited during several glacial episodes. Surficial geology is primarily glacial till (or till-like units), (approximately 68 percent of the island), and glacial and alluvial outwash (the remaining 32 percent) (King County, 2005). A regional perspective of the geologic setting is shown by cross section A-A´ (Figures 3.1 and 3.2). Off-property wells depicted on Figure 3.1

include borings used for interpretation of geologic contacts and regional wells monitored by KCSWD (DW prefix in well identification). Refer to Section 6.1.3 for a discussion of groundwater monitoring results from off-property wells. The regional cross section is based on unpublished work from the University of Washington (used by permission; Troost, 2004).

The following descriptions are based on a U.S. Geological Survey (USGS) geologic map of Vashon and Maury Islands (Booth, 1991). Data suggest that tills representing at least three separate glacial advances occur on Vashon Island. The most recent of these was deposited during the Vashon Stade of the Fraser Glaciation, which reached its maximum southerly extent near Olympia about 17,000 years ago. A stade is a short period of time characterized by climatic conditions associated with maximum glacial extent. The Vashon till (Qvt) mantles most of the island and is widespread throughout the Puget Lowlands. Surficial geologic materials in the VLF area consist of Quaternary (Vashon) till and advance outwash. Although Vashon ice contact deposits mantling the till east of the VLF have been mapped, these materials were not identified in explorations completed at the landfill (see boring logs compiled in Appendix B).

The till is underlain by advance outwash (Qva) soils formed by water flowing in front of the approaching glacier; these outwash deposits were subsequently overridden and compacted by glacial ice and till. The advance outwash deposit tends to grade downward from gravelly sand to uniform fine to medium sand. The USGS map (Booth, 1991) shows Vashon advance outwash as occurring at or below the 300-foot elevation west and south of the VLF. At the VLF, sands directly beneath the till are presumed to be advance outwash. The upper (gravelly) advance outwash was not encountered at the VLF; soils directly beneath the advance outwash are typically a poorly graded fine sand or slightly silty sand.

Distribution of pre-Vashon and pre-Fraser deposits beneath the advance outwash is complex. The base of the advance outwash is defined by the uppermost appearance of interglacial silts or clay or oxidized non-glacial clasts. Exposures of the Quaternary pre-Fraser fine-grained facies (Qpff) unit are mapped on the steep bluff just west of the landfill at elevations at or below 200 feet. A small outcrop of older pre-Fraser clay and silt has also been identified at the base of the sea cliffs southwest of the VLF property. All VLF soils beneath the uppermost (“advance outwash”) sands are presumed to be pre-Fraser in age and laterally continuous with those soils mapped west of the landfill. For the VLF, these soils include alluvial, fluvial, and lacustrine or glaciolacustrine sediments.

3.3.2 Regional Hydrogeology

Groundwater flow on Vashon-Maury Island (VMI) is largely radial and downward, flowing outward from the island’s central uplands towards the surrounding Puget Sound (King County, 2005). Groundwater is recharged from precipitation. In areas with glacial till surficial soils, infiltration rates are low compared to those with coarser grained surficial soils derived from glacial outwash. Rainwater either infiltrates or flows overland into lakes or streams that ultimately discharge to the Puget Sound. Surface water may also infiltrate, if for example, the stream flows through an area with coarse soils.

Regional hydrogeology has been examined over the years by the following studies: a 1983 water resources study, frequently referred to as the Carr Report (Carr/Associates, 1983); VMI Ground Water Management Plan (VMI Ground Water Advisory Committee [GWAC], 1998); and VMI Water Resources Evaluation 2004-2010 (multiple reports). The broader purpose of the studies was to evaluate different components of the island's water budget, water supply sustainability, and water quality.

The Carr Report (Carr/Associates, 1983) identified two primary aquifers used as Vashon Island's water supply source: the Principal Aquifer generally located above sea level yielding moderate amounts of water to wells, and the Deep Aquifer at depths of about 100 to 300 feet below sea level capable of yielding larger quantities of water. The 1998 groundwater management plan (GWAC, 1998) defined four hydrostratigraphic zones based on water level data and completion depths from 25 wells.

Broadly speaking, Zones 1 and 2 are within the Principal Aquifer and Zones 3 and 4 are within the Deep Aquifer identified in the Carr Report. In both studies, groundwater flow in the shallower aquifers was to the east and west from a topographic high that extends in an approximate north-south axis along the island, with steeper gradients along the west side.

Groundwater modeling completed as a component of the Water Resources Evaluation confirmed this aspect of groundwater flow on the island (King County, 2005). Research for the groundwater modeling found that groundwater use is fairly evenly divided among the shallow advance outwash, upper deep, and lower deep aquifers. What the groundwater modeling report refers to as "deep aquifers" are stratigraphically below the pre-Fraser fine-grained facies referred to in the previous section. Drinking water wells located in the vicinity of the VLF property are illustrated on Figure 3.1. Appendix C provides a summary table and figure of drinking water wells within a 2-mile radius of the VLF property as recorded in the Department of Ecology and Department of Health databases.

3.4 Site Geology and Hydrogeology

This section provides a summary of the updated hydrogeologic conceptual model for the VLF. Initially developed by Berryman & Henigar et al. (2000), Berryman & Henigar and UES (2004, 2006a) and King County (2011b), the updated hydrogeologic conceptual model described below reflects data collected since 2014.

3.4.1 Site Stratigraphic Model

The site stratigraphic model categorizes the subsurface into seven primary units, designated A through G, based on interpreted geologic origin. The principal stratigraphic units for the current site model are summarized below from shallowest to deepest. Monitoring wells installed on the VLF property and their assigned completion units are shown on Figure 3.3 and in Table 3.1. Cross sections, whose positions are noted on Figure 3.3, are shown on Figures 3.4 through 3.6. Stratigraphic interpretations provided in the cross sections are a refinement of work completed by King County in 2012 (King County, 2012; included in Appendix D of this report).

3.4.1.1 Unit A

Unit A consists of relatively impermeable Vashon Till that mantles the landfill property east of the Westside Highway SW. Soils in this unit consist of gravelly, silty sand. The till ranges in thickness from 15 to 50 feet, except where it has been eroded or removed by landfill-related activities. As illustrated on cross section C-C´ (Figure 3.5) and Figure 2.4, the area where till is known to be absent is at the south end of the VLF property. Groundwater has not been identified in Unit A and no monitoring wells are completed in this unit.

3.4.1.2 Unit B

Underlying the till is an advance outwash sand designated as Unit B. This unit has been encountered in all borings that extend beyond Unit A and ranges in thickness from about 40 to 50 feet.

3.4.1.3 Unit C

Unit C consists of variable fine-grained glacially derived sediments approximately 100 to 120 feet thick. Groundwater that has been impacted by the VLF occurs within Unit C coarse-grained material; therefore, the depositional environment is discussed in more detail compared to other units and subunits have been defined.

The fine-grained portions of Unit C (indicated by Cf for Unit C fine-grained) act as an aquitard and consist of interbedded sandy silts, silts, and clays. Incised within the fine-grained soil are coarser sand deposits (indicated by Cc for Unit C coarse-grained). The Cf soils were deposited in a low-energy glaciomarine or glaciolacustrine setting and the Cc sediments are a higher energy glaciofluvial deposit. Glaciofluvial deposits are typically less laterally extensive than non-glaciofluvial deposits and appear to represent subglacial meltwater channel deposits and possibly eskers (sinuous ribbons of sand and gravel deposited in meltwater tunnels at the base of the ice). Glaciofluvial sand can also be deposited in a meltwater channel below floating or grounded glacial ice.

Three coarser units have been identified within Unit C, designated from shallowest to deepest as Cc1, Cc2, and Cc3. Surface outcrops of Units Cc2 and Cc3 were observed during a survey completed of the steep West Hillslope located on the west side of the property (King County, 2011a). As depicted in the cross sections, the Cc units are not continuous across the VLF property. For example, Unit Cc3 was not observed in borings completed north of the VLF closure area. Unit Cc2 was not observed in borings southeast and northwest of the VLF closure area.

Borings completed at the VLF indicate limited hydraulic interconnection between the three Cc units, consistent with what is known of their glacial depositional environment. These units are separated from one another by highly variable Cf units as discussed in detail below:

- Cf between Cc1 and Cc2 includes 10 feet of silt or silt with fine sand layers below which the unit has interlayers of silt, sandy silt, and silty sand.
- Cf between Cc2 and Cc3 consists of interlayers of silt, sandy silt, silty sand, and clay.

- Cf between Cc3 and Unit D consists of interlayers of sandy silt, silt, and gravelly silt. The Cf between Units Cc3 and D has been identified in all borings that extend to Unit D or deeper.

3.4.1.4 Unit D

Unit D is comprised of fluvial deposits exhibiting a wide range in texture consistent with varying energy in a fluvial environment. Textures range from sandy gravel channel deposits to fine-grained overbank deposits, and the unit exhibits a corresponding range of hydraulic properties. Thickness of Unit D ranges from about 25 to 65 feet and has been encountered in all deeper borings.

3.4.1.5 Unit E

Unit E is a lacustrine unit approximately 40 feet thick, underlies Unit D and is thought to be continuous beneath the site. This unit is mainly comprised of silt and acts as an aquitard between the water-bearing fluvial deposits in Unit D and Unit F.

3.4.1.6 Unit F

Unit F consists of Pre-Vashon fluvial deposits of widely varying texture, similar to those of Unit D. The thickness of Unit F ranges from 30 to over 90 feet.

3.4.1.7 Unit G

Unit G is the oldest and deepest unit encountered in soil borings at the VLF and is a dark gray, varved clay thought to be regionally extensive and over 50 feet thick.

3.4.2 Site Hydrogeology

The following sections present information on the site-specific hydrogeology based on observations from monitoring wells completed at the VLF. Details on the groundwater bearing units and aquifer characteristics including flow direction, recharge, and hydraulic conductivity identified at the VLF are presented below.

3.4.2.1 Groundwater Occurrence

Four principal water-bearing units were identified based on existing hydrogeologic data: Unit Cc2, Unit Cc3, Unit D, and Unit F. Three criteria were developed to interpret the principal water-bearing units:

- The relationship of groundwater occurrence to specific geologic units.
- Water level elevations (i.e., wells with similar water level elevations were grouped together).
- Water level response to recharge (i.e., wells with similar water level changes were grouped together).

Table 3.1 provides a well completion summary for groundwater monitoring wells completed at the VLF, organized by the stratigraphic unit in which the well is completed.

Units B and Cc1 are not considered principal water-bearing units. While occasional groundwater has been measured in wells completed in these units, the saturated zone is thin to dry and with strong seasonal variability. Wells MW-1 (decommissioned in 2015), MW-3, and MW-4, completed in Unit Cc1 are seasonally dry.

Generally, water levels in the Units Cc2 and Cc3 indicate unconfined groundwater conditions, with the exception of wells MW-20 and MW-33, at the southern portion of the property, and MW-36 at the western portion of the property. Groundwater elevations in these three wells are above coarse-grained portions of the unit indicating confined conditions. Similarly, water levels in Unit D indicate unconfined conditions with the exception of well MW-34 where water levels are approximately 25 feet above the top elevation of Unit D.

Units C, D, and F have been evaluated in light of previous Vashon Island regional aquifer classification systems (Berryman & Henigar and UES, 2006a), which were developed for a King County water resource study (Carr/Associates, 1983) and the Vashon-Maury Island Groundwater Management Plan (GWAC, 1998). These regional classification systems are simplified characterizations of the regional geology, and the hydrostratigraphic classification at the landfill generally correlates with them. Unit C corresponds to the upper portion of the Principal Aquifer in the Carr Report (Carr/Associates, 1983) and “Zone 1” of the Vashon groundwater management plan (GWAC, 1998). Both Units D and F correspond with the Principal Aquifer in the Carr Report and “Zone 2” of the Vashon GWMP. These correlations are based on geologic unit and stratigraphic descriptions provided in the reports.

The completion depth and/or well log of private water supply wells sampled by KCSWD since 2002 indicate that three drinking water wells (85 acres [‘DW-85”], Smith-Shiratori [“DW-SS”], and Paquette [“Paquette”]) may be installed in Unit D or deeper, as depicted in cross sections A-A´ (Figure 3.2) and D-D´ (Figure 3.6) (Berryman & Henigar and UES, 2006a). Groundwater monitoring results are provided in Section 6.

Additional private water wells identified in the vicinity of the VLF (Appendix C) but not sampled by KCSWD were further reviewed to assess whether they are completed in Units C or D. Based on the completion depth of the wells and property elevations, wells west of the VLF are likely completed in Unit D or deeper. Similarly, wells to the immediate south of the VLF are likely completed in Unit D or deeper, with one exception: Ecology Well ID 190701, located approximately 1,100 feet from where property elevations range between 345 and 305 feet, may be completed in the lower portion of Unit C.

3.4.2.2 Aquifer Characteristics

Local groundwater flow direction, recharge, and hydraulic conductivity are summarized here.

Groundwater Flow Direction

Groundwater potentiometric surface maps for Unit Cc2 from the first and third quarters of 2017 are presented on Figures 3.7 and 3.8, respectively. Groundwater has been shown to flow in a westerly direction with discharge occurring at springs (24S and 18S on Figures 3.7 and 3.8) located on the steep slope on the west side of Westside Highway SW (King County, 2011a). Figures 3.7 and 3.8 are consistent with this interpretation. Groundwater flow is westward at an average gradient of 0.013 with discharge occurring at the West Hillslope springs. Flow direction showed only minor variation between the first quarter (Figure 3.7) and third quarter (Figure 3.8). West Hillslope springs 24S and

18S (Figure 3.8) are interpreted as discharge from the uppermost portion of the Cc2 aquifer; the elevation at these springs is representative of the groundwater head within the Cc2 aquifer. Seeps farther downslope discharge from lower portions of the Cc2 aquifer; these lower elevations are representative of point of discharge where Cc2 groundwater daylights, rather than hydraulic head in the Cc2 aquifer, which is the upper most discharge point on the slope.

Monitoring well MW-20 is the most upgradient monitoring well completed in Unit Cc2. This well is upgradient of the South Slope Area and slightly crossgradient of the 2001 closure area. Monitoring wells MW-33, MW-35, and the West Hillslope springs (24S and 18S) are downgradient of the South Slope Area, while monitoring wells MW-2 and MW-21 lie crossgradient from the South Slope Area (Figure 3.7).

Groundwater potentiometric surface maps for Unit D from the first and third quarters of 2017 are presented on Figures 3.9 and 3.10, respectively. Groundwater flow direction in Unit D is strongly influenced by high water levels in MW-34 and MW-7 which create a groundwater divide in the Unit D aquifer beneath the 2001 closure area. Groundwater flow is generally southerly south of the divide and northwesterly to northeasterly north of the divide. The groundwater gradient south of the divide is less steep than that the north of the divide. This variation in groundwater gradient may be related to a permeability change within the Unit D or other stratigraphic controls. Monitoring well MW-7 consistently exhibits the highest water levels in Unit D and is upgradient of the landfill refuse. Unit D wells downgradient from the landfill include MW-12 to the south and MW-19, MW-26, MW-28, MW-29, and MW-25 to the north. Monitoring well MW-34 is crossgradient from the refuse.

The screen interval of MW-27 was initially interpreted as a Unit D well but was reinterpreted to be screened within Unit Cc3, based on the continuous soil core collected from adjacent well MW-34. MW-27 had a pea gravel backfill section beneath the screen interval that extended into Unit D. Because of this potential interconnection of Units Cc3 and D, monitoring well MW-27 was decommissioned in July 2016 by overdrilling using sonic drilling methods. A memorandum documenting the decommissioning is included in Appendix B.

Recharge

Hydrographs for selected monitoring wells completed in Units Cc1, Cc2, Cc3, and D are shown on Figure 3.11 along with precipitation data from King County's West Judd Creek Rain Gage (28Y). The lag time between precipitation events and response in groundwater elevation ranges from 4 weeks (Unit Cc1) to 8 weeks (deeper Unit D wells). Lowest groundwater elevations typically occur in November following relatively dry summer/fall months, and maximum groundwater elevations occur in March/April. As shown on Figure 3.11, MW-3 completed in Unit Cc1 was likely dry from July until late November 2015. The response time in the Cc1 aquifer may be less than 4 weeks as shown on Figure 3.11 as there is a time lag between water level rise in the aquifer in response to the beginning of the wet season precipitation and the water level response observed in monitoring well MW-3, which is completed higher than the base of Unit Cc1. It is further hypothesized, based on seasonally dry conditions in most of the Unit Cc1 wells and the hydrograph presented on Figure 3.11, that the residence time of groundwater in this unit is short and that the presence of groundwater in Unit Cc1 wells is likely a transient reflection of downward migration of recharge.

The hydrographs indicate that recharge diminishes with increasing depth. The greatest water level increase during the 2016 wet season, depicted on Figure 3.11, occurred in Unit Cc1 with over 5 feet of water level increase. Seasonal water level rise in the deeper aquifers was generally less than 2 feet. Moreover, the magnitude of the seasonal fluctuation declines with depth, with Unit D aquifer showing the smallest wet season water level increase.

Superimposed on the water level trends are short-duration fluctuations attributed to variations in barometric pressure. Barometric pressure effects are typically observed in confined aquifers. Thus, the water level data support some degree of confinement for the Cc2 and deeper aquifers and an unconfined condition for Unit Cc1. Under confining conditions, changes in barometric pressure cause inverse changes in water levels in the confined aquifer.

Hydraulic Conductivity and Groundwater Velocity

Aquifer testing was completed to estimate hydraulic conductivity and update groundwater flow velocity estimates for the principal water-bearing units. Hydraulic conductivity estimates are compiled in Table 3.2. Groundwater flow velocity estimates are provided in Table 3.3.

Estimated hydraulic conductivity for Unit Cc1 ranges from 0.43 to 8.79 feet per day, with a geometric mean of 2.69 feet per day. However, because this unit is generally dry seasonally, horizontal migration of groundwater is expected to be limited in Unit Cc1.

In Unit Cc2, estimated hydraulic conductivity ranges from 0.45 to 46.1 feet per day, with a geometric mean of 5.43 feet per day. Horizontal gradient is estimated at 0.011 to 0.015 (Figures 3.7 and 3.8). If effective porosity is assumed to be 0.20, the calculated groundwater velocity in Unit Cc2 property-wide is 0.024 to 3.4 feet per day, with an average of 0.35 feet per day. For the South Slope Area, groundwater velocity is calculated to be 0.087 to 1.4 feet per day, with an average of 0.370 feet per day. The springs discharging from the West Hillslope near the VLF property boundary are approximately 900 feet from the refuse source on the South Slope Area. Given this distance and estimated average velocity, the travel time from source to spring is approximately 2 to 28 years (7 years based on the average).

Estimated hydraulic conductivity for Unit Cc3 ranges from 3.53 to 23.04 feet per day, with a geometric mean of 11.6 feet per day. Insufficient data are available for this unit for the purpose of estimating horizontal gradient and therefore, groundwater velocity.

Unit D estimated hydraulic conductivity ranges from 4.4 to 46.1 feet per day, with a geometric mean of 10.2 feet per day. With a gradient of 0.02 south of the divide and an effective porosity of 0.20, the calculated groundwater velocity in Unit D south of the divide is 0.4 to 4.6 feet per day, with an average of 1 foot per day. With a gradient of 0.04 north of the divide and an effective porosity of 0.20, the calculated groundwater velocity in Unit D north of the divide is 0.9 to 9.2 feet per day, with an average of 2.1 feet per day.

3.5 Landfill Gas

LFG is generated at the VLF during decomposition of municipal solid waste. The LFG generation rate depends on many factors, for example:

- Volume – greater waste volume results in greater LFG generation rates.
- Age – LFG generation rates decrease with increasing age of waste.
- Waste type – LFG generation is greater for organic waste (such as food waste) than inert waste (such as concrete or fiberglass).

The primary components of LFG are methane and carbon dioxide (CO_2). Methane is generated from anaerobic decomposition, while CO_2 is generated from aerobic and anaerobic decomposition. LFG also includes small concentrations of VOCs which may come from the waste itself (for example Freon from disposed refrigerators) or from decomposition (for example ketones from fat decomposition).

Methane is potentially explosive in air and is not to exceed the lower explosive limit in compliance gas probes (Code of the King County Board of Health, Section 10.09.050 and WAC 173-351-200 (4)). The lower explosive limit for methane is 5 percent by volume in air. While there is no regulatory criterion for CO_2, it is also an indicator of LFG migration. Background CO_2 concentrations are due to naturally occurring soil respiration.

4 Previous Investigations

Hydrogeology, water quality, and environmental investigations have been conducted at the VLF since 1983, led by R.W. Beck and Associates and Sweet, Edwards and Associates (1984), Harper-Owes (1986), Harper-Owes, et al. (1988), CH2M HILL (1995, 1996), Berryman & Henigar et al. (2000, 2001), Berryman & Henigar and UES (2004, 2006a), King County (2010), and Aspect (2012). Figure 4.1 provides a visual representation of the investigation timeline within the context of landfilling and landfill closure activities. Table 4.1 lists historical explorations at the VLF and bibliographic references. KCSWD has sampled groundwater and seeps since 1986 and monitored LFG and leachate at the VLF since environmental monitoring infrastructure was first installed in approximately 1988.

The following sections provide a summary of the investigations completed at the VLF, organized by media (groundwater, surface water, LFG, and leachate). Findings of these investigations are presented in Section 6 to describe the nature and extent of contamination and Section 7 to support the conceptual site model. All exploration locations are depicted on Figure 4.2, including borings, test pits, probes, wells, and surface water sampling locations. VLF groundwater monitoring well locations are illustrated on Figure 4.3, color-coded by the aquifer monitored. Off-property groundwater and surface water sampling locations are mapped on Figure 4.4. On-property surface water sampling locations are shown on Figure 4.5.

4.1 Groundwater

The following sections document groundwater investigations that have been completed at the VLF. The monitoring well network is illustrated on Figure 4.3. Boring logs are provided in Appendix B.

4.1.1 Initial Characterizations

The first four groundwater monitoring wells at the landfill were installed in 1983. Piezometers P-1/1A/1B and P-2/2A, located within the refuse area on the east side, were decommissioned in 1988. Piezometers MW-13 (originally numbered P-3) and MW-24 (originally numbered P-4) were installed in 1992. MW-13 is now used as a monitoring well for water level measurements and geochemical sampling. MW-24 is used only for groundwater level monitoring (King County, 2010).

Monitoring wells MW-1 through MW-4 were installed in 1983. Wells MW-5 and MW-6 were installed in 1986. These wells were installed in the early to mid-1980s as part of a site assessment completed to determine how to best bring the landfill into compliance with state and local solid waste disposal regulations. Wells MW-1, MW-5, and MW-6 have since been decommissioned (refer to Section 4.1.5 for details).

Eight additional monitoring wells (MW-7, MW-8, MW-9, MW-10, MW-11, MW-12, MW-14, and MW-19) were installed in summer 1995. MW-20 and MW-21 were installed in fall 1998 to further evaluate Unit Cc2 groundwater (King County, 2010). Well MW-14 has since been decommissioned (refer to Section 4.1.5 for details).

Four wells (MW-26 through MW-29) and one piezometer (MW-25) were installed during summer 2003 to expand the monitoring network. However, MW-28 has been dry since installation (King County, 2010). Well MW-27 has since been decommissioned (refer to Section 4.1.5 for details).

4.1.2 West Hillslope Investigation

King County's Water and Land Resources Division (KCWLRD) completed a hydrogeologic investigation focusing on the West Hillslope, west of the closed landfill area and west of Westside Highway. The scope of work included a reconnaissance of the West Hillslope to help design a stratigraphic model for the VLF. This 2005 survey provided a better understanding of the spatial orientation of saturated geologic units that outcrop on the steep slope. A copy of the report is provided in Appendix D.

With a better understanding of where the Cc aquifers outcrop on the West Hillslope, the KCWLRD completed an extensive water sampling program assessing the nature and extent of contamination along the hillslope relative to upgradient VLF wells. Work included:

- Installation of wells MW-30 through MW-32 in hand-augered borings.
- Installation of weirs downgradient of seeps (SW-W4 through SW-W7).
- Water quality sampling of hillslope seeps and weirs and of existing VLF wells (Unit Cc2: MW-5D, MW-9, MW-12; Unit D: MW-12, MW-19, MW-27).

Findings and conclusions from that investigation (King County, 2011a) have been incorporated into this RI Report.

4.1.3 Landfill Gas and Leachate Effects on Groundwater

In 2005, an analysis of groundwater and leachate data was completed to determine whether LFG or leachate was the primary source of contamination in Unit Cc2 groundwater (Berryman & Henigar, 2006b). Data from the period 1987 through 2005 on general water quality parameters and volatile organic compounds (VOCs) were used for the analysis. Unit Cc2 wells MW-2, MW-5D, and MW-21 represented impacted groundwater and well MW-20 represented background groundwater quality. Landfill gas data used in the evaluation was collected in October 2003. The findings of this investigation are discussed in Section 7.2 of this RI Report (Contaminants and Source Analysis).

4.1.4 Monitoring Well Installation, MW-33 though MW-36

Four groundwater monitoring wells (MW-33 through MW-36) were installed in spring 2015. Rotary sonic drilling methods were used for these installations and provided continuous soil samples to aid in the refinement of the hydrostratigraphy. MW-33 was drilled at the South Slope Area of the landfill through the unlined refuse zone, targeting Unit Cc2. MW-34 was drilled into the Unit D near MW-27 to investigate anomalous groundwater elevations in MW-27. MW-35 was installed in Unit Cc2 as a replacement for MW-5D, which was decommissioned (see Section 4.1.5). Since MW-35 was installed to replace MW-5D, these wells are referred to as co-located for data analysis purposes, but they are not contemporaneous. MW-36 was installed in Unit Cc3 as a replacement for

MW-14, which was decommissioned (see Section 4.1.5). New monitoring wells MW-33 through MW-36 were developed following installation.

4.1.5 Monitoring Well Decommissioning

Piezometers P-1/1A/1B and P-2/2A, located within the refuse area on the east side, were decommissioned in 1988. MW-11 was damaged in the February 2001 Nisqually earthquake and was not sampled after that event. MW-6S and MW-6D were also damaged during the earthquake. These wells were decommissioned in 2003 and no new wells were installed to replace them (King County, 2010).

Work conducted in spring 2015 included decommissioning MW-1, MW-5S/5D and MW-14. Having not yielded groundwater samples for several years, MW-1 was not a useful monitoring well. MW-5S/5D was completed in 1986 but did not meet current monitoring well standards and was subsequently replaced by MW-35. Therefore, both wells were over-drilled with a sonic drill rig and decommissioned by sealing the borehole with bentonite chips.

MW-14 was decommissioned because the dedicated pump got stuck above the screen. KCSWD obtained video footage downhole above the pump and attempted—unsuccessfully—to loosen the pump. Drilling subcontractors were also unsuccessful in their attempts to remove the pump. MW-14 was over-drilled with a sonic drill rig and decommissioned by sealing the borehole with bentonite slurry.

MW-27 was decommissioned in 2015. The memorandum documenting the MW-27 decommissioning is included in Appendix B.

4.1.6 2015 Monitoring Well Redevelopment and Maintenance

In preparation for the aquifer hydraulic testing, existing monitoring wells were redeveloped while the drilling contractor was mobilized at the landfill for the installation of MW-33 through MW-36 in spring 2015. The existing monitoring wells that were redeveloped included: MW-2, MW-3, MW-4, MW-7, MW-8, MW-9, MW-10, MW-12, MW-13, MW-14, MW-19, MW-20, MW-21, MW-24, MW-25, MW-26, MW-27, and MW-29.

Observations during redevelopment indicate improved connection between the well and the surrounding aquifer. Pumps and tubing showed signs of biofouling, which was also, presumably, on the inside of the well screen. Surging with a tight-fitting surge block removed biofouling from the well screen, and the pump screens were cleaned with non-phosphate detergent (Alconox®) scrub, potable water rinse, and distilled water rinse. Deteriorated pump tubing was replaced in MW-7, MW-8, MW-9, MW-10, and MW-19. Pump bladders were replaced in wells MW-8, MW-9, MW-10, and MW-12.

4.1.7 Downhole Monitoring Well Geophysical Survey

A geophysical survey of MW-7, MW-19, and MW-27 was conducted on February 5, 2015 (Duoos, 2015). A copy of the report is provided in Appendix D. The geophysical survey was conducted using natural gamma and electromagnetic (EM) induction logging to evaluate down hole stratigraphy at each well location. Stratigraphic units across the VLF were correlated to the geophysical survey findings to further refine the hydrogeological conceptual model. In summary, the geophysical survey found:

- Natural gamma logs are not reliable indicators of silt or clay at the VLF, likely due to the overburden materials in which the wells are installed and the bentonite grout used to fill the annulus of the wells.
- EM conductivity responded well to the stratigraphy and there appears to be good correlation with the material descriptions in the geologic boring logs. In general, shallow sand and gravels had lower EM conductivity than deeper silt layers, and the fat clays correlated with the highest conductivity values.
- Steel centralizers used in well construction adversely affected the EM responses. The steel centralizers are identifiable on the EM conductivity log by the bands of high magnitude erratic response and appear approximately every 50 feet in MW-7 and MW-19.

4.1.8 Aquifer Hydraulic Testing

Eleven wells in Units Cc1, Cc2, Cc3, and D were selected for aquifer hydraulic testing to estimate hydraulic conductivity and to update groundwater flow velocity estimates. For Unit Cc2, groundwater flow velocities calculated from previous hydraulic conductivity estimates (mean value of ~0.002 ft/day) are inconsistent with facility impacts observed in the West Hillslope springs in that the travel time calculated from the previous conductivity data is on the order of 500 years but the earliest waste placement occurred about 100 years ago. The new tests were conducted to confirm previous work and refine groundwater flow velocities in Unit Cc2. Hydraulic conductivity testing was conducted on MW-2, MW-13, MW-20, MW-21, MW-24, MW-25, MW-26, MW-33, MW-34, MW-35, and MW-36. Two of the existing wells initially selected for testing (MW-1 and MW-5S) were dry and were therefore not tested. Results of the aquifer hydraulic testing and comparison to previous results have been integrated into Section 3.4.2.2 and are compiled in Appendix E.

The completion of Unit D well MW-25 includes a 3-inch-diameter screen inserted into a 4-inch-diameter screen that was broken during well installation. Because of the abnormal well completion, hydraulic conductivity test results on MW-25 are not representative of the aquifer but show that flow is restricted from entering the well. For this reason, results from MW-25 were excluded when calculating Unit D hydraulic conductivity estimates discussed in Section 3.4.2.2.

4.1.9 Continuous Water Level Measurements

In 2015/2016, nine wells, in Units Cc1, Cc2, Cc3, and D, were instrumented with a Schlumberger Water Services Micro-Diver pressure transducer (Diver) to measure water levels over time. Divers were installed in the following wells:

- Unit Cc1 – MW-3
- Unit Cc2 – MW-2, MW-9, MW-20, MW-33, MW-35
- Unit Cc3 – MW-8

- Unit D – MW-12, MW-34

Divers record water pressure with a range of 10 meters and an accuracy of ± 1.0 cm of water. The Divers were set to record water levels in the well every 15 minutes, and the water levels were adjusted for barometric pressure using a Schlumberger Water Services Baro-Diver installed in the well casing of MW-12. Data from King County's West Judd Creek Rain Gage (28Y) were used to compare precipitation to water level trends. Water levels measured with the transducers were consistent with the quarterly water level measurements collected by the KCSWD, as presented in Appendix F. Results have been incorporated into Section 3.4.2.

4.1.10 Geochemical Evaluations

In 2015/2016, Anchor QEA (2017) completed a geochemical investigation with two primary objectives:

- Identify the transport pathways for VOCs detected in Unit Cc2 (e.g., via infiltration of landfill leachate or interaction with LFG).
- Evaluate mobilization of metals and attenuation of VOCs and metals in groundwater downgradient of the landfill.

Selected wells (MW-2, MW-20, MW-21, MW-33, MW-35) and seeps (SW-1, SW-2, SW-3) were sampled in September 2015 (dry season) and February 2016 (wet season). Samples were also collected from the leachate system during both sampling events. Analyses included isotopic measurements of carbon, oxygen, hydrogen, sulfur, arsenic III/V speciation, and atmospheric chlorofluorocarbons.

Details and results are included in Appendix D. A summary of the findings to the primary objectives is provided in the Section 7.2 (Contaminants and Source Analysis).

4.1.11 Groundwater Sampling

KCSWD performs routine groundwater monitoring to meet the landfill's permit requirement for detection monitoring. The monitoring is conducted in accordance with the "Environmental Monitoring Sampling and Analysis Plan and Quality Assurance Project Plan for Vashon Island Landfill" (King County, 2016). The following tasks are completed by KCSWD:

- Quarterly groundwater sampling for Appendix I and II analytes plus dichlorodifluoromethane, as per detection monitoring requirements set forth in WAC 173-351-430 and WAC 173-351-990.
- Annual groundwater sampling for Appendix III analytes defined by WAC 175-351-440 as a condition of assessment monitoring.
- Quarterly water level measurements to assess groundwater flow conditions.

Results of the routine groundwater monitoring are presented in Section 6.1.

4.2 Refuse Extent Investigations

In 2018, investigations were completed to meet two objectives:

- Define the extent of refuse beyond the main landfill refuse footprint in the West Perimeter Road and South Slope Area.
- Further characterize LFG within and adjacent to these delineated areas, including the source of LFG currently being extracted in the South Slope Area.

Results from a surface geophysical investigation (Aspect and Duoos, 2018) were used to refine the locations of the borings completed in April 2018—B-6 through B-12, and LFG probe installations VTP-7 through VTP-11D. Findings from this investigation have been included in the discussion on the extent of refuse (Section 2.2.1.1). While LFG characterization is ongoing, investigations completed to date are discussed in Section 4.4 (Landfill Gas).

4.3 Surface Water

This section describes the VLF surface water management and monitoring systems.

4.3.1 Surface Water Management System

Prior to 1979, the surface water management system at the VLF consisted of ditches, culverts, and natural drainage paths, with surface water runoff flowing to the southern extent of the landfill and off-property via an unnamed tributary to Judd Creek. After a 1986 storm caused off-property deposition of sediment in the unnamed tributary, a sediment control pond (South Siltation Pond) and stormwater detention pond (South Detention Pond) were constructed in the ravine at the southern VLF property boundary. During subsequent developments, additional surface water conveyance and control infrastructure were built, including leachate control facilities, a landfill liner, the transfer station, other stormwater improvements (Berryman & Henigar, 1999).

Surface water generated at the VLF continues to discharge off property to the south via the unnamed tributary to Judd Creek. The following infrastructure, shown on Figure 2.5, provides detention and conveyance to the outfall (SW-B).

Flows generated from former borrow material areas to the north of the VLF and from the transfer station are conveyed to a series of four unlined ponds that discharge through a conveyance pipe to the outfall. An overflow structure is included in the conveyance pipe at the South Detention Pond.

Surface water from the capped landfill, asphalt-lined ditches around the closed landfill, and the area east of the capped landfill are directed to a lined detention pond (East Pond) southeast of the refuse area. Flow from the East Pond is also directed to the outfall at the southern end of the VLF.

All other surface water generated at the VLF consists of overland flow from the South Slope Area to the South Siltation Pond or runoff from the VLF entry area that is collected in surface ditches and directed to the south ponds.

A 2012 investigation of the VLF surface water management system (Aspect et al., 2012a) yielded three recommendations for improvement:

- South Siltation Pond – Convert the pond from a sediment control feature (no longer required because landfilling had ceased) to a detention pond. Design the detention pond to prevent permanent standing water and associated mosquito-related public health concerns.
- Northwest Landfill Drainage Improvements – Maintain the grass-lined ditches to prevent low spots and ponding due to settlement in an area above an unlined portion of the landfill.
- Asphalt Ditch Maintenance – Remove vegetation and debris from the asphalt-lined ditches surrounding the capped landfill to maintain clear flow paths and prevent ponding.

4.3.2 Surface Water Monitoring

Surface water is routinely monitored at three locations on the VLF property (Figure 4.5), two on the eastern portion and one at the springs on the West Hillslope west of Westside Highway SW. Results of a 2012 site visit and evaluation of the existing surface water monitoring at the VLF (Aspect et al., 2012a) are summarized in the following sections, and discussed in Section 6.2 (Surface Water).

4.3.2.1 Borrow Area Stormwater Pond (SW-D)

Sample point SW-D is located at the outfall from the series of borrow area stormwater ponds. This sample location is intended to provide water quality information for flows from the transfer station and borrow areas prior to mixing with other surface water sources. No modifications were recommended for this location.

4.3.2.2 Vashon Landfill Outfall (SW-B)

Combined surface water from the VLF is conveyed off-property to an unnamed tributary to Judd Creek. At sample location SW-B, immediately upstream of the southern property boundary, samples representative of the entire property are collected from a surface water conveyance structure. No changes to the sampling location or program were suggested, unless surface water quality issues were detected at SW-B, in which case it was recommended that additional sampling locations be considered to identify the origin of the issue.

4.3.2.3 West Hillslope

Groundwater springs along the West Hillslope west of the Westside Highway SW produce surface water flows that discharge off-property. Compliance sampling is conducted upstream of the property boundary. Alternatives to improve sample collection of the West Hillslope spring flows were provided (Aspect et al., 2012a). These alternatives will be further evaluated in the FS.

4.4 Landfill Gas

This section describes previous and ongoing investigations of LFG migration control, and collection system inspections and improvements, and LFG monitoring activities.

4.4.1 Landfill Gas Probe Installations

Compliance gas probes to evaluate LFG migration control were installed between 1986 to 1995 in soils around the refuse perimeter, near the property boundary. Temporary gas probes were installed between 2014 to 2018 in or near refuse to assess the performance of the LFG collection system. Construction details are tallied in Table 4.2 and probe locations are shown on Figure 2.7.

4.4.1.1 Compliance Probes

In 1986, probes P-1 and P-2 were installed, with the top of screen interval approximately 3 and 5 feet bgs, respectively. Probes GP-5 and GP-6 were also installed, with the top of screen approximately 3 feet bgs. GP-5 was installed within the same borehole as monitoring well MW-5S/D and GP-6 was installed within the same borehole as monitoring well MW-6S/D. Although all four probes had 2-foot-long screens, the filter pack intervals extended below the gas probes to depths ranging from approximately 85 to 116 feet bgs.

In 1992, LFG probes GP-1 and GP-2 were installed, with the top of screen approximately 20 and 25 feet bgs, respectively, and the bottom of screen at approximately 30 feet bgs. Each probe's filter pack extended 6 feet below the bottom of screen.

In 1995, eight LFG probe sets were installed (NP-1 through NP-8), each with three completion intervals across the vadose zone. Depending on location, the tops of screen were set 10 to 12 feet bgs for the shallow probes, 30 to 49 feet bgs for the intermediate probes, and 65 to 95 feet bgs for the deep probes.

Starting in 2010, monitoring wells MW-13 and MW-24 have been monitored routinely for LFG concentrations. These groundwater monitoring wells are located next to gas probe set NP-3.

4.4.1.2 Temporary Probes

In 2014, temporary probes VTP-1S, VTP-2S, and VTP-2D were installed to assess LFG conditions inside the property boundary. VTP-1S was installed in native soils west of the EF-3 horizontal collector to assess potential LFG migration (location not shown on Figure 2.7). Its screen interval was typically submerged by perched groundwater, and no LFG was measured; this probe was decommissioned in 2016. VTP-2S and VTP-2D were installed in the South Slope Area, the former in the gravel gas collection layer above refuse and the latter in refuse.

In August 2016, two temporary probe pairs (VTP-3S/VTP-3D, and VTP-4S/VTP-4D) were installed to: supplement existing probes VTP-2S and VTP-2D, assess the extent of LFG migration, and monitor the performance of LFG extraction well GW-9 at controlling LFG migration during an "influence test" conducted from September 14, 2016, through March 1, 2017. Shallow probes (VTP-3S and VTP-4S) were installed within the waste, and deep probes (VTP-3D and VTP-4D) were installed in native soils below the waste. Installation of extraction well GW-9 is discussed in Section 4.4.2.2.

In January 2017, two additional temporary probe pairs (VTP-5S/VTP-5D, and VTP-6S /VTP-6D) were installed during the influence test to further investigate the extent of refuse, assess the potential for methane migration (methane is an indicator of LFG), and help determine the radius of influence of GW-9.

In April 2018, four temporary probes and one temporary probe pair (VTP-7, VTP-8, VTP-9, VTP-10, and VTP-11S/VTP-11D) were installed during an investigation of refuse extent. Temporary probes VTP-7 through VTP-10 were installed in the South Slope Area, and VTP-11S and VTP-11D were installed outside the northwest corner of the perimeter road.

4.4.2 Gas Collection System Inspections and Improvements

Since closure of the VLF in 2001, LFG collection system performance has been evaluated through camera surveys, blockage removals, and satellite gas extraction well installation.

4.4.2.1 Camera Survey and Blockage Removal

A camera survey was conducted in June 2015 to assess potential blockages within laterals EF-1, EF-2, EF-3, and T-2 (Herrera Environmental Consultants [HEC], 2015). These horizontal collectors were characterized by lower flow rates and LFG concentrations than anticipated, indicating potential blockage. Although limited gravel debris was found inside the horizontal collectors, no blockages were identified (HEC, 2015). Relative to the design drawings, the location of EF-1 appeared to be shifted approximately 10 feet to the south, and EF-2 appeared to be shifted approximately 30 feet to the west and not beneath the landfill liner (HEC, 2015). The functionality of lateral EF-1 was thought to be compromised, as excavation inspection and the camera survey revealed fine-grained material in the pipe-bedding, which could limit or impede vacuum influence through the material.

4.4.2.2 Extraction Well Installation

In August 2016, a vertical LFG extraction well (GW-9) was installed to initiate LFG collection in the South Slope Area (Figure 2.7). GW-9 was completed across the refuse, except for the bottom seal and the top annular seal. The aboveground wellhead was connected to the active LFG collection system with an aboveground lateral. A valved monitoring assembly was installed to adjust flow, and to measure flow, gas concentrations, and static pressure.

In June 2018, two vertical LFG extraction wells (GW-10 and GW-11) were installed to supplement LFG collection in the South Slope Area. In September 2018, GW-10 and GW-11 were incorporated into the active LFG collection system, the activities for which included a well location survey, connection to the active LFG collection system, and influence testing. Active influence testing began on September 12, 2018. This work is described further in Section 8.3.

4.4.3 Landfill Gas Monitoring

KCSWD performs routine LFG monitoring to meet the landfill's permit requirement. Current LFG compliance probe monitoring is conducted in accordance with the "Environmental Monitoring Sampling and Analysis Plan and Quality Assurance Project Plan for Vashon Island Landfill" (King County, 2016). KCSWD monitors compliance probes (see Figure 2.7) on a monthly basis for methane, CO_2, and oxygen.

Routine LFG operations monitoring is conducted in accordance with the "Vashon Island Closed Landfill Plan of Operations and Post-Closure Plan" (Berryman & Henigar, 2005). KCSWD monitors the LFG collection system locations (see Figure 2.7) on a monthly basis for LFG concentrations, temperature, static pressure, and flow rate.

Influence testing of new extraction well GW-9, including monitoring temporary gas probes, was conducted in accordance with the work plan (Herrera, 2016). Findings and recommendations were provided in the influence test report (Aspect, 2017b). KCSWD continues to monitor GW-9 on a monthly basis for LFG concentrations, temperature, static pressure, and flow rate. KCSWD also continues to monitor selected temporary probes for LFG concentrations.

The LFG monitoring data were analyzed and summarized for the purpose of this RI Report, and are presented in Section 6.3.

4.5 Leachate Management System

Leachate evaluations at the VLF fall into two categories: those completed prior to installation of the leachate collection system and those completed after. Both sets of evaluation assessed the potential impacts and influence of VLF leachate on surrounding groundwater and surface water, as summarized in the following sections.

4.5.1 Evaluations Prior to Leachate System Installation

The most relevant pre-1988 evaluations are listed below with abbreviated summaries.

- "Groundwater Geology/Quality Investigations for the Rural Landfills" (R.W. Beck and Associates and Sweet, Edward and Associates, 1984) – This investigation included installation of four monitoring wells, a groundwater sampling and analysis program, and identification of potential impacts. Results were inconclusive regarding the influence of solid waste disposal activities on groundwater. Recommended measures included establishing routine monitoring and further investigation into impacts on surface water, particularly Judd Creek.
- "Technical Memorandum, Vashon Landfill Leachate Control, Task 1A: Conceptual Alternatives Development" (Harper-Owes, 1985) – This memorandum recommended leachate control alternatives, which were further investigated and superseded by the 1986 Task 1B Technical Memorandum (next bullet).
- "Technical Memorandum, Vashon Leachate Control, Task 1B: Geotechnical and Water Quality Investigations" (Harper-Owes, 1986b) – This memorandum

reported additional investigations that resulted in the following recommendations for future leachate control:

- Provide facilities to minimize leachate migration (e.g., interceptor drains, liner/cover systems).
- Close the southern area and continue operation of the northern area.
- Monitor the West Hillslope springs.
- Install a collection system at the springs, initiate remedial action for impacted wells if any are identified, or both.

4.5.2 Evaluations After Leachate System Installation

Installation of the leachate collection system and associated lining and cover systems during Phase 1 landfill closure led to a significant change in leachate generation and flow. The evaluations conducted after leachate system installation are listed below with abbreviated summaries.

- "Vashon Island Landfill Hydrogeologic Report" (Berryman & Henigar et al., 2000) – This report was written to satisfy requirements of WAC 173-351-490 and includes a water balance and water quality analysis.
  - The lined portions of the landfill "are not relevant [for the water balance] … as they assume liner competence and therefore generate negligible values of infiltration and leachate generation."
  - A small portion of refuse area (i.e., the South Slope Area of the VLF) is included in the water balance, even though it is served by an engineered leachate collection system draining to pump station PS-2.
  - Groundwater chemistry data indicated that leachate from the VLF was not impacting either the regional aquifer or the perched groundwater beneath the VLF. Impacts may have occurred prior to the Phase 1 lining, cover, and leachate collection system improvements.
  - Leachate was not currently impacting stormwater discharging from the VLF.
- "Vashon Island Landfill Hydrogeologic Report Update" (Berryman & Henigar and UES, 2004) – This update to the 2000 VLF Hydrogeologic Report documents investigations performed between 2000 and 2004. Groundwater monitoring recommendations are updated, but earlier conclusions about potential leachate impacts on groundwater remain unchanged.
- "Vashon Island Closed Landfill Environmental Evaluation" (Berryman & Henigar and UES, 2006a) – The purposes of this evaluation were to summarize the existing environmental control systems, inventory potential source areas for LFG and leachate, and review the effects of these potential sources on surface water and groundwater.

    - Two likely sources were identified, each an unlined refuse area without a geomembrane cover: the northwest portion of the waste placement area and the southern portion of the VLF. Neither source area was identified as producing significant leachate volume.
    - Two recommendations were provided to further reduce potential leachate impacts:
        - Repair west perimeter ditches to improve surface water drainage and limit infiltration.
        - Improve the cover on the South Slope Area.

- "Vashon Island Closed Landfill: Potential Effects of Landfill Gas and Leachate on Vashon Landfill Groundwater and Springs" (Berryman & Henigar and UES, 2006b) – This investigation concludes that while leachate may have been a dominant factor influencing groundwater and spring quality in the past, its influence appears to have become minimal. LFG appears to have been the dominant factor controlling the water quality characteristics in recent years.
- "Vashon Island Closed Landfill: Environmental Investigations, Monitoring, and Remediation Services" (Aspect et al., 2012 – The purposes of this evaluation of the environmental monitoring system at the VLF were to further refine groundwater flow paths and LFG and leachate source areas, and to recommend improvements for environmental monitoring. The leachate portion of the report focuses in the South Slope Area and source sampling. Two modifications to leachate sample collection were recommended.
    - Add a sample location at pump station PS-2.
    - Revise the sample collection protocol at the leachate vault (sample point LVB) to collect leachate directly from the leachate pipes.
- "Vashon Island Landfill Leachate System Flow Characterization" (BHC, 2014; see Appendix D) – This document identifies primary contributors to leachate constituent loading by source and majority source of flow (direct precipitation on the Leachate Lagoon accounts for 46 percent of total flow). Three options were offered to reduce the frequency and cost of leachate hauling: discharge to the Vashon Island wastewater treatment plant, on-site treatment, and installation of a cover for the Leachate Lagoon.

4.5.3 Leachate Monitoring

In accordance with the "Environmental Monitoring Sampling and Analysis Plan and Quality Assurance Project Plan for Vashon Island Landfill" (King County, 2016), KCSWD routinely monitors leachate to meet the landfill's permit requirement for detection monitoring. Leachate monitoring is conducted quarterly, and findings are reported annually. Results of the routine leachate monitoring are presented in Section 6.4 (Leachate).

4.6 Landfill Cover System

The landfill cover system has been evaluated on multiple occasions. These evaluations include routine inspections by KCSWD Operations staff, investigations of the leachate and LFG systems, and settlement surveys. Two investigations that included cover system evaluations are summarized below:

- "Vashon Island Closed Landfill Environmental Evaluation" (Berryman & Henigar and UES, 2006a) – Areas containing refuse outside of the landfill cap were identified. Improvements to the cover system in the South Slope Area were recommended as a method of controlling sources of LFG and leachate.
- "Vashon Island Landfill Site Visit: Site Visit Report and Photo Log" (Aspect et al., 2011) – Based on visual observations, the cover appeared to be in good condition, with no indication of differential settlement or a compromised cover system.

Landfill settlement surveys at 29 permanently established points across the cover were conducted in late 2016 as a baseline event, in mid-2017, and in early 2018. These surveys were conducted to comply with Ecology (2011) guidelines recommending surveys of fixed points at least 2 years apart to assess landfill settlement, whether during or after the post-closure period (WAC173-304-100(59)). At the time this report was written, the landfill had not reached the end of its 30-year post-closure period nor had 2 years elapsed since the baseline settlement survey. Final results of the settlement survey program will be presented under separate report after the final survey is completed.

5 Proposed Preliminary Cleanup Levels

This section identifies potentially applicable environmental regulations and PCULs for media, potential receptors that may require protection, and potential exposure pathways which may require protection per environmental regulations. In Section 6, chemical concentrations detected in the VLF area are compared to PCULs to identify COCs.

5.1 Potentially Applicable Regulatory Requirements

The following potentially applicable or relevant and appropriate requirements (ARARs) based on local, state, and federal laws apply to the VLF:

- Washington Model Toxics Control Act (MTCA, WAC 173-340).
- Washington State statute on Chemical Contaminants and Water Quality (Chapter 70.142 RCW), Washington State statute on Water Pollution Control (Chapter 90.48 RCW), and implementing regulations (Water Quality for Surface Waters, WAC 173-201A).
- Washington State primary maximum contaminant levels (MCLs) for drinking water (WAC 246-290-310).
- Clean Water Act (CWA) (33 United States Code [USC] Section 1251 et seq.), including Washington State-specific human health criteria (water and organisms) promulgated by the U. S. Environmental Protection Agency (EPA) under Section 303(c) (EPA, 2016).
- National Toxics Rule (NTR) (40 Code of Federal Regulations [CFR] 131.36) specifying chemical- and state-specific numeric criteria for priority pollutants not otherwise covered by the CWA.
- Criteria for Municipal Solid Waste Landfills (WAC 173-351), landfill operation and closure requirements.
- Resource Conservation and Recovery Act (RCRA) and Subtitle C regulations, to the extent that hazardous wastes are discovered during the remedial action; and Subtitle D regulations requiring LFG migration control at municipal solid waste landfills.
- Washington Hazardous Waste Management Act and Dangerous Waste regulations (70.105 RCW and WAC 173-303), to the extent that dangerous wastes, as defined under these regulations, are discovered during any remedial action.
- Federal and State Clean Air Acts (42 USC 7401 et seq.; 40 CFR 50; 70.94 RCW;WAC 173-400; WAC 173-403), to the extent that air emissions are generated during interim measures and long-term remedies (i.e., LFG flares, soil vapor extraction, and vapor mitigation).

- King County's Construction Standards for Methane Control, Title 10, Board of Health Solid Waste Regulations, 10.09.060, detailing requirements for construction to prevent methane migration on or within 1,000 feet of a landfill that generates methane at or above its lower explosive limit.

5.2 Applicable or Relevant and Appropriate Requirements for Development of Preliminary Cleanup Levels

MTCA relies on a risk-based evaluation of potential human health and environmental exposures to COCs. Part of the process includes development of cleanup standards, which consist of preliminary cleanup levels with a chemical- and medium-specific location where the PCUL must be met. These locations are known as "points of compliance" (POC) and by MTCA definition are throughout the site. MTCA allows for establishing conditional POC if it can be demonstrated that it is not practicable to meet PCULs throughout the site (173-340-720 through -760 WAC); however, the conditional POC cannot extend beyond the property boundary.

The PCUL for a given constituent in soil, groundwater, surface water, or air must be at least as stringent as established state or federal standards, if available, or other requirements (i.e., ARARs) developed for human health and environmental protection. If a state or federal standard is available, that ARAR is evaluated to ensure that it is protective under MTCA. If the ARAR is not protective, the PCUL is adjusted to ensure its protectiveness.

The PCUL for one medium must also be protective of the beneficial uses of other affected media. PCUL development, as outlined in WAC 173-340-720 (groundwater), -730 (surface water), -740 (soil), and -750 (air), includes specific rules for evaluating cross-media protectiveness.

MTCA and Water Quality Standards for Surface Waters (WAC 173-201A) were of primary consideration in developing PCULs for the VLF. Washington State freshwater surface water standards (WAC 173-201A) are considered potentially applicable. Federal surface water criteria under the Clean Water Act and NTR are also considered potentially applicable.

Landfill closure and post-closure requirements in WAC 173-351 were considered during development and evaluation of cleanup standards. The post-closure period lasts 30 years, or longer if necessary for the facility to stabilize (i.e., no longer a threat to human health or the environment at the point of exposure). During this time, monitoring of groundwater, surface water, and LFG is required, as is maintenance of the facility, facility structures, and monitoring systems. Constituents for which detection monitoring samples must be analyzed are listed in Criteria for Municipal Solid Waste Landfills (WAC 173-351), but modifications are possible if certain requirements specified in WAC 173-351-450 are met. Per *Criteria for Municipal Solid Waste Landfills* (WAC 173-351), the POC must be located no more than 150 meters (492 feet) from the boundary of the waste management unit.

RCRA Subtitle C and Washington state Dangerous Waste regulations are not expected to apply unless dangerous wastes as defined under these regulations are discovered or generated during the remedial action.

5.3 Potential Exposure Pathways

According to MTCA, an exposure pathway is: "…*the path a hazardous substance takes or could take from a source to an exposed organism. An exposure pathway describes the mechanism by which an individual or population is exposed or has the potential to be exposed to hazardous substances at or originating from a site.*" Listed by media, the potential current and future exposure pathways for both human and ecological receptors at the VLF are:

Groundwater

- Direct human contact with impacted groundwater.
- Human ingestion of impacted groundwater.
- Human inhalation resulting from soil vapor discharge and intrusion to indoor and ambient air; soil vapor caused by volatilization of VOCs in shallow groundwater has the potential to migrate.
- Groundwater discharge to surface water (see surface water pathway below).

Surface water

- Discharge of impacted groundwater to surface water.
- Direct human contact with impacted surface water.
- Direct exposure of ecological receptors (aquatic and terrestrial) to impacted surface water.
- Human consumption of aquatic organisms exposed to impacted surface water.

Landfill gas

- Inhalation by occupants of current and future structures of indoor air impacted—via vapor intrusion—by VOCs originating from fugitive LFG.
- Direct human contact from explosions of fugitive LFG.
- Human inhalation of air impacted by fugitive LFG vapors.
- Fugitive landfill gas discharge to groundwater (see groundwater pathway above).

Leachate

- Human contact with fugitive leachate.
- Fugitive leachate discharge to groundwater (see groundwater pathway above).

Refuse

- Direct human contact by below-ground workers to shallow refuse.
- Direct contact by burrowing terrestrial organisms to shallow refuse.

Direct exposure to air contaminated by LFG is addressed in the LFG discussion above and may occur during facility operations and maintenance activities, but these activities are performed with worker protection controls in place. These potential exposure pathways are evaluated in Section 7 (Conceptual Site Model).

5.4 Potential Receptors

Both human and ecological receptors may be exposed at the VLF:

- Human Receptors. For evaluation of human exposure, MTCA allows for consideration of various exposure scenarios depending on land use (173-340-708 WAC).
    - Residential occupants of structures off-property under current and potential future development scenarios.
    - VLF staff and future construction workers (above- and below-ground); KCSWD maintains internal controls to ensure that VLF staff receive appropriate training and monitoring. Off-property workers include commercial occupants of structures under current and future land use scenarios as well as above- and below-ground workers (e.g., utility and construction workers).
    - Recreational and other users of property adjacent to but outside of the VLF boundary; property access restrictions preclude recreational users on the VLF property as potential receptors.
- Ecological Receptors.
    - Aquatic species.
    - Terrestrial species.

These potential receptors are evaluated in Section 7 (Conceptual Site Model).

5.5 Development of Preliminary Cleanup Levels for Detected Chemicals

Preliminary cleanup levels for detected chemicals are described in the following sections. Final cleanup levels will be selected by Ecology and presented in the Cleanup Action Plan. The value and source of groundwater and surface water PCULs are presented in Table 5.1.

5.5.1 Groundwater

PCUL values for groundwater were obtained from the following chemical-specific regulatory criteria for Washington State:

- State primary MCLs (WAC 246-290-310) protective of the human health ingestion pathway.
- Cleanup levels (WAC 173-340-740) protective of the human health ingestion pathway established by MTCA Method A (table values for 25 to 30 of the most common hazardous substances in soil or groundwater) or calculated by MTCA Method B (using standard or generic default assumptions).
- Surface water cleanup standards as detailed in the next section.

Per MTCA, groundwater PCULs shall be based on estimates of the highest beneficial use. For most sites, including the VLF, use of groundwater as a source of drinking water is the beneficial use. Furthermore, Vashon-Maury Island was designated a “sole source aquifer” by the EPA in June 1994, meaning the aquifer is the principal source of drinking water for the island. The sole source aquifer boundary is coincident with the shoreline of the island and includes all potable aquifers, regardless of depth (EPA, 1994). MTCA may require more stringent PCULs in situations when protection of other beneficial uses is necessary. For the VLF, groundwater discharges to surface water, so the development of groundwater PCULs accounted for the protection of surface waters (WAC 173-340-720(1)(d)).

For carcinogens that also have a state or federal MCL, MTCA allows for modification of the cleanup level to a target excess lifetime cancer risk of $1x10^{-5}$ (1 in 100,000). The calculations presented in WAC 173-340-720 were used to adjust the MTCA Method B values for selected carcinogenic COCs and the adjusted values were compared to state MCLs (WAC 246-290-310).

When a natural background value was available, it was used as the PCUL instead of risk-based values. The MTCA Method A groundwater cleanup level for arsenic of 5 micrograms per liter (µg/L) is based on background concentrations for the State of Washington.

The MCL for trichloroethene (TCE) has been adjusted to 4 µg/L from the MCL of 5 µg/L specified in WAC 246-290-310 (as per Ecology, 2012). The adjustment is necessary because an MCL of 5 µg/L exceeds a hazard quotient of 1. This adjusted state MCL is lower (i.e., more conservative) than the adjusted Method B formula value and is used in the RI as the PCUL for TCE.

5.5.2 Surface Water

For surface water, possible PCUL values were obtained from the following federal and state chemical-specific applicable regulatory criteria (Table 5.1):

- Washington State-specific and EPA human health criteria (water and organisms) promulgated under CWA Section 303(c) (EPA, 2016).
- National recommended water quality criteria pursuant to CWA Section 304(a) for human health and freshwater aquatic life.

- Water quality standards for surface waters of the State of Washington (WAC 173-201A) that are protective of the human health ingestion and ecological health pathways (freshwater standards).
- Washington State MTCA surface water cleanup levels (WAC 173-340-730) calculated using Method B (standard formula values) that are protective of the human health ingestion and the ecological health pathways (freshwater standards).

Regulatory criteria for certain metals are hardness-dependent. PCULs for these metals were derived from the site-specific hardness-corrected chronic freshwater criteria.

For arsenic, the most stringent level is EPA’s (2016) Washington State-specific CWA criterion of 0.018 µg/L, based on human consumption of fish. However, according to the Governor’s 2014 surface water policy brief (Inslee, 2014), the fish consumption criterion for arsenic “is not attainable and essentially meaningless because it is set below levels that occur naturally in much of our surface water and groundwater.” Therefore, the surface water PCUL for arsenic has been adjusted to 5 µg/L—the MTCA Method A natural background for groundwater (natural background for surface water has not been established).

5.5.3 Landfill Gas

For LFG, PCUL values were obtained from WAC 173-351-200 (Criteria for Municipal Solid Waste Landfills, Operating Criteria) and in the Code of the King County Board of Health, Title 10 (see Section 10.09.050).

6 Nature and Extent of Contamination

For this RI, data from 2001 through 2017 were selected for discussion and analysis. In the following sections, site-specific data are compared with the PCULs identified in the previous section. The purpose of screening using the regulatory criteria is to identify parameters requiring further evaluation. For each environmental media, the constituents retained after screening (i.e., COCs) are identified. The nature and extent of COCs are then discussed.

6.1 Groundwater

6.1.1 Data Screening and Constituent of Concern Selection

Groundwater samples were analyzed for hundreds of parameters, as summarized in Tables 6.1 (VLF wells) and 6.2 (off-property drinking water wells) and all groundwater data (2001 through 2017) are fully tabulated in Appendix G. Groundwater data from VLF wells were compared to the most stringent screening level based on protection of groundwater as drinking water and for the highest beneficial use for the protection of surface water for ecological receptors. Data from off-property drinking water wells were compared to the most stringent screening level based on protection of groundwater as drinking water.

Tables 6.1 and 6.2 provide the minimum, maximum, and average detected concentrations for each analyte as well as the number and frequency of PCUL exceedances. Of the 252 parameters for which samples were analyzed, 57 were detected in more than one sample. The detected compounds included metals (total and dissolved), a suite of VOCs, field parameters, and conventional groundwater quality parameters. Of the 57 compounds detected, 14 were found at concentrations above their respective PCUL, but only in groundwater quality samples collected from VLF monitoring wells:

- Conventional parameters – nitrate
- Metals – aluminum, arsenic, cadmium, copper, iron, manganese, mercury, selenium, zinc
- VOCs – 1,2-dichloropropane, benzene, TCE, vinyl chloride

The next step in the COC selection process is to further evaluate the compounds with PCUL exceedances. The specific factors used to evaluate whether a compound is retained as a COC is based largely on exceedance frequency and time elapsed since last exceedance.

Nitrate had a detection frequency of 62 percent but exceeded the PCUL in a single sample: MW-10 at 10.3 mg/L, slightly above the 10 mg/L PCUL. Therefore, nitrate is not considered a COC.

Of the metals detected at concentrations above their respective PCUL, only arsenic and iron are retained as COCs, as these compounds exceeded PCULs in more than 10 percent of samples. The other seven metals exceeded their respective PCUL in only 0.1 to

2 percent of samples. Four exceedances were found for aluminum: one sample from well MW-10, one sample from well MW-19, and two samples from co-located wells MW-5D/MW-35. Manganese concentrations slightly exceeded the PCUL at well locations MW-5D/MW-35 and upgradient well MW-20, with higher concentrations at the upgradient well. Of the two selenium exceedances, the higher concentration was found at upgradient well MW-20. Two zinc concentrations were higher than the PCUL: one sample from well MW-29 and one sample from well MW-31. Aluminum, cadmium, copper, manganese mercury, selenium, and zinc are therefore not considered COCs.

For VOCs, vinyl chloride has the highest exceedance frequency at 21 percent. While other VOCs exceedance frequencies are low, ranging between 1 to 7 percent, they have been retained as COCs because detections are recent and are located within the vinyl chloride plume, as discussed below.

6.1.2 Groundwater Quality

This section describes the nature and extent of impacted groundwater at the VLF. The COCs for groundwater include dissolved arsenic, dissolved iron, 1,2-dichloropropane, benzene, TCE, and vinyl chloride. Table 6.3 provides a summary of groundwater PCULs for COCs. While several VOCs are considered COCs, the focus of the RI is on vinyl chloride as an indicator compound because the other VOCs are co-located within the vinyl chloride plume.

This discussion also evaluates water quality parameters that, while not identified as COCs, represent landfill-related indicators signifying impacts other than PCUL exceedances. Appendix H provides water quality trend plots for the following parameters at select wells. The combined set of parameters evaluated in water quality trend plots and as part of the nature and extent discussion includes:

- Arsenic (dissolved)
- Iron (dissolved)
- Chlorinated VOCs – TCE and Vinyl Chloride
- Other VOCs – Benzene and 1,2-dichloropropane
- Water Quality Parameters – Alkalinity and Chloride

The lowest PCULs for arsenic and iron are based on protection of surface water for ecological receptors. The following discussion of metals exceedances are for dissolved fraction only, as this fraction is more toxic to ecological receptors compared to the total fraction.

KCSWD presents Mann Kendall statistical trend evaluations in the annual groundwater data evaluation reports presented to the Agencies. Table 6.8 presents a summary of the statistical trends developed for groundwater data through 2017 for key indicator parameters including alkalinity, chloride, dissolved iron, benzene, vinyl chloride, 1,2-dichloropropane, and TCE. The trends are presented as long-term and short-term, according to the time period that was evaluated for a specific well and identify whether an increasing, decreasing, or no noticeable trend is present. Long-term trends evaluate the last 50 samples collected. Short-term trends evaluate only the last eight samples collected (e.g. 2016 and 2017 samples). Wells with limited datasets were only evaluated for long-term trends. The results of the statistical trend evaluation indicate that there were no noticeable trends for any of the short-term evaluations. The most notable statistically significant decreasing long-term trends were that of benzene, vinyl chloride, and 1,2-dichloropropane. By example, vinyl chloride had statistically significant decreasing long-term trends in MW-4, MW-2, MW-5D, and MW-21. None of the VOCs evaluated had statistically significant increasing trends. Further evaluation of the statistically significant trends are presented in the *VLF 2017 Annual Groundwater Data Evaluation Report* (King County, 2018).

6.1.2.1 Arsenic

Arsenic is a naturally occurring, nonconservative metal in groundwater that has been detected above the PCUL in both upgradient and downgradient monitoring wells at the VLF. A parameter is considered nonconservative when its concentrations depend on the geochemical environment. Arsenic mobility in groundwater is enhanced by alkaline pH and by moderately reducing conditions.

Elevated concentrations of arsenic have been detected in deeper aquifers on Vashon Island and are attributed to naturally-occurring arsenic in region soils. For the Vashon-Maury Island Water Resources Evaluation, water quality monitoring included an assessment of arsenic concentrations in 95 wells (King County, 2013). Eleven sites in the study had arsenic concentrations greater than 10 µg/L while 23 sites had concentrations ranging between 5 and 10 µg/L. The remaining 61 sites were below 5 µg/L. Overall, higher values were reported for wells completed in deeper aquifers, corresponding to Unit D or deeper; therefore, soils are considered to be the predominant source rather than an anthropogenic source.

The extent of dissolved arsenic exceeding the PCUL in Units Cc2 and D from 2002 through 2017 is illustrated on Figures 6.1 and 6.2, respectively. Analytical results are compared to the Washington State background of 5 µg/L established in MTCA (Table 720-1 of WAC 173-340-900), as detailed below.

- Unit Cc1 –Dissolved arsenic concentrations range between 0.12 and 5 µg/L in Unit Cc1 wells. Unit Cc1 is not considered to be impacted by arsenic from landfilling processes.
- Unit Cc2 – As illustrated on Figure 6.1, the highest arsenic concentrations were found at the south end of the VLF; the maximum concentrations were reported at well MW-33, located in the South Slope Area, and at MW-35, located approximately 200 feet downgradient of MW-33. Dissolved arsenic concentrations at these wells range between 22.9 and 57.2 µg/L, with values at the higher end of the range from MW-33. By contrast, concentrations at upgradient well MW-20 range between 1 and 5 µg/L.

  Dissolved arsenic concentrations decrease downgradient of wells MW-33 and MW-35, to the west, likely due to attenuation and distance from geochemical changes to groundwater caused by landfill processes. Specifically, arsenic (among other metals such as barium, iron, and manganese) occur naturally in soil, and their occurrence in groundwater can depend on local groundwater oxidation-reduction (redox) conditions. Although not directly sensitive to redox, arsenic is strongly adsorbed to iron oxides and oxyhydroxides or manganese oxides and can be released under reducing conditions. Seeps attributed to Unit Cc2 groundwater, discharge from the West Hillslope, and flow downslope to weirs SW-W2 and SW-W3 at the west property boundary. Dissolved oxygen increases along this flow path leading to metals precipitation and a decrease in dissolved arsenic concentrations at these weirs to below 5 µg/L. Arsenic does not exceed PCULs at the western property boundary. Figure 6.1 also demonstrates that arsenic concentrations do not exceed PCULs at the southern property boundary.

- Unit Cc3 –Dissolved arsenic concentrations range between 0.45 and 3.5 µg/L in Unit Cc3 wells. Unit Cc3 is not considered to be impacted by arsenic from landfilling processes.
- Unit D –Dissolved arsenic concentrations range between 1 and 9 µg/L in Unit D wells (Figure 6.2). A similar range has been measured at upgradient well MW-7 (2.1 to 9 µg/L). One elevated concentration was detected at well MW-19 (27 µg/L) in October 2004. All other data from this well have been comparable to other Unit D wells, so the detection of 27 µg/L is considered an outlier.

  As discussed above, dissolved arsenic concentrations greater than 5 µg/L have been measured in wells in the Vashon-Maury Island area, especially in aquifers corresponding to Unit D or deeper. Dissolved arsenic concentrations in Unit D are not attributable to releases at the landfill, but rather to naturally occurring conditions in regional soils. The Unit D is not considered to be impacted by arsenic from landfilling processes.

6.1.2.2 Iron

Iron is a naturally occurring, nonconservative metal in groundwater that has been detected above the PCUL in VLF groundwater. Because of its nonconservative nature, dissolved iron is common when geochemical processes (water-rock interactions) cause reducing groundwater conditions. Conversely, in oxidized groundwater, iron forms hydroxide (rust-like) mineral grain coatings. The concentrations of iron relative to background values helps reveal whether groundwater is undergoing geochemical changes.

The extent of dissolved iron in Units Cc2 and D from 2002 through 2017 is illustrated on Figures 6.3 and 6.4, respectively.

- Unit Cc1 – Iron—Dissolved iron concentrations range between 8.1 and 490 µg/L in Unit Cc1 wells (PCUL is 1,000 µg/L). Unit Cc1 is not considered to be impacted by iron resulting from reducing conditions from landfill processes.
- Unit Cc2 – As illustrated on Figure 6.3, exceedances (maximum concentration of 26,000 µg/L) occur south of the Phase 2 closure area in wells MW-21, MW-33, and co-located wells MW-5D/MW-35. At other Cc2 wells, dissolved iron

concentrations range between 5.9 and 974 µg/L, with a much narrower range at upgradient well MW-20 (5 to 293 µg/L). Dissolved iron is below PCULs at the southern property boundary except one slight exceedance at well MW-21 in September 2015 (1,120 µg/L).

Unit C groundwater flows west and discharges as seeps on the West Hillslope. As discussed in Section 6.2, dissolved iron concentrations in surface water are below PCULs at the western property boundary. Therefore, dissolved iron exceedances in Unit Cc2 do not result in impacts beyond the VLF property boundary.

- Unit Cc3 –Dissolved iron concentrations range between 7 and 300 µg/L in Unit Cc3 wells. Unit Cc3 is not considered to be impacted by dissolved iron from landfilling processes.
- Unit D –Dissolved iron concentrations range typically between 11 and 420 µg/L in Unit D wells, with upgradient well MW-7 having a much narrower range (10 to 100 µg/L). Despite the higher concentrations in well MW-29 (290 to 975 µg/L), values remain below the PCUL for protection of surface water and drinking water. Figure 6.4 depicts the Unit D PCUL exceedances for dissolved iron. Unit D is not considered to be impacted by dissolved iron from landfilling processes.

6.1.2.3 Chlorinated Volatile Organic Compounds

Chlorinated VOCs are of anthropogenic origin that occur in both landfill leachate and LFG. They are commonly present in LFG because of their high vapor pressure and low solubility. Only vinyl chloride has been identified as a COC for the VLF and thus is the only chlorinated VOC evaluated further in this RI.

The extent of vinyl chloride in Units Cc2 and D from 2002 through 2017 is illustrated on Figures 6.5 and 6.6, respectively. Exceedances of vinyl chloride (PCUL of 0.02 µg/L) have been found in Unit C wells only, primarily within Unit Cc2, as detailed below:

- Unit Cc1 – In two samples, vinyl chloride concentration was greater than the PCUL: 0.5 µg/L at well MW-4 in May 2007 and 0.02 µg/L at well MW-13 in February 2008. Vinyl chloride was not detected in any other Unit Cc1 groundwater sample (including those from these two wells) with all other results reported as non-detect. Unit Cc1 is not considered to be impacted by vinyl chloride from landfilling processes.
- Unit Cc2 – As illustrated on Figure 6.5, exceedances occur at the south end of the property, with the highest concentrations reported in the South Slope Area at MW-33 (28.3 to 53.1 µg/L, since its installation in 2015). Concentrations of vinyl chloride decrease in the downgradient direction from well MW-33, to the west. Groundwater seeps attributed to Unit Cc2 discharge from the West Hillslope. Surface water sampling results for the seeps are discussed in Section 6.2.

  Vinyl chloride concentrations in Unit Cc2 groundwater exceed PCULs at the south property boundary at wells MW-2 and MW-21, cross-gradient from MW-33; however, the concentrations are significantly lower than those detected at MW-33.

- Unit Cc3 – One vinyl chloride sample exceeded the PCUL: 0.04 µg/L at well MW-14 in February 2008. Vinyl chloride was not detected in any other Unit Cc3 sample, including those from well MW-14. Unit Cc3 is not considered to be impacted by vinyl chloride from landfilling processes.
- Unit D – As depicted in Figure 6.6, vinyl chloride has not been detected in Unit D. Unit D is not considered to be impacted by vinyl chloride from landfilling processes.

TCE exceedances (PCUL 0.3 µg/L) are within the area of vinyl chloride exceedances at co-located wells MW-5D/MW-35. Concentrations from 2001 to present have ranged between 0.45 to 1.08 µg/L.

The TCE detected in one sample from Unit D well MW-12 (0.4 µg/L) is considered an outlier data point. TCE was not detected in any other sample from well MW-12. This anomalous concentration, despite being above the PCUL (0.3 µg/L) is below the TCE screening levels for protection of groundwater as a drinking water source, 5 µg/L. Unit D, a source of drinking water, is not considered to be impacted by TCE from landfilling processes.

6.1.2.4 Other Volatile Organic Compounds

Of anthropogenic origin, benzene and 1,2-dichloropropane are VOCs that can occur in both landfill leachate and LFG (Solid Waste Association of North America [SWANA], 2000). These other VOCs have been detected above their respective PCULs, but only in Unit Cc2 at the south/southwest portion of the VLF property. Units Cc1, Cc3, and D are not considered to be impacted by benzene or 1,2-dichloropropane from landfilling processes. Benzene data for Units Cc2 and D from 2002 through 2017 are illustrated on Figure 6.7 and 6.8, respectively.

The highest benzene concentrations were detected at well MW-33 (0.98 to 1.8 µg/L) (PCUL 0.44 µg/L). Concentrations decrease at downgradient co-located wells MW-5D/MW-35 (0.25 to 1.6 µg/L).

Exceedances and detections of 1,2-dichloropropane (PCUL 0.71 µg/L) are co-located with benzene exceedances at wells MW-33, MW-5D, and MW-35. Concentrations at MW-33 (0.24 and 13 µg/L) are higher than those at downgradient of co-located wells MW-5D/MW-35 (non-detect to 2.3 µg/L).

6.1.2.5 Water Quality Parameters

Alkalinity and chloride are two key indicator parameters that are used to identify landfill impacts on groundwater. Alkalinity is a measurement of the ability of water to neutralize (buffer) an acid. Bicarbonate alkalinity in groundwater can form from dissolution of carbonate and silicate minerals in aquifer material by dissolved carbon dioxide gas (carbonic acid) from either landfill leachate or LFG.

Chloride is a naturally occurring, conservative ion that is also found in landfill leachate. Dissolved chloride concentrations remain relatively unchanged by natural chemical processes in groundwater (except for mixing).[1] More typically present in landfill leachate, chloride is not a significant component of LFG and thus not indicative of LFG impacts. Chloride in groundwater above background levels could originate from landfill leachate.

Both parameters can be elevated in leachate, and LFG can increase alkalinity. Data from upgradient wells are provided for Units Cc2 and D, units where sufficient information is available to establish horizontal gradient, thus identify upgradient wells.

- Unit Cc1 – Alkalinity concentrations range between 18 and 110 mg/L (average 59.8 mg/L) in Unit Cc1 wells. Chloride concentrations range between 1 and 10.6 mg/L (average 3.3 mg/L).
- Unit Cc2 – At upgradient well MW-20, alkalinity ranges between 58.5 and 94.9 mg/L and chloride ranges between 3 and 4.1 mg/L. Corresponding ranges in the southern portion of the VLF, where COC impacts are noted above, are 117 to 496 mg/L (average 242 mg/L) for alkalinity and 2.1 to 8.7 mg/L (average 3.8 mg/L) for chloride.
- Unit Cc3 – Alkalinity concentrations range between 46.5 and 84 mg/L (average 64 mg/L) in Unit Cc3 wells. Chloride concentrations range between 2.8 and 6.23 mg/L (average 3.9 mg/L).
- Unit D – At upgradient well MW-7, alkalinity concentrations range between 58 and 100 mg/L; chloride ranges between 2.7 and 5 mg/L. Corresponding concentrations in Unit D wells are 3 to 110 mg/L (average 78 mg/L) for alkalinity and. 2.7 to 7 mg/L (average 4 mg/L) for chloride.

The alkalinity concentrations observed in Unit Cc2 are in stark contrast to the up-gradient well, MW-20 and alkalinity concentrations detected in the other water bearing units at the VLF. However, chloride concentrations appear relatively consistent across the VLF. These results indicate that LFG may be the primary source impacting Unit Cc2 groundwater on the south side of the VLF.

6.1.3 Off-Property Groundwater Monitoring

In 2002, KCSWD sampled groundwater from 11 domestic wells located near the landfill and found no evidence of impacted water quality originating from the VLF. The locations of these wells are depicted on Figure 3.1 and include, from north to south, DW-FL, DW-BA, DW-SE, DW-AV, DW-HU, DW-LO, DW-PA, DW-OR, DW-SS, DW-85, and DW-GE. KCSWD continued monitoring the Smith-Shiratori well (DW-SS on Figure 3.1) from 2005 through 2008. The Paquette well (DW-PA, located west of the VLF) and 85 Acres Water Company (DW-85 located south of the VLF) are still monitored routinely by KCSWD and data are available from 2002 through 2017. Shown on cross sections A-A´ (Figure 3.2) and D-D´ (Figure 3.6), these three wells are interpreted to be

[1] In contrast, nonconservative ions change concentrations as the result of natural chemical processes such as water-rock interactions.

completed in Unit D or deeper based on the elevation of the well screen or open casing in relation to the inferred hydrostratigraphy.

VOC detections in off-property wells were sporadic and at low levels, below PCULs. VOC detections in off-property wells are likely due to post-sampling cross-contamination of the samples rather than VLF impacts to off-property wells. Detected compounds have included acetone, 2-butanone and chloromethane, which are common lab contaminants. Other detected VOCs included toluene, TCE, bromomethane, and carbon disulfide. These compounds have also been detected in quality control samples (i.e., trip blanks and laboratory blanks).

All data from domestic drinking water wells are compiled in Appendix G. No evidence of contamination originating from the VLF has been found in any of the domestic wells.

6.2 Surface Water

6.2.1 Data Screening

Surface water samples were analyzed for hundreds of parameters, as summarized in Table 6.4 and fully tabulated in Appendix G. Surface water data were compared to the most stringent screening level based on the highest beneficial use for the protection of surface water for human and ecological receptors.

Table 6.4 provides the minimum, maximum, and average detected concentrations for each analyte, as well as the number of detections and a comparison to PCULs. Of the 129 parameters for which samples were analyzed, 70 were detected in more than one surface water sample. The detected compounds included metals (total and dissolved), a suite of VOCs, one pesticide, field parameters, and conventional surface water quality parameters. Of the compounds detected, dissolved arsenic, dissolved iron, 1,2-dichloropropane, benzene, and vinyl chloride are retained as COCs with exceedance frequencies greater than 5 percent. With exceedance frequencies less than 5 percent, aluminum, mercury, selenium, zinc, and acrylonitrile are thus not considered COCs.

6.2.2 Surface Water Quality

This section describes the nature and extent of surface water quality at the VLF at the following locations: Borrow Area Pond, the VLF outfall, and West Hillslope seeps and weirs. Surface water sampling locations are depicted on Figure 4.5. Table 6.5 provides a summary of surface water PCULs for COCs. The lowest PCULs for arsenic and iron are based on protection of surface water for ecological receptors. The following discussion of metals exceedances are for dissolved fraction only, as this fraction is more toxic to ecological receptors compared to the total fraction.

Only one analyte—iron (PCUL 1,000 µg/L)—was identified as a COC at the Borrow Area Pond (SW-D). Concentrations at this location range between 113 and 4,100 µg/L, with an average of 846 µg/L.

Iron was also the only COC identified at the VLF outfall (SW-B). Concentrations at this location range between 108 and 1,560 µg/L, with an average of 557 µg/L.

Along the West Hillslope, groundwater discharges as seeps, flows downhill as overland flow, and is intercepted by weirs at the western property boundary. Elevation and visual reconnaissance of outcrops at the surface indicate that seeps sampled on the West Hillslope are groundwater discharging from Unit C. Overland flow of groundwater discharge from Unit Cc2 made it difficult to discern if seepage from Unit Cc3 occurs, however, discharge was noted to increase at lower elevations that are comparable to Unit Cc3 elevation. Unit Cc2 groundwater seeps were more visually apparent than Unit Cc3 as there was little to no upslope groundwater seepage to obscure the Unit Cc2 seep locations.

Four COCs are present in the seep and weir samples.

- Dissolved Arsenic – Concentrations at the seeps range between 0.9 and 34.1 µg/L, with an average of 6.3 µg/L (PCUL 5 µg/L). Concentrations at the weirs range between 1 and 16 µg/L, with an average of 2.2 µg/L.
- Dissolved Iron – Concentrations at the seeps range between 10 and 27,000 µg/L, with an average of 5,000 µg/L (PCUL 1,000 µg/L). Concentrations at the weirs, located downslope from the seeps, range between 10 and 8,970 µg/L, with an average of 186 µg/L. Dissolved iron concentrations at weirs SW-W2 and SW-W3 are below 1,000 µg/L, indicating iron is below PCULs at the western property boundary, with one outlier from SW-W2 in February 2016 (8,970 µg/L).
- Vinyl chloride – Concentrations at the seeps range between 0.02 and 7.4 µg/L, with an average of 1.4 µg/L (PCUL 0.02 µg/L). Vinyl chloride was detected at only weirs SW-1 and SW-3; concentrations range between 0.02 and 0.14 µg/L, with an average of 0.05 µg/L.

  From the property boundary weirs, of which only SW-W3 has exceeded the PCUL, water continues downslope as surface water and enters Robinwood Creek. Vinyl chloride has not been detected in surface water sampling location SW-E located approximately 1,500 feet from the VLF property in Robinwood Creek.
- Benzene – Benzene was detected only at the seeps; concentrations range between 0.24 and 3.2 µg/L, with an average of 0.91 µg/L (PCUL 0.44 µg/L).

6.3 Landfill Gas

For this RI, LFG compliance monitoring data and operations monitoring data were assessed for control of LFG migration and performance of the LFG collection system. In addition, an air quality evaluation was conducted by Herrera in 2013 based on laboratory sample results for VOCs in LFG (Appendix I). Finally, influence test findings for the South Slope Area support the efficacy of interim actions focused on LFG collection.

6.3.1 Landfill Gas Compliance Monitoring and Results

This section presents a summary of LFG compliance monitoring, which KCSWD performs routinely to meet requirements of the landfill's permit. LFG is monitored monthly at 26 gas probes, in accordance with the "Environmental Monitoring Sampling and Analysis Plan and Quality Assurance Project Plan for Vashon Island Landfill" (King

County, 2016). Probe monitoring is used to demonstrate lateral control of LFG migration and protection of surrounding properties.

At the VLF, the priority has been and remains control of LFG migration. Figure 6.9 illustrates maximum annual methane and CO_2 concentrations since 1997 and 1999, respectively. In 1997, the maximum methane concentrations were observed at NP-5 probes (28 to 79 percent methane by volume). Since active LFG collection started, maximum annual methane concentrations have remained consistently below the 5 percent by volume regulatory threshold at all compliance probes. By comparison, CO_2 concentrations have been approaching background levels. Elevated CO_2 concentrations observed at NP-8S and NP-8I have been decreasing over time and illustrate the importance of LFG collection at the north end of the VLF. Overall, LFG compliance monitoring results indicate that lateral LFG migration has been and is being controlled.

6.3.2 Landfill Gas Operations Monitoring and Results

The following provides a discussion of the performance of the LFG collection system as a whole in addition to the performance of individual collection points. The extent of methane (both within and outside the closed landfill area) is also discussed below as it further illustrates the performance of LFG controls in terms of methane migration.

6.3.2.1 Overall Landfill Gas System Performance

The LFG collection system has been operated at high flow rates to maximize LFG migration control. The system has been designed to provide 360 standard cubic feet per minute (scfm) of total flow rate. System maximization is illustrated by the observed collection rates of methane, CO_2, oxygen, and balance gas over time. As illustrated in the upper graph of Figure 6.10, the annual average system flow rate has ranged between 164 and 307 scfm since 2006. The system flow rate was increased in 2013 in an attempt to improve LFG collection efficiency. This increase in flow rate resulted in greater collection of atmospheric air (i.e., oxygen and balance gas), not LFG (i.e., methane and CO_2). These results indicated that the zone of influence for the LFG collection system was maximized.

Over the long-term, calculated LFG generation and observed LFG collection have trended downward. In the bottom graph on Figure 6.10, methane and CO_2 results from EPA’s LFG generation model (LandGEM) are superimposed over the annual average system flow rate. Input to the LandGEM model include total waste mass (726,000 tons based on 968,000 cubic yards with a density of 1,500 pounds per cubic yard), the age of waste (uniformly placed from 1950 through 1999), and the methane-generating capacity of the waste. The methane-generating capacity was adjusted from a default value of 170 cubic meters per megagram to 40 cubic meters per megagram so that LandGEM results would more closely match observed gas collection rates. This adjustment reduced the calculated 2017 total LFG generation rate from 148 scfm (not shown in tabulated results beneath graph) to 35 scfm, a close match with the 36 scfm of LFG actually collected. With this adjustment, the LandGEM model results are useful for projecting long-term LFG generation rates and will support the Feasibility Study.

6.3.2.2 Landfill Gas Collection Point Performance

The individual LFG collection points have been operated consistently over time to maximize LFG collection rates. Figure 6.11 displays a set of stacked column charts reflecting performance at each LFG collection point for 2006, 2016 (before GW-9 was installed), and 2017 (after GW-9 was installed). The graphs on the left show LFG concentrations, while the graphs on the right show LFG flow rates. The locations of the LFG collection points are mapped on Figure 2.7.

LFG collection has been focused on those locations with greater concentrations of methane and CO_2. LFG collection was not attempted from those locations with little to no methane or CO_2. Between 2006 and 2016, methane and CO_2 concentrations decreased while oxygen and balance gas concentrations increased. During 2017, methane collection at GW-9 was approximately 0.9 scfm. The effectiveness of GW-9 is further illustrated by the observed decrease in the methane collection from nearby EF-1 and EF-2 where the combined methane collection decreased from 0.4 scfm in 2016 to 0.1 scfm in 2017.

6.3.2.3 Extent of Methane

The extent of methane outside the lined and covered landfill decreased between 2006 and 2016 (before GW-9 was installed) and between 2016 and 2017/2018 (after GW-9 was installed). Figure 6.12 provides maps with color-coded indicators of methane concentrations at compliance probes, temporary probes, and LFG collection points outside the VLF. Elevated methane concentrations were observed in the South Slope Area, but not at the compliance probes. Operation of GW-9 resulted in lower methane concentrations across most of the South Slope Area. Elevated methane at VTP-7 will be addressed by operating GW-10 and GW-11, further discussed in Section 8.3.

6.3.3 Volatile Organic Compounds in Landfill Gas and Air Quality Evaluation

In 1997, KCSWD requested and received a permit from Puget Sound Air Pollution Control Agency (Notice of Construction No. 6513; Registration No. 1104) to treat LFG collected from the VLF using granular activated carbon. LFG treatment is typically required to protect air quality from VOCs identified as toxic air pollutants in air quality regulations (WAC 173-460). The VOC concentrations observed at the blower inlet in 2013 (summarized on Table 6.6) were compared to typical concentrations observed at municipal solid waste landfills as compiled by the EPA. This comparison is presented on Figure 6.13. Under the Clean Air Act, EPA provides average VOC concentrations (or "emission factors") for municipal solid waste landfills in *Compilation of Air Pollutant Emission Factors (AP-42)* (EPA, 1995). The left graph in Figure 6.13 displays VOC concentrations measured on May 1, 2013 (Table 6.6 and Appendix I), on the y-axis relative versus EPA emission factors on the x-axis. Error bars represent a correction factor of 11.62 to account for the effects of air intrusion, per EPA guidance; the correction factor was calculated from the average LFG concentrations (2 percent methane and 7 percent CO_2) observed in March and April 2013. A dashed line on the left graph in Figure 6.13 shows where the observed concentration would match the EPA emission factor. The adjusted observed VOC concentrations are all below the dashed line, and less than the EPA emission factors, indicating that the VLF has fewer VOCs in collected LFG than typical landfills.

As a preliminary air quality evaluation for this RI, the potential to emit toxic air pollutants was assessed by comparing estimated treatment system loading rates with regulatory thresholds. The regulatory thresholds for each toxic air pollutant are listed in WAC 173-460-150; for example, the small quantity emissions rate (SQER) for vinyl chloride is 2.46 pounds per year. If a potential source has an emissions rate below the SQER, then the source complies with air quality regulations without further assessment. The right graph in Figure 6.13 compares the loading rates and SQERs in units of pounds per averaging period. A dashed line on the right graph in Figure 6.13 shows where the loading rate would match the SQER. In all cases, the VOC loading rates were below the dashed line, and less than the respective SQER. Therefore, an air quality permit may not be necessary for VOCs in LFG collected from the VLF. Additional sampling may be required, considering LFG collection system improvements and to quantify potential hydrogen sulfide emissions.

6.3.4 South Slope Area Influence Testing Results

Operation of extraction well GW-9 has increased LFG collection from the South Slope Area. A set of temporary probes was installed across the South Slope Area to observe changes in LFG concentrations during the GW-9 influence test. As shown in Figure 6.14, monthly maximum methane and CO_2 concentrations in temporary probes decreased substantially during and following the influence test. The effective radius of influence of GW-9 during the influence test was approximately 100 feet (Aspect, 2017a).

In April 2018, an additional set of temporary probes was installed across the South Slope Area to further define the extent of refuse and methane. Elevated methane and CO_2 was observed in VTP-7 (see Figure 6.12). Based on the radius of influence determined from the influence test for GW-9, two additional gas extraction wells (GW-10 and GW-11) were installed by Aspect in June 2018. These new extraction wells were installed at locations shown on Figure 2.7 to maximize LFG collection and minimize potential for air intrusion. Gas extraction wells GW-10 and GW-11 were connected to the extraction system and became operational on September 12, 2018 for the start of the influence test.

6.4 Leachate

Results of leachate sample analyses are summarized in Table 6.7 and fully tabulated in Appendix G. Compounds detected in more than one leachate sample included conventional parameters, 24 metals, 3 chlorinated herbicides, and 14 VOCs.

Unlike groundwater and surface water, regulatory values for leachate are not available, and thus COCs for leachate are not identified. For this RI, constituents detected in leachate were evaluated qualitatively to see if they were also detected in groundwater. Of the constituents detected in leachate, those with a detection frequency greater than 50 percent are barium, calcium, copper, magnesium, nickel, potassium, sodium, and zinc. VOCs and chlorinated herbicides were detected at a frequency less than 15 percent in leachate samples. Anchor QEA performed a geochemical evaluation of groundwater to distinguish leachate from LFG impacts using data from selected Unit Cc2 wells (Anchor QEA, 2017). A summary of this evaluation is presented below in Section 7.2 and a copy of the geochemical analysis is included in Appendix D of this report.

7 Conceptual Site Model

The conceptual site model (CSM) for the VLF is developed from historical land use information, existing environmental data, and the contaminant fate and transport processes that control the migration of COCs in the natural environment. The following sections describe the components of the CSM and evaluate potential exposure pathways and receptors.

7.1 Physical Conceptual Site Model

The physical components of the CSM are summarized here from more detailed information presented in earlier chapters of this RI.

7.1.1 Hydrogeologic Setting

VLF geology is composed of glacially derived sediments, with surficial geology in the southern portion of the property being primarily glacial till and advance outwash. Groundwater in two underlying stratigraphic units (Unit C and Unit D) has been characterized for the nature and extent of COCs at the VLF.

Unit C is glacially derived, consisting of fine-grained Cf soils deposited in a low-energy glaciomarine or glaciolacustrine setting and coarser-grained soils (Cc) deposited in a higher-energy glaciofluvial deposit. Subunits Cc2 and Cc3 are considered to be the principal water-bearing layers of Unit C and groundwater contamination is limited to Unit Cc2.

As depicted in the cross sections (Figures 3.2 through 3.6), the Cc units are not continuous across the VLF. For example, Unit Cc3 has not been observed in borings completed north of the VLF closure area. Unit Cc2 was not observed in borings southeast and northwest of the VLF closure area. Furthermore, borings completed at the VLF indicate limited hydraulic interconnection between Cc units, consistent with what is known of their glacial depositional environment. These units are separated from one another by fine grained soils (Cf).

Groundwater with concentrations of COCs exceeding PCULs is limited to Unit Cc2. Groundwater flow in Unit Cc2 is westerly and discharges from seeps located on the steep hillslope on the western side of the VLF property.

Unit D is a fluvial deposit exhibiting a wide range in texture consistent with varying energy in a fluvial environment, including sandy gravel channel deposits to fine-grained overbank deposits. Groundwater COCs have not been detected above PCULs in Unit D, whether in on-property wells or off-property domestic drinking water wells monitored by KCSWD. In all deeper borings completed onsite, a fine-grained portion of Unit C was observed separating the water-bearing portions of Unit C from the Unit D aquifer.

7.1.2 Extent of Solid Waste

Solid waste disposal activities have occurred at the VLF since the early 1900s. Based on review of historical topographic maps, solid waste was placed in a former valley. As detailed in Section 2.2, the northwest portion of the landfill (Phase I) was closed in 1988, at which time a liner was placed across the central portion of the landfill. The landfill accepted refuse for placement in the landfill until 1999. Site investigations suggest that refuse extends approximately 300 feet south of the Phase 2 closure area, in the South Slope Area.

The estimated location of unlined solid waste (waste placed prior to 1988) is shown on Figure 2.4. Site investigations suggest that refuse extends approximately 300 feet south of the Phase 2 landfill closure area and approximately 70 feet west of the Phase 1 closure area. As shown in Figure 2.4, much of this area is covered by geotextile fabric installed in 1988 at a depth of 3.5 to 6.5 feet bgs. In this unlined area to the south, the geotextile was installed and covered with topsoil at a thickness of 7 or more feet with one exception as follows. Approximately 100 feet north of the South Siltation Pond is boring VTP-6S/D, the fill soil cover over refuse is 4 feet thick. West of the Phase I closure area, 6 or more feet of soil has been noted to cover the waste in explorations along the West Perimeter Road, with one exception. Fill soil overlying waste at boring BH-8 completed in 1995 is approximately 4.5 feet.

Within the context of underlying geology, solid waste is in contact with till or the advance outwash. As a coarser grained unit, the advance outwash would permit greater contaminant transport than the till.

7.2 Contaminants and Source Analysis

The constituents detected in groundwater at concentrations exceeding PCULs are metals (arsenic and iron) and VOCs (vinyl chloride, TCE, benzene, and 1,2-dichoropropane). LFG generated from the refuse area is the primary source of groundwater quality impacts at the VLF, as shown in the following summary of the source analyses and contaminant migration assessments.

7.2.1 Landfill Gas

A suite of gases consisting primarily of methane, CO_2, and oxygen, known collectively as LFG, are typically produced within the subsurface at municipal solid waste landfills as the chemical and biological degradation of solid waste containing organic matter progresses as the landfill ages. Methane is most notable due to its flammable and potentially explosive nature. Frequently, due to the type of wastes disposed of within landfills, VOCs may be present and may migrate with the movement of LFG. In LFG-driven contamination scenarios, the pathway begins as VOC vapors expelled from the refuse commingle with LFG. VOCs in the migrating gas dissolve into the soil porewater that subsequently migrates to the water table. VOCs can also dissolve directly into groundwater at the gas-groundwater contact (Walter et al., 2003). The following subsections summarize the results of key source analysis investigations.

7.2.1.1 Landfill Gas Effects on Groundwater Analysis

Time-series plots and trilinear diagrams developed for a 2005 source evaluation (Berryman & Henigar, 2006b) and included as source evaluation (copies of trilinear plots in Appendix J) indicate that groundwater conditions at the VLF changed in response to closure activities. Their analysis of groundwater and LFG quality indicates that leachate was impacting water quality in the past (prior to and just after Phase 2 landfill closure), but since Phase 2 closure, the leachate influences have become minimal and LFG is the primary source of water quality impacts to groundwater and springs. Time-series plots developed by Berryman & Henigar of groundwater data from impacted wells show a decrease in several parameters (chloride, iron, calcium, magnesium, potassium, sodium, total dissolved solids, and alkalinity). Calcium, magnesium, potassium, and alkalinity were likely due to dissolution of carbonate materials by carbonic acid from LFG CO_2 (Kerfoot et al., 2004).

Trilinear plots of cation and anion groundwater data (Appendix J of this report) provide a water composition assessment and indicate that the impacts to the springs are not the result of mixing of background groundwater and leachate. For the trilinear plot of pre-1997 data (Figure 13 in Appendix J), the data from wells MW-2, MW-5D, and leachate (LS-B), plot closely due to similar concentrations of calcium, chloride and sulfate. The groundwater and leachate data groups diverge in the plot of 2004 and 2005 data due to changes in leachate composition—increase in chloride and decrease in sulfate. Theoretically, if the groundwater and seep chemistry were the result of mixing of background groundwater (as monitored at MW-20) and leachate (monitored at LS-B), then the water quality at the West Hillslope weirs and monitoring wells would fall on a line between the two points (see red line on trilinear plot, Figure 15 in Appendix J). Rather, the groundwater and weir data (sample points downslope from West Hillslope seeps) plot closely together and not on this line indicating leachate is not a predominant factor in water quality composition.

Further analysis by Berryman & Henigar (2006b) using groundwater, leachate, and LFG VOC data verified the changes in how leachate has impacted groundwater and LFG impacts on groundwater. In a correlation analysis of pre-closure data, calcium, magnesium, and sodium concentrations from Unit Cc2 wells were highly correlated with leachate chloride concentrations. Alkalinity was correlated with VOCs in both leachate and LFG. A similar analysis of post-closure data found that alkalinity, calcium, magnesium, and sodium in groundwater from these wells were correlated with VOCs in LFG. Berryman & Henigar (2006b) conclude that both LFG and leachate influenced these constituents prior to VLF closure, but that LFG appears to be the dominant influence on groundwater conditions post-closure.

7.2.1.2 Geochemical Source Analysis

Anchor QEA performed a geochemical evaluation of groundwater to distinguish leachate from LFG impacts using data from selected Unit Cc2 wells (MW-2, MW-20 MW-21, MW-33, MW-35), West Hillslope seeps, and from a leachate conveyance structure (LSB; referred to as "Leachate Box" in Anchor QEA report) (Anchor QEA, 2017; included in Appendix D of this report). Well MW-20 was included to represent background groundwater conditions. The analyses were completed as a line of evidence for attributing groundwater impacts to leachate or LFG. Based on alkalinity, chloride, and sulfate concentrations, the chemistry of groundwater and seep water differs from that of leachate. Groundwater did not have elevated chloride concentrations indicative of influence from leachate, with one exception, seep SW-2. Slightly higher chloride and sodium concentrations observed at seep SW-2 compared to other groundwater sample locations suggest a minor contribution of leachate at this location.

Elevated alkalinity at wells MW-33 and MW-35 and seeps SW-2 and SW-3 are consistent with LFG influences, not leachate influences. A comparison of alkalinity versus TDS indicated that elevated alkalinity at these wells and seeps is not consistent with impacts from leachate because chloride remains low (Figures 2 and 3 of Anchor QEA, 2017). Furthermore, increased alkalinity in leachate typically also corresponds with increased TDS, whereas the results of this analysis showed that TDS remained low in VLF groundwater data. And finally, sulfate and chloride data are low in groundwater compared to higher concentrations in leachate, for a given TDS concentration. This supports the assertion that leachate is not a source of impact to groundwater.

Further evidence of LFG influence on groundwater includes low dissolved oxygen (0.2 to 0.6 mg/L), absence of detectable nitrate, elevated manganese (959 to 2,030 µg/L),) and elevated dissolved iron (710 to 12,200 µg/L) in wells MW-33 and MW-35. These observations in groundwater are consistent with localized and, likely LFG-induced, mildly reducing conditions downgradient of the landfill. Furthermore, elevated dissolved arsenic concentrations detected at MW-33, MW-35, and seep SW-2 (the wet-season sample) are associated with elevated dissolved iron concentrations. Dissolved iron and arsenic were not detected in leachate samples, confirming that arsenic and iron are mobilized in the aquifer under the reducing conditions caused by LFG.

The final step in the geochemical evaluation (Anchor QEA, 2017) was an isotopic analysis to confirm LFG as the primary source. Downgradient wells and seeps, except for SW-2, had higher carbon-14 concentrations than upgradient well MW-20 but no increase in chloride concentrations, indicating that the carbon-14 enrichment is due to LFG and not leachate. Isotopic analyses of oxygen ($\delta^{18}O$) and hydrogen (δD) also preclude leachate as a source. The leachate sample was isotopically enriched in δD, reflecting isotopic fractionation associated with methanogenesis, which occurs within the landfill. None of the groundwater and seep samples showed δD-enrichment.

Anchor's findings that LFG is the primary source of groundwater contamination are consistent with the broader VLF dataset. Figures 7.1, 7.2, and 7.3 illustrate the differences between chloride and alkalinity data from leachate (LS-B) with data from Unit Cc2 groundwater wells and groundwater seeps in the south and west slope area where groundwater is impacted (wells MW-5D/MW-35 and MW-33 and seeps SW-S1 through SW-S6). Figures 7.1 and 7.2 are time-series plots for chloride and alkalinity data, respectively, from 2001 through 2017 and Figure 7.3 plots chloride versus alkalinity for the same time period. The data illustrate four key points:

- Chloride concentrations in groundwater have decreased overtime since landfill closure while concentrations in leachate have remained relatively constant, indicating a decline in impacts from leachate to groundwater. Alkalinity concentrations remain elevated in wells MW-33 and MW-35 compared to leachate indicating LFG influences.
- Alkalinity concentrations have decreased in leachate indicating LFG controls have been effective within the lined cells.

- No correlations are seen between alkalinity concentrations in groundwater compared to chloride, with the exception of SW-2. In groundwater, chloride concentrations remain low while alkalinity is elevated.
- Seep SW-S2 has higher chloride concentrations than other groundwater sampling locations indicating some possible residual influence from leachate at this seep; Chloride concentrations have decreased from approximately 50 mg/L to approximately 20 mg/L between 2010 and 2017.

7.2.1.3 Effects of LFG Extraction

In 2016 and 2018, LFG extraction has expanded into unlined solid waste in the South Slope Area with the completion of LFG extraction wells GW-9, GW-10 and GW-11. In 2016, a set of temporary probes were installed across the South Slope Area to observe changes in LFG concentrations during the influence test of extraction well GW-9. Figure 6.14 shows monthly methane and CO_2 concentrations observed in temporary probes from July 2016 through March 2018. The GW-9 influence test was conducted from September 14, 2016 through March 1, 2017. Methane and CO_2 concentrations decreased substantially in temporary probes during and following the influence test. The effective radius of influence of GW-9 in the South Slope Area during the influence test was estimated at approximately 100 feet (Aspect, 2017a).

In April 2018, an additional set of temporary probes were installed across the South Slope Area to further define the extent of refuse and methane. Figure 6.12 shows the maximum methane observed at VTP-7 through VTP-10. Based on the radius of influence determined during the influence test for GW-9, confirmed by methane observed at VTP-7, two additional gas extraction wells (GW-10 and GW-11) were installed by Aspect in June 2018. At the time of this RI, work to connect these wells to the LFG collection system is on-going. It is hypothesized that the expansion of the extraction well network in the South Slope Area will provide improvements in groundwater quality in the impacted aquifer, Unit Cc2.

7.2.2 Leachate

Landfill leachate impacts can be inferred when chloride concentrations in groundwater are higher than background values. As discussed in Section 7.2.1, chloride data indicate leachate-influenced contaminant concentrations in groundwater prior to VLF closure (Berryman & Henigar, 2006b; Anchor QEA, 2017). Leachate does not appear to be a primary source to groundwater contamination post-closure, except at seep SW-2, where slightly higher chloride and sodium concentrations than those at MW-33 and MW-35 at suggest a minor contribution of leachate at this location, in addition to contribution by LFG (Anchor QEA, 2017). Chloride concentrations observed at SW-2 are consistent with a residual leachate impact because chloride concentrations have decreased overtime. For example, SW-2 chloride concentrations were near 50 mg/L in 2010, but by 2017 had decreased to 20 mg/L. This decreasing trend in chloride concentrations with consistent elevated alkalinity concentrations presents strong evidence that leachate is a residual impact and LFG is the current and primary impact (Figures 7.1 and 7.2).

7.2.3 Groundwater to Surface Water

Surface water impacts are located along the West Hillslope. Groundwater from Unit C discharges as seeps along the West Hillslope on the west side of the VLF property, flows downhill, and is intercepted by weirs near the western property boundary. The water flows as surface water beyond the western property boundary in an unnamed tributary of Robinwood Creek. Elevation and visual reconnaissance of the soil outcrops at the surface indicate that the seeps are expressions of groundwater discharging from Unit C. An analysis of groundwater chemistry from these seeps and impacted VLF monitoring wells indicates that Unit Cc2 is the primary source of contamination at the seeps. Thus, groundwater discharging from the property is a source to downgradient surface water.

7.3 Fate, Transport, and Attenuation Processes

7.3.1 Fate and Transport

The following sections describe the fate and transport of COCs in groundwater within the VLF. As discussed further in the following sections, the primary contaminant fate and transport processes include:

- Migration of LFG from refuse, followed by dissolution of VOCs to groundwater.
- Migration of leachate from refuse.
- Migration of COC-affected groundwater to potential receptors.

7.3.1.1 Migration of LFG from Refuse

The LFG generated by waste in the landfill closure area is controlled to the maximum extent possible by the existing LFG collection system. A long history of effective control of horizontal LFG migration has been observed during routine monitoring at compliance probes. In the South Slope Area, LFG control measures were implemented with the operation of extraction well GW-9 beginning in September 2016. Control of LFG migration from unlined waste in the South Slope Area was demonstrated within a radius of approximately 100 feet of extraction well GW-9. Additional measures are being implemented to further control LFG in the South Slope Area with the installation and operation of extraction wells GW-10 and GW-11 in 2018, as discussed in Sections 4.4 and 8.3.

LFG not intercepted by the collection system migrates through the native unsaturated zone soils, as inferred from VOCs and LFG in gas probes and effects groundwater quality in the South Slope Area. LFG migrating through the vadose zone contains VOCs that interact with groundwater, where they are then available to migrate to shallow groundwater or to commingle with LFG at the gas-groundwater contact. LFG causes VOCs, in particular vinyl chloride and its parent products, to partition into groundwater. Furthermore, the commingling of groundwater and CO_2 in LFG generates geochemically reducing conditions (i.e., redox conditions) accompanied by dissolution of naturally occurring metals, which is illustrated at the VLF by the elevated dissolved arsenic and iron concentrations in Unit Cc2 groundwater.

7.3.1.2 Migration of Leachate from Refuse

Leaching of constituents from refuse is a normal process at a landfill, at rates that depend upon refuse age and stage of decomposition. VLF closure included installation of infrastructure to collect leachate and prevent it from commingling with groundwater. Leachate not captured by the collection system may migrate from refuse through the native soils or via other preferential pathways, such as landfill infrastructure. Historically, groundwater in the south VLF area was impacted by leachate (Section 7.2.1). As the impact has attenuated over time, little evidence of leachate migration to groundwater is currently observed.

7.3.1.3 Migration of COC-Affected Groundwater to Potential Receptors

Groundwater contamination at the VLF is limited to Unit Cc2 groundwater at the southern and western portions of the property. The COCs in impacted groundwater are VOCs and dissolved metals. The vinyl chloride-impacted groundwater plume is located adjacent to the South Slope Area of unlined solid waste. Groundwater flow through Unit Cc2, and thus COC transport and attenuation, is toward the west, with discharges as seeps along the steep West Hillslope west of Westside Highway SW. At two surface water sampling weirs downhill from West Hillslope seeps, vinyl chloride exceeded its PCUL. Exceedances of dissolved metals and other VOC are found within the VLF property and are generally co-located with vinyl chloride exceedances.

Vinyl chloride concentrations in surface water decrease further downgradient as VOCs volatilize during aeration of surface water before it enters Robinwood Creek, located 800 feet west of the VLF property boundary. Vinyl chloride was not detected at surface water sampling location SW-E on Robinwood Creek, located 1,500 ft downstream from the western property boundary.

Unit Cc2 is not a known primary drinking water source in the landfill vicinity and deeper groundwater from Unit D and Cc3 or lower is not impacted by VLF COCs.

7.3.2 Groundwater Attenuation

7.3.2.1 Natural Attenuation of Organic Compounds

The concentrations of VOCs in Unit Cc2 wells and the seeps have decreased consistently over time. Declining concentrations in wells completed in Unit Cc2 and confirmed presence of chlorinated VOC degrading bacteria (Anchor QEA, 2017) indicate attenuation is due to both physical (dispersion, dilution) and biological (reductive dechlorination) processes. Natural attenuation is evident temporally and spatially. Times-series data for vinyl chloride (Figures 7.4 and 7.5) illustrate the decreases at wells MW-2, MW-21, and co-located wells MW-5D/MW-35, since VLF closure in 2001. Vinyl chloride concentration in seeps on the West Hillslope have shown a similar decrease. When seeps were sampled between 2007 and 2010, detected concentrations of vinyl chloride ranged between 0.03 and 7.4 µg/L. When resampled during wet- and dry-season events in 2016/2017, concentrations ranged between non-detect and 0.064 µg/L.

Spatially, natural attenuation of vinyl chloride can be seen in Figures 7.4. This figure depicts decreasing vinyl chloride concentrations along an approximate flow path within Unit Cc2 from well MW-33, downgradient to weir SW-W3 on the West Hillslope where groundwater from Unit Cc2 is known to discharge at the surface. Vinyl chloride concentrations decrease by and order-of-magnitude across the illustrated flow path. For example, in 2017, average vinyl chloride concentrations start at 35 µg/L at MW-33, decrease to 3 µg/L at MW-35, and then are 0.05 µg/L at SW-W3.

Microorganisms capable of degrading chlorinated VOCs (e.g., *Dehalococcoides* spp.) are found in MW-2, MW-21, MW-33, MW-35, SW-2, and SW-3 (Anchor QEA, 2017). The reported abundances of these microbes are highest in the wells with the highest detected VOC concentrations (MW-33 and MW-35).

In February 2016, well and seep samples were collected and analyzed for dissolved methane, ethane, and ethene to represent wet-season conditions. Methane is an indicator of strongly reducing conditions; ethane and ethene are products of microbial reductive dechlorination of chlorinated ethenes and ethanes. All constituents were detected in the wells and seeps sampled, with the highest concentrations detected at wells MW-33 and MW-35, and seep SW-2. No chlorinated VOCs were detected in SW-2, and vinyl chloride was detected sporadically at only trace concentrations (approximately 0.05 µg/L) in SW-1 and SW-3, indicating essentially complete biodegradation of chlorinated VOCs upgradient of the seeps.

7.3.2.2 Natural Attenuation of Metals

The microbial decomposition of organic matter in landfills creates reducing conditions ultimately leading to methanogenic fermentation. Increased arsenic and iron concentrations commonly occur under reducing conditions, as arsenic can be released by the dissolution of naturally occurring arsenic-bearing iron oxyhydroxides in the aquifer matrix (Anchor QEA, 2017).

Arsenic and iron mobilization is associated with reducing conditions. Arsenic and iron attenuate downgradient of the VLF with the infiltration of oxygenated water. The oxygenated water oxidizes iron to iron oxides, which become effective sorbents for dissolved arsenic. Dissolved oxygen concentrations increase downgradient of wells MW-33 and MW-35 to levels similar to background (1 to 2 mg/L) and, in the seeps, even higher (7 to 11 mg/L), indicating a return to aerobic conditions. Under these conditions, iron is oxidized and typically precipitates as iron oxide coatings on the aquifer matrix grains and hillslope soils. The iron oxides strongly adsorb dissolved arsenic from groundwater, resulting in its attenuation. As a result, all but one of the seep samples have very low dissolved arsenic (<5 µg/L) and iron (<1,000 µg/L). The exception is SW-2, where attenuation in the wet season sample for arsenic (16 µg/L) and iron (approximately 9,000 µg/L) is less relative to attenuation observed during the dry season (1.6 µg/L arsenic and approximately
20 µg/L iron). This differential attenuation may be due to the wet season's higher flow rate and shorter residence time of groundwater downgradient of the landfill.

7.3.3 Landfill Gas Attenuation

LFG attenuates with distance from its source. The farther the gas must travel through the subsurface, the more likely it is that COC concentrations in the gas will be reduced. Attenuation of gas in the soil results from the same processes that control vapor transport, including diffusion, advection, sorption, and transformation reactions (EPA, 2008).

Dilution also occurs. However, the relative importance of these attenuation factors differs over a site because of temporal and spatial variability. LFG migration control at the VLF is dominated by the active LFG collection system, represented by reduction in the extent of methane, as depicted on Figure 6.12.

7.3.4 Leachate Attenuation

Leachate attenuates with distance from its source through both physical (dispersion, dilution) and biological (reductive dechlorination) processes. Leachate attenuation is also attributed to reduced leachate generation as the landfill ages.

7.4 Pathways of Exposure and Receptors

Potential exposure pathways were introduced in Section 5.3. This section evaluates the likelihood for these exposure pathways to be complete under current or potential future uses on and off the VLF property, based on the data presented in the preceding sections and the pathway-specific PCULs identified in Section 5.

Exposure pathways identified in Section 5 that are applicable to metal COCs in groundwater are limited because they are not volatile and have limited mobility. One of the metal COCs, iron, also exhibits very low toxicity to humans and therefore has very high screening levels for exposure via direct contact. The driver for iron being a COC in this RI is for the protection of aquatic ecological receptors. However, as depicted in Figure 6.3, the only exceedances of the iron PCUL have been in groundwater within the VLF property and thus aquatic ecological receptors are not adversely exposed to concentrations of iron in surface water. Arsenic is classified as a human carcinogen and thus the arsenic PCUL takes into account human health exposure. As depicted on Figure 6.1, exceedances of the arsenic PCUL for the protection of human receptors have largely been confined to groundwater within the VLF property. Figure 6.1 also summarizes detections of arsenic in surface water sample locations along the western property boundary (as surface expressions of groundwater) and demonstrates that there have been no exceedances of the arsenic PCUL. Maximum detected concentrations of arsenic were below applicable screening levels for the protection of ecological receptors.

The main COCs driving the evaluation of the exposure pathways under current and future uses presented in Table 7.1 are volatile COCs (1,2-dichloropropane, benzene, TCE and vinyl chloride). There are no screening levels developed for volatile COCs for the protection of ecological receptors.

Some of the potential pathways and receptors presented in Section 5 are not complete, based on evaluation of the data or when factoring in the VLF operational environmental control systems that are in place. An exposure pathway was considered complete if all of the following criteria apply:

1. There is a chemical release from a source.
2. There is an exposure point where contact can occur.
3. There is an exposure route for contact to occur.

On-property, there are no current residential receptors because the property is actively managed as a landfill. King County Board of Health Code, Title 10, Section 10.09.060 provides construction restrictions for any enclosed structures on or within 1,000 feet of an active, closed, or abandoned landfill. Enclosed structures must be constructed to be protective from potential methane migration. Documentation of the methane migration protection must be provided in a report authored by a licensed professional engineer. Given these development restrictions, the likelihood of potential future residential development of the VLF property for residential land-use is low, therefore current and potential future residents are not considered receptors on the VLF property. Title 12 Section 12.24.010(C)(4) prohibits installation of new public drinking water wells within 1,000 feet of a sanitary or abandoned landfill. Likewise, WAC 173-160-171 prohibits installation of a drinking water well within 1,000 feet of an existing landfill. These drinking water well restrictions eliminate the residential exposure pathway on or within 1,000 feet of the VLF.

All the exposure pathways and receptors evaluated are listed in Table 7.1, and each is assigned a status as complete/potentially complete, incomplete, or mitigated. Complete/potentially complete exposure pathways for human and ecological receptors that represent an existing or potential future risk on and off the VLF property are summarized below.

7.4.1 Groundwater

Complete and potentially complete exposure pathways for COCs in groundwater to reach human receptors include direct contact, ingestion, and discharge to surface water. To evaluate this pathway, PCULs for the protection of groundwater were used (Table 6.2).

Direct human exposure via dermal contact. Direct contact of current and potential future on-property VLF staff and construction workers is an exposure pathway mitigated by landfill safety procedures. Although currently mitigated, this represents a potential future exposure pathway that would need to be addressed in the FS. Direct human exposure is a potentially complete pathway for above- and below-ground workers and residents off-property because the extent of impacted Unit Cc2 groundwater to the south of the VLF property is unknown. Off-property exposure would need to be addressed in the FS.

Direct human exposure via ingestion. This is considered a potentially complete pathway for off-property for both current and potential future residents because the extent of impacted Unit Cc2 groundwater to the south of the VLF property is unknown. Ingestion of Unit Cc2 groundwater by current or potential future residents would need to be addressed in the FS. Existing King County Board of Health regulations prohibit the installation of drinking water wells within 1,000 feet of landfills.

Discharge to surface water. To evaluate this pathway, PCULs for the protection of surface water were used (Table 6.3). Groundwater on the VLF property exceeds these screening levels for arsenic, iron, 1,2-dichloropropane, benzene, TCE, and vinyl chloride. Complete surface water exposure pathways are further summarized below.

7.4.2 Surface Water

Complete and potentially complete exposure pathways for COCs in surface water to reach human and ecological receptors include direct contact with surface water, ingestion of surface water, and ingestion of aquatic organisms.

Direct contact with surface water. This exposure pathway is complete for current and potential future on-property ecological receptors. This exposure pathway is potentially complete for current and future off-property residents, off-property recreational users, and off-property ecological receptors. Vinyl chloride is the driver of this pathway being complete for exposure to human receptors. Iron is the driver for this pathway being complete for ecological receptors. These complete on- and off-property exposures would need to be addressed in the FS. As indicated above, a covenant restricting residential and recreational land-use of the VLF property would make these pathways incomplete for these receptors.

Ingestion of surface water. This exposure pathway is potentially complete for current and potential future on- and off-property ecological receptors. However, the RI data indicates that dissolved metals are not present at the property boundary and thus are not migrating off-property at concentrations exceeding PCULs for the protection of ecological receptors. This exposure pathway would not need to be addressed in the FS.

Ingestion of aquatic organisms. There are only off-property complete pathways for this exposure route. Off-property, this exposure pathway is complete for current residents and recreational users and potentially complete for future residents and recreational users. This exposure pathway is driven by the human ingestion of aquatic organisms containing bioaccumulative compounds originating from discharge of groundwater to surface water. These complete and potentially complete exposure pathways would need to be addressed in the FS.

7.4.3 Landfill Gas

Potential exposure pathways for LFG are inhalation, explosivity, and impact to groundwater. This exposure pathway affects landfill workers. There is no evidence of off-property LFG migration, so this exposure pathway is incomplete for off-property receptors.

Inhalation of fugitive LFG. Exposure to current and potential future on-property above- and below-ground VLF staff and construction workers is mitigated by landfill safety procedures. This exposure pathway would need to be addressed in the FS.

Landfill gas explosions. Exposure to current and potential future on-property above- and below-ground VLF staff and construction workers is mitigated by landfill safety procedures and routine monitoring that are in place for staff and worker protection. This exposure pathway would need to be addressed in the FS.

Impact to groundwater. The migration of fugitive LFG to groundwater is a complete pathway. See the groundwater discussion above.

7.4.4 Leachate

Potential exposure pathways for leachate are direct contact and discharge to groundwater. This exposure pathway affects VLF staff and construction workers. There is no evidence of off-property leachate migration, so this exposure pathway is incomplete for off-property receptors.

Direct contact to fugitive leachate. Exposure to current and potential future on-property above- and below-ground VLF staff and construction workers is mitigated by landfill safety procedures. Placement of a covenant restricting future sub-surface work would make this pathway incomplete for potential future below-ground workers. This pathway would need to be addressed in the FS.

Impact to groundwater. The migration of fugitive leachate to groundwater is a complete pathway; however, as the landfill ages, this pathway is diminishing. See the groundwater discussion above.

7.4.5 Refuse

Potential exposure pathways for soil include direct contact with shallow refuse. This exposure pathway is only relevant in areas where refuse is present at depths shallower than 15 feet, as specified by MTCA. Figure 2.4 depicts the areas where refuse extends beyond the final cover and identifies the depth to which refuse was observed. This exposure pathway affects only below-ground workers. There is no evidence of off-property refuse placement, so this exposure pathway is incomplete for off-property receptors.

Direct contact by below-ground workers. This exposure pathway is complete for current below-ground workers and potentially complete for potential future below-ground workers. As depicted in Figure 2.4, a geotextile liner and cover soil separates most of the refuse from ground surface in the South Slope Area; however, there are three locations outside the geotextile liner boundary that have refuse shallower than 15 feet bgs. Placement of a covenant restricting current and future sub-surface work would make this pathway incomplete. This pathway would need to be addressed in the FS.

7.4.5.1 Terrestrial Ecological Evaluation Exclusion

The VLF area qualifies for an exclusion from the terrestrial ecological evaluation consistent with Chapter 173-340-7491(1) WAC. The VLF area qualifies for the exclusion because refuse is either beneath a physical barrier or is at a depth of 6 feet or more.

Within the Phase 1 and Phase 2 closure areas, refuse is beneath a geomembrane, providing a physical barrier to prevent exposure of plants and wildlife. In the South Slope Area, refuse containing hazardous substances may be present near ground surface has an average soil cover thickness of 10 feet, as estimated from borings that have been completed in the unlined portions of landfill. The South Slope Area soil cover thickness is greater than 6 feet except near VTP-6S/D. The depth of biological activity in the South Slope Area is further reduced by a geotextile fabric that is placed across the South Slope Area to stabilize soils. The geotextile fabric is at an approximately depth of 3.5 to 6.5 feet and its lateral extent is illustrated on Figure 2.4. Based on the terrestrial ecological evaluation exclusion criteria, the exposure pathway of direct contact by terrestrial receptors is therefore considered incomplete.

The exclusion to the ecological evaluation based on depth to refuse is an institutional control that would need to be captured in a restrictive covenant.

8 Remedial Investigation Conclusions

8.1 Conclusions

8.1.1 Groundwater

- Groundwater contamination at the VLF is vertically limited to Unit Cc2 groundwater at the southern and western portion of the property. The horizontal extent of contamination is depicted on Figure 8.1. The extent of vinyl chloride exceedances in Unit Cc2 groundwater south of wells MW-2 and MW-21 and near the west VLF property boundary remains undefined.
- Groundwater COCs include dissolved metals (arsenic and iron) and VOCs (vinyl chloride, benzene, 1,2-dichloropropane, and TCE).
- None of the volatile COCs evaluated, including vinyl chloride, benzene, 1,2-dichloropropane, and TCE, had statistically significant increasing trends.
- Unit Cc2 groundwater flow direction is westerly and discharges as seeps on the West Hillslope on the west side of the VLF property.
- Primary source of impacts to groundwater is LFG. Residual leachate impacts have diminished overtime.
- Unit Cc2 is not a primary drinking water source. Unit D and deeper groundwater is not impacted by VLF COCs.
- Potentially active exposure pathways for impacted groundwater are fish consumption and direct contact with surface water on the VLF property.

MTCA defines “Site” or “Facility” as everywhere that contamination has come to be located. The VLF MTCA Site includes those areas delineated on Figure 8.1 where COCs exceed PCULs. More specifically, the VLF MTCA Site is bounded to the north by the edge of the Phase 2 final cover and by MW-4 and MW-36, and to the east by the estimated extent of unlined refuse and MW-20. To the south, COC concentrations at MW-21 are expected to continue to decline with the expansion of the LFG collection system to include GW-10 and GW-11. At the west property boundary, only vinyl chloride exceeds PCULs; however, downgradient of the VLF, concentrations of vinyl chloride do not exceed PCULs at a sampling location 1,600 feet west of the VLF in Robinwood Creek.

8.1.2 Surface Water

- Surface water contamination at the VLF is limited to surface water locations downgradient of Unit Cc2 groundwater discharge points along the West Hillslope of the VLF property.
- COCs exceeding surface water PCULs include dissolved metals (arsenic and iron) and VOCs (vinyl chloride, benzene, 1,2-dichloropropane).

- Only vinyl chloride exceeds PCULs at the west VLF property boundary. Attenuation of vinyl chloride is evidenced by the marked decrease in concentration across the flow path.
- Potentially active exposure pathways for impacted surface water are the same as those for groundwater.

8.1.3 Landfill Gas

- LFG is the primary source of groundwater impact.
- LFG contacts infiltrating precipitation and shallow groundwater, resulting in reducing conditions in groundwater.
- The locations where methane is present in temporary gas probes completed directly below refuse coincides with the area where COCs are present in groundwater (i.e., on the south side of the landfill). This, coupled with the results from the geochemical investigation, provide evidence supporting the LFG-to-groundwater pathway.
- Lateral control of LFG is maintained by active LFG collection infrastructure. No off-property migration of LFG has been observed since at least 1998, as exemplified by Figure 6.9 depicting compliance probes with less than 5 percent (and typically 0 percent) methane.
- LFG extraction from GW-9 provided measurable control of migration within a 100-foot zone-of-influence from the extraction well GW-9, reflected in the methane extent mapped on Figure 6.12. To provide further LFG mitigation in the South Slope Area, two additional extraction wells, GW-10 and GW-11, were installed and connected to the LFG mitigation system in September 2018. Influence testing is on-going and details of the results of the influence testing are to be discussed in a separate report.
- Vertical control of LFG migration has been pursued through interim actions conducted by KCSWD since landfill closure, including installation of vertical extraction wells GW-1 through GW-9, and the ongoing expansion of the LFG control system in the South Slope Area with installation of GW-10 and GW-11.

8.1.4 Leachate

- Leachate was evaluated only in the context of the leachate-to-groundwater pathway.
- Historically, leachate was found to be a source of impact to groundwater; however, the geochemical evaluation identified that leachate generation at the landfill has decreased significantly such that leachate is no longer a main source of impact to groundwater.
- Concentration trend plots and current groundwater monitoring results indicate that leachate is now a limited, isolated low-level source to groundwater.
- The primary area for potential leachate impact to groundwater is at SW-2.

8.2 Ongoing Interim Actions

As noted above, two new LFG extraction wells (GW-10 and GW-11) were installed and connected to the LFG mitigation system in September 2018. The locations of GW-10 and GW-11 are mapped on Figure 2.7. At the time this RI Report was produced, additional interim actions related to LFG collection were in the planning and early implementation phases. These interim actions include:

- Influence testing at GW-10 and GW-11 began September 12, 2018.
- LFG collection and extraction point monthly monitoring in the South Slope Area from September 2018 to September 2019.
- Optional LFG quality sampling from South Slope Area monitoring locations is dependent on review of influence testing and monthly monitoring. A decision on this optional task will be made at a decision gate meeting to be held mid-October, 2018.
- LFG evaluation and recommendations based on the findings of the above interim actions in the 3rd quarter 2019.

The effect of LFG extraction at GW-10 and GW-11 on groundwater concentrations in the South Slope and West Hillslope areas will be reevaluated in the 3rd quarter 2019. Reevaluating groundwater at that time will provide insight into the performance of the interim action as a remedy to improve groundwater conditions.

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10 Limitations

Work for this project was performed for King County (Client), and this report was prepared in accordance with generally accepted professional practices for the nature and conditions of work completed in the same or similar localities, at the time the work was performed. This report does not represent a legal opinion. No other warranty, expressed or implied, is made.

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Please refer to Appendix K titled "Report Limitations and Guidelines for Use" for additional information governing the use of this report.

TABLES

Table 3.1 - Well Construction Information

Project No. 090057-310.3, Vashon Island Closed Landfill, Vashon Island, King County, Washington

Well ID	Historical Boring Log ID (if different) [a]	Well Diameter (in)	Stick up (ft)	TOC Elevation (ft, NAVD88)	Well Completion Depth [b] (ft bgs)	Screened Interval [b] (ft bgs)	Filter Pack Interval [b] (ft bgs)	Screened Interval Soil Type [c]	Comments/Notes
Unit B									
MW-24	P-4	2	NA	377.53	90	80 - 90	77 - 90	Very dense, silty, fine to medium SAND (SM)	
Unit Cc1									
MW-1	NA	3	NA	407.2	128	118 - 128	115 - 130	Poorly graded, fine to medium SAND (SP)	Decommissioned in April 2015.
MW-3	NA	3	NA	318.12	40	35 - 40	32 - 40	Poorly graded fine to medium SAND (SP)	
MW-4	NA	3	NA	377.3	110	100 - 110	95 - 110	Dense, SILT with trace sand (ML)	
MW-5S	NA	2	NA	395.59	84	74 - 84	69 - 84	Dense fine to coarse SAND (SP)	Decommissioned April 2015, originally screened in proglacial sand, sand, and silt.
MW-10	MW-10A, B	2	NA	410.21	155	143 - 155	140 - 155	Poorly graded SAND with silt (SP-SM)	
MW-13	P-3	2	NA	377.37	113	108 - 113	106 - 113	Very dense, silty SAND (SM)	
MW-6S	NA	2	NA	NA	115	105 - 115	102.5 - 115	Very dense SAND, with trace gravel and silt (SP); and Very stiff, SILT (ML)	Damaged by Nisqually Earthquake. Decommissioned in August 2003 by Udaloy.
Unit Cc2									
MW-2	NA	3	NA	318.09	84	79 - 84	68 - 85	Dense SILT with clay (ML)	
MW-5D	NA	2	NA	360.8	126	115 - 126	113 - 126	Screened across dense SAND and SILT, SAND, and SILT (SM and CH)	Decommissioned in April 2015; replaced by MW-35.
MW-9	MW-9B	2	NA	405.32	179	167 - 179	164 - 180	Poorly graded GRAVEL, trace sands (SW)	
MW-20	NA	2	NA	370.43	132	127.7 -132	124.4 - 134	Dense, fine SAND (SP)	
MW-21	NA	2	NA	348.95	110	100.6 - 110	95 - 111	Dense, fine SAND (SP)	
MW-30	NA	2	1.2	239.32	9	4 - 9	3 - 9	Silty SAND with silt, trace coarse gravel (SM-SC)	
MW-32	NA	2	1.93	258.32	20	10 - 20	8 - 20	Medium to coarse SAND with silt (SM)	
MW-33	NA	4	2.25	359.24	137.7	127.3 - 137.3	124.2 - 139.3	Fine SAND with trace silt (SP)	
MW-35	NA	4	2.65	361.48	124.8	114.5 - 124.5	111.5 - 125.2	Fine SAND with trace silt (SP)	Replaced MW-5D (decommissioned).
MW-6D	NA	2	NA	NA	160.5	150.5 - 160.5	148 - 160.5	Dense, fine SAND, trace gravel and silt and gravelly SAND (SW-SP)	Damaged by Nisqually Earthquake. Decommissioned in August 2003 by Udaloy.
Unit Cc3									
MW-8	MW-8B	2	NA	386.13	180	170 - 180	167 - 180	Medium coarse sitly SAND (SM)	
MW-14	MW-4B	2	NA	379.28	173	161 - 171	155 - 173	Poorly graded SAND with silt and silty SAND (SM); and Dense SILT (ML)	Decommissioned in April 2015; replaced by MW-36.
MW-31	NA	2	2.08	209.24	10	5 - 10	4 - 10.5	Silty SAND with silt, trace coarse gravel (SM-SC)	
MW-36	NA	4	2.75	378.26	164.3	154 - 164	152 -165	Fine to medium silty SAND (SP-SM)	Replaced MW-14 (decommissioned).
MW-27	NA	4	NA	386.34	201.3	186.5 - 200.7	183.5 -237	Gravelly SAND (SP); and Silty GRAVEL (GW-GM)	Bottom of borehole extended into Unit D. Well completion included pea gravel from 203.5 - 237 ft bgs. Decommissioned in 2015.

Table 3.1 - Well Construction Information

Project No. 090057-310.3, Vashon Island Closed Landfill, Vashon Island, King County, Washington

Well ID	Historical Boring Log ID (if different) [a]	Well Diameter (in)	Stick up (ft)	TOC Elevation (ft, NAVD88)	Well Completion Depth [b] (ft bgs)	Screened Interval [b] (ft bgs)	Filter Pack Interval [b] (ft bgs)	Screened Interval Soil Type [c]	Comments/Notes
Unit D									
MW-7	MW-7C	2	NA	376.56	232	220 - 232	217 - 233	Poorly graded SAND with silt and gravel (SP-SM)	
MW-12	MW-2C	2	NA	315.67	182.5	170.5 - 181	167 - 186	Poorly graded SAND (SP)	Well completion includes pea gravel from 184 - 186 ft bgs, beneath silica sand.
MW-19	MW-9C	2	NA	405.58	271.5	260 - 271.5	260 - 273	Poorly graded SAND with silt (SP-SM)	
MW-25	NA	4	NA	402.48	263.3	248.5 - 262.6	245 - 275.4	Very dense, slightly silty gravel (GP-GM)	Well damaged during construction, and cannot be developed properly. Installed with piezometer after MW-6 was decommissioned.
MW-26	NA	4	NA	406.58	260.8	246.1 - 260.2	242.3 - 267	Sandy fine GRAVEL and clayey GRAVEL (GP & GC)	Well completion includes pea gravel from 263.7 - 267 ft bgs, beneath silica sand.
MW-29	NA	4	NA	413.79	253.2	238.4 - 252.6	235.8 - 261.5	Sandy GRAVEL (GW)	Replaced MW-11 (decommissioned). Well completion includes pea gravel from 255.6 - 261.5 ft bgs, beneath silica sand.
MW-34	NA	4	2.63	385.94	245.6	235.3 - 245.3	232 -247.5	Slightly gravelly, fine SAND (SP)	
MW-11	MW-1C	3	NA	NA	254	242 - 254	240 - 260	Silty SAND with gravel (SM)	Damaged by Nisqually earthquake. Decommissioned in July 2003. Well completion included pea gravel from 254-260 ft bgs, beneath silica sand.
MW-28	NA	4	NA	398.72	234.4	219.6 - 234	216.5 - 235.8	Silty SAND (SP-SM); silty GRAVEL (GW-GM); and SILT (ML)	Groundwater not collected from MW-28 because it is a dry well; requires 2 foot rise in groundwater levels. Installed at contact between Units D and E.

Notes:

ft = feet

ft bgs = feet below ground surface

ft btoc = feet below top of casing

in = inches

TOC = top of casing

NA = Data not available or unknown

ft, NAVD88 = feet, North America Vertical Datum of 1988

a - Boring logs in Appendix B note both the current and historical boring log identification number.

b - Screened interval, filter pack, and unit designation derived from boring logs (Appendix B). Well completion depth is bottom of casing.

c - Unified Soil Classification System (USCS) two-letter soil texture classification provided in parentheses.

Table 3.2 - Hydraulic Conductivity Estimates

Project No. 090057-310.3, Vashon Island Closed Landfill, Vashon Island, King County, Washington

Well	Slug Test Completed by/Reference	Soil Description at Screened Interval [a]	Estimated Hydraulic Conductivity (k)	
			ft/day	cm/sec
Unit B				
MW-24	Aspect[a]	Very dense, silty, fine to medium SAND (SM)	8.61	3.04E-03
Unit Cc1				
MW-13	Aspect [a]	Very dense, silty SAND (SM)	4.40	1.22E-03
MW-1	Golder Associates, 1986	Poorly graded, fine to medium SAND (SP)	0.48	1.70E-04
MW-3	Golder Associates, 1986	Poorly graded fine to medium SAND (SP)	8.79	3.10E-03
MW-4	Golder Associates, 1986	Dense, SILT with trace sand (ML)	0.43	1.50E-04
MW-5S	Golder Associates, 1986	Dense fine to coarse SAND (SP)	8.22	2.90E-03
MW-10	CH2M HILL, 1996	Poorly graded SAND with silt (SP-SM)	5.76	2.00E-03
Geometric mean for Unit Cc1			2.69	9.08E-04
Cf between Cc1 and Cc2				
MW-5 borehole	Golder Associates, 1986	Silt (ML)	0.01	1.90E-06
Unit Cc2				
MW-2	Aspect [b]	Dense SILT with clay (ML)	3.46	1.22E-03
MW-20	Aspect [b]	Dense, fine SAND (SP)	1.61	5.68E-04
MW-21	Aspect [b]	Very dense, silty fine to medium SAND (SM)	9.08	3.20E-03
MW-33	Aspect [b]	Fine SAND with trace silt (SP)	6.79	2.40E-03
MW-35	Aspect [b]	Fine SAND with trace silt (SP)	19.35	6.82E-03
MW-9	CH2M HILL, 1996	Poorly graded GRAVEL, trace sands (SW)	46.08	1.60E-02
MW-2	Golder Associates, 1986	Dense SILT with clay (ML)	0.45	1.6E-04
Geometric mean for Unit Cc2 [c]			8.21	2.89E-03
Unit Cc3				
MW-36	Aspect [b]	Dense, slightly gravelly fine SAND (SP)	19.21	6.78E-03
MW-8	CH2M HILL, 1996	Medium coarse sitly SAND (SM)	23.04	8.20E-03
MW-14	CH2M HILL, 1996	Silty SAND (SM)	3.53	1.25E-03
Geometric mean for Unit Cc3			11.6	4.1E-03
Unit D				
MW-26	Aspect [b]	Sandy fine GRAVEL and clayey GRAVEL (GP-GC)	46.09	1.63E-02
MW-34	Aspect [b]	Slightly gravelly, fine SAND (SP)	4.37	1.54E-03
MW-7	CH2M HILL, 1996	Poorly graded SAND with silt and gravel (SP-SM)	9.00	3.20E-03
MW-12	CH2M HILL, 1996	Poorly graded SAND (SP)	6.19	2.20E-03
MW-19	CH2M HILL, 1996	Poorly graded SAND with silt (SP-SM)	9.79	3.51E-03
Geometric mean for Unit D			10.19	3.62E-03

Notes:

ft/day = feet per day

cm/sec = centimeters per second

a - Unified Soil Classification System (USCS) two-letter soil texture classification provided in parentheses.

b - Refer to Appendix E for slug test analyses and figures completed by Aspect in 2015.

c - Hydraulic conductivity value obtained by Golder in 1986 from MW-2 has not been included in the calculation of the geometric mean as the value is significantly lower than the remeasurement completed by Aspect in 2015.

Table 3.3 - Groundwater Velocity Estimates

DRAFT

Project No. 090057-310.3, Vashon Island Closed Landfill, Vashon Island, King County, Washington

Groundwater Zone	Horizontal Hydraulic Conductivity			Horizontal Hydraulic Gradient	Effective Porosity	Horizontal Groundwater Velocity	General Direction of Groundwater Flow
	Range	(cm/s)	(ft/d)	(ft/ft)		(ft/d)	
Unit Cc2 Aquifer (property wide)	Low	1.6E-04	0.45	0.011	20%	0.024	West
	High	1.6E-02	46.1	0.015	20%	3.4	
	Average	1.9E-03	5.43	0.013	20%	0.35	
Unit Cc2 Aquifer (South Slope area)	Low	5.7E-04	1.61	0.011	20%	0.087	West
	High	6.8E-03	19.4	0.015	20%	1.4	
	Average	2.1E-03	5.81	0.013	20%	0.37	
Unit D Aquifer (northerly flow direction)	Low	1.5E-03	4.4	0.04	20%	0.9	North - away from ridge
	High	1.6E-02	46.1	0.04	20%	9.2	
	Average	3.6E-03	10.3	0.04	20%	2.1	
Unit D Aquifer (southerly flow direction)	Low	1.5E-03	4.4	0.02	20%	0.4	South - away from ridge
	High	1.6E-02	46.1	0.02	20%	4.6	
	Average	3.6E-03	10.2	0.02	20%	1.0	

Notes

Unit Cc2 potentiometric surface is illustrated on Figures 3.12 and 3.13.

Unit D potentiometric surface is iluustrated on Figure 3.14 and 3.15.

Horizontal hydraulic conductivity values detailed in Table 3.2. Average hydraulic conductivity values are the geometric mean of those listed in that table, by unit.

Horizontal hydraulic gradients based on gradients measured at several points from the potentiometric maps shown in Figure 3.12 through 3.15.

Effective porosity values are adapted from Potentiometric Surface Maps and Ground Water Velocity Estimates (HWA GeoSciences, 2004).

Horizontal hydraulic conductivity values used for the South Slope area are based on values from wells MW-2, MW-20, MW-21, MW-33, and MW-35.

cm/s = centimeter/second

ft/d = feet/day

ft/ft = feet/feet (unitless)

Table 4.1 - Summary of Site Explorations

DRAFT

Project No. 090057-310.3, Vashon Island Closed Landfill, Vashon Island, King County, Washington

Well(s)[a]	Installation Date	Installed By/Reference[b]	Comments
Units B and C Monitoring Wells			
MW-1 through MW-4	Sep-83	R.W. Beck and Sweet. Edwards and Associates, Inc., 1984	Installed for background monitoring and water quality monitoring. MW-1 decommissioned in April 2015.
MW-5	Mar-86	Golder Associates, 1986	Decommissioned in April 2015.
MW-8 through MW-10	Jun-95	CH2M HILL, 1996	Installed for background monitoring and water quality monitoring.
MW-13	Apr-92	Terra Associates, 1992	Installed for water quality monitoring.
MW-14	Jun-95	CH2M HILL, 1996	Decommissioned in April 2015.
MW-20 through MW-21	Oct-98	B&H and UES, 1999	Installed for background monitoring and water quality monitoring.
MW-24	Apr-92	Terra Associates, 1992	Installed for water level monitoring.
MW-30 through MW-32	Dec-09	King County, 2009	Hand auger, monuments above ground.
MW-6	Mar-86	Golder Associates,1986	Damaged by Nisqually Earthquake in 2001. Decommissioned in August 2003.
Unit D Monitoring Wells			
MW-7	Apr-95	CH2M HILL, 1996	Installed for water quality monitoring, downgradient well.
MW-12	May-95	CH2M HILL, 1996	Installed for water quality monitoring, downgradient well.
MW-19	Jun-95	CH2M HILL, 1996	Installed for water quality monitoring.
MW-25 through MW-29	Aug-03	B&H and UES, 2003a,b	Installed for water quality and level monitoring. MW-28 screened in upper contact of till aquitard, currently dry. MW-25 was damaged during construction (2003).
MW-11	May-95	CH2M HILL, 1996	Damaged by Nisqually Earthquake in 2001. Decommissioned in August 2003.
MW-33 through MW-36	Mar-15	Aspect, 2015	Installed for water quality monitoring and hydrostratigraphic data collection. MW-35 replaced MW-5D. MW-36 replaced MW-14.
Gas Probes			
GP-1 through GP-2	Apr-92	Terra Associates, 1992	
GP-5	Mar-86	Golder Associates, 1986	Installed in boring for MW-5.
GP-6	Mar-86	Golder Associates, 1986	Installed in boring for MW-6.
NP-1 through NP-5	May-95	CH2M HILL, 1996	NP-1 through NP-8 are multiple completion installations, with three probes installed in a single borehole.
NP-6 through NP-7	Jun-95	CH2M HILL, 1996	
NP-8	May-95	CH2M HILL, 1996	
P-1 (LFG), P-1A, P-1B	Mar-86	Golder Associates, 1986	Multiple completions in each borehole. Decommissioned prior to construction of landfill liner in 1989.
P-2 (LFG), P-2A	Mar-86	Golde Associatesr, 1986	Multiple completions in each borehole. Decommissioned prior to construction of landfill liner in 1989.
Temporary Gas Probes			
VTP-1D	Aug-16	Aspect, 2016	
VTP-1S	Apr-13	Herrera, 2015	Decommissioned in 2016. Replaced with VTP-1D.
VTP-2D	Apr-13	Herrera, 2015	
VTP-2S	Apr-13	Herrera, 2015	
VTP-3D	Aug-16	Aspect, 2016	
VTP-3S	Aug-16	Aspect, 2016	
VTP-4D	Aug-16	Aspect, 2016	
VTP-4S	Aug-16	Aspect, 2016	
VTP-5D	Jan-17	Aspect, 2017	
VTP-5S	Jan-17	Aspect, 2017	
VTP-6D	Jan-17	Aspect, 2017	
VTP-6S	Jan-17	Aspect, 2017	
VTP-7 through VTP-10, VTP-11S, VTP-11D	Apr-18	Aspect, in preparation (a)	

Table 4.1 - Summary of Site Explorations

Project No. 090057-310.3, Vashon Island Closed Landfill, Vashon Island, King County, Washington

Well(s)[a]	Installation Date	Installed By/Reference[b]	Comments
LFG Extraction Wells			
GW-1 through GW-8	Mar-97	CH2M HILL, 1997b	
GW-9	Aug-16	Aspect, 2016	
GW-10 and GW-11	Jun-18	Aspect, 2018	
Soil Borings/Explorations			
B-1 through B-5	Jul-17	King County, 2017	Geotechnical explorations for transfer station road.
B-6 through B-12	Apr-18	Aspect, in preparation (a)	
BH-4A	Jun-01	HWA Geosciences, 2002	Borings were backfilled at time of exploration. Conducted for Transfer Station Geotech Assessment.
BH-4B	Jun-01	HWA Geosciences, 2002	Borings were backfilled at time of exploration.
BH-5	Jun-01	HWA Geosciences, 2002	Borings were backfilled at time of exploration.
BH-6	Jun-01	HWA Geosciences, 2002	Borings were backfilled at time of exploration.
BH-7	Jun-01	HWA Geosciences, 2002	Borings were backfilled at time of exploration.
BH-8	Jun-01	HWA Geosciences, 2002	Borings were backfilled at time of exploration.
BH-9	Jun-01	HWA Geosciences, 2002	Borings were backfilled at time of exploration.
BH-10	Jun-01	HWA Geosciences, 2002	Borings were backfilled at time of exploration.
BH-11	Jun-01	HWA Geosciences, 2002	Borings were backfilled at time of exploration.
P-4 through P-9	Jul-88	Golder Associates, 1988	Geotechnical explorations (only P-8 and P-9 were completed as wells).
Refuse Extent Explorations			
TP-1 through TP-8	Mar-86	Golder Associates, 1986	Used to identify extent of refuse and to identify geologic units.
HP-1 through HP-10	Mar-86	Golder Associates, 1986	Hand augered.
TP-1 through TP-32	Oct-87	Golder Associates, 1987	Investigation for landfill closure, backfilled at time of exploration.
B-6 through B-12	Apr-18	Aspect, in preparation (a)	
Piezometer Installation			
P-4 through P-9	Mar-88	Golder Associates, 1988	Piezometer locations, installed for investigation during expansion phase.
P-3 through P-4	Jul-92	Terra Associates, 1992	Piezometer locations (gas probes).
P-1/1A/1B, P-2/2A	Aug-86	Golder Associates, 1986	Multiple completions in each borehole. Decommissioned prior to construction of landfill liner in 1989.

Notes:

B&H = Berryman & Henigar

LFG = landfill gas

UES = Udaloy Environmental Services

a - Well list does not include secondary water level locations.

b - Installation references are presumed based on the date of the well installation, if not provided. If reference is blank, then no reference information is known.

Table 4.2 - Gas Probe Construction Information

Project No. 090057-310.3, Vashon Island Closed Landfill, Vashon Island, King County, Washington

Well ID	Well Diameter (in)	Stick-up (ft)	TOC Elevation (ft, NAVD88)	Ground Surface Elevation [a] (ft, NAVD88)	Boring Depth (ft bgs)	Screened Interval (ft bgs)	Filter Pack Interval (ft bgs)	Screened Geologic Unit [b]	Notes
Gas Probes									
GP-1	2	2.48	NA	361.28	36	20 - 30	20 - 36	Upper Unit B	
GP-2	2	2.48	NA	363.68	36	25 - 30	25 - 35	Upper Unit B	
GP-5	0.75	NA	NA	359.46	151	3 - 5	3 - 84.5	NA	In MW-5 boring, decommissioned
GP-6	0.75	NA	NA	396.02	166.5	2.5 - 5	3 - 116	NA	In MW-6 boring, decommissioned
NP-1D	0.75	NA	NA	406.72	104.5	90 - 104	58 - 104.5	Unit B	Three probes in singular borehole
NP-1M	0.75	NA	NA	406.72	104.5	38 - 48	36 - 52	Lower Unit A and Upper Unit B	
NP-1S	0.75	NA	NA	406.72	104.5	12 - 22	10 - 25	Unit A	
NP-2 D	0.75	NA	NA	394.81	104.7	79.5 - 94.5	63 - 95	Lower Unit B	
NP-2 M	0.75	NA	NA	394.81	104.7	47 - 57	44 - 58	Upper Unit B	Three probes in singular borehole
NP-2 S	0.75	NA	NA	394.81	104.7	12 - 22	10 - 24	Unit A	
NP-3D	0.75	NA	NA	376.49	100	77 - 92	50 - 97	Unit B and Upper C Unit	Three probes in singular borehole
NP-3M	0.75	NA	NA	376.49	100	33 - 44	31 - 45	Unit A and Upper Unit B	
NP-3S	0.75	NA	NA	376.49	100	12 - 22	10 - 23	Unit A	
NP-4D	0.75	NA	NA	360.48	120	75 - 90	73 - 91	Lower Unit B and Upper Cc1 Unit	
NP-4M	0.75	NA	NA	360.48	120	32 - 42	30 - 43	Upper Unit B	Three probes in singular borehole
NP-4S	0.75	NA	NA	360.48	120	12 - 22	10 - 23	Unit A	
NP-5D	0.75	NA	NA	358.09	90	65 - 80	63 - 85	Unit Cc1	
NP-5M	0.75	NA	NA	358.09	90	30 - 40	28 - 42	Lower Unit B	Three probes in singular borehole
NP-5S	0.75	NA	NA	358.09	90	10 - 20	8 - 21	Lower Unit A and Upper Unit B	
NP-6D	0.75	NA	NA	384.52	115	90 - 105	88 - 108	Unit Cc1	Three probes in singular borehole
P-6M	0.75	NA	NA	384.52	115	35 - 45	33 - 46	Unit B	
NP-6S	0.75	NA	NA	384.52	115	12 - 22	10 - 23	Unit A	
NP-7D	0.75	NA	NA	376.49	110	86 - 99	84 - 104	Lower Unit B and Upper Cc1 Unit	Three probes in singular borehole
NP-7M	0.75	NA	NA	376.49	110	39 - 49	37 - 50	Upper Unit B	
NP-7S	0.75	NA	NA	376.49	110	12 - 22	10 - 24	Unit A	
NP-8D	0.75	NA	NA	403.24	125	95 - 110	93 - 112	Lower Unit B and Unit Cf	
NP-8M	0.75	NA	NA	403.24	125	49 - 59	47 - 60	Mid Unit B	Three probes in singular borehole
NP-8S	0.75	NA	NA	403.24	125	12 - 22	10 - 24	Unit A	
P-1	0.75	NA	NA	396.6	5	3 - 5	NA	NA	Decommissioned
P-1	1	NA	NA	396.6	99.5	89.5 - 90.5	NA	NA	Decommissioned
P-1	1	NA	NA	396.6	140	114 - 124	NA	Unit Cc1 and Unit Cf	Decommissioned
P-1A	1	NA	NA	394.02	128.5	114 - 124	NA	NA	Decommissioned
P-1B	1	NA	NA	396.68	106	94 - 104	NA	Lower Unit B	Decommissioned.
P-1D	NA	NA	NA	398.6	140 est	NA	NA	Unit Cc1 and Unit Cf	Decommissioned.
P-2	1.25	NA	NA	377.35	126	100 - 115	NA	Unit Cf	Decommissioned.
P-2A	2	NA	NA	377.2	94	80 - 92	NA	Unit Cc1	Decommissioned.
P-3	2	NA	377.37	377.67	115.5	108 - 113	106 - 113	Unit Cc1	Renamed MW-13
P-4	2	NA	377.93	377.53	90.5	80 - 90	77 - 90	Unit B	Renamed MW-24

Table 4.2 - Gas Probe Construction Information

Project No. 090057-310.3, Vashon Island Closed Landfill, Vashon Island, King County, Washington

Well ID	Well Diameter (in)	Stick-up (ft)	TOC Elevation (ft, NAVD88)	Ground Surface Elevation [a] (ft, NAVD88)	Boring Depth (ft bgs)	Screened Interval (ft bgs)	Filter Pack Interval (ft bgs)	Screened Geologic Unit [b]	Notes
Temporary Gas Probes									
VTP-1D	0.75	3	NA	NA	34	31 - 33.5	30 - 34	Unit B (SP)	Boring log notes overdrilling VTP-1S to 10 ft bgs and installing VTP-1D in the same location.
VTP-1S	NA	NA	NA	NA	NA	NA	NA	NA	Decommissioned.
VTP-2D	0.75	3.5	NA	NA	25	21.5 - 24	15 - 25	Refuse	
VTP-2S	0.75	3	NA	NA	7	4.5 - 7	4 - 7	Soil cover (GW/ML)	
VTP-3D	0.75	3	365.08	361.58	43.5	36 - 38.5	34 - 40	Unit B (SP)	
VTP-3S	0.75	3	365.90	362.15	40	25 - 27.5	23 - 29	Refuse	Nested with VTP-3D.
VTP-4D	0.75	3	361.86	358.08	60	51.5 - 54	50 - 56	Unit B (SP)	
VTP-4S	0.75	3	362.58	358.58	45	22.5 - 25	21 - 27	Refuse	Not nested with VTP-4D.
VTP-5D	0.75	3.4	363.09	359.69	30	24 - 26.5	22 - 28	Unit B (SP)	
VTP-5S	0.75	3.37	363.38	360.01	30	15 - 17.5	13 - 19	Refuse	Nested with VTP-5D.
VTP-6D	0.75	3.47	328.31	324.84	40	18.5 - 21	17 - 23	Unit B (SP)	Alternating layers of poorly graded sand and silty sands (SP-SM) below 25 ft bgs.
VTP-6S	0.75	3.74	328.25	324.51	20	6.5 - 9	4 - 10	Refuse	
VTP-7	2	0.58	359.2	359.78	20	9 - 14	4 - 15	Refuse	
VTP-8	2	0.43	358.89	359.32	25	15 - 20	14 - 21	Refuse	
VTP-9	2	0.43	373.22	373.65	10	7.5 - 10	7 - 10	Unit A (SM)	
VTP-10	2	0.83	375.31	376.14	10	7.5 - 10	6.75 - 10	Unit A (SM)	
VTP-11S	2	0.65	400.83	401.48	15	6 - 11	5 - 12	Unit A (SM)	
VTP-11D	2	0.67	401.48	402.15	45	31 - 41	30 - 42	Unit B (SP)	
Landfill Gas Extraction Wells									
GW-1 to -8	NA	NA	NA	NA	NA	NA	NA	NA	
GW-9	4	3	362.28	358.19	40	17 - 35	17 - 35	Refuse	
GW-10	4	3.5	361.81	359.95	35	15.5 - 28.5	14.5 - 29.5	Refuse	
GW-11	4	3.6	361.58	360.16	25	10.5 - 17	9.5 - 18	Refuse	

Notes:

ft = feet

ft, NAVD88 = feet, North America Vertical Datum of 1988.

ft bgs = feet below ground suface

ft btoc = feet below top of casing

in = inches

NA = data not available

a Ground elevation for probes listed as "Gas Probes" have been adjusted to NAVD88 by adding 3.6 feet. Original elevationswere provided on borings logs in NGVD29.

b - Unified Soil Classification System (USCS) two-letter soil texture classification provided in parentheses. Refer to the Figure B-1 Exploration Log in Appendix B for details.

Table 5.1 - Applicable Groundwater and Surface Water Criteria

Project No. 090057-310.3, Vashon Island Closed Landfill, Vashon Island, King County, Washington

			Compiled Applicable Screening Values																	
			Protection of Groundwater for Human Health (Drinking Water)							Protection of Surface Water for Human Health						Protection of Surface Water for Ecological Receptors				
			MTCA Method A	Calculated MTCA Cleanup Levels (applicable if no sufficiently protective criterion in ARARs)			ARARs			Calculated MTCA Cleanup Levels (applicable if no sufficiently protective criterion in ARARs)			Human Health via Freshwater			Ecological: Freshwater Toxicity				
CAS	Analytes	units	Table 720-1 WAC 173-340-900	MTCA Method B (non carcinogen)	MTCA Method B (carcinogen)	Modified MTCA Method B [a] (carcinogen)	Groundwater Maximum Contaminant Level	Groundwater WA Maximum Contaminant Level (WAC 246-290-310	Lowest Value, Human Health via Drinking Water	MTCA Method B (non carcinogen)	MTCA Method B (carcinogen)	Modified MTCA Method B [a] (carcinogen)	National Toxics Rule 40 CFR 131 (applicable if no Clean Water Act value established)	Clean Water Act Effective Criteria (water+ organism), Section 304 (2016) [b]	Lowest Value, Human Health via Surface Water	WA SW Regs (WAC 173-201A) (chronic)	Clean Water Act Section 304(a) (chronic)	National Toxics Rule 40 CFR 131 (chronic)	Lowest Value, Ecological, Fresh Water	Lowest Value, All Receptor Pathways
Metals																				
7429-90-5	Aluminum	µg/L	--	16000	--	--	--	--	16000	--	--	--	--	--	--	--	87	--	87	87
7440-36-0	Antimony	µg/L	--	6.4	--	--	6	6	6	1000	--	--	14	6	6	--	--	--	--	6
7440-38-2	Arsenic [c]	µg/L	5	4.8	0.058	0.58	10	10	0.58	18	0.098	0.98	0.018	0.0018	0.0018	190	150	190	150	5
7440-39-3	Barium	µg/L	--	3200	--	--	2000	2000	2000	--	--	--	--	--	--	--	--	--	--	2000
7440-41-7	Beryllium	µg/L	--	32	--	--	4	4	4	270	--	--	--	--	270	--	--	--	--	4
7440-43-9	Cadmium [d]	µg/L	5	8	--	--	5	5	5	40	--	--	--	--	40	1.87	1.32	1	1.32	1.32
7440-47-3	Chromium [d]	µg/L	100	--	--	--	100	100	100	--	--	--	--	--	--	345	143	--	143	100
7440-48-4	Cobalt	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
7440-50-8	Copper [d]	µg/L	--	640	--	--	1300	1300	1300	2900	--	--	--	1300	1300	22.6	9	11	22.6	22.6
7439-89-6	Iron	µg/L	--	11000	--	--	--	--	11000	--	--	--	--	--	--	--	1000	--	1000	1000
7439-92-1	Lead [d]	µg/L	15	--	--	--	15	15	15	--	--	--	--	--	--	6	5.98	2.5	5.98	5.98
7439-95-4	Magnesium	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
7439-96-5	Manganese	µg/L	--	2200	--	--	--	--	2200	--	--	--	--	--	--	--	--	--	--	2200
7439-97-6	Mercury	µg/L	2	--	--	--	2	2	2	--	--	--	0.14	--	0.14	0.012	0.77	0.012	0.012	0.012
7440-02-0	Nickel [d]	µg/L	--	320	--	--		100	100	1103	--	--	610	80	80	311	103	160	103	80
7440-09-7	Potassium	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
7782-49-2	Selenium	µg/L	--	80	--	--	50	50	50	2700	--	--	--	60	60	5	5	5	5	5
7440-22-4	Silver [d]	µg/L	--	80	--	--			80	26000	--	--	--	--	26000	13.81	12.88	--	12.88	12.88
7440-23-5	Sodium	µg/L	--	--	--	--			--	--	--	--	--	--	--	--	--	--	--	--
7440-28-0	Thallium	µg/L	--	0.16	--	--	2	2	0.16	0.22	--	--	1.7	1.7	1.7	--	--	--	--	0.16
7440-31-5	Tin	µg/L	--	9600	--	--			9600	--	--	--	--	--	--	--	--	--	--	9600
7440-62-2	Vanadium	µg/L	--	80	--	--	--	--	80	--	--	--	--	--	--	--	--	--	--	80
7440-66-6	Zinc [d]	µg/L	--	4800	--	--	--	--	4800	17000	--	--	--	1000	1000	207	232	100	207	207
Conventional Parameters																				
DO	Dissolved Oxygen	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
7664-41-7	Ammonia as N	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
124-38-9	Carbon Dioxide	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
COD	Chemical Oxygen Demand	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
16887-00-6	Chloride	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	230000	230000	--	230000	230000
57-12-5	Cyanide	µg/L	--	9.6	--	--	200	200	9.6	1600	--	--	700	9	9	5.2	5.2	5.2	5.2	5.2
DOC	Dissolved Organic Carbon	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
16984-48-8	Fluoride	µg/L	--	640	--	--	4000	4000	4000	--	--	--	--	--	--	--	--	--	--	4000
N+N	Nitrate + Nitrite as N	µg/L	--	--	--	--			--	--	--	--	--	--	--	--	--	--	--	--
14797-55-8	Nitrate as N	µg/L	--	26000	--	--	10000	10000	10000	--	--	--	--	--	--	--	--	--	--	10000
14797-65-0	Nitrite as N	µg/L	--	1600	--	--	1000	1000	1000	--	--	--	--	--	--	--	--	--	--	1000
7727-37-9	Nitrogen	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
7782-44-7	Oxygen	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PO4	Phosphate, Total	µg/L	--		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
7723-14-0	Phosphorus	µg/L	--	0.16	--	--	--	--	0.16	--	--	--	--	--	--	--	--	--	--	0.16
P(SOL)	Phosphorus, Soluble Reactive	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
7631-86-9	Silica	µg/L	--	--	--	--			--	--	--	--	--	--	--	--	--	--	--	--
14808-79-8	Sulfate	µg/L	--	--	--	--			--	--	--	--	--	--	--	--	--	--	--	--
18496-25-8	Sulfide	µg/L	--	--	--	--			--	--	--	--	--	--	--	--	--	--	--	--
TDS	Total Dissolved Solids	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TOC	Total Organic Carbon	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
BOD	Biological Oxygen Demand	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
7440-42-8	Boron	µg/L	--	3200	--	--	--	--	3200	--	--	--	--	--	--	--	--	--	--	3200
Polychlorinated Biphenyls																				
12674-11-2	Aroclor 1016	µg/L	--	1.1	1.3	13	--	--	1.1	0.006	0.003	0.030	--	--	0.003	--	--	0.014	0.014	0.003
11104-28-2	Aroclor 1221	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
11141-16-5	Aroclor 1232	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
53469-21-9	Aroclor 1242	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
12672-29-6	Aroclor 1248	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
11097-69-1	Aroclor 1254	µg/L	--	0.32	0.044	0.44	--	--	0.044	0.00167	0.0001	0.001	--	--	0.0001	--	--	0.014	0.014	0.0001
11096-82-5	Aroclor 1260	µg/L	--	--	0.044	0.44	--	--	0.044	--	--	--	--	--	--	--	--	0.014	0.014	0.014
T_AROCLOR	Total Aroclors	µg/L	--	--	--	--	--	--	--	--	--	--	--	7.00E-06	7.0E-06	--	--	--	--	7.0E-06

Table 5.1 - Applicable Groundwater and Surface Water Criteria

Project No. 090057-310.3, Vashon Island Closed Landfill, Vashon Island, King County, Washington

			Compiled Applicable Screening Values																	
			Protection of Groundwater for Human Health (Drinking Water)							Protection of Surface Water for Human Health						Protection of Surface Water for Ecological Receptors				
			MTCA Method A	Calculated MTCA Cleanup Levels (applicable if no sufficiently protective criterion in ARARs)			ARARs			Calculated MTCA Cleanup Levels (applicable if no sufficiently protective criterion in ARARs)			Human Health via Freshwater			Ecological: Freshwater Toxicity				
CAS	Analytes	units	Table 720-1 WAC 173-340-900	MTCA Method B (non carcinogen)	MTCA Method B (carcinogen)	Modified MTCA Method B [a] (carcinogen)	Groundwater Maximum Contaminant Level	Groundwater WA Maximum Contaminant Level (WAC 246-290-310	Lowest Value, Human Health via Drinking Water	MTCA Method B (non carcinogen)	MTCA Method B (carcinogen)	Modified MTCA Method B [a] (carcinogen)	National Toxics Rule 40 CFR 131 (applicable if no Clean Water Act value established)	Clean Water Act Effective Criteria (water+ organism), Section 304 (2016) [b]	Lowest Value, Human Health via Surface Water	WA SW Regs (WAC 173-201A) (chronic)	Clean Water Act Section 304(a) (chronic)	National Toxics Rule 40 CFR 131 (chronic)	Lowest Value, Ecological, Fresh Water	Lowest Value, All Receptor Pathways
Radionuclide Parameters																				
12587-46-1	Gross Alpha Activity	pci/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
12587-47-2	Gross Beta Activity	pci/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
R226+228	Radium 226 AND 228	pce/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
13982-63-3	Radium-226	pci/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
15262-20-1	Radium-228	pci/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
10028-17-8	Tritium	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Pesticides																				
57-74-9	Chlordane	µg/L	--	8	0.25	2.5	2	2	2	0.093	0.0013	0.013	0.00057	2.2E-05	2.2E-05	0.0043	0.0043	0.0043	0.0043	2.2E-05
93-76-5	2,4,5-T	µg/L	--	160	--				160	--	--	--	--	--	--	--	--	--	--	160
93-72-1	2,4,5-TP Silvex	µg/L	--	128	--		50	50	50	--	--	--	--	--	--	--	--	--	--	50
94-75-7	2,4-D	µg/L	--	160	--		70	70	70	--	--	--	--	--	--				--	70
72-54-8	4,4'DDD	µg/L	--	--	0.36	3.6			0.36	--	5.0E-04	0.0050	8.3E-04	7.9E-06	7.9E-06	0.001	--	--	0.001	7.9E-06
72-55-9	4,4'DDE	µg/L	--	--	0.26	2.6			0.26	--	3.5E-04	0.0035	5.9E-04	8.8E-07	8.8E-07	0.001	--	--	0.001	8.8E-07
50-29-3	4,4'DDT	µg/L	0.3	8	0.26	2.6			0.26	0.0240	3.5E-04	0.0035	5.9E-04	1.2E-06	1.2E-06	0.001	0.001	0.001	0.001	1.2E-06
309-00-2	Aldrin	µg/L	--	0.24	0.0026	0.026	--	--	0.0026	0.017	8.1E-05	0.0008	1.3E-04	4.1E-08	4.1E-08	0.0019	--	--	0.0019	4.1E-08
319-84-6	Alpha BHC	µg/L	--	130	0.014	0.14	--	--	0.014	160	0.00791	0.079	0.0039	4.8E-05	4.8E-05	--	--	--	--	4.8E-05
5103-71-9	Alpha Chlordane	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
319-85-7	Beta BHC	µg/L	--	--	0.049	0.49	--	--	0.05		0.028	0.28	0.014	0.0013	0.0013	--	--	--	--	0.0013
319-86-8	Delta BHC	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
60-57-1	Dieldrin	µg/L	--	0.8	0.005	0.05	--	--	0.005	0.028	8.6E-05	0.00086	1.4E-04	7.00E-08	7.0E-08	0.0019	0.056	0.0019	0.0019	7.0E-08
88-85-7	Dinoseb	µg/L	--	16	--	--	7	7	7	--	--	--	--	--	--	--	--	--	--	7
959-98-8	Endosulfan I	µg/L	--	--	--	--	--	--	--	--	--	--	--	6	6	--	--	--	--	6
33213-65-9	Endosulfan II	µg/L	--	--	--	--	--	--	--	--	--	--	--	9.7	9.7	--	--	--	--	9.7
1031-07-8	Endosulfan Sulfate	µg/L	--	--	--	--	--	--	--	--	--	--	--	9	9	--	--	--	--	9
72-20-8	Endrin	µg/L	--	4.8	--	--	2	2	2	0.19	--	--	0.76	0.002	0.002	0.0023	0.036	0.0023	0.0023	0.002
7421-93-4	Endrin Aldehyde	µg/L	--	--	--	--	--	--	--	--	--	--	--	0.034	0.034	--	--	--	--	0.034
5566-34-7	Gamma-Chlordane	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
76-44-8	Heptachlor	µg/L	--	8	0.019	0.19	0.4	0.4	0.19	0.118	1.3E-04	0.001	2.1E-04	3.40E-07	3.4E-07	0.0038	0.0038	0.0038	0.0038	3.4E-07
1024-57-3	Heptachlor Epoxide	µg/L	--	0.104	0.005	0.05	0.2	0.2	0.05	0.003	6.5E-05	6.5E-04	1.0E-04	2.40E-06	2.4E-06	--	0.0038	0.0038	0.0038	2.4E-06
465-73-6	Isodrin	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
58-89-9	Lindane (Gamma BHC)	µg/L	0.2	4.8	0.080	0.80	0.2	0.2	0.2	5.98	0.045	0.45	0.019	0.43	0.43	0.08	--	0.08	0.08	0.08
72-43-5	Methoxychlor	µg/L	--	80	--	--	40	40	40	8.1	--	--	--	--	8.10	--	0.03	--	0.03	0.03
8001-35-2	Toxaphene	µg/L	--	--	0.08	0.80	3	3	0.80	--	4.5E-04	0.005	7.3E-04	3.2E-05	3.2E-05	2.0E-04	2.0E-04	2.0E-04	2.0E-04	3.2E-05
Dissolved Gases																				
74-84-0	Ethane	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
74-85-1	Ethene	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
74-82-8	Methane	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Volatile Organic Compounds																				
630-20-6	1,1,1,2-Tetrachloroethane	µg/L	--	240	1.7	17			1.7	--	--	--	--	20000	20000	--	--	--	--	1.7
71-55-6	1,1,1-Trichloroethane	µg/L	200	16000	--		200	200	200	930000	--	--	--	--	930000	--	--	--	--	200
79-34-5	1,1,2,2-Tetrachloroethane	µg/L	--	160	0.22	2.2			0.22	10000	6.5	65	0.17	0.1	0.1	--	--	--	--	0.1
79-00-5	1,1,2-Trichloroethane	µg/L	--	32	0.77	7.7	5	5	5	2300	25	250	0.6	0.35	0.35	--	--	--	--	0.35
75-34-3	1,1-Dichloroethane	µg/L	--	1600	7.7	77			7.7	--	--	--	--	--	--	--	--	--	--	7.70
75-35-4	1,1-Dichloroethene	µg/L	--	400	--		7	7	7	23000	--	--	0.057	700	700	--	--	--	--	7
563-58-6	1,1-Dichloropropene	µg/L	--	--	--				--	--	--	--	--	--	--	--	--	--	--	--
96-18-4	1,2,3-Trichloropropane	µg/L	--	32	0.0015	0.015			0.0015	--	--	--	--	--	--	--	--	--	--	0.0015
96-12-8	1,2-Dibromo-3-chloropropane	µg/L	--	1.6	0.055	0.50	0.2	0.2	0.2	--	--	--	--	--	--	--	--	--	--	0.2
106-93-4	1,2-Dibromoethane (EDB)	µg/L	--	72	0.022	0.20	0.05	0.05	0.05	--	--	--	--	--	--	--	--	--	--	0.05
95-50-1	1,2-Dichlorobenzene	µg/L	--	720	--		600	600	600	4200	--	--	2700	700	700	--	--	--	--	600
107-06-2	1,2-Dichloroethane (EDC)	µg/L	5	48	0.48	4.8	5	5	4.8	13000	59	590	0.38	8.9	8.9	--	--	--	--	4.8
78-87-5	1,2-Dichloropropane	µg/L	--	720	1.2	12	5	5	5	57000	44	440	--	0.71	0.71	--	--	--	--	0.71
541-73-1	1,3-Dichlorobenzene	µg/L	--	--	--				--	--	--	--	400	2	2	--	--	--	--	2
142-28-9	1,3-Dichloropropane	µg/L	--	--	--				--	--	--	--	--	0.22	0.22	--	--	--	--	0.22
542-75-6	1,3-Dichloropropene	µg/L	--	240	0.44	4.4			0.44	41000	34	340	10	--	10	--	--	--	--	0.44
110-57-6	1,4-Dichloro-2-Butene	µg/L	--	--	--				--	--	--	--	--	--	--	--	--	--	--	--

Table 5.1 - Applicable Groundwater and Surface Water Criteria

Project No. 090057-310.3, Vashon Island Closed Landfill, Vashon Island, King County, Washington

			Compiled Applicable Screening Values																	
			Protection of Groundwater for Human Health (Drinking Water)							Protection of Surface Water for Human Health						Protection of Surface Water for Ecological Receptors				
			MTCA Method A	Calculated MTCA Cleanup Levels (applicable if no sufficiently protective criterion in ARARs)			ARARs			Calculated MTCA Cleanup Levels (applicable if no sufficiently protective criterion in ARARs)			Human Health via Freshwater			Ecological: Freshwater Toxicity				
CAS	Analytes	units	Table 720-1 WAC 173-340-900	MTCA Method B (non carcinogen)	MTCA Method B (carcinogen)	Modified MTCA Method B [a] (carcinogen)	Groundwater Maximum Contaminant Level	Groundwater WA Maximum Contaminant Level (WAC 246-290-310	Lowest Value, Human Health via Drinking Water	MTCA Method B (non carcinogen)	MTCA Method B (carcinogen)	Modified MTCA Method B [a] (carcinogen)	National Toxics Rule 40 CFR 131 (applicable if no Clean Water Act value established)	Clean Water Act Effective Criteria (water+ organism), Section 304 (2016) [b]	Lowest Value, Human Health via Surface Water	WA SW Regs (WAC 173-201A) (chronic)	Clean Water Act Section 304(a) (chronic)	National Toxics Rule 40 CFR 131 (chronic)	Lowest Value, Ecological, Fresh Water	Lowest Value, All Receptor Pathways
106-46-7	1,4-Dichlorobenzene	µg/L	--	560	8.1	81	75	75	75	3200	21	210	400	200	200	--	--	--	--	75
594-20-7	2,2-Dichloropropane	µg/L	--	--	--				--	--	--	--	--	--	--	--	--	--	--	--
78-93-3	2-Butanone	µg/L	--	4800	--				4800	--	--	--	--	--	--	--	--	--	--	4800
110-75-8	2-Chloroethyl Vinyl Ether	µg/L	--	--	--				--	--	--	--	--	--	--	--	--	--	--	--
591-78-6	2-Hexanone	µg/L	--	--	--				--	--	--	--	--	--	--	--	--	--	--	--
78-83-1	2-Methyl-1-Propanol	µg/L	--	2400	--				2400	--	--	--	--	--	--	--	--	--	--	2400
107-05-1	3-Chloropropene	µg/L	--	--	2.08	20.8			2.08	--	--	--	--	--	--	--	--	--	--	2.08
460-00-4	4-Bromofluorobenzene	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
60-11-7	4-Dimethylaminoazobenzene	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
108-10-1	4-Methyl-2-pentanone	µg/L	--	640	--	--	--	--	640	--	--	--	--	--	--	--	--	--	--	640
67-64-1	Acetone	µg/L	--	7200	--	--	--	--	7200	--	--	--	--	--	--	--	--	--	--	7200
75-05-8	Acetonitrile	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
107-02-8	Acrolein	µg/L	--	4	--	--	--	--	4	--	--	--	320	1	1	--	--	--	--	1
107-13-1	Acrylonitrile	µg/L	--	320	0.081	0.8	--	--	0.081	3500	0.40	4.0	0.059	0.019	0.019	--	--	--	--	0.019
71-43-2	Benzene	µg/L	5	32	0.80	8.0	5	5	5	2000	23	230	1.2	0.44	0.44	--	--	--	--	0.44
74-97-5	Bromochloromethane	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
75-27-4	Bromodichloromethane	µg/L	--	160	0.71	7.1	80	0.08	0.08	14000	30	300	0.27	0.73	0.73	--	--	--	--	0.08
74-96-4	Bromoethane	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
75-25-2	Bromoform	µg/L	--	160	5.5	55	80	80	55	14000	200	2000	4.3	4.6	4.6	--	--	--	--	4.6
74-83-9	Bromomethane	µg/L	--	10	--	--	--	--	10	960			48	300	300	--	--	--	--	10
75-15-0	Carbon Disulfide	µg/L	--	800	--	--	--	--	800	--	--	--	--	--	--	--	--	--	--	800
56-23-5	Carbon Tetrachloride	µg/L	--	32	0.63	6.3	5	5	5	550	4.87	48.7	0.25	0.2	0.2	--	--	--	--	0.2
108-90-7	Chlorobenzene	µg/L	--	160	--	--	100	100	100	5200	--	--	680	100	100	--	--	--	--	100
75-45-6	Chlorodifluoromethane	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
75-00-3	Chloroethane	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
593-70-4	Chlorofluoromethane	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
67-66-3	Chloroform	µg/L	--	80	1.4	14	80	80	14	6800	55	550	5.7	100	100	--	--	--	--	14
74-87-3	Chloromethane	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
126-99-8	Chloroprene	µg/L	--	160	--	--	--	--	160	--	--	--	--	--	--	--	--	--	--	160
156-59-2	cis-1,2-Dichloroethene (DCE)	µg/L	--	16	--	--	70	70	70	--	--	--	--	--	--	--	--	--	--	70
10061-01-5	cis-1,3-Dichloropropene	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
124-48-1	Dibromochloromethane	µg/L	--	160	0.52	5.2	80	80	5.2	14000	20	200	0.41	0.6	0.6	--	--	--	--	0.6
74-95-3	Dibromomethane	µg/L	--	80	--	--	--	--	80	--	--	--	48	--	48	--	--	--	--	48
75-71-8	Dichlorodifluoromethane	µg/L	--	1600	--	--	--	--	1600	--	--	--	--	--	--	--	--	--	--	1600
75-43-4	Dichloromonofluoromethane	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
97-63-2	Ethyl Methacrylate	µg/L	--	720	--	--	--	--	720	--	--	--	--	--	--	--	--	--	--	720
100-41-4	Ethylbenzene	µg/L	700	800	--	--	700	70	70	6800	--	--	3100	29	29	--	--	--	--	29
76-13-1	Freon 113	µg/L	--	240000	--	--	--	--	240000	--	--	--	--	--	--	--	--	--	--	240000
MPX	m,p-Xylene	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
126-98-7	Methacrylonitrile	µg/L	--	0.8	--	--	--	--	0.8	--	--	--	--	--	--	--	--	--	--	0.8
80-62-6	Methyl Methacrylate	µg/L	--	11000	--	--	--	--	11000	--	--	--	--	--	--	--	--	--	--	11000
75-09-2	Methylene Chloride	µg/L	5	48	22	220	5	5	5	17000	3600	36000	4.7	10	10	--	--	--	--	5
74-88-4	Methyliodide	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
124-18-5	n-Decane	µg/L	--	--	--	--	--	--	--		--	--	--	--	--	--	--	--	--	--
593-45-3	n-Octadecane	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
95-47-6	o-Xylene	µg/L	--	1600	--	--	--	--	1600	--	--	--	--	--	--	--	--	--	--	1600
74-98-6	Propane	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
107-12-0	Propionitrile	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
100-42-5	Styrene	µg/L	--	1600	--	--	100	100	100	--	--	--	--	--	--	--	--	--	--	100
2551-62-4	Sulfur Hexafluoride	µg/L	--	--	--	--			--	--	--	--	--	--	--	--	--	--	--	--
127-18-4	Tetrachloroethene (PCE)	µg/L	5	48	20	200	5	5	5	500	100	996	0.8	2.4	2.4	--	--	--	--	2.4
108-88-3	Toluene	µg/L	1000	640	--	--	1000	1000	640	19000	--	--	6800	72	72	--	--	--	--	72
1330-20-7	Total Xylenes	µg/L	1000	1600	--	--	10000	10000	10000	--	--	--	--	--	--	--	--	--	--	10000
156-60-5	trans-1,2-Dichloroethene	µg/L	--	160	--	--	100	100	100	32000	--	--	--	200	200	--	--	--	--	100
10061-02-6	trans-1,3-Dichloropropene	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
79-01-6	Trichloroethene (TCE)	µg/L	5	4	0.54	5.4	5	5	5	118	12.8	128	2.7	0.3	0.3	--	--	--	--	0.3

CAS	Analytes	units	Compiled Applicable Screening Values: Protection of Groundwater for Human Health (Drinking Water): MTCA Method A: Table 720-1 WAC 173-340-900	Calculated MTCA Cleanup Levels (applicable if no sufficiently protective criterion in ARARs): MTCA Method B (non carcinogen)	MTCA Method B (carcinogen)	Modified MTCA Method B [a] (carcinogen)	ARARs: Groundwater Maximum Contaminant Level	Groundwater WA Maximum Contaminant Level (WAC 246-290-310	Lowest Value, Human Health via Drinking Water	Protection of Surface Water for Human Health: Calculated MTCA Cleanup Levels (applicable if no sufficiently protective criterion in ARARs): MTCA Method B (non carcinogen)	MTCA Method B (carcinogen)	Modified MTCA Method B [a] (carcinogen)	Human Health via Freshwater: National Toxics Rule 40 CFR 131 (applicable if no Clean Water Act value established)	Clean Water Act Effective Criteria (water+ organism), Section 304 (2016) [b]	Lowest Value, Human Health via Surface Water	Protection of Surface Water for Ecological Receptors: Ecological: Freshwater Toxicity: WA SW Regs (WAC 173-201A) (chronic)	Clean Water Act Section 304(a) (chronic)	National Toxics Rule 40 CFR 131 (chronic)	Lowest Value, Ecological, Fresh Water	Lowest Value, All Receptor Pathways
75-69-4	Trichlorofluoromethane	µg/L	--	2400	--	--	--	--	2400	--	--	--	--	--	--	--	--	--	--	2400
108-05-4	Vinyl Acetate	µg/L	--	8000	--	--	--	--	8000	--	--	--	--	--	--	--	--	--	--	8000
75-01-4	Vinyl Chloride	µg/L	0.2	24	0.029	0.29	2	2	0.29	6500	3.7	37	2	0.02	0.02	--	--	--	--	0.02
Semi-Volatile Organic Compounds																				
95-94-3	1,2,4,5-Tetrachlorobenzene	µg/L	--	4.8	--				4.8	--	--	--	--	--	--	--	--	--	--	4.8
120-82-1	1,2,4-Trichlorobenzene	µg/L	--	80	1.51	15.1	70	70	15	200	2.0	20	--	0.036	0.036	--	--	--	--	0.036
122-66-7	1,2-Diphenylhydrazine	µg/L	--	--	0.11	1.1			0.11		0.32	3.2	0.04	0.01	0.01	--	--	--	--	0.01
99-35-4	1,3,5-Trinitrobenzene	µg/L	--	480	--				480	--	--	--	--	--	--	--	--	--	--	480
130-15-4	1,4-Naphthoquinone	µg/L	--	--	--				--	--	--	--	--	--	--	--	--	--	--	--
134-32-7	1-Naphthylamine	µg/L	--	--	--				--	--	--	--	--	--	--	--	--	--	--	--
108-60-1	2,2-Oxybis (1-Chloropropane)	µg/L	--	320	0.63	6.3			0.63	41500	37	370	--	400	400	--	--	--	--	0.63
608-27-5	2,3-Dichloroaniline	µg/L	--	--	--				--	--	--	--	--	--	--	--	--	--	--	--
95-95-4	2,4,5-Trichlorophenol	µg/L	--	800	--				800	--	--	--	--	--	--	--	--	--	--	800
88-06-2	2,4,6-Trichlorophenol	µg/L	--	8	4.0	40			4	17	3.9	39	2.1	0.25	0.25	--	--	--	--	0.25
120-83-2	2,4-Dichlorophenol	µg/L	--	24	--				24	190	--	--	93	10	10				--	10
105-67-9	2,4-Dimethylphenol	µg/L	--	160	--				160	550	--	--	--	85	85				--	85
51-28-5	2,4-Dinitrophenol	µg/L	--	32	--				32	3500	--	--	70	30	30				--	30
121-14-2	2,4-Dinitrotoluene	µg/L	--	32	0.28	2.8			0.28	1400	5.5	55	0.11	0.039	0.039	--	--	--	--	0.039
87-65-0	2,6-Dichlorophenol	µg/L	--	--	--				--	--	--	--	--	--	--	--	--	--	--	--
606-20-2	2,6-Dinitrotoluene	µg/L	--	4.8	0.058	0.6			0.058	--	--	--	--	--	--	--	--	--	--	0.058
53-96-3	2-Acetylaminofluorene	µg/L	--	--	--				--	--	--	--	--	--	--	--	--	--	--	--
91-58-7	2-Chloronaphthalene	µg/L	--	640	--				640	1000	--	--	--	100	100	--	--	--	--	100
95-57-8	2-Chlorophenol	µg/L	--	40	--				40	99.7	--	--	--	15	15	--	--	--	--	15
91-57-6	2-Methylnaphthalene	µg/L	--	32	--				32	--	--	--	--	--	--	--	--	--	--	32
95-48-7	2-Methylphenol	µg/L	--	400	--				400	--	--	--	--	--	--	--	--	--	--	400
91-59-8	2-Naphthylamine	µg/L	--		--				--	--	--	--	--	--	--	--	--	--	--	--
88-74-4	2-Nitroaniline	µg/L	--	160	--				160	--	--	--	--	--	--	--	--	--	--	160
88-75-5	2-Nitrophenol	µg/L	--	--	--				--	--	--	--	--	--	--	--	--	--	--	--
91-94-1	3,3'-Dichlorobenzidine	µg/L	--	--	0.19	1.9			0.19	--	0.046	0.46	0.04	0.0031	0.0031	--	--	--	--	0.0031
15831-10-4	3-,4-Methylphenol mixture	µg/L	--	--	--				--	--	--	--	--	--	--	--	--	--	--	--
56-49-5	3-Methylcholanthrene	µg/L	--	--	--				--	--	--	--	--	--	--	--	--	--	--	--
108-39-4	3-Methylphenol	µg/L	--	400	--				400	--	--	--	--	--	--	--	--	--	--	400
99-09-2	3-Nitroaniline	µg/L	--	--	--				--	--	--	--	--	--	--	--	--	--	--	--
534-52-1	4,6-Dinitro-2-methylphenol	µg/L	--	--	--	--	--	--	--	--	--	--	--	3	3	--	--	--	--	3
92-67-1	4-Aminobiphenyl	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
101-55-3	4-Bromophenyl phenyl ether	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
59-50-7	4-Chloro-3-methylphenol	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
7005-72-3	4-Chlorophenyl phenyl ether	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
106-44-5	4-Methylphenol	µg/L	--	800	--	--	--	--	800	--	--	--	--	--	--	--	--	--	--	800
100-01-6	4-Nitroaniline	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
100-02-7	4-Nitrophenol	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
99-55-8	5-Nitro-o-toluidine	µg/L	--	320	9.7	97.0	--	--	9.7	--	--	--	--	--	--	--	--	--	--	9.7
57-97-6	7,12-Dimethylbenz(a)anthracene	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
208-96-8	Acenaphthylene	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
83-32-9	Acenaphthene	µg/L	--	960	--	--	--	--	960	650	--	--	--	30	30	--	--	--	--	30
98-86-2	Acetophenone	µg/L	--	800	--	--	--	--	800	--	--	--	--	--	--	--	--	--	--	800
62-53-3	Aniline	µg/L	--	56	7.7	77	--	--	7.7	--	--	--	--	--	--	--	--	--	--	7.7
120-12-7	Anthracene	µg/L	--	4800	--	--	--	--	4800	26000	--	--	9600	100	100	--	--	--	--	100
92-87-5	Benzidine	µg/L	--	48	3.8E-04	0.0038	--	--	3.8E-04	88	3.2E-04	0.0032	1.2E-04	2.0E-05	2.0E-05	--	--	--	--	2.0E-05
56-55-3	Benz(a)anthracene	µg/L	--	--	0.12	1.2	--	--	0.12	--	0.30	3.0	0.0028	1.6E-04	1.6E-04	--	--	--	--	1.6E-04
50-32-8	Benzo(a)pyrene	µg/L	0.1	--	0.012	0.12	0.2	0.2	0.12	--	0.030	0.30	0.0028	1.6E-05	1.6E-05	--	--	--	--	1.6E-05
205-99-2	Benzo(b)fluoranthene	µg/L	--	--	0.120	1.2	--	--	0.12	--	0.30	3.0	0.0028	1.6E-04	1.6E-04	--	--	--	--	1.6E-04
BJK	Benzo(b,j,k)fluoranthene	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
191-24-2	Benzo(g,h,i)perylene	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
207-08-9	Benzo(k)fluoranthene	µg/L	--	--	1.20	12	--	--	1.2	--	2.96	29.6	0.0028	0.0016	0.0016	--	--	--	--	0.0016
65-85-0	Benzoic acid	µg/L	--	64000	--	--	--	--	64000	--	--	--	--	--	--	--	--	--	--	64000
100-51-6	Benzyl alcohol	µg/L	--	800	--	--	--	--	800	--	--	--	--	--	--	--	--	--	--	800
111-91-1	Bis(2-chloroethoxy)methane	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Table 5.1 - Applicable Groundwater and Surface Water Criteria

Project No. 090057-310.3, Vashon Island Closed Landfill, Vashon Island, King County, Washington

			Compiled Applicable Screening Values																	
			Protection of Groundwater for Human Health (Drinking Water)							Protection of Surface Water for Human Health						Protection of Surface Water for Ecological Receptors				
			MTCA Method A	Calculated MTCA Cleanup Levels (applicable if no sufficiently protective criterion in ARARs)			ARARs			Calculated MTCA Cleanup Levels (applicable if no sufficiently protective criterion in ARARs)			Human Health via Freshwater			Ecological: Freshwater Toxicity				
CAS	Analytes	units	Table 720-1 WAC 173-340-900	MTCA Method B (non carcinogen)	MTCA Method B (carcinogen)	Modified MTCA Method B [a] (carcinogen)	Groundwater Maximum Contaminant Level	Groundwater WA Maximum Contaminant Level (WAC 246-290-310	Lowest Value, Human Health via Drinking Water	MTCA Method B (non carcinogen)	MTCA Method B (carcinogen)	Modified MTCA Method B [a] (carcinogen)	National Toxics Rule 40 CFR 131 (applicable if no Clean Water Act value established)	Clean Water Act Effective Criteria (water+ organism), Section 304 (2016) [b]	Lowest Value, Human Health via Surface Water	WA SW Regs (WAC 173-201A) (chronic)	Clean Water Act Section 304(a) (chronic)	National Toxics Rule 40 CFR 131 (chronic)	Lowest Value, Ecological, Fresh Water	Lowest Value, All Receptor Pathways
111-44-4	Bis(2-chloroethyl) ether	µg/L	--	--	0.040	0.40	--	--	0.04		0.85	8.5	0.031	0.02	0.02	--	--	--	--	0.02
117-81-7	Bis(2-ethylhexyl) phthalate	µg/L	--	320	6.3	63	6	6	6	400	3.6	36.0	1.8	0.045	0.045	--	--	--	--	0.045
85-68-7	Butylbenzylphthalate	µg/L	--	3200	46	460			46	1300	8.32	83.2	--	0.013	0.013	--	--	--	--	0.013
86-74-8	Carbazole	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
143-50-0	Chlordecone (Kepone)	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
510-15-6	Chlorobenzilate	µg/L	--	320	0.8	8.0	--	--	0.8	--	--	--	--	--	--	--	--	--	--	0.8
58-90-2	2,3,4,6-Tetrachlorophenol	µg/L	--	480	--	--	--	--	480	--	--	--	--	--	--	--	--	--	--	480
218-01-9	Chrysene	µg/L	--	--	12	120			12	--	30	300	0.0028	0.016	0.016	--	--	--	--	0.016
17708-57-5	Cis-Diallate	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
17627-76-8	cis-Isosafrol	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1319-77-3	Cresol (mixed isomers)	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
60-51-5	Cygon	µg/L	--	3.2	--	--	--	--	3.2	--	--	--	--	--	--	--	--	--	--	3.2
2303-16-4	Di-allate	µg/L	--	--	1.4	14.0	--	--	1.4	--	--	--	--	--	--	--	--	--	--	1.4
53-70-3	Dibenzo(a,h)anthracene	µg/L	--	--	0.012	0.12	--	--	0.012	--	0.030	0.3	0.0028	1.6E-05	1.6E-05	--	--	--	--	1.6E-05
132-64-9	Dibenzofuran	µg/L	--	16	--	--	--	--	16	--	--	--	--	--	--	--	--	--	--	16
84-66-2	Diethyl phthalate	µg/L	--	13000	--	--	--	--	13000	28000	--	--	23000	200	200	--	--	--	--	200
131-11-3	Dimethyl phthalate	µg/L	--	--	--	--	--	--	--	--	--	--	313000	600	600	--	--	--	--	600
84-74-2	Di-n-butyl phthalate	µg/L	--	1600	--	--	--	--	1600	2900	--	--	2700	8	8	--	--	--	--	8
117-84-0	Di-n-octyl phthalate	µg/L	--	160	--	--	--	--	160	--	--	--	--	--	--	--	--	--	--	160
122-39-4	Diphenylamine	µg/L	--	400	--	--	--	--	400	2200	--	--	--	--	2200	--	--	--	--	400
298-04-4	Disulfoton	µg/L	--	0.64	--	--	--	--	0.64	--	--	--	--	--	--	--	--	--	--	0.64
62-50-0	Ethyl methanesulfonate	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
52-85-7	Famphur	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
206-44-0	Fluoranthene	µg/L	--	640	--	--	--	--	640	90	--	--	300	6	6	--	--	--	--	6
86-73-7	Fluorene	µg/L	--	640	--	--	--	--	640	3500	--	--	1300	10	10	--	--	--	--	10
118-74-1	Hexachlorobenzene	µg/L	--	12.8	0.055	0.55	1	1	0.55	0.238	4.7E-04	4.7E-03	7.5E-04	5.0E-06	5.0E-06	--	--	--	--	5.0E-06
87-68-3	Hexachlorobutadiene	µg/L	--	8	0.56	5.6	--	--	0.56	926	29.7	297	0.44	1.0E-02	0.01	--	--	--	--	0.01
77-47-4	Hexachlorocyclopentadiene	µg/L	--	48	--	--	50	50	50	3600	--		240	1	1	--	--	--	--	1
67-72-1	Hexachloroethane	µg/L	--	5.6	1.09	10.9	--	--	1.09	20.9	1.86	18.6	1.9	2.0E-02	0.02	--	--	--	--	0.02
1888-71-7	Hexachloropropene	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
193-39-5	Indeno(1,2,3-cd)pyrene	µg/L	--	--	0.12	1.2	--	--	0.12	--	0.296	2.96	0.0028	1.6E-04	1.6E-04	--	--	--	--	1.6E-04
78-59-1	Isophorone	µg/L	--	1600	46	460	--	--	46	118000	1600	16000	8.4	27	27	--	--	--	--	27
120-58-1	Isosafrole	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
99-65-0	m-Dinitrobenzene	µg/L	--	1.6	--	--	--	--	1.6	--	--	--	--	--	--	--	--	--	--	1.6
91-80-5	Methapyrilene	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
66-27-3	Methyl methanesulfonate	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
298-00-0	Methyl Parathion	µg/L	--	4	--	--	--	--	4	--	--	--	--	--	--	--	--	--	--	4
924-16-3	N,N-Dibutylnitrosoamine	µg/L	--	--	0.0081	0.081	--	--	0.0081	--	--	--	--	--	--	--	--	--	--	0.0081
91-20-3	Naphthalene	µg/L	160	160	--	--	--	--	160	4700	--	--	--	--	4700	--	--	--	--	160
98-95-3	Nitrobenzene	µg/L	--	16	--	--	--	--	16	1788	--	--	17	30	30	--	--	--	--	16
55-18-5	N-Nitrosodiethylamine	µg/L	--	--	2.9E-04	2.9E-03	--	--	2.9E-04	--	--	--	--	--	--	--	--	--	--	2.9E-04
62-75-9	N-Nitrosodimethylamine	µg/L	--	0.064	8.6E-04	0.0086	--	--	8.6E-04	800	4.9	49	6.9E-04	6.5E-04	6.5E-04	--	--	--	--	6.5E-04
621-64-7	N-Nitroso-di-n-propylamine	µg/L	--	--	0.013	0.13	--	--	0.013	--	0.84	8.4	--	0.0044	0.0044	--	--	--	--	0.0044
86-30-6	N-Nitrosodiphenylamine	µg/L	--	--	17.9	179	--	--	17.9	--	9.4	94	5	0.62	0.62	--	--	--	--	0.62
10595-95-6	N-Nitrosomethylethylamine	µg/L	--	--	0.004	0.04	--	--	0.004	--	--	--	--	--	--	--	--	--	--	0.004
100-75-4	N-Nitrosopiperidine	µg/L	--	--			--	--	--	--	--	--	--	--	--	--	--	--	--	--
930-55-2	N-Nitrosopyrrolidine	µg/L	--	--	0.021	0.21	--	--	0.021	--	--	--	--	--	--	--	--	--	--	0.021
126-68-1	o,o,o-Triethyl Phorphorothioate	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
297-97-2	o,o-Diethyl o-Pyrazinyl Phosphorothioate	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
119-93-7	Orthotolidine	µg/L	--	--	0.008	0.08	--	--	0.008	--	--	--	--	--	--	--	--	--	--	0.008
95-53-4	o-Toluidine	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
56-38-2	Parathion	µg/L	--	96	--	--	--	--	96	--	--	--	--	--	--	0.013	0.013	--	0.013	0.013
106-47-8	p-Chloroaniline	µg/L	--	32	0.22	2.2	--	--	0.22	--	--	--	--	--	--	--	--	--	--	0.22
608-71-9	Pentabromonophenol	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
608-93-5	Pentachlorobenzene	µg/L	--	13	--	--	--	--	13	--	--	--	--	--	--	--	--	--	--	13
82-68-8	Pentachloronitrobenzene	µg/L	--	48	0.34	3.4	--	--	0.34	--	--	--	--	--	--	--	--	--	--	0.34
87-86-5	Pentachlorophenol	µg/L	--	80	0.22	2.2	1	1	1	1200	1.5	15.0	0.28	0.002	0.002	12.79	15	13	12.79	0.002
62-44-2	Phenacetin	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Table 5.1 - Applicable Groundwater and Surface Water Criteria

Project No. 090057-310.3, Vashon Island Closed Landfill, Vashon Island, King County, Washington

			Compiled Applicable Screening Values																	
			Protection of Groundwater for Human Health (Drinking Water)							Protection of Surface Water for Human Health						Protection of Surface Water for Ecological Receptors				
			MTCA Method A	Calculated MTCA Cleanup Levels (applicable if no sufficiently protective criterion in ARARs)			ARARs			Calculated MTCA Cleanup Levels (applicable if no sufficiently protective criterion in ARARs)			Human Health via Freshwater			Ecological: Freshwater Toxicity				
CAS	Analytes	units	Table 720-1 WAC 173-340-900	MTCA Method B (non carcinogen)	MTCA Method B (carcinogen)	Modified MTCA Method B [a] (carcinogen)	Groundwater Maximum Contaminant Level	Groundwater WA Maximum Contaminant Level (WAC 246-290-310	Lowest Value, Human Health via Drinking Water	MTCA Method B (non carcinogen)	MTCA Method B (carcinogen)	Modified MTCA Method B [a] (carcinogen)	National Toxics Rule 40 CFR 131 (applicable if no Clean Water Act value established)	Clean Water Act Effective Criteria (water+ organism), Section 304 (2016) [b]	Lowest Value, Human Health via Surface Water	WA SW Regs (WAC 173-201A) (chronic)	Clean Water Act Section 304(a) (chronic)	National Toxics Rule 40 CFR 131 (chronic)	Lowest Value, Ecological, Fresh Water	Lowest Value, All Receptor Pathways
85-01-8	Phenanthrene	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
108-95-2	Phenol	µg/L	--	2400	--	--	--	--	2400	56000	--	--	21000	9000	9000	--	--	--	--	2400
FG-PHE	Phenol Hydroxylase (PHE)	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
298-02-2	Phorate	µg/L	--	3.2	--	--	--	--	3.2	--	--	--	--	--	--	--	--	--	--	3.2
106-50-3	P-Phenylenediamine	µg/L	--	3000	--	--	--	--	3000	--	--	--	--	--	--	--	--	--	--	3000
23950-58-5	Propyzamide	µg/L	--	1200	--	--	--	--	1200	--	--	--	--	--	--	--	--	--	--	1200
129-00-0	Pyrene	µg/L	--	480	--	--	--	--	480	2600	--	--	960	8	8	--	--	--	--	8
94-59-7	Safrole	µg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Notes:

CAS = Chemical Abstracts Services Registry Number

µg/L = micrograms per liter

MTCA = Model Toxics Control Act

a - Method B (carcinogen) has been modfied to a 1x10-5 cancer risk per WAC 173-340-720(7)(b) for groundwater and WAC 173-340-730(5)(b) for surface water

b - The most stringent values (organism+water) are listed of the Clean Water Act Effective Criteria, Section 304, as promulgated in 2016.

c - Arsenic is based on background for Washington state per MTCA Method A Table 720-1 WAC 173-340-900. Adjustment to background is allowable per WAC 173-340-720(7)(c).

d - Ecological criteria for WAC 1730201A and Clean Water Act are hadness dependent for metals cadmium, chromium, copper, lead, nickel, silver, and zinc. Hardness dependent metals criteria are based on an average seep hardness of 224 mg/L. Acute and chronic criteria were calculated and the lower of the two values has been provided in the table.

Gray shaded values are not applicable under MTCA (WAC 173-340-730-3Ciii), given that other "sufficiently protective" federal standards are available.

Table 6.1 - Frequency of Cleanup Level Exceedances - VLF Groundwater

Project No. 090057-310.3, Vashon Island Closed Landfill, Vashon Island, King County, Washington

Analyte	Number of Sampled Locations[1]	Number of Samples (excluding Field Dups)	First Sample Date	Most Recent Available Sample Date	Number of Samples with Detected Concentration	Frequency of Detection	Last Sample Date with Detected Concentration	Maxumim Detected Concentration	Minimum Detected Concentration	Average Detected Concentration	Min RDL	Max RDL	Units	Preliminary Cleanup Level (PCUL)	Date of Last PCUL Exceedance	Number of Detected Exceedances of PCUL	Number of NonDetects with Reporting Limit Above PCUL	Frequency of Detected Exceedances	Number of Samples Since Last Exceedance
Bacteria																			
Fecal Coliform	15	187	10/30/2001	11/2/2004	12	6%	5/4/2004	2	0	0.2	1	1	cfu/100mL					0%	
Total Coliform	15	187	10/30/2001	11/2/2004	68	36%	11/2/2004	56	0	2.2	1	1	cfu/100mL					0%	
Conventionals																			
Alkalinity, Total	25	1011	10/30/2001	12/5/2017	1011	100%	12/5/2017	496	18.9	108			mg/L					0%	
Ammonia as N	25	1011	10/30/2001	12/5/2017	384	38%	12/5/2017	0.46	0.0021	0.102	0.002	0.05	mg/L					0%	
Chemical Oxygen Demand	17	190	10/30/2001	11/2/2004	4	2%	11/2/2004	8	5.4	6.7	5	5	mg/L					0%	
Chloride	25	1010	10/30/2001	12/5/2017	1009	100%	12/5/2017	37.6	1.1	3.96	1	1	mg/L	230				0%	
Cyanide	18	198	10/30/2001	11/9/2012		0%					0.02	0.02		0.0052	11/9/2012	0	198	0%	
Dissolved Organic Carbon	5	10	9/15/2015	2/25/2016	6	60%	2/25/2016	6.17	1.27	3.22	1	1	mg/L					0%	
Fluoride	17	189	10/30/2001	11/2/2004		0%					1	1		4				0%	
Nitrate + Nitrite as N	17	234	10/30/2001	8/4/2005	118	50%	8/4/2005	8.1	0.01	1.1	0.01	0.05	mg/L					0%	
Nitrate as N	25	1011	10/30/2001	12/5/2017	622	62%	12/5/2017	10.3	0.01	1.06	0.01	0.05	mg/L	10	3/25/2015	1	0	0.1%	189
Nitrite as N	19	244	10/30/2001	2/25/2016	12	5%	2/24/2016	0.03	0.01	0.015	0.01	0.01	mg/L	1				0%	
pH	18	508	10/30/2001	11/17/2009	508	100%	11/17/2009	8.1	4.1	7.21			pH units					0%	
Silica	5	10	9/15/2015	2/25/2016	10	100%	2/25/2016	52.1	30.2	37.7			mg/L					0%	
Specific Conductance	24	548	5/1/2009	12/5/2017	548	100%	12/5/2017	880	96.9	248			uS/cm					0%	
Sulfate	25	1009	10/30/2001	12/5/2017	1009	100%	12/5/2017	28.5	2.6	12.9			mg/L					0%	
Sulfide	7	18	11/14/2007	2/25/2016	4	22%	2/24/2016	0.029	0.011	0.019	0.01	0.01	mg/L					0%	
Total Dissolved Solids	25	1009	10/31/2001	12/5/2017	1009	100%	12/5/2017	539	34	155			mg/L					0%	
Total Organic Carbon	25	1011	10/30/2001	12/5/2017	248	25%	12/5/2017	18.4	0.51	2.16	0.5	1	mg/L					0%	
Total Organic Halides (TOX)	17	189	10/30/2001	11/2/2004	4	2%	10/28/2002	0.06	0.05	0.06	0.05	0.05	mg/L					0%	
Total Solids	25	1011	10/30/2001	12/5/2017	1009	100%	12/5/2017	785	35	165	3	3	mg/L					0%	
Total Suspended Solids	24	1008	10/30/2001	12/5/2017	501	50%	12/5/2017	637	0.5	12.7	0.5	2	mg/L					0%	
Field Parameters																			
Dissolved Oxygen	19	186	3/31/2015	12/5/2017	186	100%	12/5/2017	10.68	0.14	3.759			mg/L					0%	
Oxidation-Reduction Potential	19	186	3/31/2015	12/5/2017	186	100%	12/5/2017	461	-153	161			mV					0%	
pH	25	1003	10/30/2001	12/5/2017	1003	100%	12/5/2017	9.2	5.55	7.31			pH units					0%	
Specific Conductance	25	1000	10/30/2001	12/5/2017	1000	100%	12/5/2017	921.6	88	224.6			uS/cm					0%	
Temperature	25	1004	10/30/2001	12/5/2017	1004	100%	12/5/2017	17.8	8.5	10.549			deg C					0%	
Turbidity	19	164	3/31/2015	12/5/2017	164	100%	12/5/2017	104.3	-1.77	4.538			NTU					0%	
Metals (dissolved)																			
Aluminum	18	191	10/30/2001	11/14/2007	56	29%	11/2/2004	180	21	44	0.02	0.02	ug/L	87	10/30/2002	4	0	2%	136
Antimony	25	1011	10/30/2001	12/5/2017	1	0%	2/25/2010	1.34	1.34	1.34	3.0E-04	0.01	ug/L	6	7/28/2005	0	3	0%	
Arsenic	25	1011	10/30/2001	12/5/2017	838	83%	12/5/2017	140	0.33	9.65	5.0E-05	0.001	ug/L	5	11/14/2017	170	0	17%	10
Barium	25	1011	10/30/2001	12/5/2017	1011	100%	12/5/2017	64.3	1.2	9.15			ug/L	2000				0%	
Beryllium	25	1011	10/30/2001	12/5/2017		0%					1.0E-04	0.001		4				0%	
Cadmium	25	1011	10/30/2001	12/5/2017	11	1%	8/7/2017	3	0.0697	2.23	5.0E-05	0.002	ug/L	1.32	2/16/2017	10	949	1%	52
Calcium	25	1010	10/30/2001	12/5/2017	1010	100%	12/5/2017	77400	4300	17100			ug/L					0%	
Chromium	25	1011	10/30/2001	12/5/2017	31	3%	12/5/2017	5.9	0.21	2.83	2.0E-04	0.005	ug/L	100				0%	
Cobalt	25	1011	10/30/2001	12/5/2017	16	2%	11/17/2017	1.77	0.0516	0.679	5.0E-05	0.003	ug/L					0%	
Copper	25	1011	10/30/2001	12/5/2017	26	3%	11/17/2017	29	0.201	4.38	2.0E-04	0.002	ug/L	22.6	4/30/2007	1	0	0.1%	675
Iron	25	1010	10/30/2001	12/5/2017	688	68%	11/17/2017	26000	5.9	1670	0.005	0.01	ug/L	1000	11/14/2017	108	0	11%	10
Lead	25	1011	10/30/2001	12/5/2017	3	0%	2/7/2008	2	1.1	1.4	1.0E-04	0.001	ug/L	5.98				0%	
Magnesium	25	1010	10/30/2001	12/5/2017	1010	100%	12/5/2017	65100	1800	14200			ug/L					0%	
Manganese	25	1008	10/30/2001	12/5/2017	662	66%	12/5/2017	2560	0.129	307	1.0E-04	0.001	ug/L	2200	11/14/2017	7	0	1%	11
Mercury	25	996	10/30/2001	12/5/2017	7	1%	5/6/2005	0.3	0.1	0.1	5.0E-05	1.4E-04	ug/L	0.012	12/5/2017	7	989	1%	783
Nickel	25	1011	10/30/2001	12/5/2017	59	6%	12/5/2017	17	0.108	3.82	1.0E-04	0.01	ug/L	80				0%	
Potassium	25	1011	10/30/2001	12/5/2017	1011	100%	12/5/2017	3870	590	2080			ug/L					0%	
Selenium	25	1011	10/30/2001	12/5/2017	32	3%	2/12/2008	12	1	2.1	5.0E-04	0.01	ug/L	5	2/12/2008	2	37	0.2%	613
Silver	25	1011	10/30/2001	12/5/2017	1	0%	4/23/2003	11	11	11	4.0E-05	0.003	ug/L	12.88				0%	
Sodium	25	1011	10/30/2001	12/5/2017	1011	100%	12/5/2017	21400	2200	7250			ug/L					0%	
Thallium	25	1011	10/30/2001	12/5/2017		0%					1.0E-04	0.002		0.16	2/16/2017	0	959	0%	
Tin	18	198	10/30/2001	11/9/2012		0%					0.01	0.01		9600				0%	
Vanadium	25	1011	10/30/2001	12/5/2017	489	48%	12/5/2017	11	0.0913	3.82	7.5E-05	0.002	ug/L	80				0%	
Zinc	25	1011	10/30/2001	12/5/2017	152	15%	11/17/2017	1700	0.51	22.5	5.0E-04	0.004	ug/L	207	8/20/2010	2	0	0.2%	452
Metals (total)																			
Antimony	20	299	5/6/2013	12/5/2017		0%					3.0E-04	0.001		6				0%	
Arsenic	20	299	5/6/2013	12/5/2017	249	83%	12/5/2017	91.9	0.123	7.87	0.001	0.001	ug/L	5	11/14/2017	58	0	19%	10
Barium	20	299	5/6/2013	12/5/2017	299	100%	12/5/2017	63.6	3.08	10.8			ug/L	2000				0%	
Beryllium	20	299	5/6/2013	12/5/2017		0%					1.0E-04	0.001		4				0%	
Cadmium	20	299	5/6/2013	12/5/2017	3	1%	9/6/2017	0.092	0.0582	0.0744	5.0E-05	0.002	ug/L	1.32	2/16/2017	0	247	0%	
Calcium	20	299	5/6/2013	12/5/2017	299	100%	12/5/2017	78700	7970	18600			ug/L					0%	
Chromium	20	299	5/6/2013	12/5/2017	41	14%	12/5/2017	12	0.204	2.63	2.0E-04	0.005	ug/L	100				0%	
Cobalt	20	299	5/6/2013	12/5/2017	24	8%	12/5/2017	3.79	0.0537	0.812	5.0E-05	0.003	ug/L					0%	
Copper	20	299	5/6/2013	12/5/2017	31	10%	12/5/2017	20.2	0.2	2.58	2.0E-04	0.002	ug/L	22.6				0%	
Iron	20	299	5/6/2013	12/5/2017	257	86%	12/5/2017	15400	10	1590	0.01	0.01	ug/L	1000	11/17/2017	62	0	21%	3
Lead	20	299	5/6/2013	12/5/2017	10	3%	12/5/2017	5.13	0.122	1.43	1.0E-04	0.001	ug/L	5.98				0%	
Magnesium	20	299	5/6/2013	12/5/2017	299	100%	12/5/2017	59600	2420	15200			ug/L					0%	
Manganese	20	299	5/6/2013	12/5/2017	239	80%	12/5/2017	2920	0.188	343	1.0E-04	0.001	ug/L	2200	11/14/2017	9	0	3%	11
Mercury	20	306	11/9/2011	12/5/2017		0%					5.0E-05	1.0E-04		0.012	12/5/2017	0	306	0%	
Nickel	20	299	5/6/2013	12/5/2017	53	18%	12/5/2017	17.9	0.102	2.57	1.0E-04	0.01	ug/L	80				0%	
Potassium	20	299	5/6/2013	12/5/2017	299	100%	12/5/2017	3890	975	2220			ug/L					0%	
Selenium	20	299	5/6/2013	12/5/2017		0%					5.0E-04	0.001		5				0%	
Silver	20	299	5/6/2013	12/5/2017	6	2%	11/17/2017	0.0982	0.0412	0.0568	4.0E-05	0.003	ug/L	12.88				0%	
Sodium	20	299	5/6/2013	12/5/2017	299	100%	12/5/2017	20800	4320	7710			ug/L					0%	

Analyte	Number of Sampled Locations[1]	Number of Samples (excluding Field Dups)	First Sample Date	Most Recent Available Sample Date	Number of Samples with Detected Concentration	Frequency of Detection	Last Sample Date with Detected Concentration	Maxumim Detected Concentration	Minimum Detected Concentration	Average Detected Concentration	Min RDL	Max RDL	Units	Preliminary Cleanup Level (PCUL)	Date of Last PCUL Exceedance	Number of Detected Exceedances of PCUL	Number of NonDetects with Reporting Limit Above PCUL	Frequency of Detected Exceedances	Number of Samples Since Last Exceedance
Thallium	20	299	5/6/2013	12/5/2017		0%					1.0E-04	0.001		0.16	2/16/2017	0	247	0%	
Vanadium	20	299	5/6/2013	12/5/2017	166	56%	12/5/2017	14.2	0.0768	3.64	0.000075	0.002	ug/L	80				0%	
Zinc	20	299	5/6/2013	12/5/2017	65	22%	12/5/2017	803	0.506	24.8	5.0E-04	0.004	ug/L	207	11/23/2015	2	0	1%	141
PCBs																			
Aroclor 1016	16	195	10/30/2001	11/9/2012		0%					0.009	0.011		0.003	11/9/2012	0	195	0%	
Aroclor 1221	16	195	10/30/2001	11/9/2012		0%					0.009	0.011						0%	
Aroclor 1232	16	195	10/30/2001	11/9/2012		0%					0.009	0.011						0%	
Aroclor 1242	16	195	10/30/2001	11/9/2012		0%					0.009	0.011						0%	
Aroclor 1248	16	195	10/30/2001	11/9/2012		0%					0.009	0.011						0%	
Aroclor 1254	16	195	10/30/2001	11/9/2012		0%					0.009	0.011		0.0001	11/9/2012	0	195	0%	
Aroclor 1260	16	195	10/30/2001	11/9/2012		0%					0.009	0.011		0.014				0%	
Total Aroclors	16	195	10/30/2001	11/9/2012		0%					0.009	0.025		0.000007	11/9/2012	0	195	0%	
Pesticide																			
2,4,5-T	16	195	10/30/2001	11/9/2012		0%					2	2		160				0%	
2,4,5-TP Silvex	16	195	10/30/2001	11/9/2012		0%					1	1		50				0%	
2,4-D	16	195	10/30/2001	11/9/2012		0%					5	5		70				0%	
4,4'DDD	16	195	10/30/2001	11/9/2012		0%					0.093	0.11		0.0000079	11/9/2012	0	195	0%	
4,4'DDE	16	195	10/30/2001	11/9/2012		0%					0.093	0.11		0.00000088	11/9/2012	0	195	0%	
4,4'DDT	16	195	10/30/2001	11/9/2012		0%					0.093	0.11		0.0000012	11/9/2012	0	195	0%	
Aldrin	16	195	10/30/2001	11/9/2012		0%					0.023	0.027		0.000000041	11/9/2012	0	195	0%	
Alpha BHC	16	195	10/30/2001	11/9/2012		0%					0.023	0.027		0.000048	11/9/2012	0	195	0%	
Alpha Chlordane	16	195	10/30/2001	11/9/2012		0%					0.023	0.027						0%	
Beta BHC	16	195	10/30/2001	11/9/2012		0%					0.023	0.027		0.0013	11/9/2012	0	195	0%	
Delta BHC	16	195	10/30/2001	11/9/2012		0%					0.093	0.11						0%	
Dieldrin	16	195	10/30/2001	11/9/2012		0%					0.093	0.11		0.00000007	11/9/2012	0	195	0%	
Dinoseb	16	195	10/30/2001	11/9/2012		0%					1	1		7				0%	
Endosulfan I	16	195	10/30/2001	11/9/2012		0%					0.093	0.11		6				0%	
Endosulfan II	16	195	10/30/2001	11/9/2012		0%					0.093	0.11		9.7				0%	
Endosulfan Sulfate	16	195	10/30/2001	11/9/2012		0%					0.47	0.53		9				0%	
Endrin	16	195	10/30/2001	11/9/2012		0%					0.093	0.11		0.002	11/9/2012	0	195	0%	
Endrin Aldehyde	16	195	10/30/2001	11/9/2012		0%					0.19	0.21		0.034	11/9/2012	0	195	0%	
Heptachlor	16	195	10/30/2001	11/9/2012		0%					0.023	0.027		0.00000034	11/9/2012	0	195	0%	
Heptachlor Epoxide	16	195	10/30/2001	11/9/2012		0%					0.023	0.027		0.0000024	11/9/2012	0	195	0%	
Isodrin	16	195	10/30/2001	11/9/2012		0%					9.3	11						0%	
Lindane (Gamma BHC)	16	195	10/30/2001	11/9/2012		0%					0.023	0.027		0.08				0%	
Methoxychlor	16	195	10/30/2001	11/9/2012		0%					1.9	2.1		0.03	11/9/2012	0	195	0%	
Toxaphene	16	195	10/30/2001	11/9/2012		0%					2.3	2.7		0.000032	11/9/2012	0	195	0%	
SVOCs																			
1,2,4,5-Tetrachlorobenzene	5	16	5/2/2003	11/9/2012		0%					4.8	10		4.8	11/9/2012	0	16	0%	
1,2,4-Trichlorobenzene	5	16	5/2/2003	11/9/2012		0%					3.3	10		0.036	11/9/2012	0	16	0%	
1,2-Diphenylhydrazine	1	1	11/14/2007	11/14/2007		0%					9.6	9.6		0.01	11/14/2007	0	1	0%	
1,3,5-Trinitrobenzene	5	16	5/2/2003	11/9/2012		0%					4.8	10		480				0%	
1,4-Naphthoquinone	5	16	5/2/2003	11/9/2012		0%					4.8	10						0%	
1-Naphthylamine	5	16	5/2/2003	11/9/2012		0%					4.8	10						0%	
2,2-Oxybis (1-Chloropropane)	5	16	5/2/2003	11/9/2012		0%					3.6	10		0.63	11/9/2012	0	16	0%	
2,3,4,6-Tetrachlorophenol	5	16	5/2/2003	11/9/2012		0%					4.8	10		480				0%	
2,4,5-Trichlorophenol	5	16	5/2/2003	11/9/2012		0%					2.6	10		800				0%	
2,4,6-Trichlorophenol	5	16	5/2/2003	11/9/2012		0%					2.1	10		0.25	11/9/2012	0	16	0%	
2,4-Dichlorophenol	5	16	5/2/2003	11/9/2012		0%					3.5	10		10	11/9/2012	0	7	0%	
2,4-Dimethylphenol	5	16	5/2/2003	11/9/2012		0%					9.6	11		85				0%	
2,4-Dinitrophenol	5	16	5/2/2003	11/9/2012		0%					7.1	50		30	11/9/2012	0	8	0%	
2,4-Dinitrotoluene	5	16	5/2/2003	11/9/2012		0%					0.86	10		0.039	11/9/2012	0	16	0%	
2,6-Dichlorophenol	5	16	5/2/2003	11/9/2012		0%					4.8	10						0%	
2,6-Dinitrotoluene	5	16	5/2/2003	11/9/2012		0%					1.8	10		0.058	11/9/2012	0	16	0%	
2-Acetylaminofluorene	5	16	5/2/2003	11/9/2012		0%					4.8	20						0%	
2-Chloronaphthalene	5	16	5/2/2003	11/9/2012		0%					2.2	10		100				0%	
2-Chlorophenol	5	16	5/2/2003	11/9/2012		0%					3.9	10		15				0%	
2-Methylnaphthalene	5	13	5/2/2003	11/10/2011		0%					3	10		32				0%	
2-Methylphenol	5	16	5/2/2003	11/9/2012		0%					6.2	10		400				0%	
2-Naphthylamine	5	16	5/2/2003	11/9/2012		0%					4.8	10						0%	
2-Nitroaniline	5	16	5/2/2003	11/9/2012		0%					3.4	50		160				0%	
2-Nitrophenol	5	16	5/2/2003	11/9/2012		0%					3.8	10						0%	
3,3'-Dichlorobenzidine	5	16	5/2/2003	11/9/2012		0%					6.7	20		0.0031	11/9/2012	0	16	0%	
3-,4-Methylphenol mixture	4	7	11/9/2011	11/9/2012		0%					10	10						0%	
3-Methylcholanthrene	5	16	5/2/2003	11/9/2012		0%					4.8	10						0%	
3-Nitroaniline	5	16	5/2/2003	11/9/2012		0%					1.7	50						0%	
4-(Dimethylamino)azobenzene	5	16	5/2/2003	11/9/2012		0%					4.8	10						0%	
4,6-Dinitro-2-methylphenol	5	16	5/2/2003	11/9/2012		0%					1.6	50		3	11/9/2012	0	8	0%	
4-Aminobiphenyl	5	16	5/2/2003	11/9/2012		0%					4.8	20						0%	
4-Bromophenyl phenyl ether	5	16	5/2/2003	11/9/2012		0%					2.1	10						0%	
4-Chloro-3-methylphenol	5	16	5/2/2003	11/9/2012		0%					2.7	20						0%	
4-Chlorophenyl phenyl ether	5	16	5/2/2003	11/9/2012		0%					2.3	10						0%	
4-Nitroaniline	5	16	5/2/2003	11/9/2012		0%					4.8	20						0%	
4-Nitrophenol	5	16	5/2/2003	11/9/2012		0%					3.8	50						0%	
5-Nitro-o-toluidine	5	16	5/2/2003	11/9/2012		0%					4.8	10		9.7	11/9/2012	0	7	0%	
7,12-Dimethylbenz(a)anthracene	5	16	5/2/2003	11/9/2012		0%					4.8	10						0%	

Table 6.1 - Frequency of Cleanup Level Exceedances - VLF Groundwater

Project No. 090057-310.3, Vashon Island Closed Landfill, Vashon Island, King County, Washington

Analyte	Number of Sampled Locations[1]	Number of Samples (excluding Field Dups)	First Sample Date	Most Recent Available Sample Date	Number of Samples with Detected Concentration	Frequency of Detection	Last Sample Date with Detected Concentration	Maxumim Detected Concentration	Minimum Detected Concentration	Average Detected Concentration	Min RDL	Max RDL	Units	Preliminary Cleanup Level (PCUL)	Date of Last PCUL Exceedance	Number of Detected Exceedances of PCUL	Number of NonDetects with Reporting Limit Above PCUL	Frequency of Detected Exceedances	Number of Samples Since Last Exceedance
Acenaphthene	5	16	5/2/2003	11/9/2012		0%					1.9	2.6		30				0%	
Acenaphthylene	5	16	5/2/2003	11/9/2012		0%					1.4	2.7						0%	
Acetophenone	5	16	5/2/2003	11/9/2012		0%					4.8	10		800				0%	
Aniline	1	1	11/14/2007	11/14/2007		0%					13	13		7.7	11/14/2007	0	1	0%	
Anthracene	5	16	5/2/2003	11/9/2012		0%					0.096	2.2		100				0%	
Benz(a)anthracene	5	16	5/2/2003	11/9/2012		0%					0.19	2.2		0.00016	11/9/2012	0	16	0%	
Benzo(a)pyrene	5	16	5/2/2003	11/9/2012		0%					0.096	2.7		0.000016	11/9/2012	0	16	0%	
Benzo(b)fluoranthene	5	9	5/2/2003	11/14/2007		0%					0.096	2.3		0.00016	11/14/2007	0	9	0%	
Benzo(b,j,k)fluoranthene	4	7	11/9/2011	11/9/2012		0%					1.5	1.5						0%	
Benzo(g,h,i)perylene	5	16	5/2/2003	11/9/2012		0%					0.096	3.5						0%	
Benzo(k)fluoranthene	5	9	5/2/2003	11/14/2007		0%					0.096	4.5		0.0016	11/14/2007	0	9	0%	
Benzyl alcohol	5	16	5/2/2003	11/9/2012		0%					3.6	20		800				0%	
Benzyl butyl phthalate	5	16	5/2/2003	11/9/2012		0%					3	5		0.013	11/9/2012	0	16	0%	
Bis(2-chloroethoxy)methane	5	16	5/2/2003	11/9/2012		0%					3.8	10						0%	
Bis(2-chloroethyl) ether	5	16	5/2/2003	11/9/2012		0%					3.6	10		0.02	11/9/2012	0	16	0%	
Bis(2-ethylhexyl) phthalate	5	16	5/2/2003	11/9/2012		0%					5.2	10		0.045	11/9/2012	0	16	0%	
Chlordecone (KEPONE)	5	16	5/2/2003	11/9/2012		0%					4.8	40						0%	
Chlorobenzilate	5	16	5/2/2003	11/9/2012		0%					4.8	20		0.8	11/9/2012	0	16	0%	
Chrysene	5	16	5/2/2003	11/9/2012		0%					0.19	1.7		0.016	11/9/2012	0	16	0%	
Cis-Diallate	4	7	11/9/2011	11/9/2012		0%					10	10						0%	
Cygon	5	16	5/2/2003	11/9/2012		0%					4.8	20		3.2	11/9/2012	0	16	0%	
Di-allate	5	16	5/2/2003	11/9/2012		0%					4.8	10		1.4	11/9/2012	0	16	0%	
Dibenzo(a,h)anthracene	5	16	5/2/2003	11/9/2012		0%					0.096	3.7		0.000016	11/9/2012	0	16	0%	
Dibenzofuran	5	16	5/2/2003	11/9/2012		0%					1.6	10		16				0%	
Diethyl phthalate	5	16	5/2/2003	11/9/2012		0%					2.2	5		200				0%	
Dimethyl phthalate	5	16	5/2/2003	11/9/2012		0%					1.8	5		600				0%	
Di-n-butyl phthalate	5	16	5/2/2003	11/9/2012		0%					1.6	5		8				0%	
Di-n-octyl phthalate	5	16	5/2/2003	11/9/2012		0%					5.2	10		160				0%	
Diphenylamine	5	16	5/2/2003	11/9/2012		0%					4.8	10		400				0%	
Disulfoton	5	16	5/2/2003	11/9/2012		0%					2	4.9		0.64	11/9/2012	0	16	0%	
Ethyl methanesulfonate	5	16	5/2/2003	11/9/2012		0%					4.8	10						0%	
Famphur	5	16	5/2/2003	11/9/2012		0%					9.5	20						0%	
Fluoranthene	5	16	5/2/2003	11/9/2012		0%					0.29	1.4		6				0%	
Fluorene	5	16	5/2/2003	11/9/2012		0%					1.8	2		10				0%	
Hexachlorobenzene	5	16	5/2/2003	11/9/2012		0%					2.7	5		0.000005	11/9/2012	0	16	0%	
Hexachlorobutadiene	5	16	5/2/2003	11/9/2012		0%					3.6	5		0.01	11/9/2012	0	16	0%	
Hexachlorocyclopentadiene	5	16	5/2/2003	11/9/2012		0%					4.8	7.4		1	11/9/2012	0	16	0%	
Hexachloroethane	5	16	5/2/2003	11/9/2012		0%					3.9	5		0.02	11/9/2012	0	16	0%	
Hexachloropropene	5	16	5/2/2003	11/9/2012		0%					4.8	10						0%	
Indeno(1,2,3-cd)pyrene	5	16	5/2/2003	11/9/2012		0%					0.096	3.1		0.00016	11/9/2012	0	16	0%	
Isophorone	5	16	5/2/2003	11/9/2012		0%					3.5	10		27				0%	
Isosafrole	5	16	5/2/2003	11/9/2012		0%					4.8	10						0%	
m-Dinitrobenzene	5	16	5/2/2003	11/9/2012		0%					4.8	20		1.6	11/9/2012	0	16	0%	
Methapyrilene	5	16	5/2/2003	11/9/2012		0%					4.8	100						0%	
Methyl methanesulfonate	5	16	5/2/2003	11/9/2012		0%					4.8	10						0%	
Methyl Parathion	5	16	5/2/2003	11/9/2012		0%					0.5	4.9		4	11/14/2007	0	9	0%	
N,N-Dibutylnitrosoamine	5	16	5/2/2003	11/9/2012		0%					4.8	10		0.0081	11/9/2012	0	16	0%	
Naphthalene	5	16	5/2/2003	11/9/2012		0%					2.8	10		160				0%	
Nitrobenzene	5	16	5/2/2003	11/9/2012		0%					3.2	10		16				0%	
N-Nitrosodiethylamine	5	16	5/2/2003	11/9/2012		0%					4.8	20		0.00029	11/9/2012	0	16	0%	
N-Nitrosodimethylamine	5	16	5/2/2003	11/9/2012		0%					4.8	10		0.00065	11/9/2012	0	16	0%	
N-Nitroso-di-n-propylamine	5	16	5/2/2003	11/9/2012		0%					4.1	10		0.0044	11/9/2012	0	16	0%	
N-Nitrosodiphenylamine	5	16	5/2/2003	11/9/2012		0%					4.5	10		0.62	11/9/2012	0	16	0%	
N-Nitrosomethylethylamine	5	15	5/2/2003	11/9/2012		0%					4.8	10		0.004	11/9/2012	0	15	0%	
N-Nitrosopiperidine	5	16	5/2/2003	11/9/2012		0%					4.8	20						0%	
N-Nitrosopyrrolidine	5	16	5/2/2003	11/9/2012		0%					4.8	40		0.021	11/9/2012	0	16	0%	
Orthotolidine	5	16	5/2/2003	11/9/2012		0%					4.8	10		0.008	11/9/2012	0	16	0%	
o-Toluidine	5	16	5/2/2003	11/9/2012		0%					4.8	10						0%	
Parathion	5	16	5/2/2003	11/9/2012		0%					0.5	4.9		0.013	11/9/2012	0	16	0%	
p-Chloroaniline	5	16	5/2/2003	11/9/2012		0%					2.5	10		0.22	11/9/2012	0	16	0%	
Pentachlorobenzene	5	16	5/2/2003	11/9/2012		0%					4.8	10		13				0%	
Pentachloronitrobenzene	5	16	5/2/2003	11/9/2012		0%					4.8	20		0.34	11/9/2012	0	16	0%	
Pentachlorophenol	5	16	5/2/2003	11/9/2012		0%					1.7	50		0.002	11/9/2012	0	16	0%	
Phenacetin	5	16	5/2/2003	11/9/2012		0%					4.8	20						0%	
Phenanthrene	5	16	5/2/2003	11/9/2012		0%					0.096	1.7						0%	
Phenol	5	16	5/2/2003	11/9/2012		0%					3.2	19		2400				0%	
Phorate	5	16	5/2/2003	11/9/2012		0%					4.8	10		3.2	11/9/2012	0	16	0%	
P-Phenylenediamine	5	16	5/2/2003	11/9/2012		0%					9.5	10		3000				0%	
Propyzamide	5	16	5/2/2003	11/9/2012		0%					4.8	10		1200				0%	
Pyrene	5	16	5/2/2003	11/9/2012		0%					0.19	3.1		8				0%	
Safrole	5	16	5/2/2003	11/9/2012		0%					4.8	10						0%	
Thionazin	5	16	5/2/2003	11/9/2012		0%					4.8	20						0%	
Total cPAHs TEQ (ND = 1/2 RDL)	5	16	5/2/2003	11/9/2012		0%					0.078	2.1						0%	
Trans-Diallate	4	7	11/9/2011	11/9/2012		0%					10	10						0%	
Triethyl thiophosphate	5	16	5/2/2003	11/9/2012		0%					4.8	10						0%	

Table 6.1 - Frequency of Cleanup Level Exceedances - VLF Groundwater

Project No. 090057-310.3, Vashon Island Closed Landfill, Vashon Island, King County, Washington

Analyte	Number of Sampled Locations[1]	Number of Samples (excluding Field Dups)	First Sample Date	Most Recent Available Sample Date	Number of Samples with Detected Concentration	Frequency of Detection	Last Sample Date with Detected Concentration	Maxumim Detected Concentration	Minimum Detected Concentration	Average Detected Concentration	Min RDL	Max RDL	Units	Preliminary Cleanup Level (PCUL)	Date of Last PCUL Exceedance	Number of Detected Exceedances of PCUL	Number of NonDetects with Reporting Limit Above PCUL	Frequency of Detected Exceedances	Number of Samples Since Last Exceedance
VOCs																			
1,1,1,2-Tetrachloroethane	25	1014	10/30/2001	12/5/2017		0%					0.2	0.25		1.7				0%	
1,1,1-Trichloroethane	25	1014	10/30/2001	12/5/2017		0%					0.1	0.2		200				0%	
1,1,2,2-Tetrachloroethane	25	1014	10/30/2001	12/5/2017		0%					0.1	0.2		0.1	12/5/2017	0	1014	0%	
1,1,2-Trichloroethane	25	1014	10/30/2001	12/5/2017		0%					0.1	0.2		0.35				0%	
1,1-Dichloroethane	25	1014	10/30/2001	12/5/2017	50	5%	11/14/2017	2.32	0.15	0.632	0.1	0.2	ug/L	7.7				0%	
1,1-Dichloroethene	25	1014	10/30/2001	12/5/2017	9	1%	11/14/2017	0.28	0.17	0.23	0.1	0.2	ug/L	7				0%	
1,1-Dichloropropene	18	199	10/30/2001	11/9/2012		0%					0.2	0.2						0%	
1,2,3-Trichloropropane	25	1014	10/30/2001	12/5/2017		0%					0.1	0.2		0.0015	12/5/2017	0	1014	0%	
1,2-Dibromo-3-chloropropane	25	1014	10/30/2001	12/5/2017		0%					0.2	2.5		0.2	12/5/2017	0	1014	0%	
1,2-Dibromoethane (EDB)	25	1014	10/30/2001	12/5/2017		0%					0.1	0.2		0.05	12/5/2017	0	1014	0%	
1,2-Dichlorobenzene	25	1014	10/30/2001	12/5/2017		0%					0.1	0.2		600				0%	
1,2-Dichloroethane (EDC)	25	1014	10/30/2001	12/5/2017	1	0%	5/25/2017	0.12	0.12	0.12	0.1	0.2	ug/L	4.8				0%	
1,2-Dichloropropane	25	1014	10/30/2001	12/5/2017	42	4%	11/14/2017	12.5	0.24	2.88	0.1	0.2	ug/L	0.71	11/14/2017	24	0	2%	10
1,3-Dichlorobenzene	18	199	10/30/2001	11/9/2012		0%					0.2	0.2		2				0%	
1,3-Dichloropropane	18	199	10/30/2001	11/9/2012		0%					0.2	0.2		0.22				0%	
1,4-Dichloro-2-Butene	25	1014	10/30/2001	12/5/2017		0%					0.5	100						0%	
1,4-Dichlorobenzene	25	1014	10/30/2001	12/5/2017		0%					0.1	0.2		75				0%	
2,2-Dichloropropane	18	199	10/30/2001	11/9/2012		0%					0.2	0.2						0%	
2-Butanone	25	1014	10/30/2001	12/5/2017	1	0%	3/3/2015	5.21	5.21	5.21	0.25	4	ug/L	4800				0%	
2-Hexanone	25	1014	10/30/2001	12/5/2017		0%					0.5	4						0%	
2-Methyl-1-Propanol	18	199	10/30/2001	11/9/2012		0%					100	100		2400				0%	
3-Chloropropene	18	199	10/30/2001	11/9/2012		0%					10	10		2.08	11/9/2012	0	199	0%	
4-Methyl-2-pentanone	25	1014	10/30/2001	12/5/2017		0%					2.5	4		640				0%	
Acetone	25	1014	10/30/2001	12/5/2017	41	4%	9/6/2017	31	2.6	6.67	2.5	40	ug/L	7200				0%	
Acetonitrile	18	199	10/30/2001	11/9/2012		0%					100	100						0%	
Acrolein	18	199	10/30/2001	11/9/2012		0%					10	10		1	11/9/2012	0	199	0%	
Acrylonitrile	25	1014	10/30/2001	12/5/2017		0%					0.035	10		0.019	12/5/2017	0	1014	0%	
Benzene	25	1014	10/30/2001	12/5/2017	78	8%	11/14/2017	1.76	0.25	0.757	0.1	0.2	ug/L	0.44	11/14/2017	71	0	7%	10
Bromochloromethane	25	1014	10/30/2001	12/5/2017		0%					0.1	0.2						0%	
Bromodichloromethane	25	1014	10/30/2001	12/5/2017		0%					0.2	0.25		0.08	12/5/2017	0	1014	0%	
Bromoform	25	1014	10/30/2001	12/5/2017		0%					0.2	0.5		4.6				0%	
Bromomethane	25	1014	10/30/2001	12/5/2017	3	0%	10/31/2001	0.36	0.24	0.31	0.1	0.2	ug/L	10				0%	
Carbon Disulfide	25	1014	10/30/2001	12/5/2017	9	1%	11/17/2017	0.87	0.1	0.238	0.1	0.2	ug/L	800				0%	
Carbon Tetrachloride	25	1014	10/30/2001	12/5/2017		0%					0.2	0.25		0.2	12/5/2017	0	1014	0%	
Chlorobenzene	25	1014	10/30/2001	12/5/2017		0%					0.1	0.2		100				0%	
Chloroethane	25	1014	10/30/2001	12/5/2017	11	1%	11/14/2017	0.947	0.24	0.511	0.1	0.2	ug/L					0%	
Chloroform	25	1014	10/30/2001	12/5/2017	1	0%	5/4/2005	1.7	1.7	1.7	0.1	0.2	ug/L	14				0%	
Chloromethane	25	1006	10/30/2001	12/5/2017	40	4%	5/19/2017	1.72	0.2	0.379	0.2	0.25	ug/L					0%	
Chloroprene	18	199	10/30/2001	11/9/2012		0%					20	20		160				0%	
cis-1,2-Dichloroethene (DCE)	25	1014	10/30/2001	12/5/2017	157	15%	11/14/2017	52.7	0.15	7.52	0.1	0.2	ug/L	70				0%	
cis-1,3-Dichloropropene	25	1014	10/30/2001	12/5/2017		0%					0.2	0.25						0%	
Dibromochloromethane	25	1014	10/30/2001	12/5/2017		0%					0.2	0.5		0.6				0%	
Dibromomethane	25	1014	10/30/2001	12/5/2017		0%					0.1	0.2		48				0%	
Dichlorodifluoromethane	25	1014	10/30/2001	12/5/2017	227	22%	11/17/2017	27	0.2	5.54	0.1	0.2	ug/L	1600				0%	
Ethyl Methacrylate	5	16	5/2/2003	11/9/2012		0%					1	10		720				0%	
Ethylbenzene	25	1014	10/30/2001	12/5/2017		0%					0.1	0.2		29				0%	
m,p-Xylene	24	505	11/14/2007	12/5/2017	4	1%	4/22/2010	0.37	0.21	0.27	0.1	0.2	ug/L					0%	
Methacrylonitrile	18	199	10/30/2001	11/9/2012		0%					5	5		0.8	11/9/2012	0	199	0%	
Methyl Methacrylate	18	199	10/30/2001	11/9/2012		0%					2	2		11000				0%	
Methylene Chloride	25	1014	10/30/2001	12/5/2017	22	2%	2/14/2017	2.18	0.2	0.834	0.2	2.5	ug/L	5				0%	
Methyliodide	25	1014	10/30/2001	12/5/2017		0%					0.1	0.2						0%	
o-Xylene	25	696	10/30/2001	12/5/2017	3	0%	11/14/2017	0.34	0.13	0.2	0.1	0.2	ug/L	1600				0%	
Propionitrile	18	199	10/30/2001	11/9/2012		0%					60	60						0%	
Styrene	25	1014	10/30/2001	12/5/2017		0%					0.1	0.2		100				0%	
Tetrachloroethene (PCE)	25	1014	10/30/2001	12/5/2017	1	0%	2/10/2004	0.21	0.21	0.21	0.1	0.2	ug/L	2.4				0%	
Toluene	25	1014	10/30/2001	12/5/2017	20	2%	11/14/2017	2.25	0.1	0.416	0.1	0.2	ug/L	72				0%	
trans-1,2-Dichloroethene	25	1014	10/30/2001	12/5/2017	74	7%	11/14/2017	1.15	0.12	0.395	0.1	0.2	ug/L	100				0%	
trans-1,3-Dichloropropene	25	1014	10/30/2001	12/5/2017		0%					0.2	0.5						0%	
Trichloroethene (TCE)	25	1014	10/30/2001	12/5/2017	21	2%	11/14/2017	1.08	0.15	0.664	0.1	0.2	ug/L	0.3	11/14/2017	15	0	1%	11
Trichlorofluoromethane	25	1014	10/30/2001	12/5/2017	161	16%	11/14/2017	9	0.12	2.63	0.1	0.2	ug/L	2400				0%	
Vinyl Acetate	25	1014	10/30/2001	12/5/2017		0%					0.1	0.2		8000				0%	
Vinyl Chloride	25	1014	10/30/2001	12/5/2017	218	21%	11/14/2017	53.1	0.02	4.56	0.01	0.5	ug/L	0.02	11/14/2017	218	756	21%	10

Notes

RDL = Reporting Detection Limit

PCUL = Preliminary Cleanup Level

[1] - Sampling locations included in this table are all on-property monitoring wells.

Table 6.2 - Frequency of Cleanup Level Exceedances - Off-Property Drinking Water Wells

Project No. 090057-310.3, Vashon Island Closed Landfill, Vashon Island, King County, Washington

DRAFT

Analyte	Number of Sampled Locations[1]	Number of Samples (excluding Field Dups)	First Sample Date	Most Recent Available Sample Date	Number of Samples with Detected Concentration	Frequency of Detection	Last Sample Date with Detected Concentration	Maxumim Detected Concentration	Minimum Detected Concentraion	Average Detected Concentration	Units	Preliminary Cleanup Level (PCUL)	Date of Last PCUL Exceedance	Number of Exceedances of PCUL	Number of NonDetects with Reporting Limit Above PCUL	Frequency of Detected Exceedance	Number of Samples Since Last Excedance
Bacteria																	
Fecal Coliform	11	11	2/12/2002	2/14/2002		0%										0%	
Total Coliform	11	11	2/12/2002	2/14/2002	2	18%	2/14/2002	4	0	2	cfu/100mL					0%	
Conventionals																	
Alkalinity, Total	11	76	2/12/2002	9/7/2017	76	100%	9/7/2017	76	52	68.8	mg/L					0%	
Ammonia as N	11	76	2/12/2002	9/7/2017	42	55%	9/7/2017	1.3	0.01	0.235	mg/L					0%	
Chemical Oxygen Demand	11	11	2/12/2002	2/14/2002	1	9%	2/13/2002	6	6	6	mg/L					0%	
Chloride	11	76	2/12/2002	9/7/2017	76	100%	9/7/2017	8.9	2	4.38	mg/L					0%	
Cyanide	11	11	2/12/2002	2/14/2002		0%						0.0096	2/14/2002	0	11	0%	
Fluoride	11	11	2/12/2002	2/14/2002		0%						4				0%	
Nitrate + Nitrite as N	11	11	2/12/2002	2/14/2002	8	73%	2/14/2002	2.5	0.01	0.65	mg/L					0%	
Nitrate as N	11	76	2/12/2002	9/7/2017	38	50%	9/7/2017	2.5	0.01	0.902	mg/L	10				0%	
Nitrite as N	11	11	2/12/2002	2/14/2002		0%						1				0%	
pH	11	43	2/12/2002	10/29/2009	43	100%	10/29/2009	7.9	6.25	7.35	pH units					0%	
Specific Conductance	2	37	7/20/2009	9/7/2017	37	100%	9/7/2017	199	142	172	uS/cm					0%	
Sulfate	11	76	2/12/2002	9/7/2017	76	100%	9/7/2017	17	1	8.76	mg/L					0%	
Total Organic Carbon	11	76	2/12/2002	9/7/2017	11	14%	6/2/2017	7.5	0.36	1.61	mg/L					0%	
Total Organic Halides (TOX)	11	11	2/12/2002	2/14/2002		0%										0%	
Total Solids	11	76	2/12/2002	9/7/2017	76	100%	9/7/2017	150	64	111	mg/L					0%	
Total Suspended Solids	11	76	2/12/2002	9/7/2017	15	20%	10/9/2008	14	1	3.3	mg/L					0%	
Field Parameters																	
Dissolved Oxygen	11	39	2/12/2002	9/7/2017	39	100%	9/7/2017	11.64	0.01	4.175	mg/L					0%	
Oxidation-Reduction Potential	2	4	6/2/2017	9/7/2017	4	100%	9/7/2017	242	-125.3	57.33	mV					0%	
pH	11	75	2/12/2002	9/7/2017	75	100%	9/7/2017	8.41	6.5	7.48	pH units					0%	
Specific Conductance	11	75	2/12/2002	9/7/2017	75	100%	9/7/2017	207	0.202	150.7	uS/cm					0%	
Temperature	11	75	2/12/2002	9/7/2017	75	100%	9/7/2017	16.3	4.9	10.53	deg C					0%	
Turbidity	11	39	2/12/2002	9/7/2017	39	100%	9/7/2017	15.1	0.15	1.19	NTU					0%	
Metals (dissolved)																	
Antimony	3	45	4/24/2008	9/7/2017		0%						6				0%	
Arsenic	3	45	4/24/2008	9/7/2017	26	58%	9/7/2017	1.8	0.43	1.41	ug/L	0.58	9/7/2017	24	19	53%	0
Barium	3	45	4/24/2008	9/7/2017	45	100%	9/7/2017	11	3.49	6.86	ug/L	2000				0%	
Beryllium	3	45	4/24/2008	9/7/2017		0%						4				0%	
Cadmium	3	45	4/24/2008	9/7/2017		0%						5				0%	
Calcium	3	45	4/24/2008	9/7/2017	45	100%	9/7/2017	14600	11300	13100	ug/L					0%	
Chromium	3	45	4/24/2008	9/7/2017	2	4%	9/7/2017	1.91	1.79	1.85	ug/L	100				0%	
Cobalt	3	45	4/24/2008	9/7/2017		0%										0%	
Copper	3	45	4/24/2008	9/7/2017	23	51%	9/7/2017	35	3.04	15	ug/L	1300				0%	
Iron	3	45	4/24/2008	9/7/2017	26	58%	9/7/2017	560	54	103	ug/L	11000				0%	
Lead	3	45	4/24/2008	9/7/2017	8	18%	9/7/2017	4.23	0.343	1.71	ug/L	15				0%	
Magnesium	3	45	4/24/2008	9/7/2017	45	100%	9/7/2017	12700	5430	8570	ug/L					0%	
Manganese	3	45	4/24/2008	9/7/2017	29	64%	9/7/2017	120	0.116	44.8	ug/L	2200				0%	
Mercury	3	47	2/14/2002	9/7/2017		0%						2				0%	
Nickel	3	45	4/24/2008	9/7/2017	2	4%	9/7/2017	0.571	0.552	0.562	ug/L	100				0%	
Potassium	3	45	4/24/2008	9/7/2017	45	100%	9/7/2017	2890	1400	2030	ug/L					0%	
Selenium	3	45	4/24/2008	9/7/2017		0%						50				0%	
Silver	3	45	4/24/2008	9/7/2017		0%						80				0%	
Sodium	3	45	4/24/2008	9/7/2017	45	100%	9/7/2017	7330	4970	5940	ug/L					0%	
Thallium	3	45	4/24/2008	9/7/2017		0%						0.16	12/2/2016	0	41	0%	
Vanadium	3	45	4/24/2008	9/7/2017	23	51%	9/7/2017	3.55	0.0763	2.71	ug/L	80				0%	
Zinc	3	45	4/24/2008	9/7/2017	25	56%	9/7/2017	37.4	2.22	11.5	ug/L	4800				0%	
Metals (total)																	
Aluminum	11	11	2/12/2002	2/14/2002	6	55%	2/14/2002	550	35	170	ug/L	16000				0%	
Antimony	11	51	2/12/2002	9/7/2017		0%						6				0%	
Arsenic	11	51	2/12/2002	9/7/2017	35	69%	9/7/2017	2.4	0.402	1.53	ug/L	0.58	9/7/2017	32	16	63%	0
Barium	11	51	2/12/2002	9/7/2017	51	100%	9/7/2017	11	3.55	7.27	ug/L	2000				0%	
Beryllium	11	51	2/12/2002	9/7/2017		0%						4				0%	
Cadmium	11	51	2/12/2002	9/7/2017	1	2%	6/2/2017	0.178	0.178	0.178	ug/L	5				0%	
Calcium	11	51	2/12/2002	9/7/2017	51	100%	9/7/2017	14600	7000	12000	ug/L					0%	
Chromium	11	51	2/12/2002	9/7/2017	6	12%	9/7/2017	7	0.309	2.23	ug/L	100				0%	
Cobalt	11	51	2/12/2002	9/7/2017	1	2%	10/12/2005	0.0933	0.0933	0.0933	ug/L					0%	
Copper	11	51	2/12/2002	9/7/2017	36	71%	9/7/2017	273	0.25	38.4	ug/L	1300				0%	
Iron	11	51	2/12/2002	9/7/2017	46	90%	9/7/2017	1200	12	217	ug/L	11000				0%	
Lead	11	51	2/12/2002	9/7/2017	19	37%	9/7/2017	18.5	0.578	3.07	ug/L	15	6/2/2017	1	0	2%	34
Magnesium	11	51	2/12/2002	9/7/2017	51	100%	9/7/2017	11700	4600	8200	ug/L					0%	
Manganese	11	51	2/12/2002	9/7/2017	37	73%	9/7/2017	120	0.166	53.8	ug/L	2200				0%	
Mercury	11	49	2/12/2002	9/7/2017		0%						2				0%	
Nickel	11	51	2/12/2002	9/7/2017	5	10%	9/7/2017	3.37	0.553	1.17	ug/L	100				0%	
Potassium	11	51	2/12/2002	9/7/2017	51	100%	9/7/2017	2800	740	1890	ug/L					0%	
Selenium	11	51	2/12/2002	9/7/2017	6	12%	10/12/2006	5.4	1	2.3	ug/L	50				0%	
Silver	11	51	2/12/2002	9/7/2017		0%						80				0%	
Sodium	11	51	2/12/2002	9/7/2017	51	100%	9/7/2017	7100	4300	5650	ug/L					0%	
Thallium	11	51	2/12/2002	9/7/2017		0%						0.16	12/2/2016	0	47	0%	
Tin	11	11	2/12/2002	2/14/2002		0%						9600				0%	
Vanadium	11	51	2/12/2002	9/7/2017	28	55%	9/7/2017	6	0.0811	2.94	ug/L	80				0%	
Zinc	11	51	2/12/2002	9/7/2017	42	82%	9/7/2017	210	1.53	32.5	ug/L	4800				0%	

Table 6.2 - Frequency of Cleanup Level Exceedances - Off-Property Drinking Water Wells

Project No. 090057-310.3, Vashon Island Closed Landfill, Vashon Island, King County, Washington

Analyte	Number of Sampled Locations[1]	Number of Samples (excluding Field Dups)	First Sample Date	Most Recent Available Sample Date	Number of Samples with Detected Concentration	Frequency of Detection	Last Sample Date with Detected Concentration	Maxumim Detected Concentration	Minimum Detected Concentraion	Average Detected Concentration	Units	Preliminary Cleanup Level (PCUL)	Date of Last PCUL Exceedance	Number of Exceedances of PCUL	Number of NonDetects with Reporting Limit Above PCUL	Frequency of Detected Exceedance	Number of Samples Since Last Exccedance
VOCs																	
1,1,1,2-Tetrachloroethane	11	76	2/12/2002	9/7/2017		0%						1.7				0%	
1,1,1-Trichloroethane	11	76	2/12/2002	9/7/2017		0%						200				0%	
1,1,2,2-Tetrachloroethane	11	76	2/12/2002	9/7/2017		0%						0.22				0%	
1,1,2-Trichloroethane	11	76	2/12/2002	9/7/2017		0%						5				0%	
1,1-Dichloroethane	11	76	2/12/2002	9/7/2017		0%						7.7				0%	
1,1-Dichloroethene	11	76	2/12/2002	9/7/2017		0%						7				0%	
1,1-Dichloropropene	11	11	2/12/2002	2/14/2002		0%										0%	
1,2,3-Trichloropropane	11	76	2/12/2002	9/7/2017		0%						0.0015	9/7/2017	0	76	0%	
1,2-Dibromo-3-chloropropane	11	76	2/12/2002	9/7/2017		0%						0.2	9/7/2017	0	76	0%	
1,2-Dibromoethane (EDB)	11	76	2/12/2002	9/7/2017		0%						0.05	9/7/2017	0	76	0%	
1,2-Dichlorobenzene	11	76	2/12/2002	9/7/2017		0%						600				0%	
1,2-Dichloroethane (EDC)	11	76	2/12/2002	9/7/2017		0%						4.8				0%	
1,2-Dichloropropane	11	76	2/12/2002	9/7/2017		0%						5				0%	
1,3-Dichlorobenzene	11	11	2/12/2002	2/14/2002		0%										0%	
1,3-Dichloropropane	11	11	2/12/2002	2/14/2002		0%										0%	
1,4-Dichloro-2-Butene	11	76	2/12/2002	9/7/2017		0%										0%	
1,4-Dichlorobenzene	11	76	2/12/2002	9/7/2017		0%						75				0%	
2,2-Dichloropropane	11	11	2/12/2002	2/14/2002		0%										0%	
2-Butanone	11	76	2/12/2002	9/7/2017	1	1%	5/14/2007	17	17	17	ug/L	4800				0%	
2-Hexanone	11	76	2/12/2002	9/7/2017		0%										0%	
2-Methyl-1-Propanol	11	11	2/12/2002	2/14/2002		0%						2400				0%	
3-Chloropropene	11	11	2/12/2002	2/14/2002		0%						2.08	2/14/2002	0	11	0%	
4-Methyl-2-pentanone	11	76	2/12/2002	9/7/2017		0%						640				0%	
Acetone	11	76	2/12/2002	9/7/2017	2	3%	9/7/2017	4.4	4.1	4.3	ug/L	7200				0%	
Acetonitrile	11	11	2/12/2002	2/14/2002		0%										0%	
Acrolein	11	11	2/12/2002	2/14/2002		0%						4	2/14/2002	0	11	0%	
Acrylonitrile	11	76	2/12/2002	9/7/2017		0%						0.081	10/29/2009	0	43	0%	
Benzene	11	76	2/12/2002	9/7/2017		0%						5				0%	
Bromochloromethane	11	76	2/12/2002	9/7/2017		0%										0%	
Bromodichloromethane	11	76	2/12/2002	9/7/2017		0%						0.08	9/7/2017	0	76	0%	
Bromoform	11	76	2/12/2002	9/7/2017		0%						55				0%	
Bromomethane	11	76	2/12/2002	9/7/2017	3	4%	2/12/2002	0.39	0.34	0.36	ug/L	10				0%	
Carbon Disulfide	11	76	2/12/2002	9/7/2017	1	1%	2/13/2002	0.47	0.47	0.47	ug/L	800				0%	
Carbon Tetrachloride	11	76	2/12/2002	9/7/2017		0%						5				0%	
Chlorobenzene	11	76	2/12/2002	9/7/2017		0%						100				0%	
Chloroethane	11	76	2/12/2002	9/7/2017		0%										0%	
Chloroform	11	76	2/12/2002	9/7/2017		0%						14				0%	
Chloromethane	11	76	2/12/2002	9/7/2017	6	8%	8/20/2010	0.47	0.23	0.36	ug/L					0%	
Chloroprene	11	11	2/12/2002	2/14/2002		0%						160				0%	
cis-1,2-Dichloroethene (DCE)	11	76	2/12/2002	9/7/2017		0%						70				0%	
cis-1,3-Dichloropropene	11	76	2/12/2002	9/7/2017		0%										0%	
Dibromochloromethane	11	76	2/12/2002	9/7/2017		0%						5.2				0%	
Dibromomethane	11	76	2/12/2002	9/7/2017		0%						80				0%	
Dichlorodifluoromethane	11	76	2/12/2002	9/7/2017	1	1%	7/29/2008	0.43	0.43	0.43	ug/L	1600				0%	
Ethylbenzene	11	76	2/12/2002	9/7/2017		0%						70				0%	
m,p-Xylene	2	33	1/29/2010	9/7/2017		0%										0%	
Methacrylonitrile	11	11	2/12/2002	2/14/2002		0%						0.8	2/14/2002	0	11	0%	
Methyl Methacrylate	11	11	2/12/2002	2/14/2002		0%						11000				0%	
Methylene Chloride	11	76	2/12/2002	9/7/2017		0%						5				0%	
Methyliodide	11	76	2/12/2002	9/7/2017		0%										0%	
o-Xylene	11	44	2/12/2002	9/7/2017		0%						1600				0%	
Propionitrile	11	11	2/12/2002	2/14/2002		0%										0%	
Styrene	11	76	2/12/2002	9/7/2017		0%						100				0%	
Tetrachloroethene (PCE)	11	76	2/12/2002	9/7/2017		0%						5				0%	
Toluene	11	76	2/12/2002	9/7/2017	1	1%	9/1/2011	0.3	0.3	0.3	ug/L	640				0%	
trans-1,2-Dichloroethene	11	76	2/12/2002	9/7/2017		0%						100				0%	
trans-1,3-Dichloropropene	11	76	2/12/2002	9/7/2017		0%										0%	
Trichloroethene (TCE)	11	76	2/12/2002	9/7/2017	2	3%	3/31/2015	0.32	0.23	0.28	ug/L	5				0%	
Trichlorofluoromethane	11	76	2/12/2002	9/7/2017		0%						2400				0%	
Vinyl Acetate	11	76	2/12/2002	9/7/2017		0%						8000				0%	
Vinyl Chloride	11	76	2/12/2002	9/7/2017		0%						0.29				0%	

Notes:

PCUL = Preliminary Cleanup Level

[1] - Sampled locations include all off-property drinking water wells sampled by King County.

Table 6.3 - Summary of Groundwater Cleanup Levels for Constituents of Concern

DRAFT

Project No. 090057-310.3, Vashon Island Closed Landfill, Vashon Island, King County, Washington

	units	RDL	Protection of Groundwater for Human Health (Drinking Water)		Protection of Surface Water for Human Health		Protection of Surface Water for Ecological Protection		Lowest Value, All Receptor Pathways
			Cleanup Level	Source of Cleanup Level	Cleanup Level	Source of Cleanup Level	Cleanup Level	Source of Cleanup Level	
Metals [a]									
Arsenic	µg/L	1	5 [b]	Background	5 [b]	Background	5 [b]	Background	5 [b]
Iron	µg/L	10	11,000	MTCA Method B			1,000	CWA	1,000
Volatile Organic Compounds									
1,2-Dichloropropane	µg/L		5	MCL	0.71	CWA			0.71
Benzene	µg/L	0.2	5	MCL	0.44	CWA			0.44
Trichloroethene (TCE)	µg/L		5	MCL	0.3	CWA			0.3
Vinyl chloride	µg/L	0.02	0.29	Modified MTCA Method B	0.02	CWA			0.02

Notes:

Refer to Table 5.1 for a full list of criteria and analytes

µg/L = micrograms per liter

CWA = Clean Water Act

MTCA = Model Toxics Control Act

MCL = Maximum Contaminant Level

RDL = Reporting Detection Limit

a - Metals PCULs for human receptors is based on total and dissolved and dissolved fraction only for ecological receptors, as this fraction is more toxic to ecological receptors compared to the total fraction.

b - Arsenic is based on background for Washington state per MTCA Method A Table 720-1 WAC 173-340-900. Adjustment to background is allowable per WAC 173-340-720(7)(c).

Table 6.4 - Frequency of Cleanup Level Exceedances - Surface Water

Project No. 090057-310.3, Vashon Island Closed Landfill, Vashon Island, King County, Washington

Analyte	Number of Sampled Locations	Number of Samples (excluding Field Dups)	First Sample Date	Most Recent Available Sample Date	Number of Samples with Detected Concentration	Frequency of Detection	Last Sample Date with Detected Concentration	Maxumim Detected Concentration	Minimum Detected Concentraion	Average Detected Concentration	Min RDL	Max RDL	Units	Preliminary Clenaup Level (PCUL)	Date of Last PCUL Exceedance	Number of Detected Exceedances of PCUL	Number of NonDetects with Reporting Limit Above PCUL	Frequency of Detected Exceedance	Number of Samples Since Last Detected Exceedance
Bacteria																			
Fecal Coliform	6	209	11/28/2001	12/5/2017	158	76%	12/5/2017	4000	0	110	1	10	cfu/100mL					0%	
Total Coliform	6	209	11/28/2001	12/5/2017	188	90%	12/5/2017	180000	1	2730	1	1000	cfu/100mL					0%	
Conventionals																			
Alkalinity, Total	17	325	12/27/2001	12/5/2017	325	100%	12/5/2017	640	4.2	212			mg/L					0%	
Ammonia as N	17	326	11/28/2001	12/5/2017	129	40%	12/5/2017	45	0.0054	0.415	0.01	0.05	mg/L					0%	
Chemical Oxygen Demand	6	209	11/28/2001	12/5/2017	195	93%	12/5/2017	100	5	21.9	5	10	mg/L					0%	
Chloride	17	323	11/28/2001	12/5/2017	315	98%	12/5/2017	170	0.739	12.4	1	10	mg/L	230				0%	
Cyanide	6	209	11/28/2001	12/5/2017		0%					0.002	0.02		0.0052	2/1/2017	0	200	0%	
Dissolved Organic Carbon	3	5	9/16/2015	2/25/2016	5	100%	2/25/2016	6.35	2.29	3.76			mg/L					0%	
Dissolved Oxygen	10	120	11/28/2001	3/26/2009	120	100%	3/26/2009	15	6.4	10.7			mg/L					0%	
Fluoride	6	206	11/28/2001	12/5/2017	10	5%	8/8/2017	0.204	0.021	0.115	0.02	1	mg/L					0%	
Nitrate + Nitrite as N	6	209	11/28/2001	12/5/2017	188	90%	12/5/2017	9	0.01	0.859	0.01	0.05	mg/L					0%	
Nitrate as N	17	326	11/28/2001	12/5/2017	285	87%	12/5/2017	9	0.01	0.807	0.01	0.05	mg/L					0%	
Nitrite as N	5	50	11/28/2001	2/25/2016	5	10%	3/28/2005	0.03	0.01	0.02	0.01	0.01	mg/L					0%	
pH	17	195	11/28/2001	12/20/2012	195	100%	12/20/2012	8.4	6.5	7.55			pH units					0%	
Phosphate, Total	5	45	11/28/2001	5/17/2005	44	98%	5/17/2005	2.6	0.01	0.26	0.01	0.01	mg/L					0%	
Phosphorus	6	163	9/29/2005	12/5/2017	163	100%	12/5/2017	1.53	0.013	0.171			mg/L					0%	
Phosphorus, Soluble Reactive	6	209	11/28/2001	12/5/2017	204	98%	12/5/2017	1.6	0.01	0.0869	0.01	0.01	mg/L					0%	
Silica	3	5	9/16/2015	2/25/2016	5	100%	2/25/2016	41.1	37	39.8			mg/L					0%	
Specific Conductance	12	164	7/10/2009	12/5/2017	164	100%	12/5/2017	1110	34.9	374			uS/cm					0%	
Sulfate	17	326	11/28/2001	12/5/2017	325	100%	12/5/2017	45	0.988	10.4	1	1	mg/L					0%	
Sulfide	3	5	9/16/2015	2/25/2016		0%					0.01	0.01						0%	
Total Dissolved Solids	17	282	9/29/2005	12/5/2017	281	100%	12/5/2017	720	36	254	40	40	mg/L					0%	
Total Kjeldahl Nitrogen	6	209	11/28/2001	12/5/2017	157	75%	12/5/2017	6.9	0.13	0.699	0.1	1	mg/L					0%	
Total Organic Carbon	13	284	11/28/2001	12/5/2017	277	98%	12/5/2017	58	1	6.94	1	4	mg/L					0%	
Total Organic Halides (TOX)	5	116	11/28/2001	12/28/2010	15	13%	7/15/2008	0.08	0.014	0.041	0.01	0.05	mg/L					0%	
Total Solids	17	327	11/28/2001	12/5/2017	327	100%	12/5/2017	4100	40	340			mg/L					0%	
Total Suspended Solids	17	326	11/28/2001	12/5/2017	316	97%	12/5/2017	4100	1	75.6	1	2	mg/L					0%	
Turbidity	11	261	11/28/2001	12/5/2017	258	99%	12/5/2017	252	0.18	13.1	0.1	1	ntu					0%	
Field Parameters																			
Dissolved Oxygen	17	318	11/28/2001	12/5/2017	317	100%	12/5/2017	19.5	0.3	8.907	0	0	mg/L					0%	
Oxidation-Reduction Potential	4	38	6/18/2014	12/5/2017	38	100%	12/5/2017	376.7	-86	84.91			mV					0%	
pH	17	335	11/28/2001	12/5/2017	335	100%	12/5/2017	10.71	6	7.559			pH units					0%	
Specific Conductance	17	339	11/28/2001	12/5/2017	339	100%	12/5/2017	1034	55	385.79			uS/cm					0%	
Temperature	17	336	11/28/2001	12/5/2017	336	100%	12/5/2017	18.4	2.4	10.031			deg C					0%	
Turbidity	17	337	11/28/2001	12/5/2017	337	100%	12/5/2017	381	0	20.67			NTU					0%	
Metals (dissolved)																			
Aluminum	14	212	3/28/2007	12/5/2017	40	19%	12/5/2017	200	2.43	51.7	0.002	0.02	ug/L	87	12/11/2015	10	0	5%	29
Antimony	13	229	3/28/2007	12/5/2017		0%					3.0E-04	0.001		6				0%	
Arsenic	17	271	3/28/2007	12/5/2017	221	82%	12/5/2017	34.1	0.92	3.81	9.0E-04	0.001	ug/L	5	2/25/2016	26	0	10%	28
Barium	17	271	3/28/2007	12/5/2017	240	89%	12/5/2017	60.7	0.916	10.4	9.0E-04	0.001	ug/L					0%	
Beryllium	13	229	3/28/2007	12/5/2017		0%					1.0E-04	0.001		270				0%	
Cadmium	17	271	3/28/2007	12/5/2017		0%					5.0E-05	0.002		1.32	2/1/2017	0	259	0%	
Calcium	17	271	3/28/2007	12/5/2017	271	100%	12/5/2017	98500	5060	30800			ug/L					0%	
Chromium	13	229	3/28/2007	12/5/2017	11	5%	12/5/2017	1.2	0.246	0.571	2.0E-04	0.005	ug/L	143				0%	
Cobalt	13	229	3/28/2007	12/5/2017	6	3%	12/5/2017	0.0931	0.0521	0.0777	5.0E-05	0.003	ug/L					0%	
Copper	17	271	3/28/2007	12/5/2017	31	11%	12/5/2017	13.7	0.221	3.5	0.0018	0.002	ug/L	22.6				0%	
Iron	17	271	3/28/2007	12/5/2017	256	94%	12/5/2017	27000	11	1620	0.01	0.01	ug/L	1000	2/25/2016	26	0	10%	28
Lead	13	229	3/28/2007	12/5/2017	2	1%	9/20/2017	0.931	0.165	0.548	1.0E-04	0.001	ug/L	5.98				0%	
Magnesium	17	271	3/28/2007	12/5/2017	271	100%	12/5/2017	82700	2050	26800			ug/L					0%	
Manganese	17	271	3/28/2007	12/5/2017	270	100%	12/5/2017	6400	1.9	615	0.001	0.001	ug/L					0%	
Mercury	14	125	3/28/2007	10/27/2009	4	3%	1/6/2009	0.782	0.159	0.488	1.0E-04	1.4E-04	ug/L	0.012	10/27/2009	4	121	3%	34
Nickel	13	229	3/28/2007	12/5/2017	13	6%	12/5/2017	10	0.592	1.85	0.009	0.01	ug/L	80				0%	
Potassium	17	271	3/28/2007	12/5/2017	269	99%	12/5/2017	7160	804	2300	0.3	0.3	ug/L					0%	
Selenium	13	229	3/28/2007	12/5/2017	25	11%	2/4/2010	9.1	1	2.8	5.0E-04	0.001	ug/L	5	3/11/2008	4	0	2%	188
Silver	13	229	3/28/2007	12/5/2017		0%					4.0E-05	0.003		12.88				0%	
Sodium	17	271	3/28/2007	12/5/2017	271	100%	12/5/2017	24900	1460	9580			ug/L					0%	
Thallium	13	229	3/28/2007	12/5/2017		0%					1.0E-04	0.001		1.7				0%	
Tin	10	170	3/28/2007	12/5/2017		0%					5.0E-04	0.01						0%	
Vanadium	13	229	3/28/2007	12/5/2017	38	17%	12/5/2017	3.4	0.364	2.08	0.0018	0.002	ug/L					0%	
Zinc	13	229	3/28/2007	12/5/2017	94	41%	12/5/2017	2040	0.51	37.9	0.004	0.004	ug/L	207	8/11/2010	1	0	0.4%	117
Metals (total)																			
Aluminum	12	243	11/28/2001	12/5/2017	243	100%	12/5/2017	10700	22.6	720			ug/L	87	12/5/2017	222	0	91%	0
Antimony	10	235	11/28/2001	12/5/2017	1	0%	9/20/2017	0.358	0.358	0.358	3.0E-04	0.001	ug/L	6				0%	
Arsenic	12	243	11/28/2001	12/5/2017	236	97%	12/5/2017	83	1	5.59	0.001	0.001	ug/L	5	9/20/2017	68	0	28%	4
Barium	12	243	11/28/2001	12/5/2017	243	100%	12/5/2017	335	1.96	19.1			ug/L					0%	
Beryllium	10	235	11/28/2001	12/5/2017	1	0%	9/20/2017	0.18	0.18	0.18	1.0E-04	0.001	ug/L	270				0%	
Cadmium	12	243	11/28/2001	12/5/2017	4	2%	9/20/2017	8	0.208	4.55	5.0E-05	0.002	ug/L	1.32	2/1/2017	3	228	1%	205
Calcium	12	245	11/28/2001	12/5/2017	245	100%	12/5/2017	121000	3800	33200			ug/L					0%	
Chromium	10	235	11/28/2001	12/5/2017	32	14%	12/5/2017	33.4	0.543	7.98	0.0045	0.005	ug/L	143				0%	
Cobalt	10	235	11/28/2001	12/5/2017	30	13%	12/5/2017	24	0.113	4.22	0.0027	0.003	ug/L					0%	
Copper	12	243	11/28/2001	12/5/2017	94	39%	12/5/2017	22.1	0.465	5.93	0.0018	0.002	ug/L	22.6				0%	
Iron	12	243	11/28/2001	12/5/2017	243	100%	12/5/2017	76000	46	3880			ug/L	1000	12/5/2017	163	0	67%	0
Lead	10	235	11/28/2001	12/5/2017	59	25%	12/5/2017	10.6	0.189	2.59	9.0E-04	0.001	ug/L	5.98	9/20/2017	5	0	2%	4
Magnesium	12	246	11/28/2001	12/5/2017	246	100%	12/5/2017	92000	1700	27400			ug/L					0%	
Manganese	12	241	11/28/2001	12/5/2017	241	100%	12/5/2017	18000	3.61	1180			ug/L					0%	
Mercury	12	232	11/28/2001	12/5/2017	2	1%	6/7/2004	0.1	0.1	0.1	5.0E-05	1.4E-04	ug/L	0.012	12/5/2017	2	230	1%	197
Nickel	10	235	11/28/2001	12/5/2017	40	17%	12/5/2017	59	1.12	14.9	0.009	0.01	ug/L	80				0%	
Potassium	12	243	11/28/2001	12/5/2017	243	100%	12/5/2017	9500	820	2490			ug/L					0%	
Selenium	10	235	11/28/2001	12/5/2017	43	18%	9/20/2017	8.16	1	2.89	5.0E-04	0.001	ug/L	5	7/27/2006	6	0	3%	179
Silver	10	235	11/28/2001	12/5/2017	1	0%	9/20/2017	0.06	0.06	0.06	4.0E-05	0.003	ug/L	12.88				0%	
Sodium	12	242	11/28/2001	12/5/2017	242	100%	12/5/2017	25000	1500	9780			ug/L					0%	
Thallium	10	235	11/28/2001	12/5/2017	2	1%	6/7/2004	1	1	1	1.0E-04	0.001	ug/L	1.7				0%	
Tin	10	235	11/28/2001	12/5/2017		0%					5.0E-04	0.01						0%	
Vanadium	10	235	11/28/2001	12/5/2017	129	55%	12/5/2017	33.6	0.747	4.96	0.0018	0.002	ug/L					0%	
Zinc	10	235	11/28/2001	12/5/2017	107	46%	12/5/2017	412	0.783	20.7	0.004	0.004	ug/L	207	9/28/2010	2	0	1%	112

Table 6.4 - Frequency of Cleanup Level Exceedances - Surface Water

Project No. 090057-310.3, Vashon Island Closed Landfill, Vashon Island, King County, Washington

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Analyte	Number of Sampled Locations	Number of Samples (excluding Field Dups)	First Sample Date	Most Recent Available Sample Date	Number of Samples with Detected Concentration	Frequency of Detection	Last Sample Date with Detected Concentration	Maxumim Detected Concentration	Minimum Detected Concentraion	Average Detected Concentration	Min RDL	Max RDL	Units	Preliminary Clenaup Level (PCUL)	Date of Last PCUL Exceedance	Number of Detected Exceedances of PCUL	Number of NonDetects with Reporting Limit Above PCUL	Frequency of Detected Exceedance	Number of Samples Since Last Detected Exceedance
Pesticide																			
2,4,5-T	6	209	11/28/2001	12/5/2017		0%					0.0248	2						0%	
2,4,5-TP Silvex	6	209	11/28/2001	12/5/2017	3	1%	12/5/2017	0.0279	0.0259	0.027	0.0248	1	ug/L					0%	
2,4-D	6	209	11/28/2001	12/5/2017		0%					0.0495	5						0%	
Dinoseb	6	209	11/28/2001	12/5/2017		0%					0.0248	1						0%	
Endrin	6	209	11/28/2001	12/5/2017		0%					0.0119	0.12		0.002	12/5/2017	0	209	0%	
Lindane (Gamma BHC)	6	209	11/28/2001	12/5/2017		0%					0.0119	0.029		0.08				0%	
Methoxychlor	6	209	11/28/2001	12/5/2017		0%					0.0595	2.3		0.03	12/5/2017	0	209	0%	
Toxaphene	6	209	11/28/2001	12/5/2017		0%					1.19	2.9		0.000032	12/5/2017	0	209	0%	
VOCs																			
1,1,1,2-Tetrachloroethane	13	285	11/28/2001	12/5/2017		0%					0.2	2		20000				0%	
1,1,1-Trichloroethane	13	285	11/28/2001	12/5/2017	12	4%	11/5/2010	1.1	0.33	0.661	0.1	2	ug/L	930000				0%	
1,1,2,2-Tetrachloroethane	13	285	11/28/2001	12/5/2017		0%					0.1	2		0.1	12/5/2017	0	285	0%	
1,1,2-Trichloroethane	13	285	11/28/2001	12/5/2017		0%					0.1	2		0.35	3/26/2004	0	6	0%	
1,1-Dichloroethane	17	327	11/28/2001	12/5/2017	2	1%	3/25/2009	0.31	0.22	0.27	0.1	2	ug/L					0%	
1,1-Dichloroethene	13	285	11/28/2001	12/5/2017		0%					0.1	2		700				0%	
1,1-Dichloropropene	5	50	11/28/2001	7/27/2006		0%					0.2	2						0%	
1,2,3-Trichloropropane	13	285	11/28/2001	12/5/2017		0%					0.1	2						0%	
1,2-Dibromo-3-chloropropane	13	285	11/28/2001	12/5/2017		0%					0.2	2.5						0%	
1,2-Dibromoethane (EDB)	17	327	11/28/2001	12/5/2017		0%					0.1	2						0%	
1,2-Dichlorobenzene	13	285	11/28/2001	12/5/2017		0%					0.1	2		700				0%	
1,2-Dichloroethane (EDC)	13	285	11/28/2001	12/5/2017	1	0%	3/25/2009	0.2	0.2	0.2	0.1	2	ug/L	8.9				0%	
1,2-Dichloropropane	17	327	11/28/2001	12/5/2017	20	6%	11/2/2010	7.6	0.49	1.72	0.1	2	ug/L	0.71	11/2/2010	15	6	5%	101
1,3-Dichlorobenzene	5	39	11/28/2001	12/23/2004		0%					0.2	2		2	12/17/2003	0	4	0%	
1,3-Dichloropropane	5	39	11/28/2001	12/23/2004		0%					0.2	2		0.22	3/26/2004	0	6	0%	
1,4-Dichloro-2-Butene	13	285	11/28/2001	12/5/2017		0%					0.5	1000						0%	
1,4-Dichlorobenzene	13	285	11/28/2001	12/5/2017		0%					0.1	2		200				0%	
2,2-Dichloropropane	5	39	11/28/2001	12/23/2004		0%					0.2	2						0%	
2-Butanone	13	273	11/28/2001	12/5/2017		0%					0.25	40						0%	
2-Hexanone	13	285	11/28/2001	12/5/2017		0%					0.5	40						0%	
2-Methyl-1-Propanol	5	39	11/28/2001	12/23/2004		0%					100	100						0%	
3-Chloropropene	5	39	11/28/2001	12/23/2004		0%					10	100						0%	
4-Methyl-2-pentanone	13	285	11/28/2001	12/5/2017		0%					2.5	40						0%	
Acetone	13	285	11/28/2001	12/5/2017	17	6%	12/5/2017	26	2.5	8.63	2.5	40	ug/L					0%	
Acetonitrile	5	39	11/28/2001	12/23/2004		0%					100	100						0%	
Acrolein	5	39	11/28/2001	12/23/2004		0%					10	100		1	12/23/2004	0	39	0%	
Acrylonitrile	13	285	11/28/2001	12/5/2017	1	0%	1/21/2010	0.083	0.083	0.083	0.035	100	ug/L	0.019	12/5/2017	1	284	0.4%	126
Benzene	17	327	11/28/2001	12/5/2017	23	7%	11/2/2010	3.2	0.24	0.91	0.1	2	ug/L	0.44	11/2/2010	19	6	6%	101
Bromochloromethane	13	285	11/28/2001	12/5/2017		0%					0.1	2						0%	
Bromodichloromethane	13	285	11/28/2001	12/5/2017		0%					0.2	2		0.73	3/26/2004	0	6	0%	
Bromoform	13	285	11/28/2001	12/5/2017		0%					0.2	2		4.6				0%	
Bromomethane	13	285	11/28/2001	12/5/2017	3	1%	10/20/2009	2.7	0.21	1.1	0.1	2	ug/L	300				0%	
Carbon Disulfide	13	285	11/28/2001	12/5/2017	4	1%	5/10/2007	0.7	0.31	0.51	0.1	2	ug/L					0%	
Carbon Tetrachloride	13	285	11/28/2001	12/5/2017		0%					0.2	2		0.2	12/5/2017	0	285	0%	
Chlorobenzene	13	285	11/28/2001	12/5/2017		0%					0.1	2		100				0%	
Chloroethane	13	285	11/28/2001	12/5/2017	19	7%	11/5/2010	1.8	0.29	0.926	0.1	2	ug/L					0%	
Chloroform	13	285	11/28/2001	12/5/2017		0%					0.1	2		100				0%	
Chloromethane	13	283	11/28/2001	12/5/2017	20	7%	6/23/2015	2.79	0.21	0.468	0.2	2	ug/L					0%	
Chloroprene	5	39	11/28/2001	12/23/2004		0%					20	200						0%	
cis-1,2-Dichloroethene (DCE)	17	327	11/28/2001	12/5/2017	47	14%	11/5/2010	2	0.22	0.775	0.1	2	ug/L					0%	
cis-1,3-Dichloropropene	13	285	11/28/2001	12/5/2017		0%					0.2	2						0%	
Dibromochloromethane	13	285	11/28/2001	12/5/2017		0%					0.2	2		0.6	3/26/2004	0	6	0%	
Dibromomethane	13	285	11/28/2001	12/5/2017		0%					0.1	2		48				0%	
Dichlorodifluoromethane	17	327	11/28/2001	12/5/2017	56	17%	11/5/2010	4.8	0.24	1.78	0.1	2	ug/L					0%	
Ethylbenzene	13	285	11/28/2001	12/5/2017	4	1%	10/7/2008	0.32	0.23	0.26	0.1	2	ug/L	29				0%	
m,p-Xylene	10	128	1/21/2010	12/5/2017		0%					0.1	0.2						0%	
Methacrylonitrile	5	39	11/28/2001	12/23/2004		0%					5	50						0%	
Methyl Methacrylate	5	39	11/28/2001	12/23/2004		0%					2	20						0%	
Methylene Chloride	13	285	11/28/2001	12/5/2017	5	2%	5/24/2011	6.7	0.21	2.22	0.2	2.5	ug/L	10				0%	
Methyliodide	13	285	11/28/2001	12/5/2017	1	0%	10/20/2009	0.21	0.21	0.21	0.1	2	ug/L					0%	
o-Xylene	10	167	11/28/2001	12/5/2017		0%					0.1	2						0%	
Propionitrile	5	39	11/28/2001	12/23/2004		0%					60	60						0%	
Styrene	13	285	11/28/2001	12/5/2017		0%					0.1	2						0%	
Tetrachloroethene (PCE)	13	285	11/28/2001	12/5/2017		0%					0.1	2		2.4				0%	
Toluene	13	285	11/28/2001	12/5/2017	30	11%	11/2/2010	4.3	0.2	0.49	0.1	2	ug/L	72				0%	
trans-1,2-Dichloroethene	17	327	11/28/2001	12/5/2017	12	4%	11/2/2010	0.61	0.22	0.33	0.1	2	ug/L	200				0%	
trans-1,3-Dichloropropene	13	285	11/28/2001	12/5/2017		0%					0.2	2						0%	
Trichloroethene (TCE)	13	285	11/28/2001	12/5/2017	1	0%	5/9/2007	0.22	0.22	0.22	0.1	2	ug/L	0.3	3/26/2004	0	6	0%	
Trichlorofluoromethane	17	327	11/28/2001	12/5/2017	30	9%	11/5/2010	2.41	0.22	0.922	0.1	2	ug/L					0%	
Vinyl Acetate	13	285	11/28/2001	12/5/2017		0%					0.1	2						0%	
Vinyl Chloride	17	337	11/28/2001	12/5/2017	113	34%	12/5/2017	7.4	0.02	0.616	0.01	0.2	ug/L	0.02	12/5/2017	113	218	34%	0

Notes:

PCUL = Preliminary Cleanup Level

RDL = Reporting Detection Limit

Table 6.5 - Summary of Surface Water Cleanup Levels for Constituents of Concern

DRAFT

Project No. 090057-310.3, Vashon Island Closed Landfill, Vashon Island, King County, Washington

			Protection of Surface Water for Human Health		Protection of Surface Water for Ecological Protection		Lowest Value, All Receptor Pathways
	units	RDL	Cleanup Level	Source of Cleanup Level	Cleanup Level	Source of Cleanup Level	
Metals [a]							
Arsenic	µg/L	1	5 [b]	Background	5 [b]	Background	5 [b]
Iron	µg/L	10			1,000	CWA	1,000
Volatile Organic Compounds							
1,2-Dichloropropane	µg/L		0.71	CWA			0.71
Benzene	µg/L	0.2	0.44	CWA			0.44
Trichloroethene (TCE)	µg/L		0.3	CWA			0.3
Vinyl chloride	µg/L	0.02	0.02	CWA			0.02

Notes:

Refer to Table 5.1 for a full list of criteria and analytes

µg/L = micrograms per liter

CWA = Clean Water Act

MTCA = Model Toxics Control Act

RDL = Reporting Detection Limit

a - Metals PCULs for human receptors is based on total and dissolved and dissolved fraction only for ecological receptors, as this fraction is more toxic to ecological receptors compared to the total fraction.

b - Arsenic is based on background for Washington state per MTCA Method A Table 720-1 WAC 173-340-900. Adjustment to background is allowable per WAC 173-340-720(7)(c).

Table 6.6 - Summary of Volatile Organic Compounds in Landfill Gas

Project No. 090057-310.3, Vashon Island Closed Landfill, King County, Washington

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	Sample Location:	Blower Inlet				EF-2			
	Date:	5/1/2013		5/1/2013		5/1/2013		5/1/2013	
Chemical	Units	Concentration	Qualifier	Concentration	Qualifier	Concentration	Qualifier	Concentration	Qualifier
Acetone	µg/m^3	**34.0**		**46.0**		**27.9**		**35.7**	
Acrolein (Propenal)	µg/m^3	1.2	U	1.2	U	1	U	5	
Benzene	µg/m^3	**56.0**		**21.4**		**24.0**		**11.8**	
Benzyl Chloride	µg/m^3	2.6	U	2.6	U	2.6	U	2.6	U
Bromomethane	µg/m^3	1.9	U	1.9	U	1.9	U	1.9	U
Bromoform	µg/m^3	2.1	U	2.1	U	2.1	U	2.1	U
1,3-Butadiene	µg/m^3	1.1	U	1.1	U	1.1	U	1.1	U
Carbon Disulfide	µg/m^3	6.2	U	**4.1**		0.6	U	0.6	U
Carbon Tetrachloride	µg/m^3	1.3	U	1.3	U	1.3	U	1.3	U
Chlorobenzene	µg/m^3	0.9	U	0.9	U	0.9	U	0.9	U
Chloroethane	µg/m^3	1.3	U	**49.8**		1.3	U	**17.6**	
Chloroform	µg/m^3	1.0	U	1.0	U	1.0	U	1.0	U
Chloromethane	µg/m^3	1.0	U	**7.5**		1.0	U	**3.1**	
Cyclohexane	µg/m^3	**255.0**	**B**	**68.2**	**B**	**116.0**	**B**	**33.7**	**B**
1,2-Dibromoethane (EDB)	µg/m^3	1.5	U	1.5	U	1.5	U	1.5	U
Dibromochloromethane	µg/m^3	4.3	U	4.3	U	4.3	U	4.3	U
1,2-Dichlorobenzene	µg/m^3	1.8	U	1.8	U	1.8	U	7.5	U
1,3-Dichlorobenzene	µg/m^3	1.8	U	1.8	U	1.8	U	**2.7**	
1,4-Dichlorobenzene	µg/m^3	1.8	U	1.8	U	1.8	U	1.8	U
Dichlorobromomethane	µg/m^3	2.0	U	2.0	U	2.0	U	2.0	U
1,1-Dichloroethane	µg/m^3	**10.0**		**5.7**		**6.8**		**4.1**	
1,2-Dichloroethane	µg/m^3	**6.5**		0.9	U	0.8	U	0.8	U
1,1-Dichloroethene	µg/m^3	0.8	U	0.8	U	0.8	U	0.8	U
cis-1,2-Dichloroethene	µg/m^3	**23.8**		**12.8**		0.8	U	**3.9**	
trans-1,2-Dichloroethene	µg/m^3	0.8	U	0.8	U	0.8	U	0.8	U
1,2-Dichloropropane	µg/m^3	2.3	U	2.3	U	2.3	U	2.3	U
trans-1,3-dichloropropene	µg/m^3	2.3	U	2.3	U	2.3	U	2.3	U
cis-1,3-Dichloropene	µg/m^3	2.3	U	2.3	U	2.3	U	2.3	U
1,4-Dioxane	µg/m^3	3.6	U	3.6	U	3.6	U	3.6	U
Ethyl Acetate	µg/m^3	3.6	U	3.6	U	3.6	U	3.6	U
Ethyl Benzene	µg/m^3	**951.0**		**5.2**		**165.0**		**5.0**	
4-Ethyltoluene	µg/m^3	1.5	U	**3.2**		1.5	U	1.5	U
Freon 11	µg/m^3	1.7	U	1.7	U	**56.6**		**48.2**	
Freon 12	µg/m^3	**174.0**		**135.0**		**175.0**		**125.0**	
Freon 113	µg/m^3	**25.8**		**20.4**		3.8	U	3.8	U
Freon 114	µg/m^3	**67.1**		**62.4**		**134.0**		**133.0**	
Heptane	µg/m^3	**407.0**		**36.6**		**195.0**		**22.3**	
Hexachlorobutadiene	µg/m^3	10.7	U	10.7	U	10.7	U	10.7	U
Hexane	**µg/m^3**	**282.0**	**B**	**114.0**	**B**	**240.0**	**B**	**98.8**	**B**
2-Hexanone	µg/m^3	4.1	U	4.1	U	4.1	U	4.1	U
Methyl Ethyl Ketone (2-Butanone)	µg/m^3	**15.8**		**72.8**		1.5	U	**68.0**	
4-Methyl-2-pentanone (MIBK)	µg/m^3	4.1	U	4.1	U	4.1	U	4.1	U
Methyl tert-butyl ether (MTBE)	µg/m^3	0.7	U	0.7	U	0.7	U	0.7	U
Methyl methacrylate	µg/m^3	1.2	U	1.2	U	1.2	U	1.2	U

Table 6.6 - Summary of Volatile Organic Compounds in Landfill Gas

Project No. 090057-310.3, Vashon Island Closed Landfill, King County, Washington

	Sample Location:	Blower Inlet				EF-2			
	Date:	5/1/2013		5/1/2013		5/1/2013		5/1/2013	
Chemical	**Units**	**Concentration**	**Qualifier**	**Concentration**	**Qualifier**	**Concentration**	**Qualifier**	**Concentration**	**Qualifier**
Methylene chloride	µg/m^3	1.7	U	**28.8**		**9.7**		3.8	U
Naphthalene	µg/m^3	1.6	U	1.6	U	1.6	U	1.6	U
2-Propanol (isopropyl alcohol)	µg/m^3	**7.9**		**9.7**		2.5	U	9.7	U
Propylene	µg/m^3	**676.0**		**621.0**		**295.0**		**281.0**	
Styrene	µg/m^3	1.3	U	1.3	U	1.3	U	1.3	U
1,1,2,2-Tetrachloroethane	µg/m^3	2.1	U	2.1	U	2.1	U	2.1	U
Tetrachloroethene	µg/m^3	**15.7**		2.0	U	**18.5**		2.0	U
Tetrahydrofuran	µg/m^3	**132.0**		**31.2**		**7.8**		**26.6**	
Toluene	µg/m^3	**147.0**		**42.6**		**48.5**		**44.1**	
1,2,4-Trichlorobenzene	µg/m^3	2.2	U	2.2	U	2.2	U	2.2	U
1,1,1-Trichloroethane	µg/m^3	**27.1**		**9.0**		1.1	U	1.1	U
1,1,2-Trichloroethane	µg/m^3	2.7	U	2.7	U	2.7	U	2.7	U
Trichloroethene	µg/m^3	**9.0**		1.1	U	1.1	U	1.1	U
1,2,4-Trimethylbenzene	µg/m^3	**14.2**		**5.2**		**9.0**		**5.3**	
1,3,5-Trimethylbenzene	µg/m^3	**9.1**		1.5	U	1.5	U	1.5	U
Vinyl Acetate	µg/m^3	3.5	U	3.5	U	**57.7**		3.5	U
Vinyl Chloride	µg/m^3	**64.8**		**69.9**		**55.0**		**60.0**	
m,p-Xylene	µg/m^3	**1,010.0**		**9.5**		**142.0**		**9.6**	
o-Xylene	µg/m^3	**299.0**		**6.2**		**63.9**		**6.3**	
	Sample Collection Method:	TB		Summa		TB		Summa	

Notes:
U - Compound analyzed for but not detected above the reporting limit
J - Estimated value
B - Analyte dected in associated Method Blank
Bold - Detected compound above laboratory reporting limit.
TB = Tedlar Bag sample
Summa = Summa cannister sample
Source of data: Herrera Environmental Consultants, 2013
µg/m^3 = micrograms per cubic meter

Table 6.7 - Summary of Leachate Detections

Project No. 090057-310.3, Vashon Island Closed Landfill, Vashon Island, King County, Washington

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Analyte	Number of Sampled Locations	Number of Samples (excluding Field Dups)	First Sample Date	Most Recent Available Sample Date	Number of Samples with Detected Concentration	Frequency of Detection	Last Sample Date with Detected Concentration	Maxumim Detected Concentration	Minimum Detected Concentraion	Average Detected Concentration	Minimum Reporting Limit	Maximum Reporting Limit	Units
Bacteria													
Fecal Coliform	2	220	10/11/2001	12/5/2017	50	23%	12/5/2017	120000	1	4700	1	100	cfu/100ml
Total Coliform	2	219	10/11/2001	12/5/2017	160	73%	12/5/2017	2500000	0	54000	1	10000	cfu/100ml
Conventionals													
Alkalinity, Total	2	220	10/11/2001	12/5/2017	218	99%	12/5/2017	1300	21	252	1	4	mg/l
Ammonia as N	2	220	10/11/2001	12/5/2017	126	57%	12/5/2017	58	0.0022	6.94	0.002	0.05	mg/l
Chemical Oxygen Demand	2	220	10/11/2001	12/5/2017	216	98%	12/5/2017	450	7	73.9	5	5	mg/l
Chloride	2	215	10/11/2001	12/5/2017	215	100%	12/5/2017	640	2	229			mg/l
Cyanide	2	220	10/11/2001	12/5/2017	3	1%	9/23/2005	0.04	0.011	0.024	0.008	0.05	mg/l
Dissolved Organic Carbon	1	2	9/16/2015	2/25/2016	2	100%	2/25/2016	19.5	5.53	12.5			mg/l
Fecal Coliform	2	220	10/11/2001	12/5/2017	50	23%	12/5/2017	120000	1	4700	1	100	cfu/100ml
Fluoride	2	217	10/11/2001	12/5/2017	40	18%	12/5/2017	1	0.0436	0.198	0.1	10	mg/l
Nitrate + Nitrite as N	2	218	10/11/2001	12/5/2017	200	92%	12/5/2017	126	0.011	32.8	0.01	1.3	mg/l
Nitrate as N	1	2	9/16/2015	2/25/2016	2	100%	2/25/2016	44.8	7.43	26.1			mg/l
Nitrite as N	1	2	9/16/2015	2/25/2016		0%					0.01	0.01	
pH	3	158	10/11/2001	12/29/2009	158	100%	12/29/2009	8.6	3.7	7.43			pH units
Phosphate, Total	2	63	10/11/2001	8/5/2005	59	94%	8/5/2005	1.7	0.01	0.2	0.01	0.04	mg/l
Phosphorus	2	157	9/23/2005	12/5/2017	104	66%	9/21/2016	1.84	0.0123	0.103	0.01	1	mg/l
Phosphorus, Soluble Reactive	2	220	10/11/2001	12/5/2017	173	79%	12/5/2017	2	0.0064	0.0786	0.01	0.01	mg/l
Silica	1	2	9/16/2015	2/25/2016	2	100%	2/25/2016	20	19	20			mg/l
Specific Conductance	2	102	4/21/2009	12/5/2017	102	100%	12/5/2017	4560	114	1900			uS/cm
Sulfate	2	215	10/11/2001	12/5/2017	214	100%	12/5/2017	1200	4.5	329	5	5	mg/l
Sulfide	3	172	10/24/2001	12/5/2017	39	23%	12/5/2017	3.2	0.01	0.248	0.01	1	mg/l
Total Coliform	2	219	10/11/2001	12/5/2017	160	73%	12/5/2017	2500000	0	54000	1	10000	cfu/100ml
Total Dissolved Solids	1	2	3/5/2013	4/2/2013	2	100%	4/2/2013	2540	1970	2260			mg/l
Total Kjeldahl Nitrogen	2	220	10/11/2001	12/5/2017	192	87%	12/5/2017	64	0.245	6.87	0.5	1	mg/l
Total Organic Carbon	2	220	10/11/2001	12/5/2017	218	99%	12/5/2017	130	2.5	25.3	1	10	mg/l
Total Organic Halides (TOX)	2	146	10/11/2001	12/15/2010	108	74%	12/15/2010	170	0.05	1.79	0.05	0.2	mg/l
Total Suspended Solids	3	236	10/11/2001	12/5/2017	188	80%	12/5/2017	9000	1	139	0.5	8	mg/l
Total Volatile Solids	2	220	10/11/2001	12/5/2017	220	100%	12/5/2017	2000	6	388			mg/l
Fats/Oils/Grease (Non-Polar)	2	117	10/11/2001	3/12/2009	4	3%	3/1/2006	15	1.2	4.8	1	5.2	mg/l
Fats/Oils/Grease (Polar)	2	62	10/11/2001	8/5/2005	5	8%	8/23/2004	27	1.5	20	1	5	mg/l
Fats/Oils/Grease (Total)	3	202	10/11/2001	12/21/2017	41	20%	12/21/2017	27	1.2	5.5	1	5	mg/l
Dissolved Gases													
Ethane	1	2	9/16/2015	2/25/2016	2	100%	2/25/2016	0.0039	0.0029	0.0034			ug/l
Ethene	1	2	9/16/2015	2/25/2016	2	100%	2/25/2016	0.017	0.0081	0.013			ug/l
Methane	1	2	9/16/2015	2/25/2016	2	100%	2/25/2016	0.29	0.12	0.21			ug/l
Field Parameters													
Dissolved Oxygen	1	2	9/16/2015	2/25/2016	2	100%	2/25/2016	9.46	9.11	9.29			mg/L
Oxidation-Reduction Potential	1	1	9/16/2015	9/16/2015	1	100%	9/16/2015	179	179	179			mV
pH	3	269	10/11/2001	12/21/2017	269	100%	12/21/2017	8.88	3.66	7.39			pH units
Specific Conductance	3	269	10/11/2001	12/21/2017	269	100%	12/21/2017	5100	16.5	1200			uS/cm
Temperature	3	269	10/11/2001	12/21/2017	269	100%	12/21/2017	22.9	3.3	13.86			deg C
Turbidity	1	2	9/16/2015	2/25/2016	2	100%	2/25/2016	16.12	8.88	12.5			NTU
Isotope Ratios													
Age (DIC isotope ratio)	1	2	9/16/2015	2/25/2016		0%							
Age (DOC isotope ratio)	1	1	2/25/2016	2/25/2016	1	100%	2/25/2016	210	210	210			years
d13C of DIC	1	2	9/16/2015	2/25/2016	2	100%	2/25/2016	-13.8	-14.8	-14.3			o/oo VPDB
d13C of DOC	1	1	2/25/2016	2/25/2016	1	100%	2/25/2016	-45.05	-45.05	-45.05			o/oo VPDB
d14C of DIC	1	2	9/16/2015	2/25/2016	2	100%	2/25/2016	103	101.5	102.3			pMC
d14C of DOC	1	1	2/25/2016	2/25/2016	1	100%	2/25/2016	-33.28	-33.28	-33.28			o/oo VPDB
d18O of Water	1	2	9/16/2015	2/25/2016	3	150%	2/25/2016	-9.01	-9.6	-9.29			o/oo VSMOW
d2H of Water	1	2	9/16/2015	2/25/2016	3	150%	2/25/2016	-59	-66.9	-63.9			o/oo VSMOW
d34S of Sulfate	1	2	9/16/2015	2/25/2016	2	100%	2/25/2016	17.6	15.9	16.8			o/oo VCDT
Fraction Modern Carbon in DOC	1	1	2/25/2016	2/25/2016	1	100%	2/25/2016	0.9745	0.9745	0.9745			None
Metals (dissolved)													
Aluminum	3	184	10/11/2001	2/25/2016	44	24%	7/15/2008	1800	21	173	0.018	0.1	ug/l
Antimony	3	121	9/23/2005	2/25/2016	5	4%	11/16/2009	2.78	0.171	1.41	0.0009	0.001	ug/l
Arsenic	3	121	9/23/2005	2/25/2016	60	50%	12/29/2009	26	0.94	4.77	0.001	0.001	ug/l
Barium	3	184	10/11/2001	2/25/2016	184	100%	2/25/2016	290	1	73.6			ug/l
Beryllium	3	184	10/11/2001	2/25/2016		0%					0.0009	0.005	
Cadmium	3	184	10/11/2001	2/25/2016	8	4%	8/13/2008	10	2	4.9	0.0018	0.002	ug/l
Calcium	3	181	10/11/2001	2/25/2016	181	100%	2/25/2016	290000	12000	129000			ug/l
Chromium	3	184	10/11/2001	2/25/2016	10	5%	7/19/2006	8	5	6.45	0.0045	0.025	ug/l
Cobalt	3	184	10/11/2001	2/25/2016	112	61%	4/2/2013	32	3	9.2	0.0027	0.003	ug/l
Copper	3	184	10/11/2001	2/25/2016	161	88%	2/25/2016	2900	2	24.5	0.0018	0.002	ug/l
Iron	3	184	10/11/2001	2/25/2016	129	70%	2/7/2013	5200	11	713	0.005	0.01	ug/l
Lead	3	184	10/11/2001	2/25/2016	8	4%	7/19/2006	17	0.212	3.83	0.0009	0.001	ug/l
Magnesium	3	183	10/11/2001	2/25/2016	183	100%	2/25/2016	155000	2700	64400			ug/l
Manganese	3	182	10/11/2001	2/25/2016	138	76%	4/2/2013	9300	1.2	1420	0.0009	0.001	ug/l
Mercury	2	120	9/23/2005	2/25/2016	1	1%	12/22/2005	3.7	3.7	3.7	0.0001	0.00014	ug/l
Nickel	3	184	10/11/2001	2/25/2016	147	80%	2/25/2016	209	11	70	0.01	0.01	ug/l

Table 6.7 - Summary of Leachate Detections

Project No. 090057-310.3, Vashon Island Closed Landfill, Vashon Island, King County, Washington

Analyte	Number of Sampled Locations	Number of Samples (excluding Field Dups)	First Sample Date	Most Recent Available Sample Date	Number of Samples with Detected Concentration	Frequency of Detection	Last Sample Date with Detected Concentration	Maxumim Detected Concentration	Minimum Detected Concentraion	Average Detected Concentration	Minimum Reporting Limit	Maximum Reporting Limit	Units
Potassium	3	183	10/11/2001	2/25/2016	183	100%	2/25/2016	110000	1600	23600			ug/l
Selenium	3	121	9/23/2005	2/25/2016	44	36%	8/12/2009	100	1.1	17.3	0.0009	0.001	ug/l
Silver	3	184	10/11/2001	2/25/2016	2	1%	9/23/2005	22	0.124	11.1	0.0027	0.003	ug/l
Sodium	3	179	10/11/2001	2/25/2016	179	100%	2/25/2016	520000	3300	152000			ug/l
Thallium	3	121	9/23/2005	2/25/2016	1	1%	1/28/2008	1.3	1.3	1.3	0.0009	0.001	ug/l
Tin	3	184	10/11/2001	2/25/2016	1	1%	9/23/2005	0.982	0.982	0.982	0.009	0.01	ug/l
Vanadium	3	184	10/11/2001	2/25/2016	34	18%	9/29/2009	5	1.91	2.94	0.0018	0.002	ug/l
Zinc	3	183	10/11/2001	2/25/2016	175	96%	2/25/2016	420	5	54.6	0.004	0.004	ug/l
Metals (total)													
Aluminum	3	236	10/11/2001	12/5/2017	127	54%	12/5/2017	280000	20	6090	0.02	0.2	ug/l
Antimony	3	224	10/11/2001	12/5/2017	18	8%	11/16/2009	5	0.205	1.74	0.0009	0.01	ug/l
Arsenic	3	275	10/11/2001	12/21/2017	154	56%	12/21/2017	230	1	13.4	0.001	0.01	ug/l
Barium	3	236	10/11/2001	12/5/2017	236	100%	12/5/2017	2200	8.96	102			ug/l
Beryllium	3	236	10/11/2001	12/5/2017	1	0.4%	10/24/2003	2	2	2	0.0009	0.01	ug/l
Cadmium	3	275	10/11/2001	12/21/2017	16	6%	3/12/2009	17	2	4.8	0.0005	0.02	ug/l
Calcium	3	231	10/11/2001	12/5/2017	231	100%	12/5/2017	630000	8440	129000			ug/l
Chromium	3	275	10/11/2001	12/21/2017	43	16%	6/14/2013	520	5	41.2	0.002	0.05	ug/l
Cobalt	3	236	10/11/2001	12/5/2017	145	61%	12/5/2017	200	1.53	11.3	0.0005	0.03	ug/l
Copper	3	275	10/11/2001	12/21/2017	238	87%	12/21/2017	250	2.09	12.4	0.0018	0.02	ug/l
Iron	3	235	10/11/2001	12/5/2017	205	87%	12/5/2017	570000	29	9120	0.01	0.1	ug/l
Lead	3	275	10/11/2001	12/21/2017	48	17%	12/21/2017	170	0.271	17.2	0.0009	0.01	ug/l
Magnesium	3	234	10/11/2001	12/5/2017	234	100%	12/5/2017	197000	2800	63900			ug/l
Manganese	3	232	10/11/2001	12/5/2017	214	92%	12/5/2017	64000	1.23	1820	0.001	0.001	ug/l
Mercury	3	242	10/11/2001	12/5/2017	8	3%	2/11/2009	0.8	0.1	0.268	0.0001	0.0005	ug/l
Nickel	3	275	10/11/2001	12/21/2017	194	71%	12/21/2017	590	2.4	70.3	0.01	0.1	ug/l
Potassium	3	234	10/11/2001	12/5/2017	230	98%	12/5/2017	61000	1470	22500	5	60	ug/l
Selenium	3	224	10/11/2001	12/5/2017	94	42%	7/15/2009	65.8	1.1	20.2	0.0009	0.01	ug/l
Silver	3	275	10/11/2001	12/21/2017	1	0.4%	9/23/2005	0.142	0.142	0.142	0.0004	0.03	ug/l
Sodium	3	230	10/11/2001	12/5/2017	230	100%	12/5/2017	1700000	3500	151000			ug/l
Thallium	3	224	10/11/2001	12/5/2017	3	1%	6/21/2007	1.6	1	1.2	0.0009	0.01	ug/l
Tin	3	236	10/11/2001	12/5/2017	5	2%	4/27/2010	206	0.843	49.8	0.005	0.1	ug/l
Vanadium	3	236	10/11/2001	12/5/2017	65	28%	12/5/2017	590	0.863	26.4	0.00075	0.02	ug/l
Zinc	3	274	10/11/2001	12/21/2017	268	98%	12/21/2017	2700	5	106	0.004	0.005	ug/l
PCBs													
Aroclor 1016	2	219	10/11/2001	12/5/2017		0%					0.01	1	
Aroclor 1221	2	219	10/11/2001	12/5/2017		0%					0.01	1	
Aroclor 1232	2	219	10/11/2001	12/5/2017		0%					0.01	1	
Aroclor 1242	2	219	10/11/2001	12/5/2017		0%					0.01	1	
Aroclor 1248	2	219	10/11/2001	12/5/2017		0%					0.01	1	
Aroclor 1254	2	219	10/11/2001	12/5/2017		0%					0.01	1	
Aroclor 1260	2	219	10/11/2001	12/5/2017	1	0.5%	2/11/2010	0.0316	0.0316	0.0316	0.01	1	ug/l
Total Aroclors	2	53	3/7/2012	12/5/2017		0%					0.025	0.025	
Radioactive Chemistry													
Gross Alpha Activity	2	10	2/4/2003	1/28/2008	4	40%	1/28/2008	12	3.6	7.8	3	7.4	pci/l
Gross Beta Activity	2	10	2/4/2003	1/28/2008	8	80%	1/28/2008	39	4.4	18	6	6	pci/l
Radium 226 AND 228	2	10	2/4/2003	1/28/2008	3	30%	1/28/2008	1.7	1	1.4	1	2	pci/l
Radium-226	2	10	2/4/2003	1/28/2008		0%					1	1.4	
Radium-228	2	10	2/4/2003	1/28/2008	2	20%	1/28/2008	1.5	1.3	1.4	1	2	pci/l
Tritium	1	2	9/16/2015	2/25/2016	2	100%	2/25/2016	122	13	67.5			TU
Pesticides													
2,4,5-T	2	220	10/11/2001	12/5/2017		0%					0.25	30	
2,4,5-TP Silvex	2	220	10/11/2001	12/5/2017	1	0%	9/23/2005	7	7	7	0.25	15	ug/l
2,4-D	2	220	10/11/2001	12/5/2017	2	1%	12/5/2017	6.54	0.667	3.6	0.5	75	ug/l
4,4'DDD	2	220	10/11/2001	12/5/2017		0%					0.01	10	
4,4'DDE	2	220	10/11/2001	12/5/2017		0%					0.01	10	
4,4'DDT	2	220	10/11/2001	12/5/2017		0%					0.01	10	
Aldrin	2	220	10/11/2001	12/5/2017		0%					0.01	2.4	
Alpha BHC	2	220	10/11/2001	12/5/2017		0%					0.01	2.4	
Alpha Chlordane	2	220	10/11/2001	12/5/2017		0%					0.01	2.4	
Beta BHC	2	220	10/11/2001	12/5/2017		0%					0.01	2.4	
Delta BHC	2	220	10/11/2001	12/5/2017		0%					0.01	10	
Dieldrin	2	220	10/11/2001	12/5/2017		0%					0.01	10	
Dinoseb	2	220	10/11/2001	12/5/2017	2	1%	3/22/2005	2.9	1.4	2.2	0.25	15	ug/l
Endosulfan I	2	220	10/11/2001	12/5/2017		0%					0.01	10	
Endosulfan II	2	220	10/11/2001	12/5/2017		0%					0.01	10	
Endosulfan Sulfate	2	220	10/11/2001	12/5/2017		0%					0.01	10	
Endrin	2	220	10/11/2001	12/5/2017		0%					0.01	10	
Endrin Aldehyde	2	220	10/11/2001	12/5/2017		0%					0.01	20	
Heptachlor	2	220	10/11/2001	12/5/2017		0%					0.01	2.4	
Heptachlor Epoxide	2	220	10/11/2001	12/5/2017		0%					0.01	2.4	
Isodrin	2	220	10/11/2001	12/5/2017		0%					0.01	1000	
Lindane (Gamma BHC)	2	220	10/11/2001	12/5/2017		0%					0.01	2.4	

Table 6.7 - Summary of Leachate Detections

Project No. 090057-310.3, Vashon Island Closed Landfill, Vashon Island, King County, Washington

Analyte	Number of Sampled Locations	Number of Samples (excluding Field Dups)	First Sample Date	Most Recent Available Sample Date	Number of Samples with Detected Concentration	Frequency of Detection	Last Sample Date with Detected Concentration	Maxumim Detected Concentration	Minimum Detected Concentraion	Average Detected Concentration	Minimum Reporting Limit	Maximum Reporting Limit	Units
Methoxychlor	2	220	10/11/2001	12/5/2017		0%					0.05	200	
Toxaphene	2	220	10/11/2001	12/5/2017		0%					1	240	
VOCs													
1,1,1,2-Tetrachloroethane	2	218	10/11/2001	12/5/2017		0%					0.2	4	
1,1,1-Trichloroethane	2	218	10/11/2001	12/5/2017		0%					0.2	4	
1,1,2,2-Tetrachloroethane	2	218	10/11/2001	12/5/2017		0%					0.2	4	
1,1,2-Trichloroethane	2	218	10/11/2001	12/5/2017		0%					0.2	4	
1,1-Dichloroethane	2	218	10/11/2001	12/5/2017		0%					0.2	4	
1,1-Dichloroethene	2	218	10/11/2001	12/5/2017		0%					0.2	4	
1,1-Dichloropropene	2	218	10/11/2001	12/5/2017		0%					0.2	4	
1,2,3-Trichloropropane	2	218	10/11/2001	12/5/2017		0%					0.2	4	
1,2-Dibromo-3-chloropropane	2	218	10/11/2001	12/5/2017		0%					0.2	25	
1,2-Dibromoethane (EDB)	2	218	10/11/2001	12/5/2017		0%					0.2	4	
1,2-Dichlorobenzene	2	218	10/11/2001	12/5/2017		0%					0.2	4	
1,2-Dichloroethane (EDC)	2	218	10/11/2001	12/5/2017		0%					0.2	4	
1,2-Dichloropropane	2	218	10/11/2001	12/5/2017		0%					0.2	4	
1,3-Dichlorobenzene	2	218	10/11/2001	12/5/2017		0%					0.2	4	
1,3-Dichloropropane	2	218	10/11/2001	12/5/2017		0%					0.2	4	
1,4-Dichloro-2-Butene	2	218	10/11/2001	12/5/2017		0%					5	2000	
1,4-Dichlorobenzene	2	218	10/11/2001	12/5/2017		0%					0.2	4	
2,2-Dichloropropane	2	218	10/11/2001	12/5/2017		0%					0.2	4	
2-Butanone	2	218	10/11/2001	12/5/2017	7	3%	9/21/2016	43.7	4.15	16.9	2.5	80	ug/l
2-Hexanone	2	218	10/11/2001	12/5/2017		0%					4	80	
2-Methyl-1-Propanol	2	218	10/11/2001	12/5/2017	1	0.5%	9/28/2007	1500	1500	1500	50	1000	ug/l
3-Chloropropene	2	218	10/11/2001	12/5/2017		0%					1	200	
4-Methyl-2-pentanone	2	218	10/11/2001	12/5/2017		0%					4	80	
Acetone	2	218	10/11/2001	12/5/2017	43	20%	9/21/2016	380	2.5	19.4	4	80	ug/l
Acetonitrile	2	218	10/11/2001	12/5/2017		0%					25	1000	
Acrolein	2	218	10/11/2001	12/5/2017		0%					10	200	
Acrylonitrile	2	218	10/11/2001	12/5/2017		0%					0.07	200	
Benzene	2	218	10/11/2001	12/5/2017	1	0.5%	6/8/2006	0.27	0.27	0.27	0.2	4	ug/l
Bromochloromethane	2	218	10/11/2001	12/5/2017		0%					0.2	4	
Bromodichloromethane	2	218	10/11/2001	12/5/2017		0%					0.2	4	
Bromoform	2	218	10/11/2001	12/5/2017		0%					0.2	5	
Bromomethane	2	218	10/11/2001	12/5/2017	2	1%	10/19/2009	3.4	0.22	1.8	0.2	4	ug/l
Carbon Disulfide	2	218	10/11/2001	12/5/2017	2	1%	7/19/2006	0.31	0.28	0.3	0.2	4	ug/l
Carbon Tetrachloride	2	218	10/11/2001	12/5/2017		0%					0.2	4	
Chlorobenzene	2	218	10/11/2001	12/5/2017	1	0.5%	11/27/2001	2.2	2.2	2.2	0.2	4	ug/l
Chloroethane	2	218	10/11/2001	12/5/2017	5	2%	7/10/2013	4.37	0.21	1.37	0.2	4	ug/l
Chloroform	2	218	10/11/2001	12/5/2017	1	0.5%	10/19/2009	0.28	0.28	0.28	0.2	4	ug/l
Chloromethane	2	215	10/11/2001	12/5/2017	16	7%	4/2/2013	1.1	0.21	0.504	0.2	4	ug/l
Chloroprene	2	218	10/11/2001	12/5/2017		0%					1	400	
cis-1,2-Dichloroethene (DCE)	2	218	10/11/2001	12/5/2017		0%					0.2	4	
cis-1,3-Dichloropropene	2	218	10/11/2001	12/5/2017		0%					0.2	4	
Dibromochloromethane	2	218	10/11/2001	12/5/2017		0%					0.2	5	
Dibromomethane	2	218	10/11/2001	12/5/2017		0%					0.2	4	
Dichlorodifluoromethane	2	218	10/11/2001	12/5/2017		0%					0.2	4	
Ethylbenzene	2	218	10/11/2001	12/5/2017	3	1%	7/28/2009	7.79	0.22	2.75	0.2	4	ug/l
FREON 113	2	2	5/25/2017	9/6/2017	2	100%	9/6/2017	0.134	0.088	0.111			ug/l
m,p-Xylene	2	88	1/28/2010	12/5/2017	1	1%	1/8/2014	0.37	0.37	0.37	0.2	1	ug/l
Methacrylonitrile	2	218	10/11/2001	12/5/2017		0%					1	100	
Methyl Methacrylate	2	218	10/11/2001	12/5/2017		0%					2	40	
Methylene Chloride	2	218	10/11/2001	12/5/2017	27	12%	11/21/2016	24	0.21	6.4	0.2	25	ug/l
Methyliodide	2	218	10/11/2001	12/5/2017	1	0.5%	10/19/2009	0.24	0.24	0.24	0.2	4	ug/l
o-Xylene	2	218	10/11/2001	12/5/2017	6	3%	1/8/2014	10.6	0.2	4.33	0.2	4	ug/l
Propionitrile	2	218	10/11/2001	12/5/2017		0%					5	600	
Styrene	2	218	10/11/2001	12/5/2017		0%					0.2	4	
Tetrachloroethene (PCE)	2	218	10/11/2001	12/5/2017		0%					0.2	4	
Toluene	2	218	10/11/2001	12/5/2017	8	4%	10/5/2011	12	0.23	1.86	0.2	4	ug/l
trans-1,2-Dichloroethene	2	218	10/11/2001	12/5/2017		0%					0.2	4	
trans-1,3-Dichloropropene	2	218	10/11/2001	12/5/2017		0%					0.2	5	
Trichloroethene (TCE)	2	218	10/11/2001	12/5/2017		0%					0.2	4	
Trichlorofluoromethane	2	218	10/11/2001	12/5/2017	6	3%	10/5/2011	1.4	0.501	1.01	0.2	4	ug/l
Vinyl Acetate	2	218	10/11/2001	12/5/2017		0%					0.2	4	
Vinyl Chloride	2	218	10/11/2001	12/5/2017	20	9%	9/6/2017	0.92	0.0203	0.183	0.02	1	ug/l

Table 6.8 - Statistical Trend Summary of Groundwater COCs and Indicator Compounds

Project No. 090057-310.3, Vashon Island Closed Landfill, Vashon Island, Washington

	Groundwater in Unit Cc1							Groundwater in Unit Cc2										Groundwater in Unit Cc3						Groundwater in Unit D										
Well Location	MW-1[a]	MW-3	MW-4	MW-10		MW-13		MW-2		MW-5D[a]		MW-9		MW-20		MW-21		MW-8		MW-14[a]		MW-27[b]		MW-7		MW-11	MW-12		MW-19		MW-26		MW-29	
Gradient Location								Down		Down		Side		Up		Down								Up		Side	Side		Down		Down		Down	
Time Interval	Long	Long	Long	Long	Short	Long	Short	Long	Short	Long	Short	Long	Short	Long	Short	Long	Short	Long	Short	Long	Short	Long	Short	Long	Short	Long	Long	Short	Long	Short	Long	Short	Long	Short
Alkalinity, mg/L	--	--	D	--	--	I	--	D	--	D	--	I	--	--	--	D	--	D	--	--	--	D	--	--	--	--	I	--	I	--	I	--	I	--
Chloride, mg/L	--	D	--	I	--	--	--	--	--	D	--	I	--	D	--	D	--	I	--	I	--	I	--	I	--	--	I	--	--	--	D	--	D	--
Dissolved Iron, mg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	D	--	--	--	--	--	I	--	D	--	--	--	--	--	--	--	--	D	--	I	--
Benzene, ug/L	--	--	--	--	--	--	--	--	--	D	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Vinyl chloride, ug/L	--	--	D	--	--	--	--	D	--	D	--	--	--	--	--	D	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1,2-Dichloropropane, ug/L	--	--	--	--	--	--	--	--	--	D	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Trichloroethene, ug/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Notes:
Adapted from: King County, 2018, *Vashon Island Closed Landfill 2017 Annual Groundwater Data Evaluation Report* , KCDNRP Solid Waste Division, April 2018.
Mann Kendall statistical analysis used to derive statstical significance in trends.
D = decreasing trend.
I = increasing trend.
-- = no noticeable trend.
[a] Decommissioned in 2015
[b] Decommissioned in 2016
Shading indicates statistical significance
Long time interval = Data from Historical period (1987-2017)
Short time interval = Data from January 2016 through December 2017

Table 7.1 - Evaluation of Exposure Pathways

Project No. 090057-310.3, Vashon Island Closed Landfill, Vashon Island, King County, Washington

Medium	Pathway	Receptors	On-Property Current Use	On-Property Potential Future Use	Off-Property Current Use	Off-Property Potential Future Use	Preliminary Cleanup Level (PCUL) Used to Evaluate Complete Pathways	Evaluation Comments
Groundwater	Direct Contact	Above-ground Workers	M	M	●	●	Minimum Groundwater Human Health PCULs	Landfill safety procedures in place to protect workers. Off-property Unit Cc2 groundwater contamination unknown to south beyond property boundary.
	Direct Contact	Below-ground Workers	○	○	●	●	Minimum Groundwater Human Health PCULs	Depth to impacted groundwater on-property greater than 70 feet. Off-property Unit Cc2 groundwater contamination unknown to south beyond property boundary.
	Direct Contact	Residents	○	○	●	●	Minimum Groundwater Human Health PCULs	No residential use of landfill property. No residential off-property wells identifed in Unit Cc2 and no evidence of impacts to Unit D aquifer. Off-property Unit Cc2 groundwater contamination unknown to south beyond property boundary.
	Ingestion	Residents	○	○	●	●	Minimum Groundwater Human Health PCULs	
	Inhalation / Volatilization to Air	Above-ground Workers - Indoor	○	○	○	○	Protection of indoor air (MTCA Method B)	No landfill buildings are located over VOC impacted groundwater area. Landfill safety procedures in place to protect future workers if buildings were constructed. Depth to impacted groundwater greater than 70 feet so volatilization not a complete exposure pathway.
	Inhalation / Volatilization to Air	Above-ground Workers - Outdoor	○	○	○	○	Groundwater protection of ambient air (MTCA Method B)	Depth to impacted groundwater greater than 70 feet so volatilization not a complete exposure pathway.
	Inhalation / Volatilization to Air	Below-Ground Workers - Outdoor	○	○	○	○	Groundwater protection of ambient air (MTCA Method B)	
	Inhalation / Volatilization to Air	Residents - Indoor	○	○	○	○	Protection of indoor air (MTCA Method B)	No residential use of landfill property. No buildings located over VOC-impacted groundwater area and depth to impacted groundwater is greather than 70 feet on property.
	Inhalation / Volatilization to Air	Residents - Outdoor	○	○	○	○	Groundwater protection of ambient air (MTCA Method B)	No residential use of landfill property. Depth to impacted groundwater greater than 70 feet so volatilization not a complete exposure pathway.
	Discharge to Surface Water	See **Surface Water**	●	●	●	●	Minimum Surface Water PCULs	Evidence of impacted Unit Cc2 groundwater discharging via seeps to surface water.
Surface Water	Direct Contact	Residents	○	○	●	●	Minimum Surface Water Human Health PCULs	No residential use of landfill property. Vinyl chloride is driver of this potential pathway.
	Direct Contact	Recreational Users	●	●	●	●	Minimum Surface Water Human Health PCULs	Vinyl chloride is driver of this potential pathway.
	Direct Contact	Aquatic Organisms	●	●	●	●	Minimum Surface Water Ecological PCULs	Pathway is complete; however no exceedances of dissolved metals at VLF property boundary; -no ecological-based cleanup criteria for vinyl chloride or other COCs.
	Ingestion	Aquatic or Terrestrial Organisms	●	●	●	●	Minimum Surface Water Ecological PCULs	
	Ingestion of Aquatic Organisms	Residents	○	○	●	●	Organism Only Human Health PCULs	No residential use of landfill property. Ingestion of aquatic organisms containing bioaccumulative compounds originating from discharge of groundwater to surface water. Steep slope and lack of habitat on-property prevent access to current recreational users on-property.
	Ingestion of Aquatic Organisms	Recreational Users	○	○	●	●	Organism Only Human Health PCULs	Ingestion of aquatic organisms containing bioaccumulative compounds originating from discharge of groundwater to surface water. Steep slope and lack of habitat on-property prevent access to current recreational users on-property.
Landfill Gas	Inhalation	Above-ground Workers	M	M	○	○	WAC 173-304 & WAC 173-351	Landfill safety procedures in place to protect workers. No off-property migration of LFG.
	Inhalation	Below-ground Workers	M	M	○	○	WAC 173-304 & WAC 173-351	
	Inhalation	Residents	○	○	○	○	WAC 173-304 & WAC 173-351; Protection of Indoor Air (MTCA Method B)	No residential use of landfill property. No off-property migration of LFG.
	Direct Contact (Explosivity)	Above-ground Workers	M	M	○	○	WAC 173-304 & WAC 173-351	Landfill safety procedures and routine monitoring in place to protect workers. No off-property migration of LFG.
	Direct Contact (Explosivity)	Below-ground Workers	M	M	○	○	WAC 173-304 & WAC 173-351	
	Direct Contact (Explosivity)	Residents	○	○	○	○	WAC 173-304 & WAC 173-351	No residential use of landfill property. No off-property migration of LFG.
	Discharge to Groundwater	See **Groundwater**	●	●	○	○	Minimum Groundwater Human Health PCULs	LFG impact to groundwater complete pathway. No evidence of LFG to groundwater pathway off-property as there is no off-property LFG migration.

Table 7.1 - Evaluation of Exposure Pathways

Project No. 090057-310.3, Vashon Island Closed Landfill, Vashon Island, King County, Washington

Medium	Pathway	Receptors	On-Property Current Use	On-Property Potential Future Use	Off-Property Current Use	Off-Property Potential Future Use	Preliminary Cleanup Level (PCUL) Used to Evaluate Complete Pathways	Evaluation Comments
Leachate	Direct Contact	Above-ground Workers - Indoor	M	M	○	○	WAC 173-304 & WAC 173-351	Landfill safety procedures in place to protect workers. No evidence of leachate direct contact pathway off-property.
		Below-Ground Workers - Outdoor	M	M	○	○	WAC 173-304 & WAC 173-351	
	Discharge to Groundwater	See **Groundwater**	●	●	○	○	Minimum Groundwater Human Health PCULs	Leachate to groundwater complete pathway historically. Decreasing with time. Limited evidence of leachate to groundwater.
Refuse	Direct Contact	Below-Ground Workers	●	●	○	○	MTCA Direct Contact - Human Health	Geomembrane liner and geotextile fabric and cover soil separates most of the refuse, but potential exposure to refuse during excavation exists. Currently, access to the landfill property is restricted. Average depth to refuse is approximately 10 feet in unlined South Slope Area.
		Burrowing Terrestrial Organisms	○	○	○	○	MTCA Direct Contact - Ecological Receptors	Geomembrane liner and geotextile fabric and cover soil separates refuse, eliminating burrowing pathway. Average depth to refuse is approximately 10 feet in unlined South Slope Area.

Notes:

● = Complete or Potentially Complete Current or Future Pathway Based on Available Remedial Investigation Data

○ = Incomplete Pathway Based on Available Remedial Investigation Data

M = Potential Exposure Route, Currently Mitigated to Prevent Exposure to Receptors Above Acceptable Levels

LFG = Landfill Gas

MTCA = Model Toxics Control Act

VOC = Volatile Organic Compound

PCUL = Preliminary Cleanup Level

WAC = Washington Administrative Code

FIGURES

Project Location Map

Remedial Investigation
Vashon Island Closed Landfill
King County, Washington

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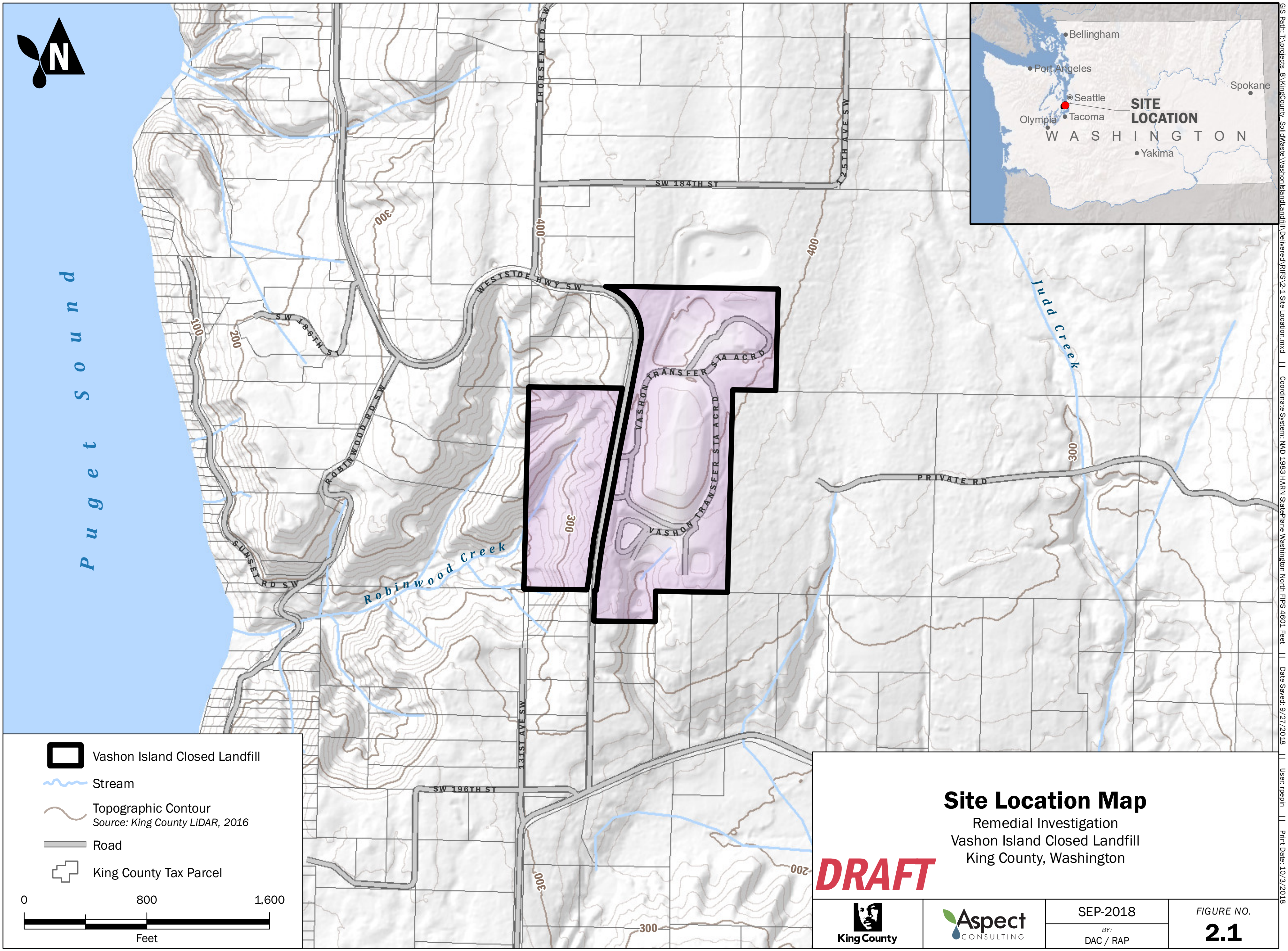
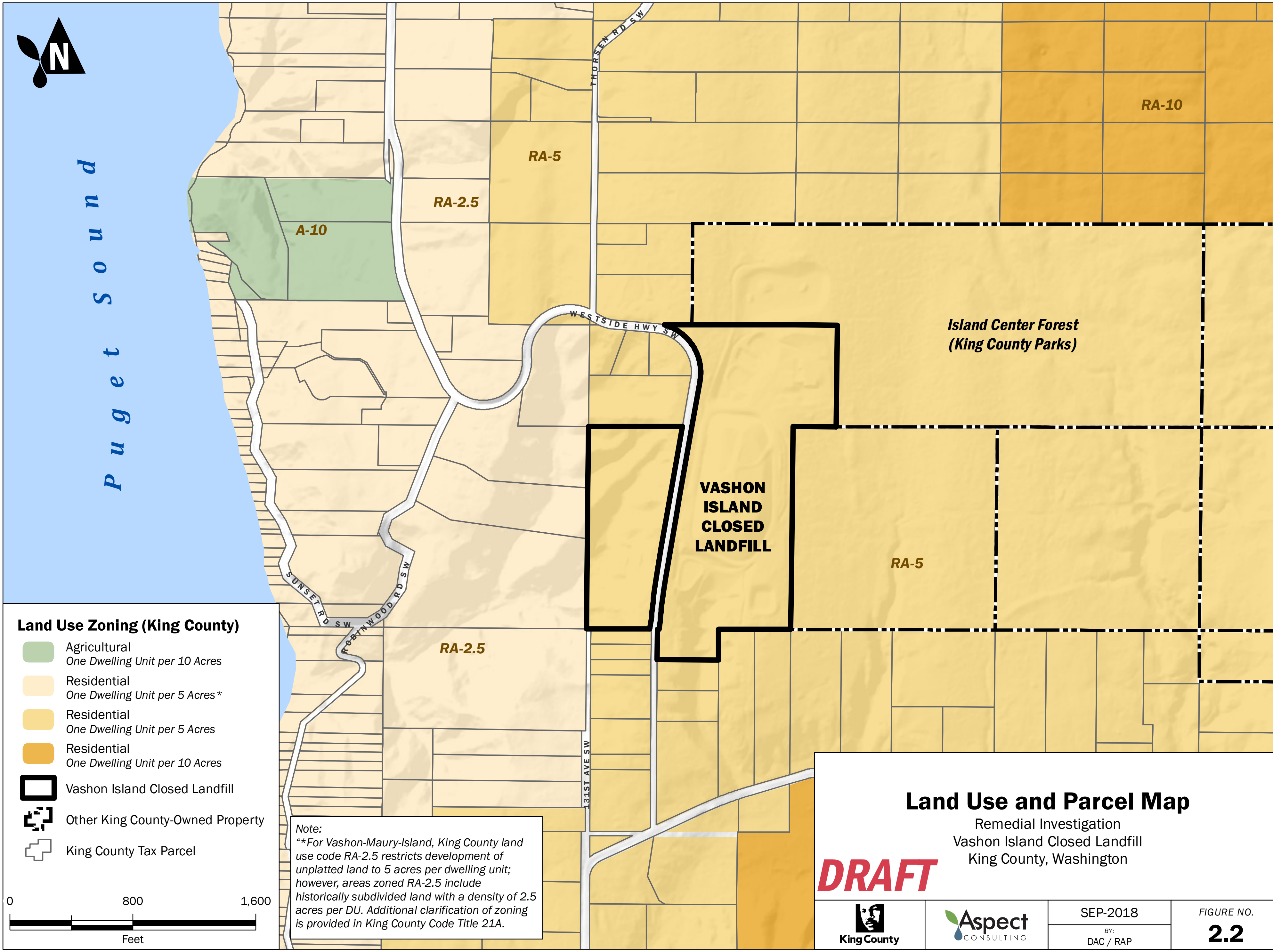
King County | Aspect CONSULTING | SEP-2018 BY: DLC / SCC | FIGURE NO. 1.1

Basemap Layer Credits || Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, © OpenStreetMap contributors, and the GIS User Community

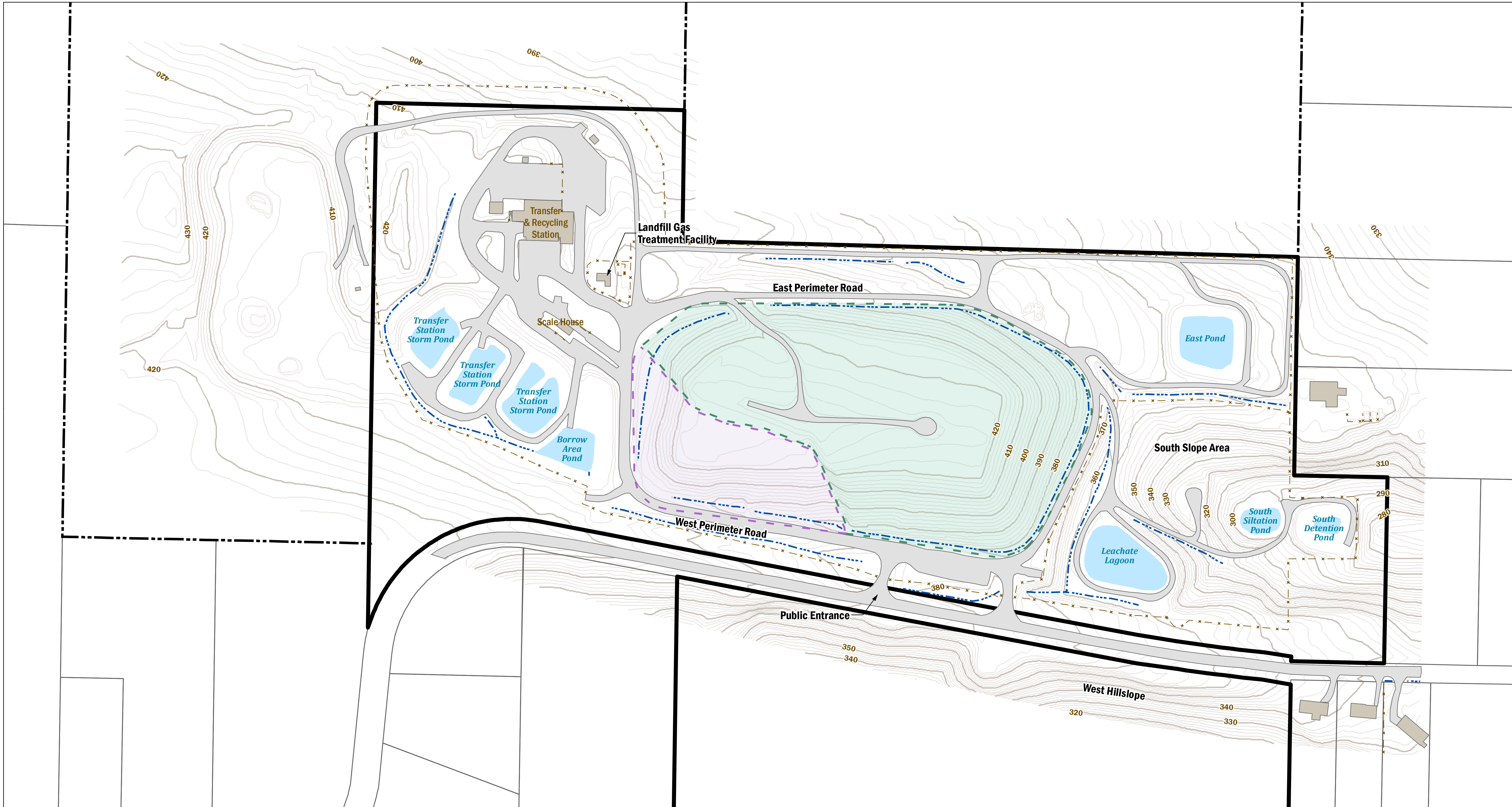


Basemap Layer Credits || Copyright:© 2014 Esri



Land Use and Parcel Map

Remedial Investigation
Vashon Island Closed Landfill
King County, Washington



Property Features
Remedial Investigation
Vashon Island Closed Landfill
King County, Washington

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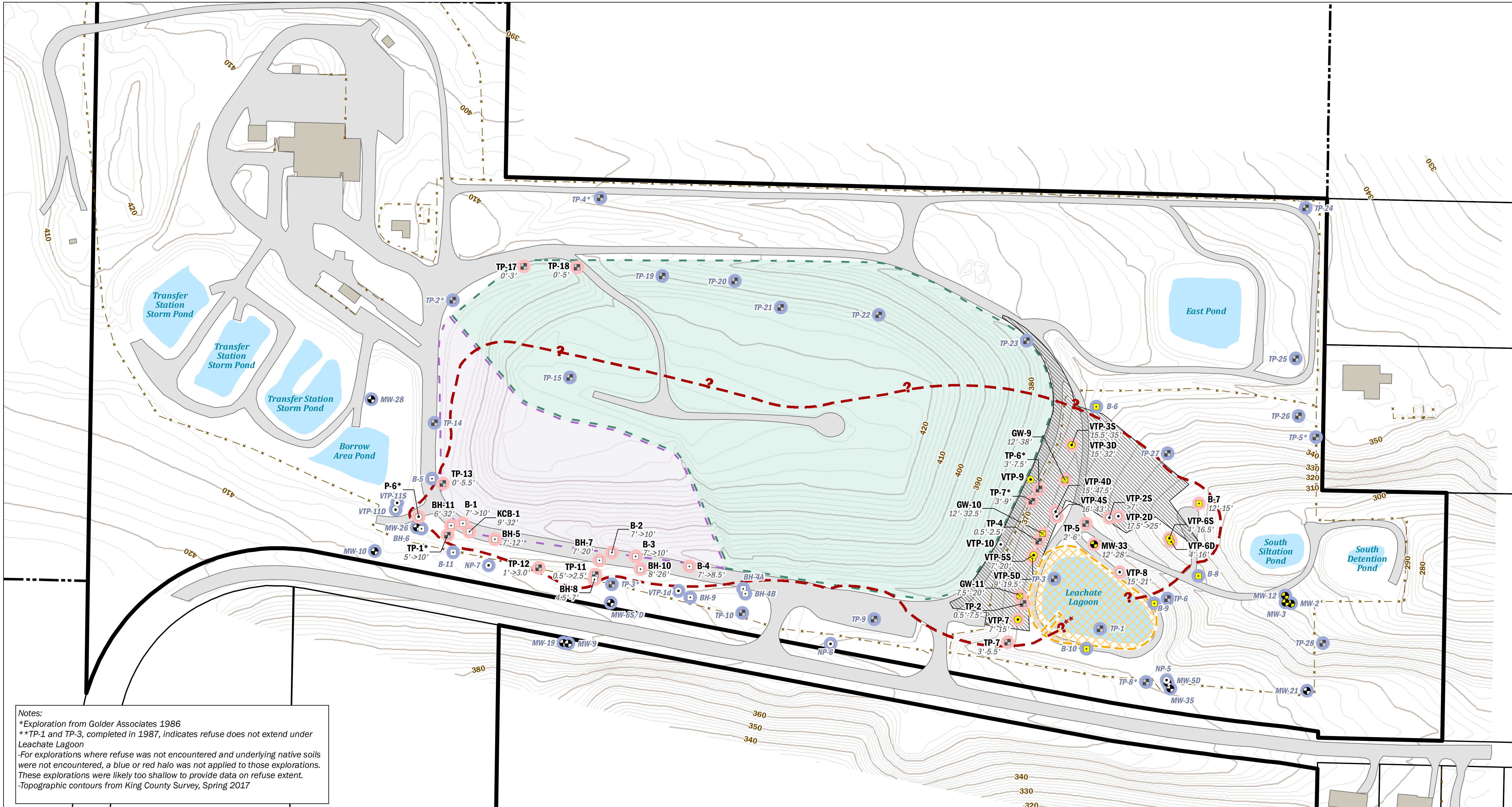
Phase 1 - 1988 Final Cover
Phase 2 - 2001 Final Cover
Pond
Ditch
Building
Road
Fence
Vashon Island Closed Landfill
Other King County-Owned Property
King County Tax Parcel

Topographic contours from King County Survey, Spring 2017

0 200 400
Feet

King County
Aspect CONSULTING
OCT-2018
BY: DAC / RAP
FIGURE NO. 2.3

GIS Path: T:\projects_8\KingCounty_SolidWaste\VashonIslandLandfill\Delivered\RIFS\2.3 Property Features.mxd || Coordinate System: NAD 1983 HARN StatePlane Washington North FIPS 4601 Feet || Date Saved: 10/3/2018 || User: rpepin || Print Date: 10/3/2018



Notes:
*Exploration from Golder Associates 1986
**TP-1 and TP-3, completed in 1987, indicates refuse does not extend under Leachate Lagoon
-For explorations where refuse was not encountered and underlying native soils were not encountered, a blue or red halo was not applied to those explorations. These explorations were likely too shallow to provide data on refuse extent.
-Topographic contours from King County Survey, Spring 2017

Boring
Gas Probe
LFG Extraction Well
Monitoring Well
Test Pit
Boring (Till Absent)
Gas Probe (Till Absent)
LFG Extraction Well (Till Absent)
Monitoring Well (Till Absent)
Estimated Extent of Unlined Refuse
Extent of Geotextile Cover Beyond Landfill Liner
Extent of Geomembrane under Leachate Lagoon
Encountered Refuse
No Refuse, Native Soils Encountered After Fill Unit
Phase 1 - 1988 Final Cover
Phase 2 - 2001 Final Cover
Pond
Building
Road
Fence
Vashon Island Closed Landfill
Other King County-Owned Property
King County Tax Parcel

0 150 300
Feet

Extent of Solid Waste

Remedial Investigation
Vashon Island Closed Landfill
King County, Washington

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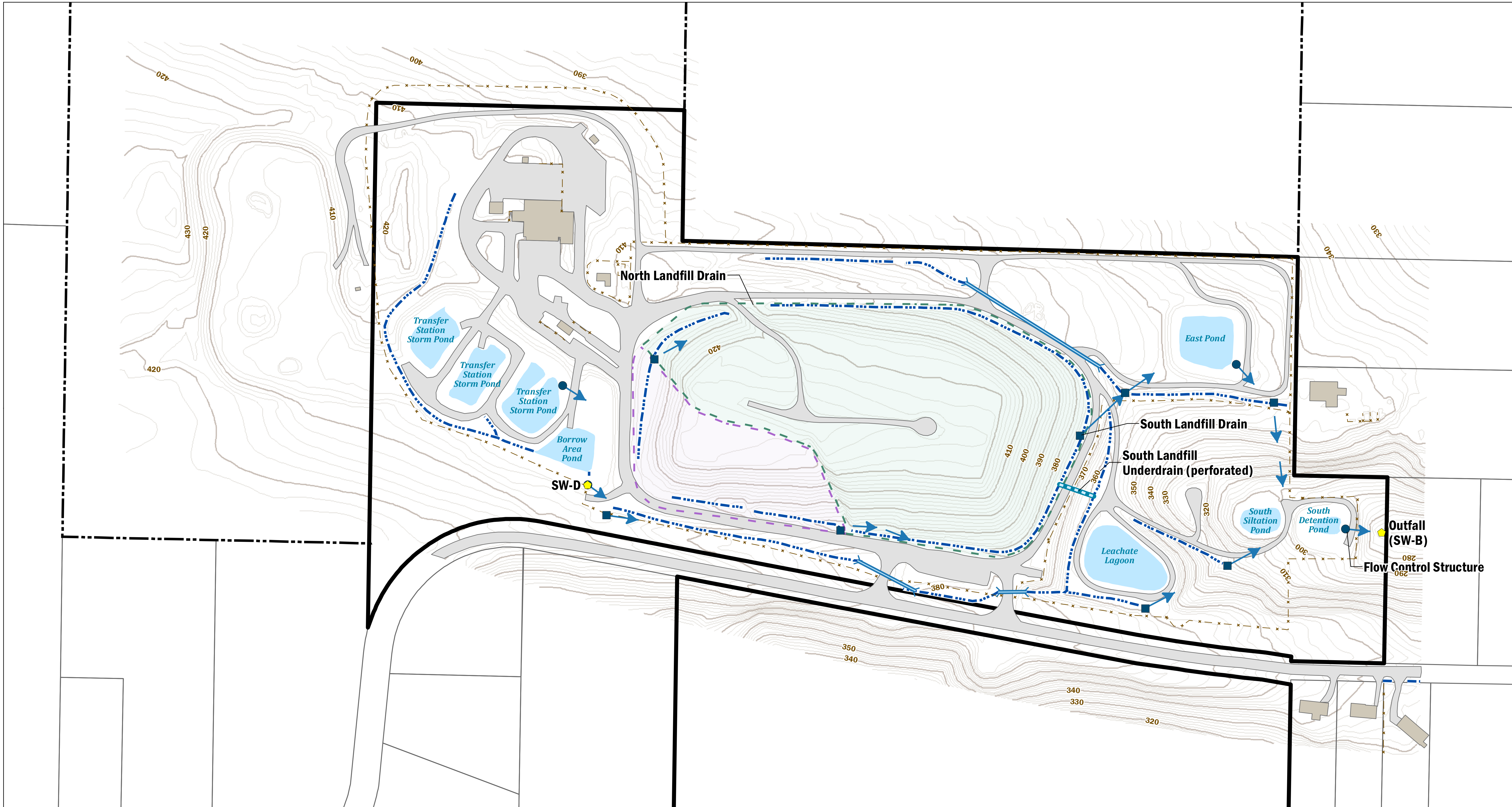
King County | Aspect CONSULTING | SEP-2018 | BY: DAC / RAP | FIGURE NO. 2.4

GIS Path: T:\projects_8\KingCounty_SolidWaste\VashonIslandLandfill\Delivered\RIFS\2.4 Extent of Solid Waste.mxd || Coordinate System: NAD 1983 HARN StatePlane Washington North FIPS 4601 Feet || Date Saved: 9/19/2018 || User: rpepin || Print Date: 10/3/2018



● Ponded Stormwater Enters Storm Drain Pipe for Conveyance

■ Surface Water Flow Enters Storm Pipe for Conveyance

Former Surface Water Monitoring Station

Culvert

Underdrain

General Direction of Flow

Ditch (Asphalt or Unlined)

Phase 1 - 1988 Final Cover

Phase 2 - 2001 Final Cover

Pond

Building

Road

Fence

Vashon Island Closed Landfill

Other King County-Owned Property

King County Tax Parcel

Topographic contours from King County Survey, Spring 2017

0 200 400

Feet

Surface Water Drainage Features

Remedial Investigation
Vashon Island Closed Landfill
King County, Washington

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King County

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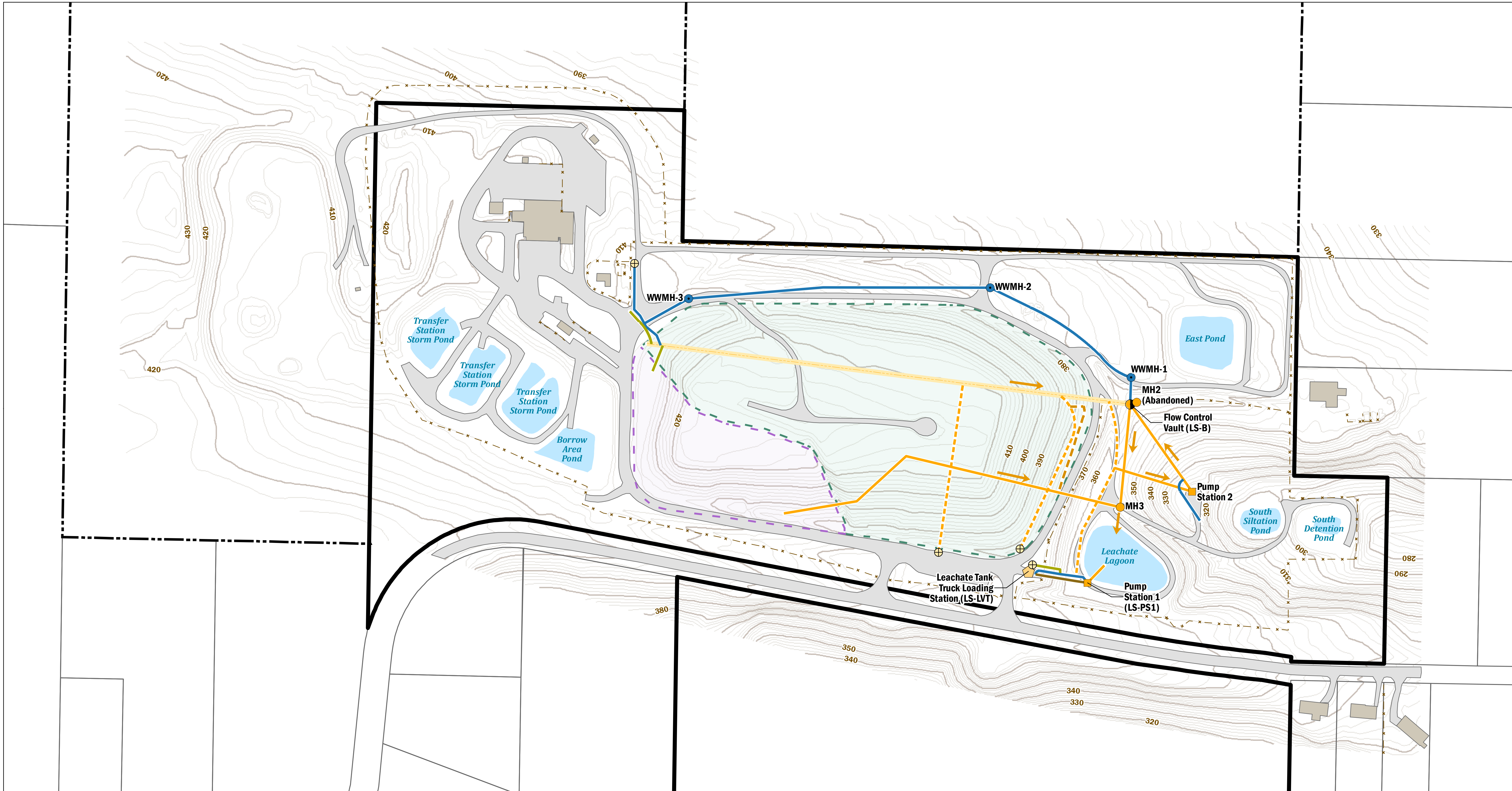
FIGURE NO. 2.5



Manhole
Pump Station
Loading Station
Flow Control Vault
Wastewater Manhole
Cleanout
General Direction of Flow
Leachate Collection Pipe
Leachate Collection Pipe (Perforated)
Leachate Collection Trench
Leachate Forcemain
Condensate Pipe
Wastewater Pipe
Underdrain Pipe
Phase 1 - 1988 Final Cover
Phase 2 - 2001 Final Cover
Pond
Building
Road
Fence
Vashon Island Closed Landfill
Other King County-Owned Property
King County Tax Parcel

0 200 400
Feet

Topographic contours from King County Survey, Spring 2017

Leachate Collection and Monitoring Systems

Remedial Investigation
Vashon Island Closed Landfill
King County, Washington

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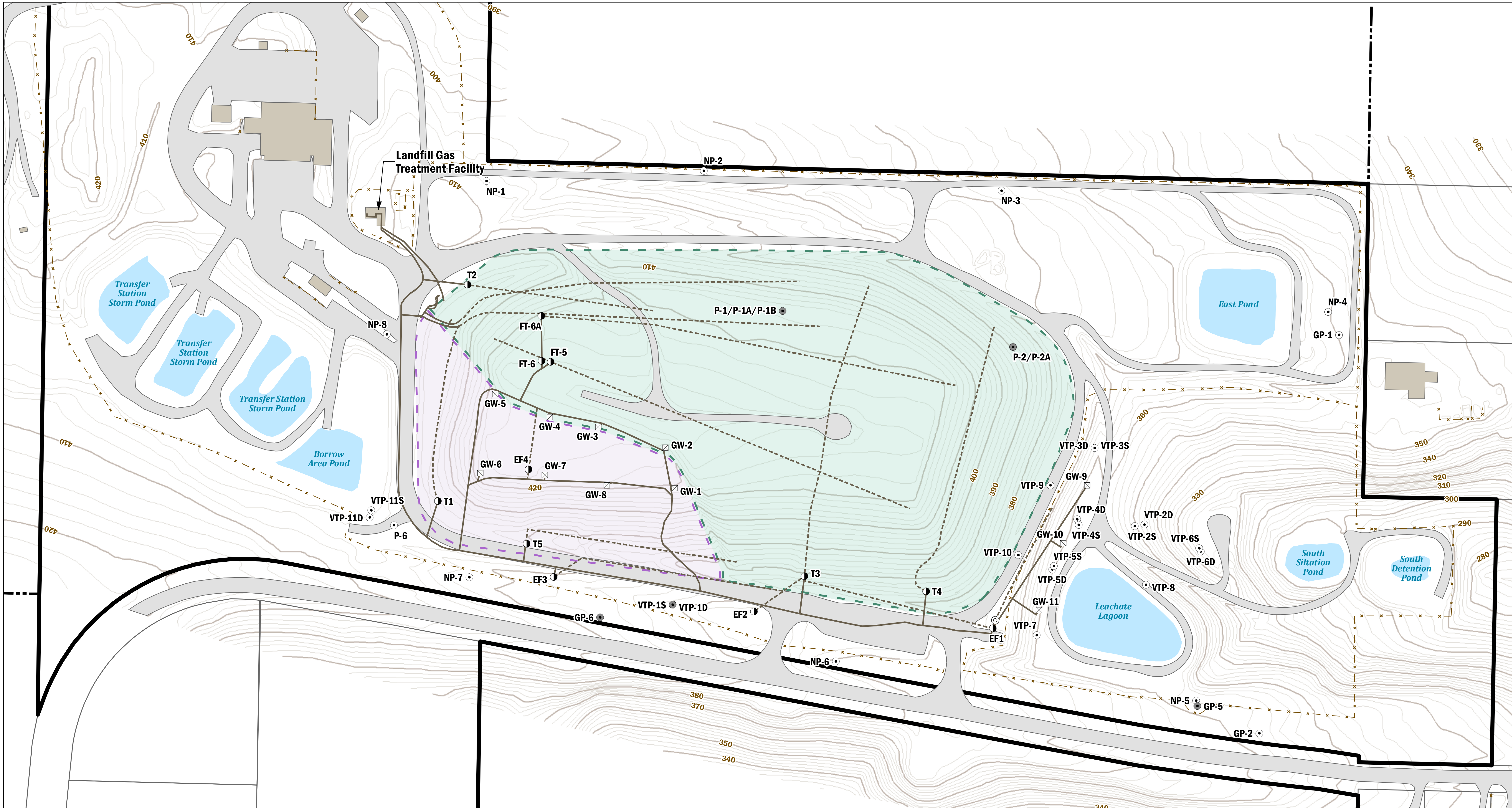
FIGURE NO.
2.6

GIS Path: T:\projects_8\KingCounty_SolidWaste\VashonIslandLandfill\Delivered\RIFS\2-6 Leachate Collection and Monitoring Systems.mxd || Coordinate System: NAD 1983 HARN StatePlane Washington North FIPS 4601 Feet || Date Saved: 10/3/2018 || User: rpepin || Print Date: 10/3/2018



- Gas Probe/Piezometer
- Decommissioned Gas Probe
- LFG Extraction Well
- LFG Trench Riser
- LFG Pipe
- LFG Pipe (Perforated)
- Phase 1 - 1988 Final Cover
- Phase 2 - 2001 Final Cover
- Pond
- Building
- Road
- Fence
- Vashon Island Closed Landfill
- Other King County-Owned Property
- King County Tax Parcel

Topographic contours from King County Survey, Spring 2017. Landfill gas system features are approximated from as-built locations, and revised to match survey data where available.

0 140 280
Feet

Landfill Gas Collection and Monitoring Systems

Remedial Investigation
Vashon Island Closed Landfill
King County, Washington

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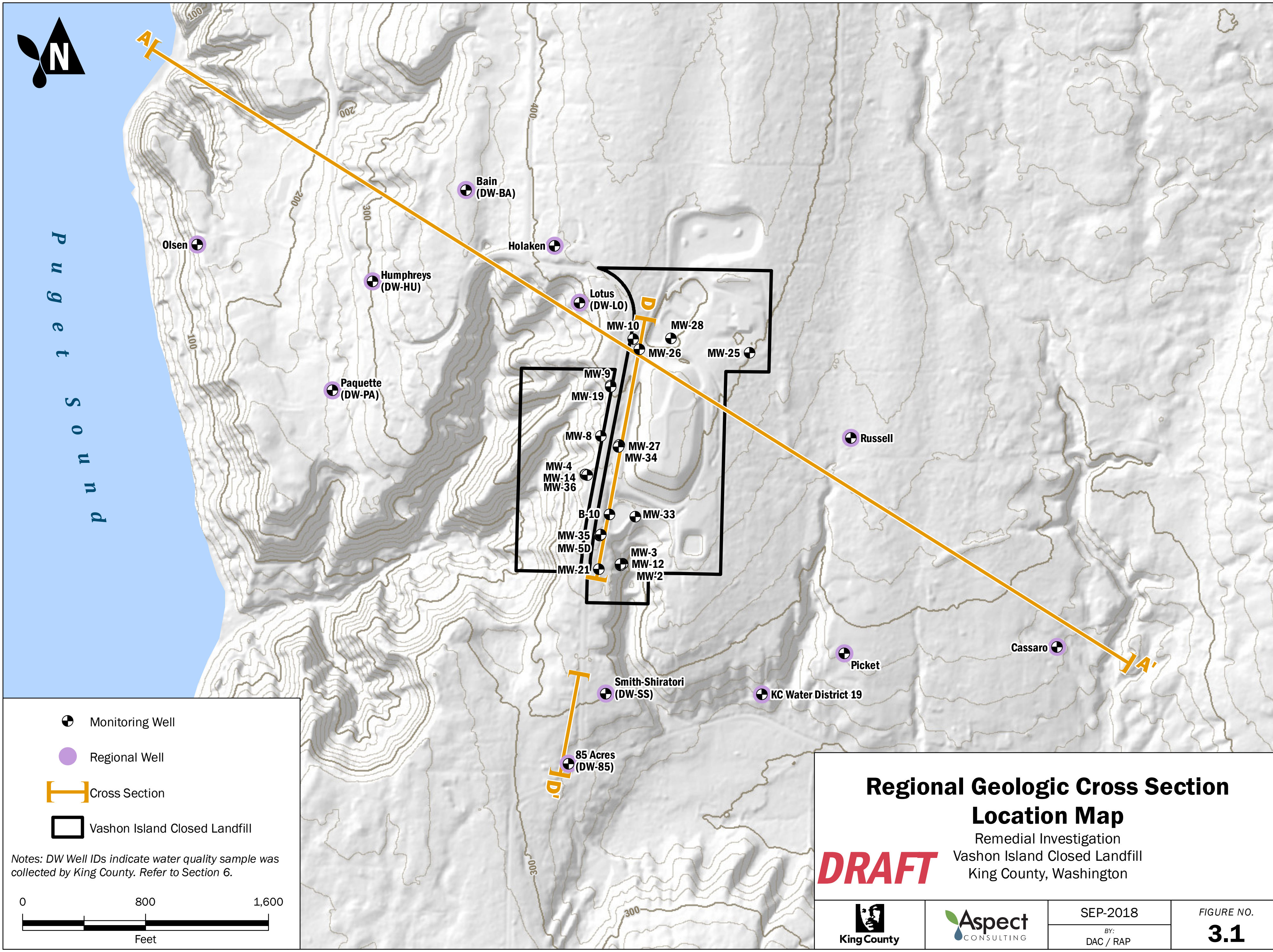

Regional Geologic Cross Section Location Map

Remedial Investigation
Vashon Island Closed Landfill
King County, Washington

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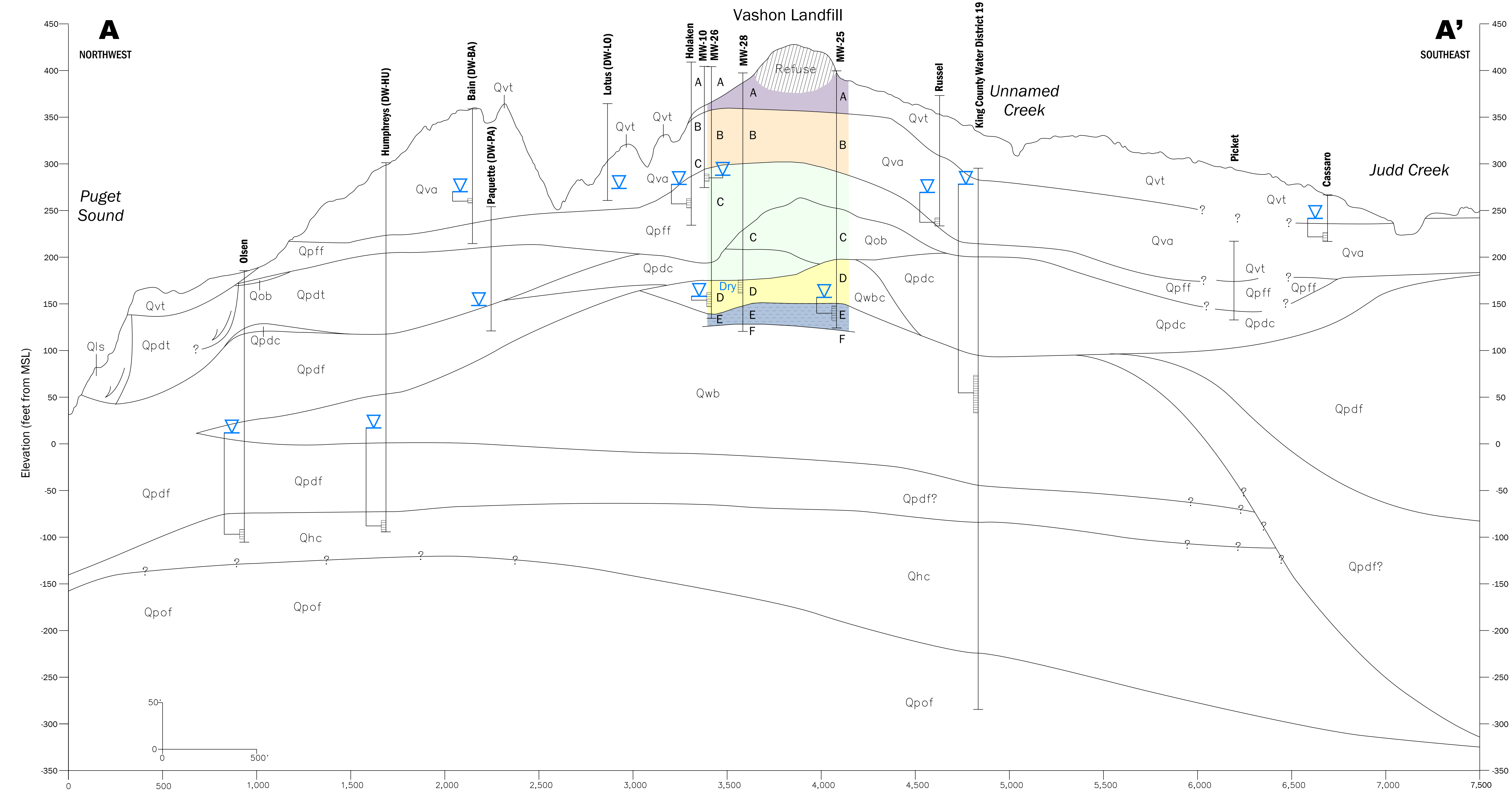
King County | Aspect Consulting | SEP-2018 | FIGURE NO. 3.1

BY: DAC / RAP

GIS Path: T:\projects_8\KingCounty_SolidWaste\VashonIslandLandfill\Delivered\RIFS\3-1 Regional Geologic Cross Section Location Map.mxd || Coordinate System: NAD 1983 HARN StatePlane Washington North FIPS 4601 Feet || Date Saved: 9/19/2018 || User: rpepin || Print Date: 10/3/2018



Source: Modified from Troost, 2004.

Geologic Units

Qls	Landslide Deposits (Holocene)
Qvt	Vashon Till
Qva	Advance Outwash
Qob	Olympia Beds
Qpdt	Possession Drift Till
Qpdc	Possession Drift, Coarse-Grained Facies
Qpdf	Possession Drift, Fine-Grained Facies
Qwbc	Whidbey Beds, Coarse-Grained Facies
Qwb	Whidbey Beds, Undifferentiated
Qhc	Hamm Creek Formation
Qpof	Pre-Olympia Deposits, Fine-Grained Facies
Qpff	Pre-Fraser Glaciation Deposits, Fine-Grained Facies

Refuse/Fill
Unit A
Unit B
Unit C
Coarse
Fine
Unit D
Unit E

Static Water Level
Screen Interval

Note: DW well ID's indicate water quality sample was collected by county. Refer to Section 6 for data.

Horizontal Scale: 1" = 500'
Vertical Scale: 1" = 100'
Vertical Exaggeration 5x

0 500 1000 Feet

Regional Geologic Cross Section A-A'

Remedial Investigation
Vashon Island Closed Landfill
King County, Washington

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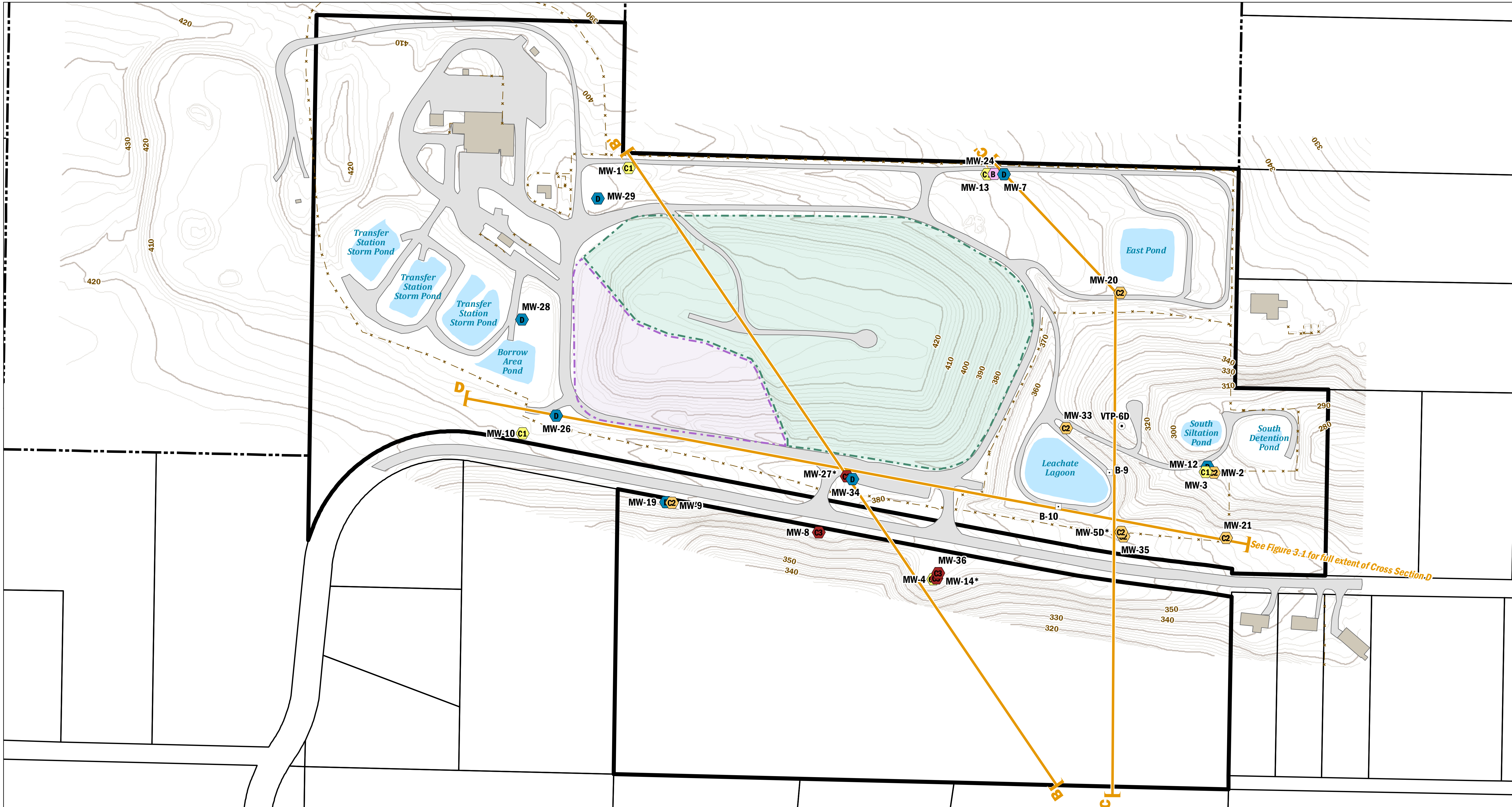
Sep-2018

BY:
DLC/SCC

FIGURE NO.
3.2

CAD Path: Q:\King County\090057 Vashon Island Landfill\2018-05 RI-FS Report\090057-AA.dwg Section A-A' || Date Saved: Sep 19, 2018 4:31pm || User: scudd



Monitoring Well Completion Aquifer

- B Unit B
- C1 Unit Cc1
- C2 Unit Cc2
- C3 Unit Cc3
- D Unit D

- Boring
- Gas Probe
- Cross Section
- Phase 1 - 1988 Final Cover
- Phase 2 - 2001 Final Cover

- Pond
- Building
- Road
- Fence

- Vashon Island Closed Landfill
- Other King County-Owned Property
- King County Tax Parcel

Topographic contours from King County Survey, Spring 2017.
**indicates decommissioned monitoring well.*

0 200 400
Feet

Site Cross Section Locations

Remedial Investigation
Vashon Island Closed Landfill
King County, Washington

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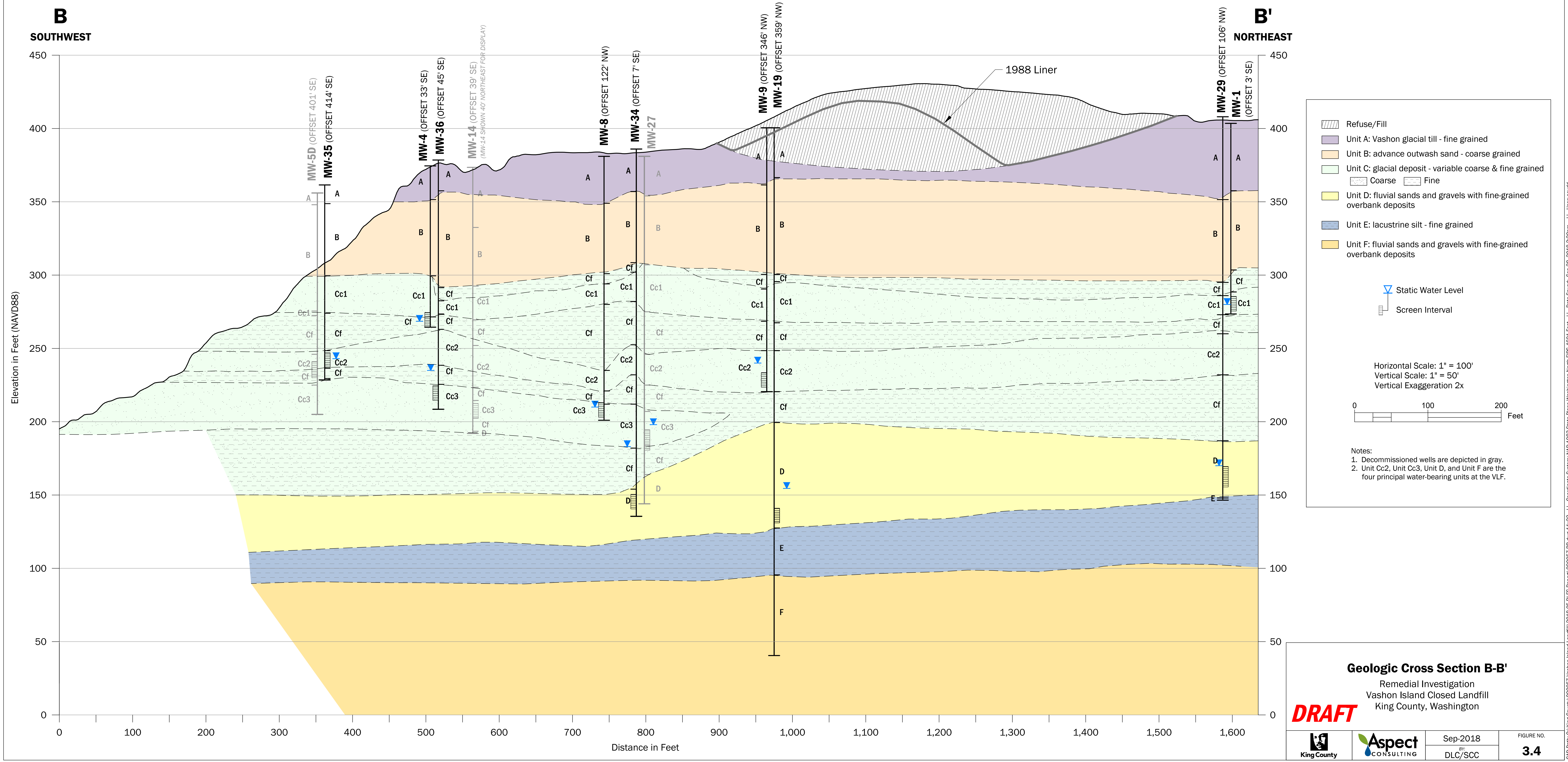
King County | Aspect Consulting | SEP-2018 | BY: DAC / RAP | FIGURE NO. 3.3



Geologic Cross Section B-B'

Remedial Investigation
Vashon Island Closed Landfill
King County, Washington

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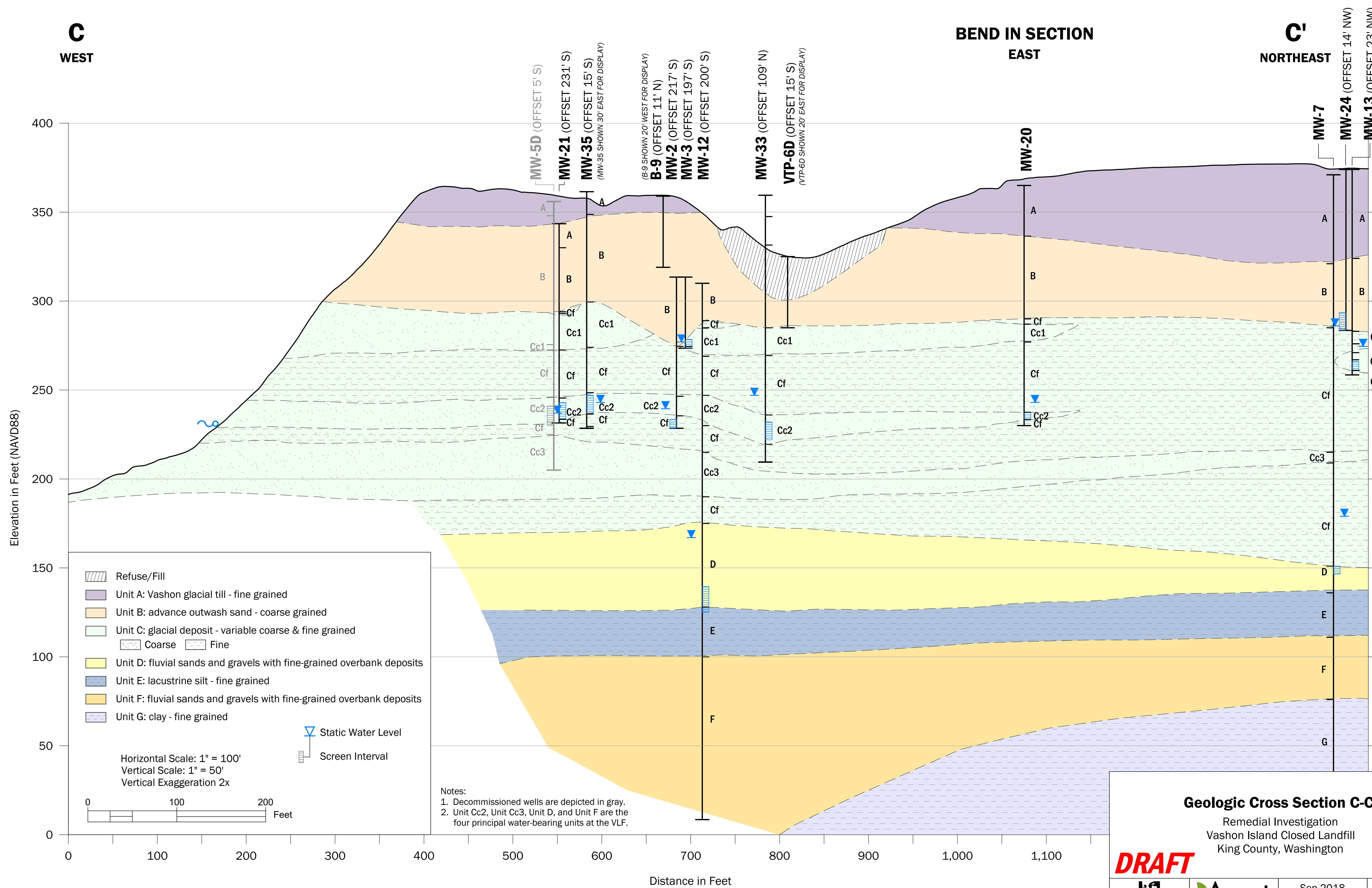
King County | Aspect CONSULTING | Sep-2018 | BY: DLC/SCC | FIGURE NO. 3.4



Geologic Cross Section C-C'

Remedial Investigation
Vashon Island Closed Landfill
King County, Washington

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King County | Aspect CONSULTING | Sep-2018 | BY: DLC/SCC | FIGURE NO. 3.5

CAD Path: Q:\King County\090057 Vashon Island Landfill\2018-05 RI-FS Report\090057-CC.dwg 11x17 Landscape || Coordinate System: NAD 1983 State Plane Washington North FIPS 4601 Feet || Date Saved: Sep 28, 2018 2:21pm || User: scudd

D
NORTH
D'
SOUTH
Elevation in Feet (NAVD88)
Break in Section (See Figure 3.5)
MW-28 (OFFSET 187' E)
MW-10 (OFFSET 55' W)
MW-26
MW-19 (OFFSET 141' W)
MW-9 (OFFSET 140' W)
MW-8 (OFFSET 140' W)
MW-27 (OFFSET 15' W)
MW-34 (OFFSET 18' W)
MW-14 (OFFSET 182' W)
MW-4 (OFFSET 199' W)
MW-36 (OFFSET 182' W)
(MW-36 SHOWN 40' SOUTH FOR DISPLAY)
MW-33 (OFFSET 173' E)
MW-5D (OFFSET 42' W)
MW-35 (OFFSET 33' W)
(MW-12 SHOWN 40' NORTH FOR DISPLAY)
MW-12 (OFFSET 157' E)
MW-3 (OFFSET 138' E)
MW-2 (OFFSET 132' E)
MW-21 (OFFSET 4' E)
Smith-Shiratori (DW-SS) (OFFSET 195' E)
85 Acres (DW-85) (OFFSET 41' E)
Refuse/Fill
Unit A: Vashon glacial till - fine grained
Unit B: advance outwash sand - coarse grained
Unit C: glacial deposit - variable coarse & fine grained
Coarse
Fine
Unit D: fluvial sands and gravels with fine-grained overbank deposits
Unit E: lacustrine silt - fine grained
Unit F: fluvial sands and gravels with fine-grained overbank deposits
Static Water Level
Screen Interval
Horizontal Scale: 1" = 100'
Vertical Scale: 1" = 50'
Vertical Exaggeration 2x
Feet
Notes:
1. Decommissioned wells are depicted in gray.
2. Unit Cc2, Unit Cc3, Unit D, and Unit F are the four principal water-bearing units at the VLF.
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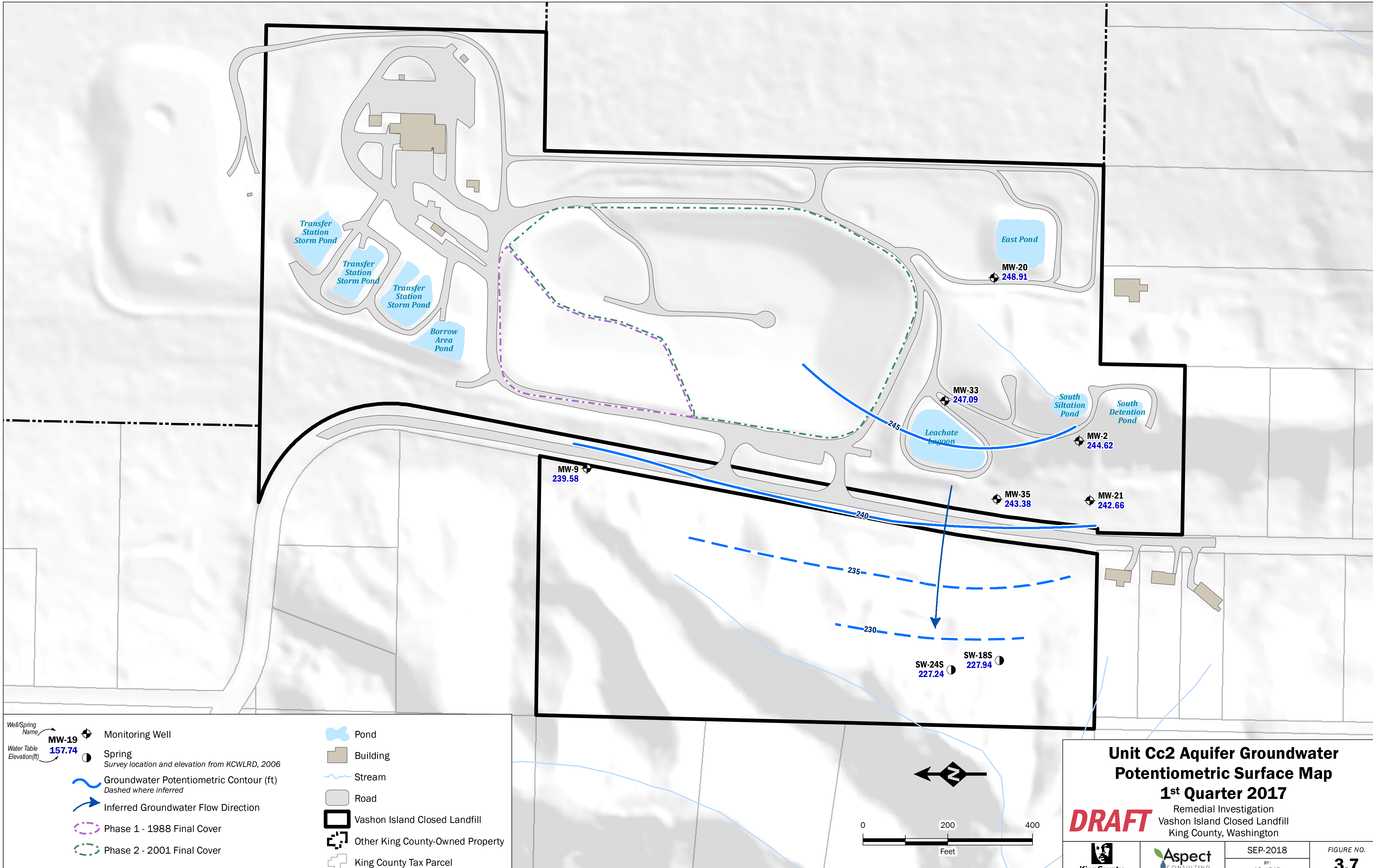
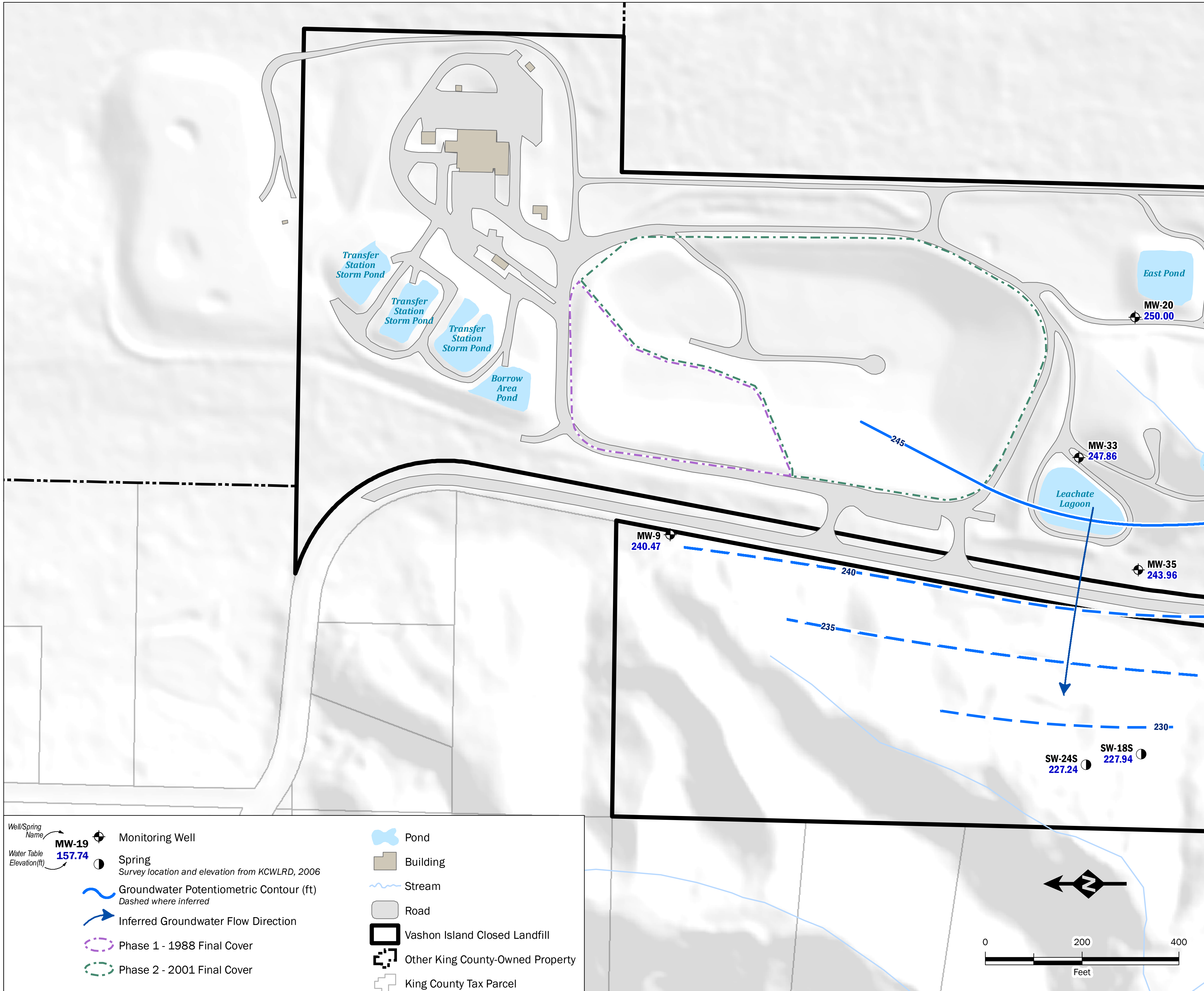
Geologic Cross Section D-D'
Remedial Investigation
Vashon Island Closed Landfill
King County, Washington
King County
Aspect CONSULTING
Sep-2018
BY:
DLC/SCC
FIGURE NO.
3.6


Transfer Station Storm Pond
Transfer Station Storm Pond
Transfer Station Storm Pond
Borrow Area Pond
East Pond
MW-20
248.91
MW-33
247.09
South Siltation Pond
South Detention Pond
Leachate Lagoon
245
MW-2
244.62
MW-9
239.58
MW-35
243.38
MW-21
242.66
240
235
230
SW-18S
227.94
SW-24S
227.24
Well/Spring Name
Water Table Elevation(ft)
MW-19
157.74
Monitoring Well
Spring
Survey location and elevation from KCWLRD, 2006
Groundwater Potentiometric Contour (ft)
Dashed where inferred
Inferred Groundwater Flow Direction
Phase 1 - 1988 Final Cover
Phase 2 - 2001 Final Cover
Pond
Building
Stream
Road
Vashon Island Closed Landfill
Other King County-Owned Property
King County Tax Parcel
0
200
400
Feet
Unit Cc2 Aquifer Groundwater Potentiometric Surface Map
1st Quarter 2017
DRAFT
Remedial Investigation
Vashon Island Closed Landfill
King County, Washington
King County
Aspect CONSULTING
SEP-2018
BY:
AO / RAP
FIGURE NO.
3.7



Unit Cc2 Aquifer Groundwater Potentiometric Surface Map 3rd Quarter 2017

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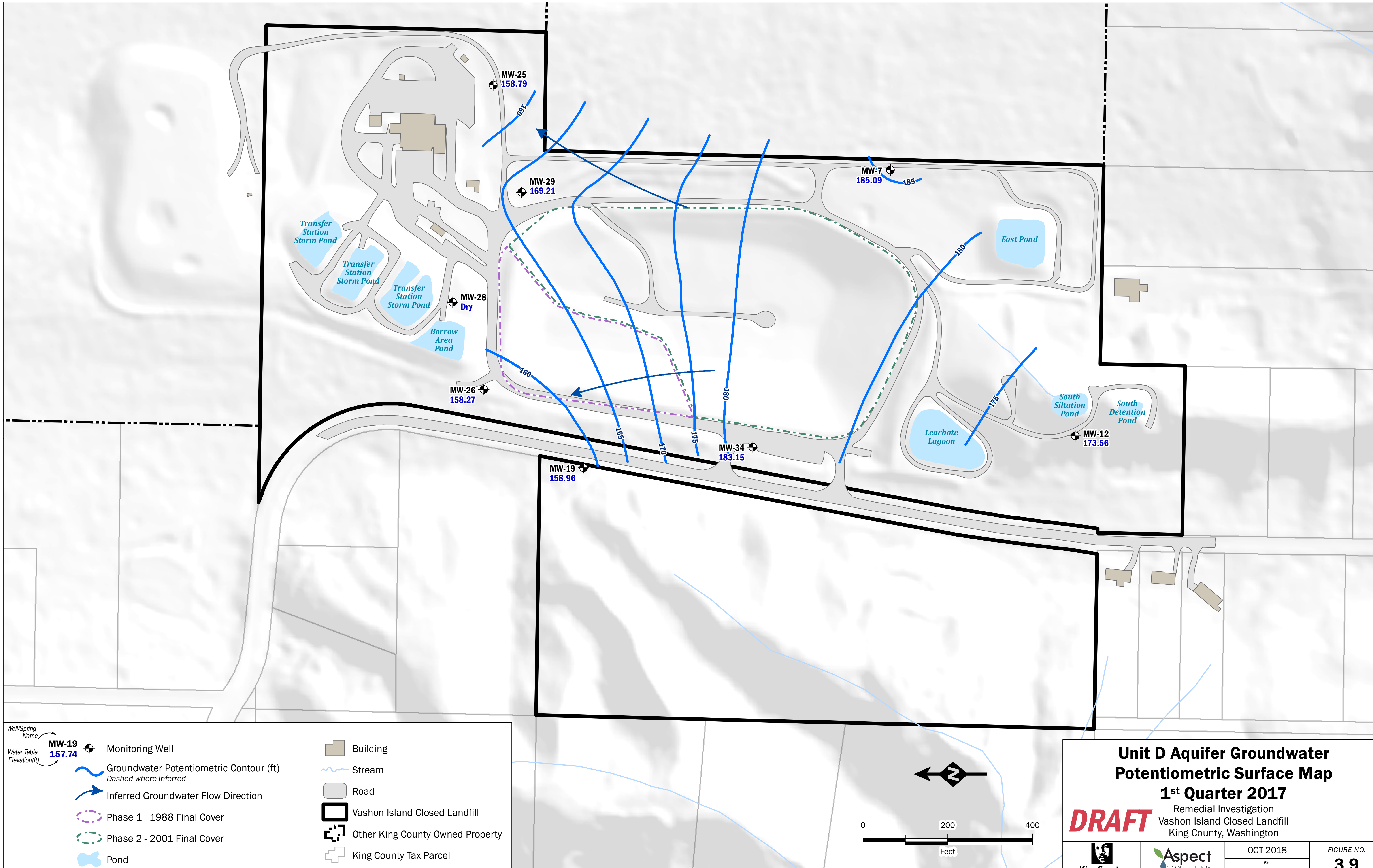
Remedial Investigation
Vashon Island Closed Landfill
King County, Washington

King County | Aspect CONSULTING | SEP-2018 BY: AO / RAP | FIGURE NO. 3.8

GIS Path: T:\projects_8\KingCounty_SolidWaste\VashonIslandLandfill\Delivered\RIFS\3-8 Aquifer Cc2 Q3 2017.mxd || Coordinate System: NAD 1983 StatePlane Washington North FIPS 4601 Feet || Date Saved: 9/27/2018 || User: rpepin || Print Date: 10/3/2018



Unit D Aquifer Groundwater Potentiometric Surface Map 1st Quarter 2017

Remedial Investigation
Vashon Island Closed Landfill
King County, Washington

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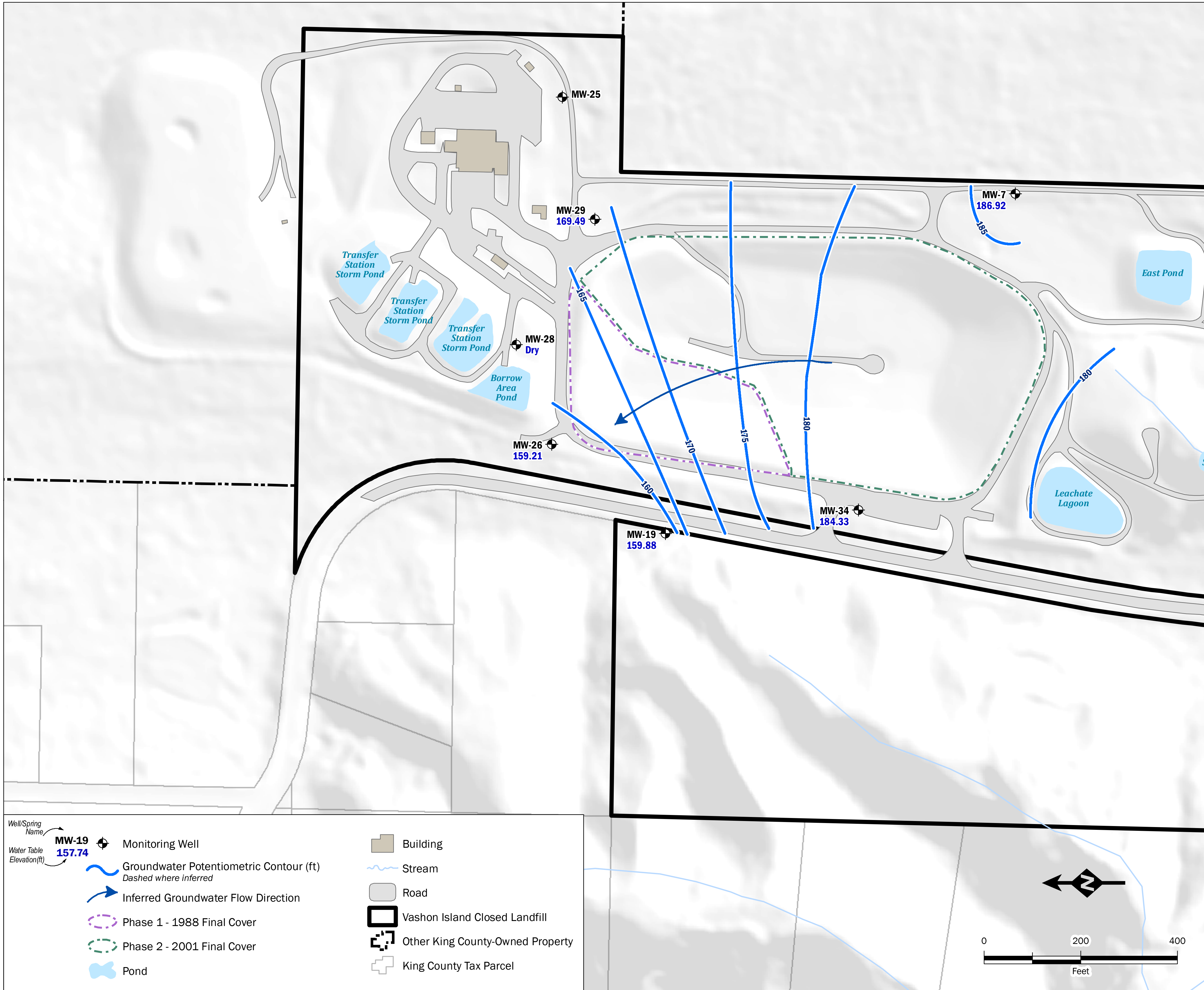
King County | Aspect CONSULTING | OCT-2018 | BY: AO / RAP | FIGURE NO. 3.9



Unit D Aquifer Groundwater Potentiometric Surface Map 3rd Quarter 2017

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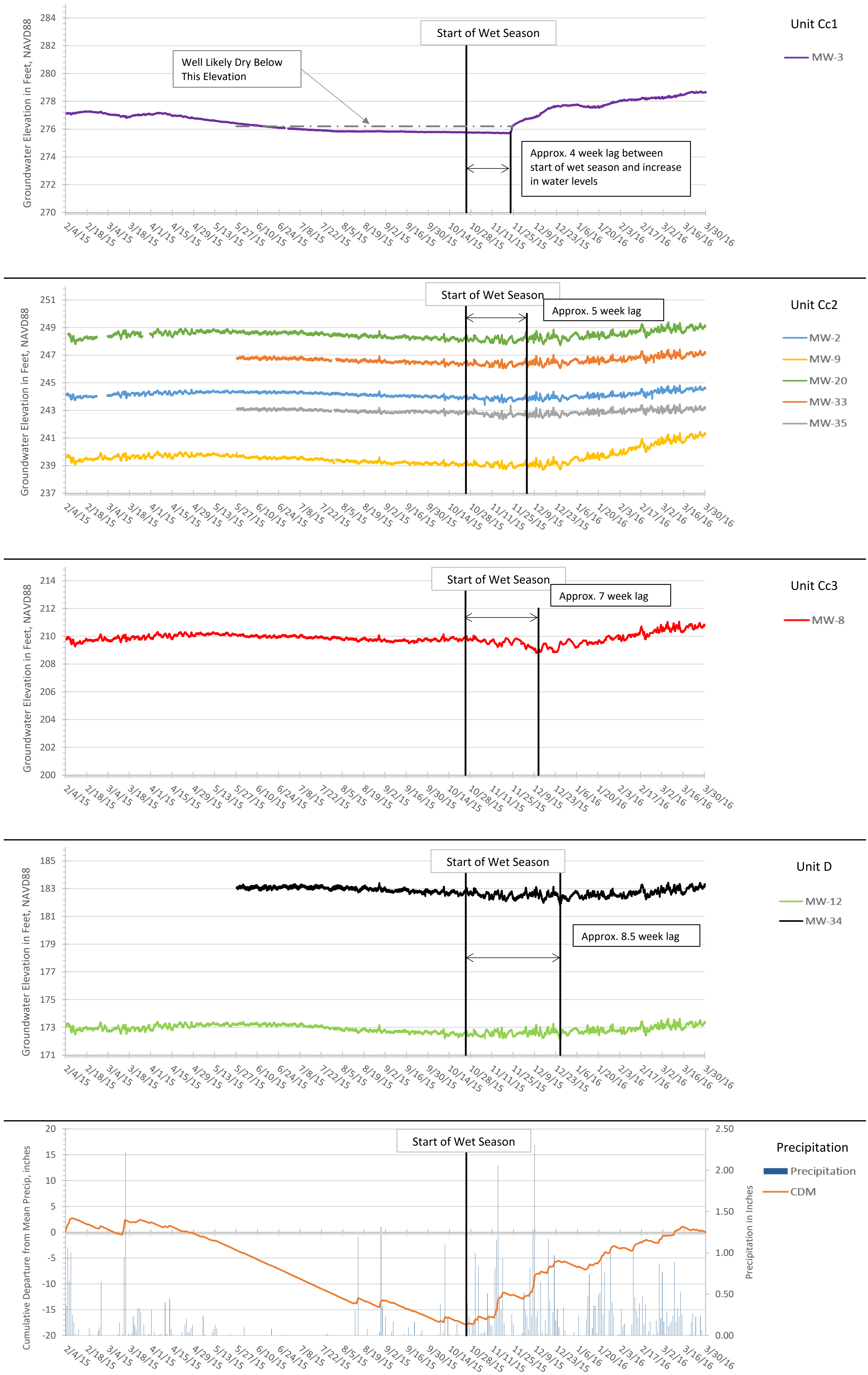
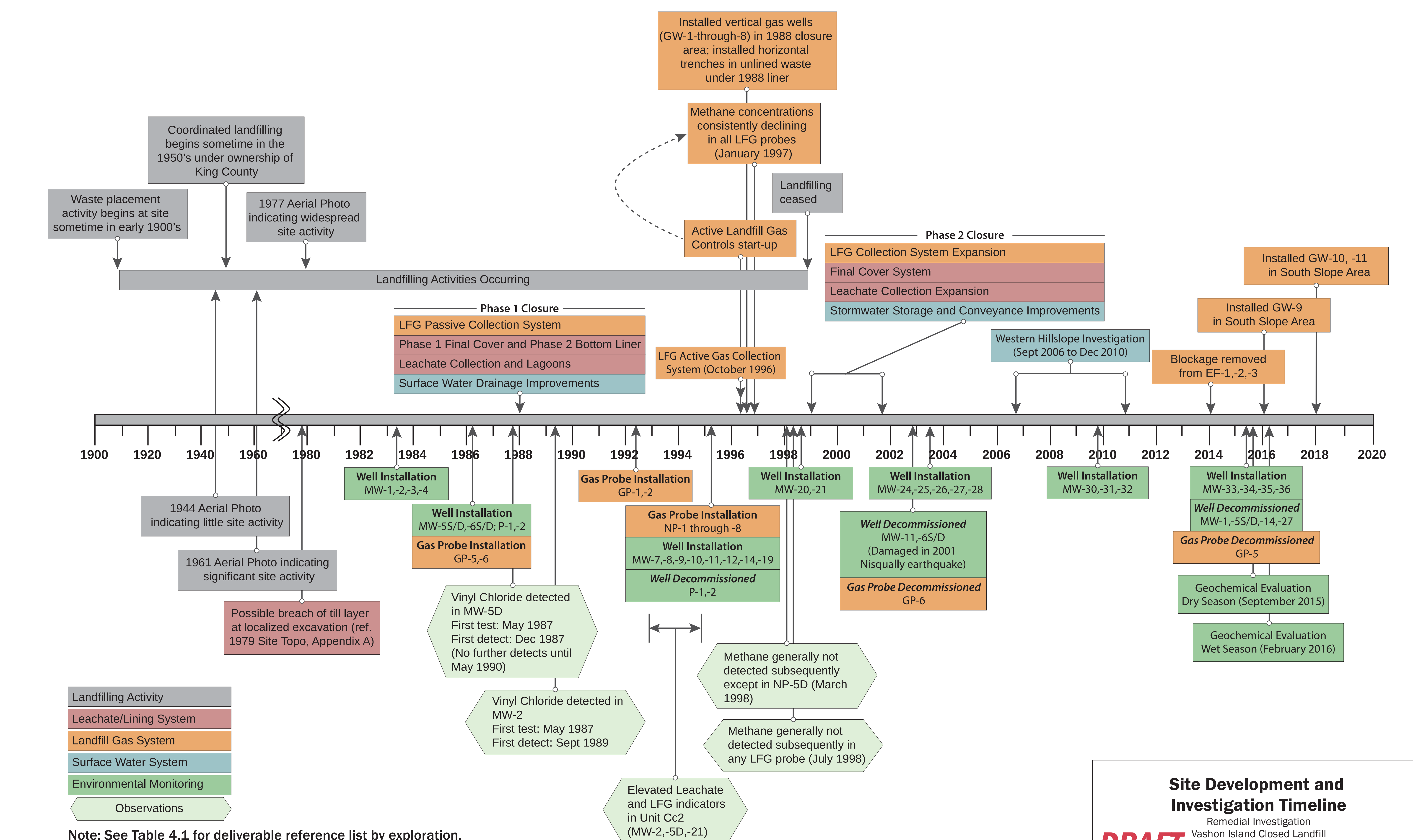
Remedial Investigation
Vashon Island Closed Landfill
King County, Washington

King County | Aspect CONSULTING | OCT-2018 BY: AO / RAP | FIGURE NO. 3.10



Aspect Consulting
October 2018
V:\090057 ClosedLandfill\Deliverables\Vashon\Task 310\310.3.1 Remedial Investigation\Agency Draft\Figures\3-11 Source File - GW Hydrographs_MASTER.xlsx

Figure 3.11
Groundwater Hydrographs (with Precipitation)
Remedial Investigation



Note: See Table 4.1 for deliverable reference list by exploration.

Site Development and Investigation Timeline

Remedial Investigation
Vashon Island Closed Landfill
King County, Washington

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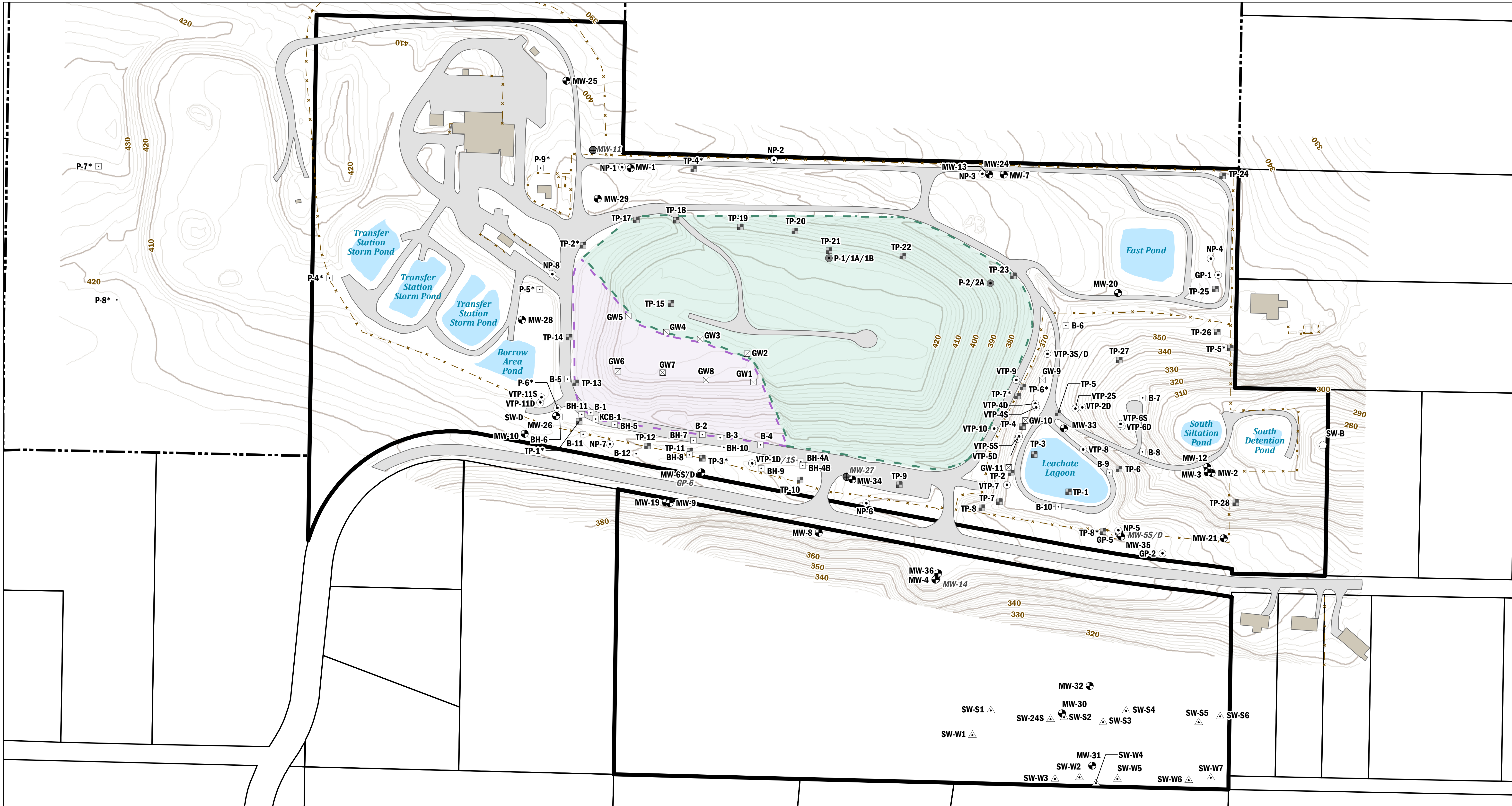
King County | Aspect CONSULTING | OCT-2018 | BY: DAC / JI | FIGURE NO. 4.1



Boring	Monitoring Well (see figure 4.3 for well aquifer completion)
Gas Probe	Decommissioned Gas Probe
LFG Extraction Well	Decommissioned Monitoring Well
Test Pit	Phase 1 - 1988 Final Cover
Seep/Weir Sampling Location	Phase 2 - 2001 Final Cover
Surface Water Monitoring Station	

Pond
Building
Road
Fence

Vashon Island Closed Landfill
Other King County-Owned Property
King County Tax Parcel

0 200 400
Feet

* indicates exploration from Golder, 1986
Topographic contours from King County Survey, Spring 2017

Exploration Locations

Remedial Investigation
Vashon Island Closed Landfill
King County, Washington

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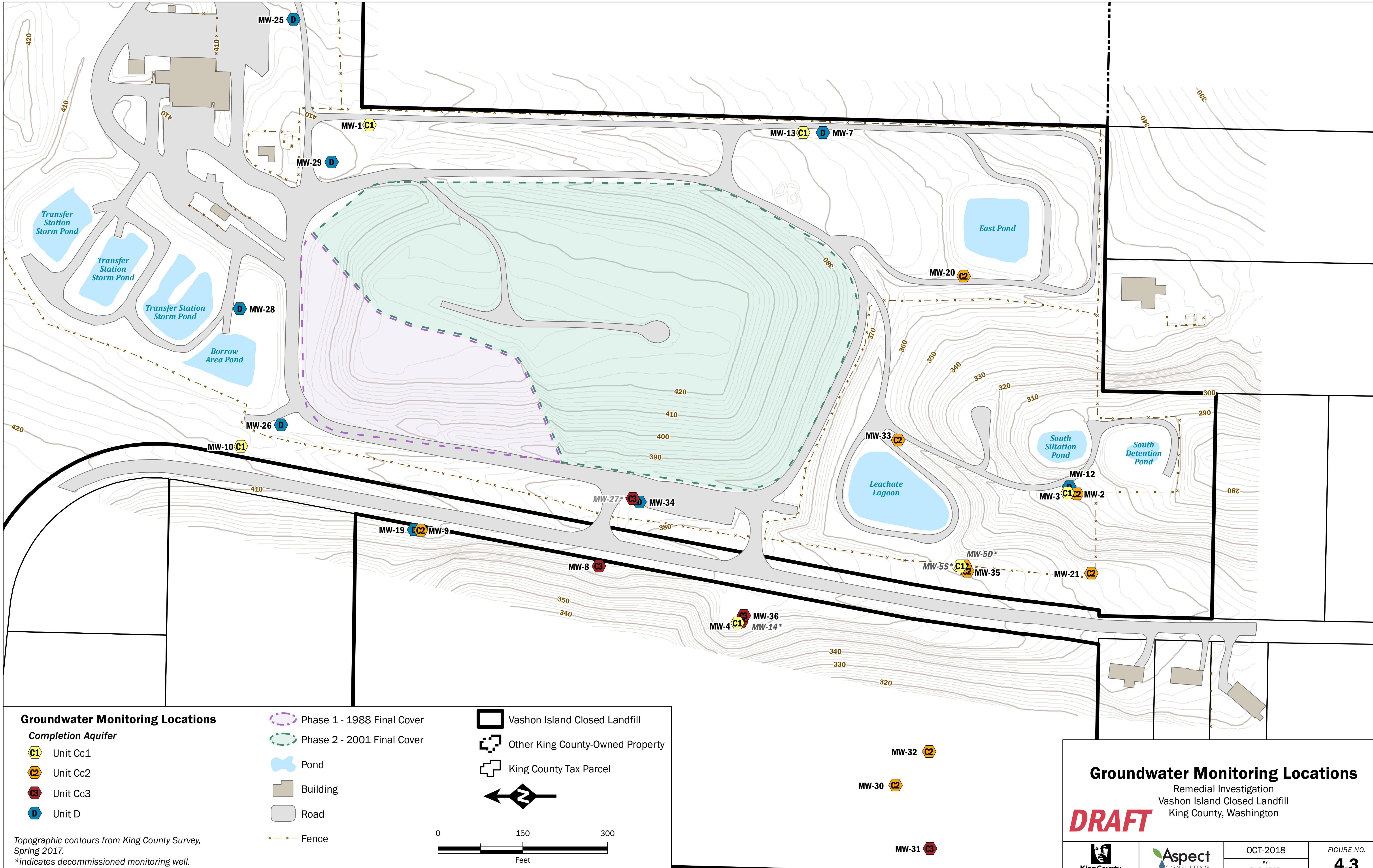
King County | Aspect CONSULTING | SEP-2018 BY: DAC / RAP | FIGURE NO. 4.2

GIS Path: T:\projects_8\KingCounty_SolidWaste\VashonIslandLandfill\Delivered\RIFS\4.2 Site Exploration Locations.mxd || Coordinate System: NAD 1983 HARN StatePlane Washington North FIPS 4601 Feet || Date Saved: 9/19/2018 || User: rpepin || Print Date: 10/3/2018



Groundwater Monitoring Locations

Remedial Investigation
Vashon Island Closed Landfill
King County, Washington

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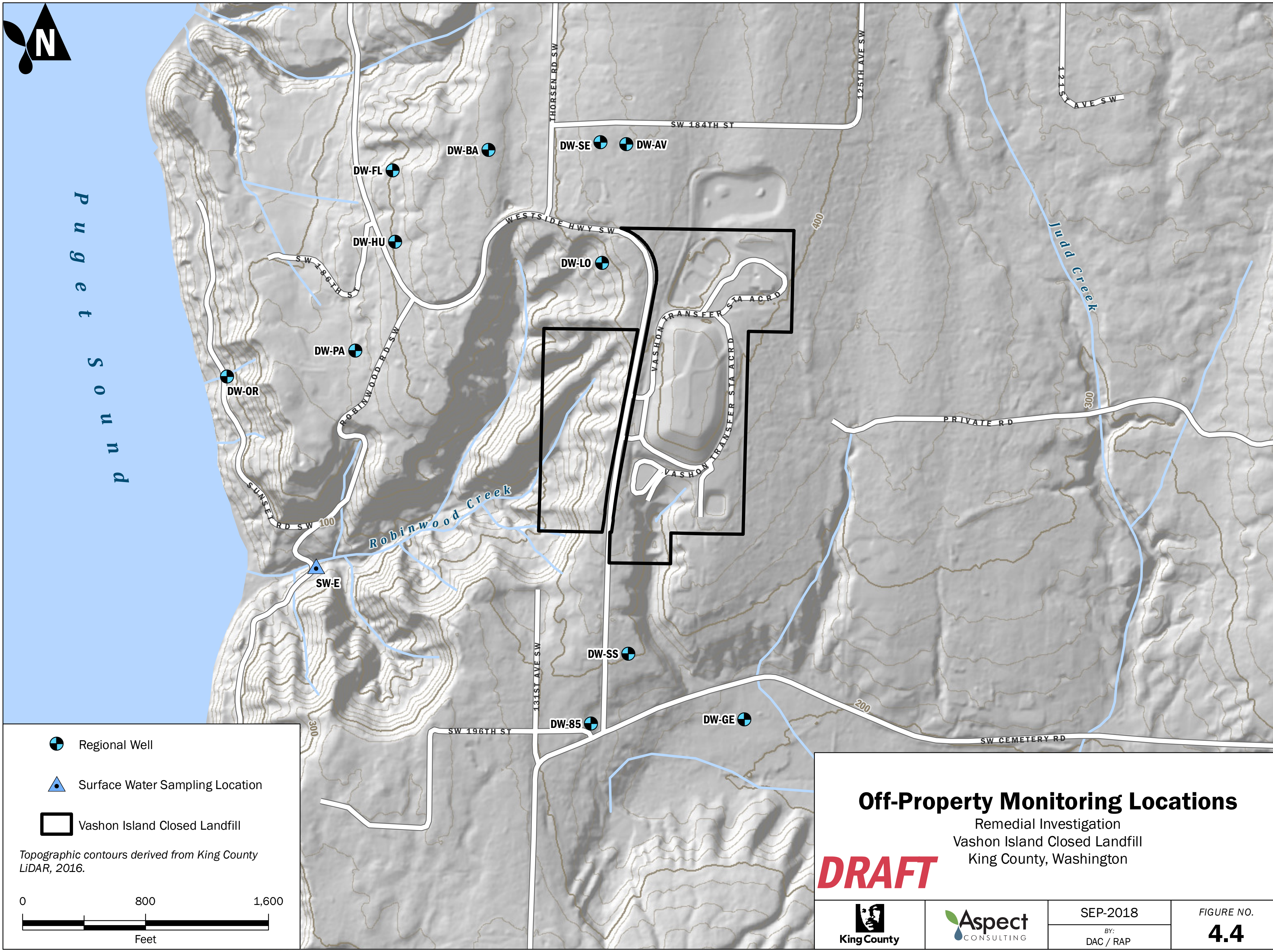
King County | Aspect Consulting | OCT-2018 | BY: DAC / RAP | FIGURE NO. 4.3



Off-Property Monitoring Locations

Remedial Investigation
Vashon Island Closed Landfill
King County, Washington

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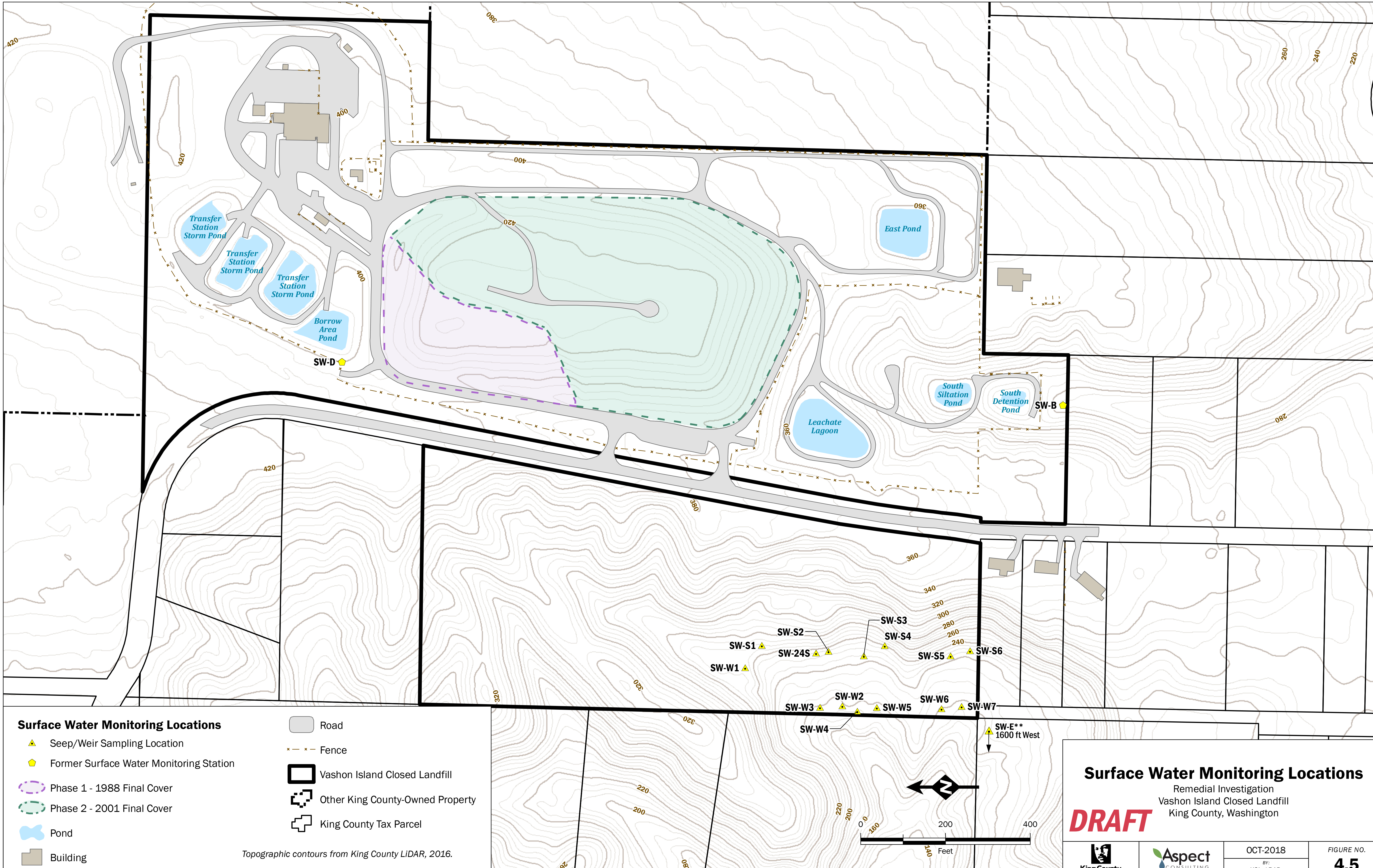
King County	Aspect CONSULTING	SEP-2018 BY: DAC / RAP	FIGURE NO. 4.4

GIS Path: T:\projects_8\KingCounty_SolidWaste\VashonIslandLandfill\Delivered\RIFS\4.4 Off-Property Monitoring Locations.mxd || Coordinate System: NAD 1983 HARN StatePlane Washington North FIPS 4601 Feet || Date Saved: 9/27/2018 || User: rpepin || Print Date: 10/3/2018



Surface Water Monitoring Locations

Remedial Investigation
Vashon Island Closed Landfill
King County, Washington

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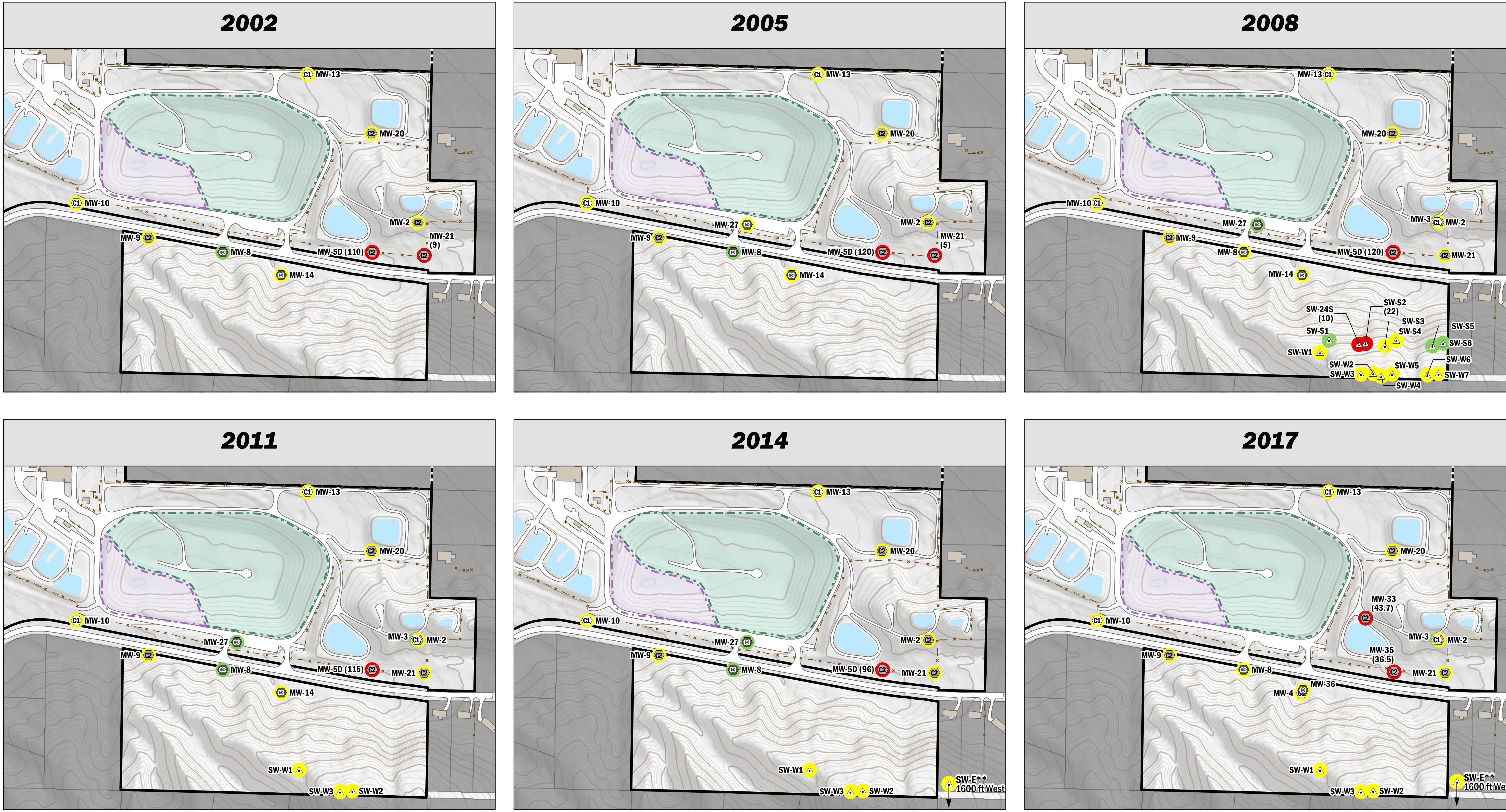
King County | Aspect CONSULTING | OCT-2018 | BY: KSL / RAP | FIGURE NO. 4.5



Monitoring Well (Unit Cc1)
Monitoring Well (Unit Cc2)
Monitoring Well (Unit Cc3)
Seep/Weir Sampling Location

Analyte Exceeds Screening Level
Analyte Detected, No Screening Level Exceedance
Analyte Not Detected
Fence
Pond

Phase 1 - 1988 Final Cover
Phase 2 - 2001 Final Cover
Building
Road
Vashon Island Closed Landfill

Other King County-Owned Property
King County Tax Parcel

Notes:
-Screening Level for Arsenic is 5 μg/L.
-All results posted are in μg/L. Only results which exceed the screening level are displayed.
-MW-14 and MW-27 were decommissioned in 2015.
*** See figure 4.2 for SW-E location*
-Topographic contours derived from King County LiDAR, 2016.

0 400 800
Feet

Extent of Dissolved Arsenic in Unit C Groundwater, 2002-2017

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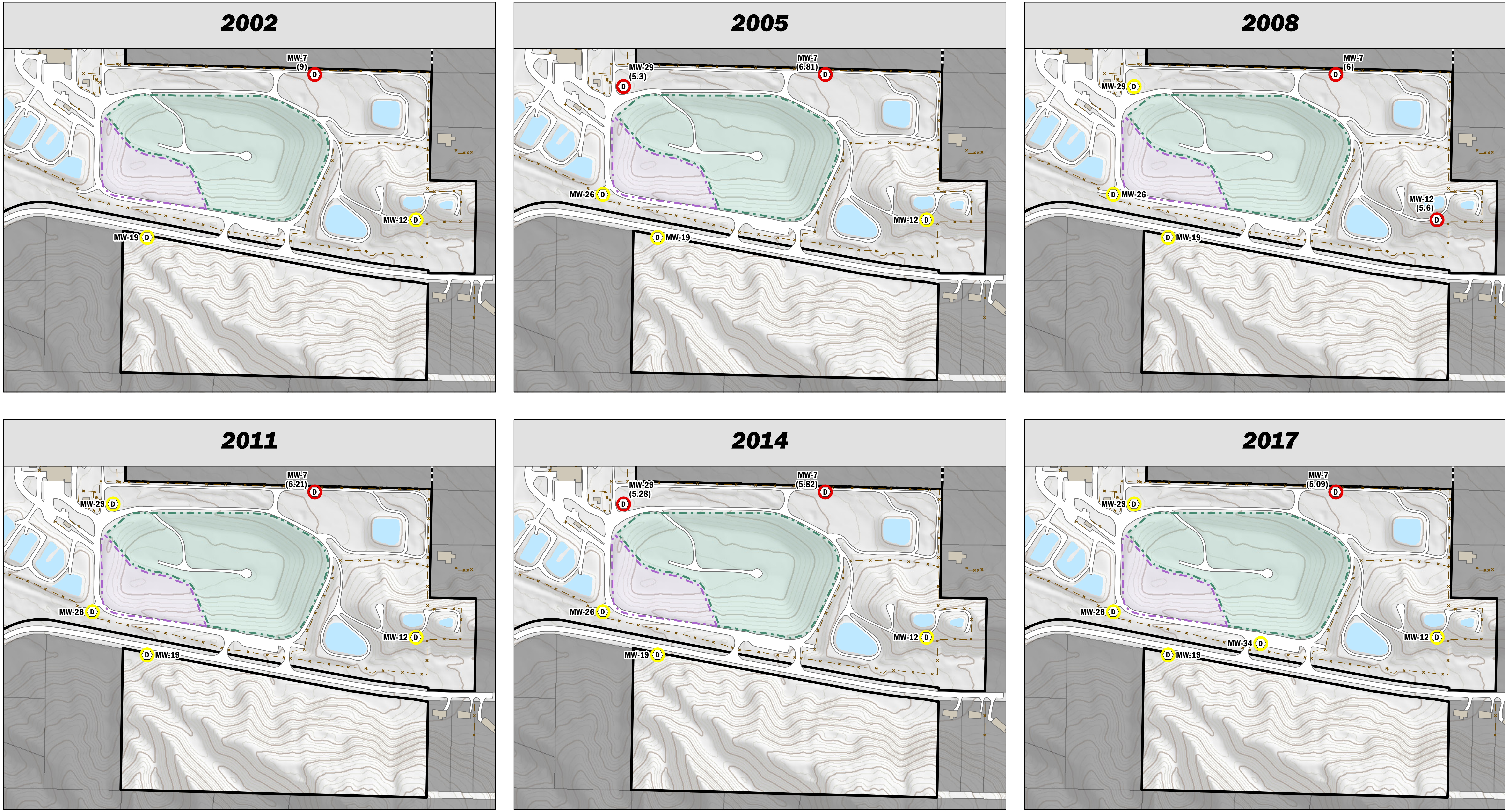
Remedial Investigation
Vashon Island Closed Landfill
King County, Washington

King County | Aspect CONSULTING | SEP-2018 | BY: DAC / RAP | FIGURE NO. 6.1



Monitoring Well (Unit D)
Analyte Exceeds Screening Level
Analyte Detected, No Screening Level Exceedance
Analyte Not Detected

Fence
Phase 1 - 1988 Final Cover
Phase 2 - 2001 Final Cover
Pond

Building
Road
Vashon Island Closed Landfill
Other King County-Owned Property
King County Tax Parcel

Notes:
-Screening Level for Arsenic is 5 µg/L.
-All results posted are in µg/L. Only results which exceed the screening level are displayed.
-Topographic contours derived from King County LiDAR, 2016.

0 400 800
Feet

Extent of Dissolved Arsenic in Unit D Groundwater, 2002-2017

Remedial Investigation
Vashon Island Closed Landfill
King County, Washington

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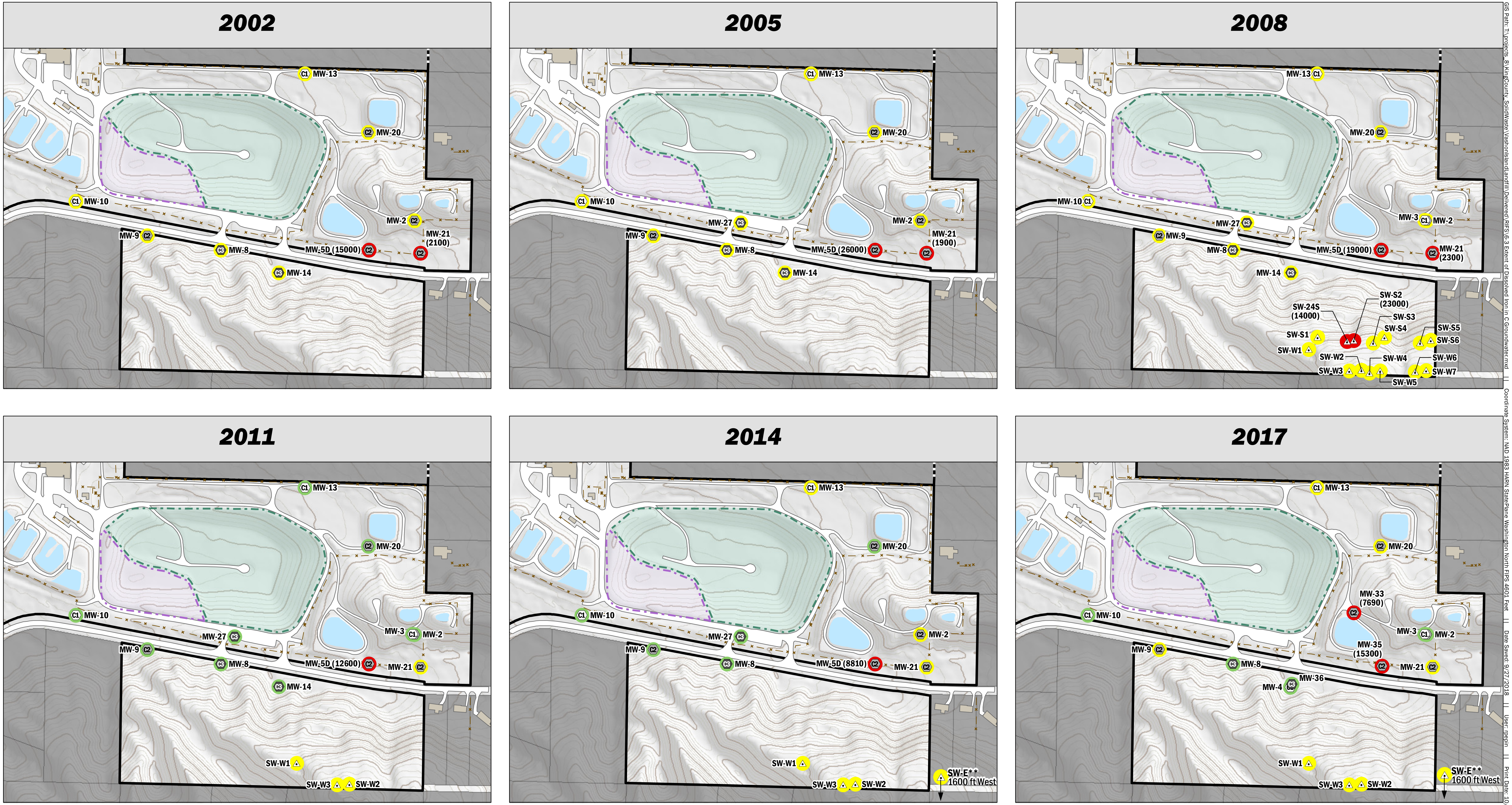
King County | Aspect CONSULTING | SEP-2018 BY: DAC / RAP | FIGURE NO. 6.2

GIS Path: T:\projects_8\KingCounty_SolidWaste\VashonIslandLandfill\Delivered\RIFS\6-2 Extent of Dissolved Arsenic in D Groundwater.mxd || Coordinate System: NAD 1983 HARN StatePlane Washington North FIPS 4601 Feet || Date Saved: 9/27/2018 || User: rpepin || Print Date: 10/3/2018



Monitoring Well (Unit Cc1)
Monitoring Well (Unit Cc2)
Monitoring Well (Unit Cc3)
Seep/Weir Sampling Location

Analyte Exceeds Screening Level
Analyte Detected, No Screening Level Exceedance
Analyte Not Detected
Fence
Pond

Phase 1 - 1988 Final Cover
Phase 2 - 2001 Final Cover
Building
Road
Vashon Island Closed Landfill

Other King County-Owned Property
King County Tax Parcel

Notes:
-Screening Level for Iron is 1,000 µg/L.
-All results posted are in µg/L. Only results which exceed the screening level are displayed.
-MW-14 and MW-27 were decommissioned in 2015.
*** See figure 4.2 for SW-E location*
-Topographic contours derived from King County LiDAR, 2016.

0 400 800
Feet

Extent of Dissolved Iron in Unit C Groundwater, 2002-2017

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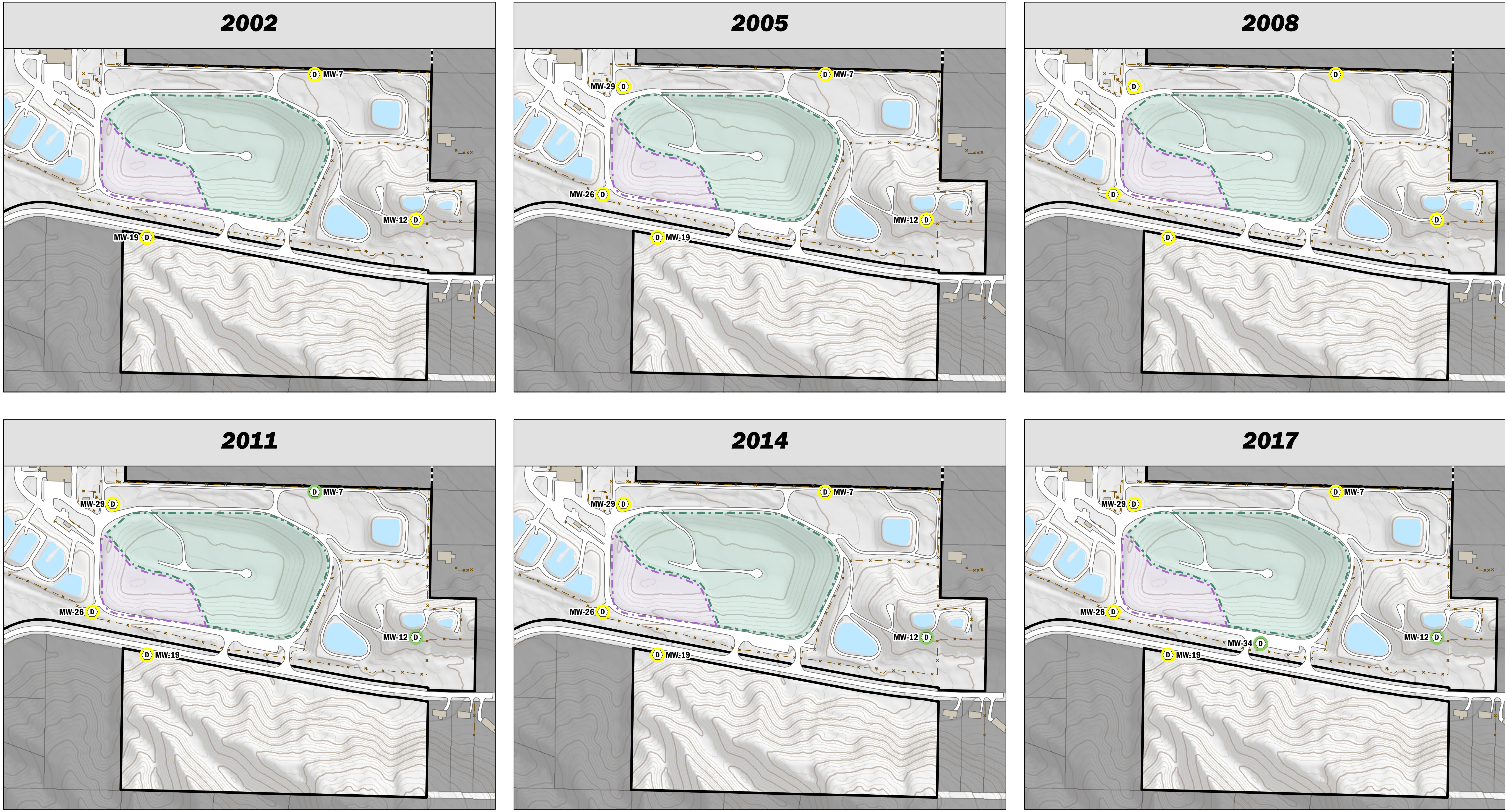
Remedial Investigation
Vashon Island Closed Landfill
King County, Washington

King County | Aspect Consulting | SEP-2018 | BY: DAC / RAP | FIGURE NO. 6.3



Monitoring Well (Unit D)
Analyte Exceeds Screening Level
Analyte Detected, No Screening Level Exceedance
Analyte Not Detected
Fence
Phase 1 - 1988 Final Cover
Phase 2 - 2001 Final Cover
Pond
Building
Road
Vashon Island Closed Landfill
Other King County-Owned Property
King County Tax Parcel

Notes:
-Screening Level for Iron is 1,000 µg/L.
-All results posted are in µg/L. Only results which exceed the screening level are displayed.
-Topographic contours derived from King County LiDAR, 2016.
-Only dissolved metals detected above laboratory quantitation levels are reported.

0 400 800
Feet

Extent of Dissolved Iron in Unit D Groundwater, 2002-2017

Remedial Investigation
Vashon Island Closed Landfill
King County, Washington

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Aspect CONSULTING

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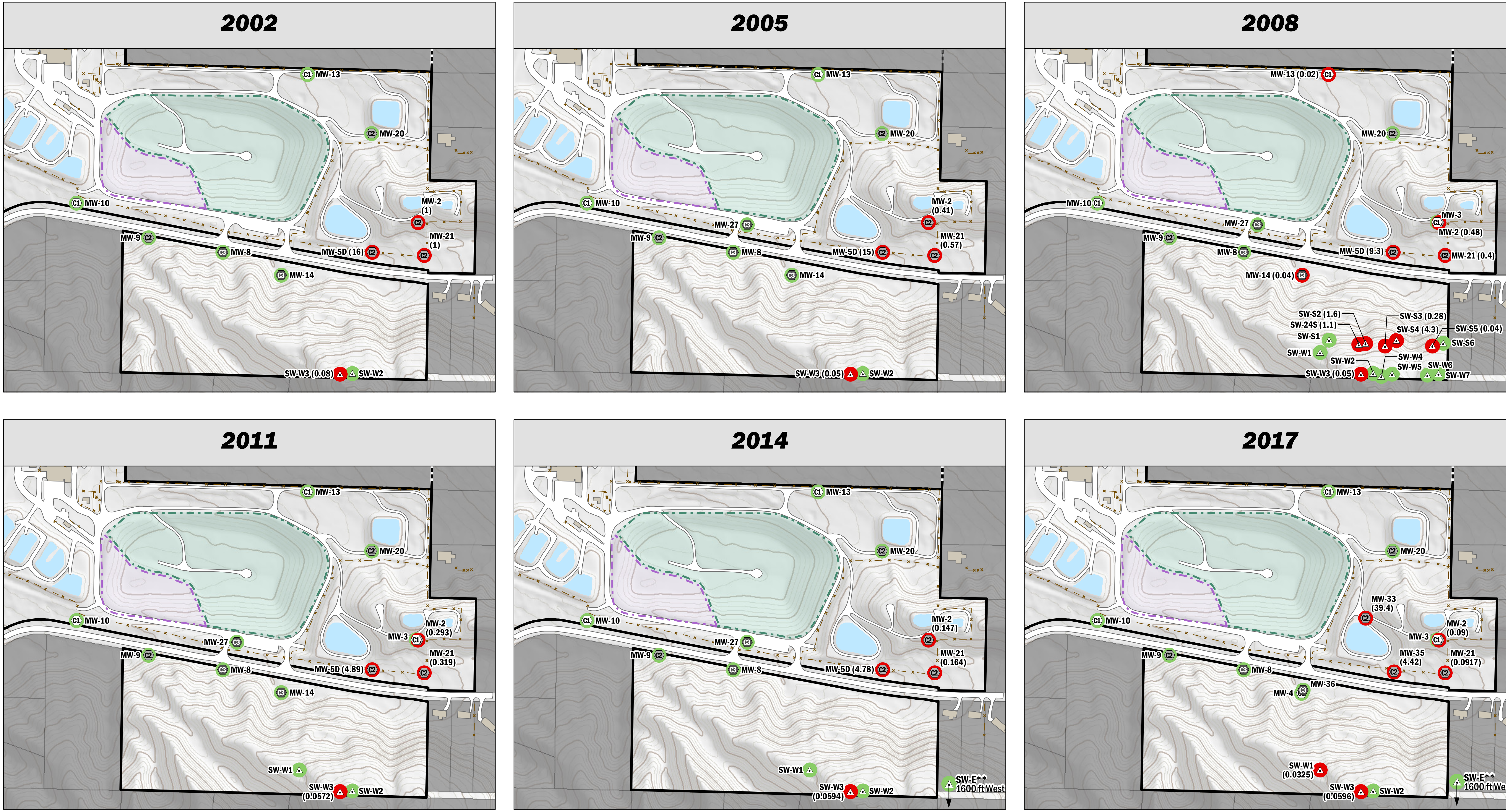
FIGURE NO. 6.4

GIS Path: T:\projects_8\KingCounty_SolidWaste\VashonIslandLandfill\Delivered\RIFS\6-4 Extent of Dissolved Iron in D Groundwater.mxd || Coordinate System: NAD 1983 HARN StatePlane Washington North FIPS 4601 Feet || Date Saved: 9/27/2018 || User: rpepin || Print Date: 10/3/2018



- Monitoring Well (Unit Cc1)
- Monitoring Well (Unit Cc2)
- Monitoring Well (Unit Cc3)
- Seep/Weir Sampling Location
- Analyte Exceeds Screening Level
- Analyte Detected, No Screening Level Exceedance
- Analyte Not Detected
- Fence
- Pond
- Phase 1 - 1988 Final Cover
- Phase 2 - 2001 Final Cover
- Building
- Road
- Vashon Island Closed Landfill
- Other King County-Owned Property
- King County Tax Parcel

Notes:
-Screening Level for Vinyl Chloride is 0.02 μg/L.
-All results posted are in μg/L. Only results which exceed the screening level are displayed.
-MW-14 and MW-27 were decommissioned in 2015.
*** See figure 4.2 for SW-E location*
-Topographic contours derived from King County LiDAR, 2016.

0 400 800
Feet

Extent of Vinyl Chloride in Unit C Groundwater, 2002-2017

Remedial Investigation
Vashon Island Closed Landfill
King County, Washington

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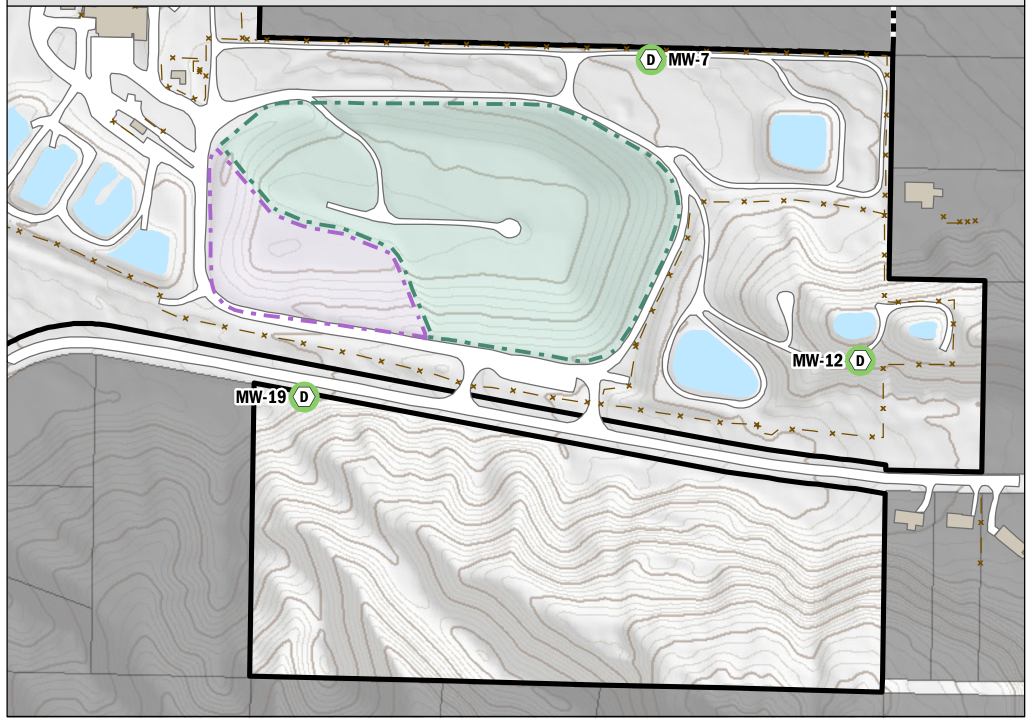
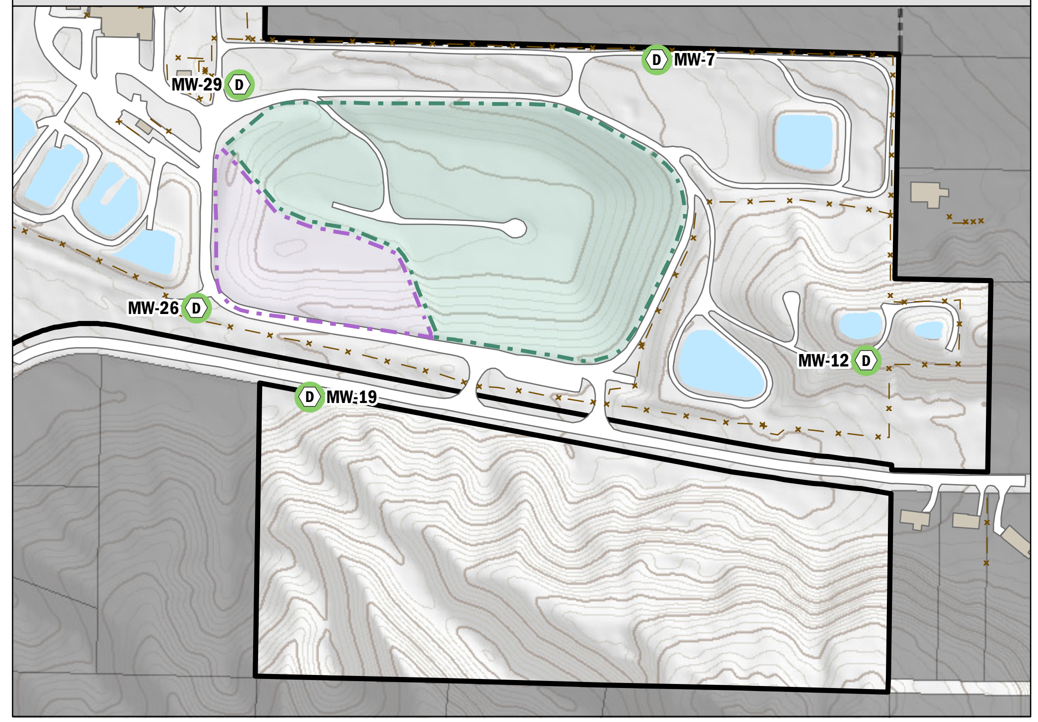
King County | Aspect Consulting | SEP-2018 | BY: DAC / RAP | FIGURE NO. 6.5

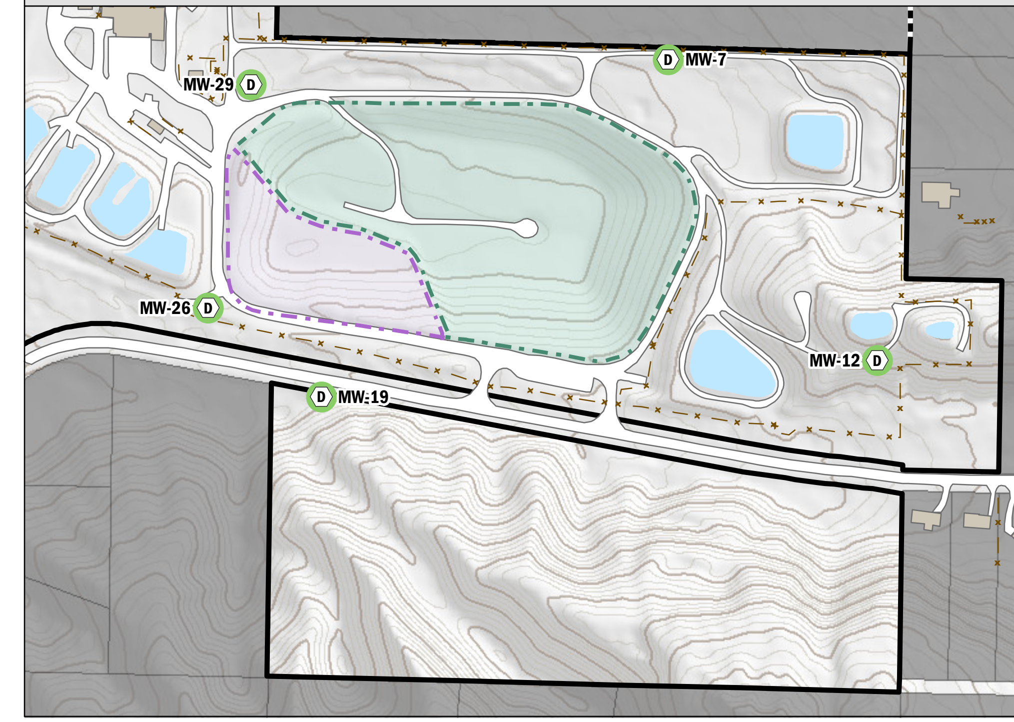
2002



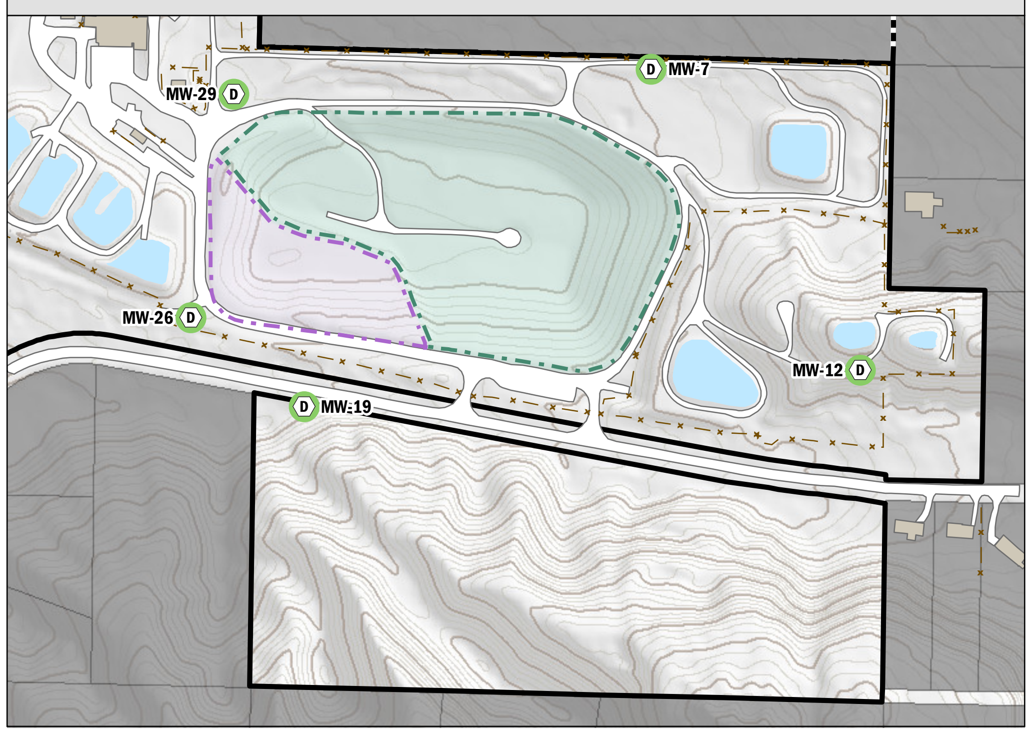
2005



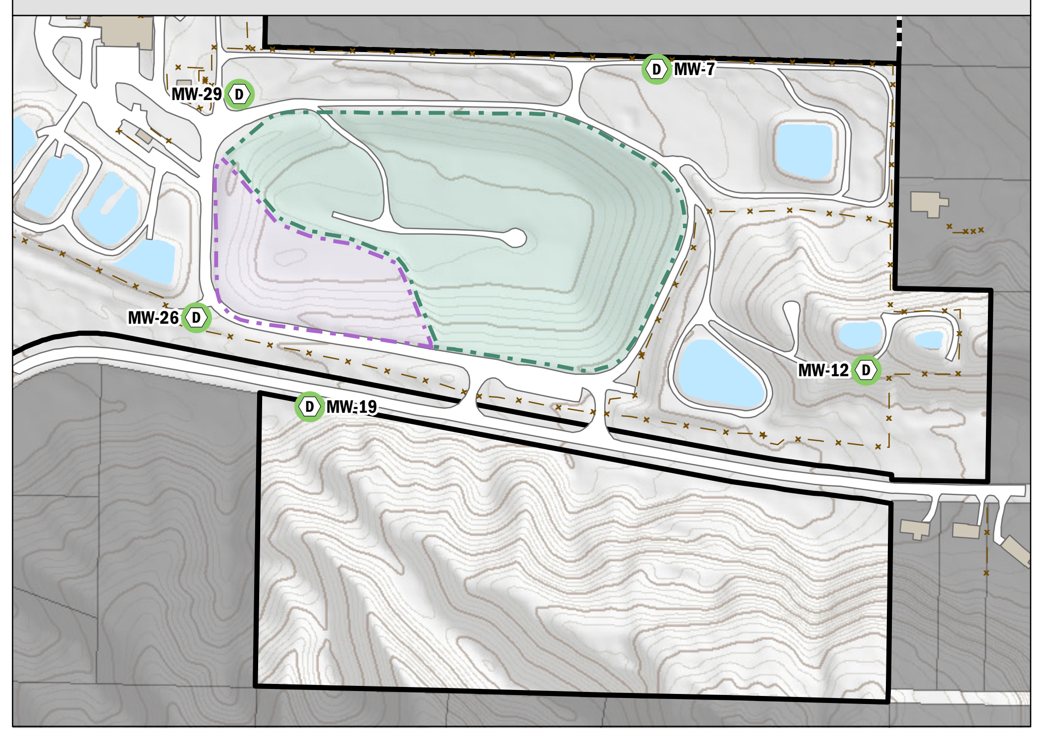
2008



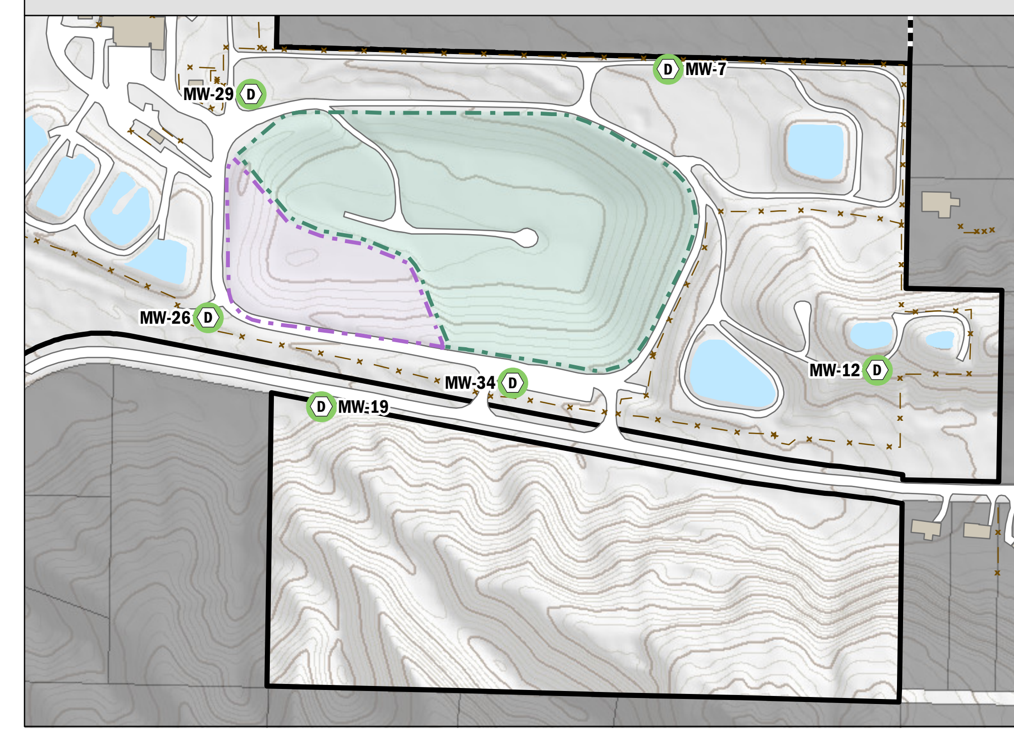
2011



2014



2017



Monitoring Well (Unit D)
Analyte Exceeds Screening Level
Analyte Detected, No Screening Level Exceedance
Analyte Not Detected

Fence
Phase 1 - 1988 Final Cover
Phase 2 - 2001 Final Cover
Pond

Building
Road
Vashon Island Closed Landfill
Other King County-Owned Property
King County Tax Parcel

Notes:
-Screening Level for Vinyl Chloride is 0.02 µg/L.
-All results posted are in µg/L. Only results which exceed the screening level are displayed.
-Topographic contours derived from King County LiDAR, 2016.

N

0 400 800
Feet

Extent of Vinyl Chloride in Unit D Groundwater, 2002-2017

Remedial Investigation
Vashon Island Closed Landfill
King County, Washington

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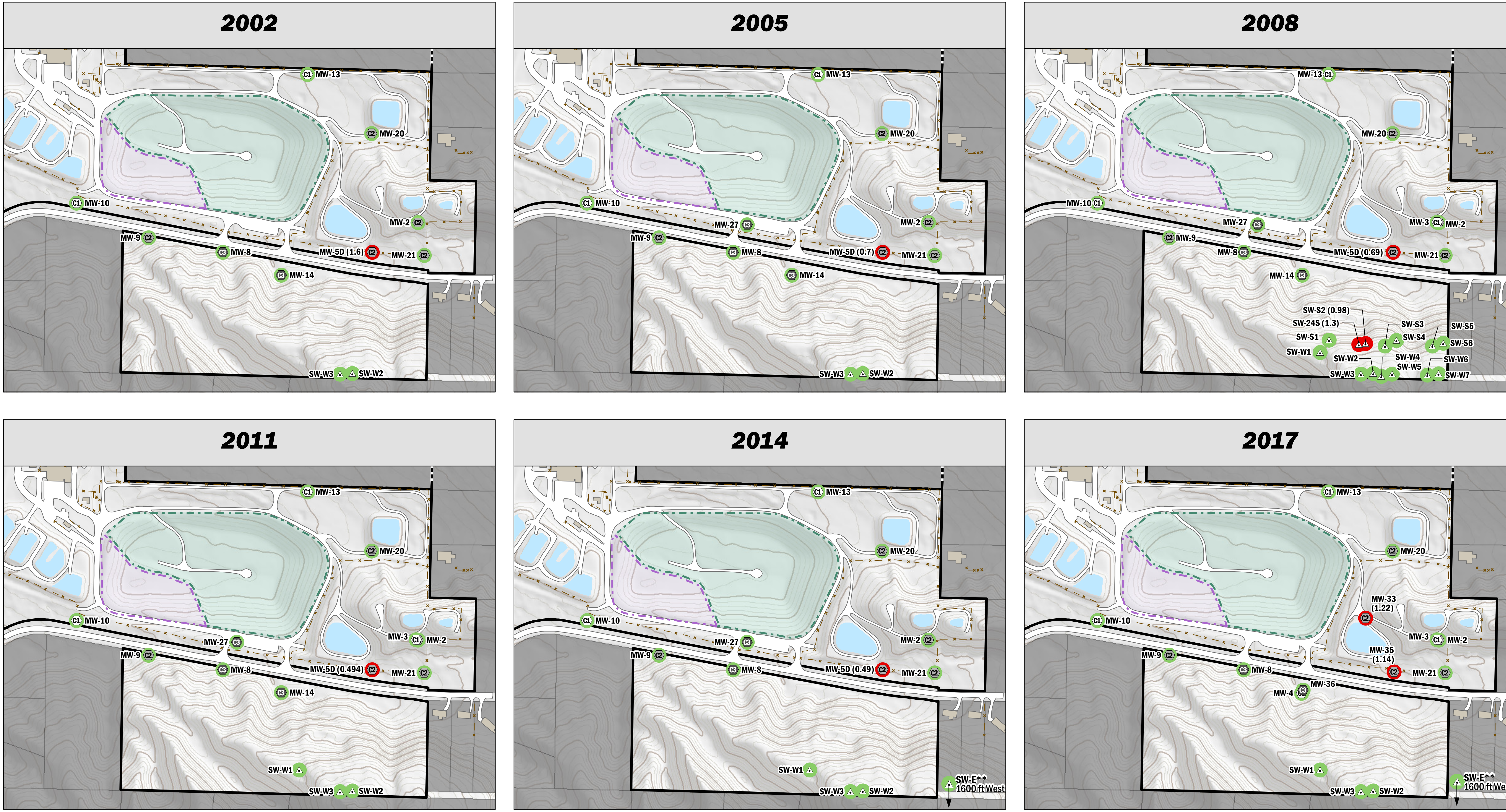
King County

Aspect CONSULTING

SEP-2018
BY:
DAC / RAP

FIGURE NO.
6.6

GIS Path: T:\projects_8\KingCounty_SolidWaste\VashonIslandLandfill\Delivered\RIFS\6.6 Extent of Vinyl Chloride in D Groundwater.mxd || Coordinate System: NAD 1983 HARN StatePlane Washington North FIPS 4601 Feet || Date Saved: 9/27/2018 || User: rpepin || Print Date: 10/3/2018



Monitoring Well (Unit Cc1)
Monitoring Well (Unit Cc2)
Monitoring Well (Unit Cc3)
Seep/Weir Sampling Location

Analyte Exceeds Screening Level
Analyte Detected, No Screening Level Exceedance
Analyte Not Detected
Fence
Pond

Phase 1 - 1988 Final Cover
Phase 2 - 2001 Final Cover
Building
Road
Vashon Island Closed Landfill

Other King County-Owned Property
King County Tax Parcel

Notes:
-Screening Level for Benzene is 0.44 µg/L.
-All results posted are in µg/L. Only results which exceed the screening level are displayed.
-MW-14 and MW-27 were decommissioned in 2015.
*** See figure 4.2 for SW-E location*
-Topographic contours derived from King County LiDAR, 2016.

0 400 800
Feet

Extent of Benzene in Unit C Groundwater, 2002-2017

Remedial Investigation
Vashon Island Closed Landfill
King County, Washington

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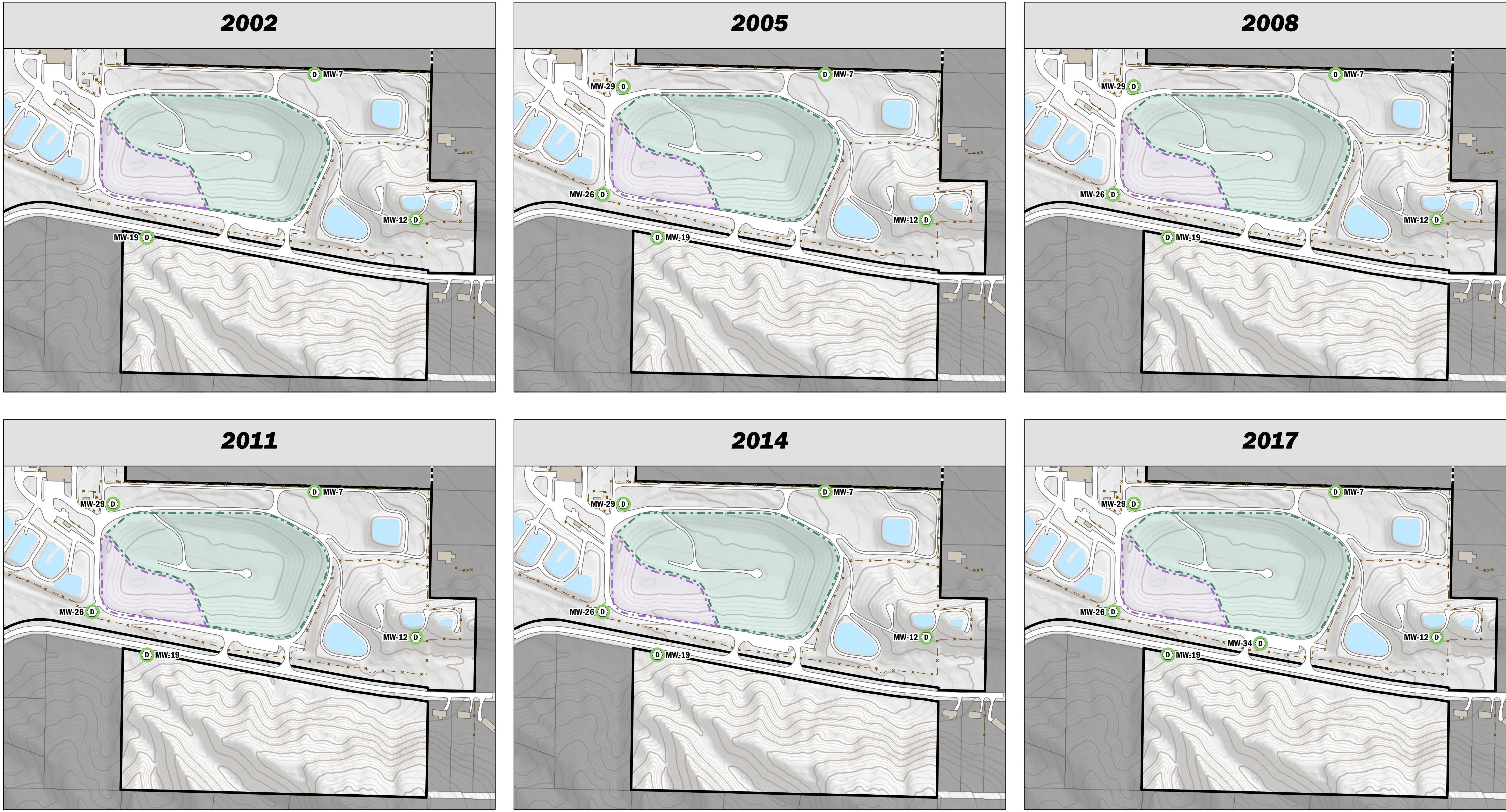
King County | Aspect Consulting | SEP-2018 | BY: DAC / RAP | FIGURE NO. 6.7



Monitoring Well (Unit D)
Analyte Exceeds Screening Level
Analyte Detected, No Screening Level Exceedance
Analyte Not Detected

Fence
Phase 1 - 1988 Final Cover
Phase 2 - 2001 Final Cover
Pond

Building
Road
Vashon Island Closed Landfill
Other King County-Owned Property
King County Tax Parcel

Notes:
-Screening Level for Benzene is 0.44 µg/L.
-All results posted are in µg/L. Only results which exceed the screening level are displayed.
*** See figure 4.2 for SW-E location*
-Topographic contours derived from King County LiDAR, 2016.

N

0 400 800
Feet

Extent of Benzene in Unit D Groundwater, 2002-2017

Remedial Investigation
Vashon Island Closed Landfill
King County, Washington

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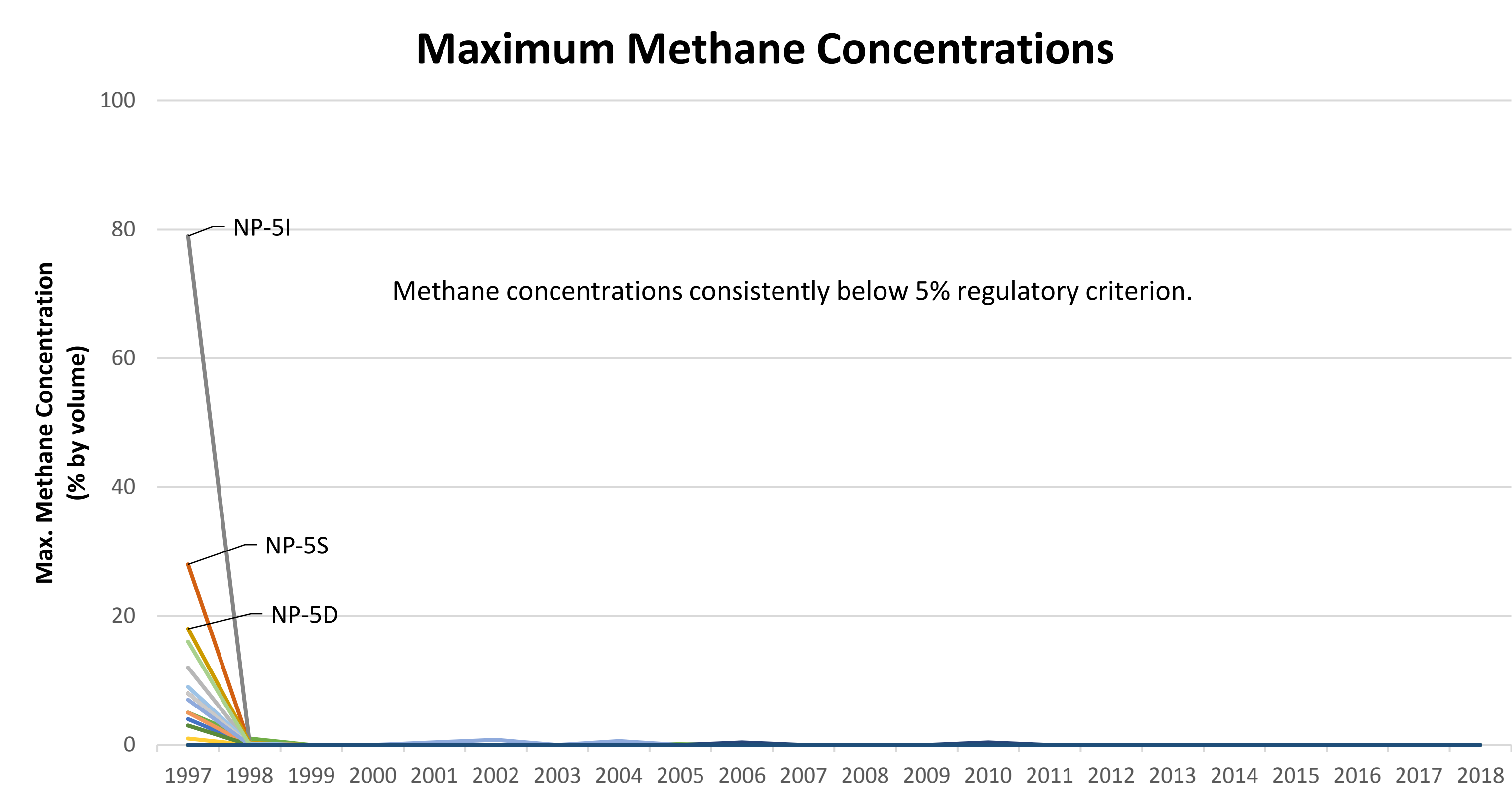
King County

Aspect CONSULTING

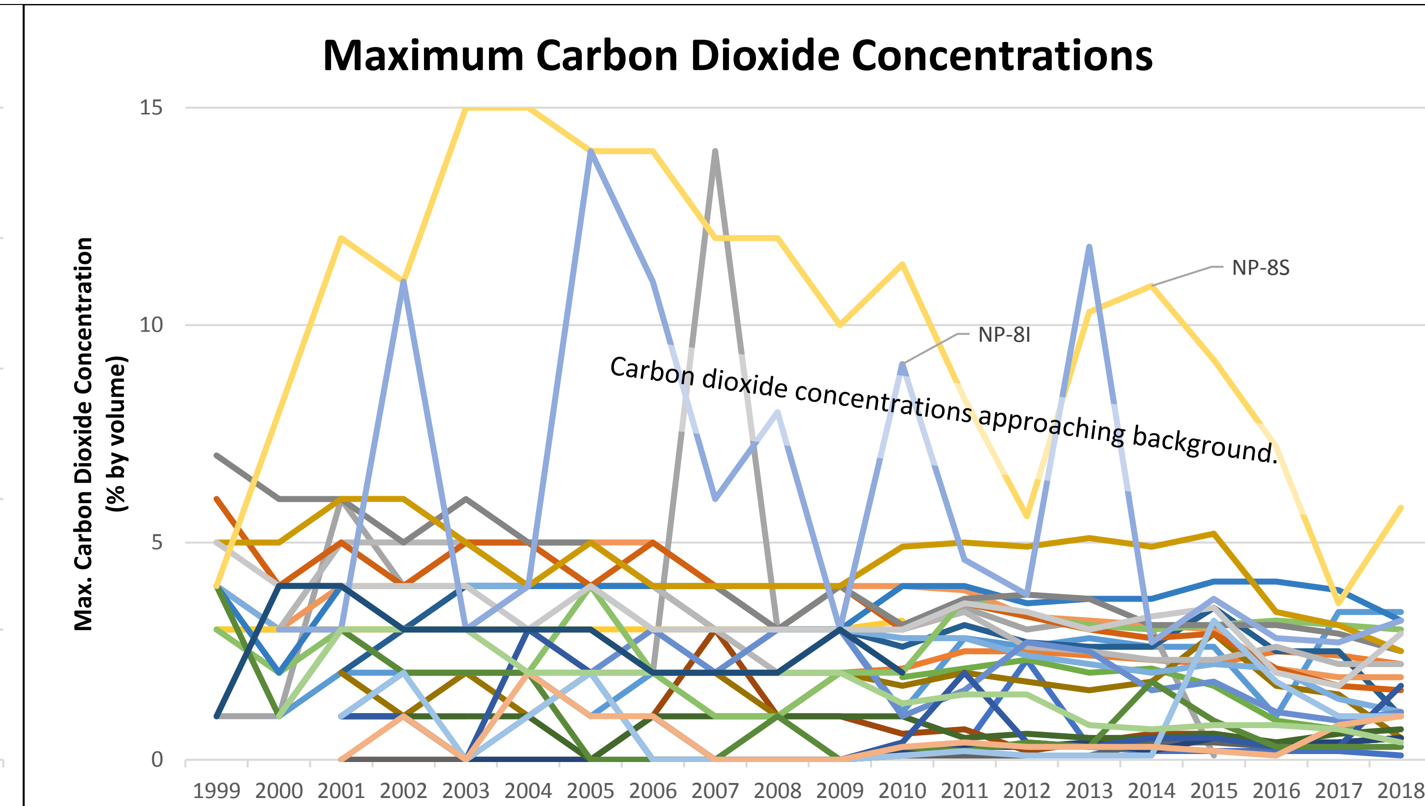
SEP-2018
BY: DAC / RAP

FIGURE NO. 6.8

GIS Path: T:\projects_8\KingCounty_SolidWaste\VashonIslandLandfill\Delivered\RIFS\6-8 Extent of Benzene in D Groundwater.mxd || Coordinate System: NAD 1983 HARN StatePlane Washington North FIPS 4601 Feet || Date Saved: 9/27/2018 || User: rpepin || Print Date: 10/3/2018



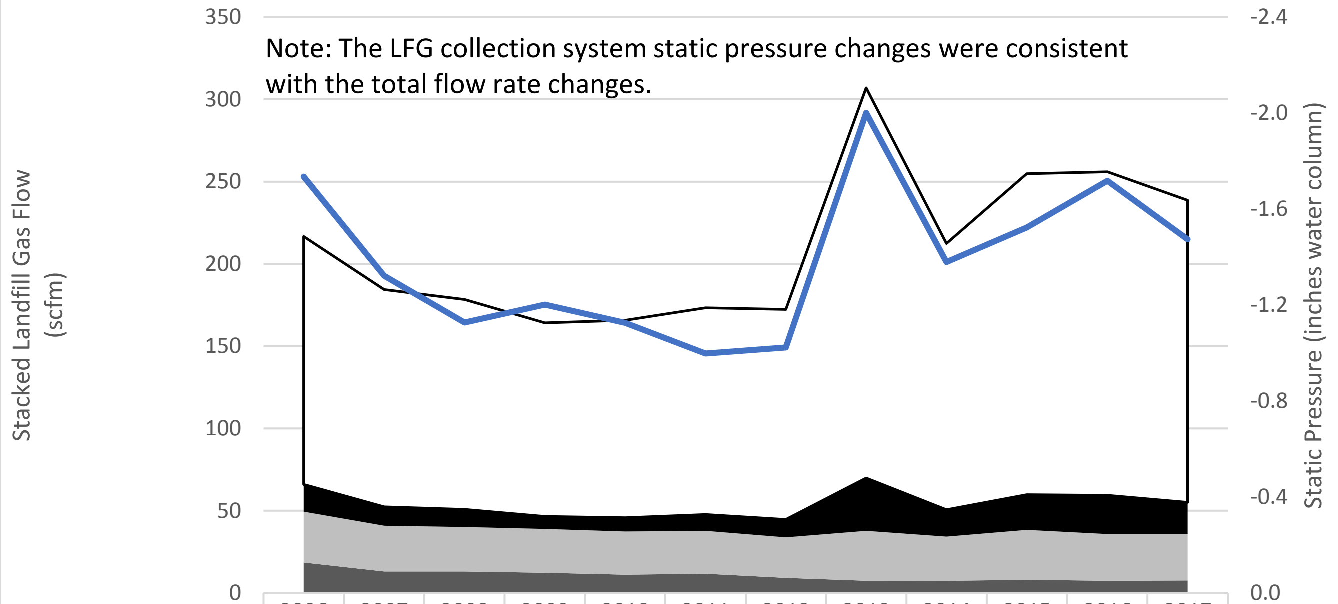
	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
GP-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GP-2	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GP-5	5	1	0	0	0	0	0	0.1	0.1	0	0	0	0	0	0	0	0	0	0			
GP-6	0	0	0	0	0	0	0															
MW-13														0	0	0	0	0	0	0	0	0
MW-24														0	0	0	0	0	0	0	0	0
NP-1S	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NP-1I	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NP-1D	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NP-2S	0	0	0	0	0	0	0	0	0	0.4	0	0	0	0.4	0	0	0	0	0	0	0	0
NP-2I	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NP-2D	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NP-3S	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NP-3I	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NP-3D	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NP-4S	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
NP-4I	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NP-4D	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NP-5S	28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NP-5I	79	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NP-5D	18	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NP-6S	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NP-6I	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NP-6D	9	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NP-7S	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NP-7I	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NP-7D	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NP-8S	7	0	0	0	0.4	0.8	0	0.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NP-8I	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NP-8D	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
P-1	3	0	0	0	0	0	0	0	0	0	0	0	0	0								



	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
GP-1		1	2	2	2	2	1	2	2	2	3	1.1	2.8	2.6	2.8	2.6	2.6	1	3.4	3.4
GP-2	4	3	3	3	3	3	3	2	2	2	2	2.1	2.5	2.5	2.4	2.3	2.2	2.5	2.4	2.2
GP-5	1	1	6	4	5	5	4	2	14	3	3	3	3.5	3	3.2	3	0.1			
GP-6			2	1	1															
MW-13												0.1	0.3	2.3	0.3	0.2	0.2	0.2	0.2	0.1
MW-24												1.9	2.1	2.3	2	2.1	1.7	0.9	0.7	1.1
NP-1S	2		2	3	4	4	4	4	3	3	3	2.6	3.1	2.7	2.6	2.6	3.5	2.5	2.5	1
NP-1I			0	0	0	0	0	1	3	1	1	0.6	0.7	0.2	0.4	0.6	0.6	0.4	0.4	0.5
NP-1D			0	0	0	0	0	0	0	0	0	0.1	0.1	0.1	0.1	0.4	0.4	0.3	0.4	0.5
NP-2S			2	1	2	1	2	2	2	1	2	1.7	2	1.8	1.6	1.8	2.9	1.7	1.5	0.5
NP-2I			1	1	0	0	0	1	0	0	0	0.2	0.3	0.3	0.4	0.2	0.5	0.4	0.4	0.5
NP-2D			1	1	1	1	0	1	1	1	1	1	0.5	0.6	0.5	0.5	0.6	0.4	0.6	0.7
NP-3S	4	3	5	4	4	4	4	3	2	3	3	2.8	2.8	2.4	2.2	2	2.2	2.1	1.4	1.1
NP-3I	3	3	4	4	5	5	5	5	4	4	4	4	3.9	3.3	3.2	3.1	3	2.1	1.9	1.9
NP-3D	3	3	5	5	5	4	4	4	3	2	3	3	3.4	2.6	2.5	2.3	2.3	2.6	2.2	2.2
NP-4S	3	3	3	3	3	3	3	3	3	3	3	3.2								
NP-4I			1	2	2	2	2	3	2	3	3	1	1.6	2.7	2.5	1.6	1.8	1.1	0.9	1.1
NP-4D	3	2	3	2	2	2	4	2	1	1	2	2	3.7	3.3	3.1	3	3.1	3.2	3.1	3
NP-5S	4	2	4	3	3	4	4	4	4	3	3	4	4	3.6	3.7	3.7	4.1	4.1	3.9	3.2
NP-5I	6	4	5	4	5	5	4	5	4	3	4	3	3.6	3.3	3	2.8	2.9	2.1	1.7	1.6
NP-5D	7	6	6	5	6	5	5	4	4	3	4	3.1	3.7	3.8	3.7	3.1	3.1	3.1	2.9	2.5
NP-6S	5	5	6	6	5	4	5	4	4	4	4	4.9	5	4.9	5.1	4.9	5.2	3.4	3.1	2.5
NP-6I			1	1	0	3	2	0	0	0	0	0.4	2	0.4	0.3	0.5	0.5	0.3	0.3	1.7
NP-6D	4	1	3	2	2	2	0	0	0	1	0	0.3	0.2	0.4	0.3	1.8	0.9	0.3	0.3	0.3
NP-7S			1	2	0	1	2	0	0	0	0	0.1	0.2	0.1	0.1	0.1	3.2	1.8	1	1
NP-7I			0	1	0	2	1	1	0	0	0	0.3	0.4	0.3	0.3	0.3	0.2	0.1	0.8	1
NP-7D	5	4	4	4	4	3	4	3	3	3	3	3	3.6	3.4	3	3.3	3.5	2	1.7	2.9
NP-8S	4	8	12	11	15	15	14	14	12	12	10	11.4	8.3	5.6	10.3	10.9	9.2	7.2	3.6	5.8
NP-8I		3	3	11	3	4	14	11	6	8	3	9.1	4.6	3.8	11.8	2.7	3.7	2.8	2.7	3.2
NP-8D		1	3	3	3	2	2	2	2	2	2	1.3	1.5	1.5	0.8	0.7	0.8	0.8	0.7	0.4
P-1	1	4	4	3	3	3	3	2	2	2	3	2								

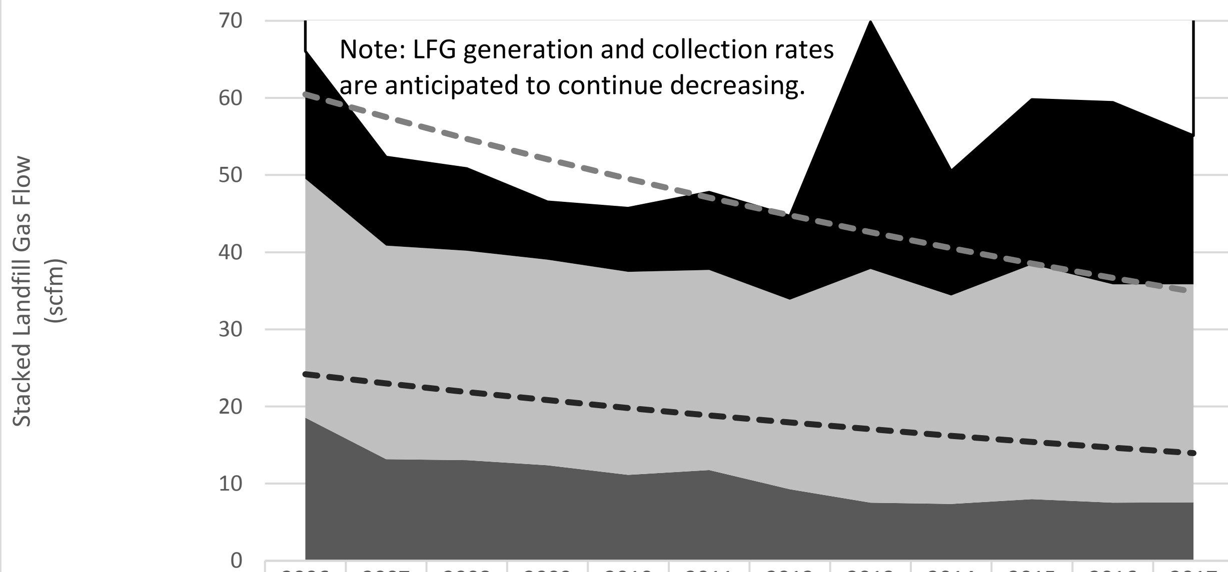
Figure 6.9
Compliance Probe LFG Concentrations Over Time

Observed LFG Collection Over Time



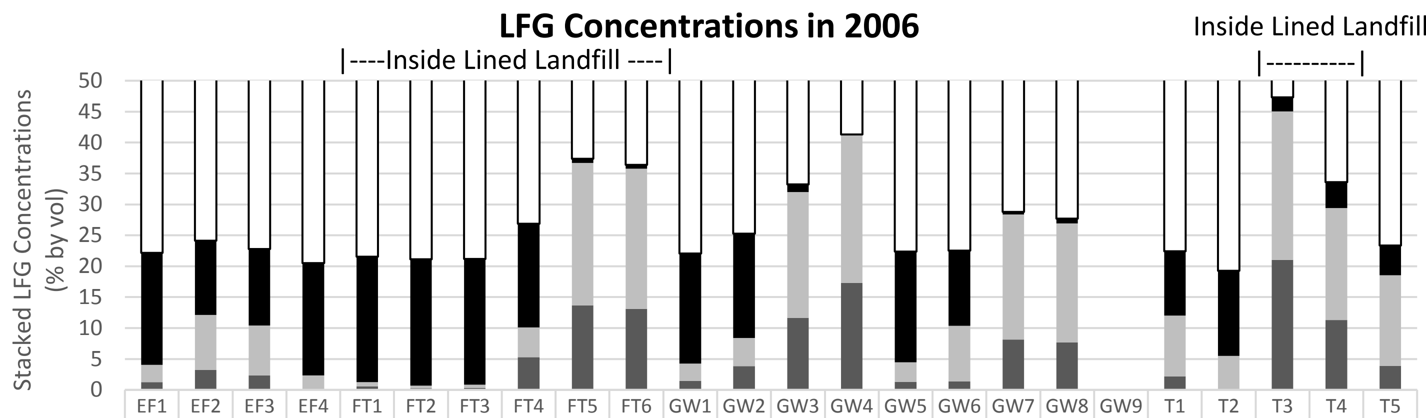
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Balance	151	132	128	118	120	126	128	237	162	195	196	183
Oxygen	17	11	11	8	8	10	11	32	16	21	24	19
CO2	31	28	27	27	26	26	25	30	27	30	28	28
Methane	19	13	13	12	11	12	9	8	7	8	8	8
Static Pressure	-1.7	-1.3	-1.1	-1.2	-1.1	-1.0	-1.0	-2.0	-1.4	-1.5	-1.7	-1.5

Comparison of Observed LFG Collection and LandGEM Model

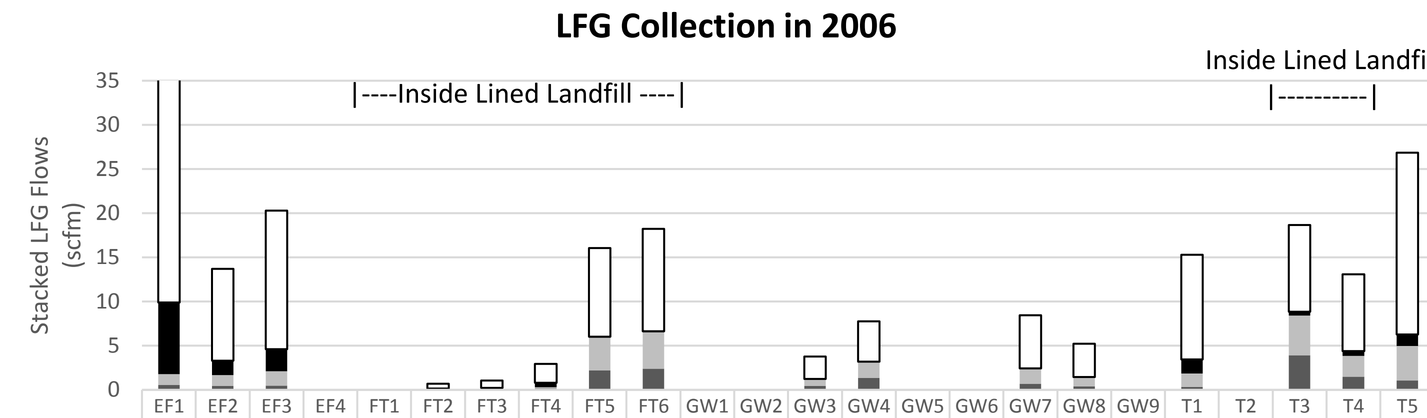


	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Balance	151	132	128	118	120	126	128	237	162	195	196	183
Oxygen	17	11	11	8	8	10	11	32	16	21	24	19
CO2	31	28	27	27	26	26	25	30	27	30	28	28
Methane	19	13	13	12	11	12	9	8	7	8	8	8
LandGEM CO2	36	35	33	31	30	28	27	26	24	23	22	21
LandGEM CH4	24	23	22	21	20	19	18	17	16	15	15	14

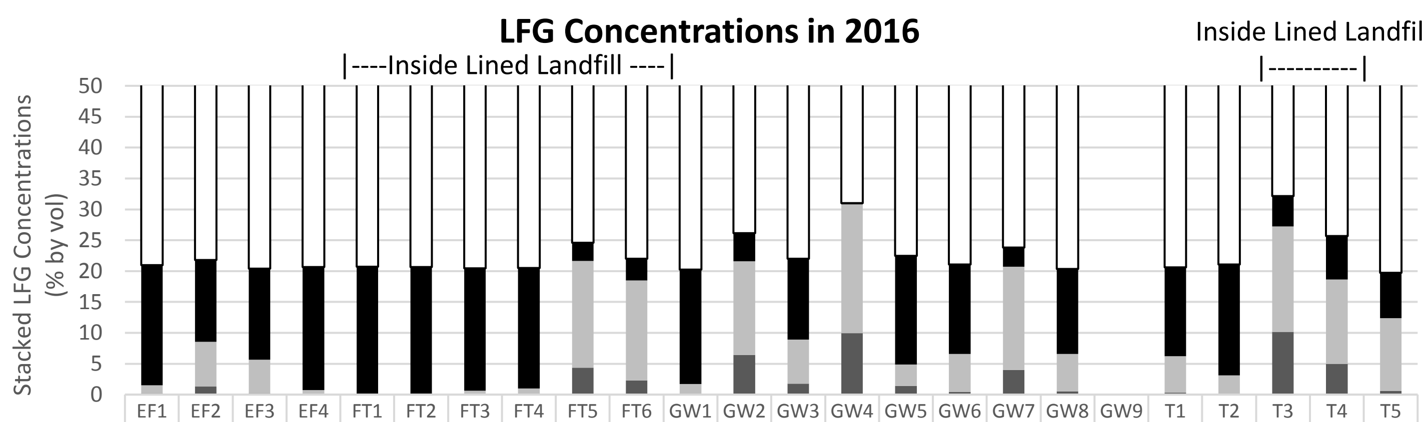
Figure 6.10
Overall LFG Collection Over Time
Remedial Investigation



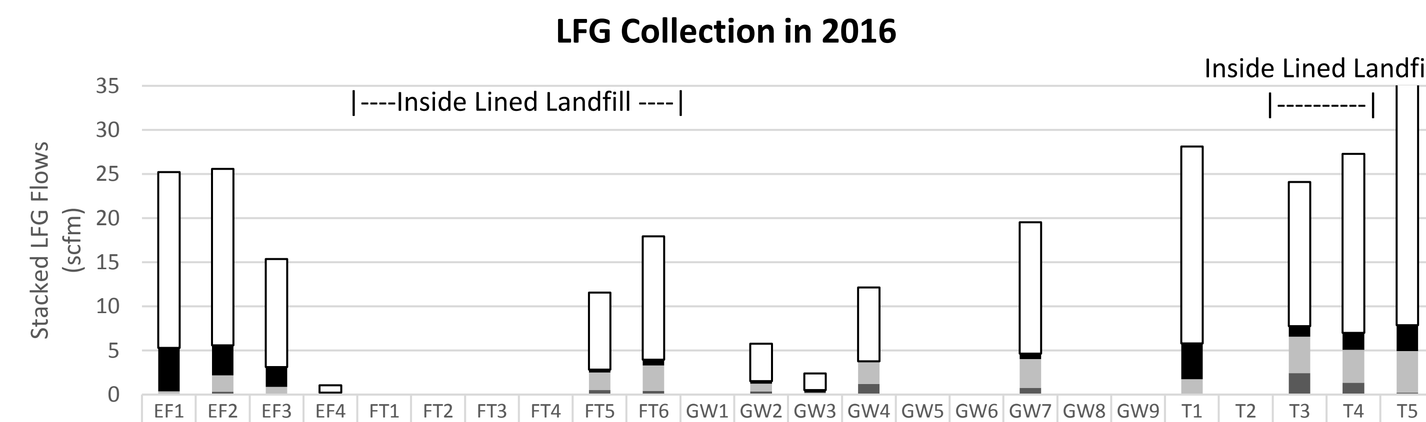
	EF1	EF2	EF3	EF4	FT1	FT2	FT3	FT4	FT5	FT6	GW1	GW2	GW3	GW4	GW5	GW6	GW7	GW8	GW9	T1	T2	T3	T4	T5
Balance	76	74	75	78	76	77	77	71	61	62	76	73	64	57	76	76	69	70	0	75	78	50	64	73
O2	18	12	12	18	20	20	20	17	1	1	18	17	1	0	18	12	0	1	0	10	14	2	4	5
CO2	3	9	8	2	1	0	1	5	23	23	3	5	20	24	3	9	20	19	0	10	5	24	18	15
CH4	1	3	2	0	1	0	0	5	14	13	1	4	12	17	1	1	8	8	0	2	0	21	11	4



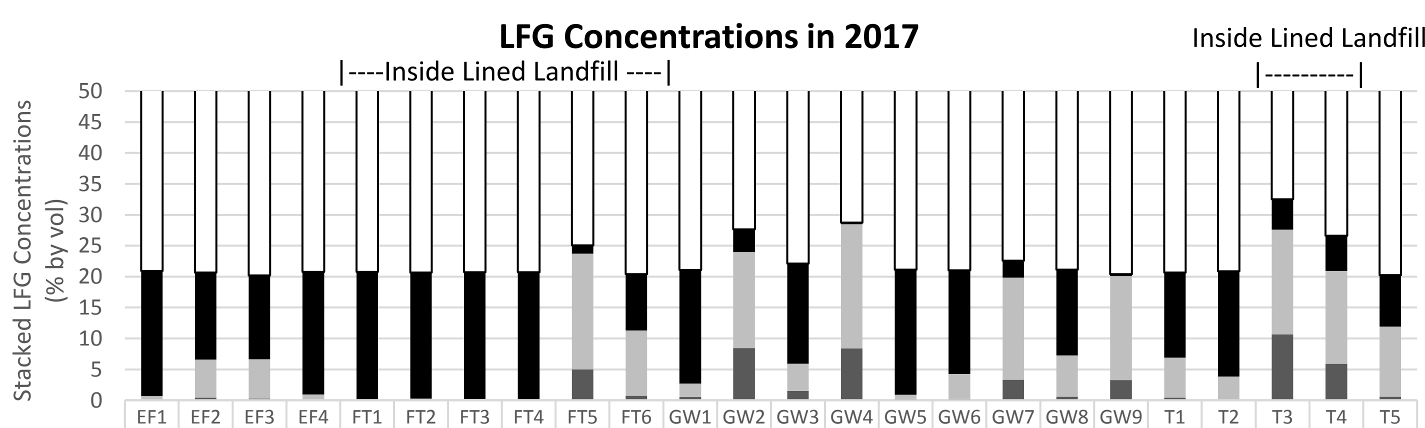
	EF1	EF2	EF3	EF4	FT1	FT2	FT3	FT4	FT5	FT6	GW1	GW2	GW3	GW4	GW5	GW6	GW7	GW8	GW9	T1	T2	T3	T4	T5
Balance	34.8	10.4	15.7	0.0	0.0	0.5	0.8	2.2	10.1	11.6	0.0	0.0	2.5	4.6	0.0	0.0	6.0	3.8	0.0	11.9	0.0	9.8	8.7	20.6
O2	8.1	1.6	2.5	0.0	0.0	0.1	0.2	0.5	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	0.0	0.4	0.6	1.3
CO2	1.2	1.2	1.6	0.0	0.0	0.0	0.0	0.1	3.7	4.1	0.0	0.0	0.8	1.9	0.0	0.0	1.7	1.0	0.0	1.5	0.0	4.5	2.4	3.9
CH4	0.6	0.4	0.5	0.0	0.0	0.0	0.0	0.2	2.2	2.4	0.0	0.0	0.4	1.3	0.0	0.0	0.7	0.4	0.0	0.3	0.0	3.9	1.5	1.0



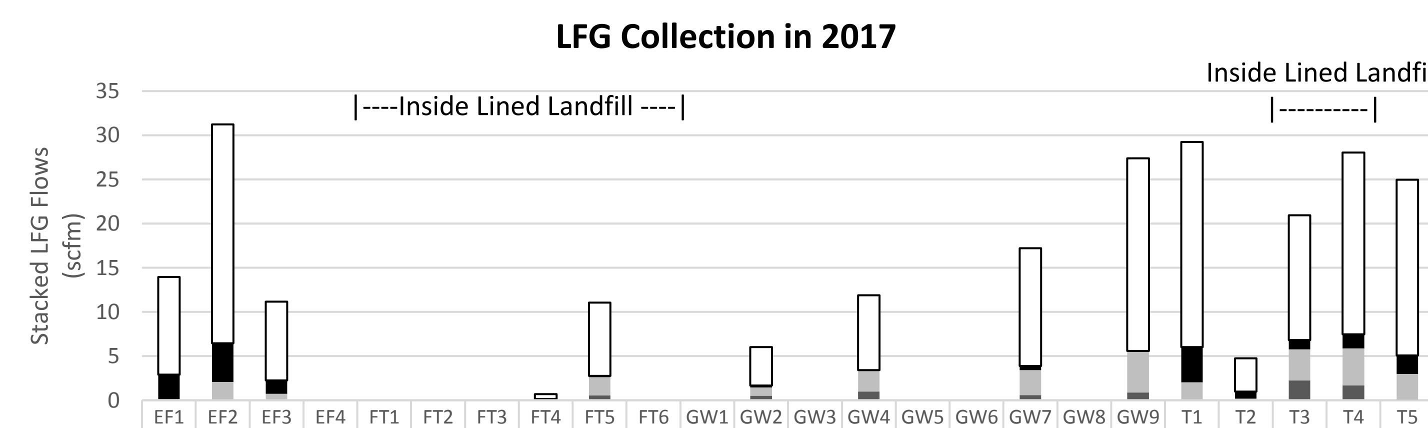
	EF1	EF2	EF3	EF4	FT1	FT2	FT3	FT4	FT5	FT6	GW1	GW2	GW3	GW4	GW5	GW6	GW7	GW8	GW9	T1	T2	T3	T4	T5
Balance	77	76	78	77	77	77	77	77	73	76	78	72	76	66	75	77	72	78	0	77	77	65	72	77
O2	19	13	15	20	21	20	20	20	3	4	19	5	13	0	18	15	3	14	0	14	18	5	7	7
CO2	1	7	5	1	0	0	1	1	17	16	2	15	7	21	3	6	17	6	0	6	3	17	14	12
CH4	0	1	0	0	0	0	0	0	4	2	0	6	2	10	1	0	4	1	0	0	0	10	5	1



	EF1	EF2	EF3	EF4	FT1	FT2	FT3	FT4	FT5	FT6	GW1	GW2	GW3	GW4	GW5	GW6	GW7	GW8	GW9	T1	T2	T3	T4	T5
Balance	19.9	20.0	12.2	0.8	0.0	0.0	0.0	0.0	8.7	14.0	0.0	4.3	1.9	8.4	0.0	0.0	14.9	0.0	0.0	22.3	0.0	16.4	20.3	32.0
O2	4.9	3.4	2.3	0.2	0.0	0.0	0.0	0.0	0.3	0.6	0.0	0.3	0.3	0.0	0.0	0.0	0.6	0.0	0.0	4.0	0.0	1.2	1.9	2.9
CO2	0.3	1.8	0.8	0.0	0.0	0.0	0.0	0.0	2.0	2.9	0.0	0.9	0.2	2.5	0.0	0.0	3.3	0.0	0.0	1.7	0.0	4.1	3.7	4.7
CH4	0.1	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.4	0.0	0.4	0.0	1.2	0.0	0.0	0.8	0.0	0.0	0.1	0.0	2.4	1.4	0.2

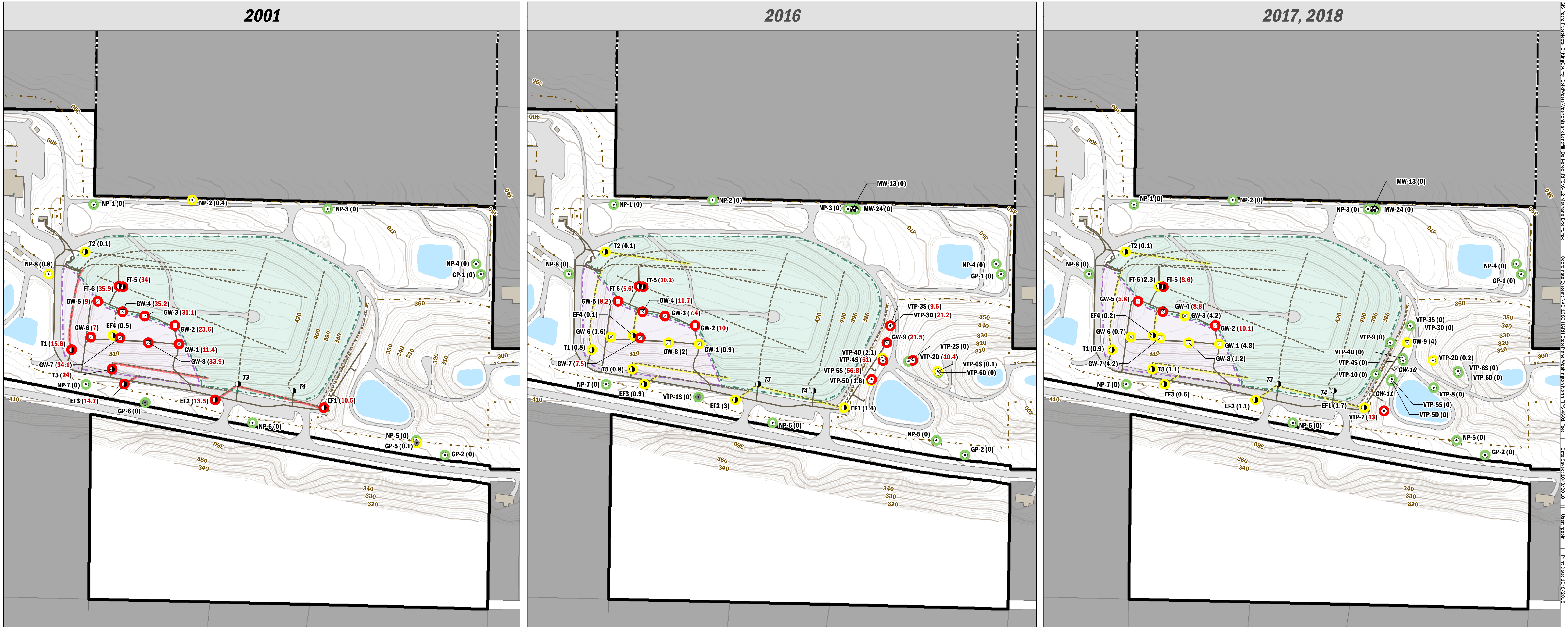


	EF1	EF2	EF3	EF4	FT1	FT2	FT3	FT4	FT5	FT6	GW1	GW2	GW3	GW4	GW5	GW6	GW7	GW8	GW9	T1	T2	T3	T4	T5
Balance	77	77	78	77	77	77	77	77	73	77	77	70	76	69	77	77	73	77	76	77	77	65	71	76
O2	20	14	14	20	21	20	21	21	1	9	18	4	16	0	20	17	3	14	0	14	17	5	6	8
CO2	1	6	6	1	0	0	0	0	19	11	2	16	4	20	1	4	17	7	17	7	4	17	15	11
CH4	0	0	0	0	0	0	0	0	5	1	1	8	1	8	0	0	3	1	3	0	0	11	6	1



	EF1	EF2	EF3	EF4	FT1	FT2	FT3	FT4	FT5	FT6	GW1	GW2	GW3	GW4	GW5	GW6	GW7	GW8	GW9	T1	T2	T3	T4	T5
Balance	11.0	24.8	8.9	0.0	0.0	0.0	0.0	0.6	8.3	0.0	0.0	4.3	0.0	8.5	0.0	0.0	13.3	0.0	21.8	23.2	3.8	14.1	20.6	19.9
O2	2.8	4.4	1.5	0.0	0.0	0.0	0.0	0.1	0.2	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.5	0.0	0.1	4.0	0.8	1.0	1.6	2.1
CO2	0.1	1.9	0.7	0.0	0.0	0.0	0.0	0.0	2.1	0.0	0.0	0.9	0.0	2.4	0.0	0.0	2.8	0.0	4.6	1.9	0.2	3.5	4.2	2.8
CH4	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.5	0.0	1.0	0.0	0.0	0.6	0.0	0.9	0.1	0.0	2.2	1.7	0.1

Figure 6.11
LFG Concentrations and Collection at Individual Points
Remedial Investigation



Maximum Methane Detected

- > 5 % by volume
- > 0 - 5 % by volume
- 0 % by volume

VTP-5D (1.6) Exploration Name (Methane Concentration, %)
*Methane concentration in **red, bold** font where concentration exceeds 5%*

- Boring
- Gas Probe
- LFG Extraction Well
- LFG Trench Riser
- Monitoring Well
- Decommissioned Monitoring Well
- LFG Pipe
- LFG Pipe (Perforated)
- Phase 1 - 1988 Final Cover
- Phase 2 - 2001 Final Cover
- Pond
- Building
- Road
- Fence
- Vashon Island Closed Landfill
- Other King County-Owned Property
- King County Tax Parcel

Note: Exploration locations without a colored halo have no results for a particular time period if a location was not yet installed, has been decommissioned, or location was not monitored. Topographic contours from King County Survey, Spring 2017. Landfill gas system features are approximated from as-built locations, and revised to match survey data where available.

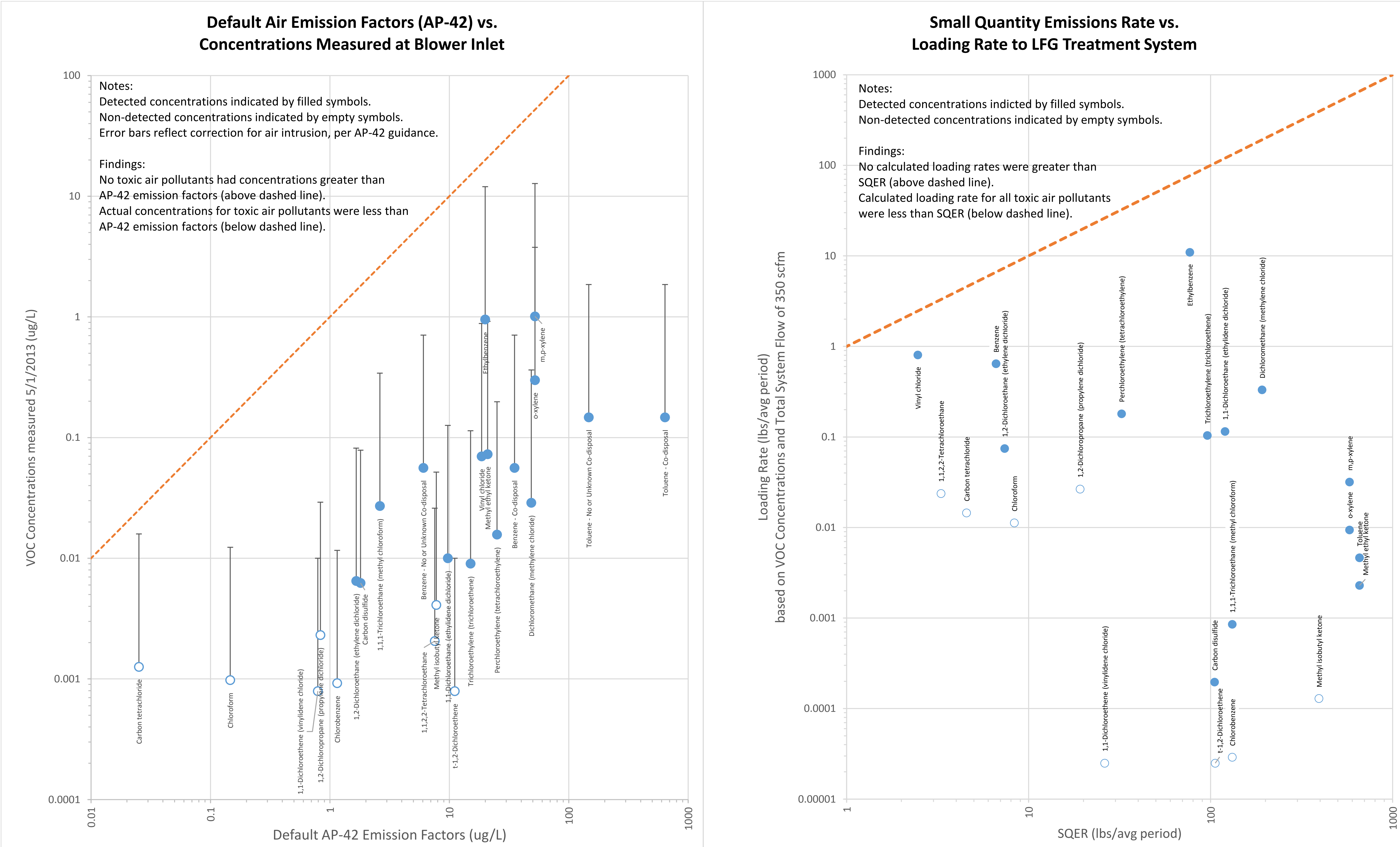
0 240 480
Feet

Methane Extent

Remedial Investigation
Vashon Island Closed Landfill
King County, Washington

DRAFT

King County | Aspect CONSULTING | OCT-2018 | BY: PSB / RAP | FIGURE NO. 6.12



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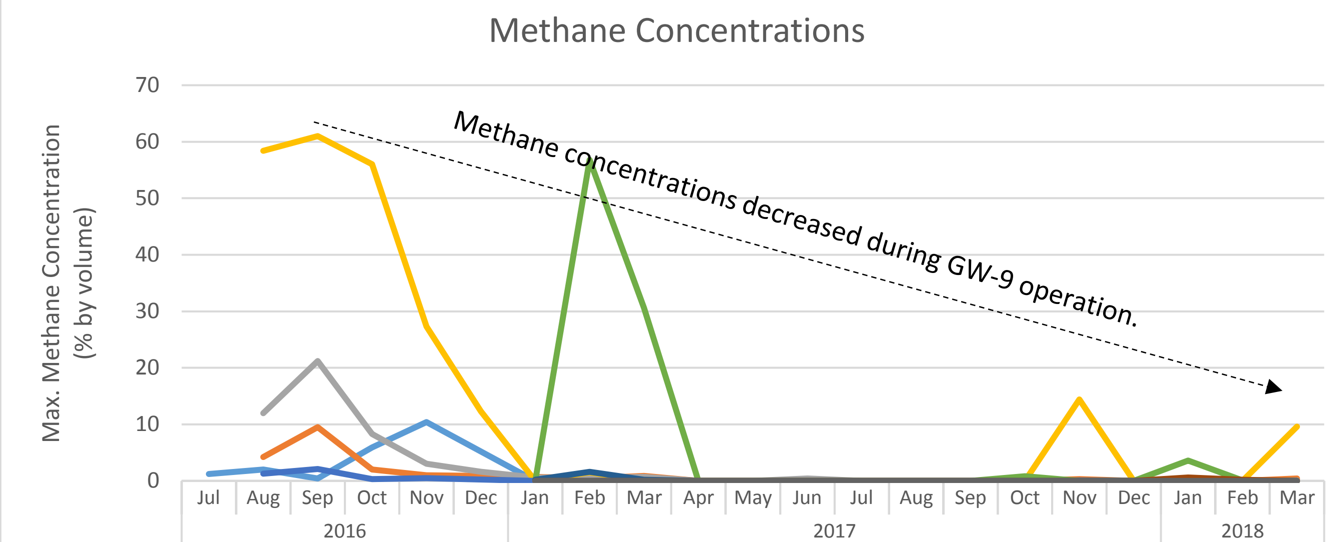
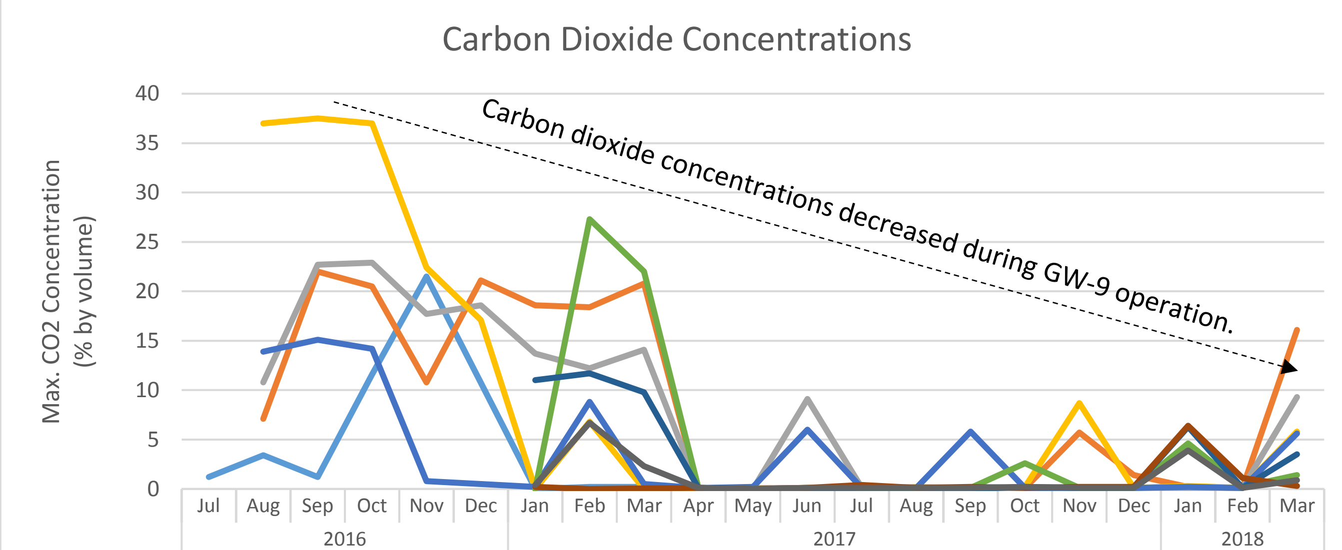
October 2018
P:\King Co Closed Landfills\Phase I\Vashon Is\Task 310.3 Tech Memo\Draft Figures\LandfillGas\Vashon Probes 1997 to 2018_Aspect_BMG.xlsx

Figure 6.13
Analysis of Observed VOCs in Landfill Gas
Remedial Investigation



	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
	2016						2017												2018		
VTP-2D	1.2	2	0.4	5.9	10.4		0	0.2	0.2												
VTP-3S		4.2	9.5	2	1	0.9	0.7	0.4	0.9	0	0	0	0	0	0	0	0.3	0	0	0	0.4
VTP-3D		12	21.2	8.3	3	1.6	0.6	0.5	0.7	0	0	0.4	0	0	0	0	0	0	0	0	0.1
VTP-4S		58.4	61	56	27.3	12.3	0	1.5	0	0	0	0	0	0	0	0	14.4	0	0	0	9.6
VTP-4D		1.3	2.1	0.3	0.5		0	0	0.1	0	0	0	0	0	0	0	0.1	0	0	0	0
VTP-5S							0	56.8	30.6	0	0	0	0	0	0	0.8	0	0	3.6	0.1	0
VTP-5D							0.2	1.6	0.2	0	0	0	0	0	0	0	0	0	0	0	0
VTP-6S							0	0		0	0	0	0	0	0	0	0	0	0.6	0.2	0
VTP-6D							0	0	0	0	0	0	0	0	0	0	0	0	0	0	0



	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
	2016						2017												2018		
VTP-2D	1.2	3.4	1.2	11.6	21.5		0	0.2	0.2												
VTP-3S		7.1	22	20.5	10.8	21.1	18.6	18.4	20.8	0.1	0.1	0.1	0.2	0.1	0.1	0.1	5.7	1.4	0.2	0.1	16.1
VTP-3D		10.8	22.7	22.9	17.7	18.6	13.7	12.2	14.1	0.1	0	9.1	0.1	0	0	0.1	0.1	0.1	0.1	0.1	9.3
VTP-4S		37	37.5	37	22.4	17.1	0	6.8	0	0	0.1	0	0.1	0.2	0.1	0.2	8.7	0.1	0.3	0.1	5.8
VTP-4D		13.9	15.1	14.2	0.8		0.2	8.8	0.5	0.1	0.2	6	0.1	0.1	5.8	0.1	0.1	0.1	0.2	0.1	5.6
VTP-5S							0	27.3	22	0.1	0	0.1	0.1	0.1	0.1	2.6	0.1	0.1	4.6	0.2	1.4
VTP-5D							11	11.7	9.8	0.1	0	0	0.1	0.1	0	0.2	0.1	0.1	6.3	0.1	3.5
VTP-6S							0.2	0		0.1	0	0.1	0.4	0.1	0.2	0.1	0.2	0.2	6.4	1.1	0.3
VTP-6D							0.4	6.7	2.3	0.1	0	0.1	0.1	0.1	0.1	0.2	0.1	0.1	3.9	0.1	0.9

Figure 6.14

Temporary Probe LFG Concentrations Over Time

Remedial Investigation

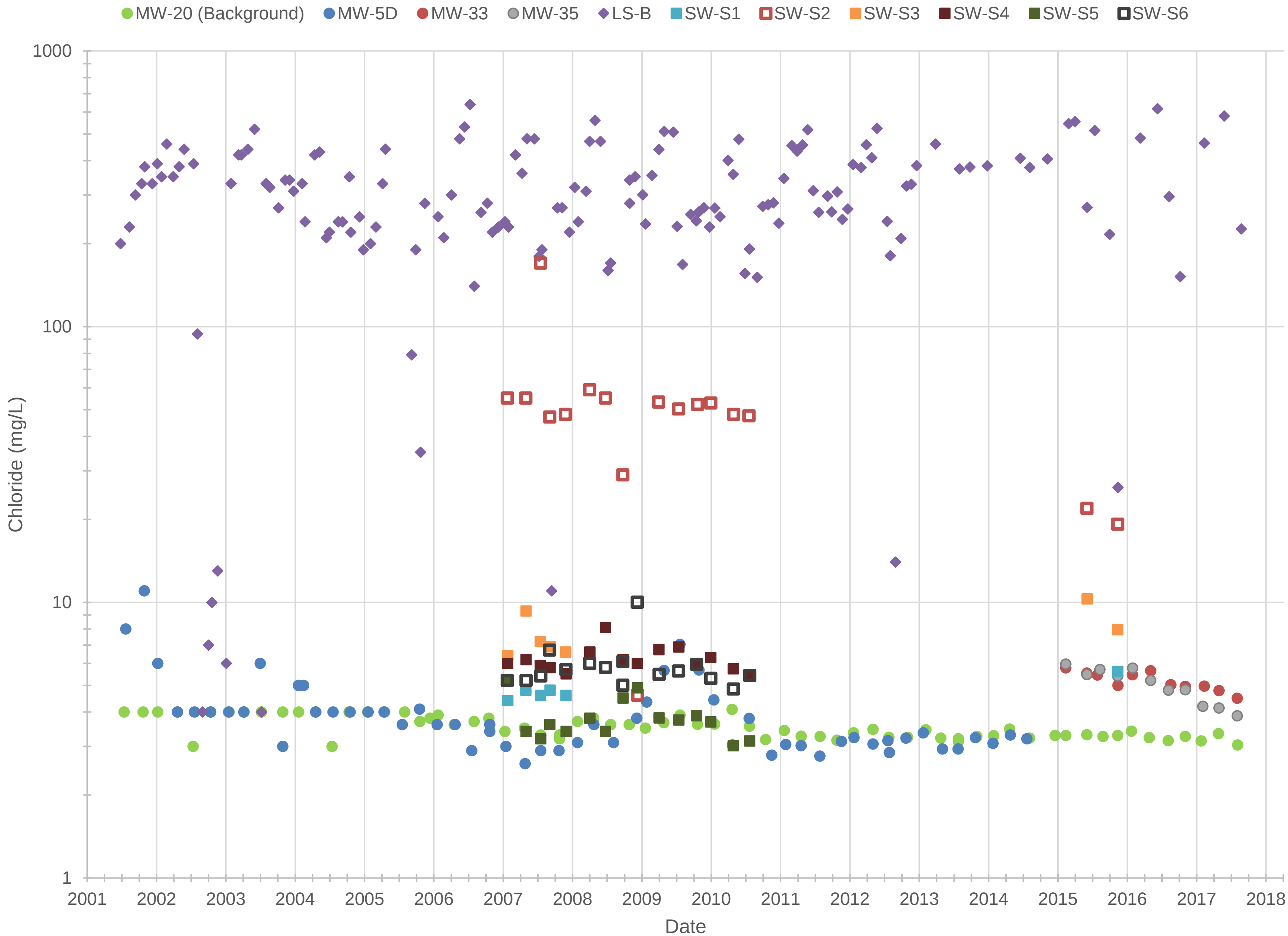


Figure 7.1

Chloride Time Series

Remedial Investigation

Aspect Consulting

October 2018

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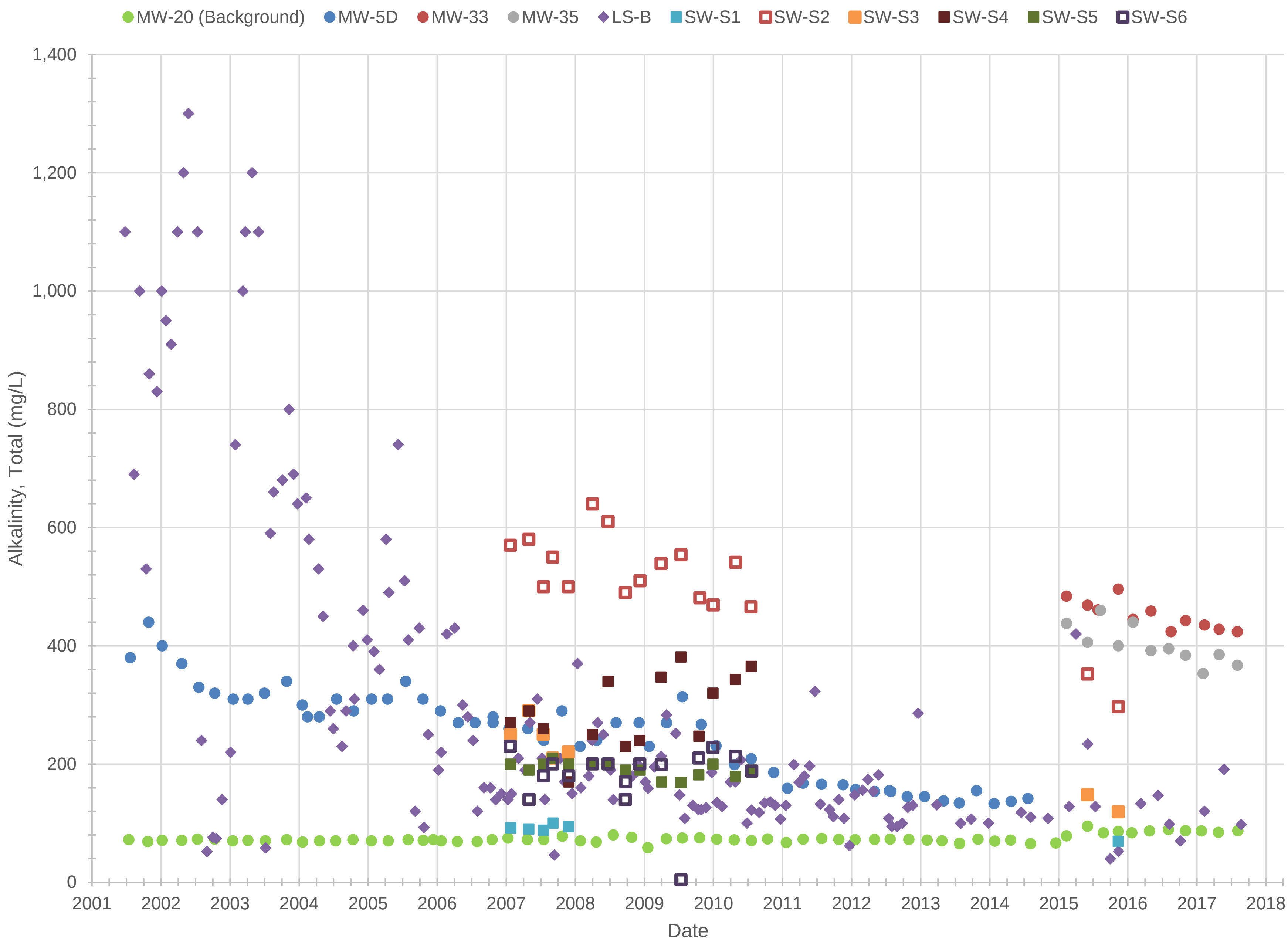

Figure 7.2
Alkalinity Time Series
Remedial Investigation

Aspect Consulting
October 2018
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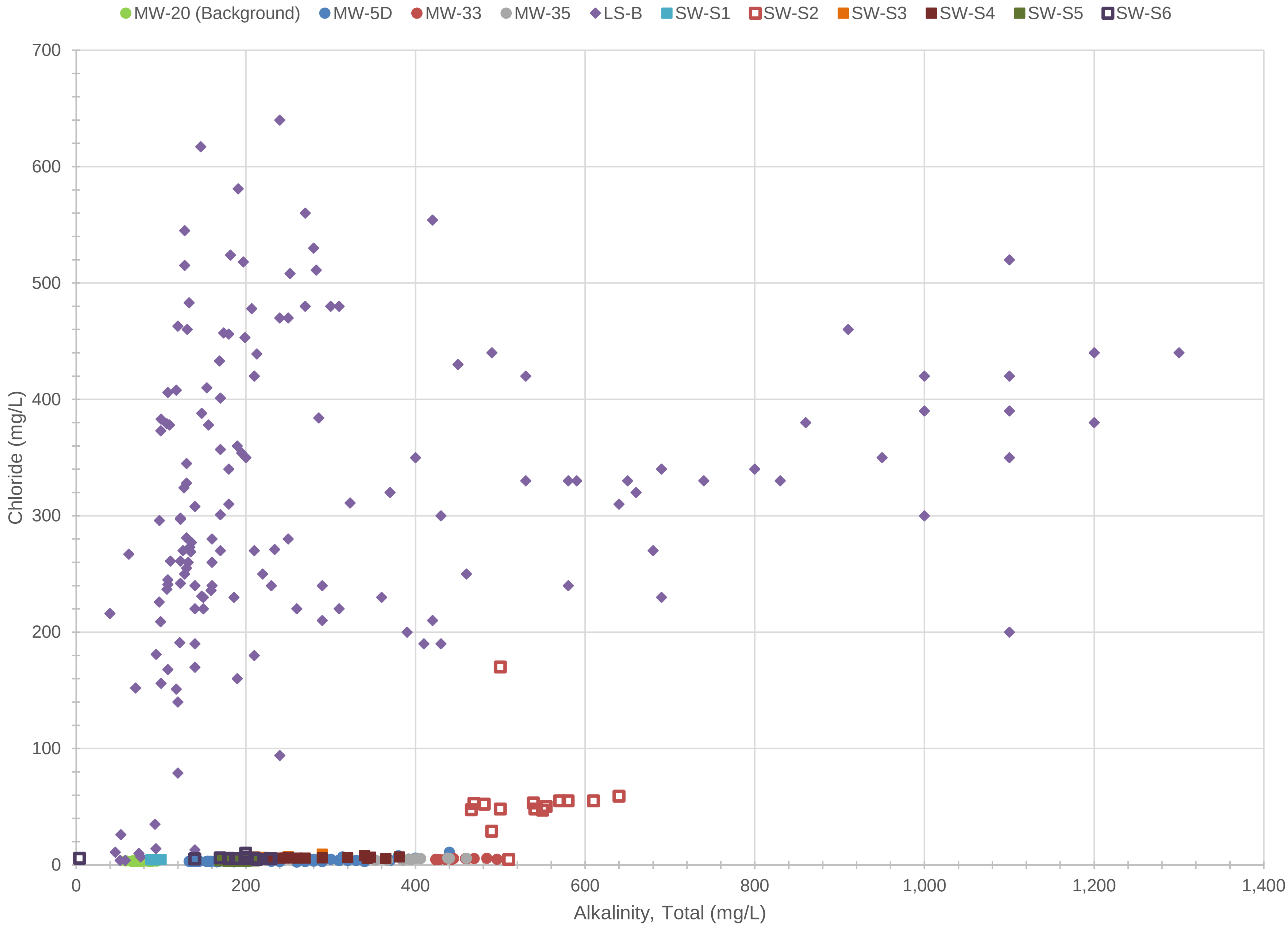

Figure 7.3
Chloride vs Alkalinity
Remedial Investigation

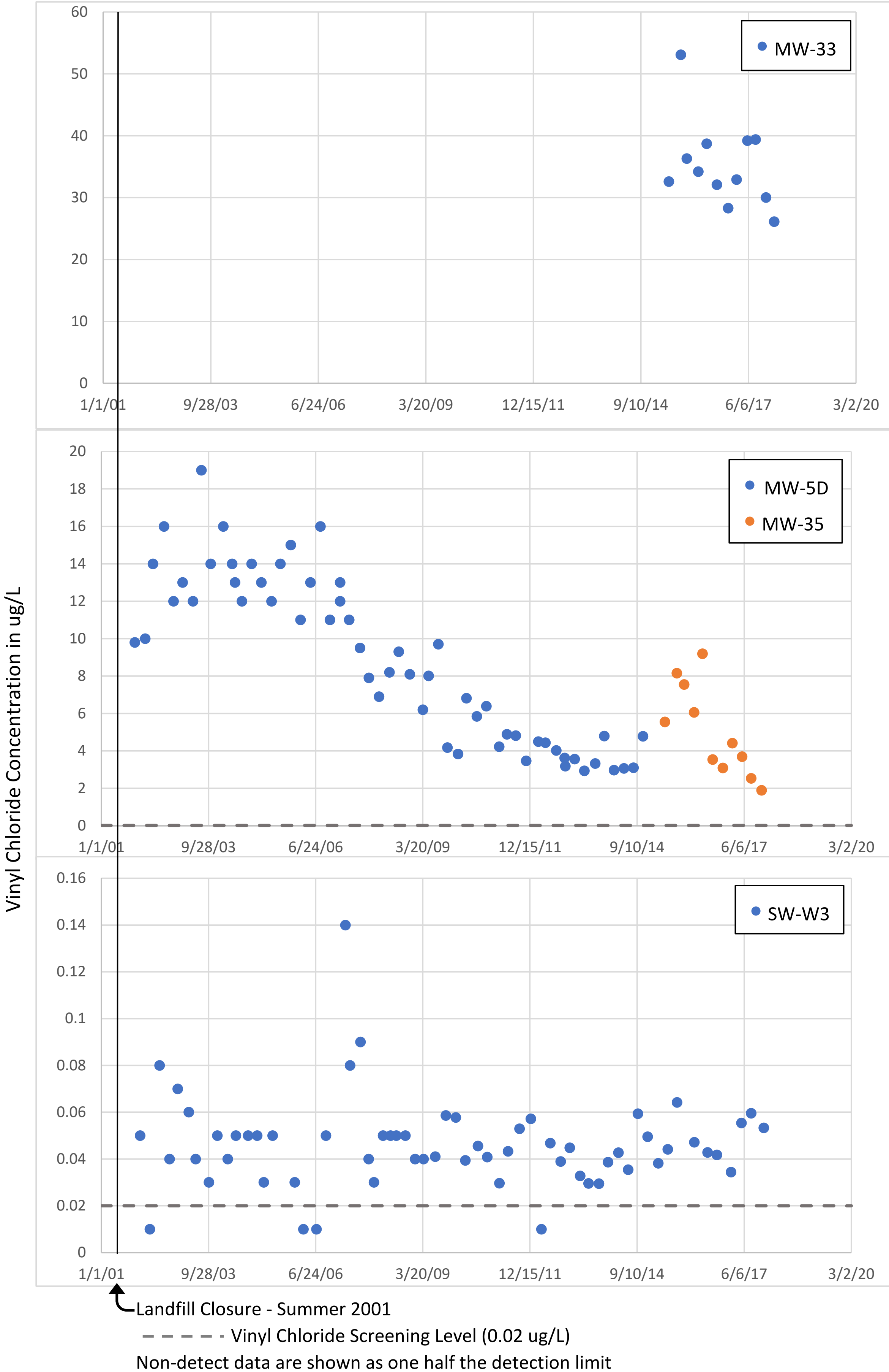

Figure 7.4

Vinyl Chloride in Groundwater, Time Series at MW-33, MW-5D/35, SW-W3

Remedial Investigation

Aspect Consulting

October 2018

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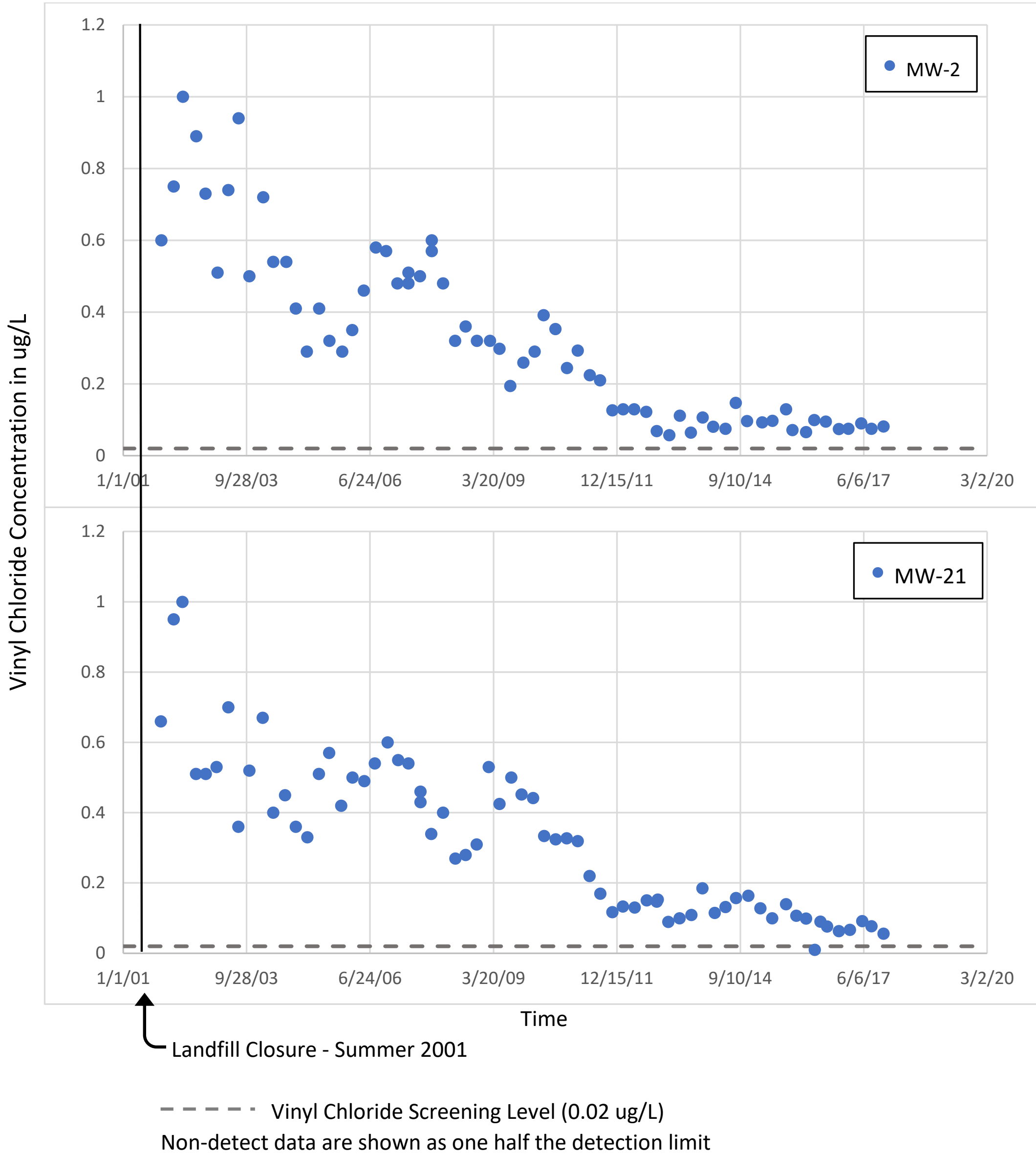
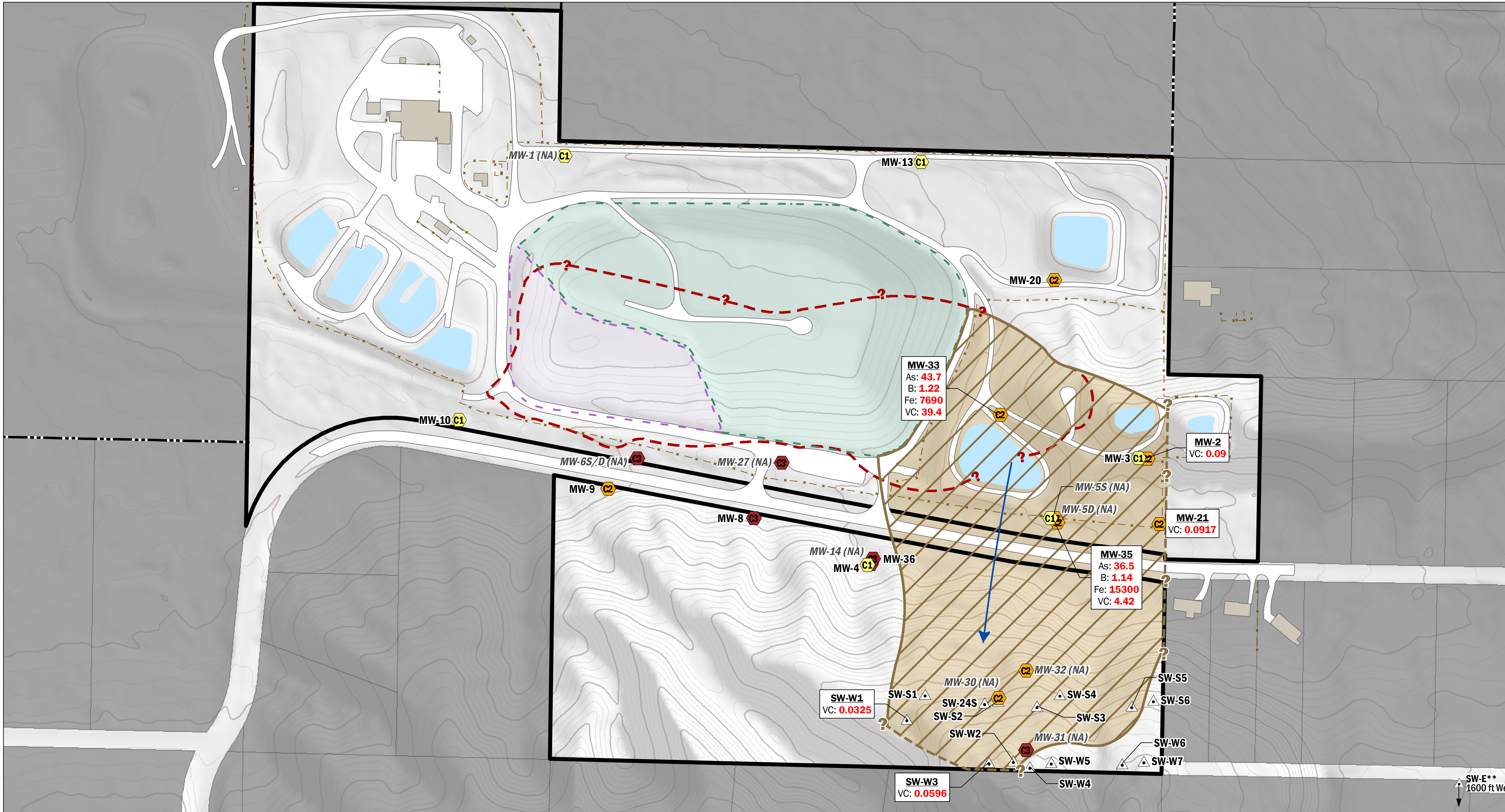


Figure 7.5
Vinyl Chloride in Groundwater, Time Series at MW-2 and MW-21
Remedial Investigation



Monitoring Well (Unit Cc1)
Monitoring Well (Unit Cc2)
Monitoring Well (Unit Cc3)
Seep/Weir Sampling Location
Extent of Contamination based on 2001-2017 dataset
Dashed Boundary Indicates Inferred Extent
Estimated Extent of Unlined Refuse
Inferred Groundwater Flow Direction
Fence
Pond
Phase 1 - 1988 Final Cover
Phase 2 - 2001 Final Cover
Building
Road
Vashon Island Closed Landfill
Other King County-Owned Property
King County Tax Parcel

Notes:

-Maximum concentration of COCs exceeding PCULs during 2017:
Dissolved Arsenic (As): 5 µg/L
Benzene (B): 0.44 µg/L
Dissolved Iron (Fe): 1,000 µg/L
Vinyl Chloride (VC): 0.02 µg/L.
-All results posted are in µg/L. Only results which exceed the screening level are displayed. "NA" indicates a location was not sampled in 2017.
-Groundwater contamination is limited to Unit Cc2.
-COCs in SW-S6 and SW-W7 did not exceed PCULs when last sampled from 2007 - 2010.
*** See figure 4.2 for SW-E location*
-Topographic contours derived from King County LiDAR, 2016.

0 200 400
Feet

N

DRAFT

Extent of Contamination

Remedial Investigation
Vashon Island Closed Landfill
King County, Washington

King County
Aspect CONSULTING

OCT-2018
BY:
DAC / RAP

FIGURE NO.
8.1

GIS Path: T:\projects_8\KingCounty_SolidWaste\VashonIslandLandfill\Delivered\RIFS\8.1 Extent of Contamination.mxd || Coordinate System: NAD 1983 HARN StatePlane Washington North FIPS 4601 Feet || Date Saved: 10/2/2018 || User: rpepin || Print Date: 10/3/2018