PUBLIC REVIEW DRAFT REPORT

REMEDIAL INVESTIGATION REPORT
RESERVE SILICA RECLAMATION SITE

Ecology Facility Site No. 2041/Cleanup Site No 4728
26000 Black Diamond Ravensdale Road
Ravensdale, Washington 98051

Submitted to:

Mr. Alan Noell and Mr. Tim O'Connor, Washington State Department of Ecology

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EXECUTIVE SUMMARY

This document, prepared by WSP USA Inc. (WSP), presents the results of the Remedial Investigation (RI) conducted at the Reserve Silica Reclamation Site located at 26000 Black Diamond Ravensdale Road in Ravensdale, Washington; (NW/4 of Section 1, Township 21 North, Range 6 East, Willamette Meridian and S/2 of SW/4 of Section 36, Township 22 North, Range 6 East, Willamette Meridian).

In September 2017, the Washington State Department of Ecology (Ecology) determined that Reserve Silica Corporation (Reserve Silica) and Holcim (US) Inc. (Holcim) were Potentially Liable Persons (PLPs) for the release of hazardous substances at the Reserve Silica Corporation site. Ecology subsequently renamed the Reserve Silica Corporation site as the Reserve Silica Reclamation site (Cleanup Site ID [CSID] 4728). Reserve Silica and Holcim entered into Agreed Order No. DE 16052 (Agreed Order) with Ecology on December 16, 2019, for the Reserve Silica Reclamation site (Preliminary Site). The Agreed Order requires Reserve Silica and Holcim to complete an RI and Feasibility Study (FS) and submit a preliminary draft Cleanup Action Plan for the Preliminary Site. Burlington Northern Santa Fe (BNSF) Railway was also notified by Ecology of its status as a PLP, but BNSF Railway declined to participate in the Agreed Order. Reserve Silica is independently cleaning up the adjacent Reserve Silica Plant site (CSID 15125), because the sources and types of contamination are distinct and do not overlap with the Preliminary Site.

The Agreed Order identified a Preliminary Site boundary that included the following King County property parcels:

- Lot 5 – King County Tax Parcel 012106-9011
- Lot 6 – King County Tax Parcel 362206-9138
- Baja Property - King County Tax Parcel 352206-9046

Figures 1-1 and 2-1 show the Preliminary Site boundary and the property parcels within the Preliminary Site. Throughout this RI report the term “Preliminary Site” will be used to describe the study area that was included in this RI. Data collected during the RI are evaluated against cleanup levels, and a “Proposed Site Boundary” is provided in Figure 7-4. The Proposed Site Boundary includes the source area, the extent of contamination, the treatment system, and topography, property boundaries, and monitoring wells that delineate the boundary. This RI report presents a summary of historical investigations and interim actions conducted at the Preliminary Site, and a detailed discussion of the RI field investigations conducted to meet the requirements of the Agreed Order and in accordance with Revised Code of Washington (RCW) 70A.305.030(1) and the Washington State Model Toxics Control Act (MTCA) Cleanup Regulations, chapter 173-340 of the Washington Administrative Code (WAC). RI data were collected following the procedures set forth in the Reserve Silica Reclamation Site Remedial Investigation/Feasibility Study Work Plan (RI/FS Work Plan) (Golder 2021a).

Historically, the Preliminary Site area was first used for underground and surface strip coal mining from the early 1900s through approximately 1950 and then for silica sand mining from 1968 through 2008. Both the surface coal mining and silica sand mining resulted in several deep pits, roughly oriented north-northwest to south-southeast. The pits are oriented along the geological “strike” or orientation relative to north of the near vertically dipping coal and sandstone bedrock units. Reclamation of the surface coal and sand pits on the Preliminary Site started in 1971 and included landfilling the pits with mine spoils (the non-economical soil and rock produced during mining) from the Preliminary Site and with imported fill material, including but not limited to cement kiln dust (CKD).

CKD was placed in two former mine pits at the Preliminary Site: a sand mining pit referred to as the Lower Disposal Area (LDA) and the surface coal strip mining pit referred to as the Dale Strip Pit (DSP). Reclamation was performed in compliance with King County Building and Land Development Permit No, 1122-58. CKD was disposed in the LDA beginning in June 1979. King County Department of Public Health issued Special Landfill Permit No. 17-101 on August 28, 1981, to authorize additional disposal of CKD in the LDA and later then DSP (Ideal 1984). Several feet of soil cover were placed above the CKD in the LDA and DSP as part of the reclamation plan. The LDA cover was upgraded in 2007, and the DSP cover was upgraded in 2010 and 2011. Public Health - Seattle & King County issues Closed Limited Purpose Landfill Permit No. PR0015708 for the post-closure care of the LDA and DSP. Figure 2-1 shows the locations of the LDA, DSP, and other historical sand mining pits. Figure 2-1 also shows the Preliminary Site boundary and property parcels.

The Preliminary Site is on the southwest flank and at the base of the bedrock high point called Ravensdale Hill (Tacoma Environmental Sciences Inc, TESI 2000). The elevation of the hill ranges from 600 to 1,000 feet above mean sea level (amsl) referenced to North American Vertical Datum of 1988 (NAVD 88), the DSP is near the topographic high point of the Preliminary Site, at an approximate elevation of 960 feet amsl, and the LDA is at a topographically lower area of the Preliminary Site, at an elevation of approximately 760 feet amsl. The Preliminary Site includes the following three geologic units 1) Eocene age sedimentary bedrock units of the Puget Group-Renton Formation, 2) Vashon-age lodgement silty sand and gravel till, and 3) Vashon recessional outwash gravel (SubTerra 2006). A surface geologic map of the Preliminary Site is provided in Figure 2-7.

Numerous environmental investigations have been conducted at the Preliminary Site since 1972 to understand the geology and hydrogeology of the Preliminary Site, and to evaluate impacts to groundwater and surface water associated with historical mining activities and the permitted disposal activities. Prior to the RI, Golder Associates Inc. (Golder), now WSP, conducted hydrogeological investigations of both the LDA and DSP which included test pit excavations, borehole drilling, piezometer measurements, dye tracer tests, geophysical investigations, and routine groundwater and surface water monitoring conducted since approximately 2005. Results from these investigations suggested shallow groundwater perched on top of the bedrock unit was entering the LDA from the southeastern end. A lobe of CKD was discovered in the southeast portion of the LDA, beyond the previously demarcated boundary, in the area where groundwater enters the LDA. The low permeability clayey sandstone that forms the bottom and side walls of the former LDA pit traps water within the LDA, inhibiting vertical or horizontal transport. This creates a bathtub effect, with water partially filling the LDA and allowing continued contact of the water with CKD and other material disposed in the LDA. Dissolution of CKD into the water produces hydroxide ion (OH^-), which raises the water pH to levels exceeding 12 standard units (SU). The high pH water solubilizes metals from the CKD and other fill material within the LDA. The high pH groundwater migrates from the LDA below the ground surface in an area along the western sidewall of the LDA. The location where the groundwater migrates from the LDA is a low area in the sandstone bedrock that forms the western wall of the LDA. Historical reports mention that fill material was brought into the Preliminary Site to raise a low area of the Lower Haul Road, which parallels the western side wall of the LDA. The fill material used to fill the low area is more permeable than the clayey sandstone that forms the walls and bottom of the LDA, as such, as water in the LDA rises to the level of the fill material along the western side wall, the water leaches from the LDA and migrates through the fill material. The high pH groundwater that migrates through the fill material of the Lower Haul Road seeps to the surface along an embankment immediately west of the Lower Haul Road. Contact of the groundwater with fill material within the Lower Haul Road, solubilizes metals from the fill material.

The presence of high pH water increases the electrical conductivity of the groundwater due to an increase in hydroxide ions and other ions in the groundwater. Geophysical surveys conducted in 2010, 2019, and 2020 mapped the areas of high pH groundwater by detecting subsurface areas of relatively higher electrical conductivity. The geophysical surveys mapped (Figure 3-5) the high pH groundwater within the LDA and the migration path and extent of high pH groundwater downgradient of the LDA.

The DSP does not show impacts to groundwater like the LDA. The DSP is near the topographic high point of the Preliminary Site (Figure 3-11), so the potential for subsurface flow of shallow groundwater into the DSP is significantly less than for the LDA. Additionally, the DSP is underlain by mined out coal seams and, therefore, has less potential for perching of water within the DSP and prolonged contact of water with CKD disposed in the DSP.

Interim actions have been performed to reduce migration of groundwater before it entered the LDA and to capture and treat high pH groundwater leaching from the LDA. The interim actions were performed to:

1) Reduce infiltration of water through the LDA and DSP covers,

2) divert stormwater away from the LDA and DSP,

3) divert a portion of the shallow groundwater from entering the LDA, and

4) collect and treat leachate emanating from the LDA.

The LDA and DSP soil covers were upgraded in 2007 and 2010/2011, respectively, to reduce the direct infiltration of rainwater into the landfills and to promote run-off of rainwater and occasional snowmelt from the LDA and DSP. Compacted soil and gravel lined stormwater diversion ditches were installed upgradient of the LDA to divert stormwater around the LDA and reduce infiltration upgradient of the LDA. A groundwater interceptor trench was installed upgradient of a portion of the LDA to divert groundwater from entering the LDA along the south end. Test trenches and toe drain structures were installed along the western toe of the LDA to capture high pH groundwater. A collection ditch and a drop inlet structure were also installed along the base of the groundwater seepage embankment west of the LDA to collect the seepage and direct it to the infiltration ponds. In 2018, a seepage treatment system was constructed, and full operation of that treatment system started in 2019 and continues today. High pH seepage water from the LDA is captured and piped to the system for treatment prior to discharge to the Infiltration Ponds. The treatment system neutralizes the water to a pH range of 7.5 to 8.0 SU using carbon dioxide sparging and pumps the water through sand filters and iron media filters to reduce the concentrations of dissolved metals in the water prior to discharge to the Infiltration Ponds. Further precipitation of dissolved solutes occurs within the Infiltration Ponds prior to infiltration of the water to groundwater beneath the ponds. Groundwater monitoring wells are installed surrounding the Infiltration Ponds to evaluate impacts to groundwater from the infiltration of treated water though the ponds. Since the start of the treatment system, significant reductions in pH and dissolved metals concentrations have occurred in the surface water and in the groundwater monitoring wells immediately downgradient of the Infiltration Ponds.

The RI field investigation included subsurface investigations such as borehole investigations and installation of additional groundwater monitoring wells. One new boring (G-AB-1) was advanced in the center of the Lower Haul Road at the location where high pH leachate from the LDA migrates under the road to the seepage embankment. The borehole encountered fill material consisting of imported rock, mine spoils, and woody debris. Trace pieces of slag were observed in the unsaturated top one to two feet of road fill material. Perched groundwater was encountered at a depth of 30 feet below ground surface in borehole G-AB-1, but the borehole log indicated that perched groundwater seasonally reaches 19 feet below the ground surface. Sandstone bedrock was encountered at a depth of approximately 35 feet, which is deeper than the approximate 10 to 12 feet depth to bedrock that was observed in other boreholes drilled into the Lower Haul Road. This data supports the historical reports that the western bedrock sidewall of the LDA has a low area that was filled. This fill area is where groundwater leaches from the LDA. The seepage collection ditch collects the leach water that seeps to the surface for neutralization and solute reductions in the treatment system.

Groundwater monitoring wells were installed within the LDA and downgradient of the Lower Haul Road to evaluate contamination in the source area. Groundwater samples were collected and analyzed for an extensive list of chemicals that can be associated with some CKD disposal sites, including dioxins and furans. The results were compared to preliminary cleanup levels (PCULs), which are based on stringent regulatory standards for groundwater and surface water. The only chemicals detected at concentrations exceeding PCULs were antimony, arsenic, lead, vanadium, and pH levels. These contaminants of concern (COCs) were analyzed in all RI samples.

Seven new monitoring wells (P-15, P-16, P-17, MW-7A, MW-8A, MW-9A, and MW-10A) were installed during the RI to investigate the nature and extent of impacts to groundwater associated with high pH leachate from the LDA. These new groundwater monitoring wells were added to the existing groundwater and surface monitoring network. The monitoring network for the LDA includes monitoring wells within the LDA, monitoring wells in the low permeability shallow soils downgradient of the LDA, bedrock monitoring wells immediately downgradient of the LDA, and monitoring wells within the recessional outwash upgradient and downgradient of the Infiltration Ponds. The monitoring network for the DSP includes bedrock monitoring wells near the DSP and the mine portal that captures leachate from the DSP.

Groundwater and surface water samples have been collected in accordance with the landfill permit, and the RI/FS Work Plan (Golder 2021a). Groundwater and surface water samples were collected on a quarterly sampling frequency to evaluate seasonal variations in groundwater and surface water quality during the RI. At least ten sampling rounds have been collected from the groundwater and surface water locations, and some of the historical locations have been sampled numerous times since approximately 2005. As such, sufficient data are available to characterize and delineate the extent of impacts to groundwater and surface water, and to evaluate remedial alternatives in the Feasibility Study (FS).

The shallow groundwater seeping out of the LDA contains antimony, arsenic, lead, and vanadium at concentrations exceeding drinking water standards. Impacted groundwater from the LDA seeps to the surface along the embankment immediately west of the Lower Haul Road and approximately 75 feet west of the LDA. A seepage collection ditch was constructed as an interim action to capture the seepage water and convey the water through buried pipe to the treatment system. A portion of the high pH groundwater leaching from the LDA migrates beneath the seepage embankment and seepage collection ditch. The geophysical studies and empirical data from groundwater and surface water samples collected indicate that impacts to groundwater extend approximately 150 feet west of the seepage area before pH levels naturally neutralize. As the groundwater pH neutralizes COC concentrations begin to attenuate to below PCULs. The concentrations of the COCs exceed the PCULs in the groundwater monitoring wells located in the areas where elevated pH levels are detected by the geophysical testing, and groundwater COC concentrations are less than PCULs in areas beyond the areas where the geophysical testing indicated elevated pH levels are present. The impacted groundwater area west of the LDA is within the property boundary. The areas where impacted water is present within the property boundary are not currently used for any purposes. Ranges of hydraulic conductivity and potential yields were determined for the shallow groundwater system where impacts are present. The low yield of the shallow impacted groundwater west of the LDA indicates the groundwater could not serve as a sustainable source of drinking water because the groundwater is present in insufficient quantity.

Continued sampling of groundwater surrounding the Infiltration Ponds has demonstrated the concentrations of the COCs recovered when treated seepage is discharged to the Infiltration Ponds. The near neutral pH levels and concentrations of COCs in bedrock monitoring wells downgradient of the LDA indicate that bedrock groundwater is not impacted by leaching of groundwater from the LDA. This is further supported by data collected during drilling of wells within the LDA, where the underlying clayey sandstone bedrock was dry with a measured pH near neutral.

There has been no confirmed release of contamination from the DSP after more than 20 years of sampling. Although residual arsenic concentrations exceed regional background concentrations in one groundwater well, the elevated arsenic concentrations are a relic of the poor development of the very-low yield bedrock well. There are no indications of a release to bedrock. Although leachate seeps through the coal seams and underground mining works, the concentrations of COCs have complied with the PCULs through more than 20 years of sampling. The CKD in the DSP is less likely to generate caustic leachate because less water enters the DSP, and the water has much less contact time with the CKD in the DSP than in the LDA.

LDA surface water monitoring locations include areas where high pH surface water historically flowed prior to installation of current interim actions and areas where high pH groundwater is present at the surface. The current groundwater and surface water monitoring program confirms that impacted water is contained within the property boundary. Two areas where high pH surface water is present include: 1) along the seepage embankment and associated seepage collection ditch, and 2) the South Pond where groundwater seasonally rises to above ground surface for approximately 3 months of the year. Both areas are completely fenced to prevent contact with high pH water. Prior to full-time operation of the Treatment System in 2019, the Infiltration Pond contained high pH surface water. Occasionally, surface seepage occurs at a location along the southwest toe of the LDA during high precipitation periods. As one of the interim measures, a toe drain was installed at this location to divert that water by a 4-inch buried pipe to the treatment system. Large gravel has been placed in this seepage area to reduce the potential for direct contact with the high pH water.

Soil samples were collected from an area that is not impacted from CKD to calculate site-specific background concentrations of COCs in soil. The soil PCULs were adjusted to the site-specific natural background concentrations of arsenic, lead, and vanadium as allowed in the MTCA regulations.

Soil sampling was conducted to determine the nature and extent of impacts to soil in areas where high pH surface water contacts soils. These areas included the seepage embankment area west of the LDA where high pH water seeps and calcium carbonate precipitates are present at the surface, and the South Pond area where high pH groundwater daylights to the surface when groundwater levels are near seasonal highs. Additionally, soil samples were collected from an area where, prior to installation of the seepage collection ditch, high pH water flowed overland to a low area west of the seepage collection ditch prior to discharge to the Infiltration Ponds. Samples were also collected from the precipitates that had accumulated in the Infiltration Ponds to evaluate the concentration of COCs within those precipitates. Soils can be impacted as the high pH water is neutralized by the natural buffering capacity of the soil and through dilution as the water mixes with rainwater and unimpacted groundwater, resulting in the solubilized metal COCs coming out of solution and adsorbing to soil.

Soil sampling results indicated that one or more COCs were present in each of the initial sampled areas at concentrations exceeding PCULs. Supplemental soil sampling was conducted in and around the initial sampled areas to delineate the nature and extent of impacts to soil. The delineated extent of soil contamination is well within the boundary of the property parcels. Arsenic was the COC mostly detected at concentrations above the soil PCULs. Antimony and lead were also detected in some soil samples at concentrations above the soil PCULs.

Vanadium was not detected in any soil samples at concentrations exceeding site-specific background. Impacted soils were generally determined to be present primarily in the top 2 to 4 inches of soil where most of the dissolution and adsorption of COCs occurred. Significant reductions in COC concentrations were noted in unsaturated soils deeper than approximately 8 inches. Soil pH levels exceeding 8.0 SU appeared to correlate with samples with the highest concentrations of COCs that derived from groundwater dissolution of CKD from the LDA. Some of the delineation soil samples contained one or more COCs exceeding the soil PCULs but had pH levels less than 7.5 SU in areas where there is no indication of current or historical contact with high pH leachate. As such, there is some uncertainty whether COC concentrations reported in those samples are attributable to contact with water that leached from the CKD or are from other natural or anthropogenic sources. Arsenic was present in most of the Infiltration Pond precipitates at concentrations exceeding soil PCUL. Lead was detected only in the sample collected closest to the discharge pipe to the Infiltration Ponds at a concentration exceeding the PCUL.

The Proposed Site Boundary is shown in Figure 7-4. The Proposed Site Boundary includes the LDA and the delineated boundary beyond where the concentrations of COCs comply with the cleanup standards. The proposed boundary includes the seepage collection, conveyance, treatment, and discharge system, including the Infiltration Ponds and the historical surface drainage pathways for the caustic seepage. The Proposed Site Boundary does not include the DSP because there has been no confirmed release of contamination after more than 20 years of monitoring bedrock wells and the mine portal.

As recommended in Section 8.4, the focus areas for remedial action should include the following:

- Evaluate and recommend actions to reduce, eliminate, and/or capture and treat high pH seepage water from the LDA.
- Evaluate and recommend actions to reduce the flow of groundwater into the LDA, specifically the flow along the top of the bedrock near the southeast end of the LDA, where most of the water enters the LDA.
- Develop and evaluate cleanup action alternatives that consider relevant and appropriate requirements for the lobe of CKD located beyond the extent of the previously demarcated LDA landfill soil cover.
- Evaluate and recommend alternatives to reduce infiltration through the LDA cover, including areas where the landfill cover was not upgraded in 2007.
- Evaluate and recommend remedial actions necessary to address ecological or human health risks posed by the COCs present in the groundwater, surface water, soil, and sediment at concentrations exceeding the CULs.
- Evaluate and recommend potential improvements to the existing treatment system, to ensure the treatment system is reliable and sustainable and meets Washington State discharge standards.
- Propose a groundwater monitoring program that is capable of detecting releases of contamination and confirms the natural attenuation of contamination. The groundwater monitoring program should be applicable and consistent with the objectives of the landfill permit and the state waste discharge permit.
- Propose relevant and appropriate institutional controls for the Proposed Site Boundary.

  Satisfy the City of Kent’s wellhead management strategies pertinent to the Proposed Site Boundary, including notifications of permitting activities, tracking the cleanup of the MTCA sites, and notifications of hazardous materials spills.

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ACRONYMS AND ABBREVIATIONS

ARAR	Applicable Or Relevant and Appropriate Requirements
AMD	Acid Mine Drainage
amsl	Above Mean Sea Level
ARI	Analytical Resources, Inc.
As	Arsenic
ASARCO	American Smelting and Refining Company
Aspect	Aspect Consulting, LLC
ATP	Aspect Test Pit
bgs	Below Ground Surface
BNSF	Burlington Northern Santa Fe Railway
BPA	Bonneville Power Administration
calcite	Calcium Carbonates
CKD	Cement Kiln Dust
cm/sec	Centimeters Per Second
CO_2	Carbon Dioxide
COC	Contaminants of Concern
COPCs	Contaminants of Potential Concern
CSID	Cleanup Site Identification Number
CSM	Conceptual Site Model
CUL	Cleanup Levels
CWA	Clean Water Act
DDES	King County Department of Development and Environmental Services
DLS	King County Department of Local Services
DNR	Washington State Department of Natural Resources
DO	Dissolved Oxygen
DOH	Washington State Department of Health
DPER	King County Department of Permitting and Environmental Review
DSP	Dale Strip Pit
DTW	Depth To Water
DU	Decision Units
E&E	Ecology and Environment
Ecology	Washington State Department of Ecology
EDR	Environmental Data Resources
EHD	Washington State Department of Health’s Environmental Health Disparities
EM	Electromagnetic Induction
Ep Toxicity	Leachable Toxicity Testing
EPA	United States Environmental Protection Agency
FE	Fundamental Error
FOC	Fraction of Organic Carbon
FS	Feasibility Study

FSID	Facility Site Identification Number
ft/ft	Feet Per Foot
gpm	Gallons Per Minute
Holcim	Holcim (US) Inc.
Ideal	Ideal Basic Industries, Inc.
IMP	Industrial Mineral Products, Inc.
ISM	Incremental Sampling Methodology
ITRC	Interstate Technology and Regulatory Council
K^+	Potassium Ion
L	Liter
LDA	Lower Disposal Area
mg/Kg	Milligrams Per Kilograms
mg/L	Milligrams Per Liter
mS/m	millisiemens per meter
MTCA	Model Toxics Control Act
MW	Monitoring Well
MWB	Bedrock Wells
NOV	Notice Of Violation
OC	Overburdened Community
OH	Hydroxide Ion
ORP	Oxidation-Reduction Potential
P- wells	Site Investigation Purposes
PCULs	Preliminary Cleanup Levels
Plant Site	Reserve Silica Sand Processing Plant
PLP	Potentially Liable Person
Public Health	Public Health - Seattle & King County
PVC	Polyvinyl Chloride
QAPP	Quality Assurance Project Plan
QC	Quality Control
RCW	Revised Code of Washington
Reserve Silica	Reserve Silica Corporation
RI	Remedial Investigation
SAP	Sampling And Analysis Plan
SGGP	Sand and Gravel General Permit
SIR	Site Inspection Report
Smith Bros.	Smith Bros. Silica Sand, Inc.
SMS	Washington Sediment Management Standards
SPLP	Synthetic Precipitation Leaching Procedure
SU	Standard units of pH (generally 0 to 14)
TDS	Total Dissolved Solids
TEE	Terrestrial Ecological Evaluation
TESI	Tacoma Environmental Sciences Inc
TOC	Total Organic Carbon

TPH	Total Petroleum Hydrocarbon
Tr	Renton Formation
µg/L	Microgram Per Liter
USCS	Unified Soil Classification System
UTL	Upper Tolerance Limit
VP	Vulnerable Population
WAC	Washington Administrative Code
WRIA	Water Resource Inventory Area

1.0 INTRODUCTION

This document, prepared by WSP USA Inc. (WSP), presents the results of the Remedial Investigation (RI) conducted at the Reserve Silica Reclamation Site. Throughout this RI report the term “Preliminary Site” will be used to describe the Reserve Silica Reclamation Site RI study area. The Preliminary Site is located at 26000 Black Diamond Ravensdale Road in Ravensdale, Washington (NW/4 of Section 1, Township 21 North, Range 6 East, Willamette Meridian and S/2 of SW/4 of Section 36, Township 22 North, Range 6 East, Willamette Meridian). Figure 1-1 shows the Preliminary Site location.

The Preliminary Site is the location of a closed, limited purpose landfill that is comprised of the Lower Disposal Area (LDA) and Dale Strip Pit (DSP), two surface mines that were partially filled with cement kiln dust (CKD), which are regulated under Chapter 173-304 of the Washington Administrative Code (WAC 173-304). Public Health – Seattle & King County (Public Health) is the jurisdictional health department that regulates the closed landfill and issues a landfill permit to the property owner, Ravensdale 6, LLC, a wholly owned subsidiary of Reserve Industries Corporation. Public Health also regulates an active inert waste landfill on the property parcels, in accordance with WAC 173-350-410, through a permit issued to Reserve Silica Corporation, a wholly owned subsidiary of Reserve Industries Corporation.

Reclamation, including filling of the LDA, DSP, and the active inert waste landfill, has been regulated by the Washington State Department of Natural Resources (DNR) and King County, as discussed further in this report. In 2010, DNR canceled the reclamation permit, because there was no ongoing or additional planned surface mining and acknowledged King County would have authority for grading and filling. Currently, King County Department of Local Services (DLS) issues Grading Permit No. GRDE15-0011 for the Reserve Silica Fill Site, which includes active mining reclamation where inert waste is placed under the permitting authority of Public Health.

The Washington State Department of Ecology (Ecology) issues Sand and Gravel General Permit (SGGP) No. WAG503029 for the Reserve Silica properties, including the active reclamation area, the inert waste landfills, the Preliminary Site, and the Reserve Silica Plant site. The SGGP requires the sampling of stormwater discharges, including sampling the Infiltration Ponds, and a vehicle wheel wash station. The SGGP does not address the mine portal discharge or seepage discharges from the LDA. The caustic seepage has been treated and discharged to the Infiltration Ponds during the formal cleanup (i.e., during the Agreed Order). Although procedural exemptions have applied during the Agreed Order pursuant to RCW 70A.305.090. Ecology’s Water Quality Program indicated that the collection, treatment, and discharge of seepage from the LDA should be regulated under an individual State Waste Discharge Permit. Reserve Silica submitted an application to obtain a State Waste Discharge Permit in December 2024. State Waste Discharge Permit No. ST0501373 was issued as a temporary permit effective February 14, 2025. Ecology anticipates finalizing the State Waste Discharge Permit in the summer of 2025.

In September 2017, Ecology determined that Reserve Silica Corporation (Reserve Silica) and Holcim (US) Inc. (Holcim) were Potentially Liable Persons (PLPs) for the release of hazardous substances at the Preliminary Site. Reserve Silica and Holcim subsequently entered into Agreed Order No. DE 16052 (Agreed Order) with Ecology. The Agreed Order requires Reserve Silica and Holcim to complete a Remedial Investigation and Feasibility Study (RI/FS) and submit a preliminary draft Cleanup Action Plan. Burlington Northern Santa Fe (BNSF) Railway was also notified by Ecology of its status as a PLP for the Preliminary Site, but BNSF Railway declined to participate in the Agreed Order. The Agreed Order only pertains to the Reserve Silica Reclamation Site (Ecology Cleanup Site ID [CSID] 4728); it does not pertain to the adjoining Reserve Silica Plant site (CSID 15125). Ecology separated these sites because the sources and types of contamination are distinct and do not overlap. Reserve Silica is independently conducting cleanup actions at the Reserve Silica Plant site.

This RI report presents the results of the field investigation conducted to meet the requirements of the Agreed Order and in accordance with Revised Code of Washington (RCW) 70A.305.030(1) and the Washington State Model Toxics Control Act (MTCA) Cleanup Regulations, Chapter 173-340 WAC. RI data were collected in accordance with the Ecology-approved Reserve Silica Reclamation Site Remedial Investigation/Feasibility Study Work Plan (RI/FS Work Plan) (Golder 2021a), and the Ecology-approved Supplemental Soil Sampling Work Plan (WSP 2023).

1.1 Objectives and Purpose

The RI was conducted in accordance with the MTCA requirements for conducting an RI/FS, which are defined in WAC 173-340-350. The objective of this RI process is to evaluate the nature and extent of hazardous substances in the environment and gather sufficient information to support an informed risk assessment and remedial action decision consistent with WAC 173-340-360, which defines the process for selection of remedial actions under MTCA Cleanup Regulations. The RI field investigation was conducted to complete an RI/FS risk assessment to determine whether sufficient human health or environmental risk exists to warrant remedial actions and, if warranted, to select the most appropriate remedial alternatives under the FS process. Field investigations conducted as a part of the RI were completed in accordance with the procedures specified in the Ecology-approved Sampling and Analysis Plan (SAP) and the Quality Assurance Project Plan (QAPP), which were provided in Appendices D and E of the RI/FS Work Plan (Golder 2021a).

The Preliminary Site has been the subject of numerous environmental investigations and previous interim actions completed under the approval of an interagency group consisting of Ecology and Public Health. The interim actions are remedial activities completed in accordance with WAC 173-340-430, to reduce a threat to human health or the environment and address environmental impacts that may become worse if the action is delayed. Routine groundwater and surface water monitoring has been conducted at the Preliminary Site since 2006 under the requirements of Limited Purpose Landfill (Post-Closure) Annual Permits issued by Public Health. Additional information on the Preliminary Site geology, hydrogeology, and disposal activities during reclamation are available from historical records and documents produced during the mining operations at the Preliminary Site and during post-closure activities. Many of these historical documents are available to download on Ecology's Reserve Silica Reclamation Site webpage (https://apps.ecology.wa.gov/cleanupsearch/site/4728). These historical sources of data combined with data collected during this RI provide a comprehensive and sufficient basis for development of a Conceptual Site Model (CSM). This RI report provides a summary of Preliminary Site historical data, data collected as a part of the RI field investigation, the completed CSM, and proposes cleanup standards based on the application of MTCA Applicable or Relevant and Appropriate Requirements (ARAR).

1.2 Report Organization

This RI report has been structured in accordance with MTCA WAC 173-340-350 [Remedial Investigation] and 173-340-840 [General Submittal Requirements] to facilitate a clear understanding of the Preliminary Site history and current conditions, previous investigations and remedial actions, regional and local geology and hydrogeology, preliminary CSM, data gaps, and the additional remedial investigations that were completed. The remaining sections of this report are organized as follows:

- Section 2 – Preliminary Site Background and Environmental Setting. Describes the Preliminary Site location and surrounding land use; Preliminary Site history, ownership, mining, and reclamation operations; and physical setting, including topography, ecological, geology, hydrogeology, and surface waters.

- Section 3 – Previous Preliminary Site Investigations and Interim Actions. Presents a summary of the previous investigations completed at the Preliminary Site including geophysical testing, groundwater, surface water, soil, and sediment sampling and analyses. Describes interim remedial actions implemented to mitigate environmental impacts at the Preliminary Site, protect human health and the environment, and provide for ongoing water treatment for the protection of groundwater and surface water.
- Section 4 – RI Field Investigation. Presents field sampling and monitoring conducted as a part of the RI.
- Section 5 – Sampling and Analytical Results. Presents the results from the field sampling and monitoring conducted as a part of the RI.
- Section 6 – Conceptual Site Model. Uses the extensive amount of Preliminary Site data provided from historical records, previous environmental investigations, and interim actions, and from current groundwater and surface water monitoring to identify the environmental setting, sources of contamination, the environmental media impacted, and the potential contaminant exposure pathways and receptors.
- Section 7 – Permitted Limited Purpose Landfill Boundaries, Cleanup Standards, and Proposed Site Boundary. This section presents the boundaries of the LDA and DSP and evaluates preliminary cleanup levels (PCULs) based on applicable or relevant and appropriate requirements for the Site against the potentially complete exposure pathways and receptors to determine cleanup standards and to define the proposed Site boundary.
- Section 8 – Presents the summary and conclusions of this RI report.

2.0 PRELIMINARY SITE BACKGROUND AND ENVIRONMENTAL SETTING

The Preliminary Site area was first used for coal mining from the early 1900s through approximately 1950[1] and then for silica sand mining from 1968 through 2008. Both the surface coal mining and silica sand mining resulted in several deep pits, roughly oriented north-northwest to south-southeast. The deep pits are oriented along the geologic “strike” or direction of the coal and sandstone bedrock units relative to the intersection of the horizontal plane. Reclamation of the surface coal and sand pits on the Preliminary Site started in 1971 and included landfilling the pits with mine spoils (the non-economical soil and rock produced during mining) from the Preliminary Site and with imported fill material including but not limited to CKD.

CKD and other materials were placed in two former mine pits at the Preliminary Site: the LDA and the DSP. These permitted landfill areas have been capped and are in the post-closure inspection, maintenance, and monitoring phase. Post-closure activities are ongoing in accordance with the Limited Purpose Landfill (Post-Closure) Annual Permit No. PR0015708. The North Pit, Upper Pit, Lower Pit, Tan Sand Pit, and Middle Pit, former sand mining pits currently in reclamation, are located between the LDA and the DSP. Backfilling of these former sand mining pits is occurring under Inert Waste Landfill Permit No. PR0082027. Locations of the LDA, DSP, and other historical sand mining pits are shown in Figure 2-1.

[1] Various references indicate different years when coal mining ended at the Site; 1950 (TESI 2000), 1947 (Ecology and Environment 1986).

The Preliminary Site boundary, as defined by Ecology in the Agreed Order, consists of three King County tax parcels, as depicted in Figure 2-1 and described below:

Lot 5: Parcel No. 0121069011, approximately 52 acres, which is in the NW¼ of Section 1, Township 21 North, Range 6 East; hereafter referred to as Lot 5 or the Inert Waste Lot. As described in Section 7.1, the LDA extends into Lot 5, where a lobe of CKD was encountered.

Lot 6: Parcel No. 3622069138, approximately 67 acres, which is in the SW¼ of Section 36, Township 22 North, Range 6 East and the NW¼ of Section 1, Township 21 North, Range 6 East; hereafter referred to as Lot 6 or the Closed Limited Purpose Landfill Lot, which contains the LDA, the DSP, and a portion of the Infiltration Ponds.

Baja Property: Parcel No. 3522069046, approximately 14 acres, which is in the SE¼ of Section 35, Township 22 North, Range 6 East; hereafter referred to as the Baja Property. The remaining portion of the Infiltration Ponds and two Preliminary Site groundwater monitoring wells are within the boundaries of the Baja Property.

The Preliminary Site is primarily zoned Mineral Resource-Related, although the Baja Property is zoned Forest (Figure 2-2). The surrounding land is comprised of:

- Undeveloped forest land to the east with recent logging and grading for coal mine reclamation and the Reserve Silica Asarco Soil Disposal Site.[2]
- Undeveloped forest land to the south.
- The Ravensdale Reclamation Trench Filling Project (Ravensdale Fill Site), operated by Ravensdale LLC, located to the northeast. Legal description: SE 1/4 of Section 36, Township 22 North, Range 6 East, and the NE 1/4 of Section 1 Township 21 North, Range 6 East, W.M.
- The former Reserve Silica Sand Processing Plant (Plant Site), Ravensdale Lake, and King County Black Diamond Open Space to the north.
- Forest land and King County Black Diamond Open Space to the west.

A 500-foot-wide Bonneville Power Administration (BPA) easement transects the Preliminary Site from east to west and contains three sets of transmission towers and overhead electrical lines.

2.1 Preliminary Site Owner and Operator History[3]

The Northwestern Improvement Company, a subsidiary of Northern Pacific Railway, conducted coal mining and strip mining within and adjacent to the Preliminary Site from the early 1900s until 1947 (Ecology and Environment 1986). Between 1947 and 1968 no operations were conducted on the Preliminary Site (Ecology and Environment 1986). Northern Pacific merged with Great Northern and several other railways on March 2, 1970, to form Burlington Northern Railroad Company (BNSF 2020). A Preliminary Investigation report, prepared by Tacoma Environmental Sciences Inc. (TESI), includes a list of individuals and corporations that had business interests in

[2] The Reserve Silica Asarco Soil Disposal Site (CSID 16998) received a No Further Action determination from Ecology in February 2024 related to the inadvertent disposal of 33 truckloads of soil from the former Asarco Tacoma Smelter facility. The Reserve Silica Asarco Soil Disposal Site is not associated with the Reserve Silica Reclamation Site.

[3] The historical site ownership and operating history described in this section are specific to the properties that currently include Lot 5 and Lot 6 parcels. Mining and filling activities were not conducted on the Baja Property; thus, the history of ownership and operating history are not applicable to the Baja Property area of the Preliminary Site.

the Preliminary Site area between the early 1970s and 1997 (TESI 2000). Smith Bros. Silica Sand, Inc. (Smith Bros.), began sand mining in approximately 1968 (Ideal 1984) under a lease from the property owner at that time, Northern Pacific Railway. The Preliminary Site was then leased by Industrial Mineral Products, Inc. (IMP), which took over from Smith Bros. in 1972. In April 1986, L-Bar Products, Inc. purchased IMP's assets and continued the sand mining operations. In May 1991, L-Bar Products, Inc. changed its name to Reserve Silica Corporation and Reserve Silica continued leasing the Preliminary Site area for sand mining operations. In 1997, Reserve Silica purchased the area that currently includes Lot 5 and Lot 6 of the Preliminary Site from Glacier Park Company (EDR 2020), a subsidiary of Burlington Northern. Sand mining and processing was conducted at the Preliminary Site from approximately 1968 to 2008.

During reclamation of the DSP and LDA, IMP hauled CKD generated at the Ideal Basic Industries, Inc. (Ideal) Seattle Cement Manufacturing Plant to the Dale Strip Pit Reclamation Project (Project) for use as fill material. This Project began in 1979 and appears to have included both the LDA and the DSP. As a result of a merger in 1990, Holnam, Inc. became the successor to Ideal and in 2001, Holnam, Inc. changed its name to Holcim (US) Inc.

2.2 Mining History

Surface and underground coal mining were conducted on portions of the Preliminary Site between the early 1900s and approximately 1950. Sandstone mining began in approximately 1968 and continued until 2008. Historical mining pits located on the Preliminary Site include:

- The DSP is a former surface strip coal mine that was mined in the 1940s and backfilled between November 1982 and 1989 with a combination of CKD, borrow (mixtures of soil, sand, and/or gravel), and other materials (Arcadis 2006), which may have included clay-rich till, sandstone mining wastes (TESI 2000) and/or rejected clay and sand batches, and glass cullet waste (Ideal 1984).
- The LDA is a former sandstone mine that operated in the late 1960s/early 1970s. CKD was disposed in the LDA between June 1979 and October 1982 (Ideal 1984). Boreholes drilled in the LDA encountered mine spoils, CKD, pieces of glass, and other debris.
- Sand mining of the Upper Pit, North Pit, Lower Pit, Tan Sand Pit, and Middle Pit occurred between the late 1980s and 2007. Most of the Upper Pit was backfilled in 2006 and 2007, but backfilling began prior to 2003 under a county grading permit. Filling of the North Pit and Lower Pit was completed in 2023 under an inert waste landfill permit. No CKD was placed in the Upper Pit, North Pit, Lower Pit, Tan Sand Pit, and Middle Pit.

2.2.1.1 Coal Mining History

Numerous coal fields are located throughout east King County; the largest and most productive coal fields are in the Ravensdale district comprised of the following mining areas: Ravensdale, Black Diamond, Franklin, Kummer, Cumberland, Bayne, Durham, and Kangley (Green 1943). The coal in this district is bituminous and occurs in Eocene-age sedimentary bedrock consisting of sandstone, siltstone, shale, and coal of the Puget Group (Green 1943). The bedrock has been uplifted and tilted by tectonic activity and dips to the southwest at an angle between 50 and 80 degrees (TESI 2000; SubTerra 2006). The coal found in King County is low in sulfur (Evans 1912; Vine 1969). Sulfur is the element primarily responsible for the generation of acid mine drainage (AMD). AMD has not been observed from the mine portal at the Preliminary Site, which is consistent with the low levels of sulfur in the coal deposits of King County.

The coal mines in the Ravensdale district were opened in 1899 by the Seattle and San Francisco Railway and Navigation Company and bought and operated by the Northwestern Improvement Company by 1912 (Evans 1912). The coal mining by Northwest Improvement Company, a subsidiary of Northern Pacific Railway, on and near the Preliminary Site consisted of underground mining of the Dale No. 1 mine from 1924 to 1933, and surface mining of the Dale No. 4 seam from 1946 to 1950 (TESI 2000). The Dale No. 1 Mine is a water level mine that was advanced from the Dale Tunnel portal to the Dale No. 4 and Dale No. 7 coal seams. The underground mining works drain through the mine portal. Beyond the Preliminary Site boundary, underground mining was performed from the Ravensdale No. 1 Mine between 1899 and 1915 (Washington Geological Survey 1912), from the McKay Workings between 1905 and 1949 (Metropolitan Engineers 1972), and from the Andersen Mine from 1945 to 1948 (Ideal 1984). Strip mining was performed from the McKay Workings between 1946 and 1954 (Metropolitan Engineers 1972).

By 1927, the operations and processing facilities associated with the Dale Mine No. 1 included a mile-long electric tramway constructed to transport coal from the McKay Workings, located to the east of the Preliminary Site, to the Dale Coal Mine processing area located adjacent to the northern portion of the Preliminary Site (Figure 2-3). The Dale Coal Mine processing area included a washery, sulfur storage, cooler and drying room, tipple, and machine shops with a generator room, transformers, and a slack/rock dump area (Figure 2-4) (Reese 1928). A number of these features appear associated with the short-lived briquetting operations, which are discussed further in the following subsection. Total production tonnage of the underground mining operations is estimated at 263,000 tons (Metropolitan Engineers 1972).

Appendix A of this RI report provides maps and aerial photographs showing historical coal mining activities on and adjacent to the Preliminary Site. Aspect Consulting, LLC (Aspect) reviewed the location of the historical coal mining facilities and found that they were located beyond the extent of potential environmental impacts associated with the CKD disposal. A report summarizing Aspect's review of historical coal mining facilities is included in Appendix B (Aspect 2023).

2.2.1.2 Coal Mining Methods

Both surface (strip) and underground coal mining occurred at the Preliminary Site. A conceptual section of the mining methods utilized for mining the Dale Mine No. 1 coal seams is included in Figure 2-5. The section view is roughly parallel to the bed of the coal seam; the line of the conceptual cross-section follows the Dale Tunnel and is shown offset in Figure 2-5. Generalized underground mine features are based on descriptions included in Coal and Coal Mining in Washington (Green 1943), modified with site-specific details (Metropolitan Engineers 1972).

Underground Mining: The underground workings of the Dale Mine No. 1 included mining of coal ore from the Dale No. 4 seam and the Dale No. 7 seam, which were worked from 1924 to 1933. From 1945 to 1948, mining was resumed on the Dale No. 7 seam by the Andersen Coal Company, who accessed the seam from a slope drift driven from the surface down the seam to the old gangway level and mined on the southerly limb of the syncline. The Andersen mine portal is southeast of the Preliminary Site (see Appendix A) (Idea 1984). The Dale Nos. 4 and 7 coal seams (excluding the Andersen Workings) were accessed via a 1,500 feet long gangway, referred to as the Dale Tunnel (NWI Co. 1936), beginning at the Dale mine portal approximately 2,000 feet northwest of the DSP at elevation 635 feet above mean sea level (amsl) (Figure 2-3). The Dale Tunnel was advanced up an unknown coal seam overlying the Dale No. 4 seam (Metropolitan Engineers 1972). The entire Dale Mine No. 1 was constructed as a self-draining mine, with the portal as the lowest point in the mine, and groundwater was allowed to drain by gravity from the mine workings, through the Dale Tunnel, and out the portal. The Dale Tunnel inclined gradually to a maximum elevation of 670 feet amsl at the southern end, corresponding to depths of 240 to 270 feet below ground surface (bgs). In their 1972 report, Metropolitan Engineers says that ‘several years ago’, presumably in the late 1960s or early 1970s, the mine portal was blocked off by filling in a short length of the Dale Tunnel at the entrance and an 18-inch culvert was installed to allow for ongoing drainage. Groundwater from the Dale No. 4 and No. 7 seams continues to gravity drain through the gangway to the mine portal where it discharges to the stormwater drainage system for the reclamation activities.

Underground mining of the Dale Mine No. 1 coal seams consisted of the chute and pillar method, commonly used for the mining of steeply dipping beds, which mines ‘chutes’ of ore while leaving ‘pillars’ of untouched material to support the roof. The narrow chutes were driven up the dip of each seam from the gangway to the chain pillar, which was left in-place to support the ground surface. Approximately 15 to 20 feet of chain pillar were left between the surface and the workings (Figure 2-5) (Metropolitan Engineers 1972). At several locations, chutes were driven to the surface for ventilation and to allow timbers to be dropped into the mine. Crosscuts connected terminated chutes to ventilation chutes, leaving pillars of coal in the spaces in between. Coal pillars were mined as mining activities withdrew, progressing laterally outward toward the mine portal and vertically downward toward the gangways (Metropolitan Engineers 1972). Historical maps indicate that the Dale No. 7 seam was mined first and then the Dale No. 4 seam was worked. Reportedly, concrete bulkheads were constructed as seals in the Dale No. 7 gangway near the entry crosscut from the Dale No. 4 seam (Metropolitan Engineers 1972). The extent of underground coal mining activities conducted on and near the Preliminary Site is depicted by the green hatched boundaries shown in Figure 2-3.

Surface (Strip) Mining: In addition to underground coal mining, the Dale No. 4 coal seam was mined at the surface using strip mining methods from approximately 1946 to 1950 (Metropolitan Engineers 1972). This surface mining of the Dale No. 4 seam created the DSP. The DSP was 1,800 feet long, north to south, averaging 140 feet wide, east to west, and 40 feet deep with sloping sides (Metropolitan Engineers 1972). The extent of the DSP is shown in Figure 2-1. During the stripping operations, chutes from the underground mining operations were reportedly encountered in the southern portion of the DSP. The chutes were reportedly open when first exposed, but later caved in. Although no specific attempt was made to fill them completely, fill material was deposited into the openings to ‘whatever degree was needed to fill them up to the bottom of the pit’ (Metropolitan Engineers 1972).

Based on a historical map of the Dale Coal Mine facilities, coal was transported in small hopper cars from the mine portal via an electric mine railroad to the tipple, a structure where coal was sorted and loaded into railroad hopper cars for transport from the mine (Figure 2-3). The railroad tracks and tipple were near the present-day Black Diamond-Ravensdale Road, with disposal of non-saleable coal to the north of the Preliminary Site (where the former Reserve Silica Plant Site was located). Coal mining-related operations and structures on the northern portion of the Preliminary Site may have included storage and/or disposal of coal and coal tailings and limited coal processing associated with the short-lived briquetting operations. In 1928, the Northern Briquetting Co. reportedly began operations at Ravensdale, and in 1929, this plant was acquired by the Paramount Briquet Co., who moved it to a new site on Lake Union in Seattle (Green 1943). Based on historical aerial photographs (see Appendix A), the facilities associated with coal mining and processing were removed between 1952 and 1957.

2.2.1.3 Sand Mining History

Silica sand mining began at the Preliminary Site in approximately 1968 with the LDA pit and continued in other portions of the Preliminary Site until production ceased in November of 2008. The raw material was a quartz-rich, clay-cemented sandstone that was excavated from open surface cuts. From this material, Reserve Silica produced golf course bunker sand and sand used in glass and cement production. Mined sandstone was processed at the Plant Site north of the Preliminary Site.

Mining of sandstone from the LDA consisted of stripping along the entire strike length from the BPA transmission lines north to the fault line in one continuous operation (TESI 2000). The presence of water in the strip pit limited the depth of the sand mining operations. Sand mining at the LDA ceased permanently in the early 1970s because of water infiltration into the mine (TESI 2000). Early reclamation, consisting of filling mined areas with material from non-sandstone beds and overburden from expanded sand mining operations, was hampered by erosion due to the tendency of the sandstone formations to ‘gully’ (TESI 2000). The early solution was to construct ditches perpendicular to the sloped sidewalls to convey runoff (TESI 2000). Water was reported to enter the mine at the south end from a gravel channel in the bedrock under the BPA power lines and at the north end near or at the bottom of the excavation (which was reportedly 60 feet deep) (TESI 2000).

Beginning in the late 1980s, sandstone was mined from five pits located between the LDA and the DSP: Upper Pit, Tan Sand Pit, Lower Pit, North Pit, and Middle Pit. The outlines of these historical pits are shown in Figure 2-1. A thin, low bedrock pillar wall separates the North Pit from the Tan Sand Pit and the Lower Pit from the Middle Pit, resulting in combined reclamation of these pit areas, as shown in the reclamation planning documents (Bennett 2014). A thin bedrock pillar wall also separates the North Pit from the LDA, which inhibits shallow groundwater if present in the former North Pit from flowing into the LDA. Mining ended in December 2007 with the completion of sandstone extraction from the Lower Pit. The reclamation of these pits is ongoing, as of the date of this report. The reclamation is being conducted under an active Inert Waste Landfill permit, which allows for acceptance and disposal of inert waste consisting of cured concrete, asphaltic materials, brick and masonry, ceramic materials produced from fired clay or porcelain, glass, stainless steel and aluminum, and soil that meets MTCA Method A cleanup levels (CULs).

2.3 Reclamation and Landfilling

Reclamation and landfilling have been conducted at the Preliminary Site under DNR Surface Mine Reclamation Permit No. 70-101346 and King County grading permits since 1971, including King County Department of Permitting and Environmental Review Grading Permit No. 7061122 (Bennett 2014) and later the King County Building and Land Development Grading Permit No. 1122-58 (Ideal 1984). King County Department of Public Health (currently Public Health) issued Special Landfill Permit No. 17-101, with permit terms that included monitoring surface water and groundwater, gating, fencing, posting, and recordkeeping requirements (Ideal 1984). Public Health has issued permits to Reserve Silica since 2012 that require the post-closure care of the closed limited purpose landfills in accordance with WAC 173-304. Public Health updates the permit annually. A 1989 Reclamation Plan presented methods and schedules for reclamation of the mining areas, including both the historical coal mine/CKD-disposal areas and the active (at that time) sand mining areas (Brown 1989). DNR ceded permitting authority to King County in 2010 based on the cessation of active surface mining. A 2014 Interim Reclamation Plan describes the reclamation activities for the Lower and North Pits (Bennett 2014), as described further below. DLS currently issues Grading Permit No. GRDE15-0011 for the Reserve Silica Fill Site.

2.3.1.1 Limited Purpose Landfill

The early disposal and permitting of the LDA and DSP are described in the Ideal petition (1984). The filling of the LDA and DSP was authorized by King County Building and Land Development Grading Permit No. 1122-58, with a condition that a solid waste disposal permit was required to dispose of CKD after August 28, 1981. Public

Health issued King County Department of Health Special Landfill Permit No. 17-101 on August 28, 1981. A summary of the LDA and DSP reclamation activities is provided below.

Lower Disposal Area: Approximately 175,000 tons of CKD were placed in the LDA between June 1979 and October 1982. The June 25, 1981, disposal permit application indicated that the excavation was full, and that IMP planned to elevate the original access road by 25 feet to form a berm and basin that will allow additional CKD disposal.

The June 25, 1981, permit application stated: "Although the original soil cover averaged 24 inches or less, the property owner, Burlington Northern, may require as much as six feet of soil cover" and stated Burlington Northern's "logging and reforestation program will influence the final revegetation of the site." The permit application states:

> "As soon as the landfill site is full so that it conforms to the topography of the surrounding landscape, the dust will be covered with a cap of clay from the washing plant settling ponds, or clay from the mine, to prevent an upward migration of soluble salts. The site will then be covered with topsoil…. Proximity to the [BPA] powerline right-of-way will prevent reforestation of the site."

The August 28, 1981, permit states that the LDA should receive a final cover as per Section 4.05 C.5 of Rules and Regulations No. VIII. The December 19, 1982, permit renewal application stated that as of October 25, 1982, the LDA was phased out and being capped with clay and CKD was being disposed at the DSP. The LDA surface was revegetated in the fall of 1983.

The regulatory closure criteria for the LDA are not specifically identified, but WAC 173-301 (Regulations Relating to Minimum Functional Standards for Solid Waste Handling) was the applicable state solid regulation at the time of closure. WAC 173-301-305 required *sanitary landfills* to "be covered with an equivalent of two feet of compacted soil adequately sloped to allow surface water to run off." The August 28, 1981, landfill permit included surface and groundwater monitoring requirements that were not provided in WAC 173-301. WAC 173-304 (Minimum Functional Standards for Solid Waste Handling) became the applicable regulation for limited purpose landfills in October 1985 and WAC 173-301 was repealed as an antiquated regulation. Limited purpose landfills are regulated under WAC 173-350-400 if they operated after February 2003.

The original LDA excavated area measured approximately 3.5 acres, was 40 feet deep from standard grade, and was filled with between 30 to 60 feet of CKD (Ideal 1984). An investigative borehole drilled in the center of the LDA in 2020 indicated that the LDA extends approximately 60 feet below the current surface of the LDA. Sandstone bedrock was encountered at the base of the LDA (Golder 2021a, Golder 2021b).

In 2007, the soil cover on the LDA was upgraded, including regrading the cover to provide positive surface water runoff at all locations, increasing the thickness of the low-permeability cover soil layer to a minimum of 2 feet at all locations, and constructing a surface water diversion ditch around the upslope boundary of the cover to divert stormwater around the LDA (Golder 2008). The specifications, observations, and effectiveness of the upgrade LDA cover is discussed in Section 8.3.

Dale Strip Pit Area: Public Health approved the disposal of CKD in the DSP under the existing Special Landfill Permit No. 17-101 on August 25, 1982. The DSP was filled with approximately 250,000 cubic yards of material beginning on November 1, 1982 (Arcadis 2006), a portion of which included CKD. Because of standing water in portions of the DSP at the time of backfilling, the southern third of the DSP was reportedly filled with clay and fine sand from the settling ponds, to prevent leaching of effluent from the CKD into the underlying coal mine workings.

Furthermore, the southern end of the northern two-thirds (i.e., the middle section) of the DSP pit appeared to have been reserved for purported inert mineral materials from Ideal Basic Industries and Northwestern Glass (Ideal 1984). In 1984, a change to Washington State waste regulations reclassified CKD as a dangerous waste and Ideal petitioned Ecology for an exemption to the Washington State Dangerous Waste Regulations (WAC 173-303) to allow for continued disposal of CKD at the DSP (Ideal 1984). Ecology issued temporary exemptions to allow for continued CKD disposal into 1988. CKD disposal reportedly continued until May 1988 but landfilling of other material continued into 1989. The DSP operated after the October 1985 effective date of the WAC 173-304. Initial capping of the DSP was completed in the early 1990s (TESI 2000). The cap of the DSP consists of a 4-foot layer of clay soil underneath 3 feet of sand overburden from sand mining operations (Hart Crowser 1989), which is consistent with the 1982 permit application. In 2010/2011, the DSP cover was upgraded, including stripping surficial vegetation and topsoil, regrading the existing surface to establish positive drainage, placing low permeability soil to provide a minimum 2 feet thick layer at all locations, filling the existing ditch along the northeast side of the DSP, replacing topsoil, and revegetating the cover surface (Golder 2013a).

2.3.1.2 Inert Waste Landfill

Public Health has issued a solid waste facility permit for Reserve Silica Corporation Inert Waste Landfill PR0082027 since 2012 (Public Health 2012a). The permit authorizes the disposal of inert waste during reclamation. The Inert Waste Landfill Permit is updated annually.

Upper Pit: The Upper Pit was filled under the Department of Development and Environmental Services (DDES; later Department of Permitting and Environmental Review [DPER]) Grading Permit No. 70G1122 and reclaimed with inert fill in the 2000s, prior to the inert waste landfill permit.

Lower and North Pits: The Lower Pit and the North Pit were reclaimed with inert waste authorized by Inert Waste Landfill Permit No. R0082027. As discussed above, reclamation for the North Pit included the Tan Sand Pit, and reclamation for the Lower Pit included the Middle Sand Pit. The inert waste landfill is permitted to accept up to 2.75 million cubic yards of inert waste, including cured concrete, asphaltic materials, brick and masonry, ceramic materials, glass, stainless steel and aluminum, and soil that meets chemical criteria defined in the permit (Public Health 2016a). Historically, Public Health also allowed for the disposal of hardy board as inert waste.

The following information was stated in the Lot 5 Historical Review, Reserve Silica Ravensdale Site report (Aspect 2019a). Inert waste landfilling in the Upper, Lower, and North Pits includes the following procedures:

- Fill is brought in by dump trucks that transport their loads to a pre-dump staging area located upslope of the depleted pit. Following confirmation from the Reserve Silica main office that the material meets the requirements for clean soil/inert waste, the load is tipped, inspected, and recorded by Reserve Silica at the staging area. Loads of material that do not meet the clean soil/inert waste criteria are rejected and sent away. Material loads meeting the clean soil/inert waste requirements are pushed into the pit. The standard operating procedures for the inert waste landfill include certification by customers that imported material meets the criteria for clean soil/inert waste, a fill monitoring plan, and detailed record keeping of the date, source, volume, and quality of imported fill, with regular reporting to King County and maintenance of records for periodic review/inspection by Public Health. The interim reclamation plan also includes a spill control plan, with requirements for reporting and addressing the release or discharge of possible pollutants.
- The Upper Pit, North Pit (including the Tan Sand Pit), and Lower Pit (including the Middle Pit) were operated as inert waste landfills. Reserve Silica requires the transporter to certify that the waste meets

the permit requirements for inert waste. In accordance with WAC 173-350-410, there are no post-closure monitoring or financial assurance requirements for inert waste landfills.

Roadway Areas: In the 1970s and early 1980s, a subsidiary of IMP, Black Knight, Inc., contracted with the American Smelting and Refining Company (ASARCO) smelting facility in Tacoma, Washington to sell the processed slag to log yards and other industrial sites where it was spread on the ground to provide a firm base (Black Knight 1993). The slag was reportedly used at the Preliminary Site to improve traction on slippery haul roads at the Preliminary Site (Ecology and Environment 1986). TESI "noted slag material, possibly from ASARCO, in the road base and eroded slopes in the vicinity of the LDA" (TESI 2000). The TESI report also notes that material in the LDA bank and base of the ditch at the west side of the Lower Haul Road includes melted glass, coal, ASARCO slag, CKD, and limestone (TESI 2000). Remedial investigation activities were completed in 2017 by Aspect Consulting, LLC (Aspect) to evaluate the potential for slag in the roadway and shoulders of the Lower Haul Road (Aspect 2017).

2.4 Preliminary Site Physical Description

This section provides detailed discussion of the Preliminary Site's physical description including geology and hydrogeology. The Preliminary Site location is shown in Figure 1-1, and the Preliminary Site and parcel boundaries are shown in Figure 2-1.

2.4.1 Regional Geology and Hydrogeology

The Preliminary Site is in the Puget Sound Lowland, a structural and topographic basin between the Cascade Range and the Olympic Mountains. During the Pleistocene Epoch (2.6 million to about 11,000 years ago), at least six major glacial episodes occurred, with the latest, the Vashon Stade, ending approximately 11,000 years ago. Repeated advance and retreat of continental ice sheets resulted in scouring and deposition of glacial sediments. The geology of the Ravensdale area is dominated by Pleistocene glacial outwash, glacial till, and Tertiary bedrock of the Puget Group, consisting of about 6,200 feet of nonmarine sedimentary rocks that range in age from early Eocene (55 to 33 million years ago) to early Oligocene (33 to 23 million years ago) (Vine 1969). The Preliminary Site is located within Water Resources Inventory Area 9 (Duwamish-Green).

2.4.2 Topography

The Preliminary Site is on the southwest flank and at the base of a glacially carved bedrock high point, known locally as Ravensdale Hill (TESI 2000). The hill rises from an elevation of approximately 600 feet at Ravensdale Lake to a high of approximately 1,000 feet. The DSP and Upper Pit are on a moderately flat glacial terrace at approximately 950 feet elevation. From this elevation, the surface slopes steeply downward to the west and southwest. The topography was modified by the mining activities, resulting in north-northwest trending pits excavated along the strike of sedimentary beds, which have subsequently been backfilled. The elevation of the Preliminary Site ranges from approximately 600 feet NAVD88 on the northern portions of the Preliminary Site, near Black-Diamond Ravensdale Road, and slopes uphill steeply to the east and southeast, reaching a high of more than 1,000 feet NAVD88 at the southeast corner.

2.4.3 Land Use

The current land use of the Preliminary Site is varied as discussed throughout this RI report. The closed limited purpose landfill is subject to the Minimum Functional Standards for Solid Waste Handling, chapter 173-304 WAC. The applicable regulations for the Inert Waste Landfill are the Solid Waste Handling Standards, chapter 173-350 WAC. Once reclamation of the Inert Waste Landfill is complete, the location will be recorded as part of the deed, in accordance with WAC 173-350-410(9). The FS will recommend an environmental covenant that restricts land use for the closed limited purpose landfill.

The environmentally sensitive areas on the Preliminary Site include wetlands, coal mine hazard areas, and steep slope and erosion hazard areas (Figure 2-6).

2.4.4 Preliminary Site Geology

Three geologic units have been identified at the Preliminary Site, in addition to artificial fill soil and peat deposits, and include 1) Vashon recessional outwash gravel (Qvr), 2) Vashon-age lodgement silty sand and gravel till (Qvt), and 3) Eocene age sedimentary bedrock units of the Puget Group-Renton Formation (Tp; SubTerra 2006). A surface geologic map of the Preliminary Site and surrounding area based on DNR (mapping scale) (2024) surface geology is provided in Figure 2-7.

Vashon recessional outwash gravel is documented to the northwest of Black Diamond-Ravensdale Road along the channel of Ravensdale Creek and is typically sandy, cobbly gravel to gravelly cobbles with low silt content (SubTerra 2006). The Vashon recessional outwash gravel averages about 40 feet thick, with local variability up to 150 feet thick, and comprises the local aquifer to the northwest portions of the Preliminary Site, and in the area of the former processing plant and underlying the settling ponds on the adjoining Reserve Silica Plant site.

The Vashon-age lodgement till occurs as a 5 to 15 feet thick mantle at the land surface, except for the bedrock highs and areas where the recessional outwash is present and consists of an unsorted mixture of cobbles and pebbles, densely compacted in a matrix of sand, silt, and clay (SubTerra 2006). Till typically functions as a confining unit and the relatively low permeability of the till on the Preliminary Site is evident by standing water that ponds on top of the till.

The Puget Group-Renton Formation forms the sedimentary bedrock core of the northwest trending ridge that underlies the Preliminary Site and consists of arkosic sandstone, siltstone, carbonaceous shale, and coal beds that were deposited in a meandering stream/floodplain environment during middle Eocene time (SubTerra 2006). These units have been uplifted and tilted by tectonic activity, so they strike about N25W and dip to the southwest at an angle typically between 50 and 60 degrees but can dip up to 80 degrees (SubTerra 2006). A normal fault truncates these beds on the northern portion of the Preliminary Site. Because of coal and sand mining, the current topography of these bedrock areas is characterized by a series of northwest trending cuts and pits separated by intact bedrock pillar walls. The cuts and pits have been completely backfilled.

2.4.5 Site Hydrogeology

Three hydrogeologic units are identified near the Preliminary Site according to studies by SubTerra (SubTerra 2006):

1) The uppermost aquifer is an unconfined aquifer in recessional outwash (Qvr) glacial deposits (Figure 2-7) that is hydraulically connected to Ravensdale Lake and Ravensdale Creek in an outwash channel that extends between Vashon till outcrops along Ravensdale Creek. Treated seepage from the LDA discharges to infiltration ponds in the recessional outwash in the north part of the Preliminary Site. Based on information presented in the Kent Wellhead Protection Program (WHPP) Update (Pacific Groundwater Group [PGG] 2022), groundwater in the outwash channel is captured by the Kent Springs wellfield approximately 2 miles downgradient of the infiltration ponds near Lake Sawyer (see excerpts from the WHPP Update in Appendix C). Surface water runoff from north of the power line drainage divide, as well as groundwater that

drains from the Dale mine portal and any seepages from the LDA that are not intercepted by the seepage collection ditch, eventually discharge to this uppermost aquifer (SubTerra 2006).

2) A glacial till (the Vashon lodgement till, [Qvt]) confining layer separates the uppermost aquifer from a lower aquifer, which is within advance glacial outwash sands and gravels and preglacial sediments that are up to 200 feet thick (SubTerra 2006). This middle, advance glacial outwash aquifer is identified to the west but is absent beneath the Preliminary Site (SubTerra 2006).

3) A bedrock aquifer in the Puget Group – Renton Formation (Tp) is generally low-yield and an unreliable source for domestic water supply (SubTerra 2006). Groundwater flow within the Puget Group-Renton Formation is extremely restricted due to high clay content (SubTerra 2006). The bedrock aquifer has been classified as a bedrock-confining unit in United States Geological Survey (USGS) groundwater studies, assuming to represent the relatively impermeable basement of the glacial aquifer system. Water wells completed within bedrock are typically low yield and unreliable with flow and recharge achieved primarily through bedrock fractures (Woodward et al. 1995).

There may be limited groundwater flow from south to north within the Puget Group-Renton Formation, along bedding planes and within bedrock fractures, but this flow is likely disrupted north of the Preliminary Site and directed towards the west by the fault that generally crosscuts the geology structure in an east-west orientation. The low permeability of the bedrock is evident where open mine cuts have been observed to hold surface water year-round. However, in areas where open cuts or permeable fill are connected to underground mine workings, groundwater flows along these higher permeability zones. The historical coal mine gangway (Dale Tunnel), which currently discharges bedrock groundwater beneath the DSP through the mine portal, creates a localized drainage effect that induces a groundwater gradient towards the mine gangway beneath the DSP (Figure 2-3). Leachate released from the DSP seeps into the underground mine works and discharges through the Dale mine portal.

Shallow perched groundwater, present in localized areas within the unconsolidated soils and fill soils at the Preliminary Site, follows the slope of the bedrock or till and can flow into the former sandstone mine cuts like the LDA, or will discharge to the recessional outwash northwest of the Preliminary Site.

2.5 Additional Preliminary Site Information

2.5.1 Groundwater Use

SubTerra presented a summary of domestic water supply wells within 1-mile upgradient and 2-miles downgradient of the Preliminary Site in 2006 (SubTerra 2006). The SubTerra study indicated that the nearest domestic wells were community water supply wells that provide water supply to the Maple Ridge Highlands community, located to the northwest. The wells ranged in total depth from 74 to 209 feet bgs. The community of Ravensdale, located north and northeast of the Preliminary Site, had municipal water service through the Evergreen Water and Improvement Association from a supply well more than 5,000 feet from the Preliminary Site. Water service to the Maple Ridge Highlands and most of the Ravensdale community, except for several Group B water systems in the Ravensdale area, is currently supplied by the Covington Water District.

A review of water well records from Ecology's database identified 69 private wells within a 1-mile radius of the Preliminary Site (Figure 2-8). The database does not provide information on the water well users (e.g., whether an individual, Group A, or Group B water system is supplied).

The closest water well is on the Baja Property approximately 500 feet southwest of the Infiltration Ponds. The Baja Property well (C.J. Construction on well log) was drilled in 2003 and operated as an individual water well.

The well was drilled to a depth of 260 feet below ground. Sandstone bedrock and coal were intersected below a depth of 57 feet. The well was backfilled to the top of bedrock with bentonite and draws water from sand and gravel (interpreted to be Vashon advanced outwash unit), between 53 and 57 feet below ground. The sand and gravel are overlain by “hardpan” (interpreted as Qvt) that extends from 7 to 53 feet below ground. The depth to water at the time of drilling was 50 feet below ground, or 3 feet above the base of the till at 53 feet below ground indicating the sand and gravel is confined.

The Baja Property well was sampled for pH and total and dissolved arsenic, cadmium, chromium, lead, iron, and manganese on April 4, 2018 (Golder 2018a), and was subsequently sampled during the RI. The results of the sampling event are provided in Table 2-1. There were no exceedances of primary drinking water standards for any of the compounds analyzed. The next closest water well is over 4,000 feet southwest and downgradient from the Baja Property well. Figure 2-8 shows the approximate locations of water wells found from Ecology’s database, including the Baja Property well.

A well log from 1988 documents the construction of a test well somewhere in the vicinity of the Preliminary Site, although its location is defined only by township, range, and section (SW ¼ of the SW ¼ of T22N, R6E, S36; Figure 2-1). The Washington State Department of Health (DOH) has a record of this well as a Group B water supply well (Well ID GrpB_11121_01). However, the driller’s well log, dated January 11, 1988, indicates ‘Test Well’ as the proposed use of the 36 feet-deep well. This test well was not located and may have only been a temporary well.

Seven (7) Group B water systems[4] were identified between the Preliminary Site and Highway 169 to the west. Information on the Group B water systems is summarized in Table 2-2. Table 2-2 also includes interpreted correlation of the Group B system to available well logs.

The City of Kent obtains a portion of the City’s water supply from three springs located to the west of the Preliminary Site, Armstrong Springs, Clark Springs, and Kent Springs (see figures in Appendix C for the spring locations). The Covington Water District Lake Sawyer Wellfield is located near Kent Springs. Information presented in the Kent WHHP Update (PGG 2022) indicates the springs are supplied via discharge from the recessional outwash (Qvr). A numerical groundwater flow model was used to delineate the 6-month, 1-year, 5-year, and 10-year capture zones for the springs (PGG 2022).

The capture zones for the springs are shown on maps included in Appendix C. The 10-year capture zone for Kent Springs wellfield extends east through the outwash channel beyond Ravensdale Lake, the town of Ravensdale, and Retreat Lake. The infiltration ponds on Site are within the 5-year capture zone of the Kent Springs wellfield. The 10-year capture zone for Armstrong Springs does not extend to the Site because of the modeled presence of the Kent Springs wellfield. Changes in operations of the Lake Sawyer Wellfield may affect the configuration of the Kent Springs capture zone and borders with the adjacent spring capture zones, however, the Kent WHPP Update (PGG 2022) did not provide any modeling results evaluating potential effects of changes in operation on the modeled capture zones. The capture zones for Clark Springs are northeast of the Site and extend east and away from the Site. The Preliminary Site is entirely within the wellhead protection area because surface water runoff from the low-permeable Vashon till and bedrock discharges to the recessional outwash within the Kent Springs wellfield capture zone.

[4] Washington Department of Health Group B water systems, https://experience.arcgis.com/experience/9dc3fd45206d450f828ebd7ed9cdf7be

2.5.2 Surface Water Use

The Preliminary Site is within the Lake Sawyer drainage basin, which is part of the Lower Green-Duwamish River Watershed of the Duwamish-Green WRIA 9. A local surface water divide roughly correlates to the BPA power transmission lines near the center of the Preliminary Site. North of this divide, drainage features receive most of their recharge via groundwater in the recessional outwash gravel. Drainage features to the south of the divide are recharged primarily by surface water that flows on the lodgement till and bedrock. Runoff from the southern mining areas remains as surface water on top of the till and drains to a wetland, which eventually discharges to Sonia Lake and Ginder Lake, located about 0.7 and 1 mile south of the Preliminary Site, respectively (Figure 2-8).

Ravensdale Lake is north of the Preliminary Site and is reportedly fed by springs and surface water. Ravensdale Lake drains to Ravensdale Creek, which is classified as a riverine, unknown perennial, unconsolidated bottom, permanently flooded stream (US Fish & Wildlife 2017), which flows directly into Lake Sawyer. According to the National Wetlands Inventory, the Lake is approximately 19.25 acres and is classified as a lacustrine, limnetic, unconsolidated bottom, permanently flooded wetland (US Fish & Wildlife 2017). King County classifies Ravensdale Lake as a Class 2 wetland (King County 2020).

The South Pond is located within the Preliminary Site and is supplied by direct precipitation and groundwater from the LDA (SubTerra 2006). Water in the South Pond is present intermittently, depending on seasonality. Field observations indicate the South Pond is dry approximately 8 months of the year. The South Pond does not receive stormwater from the site. Surface water has never been observed to flow beyond the immediate area of the South Pond. Surface water sampling of the South Pond has been conducted regularly since February 2005 for field parameters, general chemistry, and dissolved metals. When present, the pH of surface water in the South Pond has been measured between 9.2 to 13.1 standard units (SU) and is typically between 10 and 12 SU. The preliminary results of a wetland delineation completed in January 2017 indicate that the South Pond is a hydrogeomorphic wetland that is a primarily groundwater driven system (Shannon & Wilson 2017).

Reserve Silica installed ditches and culverts to prevent stormwater run-on to the LDA. These ditches and culverts are intended to prevent commingling by routing stormwater originating upslope of the LDA to other discharge locations at the facility. These drainage features may be modified during reclamation, but similar features will be constructed to prevent run-on to the LDA. Significant portions of the drainage area immediately above the LDA have been reclaimed, but some areas, including access roads, may be subject to additional fill and grading as part of final reclamation.

A series of three interconnected infiltration ponds is located to the northwest of the LDA, near the northwest corner of the Preliminary Site and is referred to as the Infiltration Ponds. A catch basin was originally installed in the area of the Infiltration Ponds to collect and infiltrate mine portal water. It is believed that the current configuration of the Infiltration Ponds was constructed in 1987 in response to King County Health Department's request that L-Bar Products install a leachate collection system to collect all runoff from the abandoned sandstone mines (Ecology and Environment 1986). The Infiltration Ponds were originally installed to collect Preliminary Site area stormwater and uncontrolled seepage water from the LDA for infiltration. As efforts were made to collect the high pH water within the LDA and collect the high pH seepage water emanating west of the LDA, discharges to the Infiltration Ponds were through a conveyance pipe network (Golder 2013b). Currently, leachate from the LDA is captured in the seep collection ditch and piped to the seepage treatment facility. Following treatment, the water is piped to the Infiltration Ponds. Surface water sampling of the Infiltration Ponds has been conducted regularly since February 2015 for field parameters, general chemistry, and dissolved metals. Before the seepage treatment system's installation in 2018, surface water pH in the Infiltration Ponds ranged from 9 to greater than 12.5 SU.

Since the full-time running of the treatment system started in 2019, the surface water pH has continued to attenuate and since November 2019 been regularly below 9.0. The water in the Infiltration Ponds is currently monitored under the Ecology SGGP (WAG503029; Ecology 2016). The treatment system discharged to the Infiltration Ponds without permit during the Agreed Order, as allowed under RCW 70A.305.090, until 2024 when Ecology required monitoring of the Infiltration Ponds under the existing SGGP. As requested by Ecology's Water Quality Program, Reserve Silica submitted an application for a State Waste Discharge Permit in December 2024 for the discharge of treated water to the Infiltration Ponds. State Waste Discharge Permit No. ST0501373 was issued as a temporary permit on February 14, 2025. Ecology anticipates finalizing the State Waste Discharge Permit in the summer of 2025. The current flow of surface water at the Preliminary Site during the wet season is shown in Figure 2-9.

2.5.3 Environmental Justice

Effective January 1, 2024, WAC 173-340-380(5)(c) requires that cleanup action plans summarize the likely impacts of selected cleanup actions on vulnerable populations and overburdened communities (VP/OCs). Ecology Publication No. 24-09-044 (Ecology 2024a) defines criteria for whether a potentially exposed population includes a likely VP/OC. These criteria were evaluated by comparing factors on the Washington State Department of Health's Environmental Health Disparities (EHD) Map and the U.S. Environmental Protection Agency's (EPA's) Environmental Justice Screening and Mapping tool (EJScreen) with the criteria in Ecology Publication No. 24-09-044:

- VP/OCs are indicated by EHD ranks of 9 or 10. The potentially exposed population near the Preliminary Site has an EHD Index rank of 2.
- VP/OCs are indicated when the census tract is at or above the 80th percentile for the Demographic Index or Supplemental Demographic Index from EPA's EJScreen map. The potentially exposed population near the Preliminary Site is ranked below the 21st percentile in EJScreen's Demographic Index and 17th percentile in Supplemental Demographic Index.

Cleanup actions for this Preliminary Site will not impact VP/OCs.

3.0 PREVIOUS PRELIMINARY SITE INVESTIGATIONS AND INTERIM ACTIONS

Numerous environmental investigations, monitoring activities, evaluations of remedial alternatives, and interim remedial actions have occurred at the Preliminary Site starting in the early 1970s and continuing to the present. This section provides an overview of the most relevant monitoring and environmental investigations completed at the Preliminary Site to evaluate and address environmental impacts associated with permitted disposal activities that historically occurred at the Preliminary Site. Figures 3-1 and 3-2 provide the locations of the piezometers, monitoring wells, boreholes, and test pits from studies conducted prior to the RI and installed during the RI. Figures 3-1 and 3-2 depict the locations for cross-sections A-A' (Figure 3-3), B-B' (Figure 3-4), and E-E' (Figure 6-1) at the Preliminary Site. Figure 3-2 shows boreholes, piezometers, test pits, and locations for cross-sections C-C' (Figure 3-8), D-D' (Figure 3-9), and F-F' (Figure 6-6) installed by Golder/WSP to investigate the LDA. Figure 3-6 shows the location of cross-sections X-X', which is depicted in Figure 3-7. Figures 3-6 and 3-7 show the borehole investigation results completed by Aspect Consulting to investigate the Lower Haul Road.

3.1 Previous Environmental Investigations

Numerous investigations have been conducted at the Preliminary Site since 1972 to evaluate and characterize environmental conditions and potential impacts associated with mining and permitted disposal activities that historically occurred at the Preliminary Site. Many of these historical site investigation and evaluation reports are available for downloading and viewing through Ecology's online electronic documents repository for the Preliminary Site (Ecology 2022a).

Relevant data and evaluations from historical reports have been incorporated into this RI report and used to develop the preliminary CSM. Below is an annotated summary of the key reports that were evaluated and presented in the RI Work Plan (Golder 2021a) and used in support of this RI report:

- Metropolitan Engineers, 1972, Final Report Geologic and Hydrologic Conditions. This report summarizes the coal mining activities, early sand mining activities, and geologic and hydrogeologic interpretations of the Preliminary Site, and includes the earliest summary of environmental conditions at the Preliminary Site.
- Ideal Basic Industries, 1984, Individual Exemption to Petition for Cement Kiln Dust Designation. This report discusses the regulatory considerations related to CKD disposal in 1984 and presents data to support continued disposal of CKD at the LDA and DSP. The report includes detailed descriptions of the CKD composition and the various uses for CKD that were occurring at that time. The report describes the LDA and the DSP and the local geology, hydrology, and hydrogeology. Also included in the report are copies of regulatory correspondence, including copies of early reclamation plans and mining permits.
- Ecology and Environment, 1986, Site Inspection Report (SIR). This report discusses the results of a file review and site inspection conducted by Ecology and Environment (E&E) on behalf of the EPA at the Preliminary Site, which was then owned by L-Bar Products. The site inspection was conducted to collect additional information on the nature and extent of past waste disposal activities at the Preliminary Site. The purpose of the inspection was to determine whether CKD posed a potential threat of contamination to local groundwater. The report indicates the following:
    - At the time of the site inspection, L-Bar used a corrugated steel pipe (mine portal culvert) to drain water collected in the abandoned coal mine workings, which then drained to a surface water catch basin. The catch basin also collected surface water runoff from the northern portion of the L-Bar property, which included surface runoff from the northern portion of the LDA. Based on this catch basin's reported location (Ecology and Environment 1986), a portion of it may have been converted into what is today known as the Infiltration Pond.
    - Section 11 of the SIR indicates King County Health Department requested L-Bar Products install a leachate collection system to collect all runoff from the LDA.
    - Four monitoring wells were installed around the DSP. Groundwater from these wells and water from the mine portal culvert were analyzed regularly by L-Bar. Groundwater samples collected and analyzed for trace metals during June and September 1986 indicated only lead was detected above the detection limit of 0.1 milligrams per liter (mg/L) in seven of ten samples in June 1986 but was not detected above the detection limit in any sample in September 1986. The SIR indicated it was not possible to determine the source of the lead based on the data available.

  - Surface water samples collected by L-Bar from the abandoned sandstone mine [the LDA] were analyzed for pH, cadmium, chromium, copper, lead, and zinc. The SIR indicated pH was approximately 12 SU and lead concentrations varied from 1 to 2 mg/L. The elevated pH of the surface water was likely caused by CKD.
  - Two CKD samples were collected by E&E from the DSP during the site inspection and analyzed for inorganic metals (arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver) and leachable toxicity testing (Ep Toxicity). Detectable concentrations of arsenic, barium, cadmium, chromium, lead, and selenium were reported in the test, but the only metal that exceeded the Ep toxicity limit was lead.
  - The report concluded that the CKD in the LDA is in a geologically safe repository and will not impact regional groundwater supplies based on the generally impervious nature of the sandstone, the existence of groundwater 20-30 feet below the base of the pit, and the clay and soil cap over the CKD.
  - The 1986 Inspection Report also notes in Section 10.0 that ASARCO slag produced at a copper smelter was used to increase traction on slippery road surfaces in the haul roads of the mine area.
- Tacoma Environmental Sciences, Inc (TESI), 2000, Preliminary Investigation Report. This report is the first comprehensive study of potential environmental impacts associated with CKD disposed at the Preliminary Site. The TESI report contains many of the elements included in an RI report. The report includes a detailed background section, including a summary of landfilling and reclamation activities; a description of the Preliminary Site topographic, hydrologic, hydrogeologic and geologic conditions; a summary of compliance groundwater and surface water monitoring activities conducted at the Preliminary Site; and a description of investigation results completed to evaluate the nature and extent of fill material in the LDA and the DSP. The report concluded that high pH seepage from the LDA resulted from a poorly constructed cap, the failure to adequately divert surface water, and the presence of water in pits upgradient of the LDA. The report did not identify any impacts to groundwater or surface water associated with the DSP but did recommend that improvements to the cap and stormwater drainage around the DSP also be completed. As described in Section 2.0 of this RI Report, significant improvements to the caps and diversion of stormwater away from the LDA and DSP caps occurred in 2007 and 2011.
- SubTerra, 2006, Revised Geology and Ground Water Report. This report was prepared as part of an environmental checklist for the revised permit and periodic review of the Reserve Silica mining operations. The report included a detailed description of the Preliminary Site geology, hydrogeology, environmental impacts associated with the CKD disposal areas, and an assessment of current operations and potential future impacts associated with proposed expansion of mining operations. Geologic cross-sections running perpendicular to the DSP and LDA were produced in the SubTerra report. These cross-sections were updated with borehole information collected after the report, and the updated cross-sections (A-A’ and B-B’) are presented in this report (Figures 3-3 and 3-4). Analytical data collected between 2002 and 2006 from Preliminary Site groundwater monitoring wells and surface water locations were reviewed in the SubTerra report. Only arsenic in wells and surface water locations downgradient of the LDA and lead in the Weir and South Pond were noted to exceed MTCA Method A standards. The report indicated that near neutral pH measurements and low metal concentrations detected in monthly sampling of the mine portal water that drains the DSP suggest there is no measurable impact to groundwater associated with the CKD disposed in the DSP. The report indicated that slightly elevated

arsenic was noted in some groundwater monitoring wells installed around the DSP, but the elevated arsenic could be naturally elevated in the coal bearing bedrock or could be slight leakage from the DSP. The report discusses the groundwater occurrences and flow beneath the DSP and LDA, including:

- Bedrock groundwater present in the Renton Formation (Tr) – Due to high clay content in the sandstone, siltstone, and carbonaceous shale, groundwater flow is extremely restricted, and the units are described as bedrock-confining units. Bedrock groundwater flow through the coal beds transmits primarily through the underground working, such as the Dale No. 4 and Dale No. 7 mine works and gangways, where groundwater is readily conveyed through the mine workings to the old mine portal.
- Perched groundwater – In mine cuts, prior to backfilling, the low permeability of the Renton Formation bedrock holds surface water year-round. Additionally, surface water infiltration will perch and flow along the contact with underlying Vashon Lodgement Till (Qvt). The typical hydraulic conductivity of the till has been measured in the range of $1x10^{-5}$ to $1x10^{-6}$ centimeters per second (cm/sec). Shallow perched groundwater will follow the slope of the bedrock or till and can flow into the former sandstone mine cuts, like the LDA, or will discharge to the recessional outwash located northwest of the Preliminary Site. Perched water that flows into the former cut areas will be contained by the confining bedrock present on all sides of the cut (like water filling a bathtub). When the groundwater within the backfilled mine cuts reaches a level that is above a low point along the rim of bedrock sidewalls, it will flow out of the former excavation and will flow along the slope of the bedrock and/or till to a downgradient discharge point. For the LDA, the discharge point is observed as seeps that are present along the side hill west of the LDA.

- Golder, 2013a, Lower Disposal Area Hydrogeological Investigations. During 2010 to 2012, a comprehensive program of test pit excavations, borehole drilling, piezometer measurements, dye tracer tests, and geophysical investigations was performed. The investigations and conclusions of this study are directly relevant to the RI and were used to help develop the current CSM. The results of this program strongly suggested that shallow groundwater is entering the LDA from the southeastern end and flowing north and west within the LDA, producing the observed high pH seeps. Other relevant findings from the comprehensive investigation of the LDA include the following:
  - Geologic units encountered in the explorations included fill and siltstone/sandstone bedrock. Three types of fill materials were encountered in the probes and borings: low permeable soil cover, mine spoils, and CKD.
    - **Low Permeability Soil Cover:** The uppermost unit encountered in the borings and probes within the LDA cover boundary. The low permeability soil cover consisted of a compact to dense mix of silty fine to medium sand and cohesive, low plasticity silt with roots and other organic material, and scattered pockets of fine-grained coal fragments. The low permeability soil cover was encountered in the upper two feet for borings installed within the LDA footprint.
    - **Mine Spoils:** Mine spoils are the coal overburden or other undesirable materials removed during mining activities. Mine spoils were encountered underlying the low permeability soil cover within the LDA and at the ground surface outside of the LDA. The mine spoils varied across the Preliminary Site but generally consisted of a loose to very dense mixture of sand, silt, gravel, and coal fragments with scattered cobbles and boulder fragments. Mine spoils were encountered in all

the probes and borings; several of these probes and borings were terminated within the mine spoils due to difficult drilling conditions, so the actual thickness is greater than reported.

  - **Cement Kiln Dust:** Underlying the mine spoils within the LDA cover boundary, a heterogeneous mixture of CKD and scattered pockets of mine spoils and coal fragments were encountered. The CKD was generally very dense and difficult to probe or drill. The moisture content of the CKD varied from dry to wet, although it was noted that the CKD could appear dry even below the groundwater level, making it difficult to distinguish the water table during drilling. The thickness of the CKD unit was not determined.

  - **Siltstone/Sandstone Bedrock:** Underlying the mine spoils and CKD, siltstone and sandstone of the Puget Group were encountered extending to the depths explored. The composition of the bedrock varied across the Preliminary Site.

- Piezometer readings after installation were performed by Golder. Based on the results of the groundwater level monitoring, it appears the phreatic surface generally decreases in elevation from east to west. Water levels measured in the piezometers installed within the assumed North Pit boundary were higher in elevation than those in the piezometers located within the LDA boundary, near the south end of the LDA, and west of the LDA.

- Electromagnetic induction (EM) imaging results show near surface conductivity anomalies. High EM conductivity values correlate with the high pH waters observed in the areas where impacted surface water has been previously observed. Additionally, high EM conductivity was mapped near the south end and the center of the LDA (Figure 3-5). Areas of high EM conductivity may be the result of wet CKD material and/or impacted groundwater. The high conductivity anomaly near the south end of the LDA is generally weaker or absent with increasing depth, while the high conductivity observed near the center of the LDA appears to be most prominent at the 50-foot sensing depth. The source of this high EM conductivity is interpreted to be wet CKD material and/or impacted groundwater.

- Environmentally benign, fluorescent tracers commonly used to track groundwater movement were introduced into three locations at the Preliminary Site. Yellow/green tracer dye introduced at the south end of the LDA, was observed about one week later in both seep collection test trenches and subsequently in the drainage ditch along the western boundary of the LDA. The yellow/green dyes introduced at the south end of the LDA were detected at progressively more northern locations over time. Red dyes released along the southeastern boundary of the LDA and in a piezometer in the North Pit were never observed in either of the seep collection test trenches, at any surface water sampling locations, or in the groundwater monitoring wells. This suggests that groundwater does not flow across or around the pillar wall between the North Pit and the LDA.

- The following observations support that groundwater is entering the LDA from the southern end and flowing to the north, producing the observed high pH seeps:

  - Groundwater elevations within the LDA boundary trend from south to north with a slight westerly component.

  - Tracer dyes introduced at the south end of the LDA were detected at progressively more northern locations over time.

  - Geophysical investigations indicate a high conductivity plume at the south end of the LDA and extending to the observed seep discharge area along the northwest boundary.
  - Groundwater flow is impeded by the pillar wall between the North Pit and the LDA.

- Aspect, 2017, Remedial Investigation Report. On behalf of Reserve Silica, Aspect completed a remedial investigation of the plant site and the Lower Haul Road. The results of the remedial investigation of the Reserve Silica Plant site are not discussed in this report. Investigations were conducted along the portion of the Lower Haul Road that is west of the LDA to evaluate the potential environmental impact of ASARCO smelting slag in roadbed fill (Aspect 2017). The work included advancement of eight borings to total depths of 18 to 20 feet bgs, except the northernmost boring encountered suspected bedrock at 10.5 feet bgs. Select soil samples from each boring were submitted for laboratory analysis of total arsenic and total lead and leachable arsenic and lead using the Synthetic Precipitation Leaching Procedure (SPLP). The SPLP method simulates and then analyzes a laboratory-prepared leachate using the soil samples. SPLP is designed to evaluate material sitting in-place that is exposed to rainfall[5] to simulate the leaching potential of a contaminant and assess chemical mobility in the environment. The results of Aspect's Lower Haul Road investigation determined the following:

  - The investigation indicated that road base soils were highly variable, consisting primarily of silty sand/sandy silt with gravel, coal, organic material, woody debris and brick fragments, and orange-yellow sand from sand mining operations mixed with coal and woody debris. Figures 3-6 and 3-7 show the location of the Lower Haul Road boreholes and a cross-section depicting roadbed materials encountered in each borehole. Slag was observed in the upper 2 feet of the gravel fill beneath the roadbed in borings AB-08 through AB-12 and as a minor constituent of the base course at the surface of the Lower Haul Road, as observed in loose gravel along the road shoulder. Slag was also observed to be mixed with sand/silty sand and coal fragments in soil to depths of 5.5 to 6.5 feet bgs in borings AB-11 and AB-12. Thin, interbedded layers of CKD were observed in the upper 2 feet at borings AB-07 and AB-12 and at a depth of approximately 11 feet bgs at boring AB-11. AB-05 to AB-12 borehole logs are included in Appendix D of this report.
  - As shown in Table 3-1, concentrations of total arsenic and lead are present in surface and shallow subsurface fill soil along the Lower Haul Road. The concentrations of arsenic and lead in soil do not appear to correlate to specific types of fill or with the observed presence of slag in the sample. Fifteen soil samples were submitted for analysis using the SPLP; arsenic and lead were not detected above the laboratory reporting limits in any of the simulated leachate samples (Aspect 2017).

- Aspect, 2019b, Summary of RI Data Gaps Investigation. Ecology provided comments on Aspect's 2017 RI Report, including a comment that the leachability of arsenic and lead associated with the slag used for the roadbed construction should be tested using liquid that simulates groundwater at high pH, which is more representative of pH conditions near the Lower Haul Road because of the high pH groundwater from the LDA. To address this data gap, four test pit explorations (ATP-1 through ATP-4; Figure 3-6, Appendix D) were excavated along the Lower Haul Road in the general area of the soil borings completed

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[5] The SPLP extraction fluid was prepared in accordance with SW-846 Test Method 1312 to evaluate leachability of soil from a site that is west of the Mississippi River is pH 5.00 +/- 0.05.

during the RI field activities. Soils observed in the Lower Haul Road test pits primarily consisted of gravelly, silty sand with slag fragments, and orange-yellow sand with coal and slag fragments.

Bulk soil samples were obtained from each test pit where the highest percentage of slag fragments was observed. Bulk soil was processed to segregate and estimate the relative percentages of slag and soil. One bulk sample, consisting of soil mixed with slag fragments, and one sample of segregated slag from each test pit were submitted to Friedman and Bruya, Inc., in Seattle, Washington, for laboratory analysis of leachate obtained under basic conditions (pH = 12) to simulate conditions at the Preliminary Site. The resulting leachate was analyzed for arsenic, lead, iron, and manganese. The chemical results are summarized in Table 3-2.

Processing of samples obtained from the Lower Haul Road showed a range of slag content (in percent by weight) between 5 percent (ATP-3) and 53 percent (ATP-1), as summarized in Table 3-2. Analysis of leachate from bulk soil samples showed one detection of arsenic (5.07 mg/L in ATP-1) and two detections of iron (up to 9.44 mg/L in ATP-3). Analysis of the leachate from slag-only samples showed one detection of arsenic (1.7 mg/L in ATP-3), and one detection of iron (18.8 mg/L in ATP-3). Lead and manganese were not detected in any of the leachate samples analyzed, at the detection limit of 1 mg/L. Although the highest concentration of arsenic in leachate was reported in the bulk soil sample with the greatest amount of slag by weight, three of the four slag-only samples did not contain leachable arsenic under high pH conditions at a detection limit of 1 mg/L. The Aspect report concluded that the testing suggests that the slag is not the primary source of arsenic in leachate (Aspect 2019b). The slag was detected in the boreholes and test pits within the Lower Haul Road at depths that are shallower than the underlying saturated zone.

- Golder 2018b, Interceptor Trench Investigation Summary and Recommendations. As detailed in Section 3.2.1 of this RI report, a clean groundwater interceptor trench was installed in 2013 along the south end of the LDA. The trench is approximately 220 feet long, with about 50 feet extending up the east side of the LDA from the southern end. Monitoring of the interceptor trench flow rates indicates that less than 3 gallons per minute (gpm) of groundwater is captured by the interceptor trench. Extending the trench further along the southeast side of the LDA could potentially increase the amount of groundwater captured and diverted from the LDA. In 2016 and 2017, additional investigative boreholes were drilled to determine if extending the interceptor trench along the southeast side of the LDA could effectively divert additional shallow groundwater before it enters the LDA (Golder 2018b).
  - In 2016 the first phase of drilling began with boreholes B-12 through B-17 in the access road along the southeast side of the LDA. CKD was encountered in several of these boreholes. Boreholes B-19, B-19A, and B-20 were drilled to delineate the eastern lateral extent of the CKD. A total of 9 boreholes (B-12, B-13, B-14, B-15, B-16, B-17, B-19, B-19A, B-20) were drilled to depths of between 10 and 30 feet bgs. Figure 3-1 shows the location of the boreholes, and Figure 3-8 depicts cross-section (C-C’) showing the material encountered in the boreholes. Borehole logs are included in Appendix D.
  - Fill overlying CKD was encountered in all boreholes except B-17, where no CKD was present, and B-16, where zones of CKD were interspersed with fill. The fill was encountered from the ground surface to depths of between 2 and 23 feet bgs, increasing in thickness to the north. Underlying the fill, CKD was encountered to the depths explored, except in B-17, where highly weathered

siltstone/sandstone bedrock was encountered at 25 bgs, and in B-16, where fill material was encountered beneath the CKD from a depth of 25 feet to the bottom of the borehole at 30 feet.

- Boreholes B-19, B-19A, and B-20 were drilled as close as practicable to the toe of the slope east of this part of the LDA, which forms the hill where the BPA transmission line towers are located. B-19A and B-20 were drilled at angles of 30 degrees and 10 degrees, respectively, to extend under the slope to determine if the CKD was present below the hill. In each of these borings, CKD was encountered below fill to the total depths of the boreholes.
- Groundwater was encountered in all the 2016 boreholes except B-13 and B-17. The depth to groundwater ranged from 8 to 18 feet bgs, but water levels measured in the open boreholes do not necessarily represent the static water levels. Boreholes B-15, B-16, and B-19 were backfilled with sand and the upper 5 feet was plugged with bentonite chips, so that they can be easily re-drilled for piezometer installation in the future if necessary.
- A second phase of drilling occurred in 2017. As shown in Figure 3-2, a line of boreholes was drilled further east of the LDA and uphill along the existing access road. The boreholes were drilled to delineate the extent of the CKD encountered in boreholes drilled in 2016, and to evaluate if an interceptor trench could be installed along this location to further divert shallow perched groundwater away from the LDA. A total of 7 boreholes (B-21, B-22, B-23, B-24, B-25, B-26, and B-27) were drilled to depths of between 20 and 25 feet bgs. Fill material was encountered from the ground surface to depths of between 7.5 and 17 feet bgs during the drilling. The fill consisted predominantly of silty sand mine spoils, with clayey material and coal fragments. No CKD was encountered in any of the seven boreholes. Figure 3-9 provides a cross-section depicting the lithology encountered during the 2017 borehole investigation.
- Groundwater was encountered primarily in boreholes B-21 through B-24 (the more southern boreholes). Wet soil cuttings in borehole B-22 were observed at around 11 feet bgs, but perched groundwater was not present at the top of the bedrock surface as was observed in B-21, B-23, and B-24. Observations during drilling indicated that perched groundwater is not present in significant volumes north of borehole B-24 and extending the interceptor trench beyond this location would not be useful.
- The depth to groundwater encountered during drilling ranged from 10 to 24 feet bgs. Piezometers were installed at boreholes B-21, B-24, and B-27 to provide information on groundwater elevations. Boreholes B-12 and B-15 drilled in October 2016, were also converted to piezometers in December 2017.
- Groundwater elevations obtained from December 2017 to April 2018 indicate groundwater levels range from approximately 4 to 18 feet bgs in the areas of investigation, and locally the gradient is towards the west indicating potential flow towards the LDA. Data from these boreholes will be used during the RI/FS to evaluate if placement of an interceptor trench can feasibly divert this shallow water away from the LDA.

- Golder, 2019, 2019 Geophysics Survey. The geophysical survey conducted in 2010 confirmed that EM surveys were effective in mapping the areas of high electrical conductivity that correlated with the high pH groundwater. An EM survey was completed in 2019 that overlapped with the portion of the 2010 survey west of the LDA and expanded the survey to include the areas around the South Pond, and the areas around the Infiltration Ponds. Figure 3-5 shows the areas surveyed in 2010 and 2019 combined into one figure. Consistent with the 2010 survey, the areas where high pH water is entering the seepage collection ditch appear as a zone of high conductivity. Downgradient of the South Pond, the higher conductivity measurements extend approximately 50 feet west of the pond before attenuating to background levels. In the area around the Infiltration Ponds, higher conductivity values are only present along cross/down-gradient portions (north and west) of the Infiltration Ponds. This is consistent with groundwater monitoring data collected from the existing wells surrounding the Infiltration Ponds. The high conductivity groundwater does not extend more than 50 feet downgradient of the Infiltration Ponds. The survey was conducted in the early spring, following the seasonal wet season when flow to the Infiltration Ponds is the highest. As such, this measured extent of high conductivity likely represents the typical seasonal maximum extent. This rapid attenuation is expected because the geology in the western portion of the Preliminary Site is comprised of recessional glacial deposits. The unconsolidated sands and gravels that comprise the recessional deposits have significantly higher hydraulic conductivity than the bedrock or fill materials present in other portions of the Preliminary Site. The higher groundwater flows in the recessional deposits result in rapid attenuation of the high pH water through the natural buffering provided by alkalinity of the groundwater and through simple dilution.

- Golder, 2020, 2020 Geophysics Survey. In support of developing the RI Work Plan, several preliminary RI tasks, approved by Ecology, were completed. The first of these tasks was the completion of an EM geophysical survey across the LDA to determine if the relative distribution of apparent conductivity seen in 2010 had changed. The EM geophysical survey was completed in October 2020, and results of the survey were presented as a technical memorandum to Ecology (Golder 2020). Results of the 2020 survey (provided in Figures 3-10 and 3-11) were consistent with the 2010 EM survey in its recording of the relative distribution of conductivity across the LDA. Results from the 2020 geophysical survey were also used to select the location for installation of a groundwater monitoring well within the central area of the LDA in a location where some of the highest EM readings were recorded. Results of the 2020 EM survey and the location of the new groundwater monitoring well (identified as P-14) are shown in Figures 3-10 and 3-11. Test lines of an EM geophysical survey were also completed at the DSP in October 2020, to determine if an EM geophysical survey is feasible in the DSP area. The 250 kiloVolt BPA power lines transect the DSP at a much lower overhead clearance than in the LDA geophysics area. It was uncertain if the overhead power lines would interfere with the EM geophysical instruments. The DSP EM geophysical survey was conducted using GEONICS® EM-31 and EM-34 instruments. The EM-34 is more powerful and measures electrical conductivity across a larger area than the EM-31, as such, the overhead power lines caused significant interference to the EM-34 instrument readings. The EM-31 instrument was less affected by the power lines, and electrical conductivity readings were able to be measured to a maximum depth of approximately 15 feet bgs. EM-31 data of the DSP is provided in Figure 3-11.

  Figure 3-11 illustrates both a greater relative area and intensity of EM readings in the LDA versus the DSP. The DSP primarily has only one area near the middle of the DSP with slightly higher EM readings in the 40 to 50 millisiemens per meter (mS/m). Whereas, the LDA southern half had higher EM readings in the 40 to 90 mS/m range. This does not indicate that there is more CKD in the LDA than in the DSP, but it does indicate that there is more water with elevated electrical conductivity in the LDA than in the DSP. As discussed elsewhere in the report, this is likely attributable to the low permeability sandstone that forms the bottom and sides of the LDA, which pools the water in the LDA like a bathtub and saturates the CKD and other wastes disposed in the LDA. Whereas the coal mine working beneath the DSP allow water that enters the DSP to infiltrate to the underlying coal mine workings and mine portal, resulting in significantly shorter contact time with the CKD and reduced potential to generate caustic water.

- Golder, 2021b, 2020 Remedial Investigation Activities. After Ecology approved the proposed location of P-14, borehole drilling and monitoring well installation were completed on November 20, 2020. Drilling and well installation were completed by Cascade Drilling, Inc., a Washington State-licensed driller, using roto-sonic drilling methods. Soils and fill material encountered during drilling were logged by a qualified Golder geologist in accordance with Unified Soil Classification System (USCS) standards and Golder technical guidelines. The P-14 borehole was advanced to a maximum depth of 70 feet bgs. The following general lithologies were encountered and are shown in the P-14 well log, which is included in Appendix D:
  - 0 to 2 feet bgs: Vegetated topsoil and low permeability clay cap.
  - 2 to 14 feet bgs: Clay waste mine soils; light gray clay, stiff, dry to moist.
  - 14 to 36 feet bgs: CKD material: light gray powder, dry to wet, (field testing indicated high pH approximately 13 when mixed with water).
  - 36 to 51 feet bgs: CKD mixed with mine waste soils and gravels; CKD with gravel, some pockets of sand, intermittent mottled red/brown color. Groundwater was observed within this interval at the time of drilling, at a depth of 40 feet bgs.
  - 51 to 61 feet bgs: Clayey Silt CKD mixed with mine waste soils and gravels: Clayey silt (possible saturated compacted CKD) and sand and gravel some mottling, glass fragments, and paper debris, high pH around 13 when mixed with water.
  - 61 to 70+ feet bgs: Weathered to competent sandstone bedrock; highly weathered, orange, thinly laminated sandstone, oxidized, dry to moist, neutral pH when mixed with water, an indicated confining unit upon which water in the LDA is perched.

  After bedrock was encountered, the P-14 borehole was backfilled with hydrated bentonite to a depth of 52 feet bgs, and 2 feet of 12/20 silica sand was placed above the bentonite seal. The P-14 monitoring well was constructed with 10 feet of 2-inch diameter, 0.010-inch slot size, schedule 40 polyvinyl chloride (PVC) screen placed from approximately 40 to 50 feet bgs, which is the depth interval where fully saturated CKD was predominantly encountered in the borehole.

  P-14 was developed on December 4, 2020, by purging water from the well to remove fine particles that were introduced into the well during drilling and well installation and to obtain groundwater samples that are representative of the surrounding groundwater. On December 11, 2020, groundwater samples were collected from both P-14 and P-11. P-11 is an existing monitoring well hydrologically downgradient of P-14. P-11 monitors the shallow groundwater migrating from the LDA, after the groundwater has migrated through the fill material beneath the Lower Haul Road where ASARCO slag and other fill material were observed during previous investigations (Aspect 2017, 2019b). The groundwater sample collected from P-14 was analyzed for the following contaminants of potential concern (COPCs): pH, antimony, arsenic, beryllium, chromium, lead, mercury, nickel, selenium, silver, thallium, vanadium, and 2,3,7,8-substituted dioxins & furans. The purpose of analyzing this expanded list of COPCs in P-14 was to evaluate the presence and concentrations of these compounds in groundwater within the LDA in an area where saturated CKD is present and some of the highest conductivity readings were measured during the geophysical survey. The groundwater sample collected from P-11 was analyzed for the same COPCs as P-14, except Ecology requested the P-11 sample also be analyzed for copper because copper is an additional metal that can leach from ASARCO slag. The P-11 sample was not analyzed for 2,3,7,8-substituted dioxins & furans, as these compounds were only analyzed in P-14 to determine if the CKD is contributing these compounds to groundwater at the Preliminary Site. Analyzing groundwater samples from wells P-14 and P-11 for a similar list of COPCs allowed for a preliminary evaluation of groundwater quality within and downgradient of the LDA.

Results of the P-14 and P-11 groundwater sampling were presented to Ecology in a technical memorandum (Golder 2021c). Table 3-3 presents a summary of the field parameters and laboratory metals analytical results for the groundwater samples collected from P-14 and P-11. Table 3-4 presents the dioxins and furans analytical results. The analytical results indicate the following:

- Antimony, arsenic, and lead were detected in both P-11 and P-14 at concentrations exceeding the PCULs.
- Vanadium was detected in P-11 at a concentration that exceeded the PCUL. Vanadium was also detected in P-14 but at a concentration that was below the PCUL.
- The estimated concentration of thallium in P-11 was slightly above the MTCA cleanup level, but the concentration was below the laboratory reporting limit, so the concentration is considered estimated.
- Beryllium, chromium, mercury, silver, and thallium were not detected in P-14.
- The concentrations of arsenic, chromium, lead, nickel, and vanadium in P-11 were significantly higher (more than 200% higher) than the concentrations in P-14.
- There were no dioxins or furans compounds detected above the laboratory reporting limits.

- 2006 to Present: Groundwater and Surface Water Monitoring: Quarterly surface water and groundwater monitoring has been conducted at the Preliminary Site since 2006 under the requirements of the closed landfill permits issued by the Interagency Group consisting of Ecology and Public Health. The monitoring is conducted in accordance with the procedures contained in the Bedrock Well Installation Work Plan and the SAP and QAPP submitted by Arcadis on behalf of Holcim (Arcadis 2006) and approved by the Interagency Group. Additional details on this continuous monitoring program are discussed in Section 4.3.

3.2 Previous Interim Remedial Actions

Since the early 2000s, Holcim has taken numerous interim remedial actions at the Preliminary Site to upgrade the landfill covers of the LDA and DSP to meet industry standards and to reduce infiltration of water into the LDA and DSP. Additionally, several interim remedial actions were completed to further reduce shallow groundwater flow into the LDA, and to capture, control, and treat high pH water detected in seeps west of the LDA. This section summarizes the completed actions.

3.2.1 Actions Taken to Reduce Infiltration into the LDA and DSP

In September and October 2007, the soil cover on the LDA was upgraded to reduce infiltration into the LDA and to substantially meet the landfill closure requirements of Chapter 173-304 WAC. Specific activities included: re-grading the cover to provide positive surface water runoff at all locations and provide a minimum of 2 feet of compacted low permeable material intended to achieve a permeability of $1x10^{-6}$ cm/sec across the known extent of the LDA at that time and constructing an unlined surface water diversion ditch around the upslope boundary of the cover to divert stormwater around the LDA (Golder 2008). Borehole investigations (Golder 2018b) conducted after the cover was installed, discovered an area extending from the southeast side of the LDA where CKD was disposed. This lobe of CKD along the southeast side of the LDA was not known to exist during the 2007 cover installation, and the low permeability cover does not extend over this area. Characterization of this area is discussed in Section 6 of this RI report, and evaluation of required remedial actions for the area will be carried out in the FS.

Cover upgrade activities at the DSP began in November 2010 and were completed in July 2011. Similar to activities completed for the LDA, cover upgrade activities at the DSP included: stripping surficial vegetation and topsoil, re-grading the existing surface to establish positive drainage, and providing a minimum 2-foot-thick layer of compacted material intended to achieve a permeability of $1x10^{-6}$ cm/sec at all locations, filling the existing ditch along the northeast side of the DSP, replacing topsoil, and revegetating the cover surface (Golder 2013a).

A groundwater interceptor trench was constructed at the south end of the LDA from August through October of 2013 (Golder 2014). The interceptor trench was installed along the south end of the LDA, because historical reports during mining operations indicated that water was encountered entering the mine from the wall at the south end of the mine from a gravel channel in the bedrock under the BPA power lines (TESI 2000). Additionally, Golder’s hydrogeologic study of the LDA (Golder 2013b), indicated that shallow groundwater was entering the LDA primarily from along the south and southeastern area of the LDA. The interceptor trench is approximately 220 feet long and up to 20 feet deep. Figure 3-2 shows the location of the interceptor trench. It is filled with gravel with a perforated drainage pipe in the bottom that discharges from the hillside to the south of the LDA. In accordance with the monitoring requirements established by Ecology and Public Health, groundwater discharges from the interceptor trench have been monitored monthly since installation for pH and total flow and quarterly sampled for total dissolved solids (TDS) analysis. Flow from this trench is clean (non-impacted) groundwater and generally ranges between about 0.5 to 2 gpm, with higher flows occurring during the wet seasons, and near neutral pH. Flow measurements recorded at the discharge pipe from the interceptor trench are provided in Table E.1.1 in Appendix E.

3.2.2 Remedial Action to Capture, Control, and Treat High pH Groundwater

Various actions were historically conducted at the Preliminary Site to capture, control, and treat the high pH groundwater seepage. In September 2008, two test trenches were installed to intercept and collect high pH seepage from the LDA (Golder 2008, 2009). One trench was on the bench immediately to the west of the LDA (Test Trench No. 2 in Figure 3-2), where several seeps (and resulting carbonate deposits) had been observed over the course of several years. The second trench was located at the toe of the cover slope near the southwest end of the LDA (Test Trench No. 1 in Figure 3-2). The trenches themselves were backfilled with gravel, and each included a perforated drainpipe and a standpipe system to measure flow rate. Collected seepage was discharged through a 4-inch tightline installed from the trenches to the Infiltration Ponds (Figure 3-1).

In February 2013, a collection ditch was excavated along the bench below the western seepage zone to intercept and collect seepage, and a drop inlet structure was installed to direct seepage into the tightline and convey it directly to the Infiltration Ponds, thereby reducing the volume that commingles with surface water (Golder 2013b).

In 2015, the 4-inch tightline downstream of the drop inlet was replaced with a 12-inch pipe to reduce the required frequency of cleaning resulting from carbonate precipitation in the pipe. Figures 2-9, 3-1, and 3-2 show the locations of the interceptor trench, seepage trenches, and seepage collection discharge pipe system.

In June 2016, Ecology issued a Notice of Violation (NOV) to Reserve Silica Corporation for high pH water leaching from the LDA and into the Infiltration Ponds at pH levels in excess of permit limits and above Water Quality Standards for groundwater set in Chapter 173-200 WAC. The NOV required a report indicating the measures that had been and were being taken to control release of the high pH water.

In 2016 and early 2017 as part of a response to an NOV issued to Reserve from Ecology, fencing was installed around the perimeter of the Infiltration Ponds, around the seeps and collection ditch along the northern portion of the area immediately to the west of the LDA, and around the South Pond. The fencing was installed to prevent accidental trespass and potential exposure of humans to high pH surface water and to restrict access to these areas by wildlife. Additionally, rip-rap rock was placed along the southwestern toe of the LDA to reduce potential exposure.

In continued response to the NOV, in 2018, a seepage treatment system was constructed. The high pH water collected from the LDA into the seepage collection ditch is directed to the system for treatment prior to discharge to the Infiltration Ponds. The treatment system uses carbon dioxide (CO_2) sparging as a primary treatment process to neutralize pH levels and uses an iron-based adsorption media to decrease dissolved arsenic and lead concentrations. Treated seepage water is discharged to the existing Infiltration Ponds. The seepage treatment system began operating in 2018 on a trial basis and various modifications were made, which allowed the system to begin full time operation starting in 2019. System modifications continue to be made to improve the effectiveness, reliability, and efficiency of the treatment system. Modifications have included installation of a larger CO_2 supply tank to reduce the frequency of refilling; installation of a sand filter to remove particulates prior to the iron media filters; and improved iron filter media vessels that allow easier backflushing and media replacement. Currently, water discharging from the treatment system to the Infiltration Ponds has a measured pH range from 7.5 to 8.0 SU and the pH of the water in the Infiltration Ponds has attenuated to a pH of around 8 to 8.9 SU. Elevated pH and dissolved metals previously observed in groundwater monitoring wells adjacent to the Infiltration Ponds have also attenuated. Recent and historical groundwater and surface water monitoring data are provided in Appendix E. As of November 2023, the treatment system has treated over 15 million gallons of water.

The treatment system has discharged without permit during the Agreed Order, as allowed under RCW 70A.305.090, until 2024 when Ecology required monitoring of the Infiltration Ponds under the existing SGGP. As requested by Ecology's Water Quality Program, Reserve Silica submitted a state waste discharge permit application in December 2024 for the leachate conveyance, treatment, and discharge system. State Waste Discharge Permit No. ST0501373 was issued as a temporary permit on February 14, 2025. Ecology anticipates finalizing the State Waste Discharge Permit in the summer of 2025.

The RI/FS is being conducted to evaluate additional remedial actions necessary to address the release of hazardous substances at the Preliminary Site.

4.0 RI FIELD INVESTIGATIONS

This section presents the environmental investigation, sampling, and analyses conducted during the RI field investigations to address data gaps defined in the RI Work Plan (Golder 2021a). The RI investigations included geophysical investigations, installation of additional groundwater monitoring wells, soil and sediment sampling, and groundwater and surface water sampling. Results of these field investigations are presented in Section 5.0.

4.1 Geophysical Investigation

The results of geophysical investigations conducted at the Preliminary Site in 2010, 2019, and 2020 showed a strong correlation between subsurface EM conductivity and the presence of high pH groundwater. This correlation is related to the relative abundance of the hydroxide ion (OH-) and other ions present in high pH water, which increases the electrical conductivity of the groundwater. Figure 3-5 shows the combined 2010 and 2019 geophysical surveys and depicts the areas of elevated subsurface EM conductivity. Section 3.1 summarizes the EM geophysical surveys completed in 2020 at the LDA and DSP, and Figures 3-10 and 3-11 show the results of these geophysical surveys. The geophysical survey completed in 2020 at the LDA and DSP confirms the results of the 2010 and 2019 geophysical surveys.

Geophysical surveys at the LDA and DSP were performed using a combination of two instruments: The GEONICS® EM-31 was used to survey shallower depths (approximately 0 to 15 feet), and the GEONICS® EM-34 was used to survey deeper depths (approximately 15 to 40 feet). As discussed in Section 3.1, the EM-34 is not effective in portions of the Preliminary Site where the BPA overhead power lines are close to the ground surface (e.g., in the DSP area).

The strong correlation between subsurface EM conductivity and the presence of high pH groundwater was used to estimate the extent of impacts to shallow groundwater around the LDA, and to select locations for installation of additional groundwater monitoring wells.

4.2 Subsurface Investigation and Groundwater Monitoring Well Installation

Groundwater monitoring wells were installed within the LDA where the geophysical testing indicated the highest electrical conductivity readings (i.e., highest pH groundwater areas) were present. Additionally, to provide empirical data on groundwater quality, wells were installed outside of the areas where impacts to groundwater were indicated by the geophysics. These additional wells, combined with the existing monitoring well network, were used to determine the nature and extent of impacts to groundwater at the Preliminary Site.

As a part of the RI field investigations, one soil boring (G-AB-1) and seven monitoring wells (P-15, P-16, P-17, MW-7A, MW-8A, MW-9A, and MW-10A) were installed in September 2021. The well drilling and installation investigation was summarized in a technical memorandum submitted to Ecology on June 28, 2022 (WSP 2022a). Boreholes and wells installed during this event included:

- Soil boring G-AB-1 was drilled in the center of the Lower Haul Road at a location between P-15 and P-11 to characterize the composition of the fill material in the Lower Haul Road and determine the depth to bedrock at that location. The boring was advanced to a depth of 40.0 feet bgs. The top of the bedrock was encountered at 35 feet bgs. Soil samples were at a depth of 3 feet and 23 feet bgs from this borehole. The sample from 3 feet was representative of the unsaturated soil near the surface where pieces of slag were noted. The 23-foot-deep sample was collected from the saturated soil below the perched water table. Both samples were analyzed for total metals, and for leachable metals using a modified EPA Method 1313 to allow leach tests performance at pH 5 and at pH 12 standard units.

- MW-7A and MW-8A were installed west and southwest of the Infiltration Ponds to evaluate groundwater gradients and groundwater quality.

- MW-9A and MW-10A are located west of the high pH seepage area and the South Pond, near the western property boundary to evaluate groundwater gradients and groundwater quality.
- P-15 was installed in the LDA and, like P-14, is also screened within CKD and other fill material disposed in the LDA. Groundwater samples collected from P-15 provide data on chemical composition of water just before the groundwater flows across the Lower Haul Road to daylight as seeps west of the LDA.
- P-16 was installed west (downgradient) of the high pH seepage area and east (upgradient) of the South Pond. Similar to borehole G-AB-1, soil samples were collected from P-16 borehole for total and leachable metals testing. One sample was collected at a depth of 3 feet and one sample was collected at the top of the confining glacial till unit encountered at a depth of 7 feet bgs.
- P-17 was installed per Ecology's request during their Preliminary Site visit in September 2021 and is located southwest of the LDA. This location was along a natural drainage pathway based on surface topography and the drainage map in Figure 2-9.

Figure 4-1 shows the location of borehole G-AB-1 and the new groundwater monitoring wells discussed above.

Borehole drilling and monitoring well installations were completed from September 22 to 24, 2021, by Cascade Drilling, Inc., a Washington State-licensed driller, using roto-sonic drilling methods. The roto-sonic drilling method collected continuous cores, which permitted detailed evaluation of the soils and materials encountered during drilling. Soils were logged by a WSP geologist in accordance with USCS standards and WSP technical guidelines. Soil samples were collected from borehole G-AB-1 and P-16 for analysis of total and leachable metals. Soil sampling analytical results are discussed in Section 5.2.2.

Borehole and monitoring well locations are shown in Figure 4-1. Monitoring well installation details are summarized in Table 4-1, and borehole and monitoring well construction logs are included in Appendix D.

Installed groundwater monitoring wells were incorporated into the existing Preliminary Site groundwater monitoring well network and sampling program defined in the Work Plan and as described in Section 4.3.

4.3 Groundwater and Surface Water Monitoring Program

Routine groundwater and surface water sampling has been conducted at the Preliminary Site since 2006. The purpose of the monitoring activities is to assess the groundwater and surface water conditions with respect to potential impact from the CKD placed in the LDA and the DSP, and to evaluate changes in groundwater quality associated with interim actions conducted at the Preliminary Site. Prior to the start of the RI, monitoring and reporting activities were conducted under the requirements of Post-Closure Care and Maintenance Permits issued by Public Health. The sampling frequency of groundwater and surface water sampling locations has been adjusted over the years since 2006 to match the data needs and concentrations of chemicals detected at the sampling locations. The current RI groundwater and surface water sampling frequency and requirements are detailed in the RI/FS Work Plan (Golder 2021a) and are discussed below.

The monitoring well naming convention of assigning either the prefix MW (for monitoring well) or P (for piezometer) differentiates wells that are historically associated with or will likely be associated with the closed landfill permit-required monitoring (prefix MW- or MWB- for bedrock wells), from groundwater wells that were installed for site investigation purposes (P- wells). MW and P groundwater wells are constructed similarly, and groundwater sampling of these wells follows the procedures approved in the Work Plan, thus, data collected from MW or P wells are equally representative.

Monitoring well and surface water samples were collected from LDA, DSP, and respective downgradient locations. The sampling locations and procedures are discussed in the sections below. Groundwater and surface water analytical results were provided to Ecology and Public Health in quarterly groundwater monitoring reports and are discussed in Section 5.0 of this report.

4.3.1 Groundwater and Surface Water Sampling Locations

The groundwater and surface water sampling program consists of 27 sampling locations. There are 17 LDA groundwater monitoring wells, 6 DSP groundwater monitoring wells, and 4 LDA surface water locations. These locations are shown in Figure 4-1 and are listed in Table 4-2.

LDA Sampling Locations: Prior to the RI field investigation, 10 LDA monitoring wells were sampled as a part of the groundwater monitoring program. These wells included a shallow monitoring well installed downgradient of the LDA in July 2005 (MW-3A), wells installed near the Infiltration Ponds (MW-1A, MW-2A, MW-5A, and MW-6A), and a background well (MW-4A). The Still Well is a 2-inch diameter well that connects to the horizontal collection trench (Collection Trench #1), installed by Golder in 2008 immediately upgradient of the seepage embankment area. The Still Well is sampled to evaluate groundwater quality immediately prior to the seepage area. Groundwater from the bedrock monitoring wells, MWB-1LDA, MWB-2LDA, and MWB-3 LDA located west of the LDA, are also part of the groundwater monitoring program. These bedrock wells are currently sampled annually, and field parameters are monitored semiannually.

As a part of the RI field investigations, seven new monitoring wells were installed in 2021 and were added to the groundwater monitoring program as discussed in Section 4.2. The overall list of LDA monitoring wells sampled as a part of this program is presented in Table 4-2.

DSP Sampling Locations: The DSP groundwater monitoring locations are shown in Figure 4-1 and are listed in Table 4-2. The DSP bedrock groundwater monitoring program includes four wells in the DSP area (MWB-1SDSP, MWB-1DDSP, MWB-5DSP, and MWB-6DSP), which evaluate groundwater quality beneath, upgradient, and downgradient of the DSP. Field parameters of groundwater discharging from the Portal are monitored semi-annually, and the Portal is sampled annually. The Portal was originally constructed to drain water from the Dale Strip Coal mine. In accordance with the RI/FS Work Plan, field parameters are monitored in the DSP bedrock monitoring wells semi-annually, and the wells are sampled annually. There are two additional monitoring wells (MWB-2DSP and MWB-4SDSP) near the DSP area that are monitored semi-annually for water levels and field parameters only.

Groundwater seeps from the DSP through the coal seams and underground mining works, then discharges to surface water through the Mine Portal. The Mine Portal discharge is a non-regulated flow. However, the Mine Portal functions as a compliance point for the DSP landfill.

LDA Surface Water Sampling Locations: Three LDA surface water sampling locations are sampled as a part of the surface water monitoring program. The surface water monitoring program allows the evaluation of the high pH seepage that occurs west of the LDA. Surface water samples are collected from the following locations:

- **South Pond:** The South Pond is a depression west of the high pH seepage area, which is dry most of the year, but contains water when the groundwater elevation rises higher than the bottom surface of the depression that forms the South Pond.
- **Weir:** The Weir is north of the access road to MW-3A immediately below the discharge point where high pH water historically collected prior to the installation of the seepage collection ditch and diversion of the

seepage water. If no flow is observed at the Weir, a sample is collected from the ponded water upstream of the Weir. Both the ponded water area and the Weir are seasonally dry. This sampling location was created before the high pH seepage collection ditch was installed, and water would flow overland to the ponded area, through a culvert under the road to MW-3A, and then through the Weir and to the Infiltration Ponds. Since the installation of the collection ditch in 2013, the high pH seepage water no longer flows along this overland flow path.

- **Infiltration Ponds:** The Infiltration Ponds are at the north end of the Preliminary Site near Ravensdale-Black Diamond Road and receive treated water from the on-site seepage treatment system. The surface sample is collected from the southwest area of the Infiltration Ponds.

LDA Interceptor Trench: As detailed in Section 3.2.1, the Interceptor Trench intercepts and diverts shallow groundwater before it enters the southern end of the LDA. Monitoring is performed at the Interceptor Trench outfall for flow, pH, turbidity, and TDS. The purpose of the monitoring is to ensure that the trench is not collecting impacted groundwater and to measure the volume of water diverted around the LDA.

4.3.2 Groundwater and Surface Water Sampling Procedure

The following sections summarize the procedures used during monitoring events.

4.3.2.1 Water Level and Field Parameter Measurements

Field parameters for groundwater and surface water were measured as part of the sampling activities described in the following sections. These measurements were performed with the following equipment:

- YSI ProDSS multimeter with pH, ORP (oxidation-reduction potential), conductivity, dissolved oxygen (DO), and temperature probes
- Hach 2100Q Turbidimeter

4.3.2.2 Laboratory Analysis

Laboratory analyses were performed on samples collected from the various locations described in the following sections. Although the analytic parameters varied between the types of samples, the following elements are common to all the sampling and analysis activities:

- The collected samples were transported to the laboratory within appropriate sample hold times following chain-of-custody protocols.
- The testing was performed by Analytical Resources, Inc. (ARI) of Tukwila, Washington.
- All samples were tested for the following parameters using the methods indicated:

Antimony	EPA Method 200.8
Arsenic	EPA Method 200.8
Lead	EPA Method 200.8
Potassium	EPA Method 6010D
Vanadium	EPA Method 200.8
TDS	SM 2540 C

- Interceptor Trench samples are tested for the following parameters using the method indicated:

pH	Field Measurement
TDS	SM 2540 C
Turbidity	Field Measurement

- Summaries of historical analytic data for the various sampling locations are presented in Appendix E.1 and E.2.

4.3.2.3 LDA and DSP Groundwater Sampling

- Depth to groundwater was measured in the wells prior to purging and sampling.
- Using a dedicated bladder pump or dedicated tubing connected to a peristaltic pump (if groundwater elevation allowed), water from LDA and DSP was purged at a rate between approximately 100 and 500 milliliters (mL) per minute.
- Field parameters of pH, conductivity, temperature, DO, ORP, and turbidity were measured and recorded during purging at approximately five-minute intervals until parameters were stable.
- Once the field parameters stabilized, the purging phase of the process was concluded. Groundwater samples were then collected directly from the dedicated sample tubing.
- For quality control purposes, one duplicate sample was collected from LDA and DSP each.
- Laboratory-provided containers were used to collect the samples. For each groundwater sample, one 500-mL bottle preserved with nitric acid and one 1-Liter (L) unpreserved bottle were collected. The samples were then labeled and placed in a cooler with ice.
- Grab water samples were collected from the Mine Portal (DSP sampling location) using dedicated sample tubing connected to a peristaltic pump. The water quality parameters were measured and recorded at the Portal at the time of sample collection.
- Impacted purge water generated during sample collection is treated through the seepage water treatment system.

4.3.2.4 LDA Surface Water Sampling

The following methods and procedures were used to collect surface water samples:

- Field parameters of pH, conductivity, temperature, DO, ORP, and turbidity were measured and recorded. These parameters were measured and recorded at each of the surface water locations at the time of sample collection.
- Grab surface water samples were collected using dedicated sample tubing connected to a peristaltic pump.
- For quality control purposes, a duplicate sample was collected from the Infiltration Ponds.

- Laboratory-provided containers were used to collect the surface water samples. For each surface water sample, one 500-mL bottle preserved with nitric acid and one unpreserved 1-L bottle were collected. The samples were labeled and placed in a cooler with ice.

All surface water and quality control samples were analyzed for the parameters listed in Section 4.1.

The following methods and procedures were used to collect the samples from the Interceptor Trench:

- Field pH, turbidity, and the flow rate at the Interceptor Trench outfall were measured and recorded.
- Grab water samples were collected from the Interceptor Trench by placing the sample bottles under the flow of water where it discharges from the pipe on the west side of the Lower Haul Road.
- Laboratory-provided containers were used to collect the sample for TDS lab analysis. One 1-L unpreserved bottle was collected. The sample was then labeled and placed in a cooler with ice.

4.4 Hydraulic Conductivity Testing

Slug testing was conducted in nine groundwater monitoring wells installed near or within the LDA to calculate an estimate of the bulk hydraulic conductivity of the soil within the saturated screened zone of the shallow groundwater-bearing unit and the hydraulic conductivity of the bedrock aquifer. Estimates of the hydraulic conductivity are needed to calculate the groundwater flow and volume entering the LDA, and to estimate the potential yield of wells downgradient of the LDA. These data are important to understanding the conceptual site model and for consideration of potential remedial actions in the FS. Slug testing was conducted in March 2023 on two wells screened in the CKD and fill material within the LDA (P-14 and P-15), shallow soils upgradient and downgradient of the LDA (B-15, B-21, B-27, and P-16) screened in variable material including mine spoils, silty sand, weathered till, and bedrock of the Eocene-age Puget Group east of the LDA (P-13) and west of the LDA (MWB-2LDA and MWB-3LDA). Table 4-3 summarizes the soil types within the wells screened interval, well construction information, and the depths to water measured prior to testing. Slug testing was performed with either a 6-foot-long by 1.5-inch diameter solid slug rod or a 3-foot-long by 1.5-inch diameter bailer. During each test, real-time water level data was monitored and recorded using a Seametrics PT2X pressure transducer and Seametrics Aqua4Plus version 2.2 software. Each well was tested according to the following process:

- Depth to water (DTW) below top of casing was measured. Height of the water column in the well was calculated as DTW subtracted from the total well depth.
- A pressure transducer was installed in the well and set to record at 1-second intervals.
- If the depth to water was above the well screen and the height of the water column in the well was sufficient to allow for introduction of the slug rod without disturbing the transducer at full rod submergence, the slug rod was used for both falling- and rising-head tests. This was the preferred method, and 8 of the 9 wells were tested in this manner.
- If the depth to water was within the well screen and the height of the water column was not sufficient to allow for introduction of the slug rod without disturbing the transducer, the disposable bailer was used for a rising-head test. Only one well, B-27, required this method of slug testing.
- For tests conducted with the slug rod, the slug was first introduced for a falling-head test. The slug rod was then left in the well until displaced heads recovered to approximately 90% of baseline or two hours

passed. The slug rod was then pulled from the well for a rising head test. The same criteria were met before conducting another falling head test or removing the transducer from the well.

- For the test conducted with the disposable bailer, the bailer was slowly lowered until its intake valve was sufficiently below the water level, and then the bailer was removed from the well as quickly as possible once the water level re-equilibrated.
- Depending on rates of recovery, one to four tests were conducted on each well.

To calculate hydraulic conductivities in the vicinity of each well, pressure transducer data were initially processed by correcting for barometric pressure. Hydrograph data recorded from slug testing were analyzed via the Hvorvslev method (Hvorslev 1951). To reduce the influence of the filter pack and of the introduction or removal of the slug rod or disposable bailer on the Hvorslev analysis, the timing of initial head displacement for each test was selected by visually inspecting smoothness of the test's water level recovery curve. Table 4-4 summarizes the testing and results of Hvorslev analysis for wells completed in the LDA, shallow soils, and bedrock. The analysis indicates the following:

- For wells in the LDA, the hydraulic conductivity ranged from 4.0×10^{-4} to 1.9×10^{-3} feet/min and averaged 1.1×10^{-3} feet/min.
- For wells in the shallow soils, the hydraulic conductivity ranged from 3.3×10^{-5} to 1.7×10^{-3} feet/min and averaged 9.7×10^{-4} feet/min including the result from the test in B-27. If the B-27 test is excluded, because its well screen was not fully saturated, the hydraulic conductivity ranged from 7.9×10^{-5} to 1.7×10^{-3} feet/min and averaged 1.1×10^{-3} feet/min.

Three wells screened in Puget Group bedrock, P-13, MWB-2LDA, and MWB-3LDA, were tested. The results of the slug test in P-13 indicated an average bedrock hydraulic conductivity of about 7.8×10^{-5} feet/min. The results of the testing in MWB-2LDA indicated a bedrock hydraulic conductivity of about 4.9×10^{-3} feet/min. The reason for the higher hydraulic conductivity in MWB-2LDA is uncertain but is likely attributable to MWB-2LDA being partially screened in a shale bedrock formation versus the other bedrock wells are screened in siltstone and sandstone. Observations of pumping rate and drawdown during purging for sample collection in MWB-2LDA indicate slightly higher pumping rates and less drawdown compared to other bedrock wells. The data from the testing in MWB-3LDA were not analyzed because of the very slow recovery response. Despite being allowed to recover for several hours, MWB-3LDA did not have sufficient recovery to analyze for hydraulic conductivity. The slow recovery in this well and the low hydraulic conductivity in P-13 relative to wells screened in CKD and fill or alluvial sediments indicates the Puget Group hydraulic conductivity is likely one to two orders of magnitude lower and acts as an aquitard, separating perched water in the CKD and fill and alluvial sediments from the regional, sedimentary bedrock aquifer. Hydrographs and Hvorslev analysis plots of each slug test are shown in Appendix F.

4.5 Soil and Sediment Sampling

Soil and sediment sampling was conducted in 2022 and 2023. Soil samples were collected to evaluate the nature and extent of impacts to soil in areas where high pH seepage from the LDA currently or historically contacted near surface soils. Delineating the extent of impacts to soil was completed using a phased and iterative process. Sediment sampling was conducted to characterize the nature of the accumulated precipitates that are present in the Infiltration Ponds.

4.5.1 Initial Decision Unit Sampling and Infiltration Pond Sediment Sampling

The initial round of soil sampling was conducted using the Incremental Sampling Methodology (ISM). ISM sampling was performed following the procedures detailed in the Interstate Technology and Regulatory Council (ITRC) guidance document “Incremental Sampling Methodology” (ITRC 2020). The ISM is a structured composite sampling and processing protocol that is designed to reduce data variability and increase the representativeness for a specified volume of a given media being investigated (ITRC 2020).

Sediment samples from the Infiltration Ponds were collected as grab samples. Soil and sediment sampling methodologies and techniques were detailed in the SAP (Appendix D of the RI/FS Work Plan [Golder 2021a]). The results from the initial soil and sediment sampling field investigation were presented in the technical memorandum submitted to Ecology in August 2022 (WSP 2022b). The field methodology and results from this event are also summarized below.

Soil Sampling in the Seepage Area: ISM soil sampling was conducted in three decision units (DUs) identified in the RI/FS Work Plan with the anticipated highest probability of surficial impacts to soil attributable to the discharge and overland flow of high pH groundwater from the LDA. The DU-1, DU-2, and DU-3 are shown in Figure 4-2, and include the following areas:

- DU-1 is the area along the bench west of the Lower Haul Road where the high pH seepage daylights prior to entering the seepage collection ditch. Sampling in this area focused on the areas with the highest calcite precipitates, which correlate with the past and/or current high pH groundwater seepage areas.
- DU-2 is the area west of the seepage collection trench, where high pH seepage water historically flowed overland prior to the construction of the seepage collection ditch.
- DU-3 is the South Pond area, where ephemeral upwelling of high pH groundwater occurs during the wet season of the year.

Triplicate ISM samples were collected within each DU, meaning three replicate ISM samples per DU. Samples were collected and shipped to ALS Environmental Laboratory in Kelso, Washington for processing and analysis under laboratory ISM procedures. Each ISM sample in DU-1 and DU-3 was an aggregate of 30 increments. Each ISM sample in DU-2 was an aggregate of 50 increments. ISM samples from DU-2 include more increments because the DU-2 area is larger than DU-1 and DU-3. The increments were collected along a systematic local grid within each DU. Under the systematic grid sampling design, the second replicate increment locations were collected approximately 3 feet west of the first replicate increment locations, and the third replicate increment locations were collected approximately 3 feet south of the first replicate increments. Different colored flagging was used to mark each increment location. Each sample increment was collected from the top 4 inches of soil/sediment/precipitates.

Sample increments were collected using a small hand shovel. Hand-held auger-type drilling equipment was required to collect many of the increments in the DU-1 Seepage Area because the material primarily consisted of very hard cementitious precipitates (primarily a calcium carbonate solid). At each increment location, approximately 50 grams of soil were collected and added to the respective sampling container for the DU sample. In conformance with ISM requirements, approximately equal volume/mass of material was collected from each increment at each increment location. Quality assurance checks were conducted by establishing a volume of soil equal to the desired mass in a graduated measuring container and consistently collecting increments equal to that established volume. Further checks of consistent sample mass were performed during sample collection using a field scale to measure the mass of the ISM samples and compare the triplicate samples' mass for consistency. The total mass of each ISM sample from DU-1 and DU-3 was approximately 1,500 grams and 1,750 grams, respectively. The total mass of each ISM sample from DU-2 was equal to approximately 2,500 grams (50 increments times 50 grams per increment). Collection of these higher soil volumes helps to control the fundamental error (FE) associated with the ISM soil sampling (ITRC 2020).

The following is a general description of the material sampled from each DU:

- DU-1 sampled material consisted of primarily cementitious calcium carbonates (calcite) deposited by the precipitation of the dissolved solids in the high pH seepage groundwater after it seeps to the surface and is exposed to air. The deposits were 1 to 6 inches thick in the DU-1 sample area. Underlying the deposits, weathered sandstone bedrock and/or silty fine sand soils were encountered. The sampled material was generally dry, except for the sample increments collected in areas where active groundwater seepage was observed.
- DU-2 area contained surface grass and forest debris (leaves, twigs, etc.) at the surface. This surface organic material was removed at each location prior to soil sample collection. The surficial soils generally consisted of:
  - 0 to 1-inch: dark brown, silty fine Sand, trace roots, and other natural organic matter (topsoil).
  - Below 1-inch: medium brown, silty fine to medium brown Sand, trace fine gravel, trace roots (subsoil). Within the stormwater flow erosion ditch (approximately 2 feet wide and 1 foot deep), a higher proportion of fine to coarse gravel was present.
  - In the northern end of DU2, where water ponds before discharging through the Weir, the soil was comprised of fill. The fill was medium to dark brown, silty fine to coarse Sand, trace fine to coarse gravel, trace pieces of orange-colored brick, and trace other debris.
- DU-3 South Pond soils consisted of clayey-silty fine Sand, with trace gravels present around the outer portions of the pond and more clayey high organic soil "muck" present in the center portion of the pond.

Each soil sample was analyzed for total arsenic, lead, antimony, vanadium, pH, and total organic carbon (TOC). TOC is analyzed as it can affect the bioavailability and uptake of contaminants. Soil pH was analyzed to assess the impacted area and the partitioning of naturally occurring metals.

Sediment Sampling in the Infiltration Pond: Ten surface sediment samples were collected of the accumulated precipitates within the Infiltration Ponds. The Infiltration Ponds consist of three interconnected infiltration ponds in the northwest corner of the Preliminary Site (Figures 4-1 and 4-3). The ponds were used to collect and infiltrate high pH seepage water from the LDA from about 1987 to 2018. Since 2018, treated effluent has been discharged to the ponds for infiltration. The "sediments" in the Infiltration Ponds are not naturally occurring sediments but are primarily calcium carbonate particulates that precipitated out of the infiltrating water since 1987. Figure 4-1 shows the location of the Infiltration Ponds and Figure 4-3 shows the sample locations within the ponds.

The Infiltration Ponds are an active component of the seepage treatment system, and characteristics of the sediments within the Infiltration Ponds are likely to change over time. The water from the treatment system discharges to the eastern-most pond segment via a 10-inch diameter pipe. Prior to installing the treatment system, this pipe discharged untreated high pH water collected in the seepage collection ditch. The southeast end of the pond segment is the area where high pH water historically (before the interceptor trench was constructed) flowed along a natural drainage channel into the Infiltration Ponds. Water from this eastern pond flows into the middle pond through an opening in the berm that separates the two ponds. The opening is only about 30 feet from the location where the pipe discharges into the eastern pond. Near that same location, water also flows over a low point in the berm that separates the middle pond from the western-most pond. These current and historical inflow areas were specifically identified for sample collection, along with collection of additional samples throughout the Infiltration Ponds. The RI evaluation included collecting 10 sediment grab samples distributed throughout accessible areas of the ponds. Infiltration Pond samples included the following:

- Infl-Pond-S1-0122 – Collected approximately 5 feet from the end of the discharge pipe, along the primary water flow path. Light brown, wet, Clayey Silt, fine Sand (primarily calcium carbonates precipitate type material).
- Infl-Pond-S2-0122 – Collected along the water flow path from sample S1, at a location just before water enters the middle pond from the east pond. Surface material is wet dark gray Silt, becoming lighter gray below 2 inches, Silty Clay, anoxic odor, precipitates.
- Infl-Pond-S3-0122 – Collected from the middle pond near where the water flows across the berm to the western pond and located down flow of sample S2. Dark gray, some organic leaves and debris, anoxic odor, Clayey Silt trace fine Sand, precipitates (boat required to reach this area).
- Infl-Pond-S4-0122 (and duplicate: Infl-Pond-F1-0122) - Collected within the natural drainage channel where high pH water historically entered the south portion of the eastern-most pond. During rain events, water still flows in this ditch, but the water is neutral pH and not impacted. Soil sample was damp, dark brown, fine Sandy Silt, and trace fine rounded gravel.
- Infl-Pond-S5-0122 – Collected in the same channel as sample S4, but closer to the current ponded water. Soil sample was moderate brown, Silty fine Sand, trace roots, damp to moist.
- Infl-Pond-S6-0122 – Collected where the historical drainage channel enters the eastern pond. Collected below the water. Dark gray, wet, fine Sandy Silt, mixture of soil and pond precipitates.
- Infl-Pond-S7-0122 – Collected from the middle pond, near the gate next to well MW-5A. Collected from below the water. Dark gray, wet, Clayey Silt, trace organic matter. Mostly precipitates. (Used boat to reach this area).
- Infl-Pond-S8-0122 – Collected from the center area of the middle pond. Collected from below the water. This area, based on push probing with a steel rod, appears to have the thickest accumulation of fine precipitates. Dark gray, wet, homogenous Clayey Silt. (Used boat to reach this area).
- Infl-Pond-S9-0122 – Collected from the south end of the western-most pond. Difficult area to access. Moderate brown, wet Silty Clay. Appears to be a more natural clay than the material observed in the middle pond.
- Infl-Pond-S10-0122 – Collected along the middle (NE to SE) and along the east side of the western-most pond. Difficult area to access. Moderate brown, wet, fine Sandy Silt.

Figure 4-3 shows the approximate locations of the Infiltration Ponds samples. All samples were collected from the top 10 centimeters (approximately 4 inches) of sediments/soils. The samples were collected using a stainless-steel hand driven environmental sampling device to extract a core sample that was placed directly into sample containers provided by the laboratory. The sampling device was decontaminated between each sample collected. The grab samples collected from the Infiltration Ponds were analyzed for total arsenic, lead, antimony, vanadium, and TOC.

4.5.2 Supplemental Soil Sampling

Analytical results obtained from the initial ISM decision unit sampling, which are summarized in Section 5 of this report, indicated that additional soil sampling was required to delineate the extent of COPCs in the soils. In addition, samples were collected to determine the site-specific background concentrations of COPCs in Preliminary Site soils. A Supplemental Soil Sampling Work Plan (WSP 2023) was submitted to Ecology and approved prior to conducting the additional soil sampling. The additional soil sampling was conducted in January and February 2023. Sample log sheets indicating sample ID, collection date/time, location, and description are included in Appendix D.3. The supplemental soil samples were analyzed by ARI laboratory, located in Tukwila, Washington.

4.5.2.1 Delineation Around the Decision Units

Discrete soil sampling points, located outside each decision unit boundary, were selected to delineate the extent of soil containing COPCs at concentrations exceeding the PCULs. The sampling points around each decision unit are shown in Figure 4-2 and were selected based on the following data objectives:

- DU-1 – The areas where high pH groundwater seeps to the surface (both current seeps and historical seeps) along the bench west of the LDA are clearly visible as a result of calcium carbonate precipitate accumulation. The boundary of DU-1 sample area was established along that visually impacted area. Security fencing surrounds the seepage area. Soil samples were collected north and south of DU-1. East and west of DU-1 are bounded by the Lower Haul Road and LDA to the east, and by the delineation that occurred around DU-2 and DU-3.

- DU-2 – The historical overland flow area is visually apparent based on the topography of the area and the historical observations of flow that occurred prior to completing the seepage collection ditch and treatment system. The boundary of DU-2 was established along this historical flow area. A line of sampling points along the western edge (see Figure 4-2), extending along the north and south ends of DU-2, were sampled to evaluate the concentrations of COPCs outside of the DU-2 boundary. The area east of DU-2 is delineated by the sampling completed for DU-1.

  - In addition to delineating the lateral extent of COPCs in DU-2, discrete deeper soil samples were also collected within DU-2 to delineate the vertical extent of COPCs exceeding PCULs. The ISM soil samples were collected within the top 4 inches of soil. The surficial soils were targeted as likely containing the highest concentrations of COPCs from the dissolution of metals from the high pH water and adsorption of metals into the surficial soils. Discrete soil samples were collected at a depth of approximately 8 to 12 inches bgs, at the sampling locations within DU-2 as shown in Figure 4-2.

- DU-3 – The limits of the South Pond are apparent based on the soil berm that surrounds the pond and the visual observations of seasonal standing water where the high pH groundwater daylights to the surface. The South Pond is fully fenced. Soil samples were collected around the outside perimeter of the South Pond fence as shown in Figure 4-2.

DU-1 and DU-3 both contain high pH groundwater at or near the surface that impacts the saturated soil media in these areas. Evaluation of subsurface risks in these areas is driven by the groundwater impacts; thus, deeper soil sampling was not collected in DU-1 or DU-3.

Following receipt of the delineation soil samples collected in January and February, further delineation soil samples were collected in April and June 2023 to fully delineate the extent of COPCs associated with the CKD impacts. Figure 4-2 shows the location of all soil samples collected. Results are discussed in Section 5.0.

4.5.2.2 Site-Specific Background Soil Sampling

The COPC metals detected in the DUs are naturally present in the Preliminary Site soils and can vary in concentration, depending on the composition of the soil. The concentrations of metals in surface soils can also be affected by anthropogenic activities that are not attributable to releases associated with the disposal of CKD at the Preliminary Site. An evaluation of the site-specific background concentrations of COPC metals in soils near the Preliminary Site was conducted. This evaluation was used to determine if local background soils contain one or more of the COPC metals at concentrations exceeding PCULs.

The area selected for collection of background soil samples is shown in Figure 4-2. This area has soils that are of similar composition to Preliminary Site soils but are in an area that cannot feasibly have been affected by releases from the Preliminary Site. The Preliminary Site topography and associated observations of surface flow paths of high pH water, known areas where impacted groundwater daylights, field pH screening of surface water throughout the Preliminary Site, and historical knowledge of surface flow path of high pH seepage confirm that the area selected for background soil sampling cannot have been affected by releases from the Preliminary Site. Additionally, the geophysics survey and the groundwater data from well MW-9A, confirm that groundwater impacts do not extend to the proposed background soil sampling area. The proposed background soil sampling area was presented to Ecology in the Supplemental Soil Sampling Work Plan (WSP 2023), which was approved by Ecology on January 23, 2023.

Consistent with the methods for defining site-specific background concentrations contained in WAC 173-340-709, a total of 20 discrete soil samples were collected from the background area for statistical determination of site-specific background. The samples were collected from the top 4 inches of soil, which is consistent with the sample depth interval used for DU-1, DU-2, and DU-3.

5.0 SAMPLING AND ANALYTICAL RESULTS

5.1 Quality Analysis

RI field investigations were conducted in multiple phases starting in 2021, and included soil, sediment, groundwater, and surface water sampling. Sampling procedures utilized for field data collection are detailed in the SAP (Appendix D of the RI/FS Work Plan [Golder 2021a]) and are summarized in Section 4.0 of this RI report.

Field samples collected for analysis were transported to the laboratory with a completed and signed chain-of-custody. Samples identifications were assigned to the samples according to the nomenclature system presented in the SAP. All sample analyses were performed by ARI laboratory, a Washington State-accredited laboratory in Tukwila, Washington, except for the ISM soil samples and the Infiltration Ponds sediment samples, which were analyzed by ALS Environmental, in Kelso, Washington. All samples were delivered to the laboratory the same day or within one or two days of sample collection to allow the laboratory to complete analyses within the holding times specified in the QAPP (Appendix E of the RI/FS Work Plan [Golder 2021a]).

Quality control (QC) samples such as field duplicate, field blanks, trip blanks, and matrix spike and matric spike duplicate were also collected by the field sampling team for soil, sediment, groundwater, and surface water samples at the frequency specified in the QAPP (Golder 2021a).

All analytical data packages received from the laboratory were subjected to a data validation review. Data validation was conducted in accordance with the USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review (EPA 2020), the SAP, and the QAPP (Golder 2021a). Data reporting qualifiers are included in the analytical results summary tables provided in Appendix E.1. The data validation review found that all the data were considered valid and usable, which exceeds the 90 percent completeness goal established in the QAPP.

5.2 Results

5.2.1 Geophysical Survey

Geophysical (electromagnetic) surveys were conducted at the Preliminary Site to evaluate the extent of high pH groundwater as indicated by the relative EM induction readings across the LDA and DSP. The results of the survey were presented in the technical memorandum submitted to Ecology on November 12, 2020 (Golder 2020).

Figures 3-10, 3-11, and 5-1 show the results from the geophysical survey for LDA. The results of the 2020 survey were consistent with the 2010 survey in its detection of the relative distribution of conductivity across the LDA. The survey maps areas of high subsurface conductivity starting southeast of the previously assumed extent of the LDA and extending through the center of the LDA. The high conductivity mapping continues under the Lower Haul Road to the bench where high pH groundwater seeps to the surface and is collected by the collection ditch. The high conductivity measurements attenuate west of the seepage area and are equal to site-specific background concentrations approximately 50 feet west of the South Pond. As discussed further below, groundwater data collected from monitoring wells confirms the delineation of high pH groundwater measured during the geophysical survey.

A geophysical survey was also conducted across the DSP as shown in Figure 3-11. Slightly higher EM readings, in the 40 to 50 mS/m above background, were observed in one area near the middle of the DSP. This central area of the DSP corresponds with the southern end of the northern two-thirds (i.e., the middle section) of the DSP pit that was reported to have been reserved for inert mineral materials from Ideal Basic Industries and Northwestern Glass (Ideal 1984). The DSP has relatively lower EM readings than the LDA. The lower EM readings are likely attributable to the lower overall influx of water into the DSP and the greater drainage of leachate through the more permeable coal seams and coal mine workings beneath the DSP. Water within the DSP has significantly shorter contact times with the CKD compared with the LDA, which reduces the potential to generate caustic water.

5.2.2 Boreholes and Monitoring Well Installation

Numerous boreholes and monitoring wells were installed at the Preliminary Site in association with the historical environmental studies and investigations, which are summarized in Section 3 of this RI report. As described in Section 4.2, seven additional monitoring wells were installed during the RI. The primary purpose of these wells was to provide additional groundwater quality data to further delineate the nature and extent of impacts to groundwater from the LDA. The boreholes drilled for these monitoring wells also provided additional understanding of the depth and contents of the LDA, Preliminary Site geology, groundwater gradients, and flow direction. Borehole logs and well construction diagrams are included in Appendix D. Figures 3-1 and 3-2 show the location of the groundwater monitoring wells. The following summarizes relevant information related to Preliminary

Site soil and geology obtained from each of the RI borings; groundwater data from these wells are discussed in subsequent sections.

- Soil boring G-AB-1 was drilled in the center of the Lower Haul Road where the geophysics investigation indicated high pH groundwater was migrating beneath the road. This location is also immediately upgradient of the high pH seeps that occur along the embankment west of the Lower Haul Road. The conceptual site model indicates that the low-permeability sandstone that surrounds and underlies the LDA creates a “bathtub” affect holding water within the LDA. The western sandstone bedrock sidewall of the LDA, which underlies the road, has a low area that allows groundwater to flow from the LDA under the Lower Haul Road to the west of the road. The groundwater from the LDA daylights as seeps along the embankment to the west of the Lower Haul Road. This is supported by borehole AB-5 (Aspect 2017) in the Lower Haul Road north of where bedrock was interpreted to be intercepted at 10.5 feet bgs (Figure 3-7), and boreholes P-4B and MWB-3LDA located south of where bedrock was intercepted 20 feet bgs. In boring G-AB-1, competent sandstone bedrock was not encountered until a depth of 35 feet bgs. The fill material overlying the sandstone consists of silty sand, coal fragments, and woody debris, with trace slag noted in the top 4 feet (Figure 3-3). At the time of drilling (September 2021) saturated fill material was encountered at a depth of 30 feet bgs. The borehole log (Appendix D) indicated soft, moist, mottled colored fill material starting at approximately 19 feet bgs, which indicates groundwater levels in the area of G-AB-1 are seasonally as high as 19 feet bgs.
- Monitoring wells MW-7A and MW-8A were installed west and southwest of the Infiltration Ponds to evaluate groundwater gradients and groundwater quality. The geologic conditions observed at MW-7A consisted of topsoil and subsoil to approximately 5 feet underlain by glacial recessional outwash consisting of silty sand and gravel. The geologic conditions observed at MW-8A consisted of sand and gravel fill material to 10 feet, underlain by recessional outwash. Groundwater is present within the recessional outwash.
- Monitoring wells MW-9A and MW-10A are located west of the high pH seepage area and the South Pond, near the western property boundary and provide data to evaluate groundwater gradients and groundwater quality. The geologic conditions observed at MW-9A consisted of forest topsoil in the top few feet, underlain by weathered glacial till to approximately 11 feet, and then a recessional outwash below 11 feet. At MW-10A, the glacial till appeared to extend much deeper than at MW-9A and was still present at the termination of the borehole depth at 35 feet bgs. The groundwater recharge into MW-9A was significantly greater than observed in MW-10A, which is consistent with MW-9A being partially screened in more permeable recessional gravels than MW-10A which is screened in less permeable glacial till.
- P-15 was installed within the LDA upgradient of where groundwater from the LDA migrates beneath the Lower Haul Road. Like other boreholes completed within the LDA (e.g., P-14), beneath the low permeability cover, mine spoil fill material was intercepted throughout the borehole, and trace pieces of debris (glass pieces) were occasionally noted. CKD was first encountered at approximately 10 feet bgs. During drilling, the pH of the fill/CKD was measured in the field. Below approximately 12 feet, the material had elevated pH around 12 to 13 SU. Water within the borehole was noted at a depth of 21 feet bgs. Weathered sandstone bedrock, underlying the LDA was encountered at 40 feet bgs. The pH of the sandstone at a depth of 40 feet was 7 SU, and the sandstone was dry at 42 feet bgs. A similar transition to dry, neutral pH soil was also noted in P-14, where the sandstone bedrock was encountered at a depth of 61.5 feet bgs. These data support that the sandstone surrounding and underlying the LDA is an

aquitard, preventing migration of the high pH water to the underlying bedrock aquifer, and containing the water within the LDA where the sandstone sidewalls are present.

- P-16 was installed west (downgradient) of the high pH seepage area and east (upgradient) of the South Pond. The geologic conditions observed at P-16 consisted of 5 feet of very soft, organic topsoil overlying glacial till, which was weathered and wet in the upper few feet and transitioned to dry at approximately 10 feet bgs. Groundwater was encountered relatively shallow, at a depth of 4 feet bgs. The groundwater appeared to be perched on top of hard glacial till, which was unsaturated below 7 feet. This is consistent with the CSM that the seasonal appearance of water in the South Pond surface depression is a result of shallow perched groundwater daylighting to the surface.
- P-17 was installed to evaluate groundwater quality southwest of the LDA, in a location along a former stormwater flow path. The geologic conditions observed at P-17 consist of fill material to a depth of 6 feet, underlain by weathered glacial till that was saturated below 7.5 feet, and became dry/unsaturated below 14 feet. Soil pH measured in the saturated zone was neutral, pH 7 SU.

5.2.3 Lower Haul Road and Soil Leaching Investigation Results

Borehole G-AB-1 was drilled in the center of the Lower Haul Road, where the geophysics investigation indicated high pH groundwater was migrating beneath the road. This location is also immediately upgradient of the high pH seeps that occur along the embankment west of the Lower Haul Road. The borehole was advanced to 40 feet bgs to determine the depth to bedrock in the Lower Haul Road. Data from G-AB-1 borehole was combined with the Lower Haul Road investigation conducted in association with the Reserve Silica Plant Site Remedial Investigation (Aspect 2017) to understand the nature of the groundwater flow beneath the Lower Haul Road. A summary of the Reserve Silica Plant Site Lower Haul Road investigation is provided in Section 3.1 of this report.

Historical reports indicate that fill material was used to raise the Lower Haul Road's elevation to contain CKD being added to the LDA (TESI 2000). The migration pathway of the high pH groundwater, identified during the geophysics survey, indicates that the sandstone confining unit that forms the western wall of the LDA, has a low area beneath the Lower Haul Road where the surface seepage occurs at the embankment west of the road. The continuous core collected during drilling of borehole G-AB-1 confirms this report. Fill materials consisting of silty sand, coal fragments, and woody debris were encountered in the borehole to a depth of 35 feet, where the competent sandstone bedrock is encountered. The reported ASARCO slag that was placed in the Lower Haul Road to improve traction (Ecology and Environment 1986), was detected in the top 4 feet of the borehole. The presence of slag in the top 4 feet and the observed presence of other fill material is consistent with boreholes drilled along the road during the Reserve Silica Plant Site RI (Aspect 2017). CKD was not observed in borehole G-AB-1.

Soil samples were collected from borehole G-AB-1 at depths of 3.0 feet bgs and 23.0 feet bgs. Testing of the soil sample collected at 3 feet evaluated total and leachable metals from an unsaturated portion of the Lower Haul Road where slag is present, and the sample collected at a depth of 23 feet evaluated total and leachable metals from soil at a depth where groundwater from the LDA is seasonally present. As discussed previously, the leaching test was conducted using a pH 5 leach extract, which simulates slightly acid conditions and using a pH 12 leach extract, to simulate conditions associated with high pH groundwater discharging from the LDA. The purpose of the two different leaching pH levels was to evaluate if the fill material used in the Lower Haul Road leaches COPC metals at standard pH levels compared to leaching that occurs at pH levels of groundwater emanating from the LDA.

Results of the total metals analysis and the leach testing are presented in Table 5-1. The concentrations of total arsenic, lead, and vanadium were higher in the sample collected at 3 feet, where slag was observed, than reported for the sample collected at 23 feet. The total metal concentrations in the G-AB-1 sample were all lower than site-specific background soil concentrations, except for total arsenic in the sample collected at 3 feet, which was higher than PCULs and was slightly higher than the arsenic site-specific background concentration. The TOC concentration in the sample at 3 feet was 17.2 percent, which is significantly higher than the 0.93 percent TOC reported in the sample collected at 23 feet. The high TOC value is important when evaluating the leach testing results because metals will bind to TOC and significantly reduce the leachability. At pH 5 leach extract, leaching of antimony, arsenic, and vanadium occurred in both the 3-foot and 23-foot-deep samples, and trace amount of lead also leached from the 23-foot-deep sample. The concentrations of these metals that leached were generally higher in the sample collected at 23 feet, except the concentration of antimony was slightly higher in the sample from 3 feet. The higher leaching of metals from the 23-foot-deep sample could be attributable to the much higher TOC present in the 3-foot-deep sample. The concentration of metals that leached from both the 3 feet and 23 feet-deep samples were higher using a pH 12 leach extract than the pH 5 extract. For the sample collected at 3 feet, the concentration of antimony and arsenic detected in both the pH 5 and pH 12 leach test exceeded groundwater PCULs, and lead exceeded the groundwater PCUL in only the pH 12 leach test. For the sample collected at 23 feet, the concentration of arsenic and lead detected in both the pH 5 and pH 12 leach test exceeded groundwater PCULs, and vanadium exceeded in only the pH 12.

Soil samples were also collected at 3.0 feet bgs and 7.0 feet bgs from borehole P-16 for total and leachable metals analyses. P-16 was drilled west of G-AB-1, between the seepage embankment and the South Pond (see Figure 3-2). P-16 is located to evaluate groundwater and soil along the groundwater flow path from the LDA, under the Lower Haul Road and the seepage collection ditch, and before the South Pond. Leaching tests were conducted on the soil samples collected from P-16 at pH extract levels of 5 and 12 standard units. Analytical results for P-16 are presented in Table 5-2. The total metals detected in P-16 were generally consistent with metals concentrations detected in G-AB-1, except arsenic and vanadium were notably higher in the 3-foot depth sample from G-AB-1. The total metals concentrations in the P-16 samples were all lower than site-specific background soil concentrations. The leaching results were also consistent, with overall higher concentrations in the pH 12 leaching extract than the pH 5. The relative amount of metals that leached from the G-AB-1 in ratio to the total metals was lower in the 3 feet-deep sample, compared to the ratio of leachate to total in the 3-foot sample from P-16. As discussed above, the relatively lower leaching of metals from the 3-foot-deep sample from G-AB-1 is most likely related to the much higher TOC compared to P-16 (17.2% versus 0.15%). For the sample collected at 3 feet, the concentration of antimony and arsenic detected in both the pH 5 and pH 12 leach test exceeded groundwater PCULs, and lead and vanadium exceeded the groundwater PCUL in only the pH 12 leach test. For the sample collected at 7 feet, the concentration of arsenic detected in both the pH 5 and pH 12 leach tests exceeded groundwater PCULs, and antimony and vanadium exceeded only in the pH 12 leach test.

5.2.4 Groundwater and Surface Water Monitoring

Routine groundwater and surface water monitoring has been conducted at the Preliminary Site since 2006. The current program includes 17 monitoring wells, the still well, and surface water samples from the South Pond, the weir, and the Infiltration Ponds to characterize the nature and extent of LDA impacts. Routine monitoring is also conducted of seven monitoring wells and the mine portal to evaluate the groundwater quality associated with the DSP.

The COCs identified for the groundwater and the surface water samples are:

- pH,
- Antimony,
- Arsenic,
- Lead, and
- Vanadium.

Although these metals are naturally present in groundwater and surface waters, they are identified as Preliminary Site COCs in consideration of excess dissolution of these metals and the contribution of hydroxide ion that elevates the pH of water in contact with the landfilled CKD. Additionally, all groundwater and surface water samples were also analyzed for potassium and TDS, as the relative concentration of these two parameters are elevated in waters impacted by dissolution of CKD at the Preliminary Site. Summary tables of analytical results from each sampling event for groundwater and surface water are presented in Appendix E.1.

LDA and DSP Groundwater and Surface Water Sampling

Groundwater sampling is conducted quarterly for shallow LDA wells and surface water locations, and annually for LDA and DSP bedrock wells. The sampling frequency for the different wells and sampling locations are presented in Table 4-2. Historical groundwater and surface water data are presented by sampling location in Appendix E.1. Concentration trend graphs of COCs for shallow LDA wells are provided in Appendix E.2.

Evaluation of the current and historical groundwater and surface water sampling results indicates the following:

- High pH (pH greater than 8.5) readings in groundwater and surface water samples are one of the strongest indicators of groundwater that is currently impacted by the dissolution of the CKD disposed at the Preliminary Site. These high pH readings correlate with the geophysics results indicating areas of impacts. Wells that monitor groundwater within the LDA and along the groundwater flow path downgradient of the LDA have the highest pH readings. This is depicted in Figure 5-1.
- Dissolved potassium concentrations are a very strong indicator of both current areas of groundwater impact and areas where groundwater historically was impacted from dissolution of the CKD but are not currently impacted. When CKD solubilizes in groundwater, two of its constituents dissolve: potassium, which exists in groundwater as the potassium ion (K^+), and hydroxide, which exists in groundwater as the hydroxide ion (OH^-). The abundance of hydroxide ions in the groundwater creates the high pH, resulting in caustic water. As the groundwater migrates, it is naturally neutralized by the buffering capacity of the soil and from dilution by clean infiltrating rainwater and non-impacted groundwater. As the groundwater reaches more neutral pH levels, many of the dissolved metals (arsenic, lead, vanadium) precipitate out of solution. However, while the groundwater pH is neutralized, the potassium ions stay in solution, behave conservatively, and do not participate in geochemical attenuation reactions such as mineral precipitation and adsorption. Instead, the potassium ions are only affected by physical processes such as dilution and dispersion. As such, water samples with elevated pH contain some of the highest potassium concentrations, typically more than 300,000 micrograms per liter (ug/L). Additionally, samples from groundwater monitoring wells that historically, prior to implementation of seepage collection and treatment system, contained elevated pH still have relatively higher potassium concentrations (greater than 200,000 ug/L), than samples from wells that were never along the groundwater flow path of the high pH

water. Table 5-3 lists groundwater analytical results sorted by total potassium concentrations detected, which illustrates this correlation between high pH and high dissolved potassium (e.g., P-14, P-15, P-16, Infiltration Ponds, South Pond, and Still Well). Elevated potassium concentrations are also reported in samples from wells MW-5A and MW-6A, which historically had high pH levels (see Appendix E), prior to the start of the treatment system. Potassium in well MW-8A is also slightly elevated, although concentrations are not as high as MW-5A and MW-6A, which indicates that potentially high pH water may have extended to MW-8A sometime in the past. MW-8A was installed after the pH seepage water collection ditch was installed and the treatment system was activated. Historical groundwater data prior to these remedial actions are not available from MW-8A, so there is some uncertainty if the potassium concentrations are attributable to historical impacts from the high pH groundwater or are naturally occurring at the current concentrations.

- The concentrations of potassium are higher in the mine portal than in the bedrock wells and the low-yield shallow wells that are west of the CKD impacts (i.e., MW-4A, MW-9A, MW-10A, and P-17). No CKD impacts have been observed in the bedrock wells (see next bullet) or these low-yield shallow wells. The mine portal discharges water from the underground coal mine workings, which capture leachate from the DSP. The relative elevated concentrations of potassium in the mine portal discharge support the conceptual site model that CKD leachate from the DSP discharges through the underlying coal seams and underground mining works. As shown in Table E.1.25, the caustic pH influences of CKD leachate are not observed in the mine portal discharge, and COC concentrations reported in over 20 years of sampling are below PCULs. This is presumably due to the relatively low volume of leachate from the DSP, pH buffering capacity of the low-sulfur coal, and dilution of CKD leachate within the underground mining works.

- Groundwater monitoring data from the bedrock wells in the DSP and the LDA contain near neutral pH and potassium concentrations are generally less than 6,000 ug/L, which is significantly lower than the 200,000 ug/L noted in the current or formally impacted shallow LDA wells. Additionally, the COCs detected in bedrock wells are generally much lower than the concentrations in the impacted shallow LDA wells, and except for arsenic in MWB-1SDSP and MWB-1LDA, are detected at concentrations below PCULs (Ecology 2024b). Considering that the high pH and elevated potassium indicators are not present in MWB-1SDSP and MWB-1LDA, the current slightly higher arsenic levels in these wells is not believed to be attributable to CKD-impacted groundwater. The elevated concentrations of arsenic detected in the lowest yielding bedrock wells appear to be relics of their poor development, likely related to residual suspected solids in the wells. As shown in Appendix E, the concentrations of arsenic have steadily declined in MWB-1LDA, MWB-3LDA, and MWB-1SDSP over approximately 20 years of sampling. The concentrations of arsenic are currently at or near 8.0 µg/L Puget Sound Basin background concentration.

- The variability of COC concentrations detected in the groundwater monitoring wells installed within the CKD contained in the LDA and in shallow wells downgradient of the LDA indicate that a large component of the metals concentrations in groundwater samples is attributable to the dissolution of metals from non-CKD material in contact with the high pH water. Table 5-4 presents analytical results from the March 2023 sampling of wells P-14 and P-15 which are screened within the CKD and other fill material within the LDA, and well P-16, which is installed downgradient of the LDA and just upgradient of the South Pond. Antimony and arsenic concentrations in P-14 are significantly higher than in well P-15. Conversely, the lead concentrations in well P-15 are significantly higher than in wells P-14 or P-16. The vanadium in P-16 is notably higher than concentrations in P-14 or P-15. These notable differences in concentrations indicate that dissolution of metals from CKD and from various non-CKD fill material within the LDA and within the Lower Haul Road downgradient of the LDA are being leached into solution from the high pH water. Additionally, the high pH water also leaches metals from the sorbed metals naturally present in soils. As discussed previously, these metals drop out of solution as the pH of the water attenuates.

- Surface water concentrations in samples from the Weir reduced significantly after 2014, in response to the installation of the seepage collection ditch and tightline that directed the high pH water directly to the Infiltration Ponds. Prior to installation of the seepage collection ditch, water flowed overland through the Weir to the Infiltration Ponds. Historical COC concentrations detected in samples from the Weir are provided in the Appendix E tables.
- Prior to installation of the seepage treatment system, impacted water infiltrating from the Infiltration Ponds resulted in elevated COC concentrations in wells MW-5A and MW-6A, located immediately west and southwest of the Infiltration Ponds. Well locations are shown in Figure 4-1. As illustrated in the concentration trends graphs presented in Appendix E, following start-up of the treatment system in September 2018, pH levels and concentrations of COCs reduced significantly in these wells. Antimony remains near or slightly above the PCULs in these wells but attenuates to below PCULs at well MW-7A, which is approximately 40 feet downgradient of MW-6A. Antimony, like arsenic, occurs as an oxyanion and is generally more mobile under alkaline conditions and less mobile under moderately acidic conditions. However, it behaves the opposite of arsenic in terms of its redox species. Whereas oxidized forms of arsenic (As(V)) are less mobile than reduced forms (As (III)), for antimony the opposite is the case, with the reduced species more effectively adsorbed under circumneutral conditions. As mentioned above, antimony quickly attenuates to concentrations less than PCULs less than 40 feet downgradient of well MW-6A.
- Groundwater samples from monitoring wells MW-4A, MW-7A, MW-8A, MW-9A, and MW-10A located downgradient from LDA provide empirical data that delineates the extent of impacts to shallow groundwater downgradient of the LDA.

5.2.5 Water Flow Balance Estimate

A mass balance between groundwater inflow and outflow in the LDA was estimated. Calculated hydraulic conductivities (see Section 4.4) were used with calculated hydraulic gradients at cross-sections C-C’ and D-D’ (shown in Figures 3-2, 3-8, and 3-9) and cross-sectional areas to estimate groundwater inflow using Darcy’s Law:

$Q=KiA$

where:

K is hydraulic conductivity (feet/minute)

i is the hydraulic gradient (feet/foot)

A is the cross-sectional area (square feet)

Lengths of the cross-sections were selected from the extent of saturated zones along each section. The thickness of the aquifer was selected from measured depth to water and measured depth to bedrock at the D-D’ cross-section, and inferred depth to bedrock at the C-C’ cross-section. The dimensions for each cross-section are summarized in Appendix F. Hydraulic gradients were calculated as three-point problems between wells located on opposite sides of each cross-section as measured on March 13, 2023, and these calculated gradients were visually checked on the shallow aquifer groundwater contour map from Figure 5-5 of the RI/FS Work Plan (Golder 2021a). Calculated hydraulic gradients range from 0.15 to 0.25 feet per foot (ft/ft) using wells B-12, B-15, and P-5, and from 0.20 to 0.30 ft/ft using wells B-27, B-15, and B-12.

Flow rates were calculated across both cross-sections using the geometric means of minimum and maximum hydraulic conductivities derived from slug tests in nearby wells analyzed via the Hvorslev method (Table 4-4). Table 5-5 summarizes the inputs to the flow rate calculations and the results of the calculations, and additional details are included in Appendix F. Calculated flow rates across the C-C'' cross-section range from about 1 to 8 gpm. Calculated flow rates across the D-D'' cross-section are less than 1 gpm. Flow rates measured at the outflow of the seepage collection ditch during March and April for the period of record (2021 – 2023) range from 5.5 to 13 gpm. An instantaneous and small change in water levels only affects a small area around the monitoring well being stressed. Using slug testing to determine hydraulic conductivity is limited in precision and representation of the entire aquifer but is a necessary and acceptable method when long-term pumping to stress the aquifer is not possible due to low hydraulic conductivity. The apparent difference of 5 to 13 gpm between conceptualized inflow and outflow to the LDA is within a reasonable margin of error for results of the Hvorslev method of slug testing analysis and subsequent cross-section flow calculations. In general, this evaluation supports the conceptual model indicating that the majority of the subsurface water enters the LDA along the southeast quarter of the LDA, which is also indicated by geophysics studies.

5.2.6 Soil and Sediment Sampling Results

Soil and sediment sampling completed during the RI is discussed in Section 4.5. Soil samples were collected in a phased and iterative approach to delineate impacts in the areas of current and former high pH seepage and overland flow areas. Figures 4-2 and 4-3 depict the soil sampling and Infiltration Ponds sediment sampling locations. This section presents the soil and sediment sampling analytical results.

5.2.6.1 Site-Specific Background Soil Sampling Results

Background soil samples were collected to statistically calculate representative concentrations of COPCs present in the background soils of the Preliminary Site. Table 5-6 presents the results of the site-specific background soils sampling. Arsenic, lead, and vanadium were all detected in the background samples at concentrations that exceeded at least one of the PCULs. Antimony was the only COPC detected in all background samples at concentrations less than the PCULs. The 90th percentile upper tolerance limit (UTL) background concentrations, calculated in accordance with the procedures described in the MTCA regulations (WAC 173-340-709), are provided in Table 5-6 and are summarized as follows:

- Antimony – range of detections in background samples 0.15 to 3.5 milligrams/kilograms (mg/Kg); Background UTL – 2.48 mg/Kg
- Arsenic - range of detections in background samples 4.8 to 32.8 mg/Kg; Background UTL – 24.3 mg/Kg
- Lead - range of detections in background samples 7.97 to 222 mg/Kg; Background UTL – 124 mg/Kg
- Vanadium - range of detections in background samples 26 to 76.6 mg/Kg; Background UTL – 67.5 mg/Kg
- The soil pH in the background samples ranged from 4.7 to 7.7 SU

In the following sections, concentrations are compared to the background UTL concentrations to distinguish CKD-impacted site-related concentrations from site-specific background concentrations.

5.2.6.2 Initial Soil Sampling and Sediment Sampling Results

The initial sampling focused on known current or historical areas where caustic water from the CKD daylights to the surface and/or flows or historically flowed overland. Results of the initial ISM sampling are provided in Table 5-7 and indicate the following:

- For DU-1 (seep area), arsenic was the only COPC exceeding at least one PCUL and the background concentration.
- For DU-2 (historical overland flow area) and DU-3 (South Pond), arsenic, antimony, and lead exceeded at least one of the PCULs and the background concentrations.
- Vanadium was not detected in any of the ISM samples at concentrations exceeding the background concentration.
- Soil pH in these known areas of current or historical contact with the caustic water from the CKD are elevated with levels ranging from 8.1 to 9.9 SU.

Table 5-8 summarizes the analytical results for samples taken from the Infiltration Ponds. The samples were collected from the precipitates that have accumulated in the Infiltration Ponds since the Ponds were first constructed in approximately 1987. Table 5-8 compares the Infiltration Ponds sample results to PCULs and the site-specific background concentrations. Arsenic is the only COPC that was detected in the Infiltration Ponds samples at concentrations exceeding the applicable sediment management standard PCUL and site-specific soil background concentrations. The pH measured in the Infiltration Pond samples ranged from 8.8 to 9.7 SU; except samples S4 and S5, where pH measured less than 8.0 SU. Samples S4 and S5 were collected from the soil within the historical drainage channel leading into the Infiltration Ponds, whereas the other Infiltration Pond samples were collected from the accumulated precipitates within the Ponds.

This initial sampling indicated that dissolution of the metals through precipitation or adsorption appears directly correlated with attenuation of the water pH towards neutral levels and the percentage of TOC present in the soil media. The seepage water at DU-1 seepage area is highest in pH and lowest in TOC, and except for arsenic the metals detected in the DU-1 were lower than reported in DU-2 and DU-3. This is consistent with the COCs reported at concentrations lower than PCULs in the soil sample collected at a depth of 3 feet from P-16. The soil pH is high, and the TOC is low in the area of P-16 as discussed in Section 5.2.3 and shown in Table 5-2. Lead, arsenic, and antimony precipitate from solution and adsorb to soil as the pH of the water neutralizes.

5.2.6.3 Delineation Soil Sampling Results

As discussed above, one or more COPCs were detected in DU-1, DU-2, and DU-3 at concentrations exceeding the PCULs including site-specific background concentrations. To delineate the extent of the soils impacted by COPCs derived from CKD leachate from the LDA, a total of 28 soil samples were collected along the boundaries of DU-1, DU-2, and DU-3 between the ground surface and a depth of 4 inches. Additionally, 10 samples were collected from deeper (8 to 12 inches bgs) soils in DU-2, to evaluate the vertical extent of COPC impacts in the historical overland high pH water flow area.

Table 5-9 provides the results of the delineation soil samples, and Figure 5-2 shows the delineation soil sampling locations and the extent of surface soil containing one or more COPCs at concentrations above the PCULs and the site-specific background concentrations. The analytical results indicate the following:

- Vanadium was not detected in any samples exceeding background concentrations.

- None of the samples collected around the perimeter of the South Pond (DU-2) contained COPCs exceeding background, and the soil pH was measured at levels below 8.0 SU. These results indicate that impacts to soil are confined to the seasonally inundated area of the South Pond.
- Sample DS-7, located immediately southwest of DU-2, had antimony, arsenic, and lead at concentrations exceeding background. A deeper sample, DS-7D, (collected 10 to 12 inches bgs) was also collected at this location. Antimony, arsenic, and lead concentrations detected in this deeper sample were significantly lower than in the shallow DS-7 sample. Only arsenic in sample DS-7D exceeded the background concentration.
- Samples DS-10, DS-11, and DS-24, located along the access road north of DU-2, contained antimony and arsenic above background concentration. The pH results from DS-10 and DS-11 were less than 7.0 SU and the pH result from DS-24 was 7.5 SU. These pH levels are lower than soil samples collected from areas that are known to have been in contact with caustic water from CKD leaching from the LDA and are located in areas where there is no current and no known historical flow of high pH groundwater occurring; as such, there is some uncertainty if the antimony and arsenic levels in these samples are attributable to impacts from CKD produced caustic water.
- Sample DS-14 is located along the embankment immediately west of the Lower Haul Road and north of the DU-1 seepage area. Samples DS-17, DS-18, DS-19, and DS-25 are also located along the embankment immediately west of the Lower Haul Road but are south of the DU-1 seepage area. Each of these samples contained arsenic that exceeded the background arsenic concentration. DS-18 also contained lead that exceeded the background lead concentration. The pH of the DS-18 soil sample was 9.1 SU, which is indicative of potential impacts from contact with caustic seepage from the LDA. The pH results for DS-17, DS-19, and DS-25 were 7.4, 7.0, and 6.3 SU, respectively, which are below pH levels observed in soils that are known to have been in contact with caustic water from the LDA.

The deeper soil samples collected in DU-2, were collected from the depth interval of 8 to 12 inches bgs. The purpose of these deeper samples was to evaluate the vertical extent of the COPCs that exceeded site-specific background concentrations reported in the ISM DU-2 samples. The shallower ISM DU-2 samples were collected from the top 4 inches of soil, and as discussed above, had antimony, arsenic, and lead that exceeded site-specific background concentrations (see Table 5-7). Analytical results of the deeper samples collected across DU-2 are provided in Table 5-10.

Concentrations of COPCs in the deeper DU-2 samples were generally lower than the shallower sample results and were less than site-specific background concentrations in 7 of the 10 samples. Sample DU-5D contained lead that exceeded site-specific background levels. Samples DU-9D and DU-10D, were collected from the northern part of DU-2, within the formerly constructed wetland area, and had arsenic concentrations higher than the site-specific background concentration. DU-10D also had antimony that was slightly above the site-specific background concentration. The soils in DU-2 are mostly mine spoil fill in the top 12 to 16 inches (see Appendix E, Table E3.3 sample log).

The delineation samples bounded the areas where soil exceeded site-specific background COPC concentrations. These approximate areas of soil exceedances are depicted in Figure 5-2. Soil pH appears to be a strong indicator of areas where soil impacts occurred that are attributable to contact with the caustic groundwater seepage and/or overland flow from the LDA. Some delineation soil samples contained one or more COPC at concentrations exceeding site-specific background concentrations but had pH levels that were notably lower than levels in areas of known impacts attributable to contact with caustic water that originated from the LDA. The deeper soil samples collected in DU-2 indicate that the elevated COPC concentrations attenuate quickly and were mostly below site-specific background concentrations at a depth of 8 to 12 inches bgs. The vertical extent of soil impacts in the three sample locations where the deeper soil samples still contained at least one COPC exceeding CULs and background levels was not further delineated as the shallow groundwater was encountered at a depth of approximately 14 inches.

6.0 CONCEPTUAL SITE MODEL

"Conceptual site model" (CSM) is defined in MTCA's enabling regulations (WAC 173-340-200). It provides a conceptual understanding of a site that identifies known or suspected: sources of and release mechanisms for hazardous substances, types and concentrations of hazardous substances, contaminated environmental media, and actual and potential exposure pathways and receptors. The preliminary CSM was presented in the RI/FS Work Plan (Golder 2021a). The extensive amount of available historical data, investigations, and interim actions completed at the Preliminary Site prior to the RI, allowed for the development of a comprehensive preliminary CSM. The RI/FS Work Plan identified data gaps that needed to be addressed to complete the RI, strengthen the CSM, and evaluate remedial actions in the FS. This section updates the CSM based on data collected during the RI. The CSM was used to develop the proposed cleanup standards as described in Section 7.2.

6.1 Contaminants of Concern

As discussed in the RI/FS Workplan (Golder 2021a), significant research and studies have addressed the characteristics of CKD, typical environmental impacts observed at CKD disposal sites, and contaminants that can potentially leach from CKD. Ecology recommended COPCs associated with CKD and ASARCO slag that were adopted in the RI/FS Work Plan. The COPCs evaluated at the Site are:

- Antimony, arsenic, barium, beryllium, cadmium, chromium (total), lead, mercury, nickel, selenium, silver, thallium, vanadium, and pH.
- Dioxin and furans associated with CKD.
- Arsenic, lead, copper, cadmium, chromium, and mercury associated with the roadbed slag.

The initial RI groundwater sampling included testing of groundwater within the LDA in direct contact with CKD (well P-14) and testing from a well immediately downgradient of the Lower Haul Road in the area where high pH groundwater seepage from LDA flows subsurface beneath the road. The results of this sampling were discussed above in Section 3 and are presented in Tables 3-3 and 3-4. The contaminants of concern (COC) for the Site were selected when the concentrations of the COPCs exceeded the PCULs. The COCs for the Site are:

- Antimony, arsenic, lead, vanadium, and pH.

Groundwater and surface water samples during the RI also included analysis for potassium and TDS. These water quality parameters, in addition to pH level, are strong indicators of impacts likely attributable to caustic water leaching from the CKD.

6.2 Closed Limited Purpose Landfills

CKD and other material were placed in two former mine pits at the Preliminary Site: the LDA a sand mining pit, and the DSP, a surface coal strip mining pit. Public Health is the jurisdictional health department that regulates the closed landfills under Chapter 173-304 WAC and issues an annual Post-Closure Care and Maintenance Permit to the property owner, Ravensdale 6, LLC, a wholly owned subsidiary of Reserve Industries Corporation. This section presents the CSM of the LDA and the DSP.

LDA Bedrock Groundwater: In 2006, three bedrock groundwater monitoring wells (MWB-1LDA, MWB-2LDA, and MWB-3LDA) were installed west of the LDA, screened within the sandstone formation that underlies the LDA. Groundwater sampling data have been collected from these LDA bedrock monitoring wells since 2006. Historical summary tables of analytic results for each Preliminary Site monitoring well are provided in Appendix E. Table 6-1 provides historical LDA bedrock groundwater elevations. Figure 6-2 provides a series of graphs of the historical LDA groundwater elevations.

Groundwater data from these wells have not detected any contaminants that would indicate impacts are currently occurring to the bedrock groundwater from the CKD placed in the LDA.

- LDA bedrock well MWB-1LDA contained elevated arsenic concentrations for several years after the well was installed in 2006. From 2006 to 2009, arsenic concentrations in samples from MWB-1LDA ranged from 160 µg/L to 27 µg/L, with the concentrations attenuating each year following well installation. Arsenic concentrations in MWB-1LDA have been less than 20 µg/L since 2012 and have generally been below the 10 µg/L MCL and above the 8.0 µg/L Puget Sound Basin background concentration since 2017.
- Similarly, arsenic concentrations in MWB-3LDA were slightly elevated (38 to 10 µg/L) from 2006 to 2014, attenuating over those years, and have been below 8.0 µg/L PCUL since 2016.

The pH levels and other parameters monitored in the LDA bedrock wells indicate impacts are not occurring from the CKD leachate from the LDA. The slightly elevated arsenic concentrations, likely results from the inability to fully develop the bedrock monitoring wells. The concentrations of arsenic have steadily declined in MWB-1LDA and MWB-3LDA through nearly 20 years of sampling. The flow of groundwater in the sandstone formation is extremely slow. Slug testing in MWB-3LDA was unable to get sufficient recovery to accurately calculate a hydraulic conductivity but based on the slow recovery and comparison to the shallow wells, the hydraulic conductivity is likely less than 1×10^{-6} feet/min, and the hydraulic conductivity of P-13 was about 8×10^{-5} ft/min. The results of the testing in MWB-2LDA indicated a higher bedrock hydraulic conductivity of about 4.9×10^{-3} feet/min that is interpreted to be because MWB-2LDA is partially screened within shale bedrock which can be more fractured and permeable than sandstone bedrock. Additionally, MWB-2LDA well screen also crosses the bedding planes between the sandstone unit and the shale unit, which can have higher hydraulic conductivity than wells screened within a single lithological unit. The attenuation of arsenic in MWB-1LDA and MW3-LDA is consistent with inadequate well development, residual suspended solids, and extremely slow groundwater recharge into the bedrock wells. Figure 6-3 provides a conceptual groundwater contour map of the bedrock groundwater flow at the LDA.

Further assessment of the potential for impacts to the bedrock aquifer beneath the LDA was provided during drilling of groundwater monitoring wells in the LDA. Sonic drilling in P-14 and P-15 extended through the CKD and other fill material in the LDA and a few feet into the underlying sandstone confining layer. The continuous cores from these boreholes showed that high pH water was perched on top of the bedrock, but within 2 feet beneath the bottom of the LDA the bedrock was dry and pH testing of the bedrock was neutral. This strongly supports that caustic water within the LDA does not penetrate through the underlying sandstone bedrock and impact the bedrock aquifer. Nearly 20 years of groundwater monitoring data from the LDA bedrock groundwater monitoring wells provide empirical data confirming that the bedrock aquifer is not impacted.

DSP Bedrock Groundwater: The DSP is topographically located at the top of the hill where there is minimal surrounding land upgradient of the DSP. The minimal area topographically upslope of the DSP, significantly reduces recharge of rainwater into the DSP. Additionally, unlike the LDA where the underlying sandstone bedrock serves as a confining layer creating a bathtub effect that traps water in the LDA, the DSP is underlain primarily by mined out coal seam bedrock. The high vertical permeability of the mined-out coal seam allows any groundwater and infiltrating rainwater that enters the DSP to pass through the fill material with minimal contact time with CKD. Although the coal of south King County is considered low sulfur containing coal, some pH buffering capacity is provided for any CKD leachate transmitted through the remaining coal deposits. As noted in Section 5.2.4, the concentrations of potassium are slightly elevated in the mine portal, which is consistent with the dilution and buffering of CKD leachate from DSP through the underlying coal seams and underground mining works. Data from the DSP groundwater monitoring wells and the mine portal water sampling confirm groundwater is not impacted from the CKD disposed in the DSP.

Groundwater monitoring data have been collected from monitoring wells installed beneath the DSP and along the strike of the bedrock unit that contains groundwater beneath the DSP. Data collected from these wells demonstrate that CKD disposed in the DSP is not impacting groundwater. Arsenic detected in bedrock groundwater collected from well MWB-1SDSP is approximately twice the concentration of the Puget Sound Basin background concentration (Ecology 2022), but the pH is near neutral and there are no other compounds detected in groundwater from this well that would indicate the slightly elevated arsenic is associated with leachate from the CKD. The higher arsenic concentrations reported in MWB-1SDSP may be attributable to contribution from coal bedrock lithology, which naturally contains slightly higher concentrations of metals including arsenic, and poor well development of the low yield bedrock monitoring well.

After correcting for vertical gradients observed in MWB-1SDSP and MWB-1DDSP, historical groundwater elevations indicate that groundwater flows from the north end and south end towards the middle of the DSP, near MWB-1SDSP. This is likely related to groundwater drainage that is occurring through the mine workings and discharging through the Dale tunnel to the mine portal. The actual movement of any groundwater within the DSP is likely affected by the different fill materials that were placed in the DSP as described in Sections 2.2.1.2 and 2.3.1.1. Over 20 years of sampling and analyses of water emanating from the mine portal that drains groundwater from the former coal mine workings beneath the DSP, have shown no detections that indicate impacts to groundwater from the DSP. Figure 6-1 provides a conceptual north-south cross-section of the DSP, and Figure 6-4 provides a series of graphs of the historical DSP groundwater elevations. Table 6-2 provides historical DSP bedrock groundwater elevations. Figure 6-5 provides a conceptual groundwater contour map of the bedrock groundwater flow at the DSP.

The DSP is functionally stable based on the criteria in WAC 173-304-407(7)(a) of the applicable landfill regulation:

> *The post-closure plan shall address facility maintenance and monitoring activities for at least a twenty-year period or until the site becomes stabilized (i.e., little to no settlement, gas production or leachate generation) and monitoring of groundwater, surface water, and gases can be safely discontinued.*

The DSP closed in 1989, more than 35 years ago. Putrescible wastes were not disposed in the DSP, so gas and settlement monitoring are not warranted. The DSP cover was upgraded in 2010 and 2011 to provide a low-permeability cover and to ensure that surface water drains from the landfill cover. There has been no confirmed release of contamination from the DSP based on more than 20 years of monitoring groundwater in the bedrock wells and the mine portal. The groundwater that discharges from the mine portal complies with the PCULs and the arsenic concentrations in the bedrock wells are consistent with background concentrations. The DSP appears to satisfy the ending post-closure care criteria in Ecology Publication No. 11-07-006 and its 2013 addendum (Ecology 2013).

6.3 Nature and Extent of Contamination

Data collected during the RI, combined with the extensive historical investigations and interim actions completed prior to the RI, were used to define the nature and extent of impacts at the Preliminary Site. The nature and extent of impacts to various Preliminary Site areas and media include the following:

Landfill Materials within the LDA: The CKD disposed in the LDA was reportedly covered with two feet of clay and seven feet of overburden from sand mining operations, and the surface was revegetated in 1983. The landfill cover was updated in 2007 to provide positive surface water drainage and provide 2 feet of low permeability soil, in substantial accordance with WAC 173-304-407 closure standards. CKD was encountered southeast of the previously delineated LDA boundary during the 2018 Interceptor Trench Borehole Investigation (Golder 2018b). The southeast extent of the LDA cover was delineated in the 2018 Interceptor Trench Borehole Investigation. The southeast portion of the LDA does not have a low-permeability soil cover above the CKD.

Shallow Groundwater: The hydrogeologic studies (Golder 2013b, 2018b) and the geophysical surveys (Golder 2019, 2020, and 2021b), were combined with data collected during the RI to refine the understanding of the nature and extent of impacts to shallow groundwater surrounding the LDA. The data indicate the following:

- Impacted groundwater is indicated by pH levels greater than 8.5, and the presence of one or more of the COCs (antimony, arsenic, lead, and vanadium) at concentrations exceeding PCULs. Of the COCs, antimony and arsenic are the most commonly detected metals at concentrations exceeding PCULs. Lead is less commonly detected at concentrations exceeding PCULs, likely due to its greater potential to come out of groundwater through adsorption as the pH of the groundwater starts to neutralize. Vanadium is only detected in groundwater samples collected from well P-16 at concentrations that exceed PCULs. Samples collected of groundwater within the LDA, from wells P-14 and P-15, have reported vanadium concentrations that are below 20 µg/L, which is below the PCUL of 140 µg/L. Concentrations of vanadium detected in P-16 typically exceed 200 µg/L. The concentration of vanadium detected in all other surface water and groundwater samples is about 200 times lower than detected in P-16. The data indicate that vanadium is solubilizing to groundwater from soil and fill material located under the Lower Haul Road prior to reaching P-16. Although not a COC due to its low toxicity, potassium is a strong indicator of current and in some cases historical areas where CKD impacted groundwater extended. Concentrations of potassium exceeding 200,000 ug/L generally indicate areas where groundwater impacted by the dissolution of CKD is currently present, or areas where CKD-impacted groundwater historically extended, and the concentrations of one or more COCs exceeded PCULs. Elevated dissolved potassium is an indicator of CKD dissolution because CKD solubilizes as potassium ion (K^+) and hydroxide ion (OH^-). As summarized in Table 5-3, there are sampling locations where the potassium concentrations are higher than the concentrations in wells that are located outside of any potential current or historical flow path of CKD-impacted water, but the potassium concentrations are significantly lower than 200,000 ug/L. These areas may have received some contribution of water that was impacted by CKD dissolution but based on the observed correlation between potassium and COC concentrations, the COC concentrations are and were likely below PCULs.
- Shallow groundwater currently enters the LDA along the southeast portion of the LDA. The horizontal extent of the area where perched groundwater enters the LDA was defined during the Infiltration Trench

Extension study (Golder 2018b). As described in Section 2.2.1.3, during sand mining operations, groundwater was reported to enter the sand mine at the south end through a gravel channel in the bedrock under the power lines. In 2013, the approximate 20-foot deep Interceptor Trench was constructed as a trial system to divert perched groundwater from the south end from entering the LDA. A gravel lens was encountered at the south end of the LDA during test pitting for the design of the Interceptor Trench (Golder 2014). The gravel lens was initially observed to produce water at approximately 20 gpm, which was reduced to approximately 2 gpm during construction. A collector drain was installed with the Interceptor Trench to capture this water. The Interceptor Trench does not extend along the southeast side of the LDA sufficiently to capture the shallow groundwater currently entering the LDA in that area.

- Perched groundwater entering the LDA fills the LDA like a “bathtub” as the clayey sandstone bedrock creates a confining unit beneath and along the side walls of the LDA. Along the Lower Haul Road on the west side of the LDA, the bedrock has an area where the confining wall is lower, extending as deep as 35 feet bgs in the location of borehole G-AB-1. The bedrock was encountered at depths of only 10 feet bgs in boreholes (B-4 and B-10) drilled south of G-AB-1. As the high pH water within the LDA rises and reaches the elevation of the top of the west bedrock wall it discharges beneath the Lower Haul Road and daylights as seeps along the embankment west of the Lower Haul Road. Figure 6-6 provides a conceptual northwest-southeast cross-section of the LDA and the existing Haul Road. During the wet season, the water levels within the LDA reach the seasonal highest levels, and the seepage rates are also the highest. The geophysical studies clearly map the flow path of the caustic groundwater through the LDA, beneath the Lower Haul Road, and towards the seepage area (see Figure 5-1). Figure 6-7 shows the groundwater contour map with flow directions for the shallow groundwater wells.

- Most of the high pH groundwater from the LDA discharges as seeps along the embankment on the northwest side of the LDA and the Lower Haul Road. Shallow seepage water is captured by the seepage collection ditch and directed through a buried 10-inch pipe to the on-site water treatment system for neutralization and removal of metals before discharge to the Infiltration Ponds.

- A portion of the high pH groundwater discharging from the LDA flows beneath the seepage area and associated seepage collection ditch and flows along the top of the low permeability glacial till towards the South Pond. The high pH groundwater that daylights seasonally in the South Pond has been a historical indicator of this impacted groundwater. Borehole P-16 was drilled immediately east of the South Pond, between the South Pond and the seepage area. The geologic log of P-16 (see Appendix D) indicates west of the seepage embankment groundwater is perched on glacial till that is encountered at a depth of approximately 5 feet bgs near the South Pond. Geophysical investigations indicate that the high pH groundwater attenuates to background levels within 50 feet downgradient (west) of the South Pond and within 50 feet downgradient of the seepage collection ditch in areas north of the South Pond. As depicted in Figure 3-6, the extent of impacted groundwater has been delineated using geophysical methods that have a confirmed correlation between electrical conductivity and the presence of elevated pH groundwater. Empirical data from groundwater monitoring wells MW-9A and MW-10A and from groundwater seepage areas confirm the geophysical delineation, and the attenuation of COCs to concentrations below PCULs prior to MW-9A and MW-10A.

- Prior to the construction in 2018 and full-time activation of the treatment system in 2019, the high pH seepage water was directed to the Infiltration Ponds. Shallow groundwater downgradient of the Ponds was impacted as indicated by the groundwater samples collected from wells MW-5A and MW-6A. Geophysical testing conducted downgradient of the Infiltration Ponds indicated that groundwater impacts extended less than 50 feet downgradient of MW-5A and MW-6A. Since activation of the treatment system, water entering the Infiltration Ponds is neutralized and has lower concentrations of COCs. The concentrations of the COCs have attenuated downgradient of the Infiltration Ponds, and concentrations of all COCs, except antimony, in MW-5A and MW-6A are now below PCULs. Antimony is more persistent and prone to stay in solution than the other COCs under the geochemical conditions downgradient of the Infiltration Ponds, but it also attenuates to below PCULs within approximately 50 feet downgradient of the Infiltration Ponds. The concentrations of the COCs in groundwater samples collected from downgradient monitoring wells MW-7A (within 50 feet of MW-6A) and MW-8A comply with the PCULs.

Surface Water: Surface water impacts are detected at the Preliminary Site in areas where groundwater from the LDA discharges to the surface through seeps or seasonal daylight in the South Pond during high groundwater periods, and in areas where those seeps are captured in seepage collection ditches and flow to the treatment system. Surface water pH measurements are readily made in the field with handheld pH meters. The extent of surface water impacts has been delineated. The areas where high pH surface water is present at the Preliminary Site include the following:

- The groundwater seepage area along the embankment west of the Lower Haul Road, where groundwater migrating from the LDA flows under the Lower Haul Road. Fencing surrounds the seepage area.
- The seepage collection ditch at the toe of the seepage embankment that captures the high pH water and directs the water to the treatment system. Fencing surrounds the seepage collection ditch.
- The South Pond contains water only during the rainy season, when groundwater, perched on the weathered till soil, rises to elevations higher than the bottom of the depression that creates the South Pond. Water does not discharge from the South Pond, except potentially during extreme rain events. High water has been observed to extend marginally to the east portion of the South Pond but has never been observed to flow beyond that immediate area. Fencing surrounds the South Pond.
- The Infiltration Ponds have received neutralized water since the full-time start of the treatment system in 2019, and pH has been reduced to levels that are typically near or below 8.5 since late 2019. Prior to activation of the treatment system, the high pH seepage from the LDA flowed to the Infiltration Ponds and the pond surface water pH levels could reach levels as high as 13. Fencing surrounds the Infiltration Ponds.
- During the wet season, when water rises within the LDA “bathtub” to seasonal highs, surface seepage occurs along a portion of the southwest side toe of the LDA. A toe drain and tightline convey that water to the treatment plant, but reduced infiltration to the toe drain results in the temporary presence of high pH water along that portion of the southwest side of the LDA. Large gravel was placed in these seepage areas to reduce the potential for any direct contact with the high pH water.

Soils: CKD was indicated beyond the LDA landfill in three localized areas beneath the Lower Haul Road immediately west of the LDA (Aspect 2017), although the presence of CKD beneath the Lower Haul Road was not confirmed in boreholes drilled during the RI. CKD is not present at ground surface, but calcium carbonate precipitates and COCs were deposited from impacted groundwater and surface water flowing from the LDA, as follows:

- Calcium carbonate precipitation occurs along the embankment west of the Lower Haul Road where the high pH seepage occurs and within the seepage collection ditch. The concentrations of COCs present in the precipitates and the underlying shallow soils were evaluated in the ISM soil sampling of DU-1. Arsenic was the only COC present in this area at concentrations exceeding the PCULs. The water pH typically exceeds 12 SU along the seepage area of DU-1, as such, the COCs tend to stay in solution until the water attenuates to more neutral pH levels where dissolution through adsorption to natural clay minerals can occur. Table 5-7 presents analytical results for the ISM samples.

- Prior to installation of the seepage collection ditch, high pH seepage water flowed above ground through a drainage area toward a weir northwest of the LDA. As the pH of the water was neutralized by the natural buffering capacity of the soils and mixing with rain/storm water, dissolution of carbonates and metals occurred in near surface soils. Concentrations of antimony, arsenic, and lead were detected in soil samples collected from the top 4 -inches of soil in this area at concentrations exceeding the lowest of the PCULs. Table 5-7 presents analytical results for the DU-2 (historical flow area) ISM samples. Deeper soil samples were collected to evaluate the depth of impacts to soil. Table 5-10 presents the results of the deeper soil samples collected in DU-2 area. Ten grab soil samples were collected from a depth of 8 to 12 inches below surface. The COCs in these deeper samples predominately attenuated to below background, except antimony was detected in one sample and arsenic was detected in two samples at the north end of the former overland flow area at concentrations exceeding the PCULs. The top 2 feet of soil in this former overland flow area were found to consist of predominately mine spoils and other non-CKD fill material. In several of the sample locations where the hand-dug boreholes extended deeper than 12 inches, saturated conditions were encountered at a depth of approximately 14 inches.

- Soil present in the footprint of the South Pond area contained arsenic and lead at concentrations exceeding PCULs. Antimony was also detected in one of the three ISM samples collected from the South Pond surface soil at a concentration exceeding PCULs. Deeper soil samples were not collected in the South Pond as groundwater is at or near the surface. Water pH in the South Pond is typically ranges from 9 to 11 SU, which is lower than the pH in DU-1 seepage area. This slight reduction in pH allows further COC dissolution to occur in the South Pond than what occurs in the DU-1 seepage area.

- Soil samples were collected from the top four inches of soil in areas that surround DU-1 (seep area), DU-2 (historical overland flow area), and DU-3 (South Pond) to delineate the extent of soil contamination. Analytical sample results are provided in Table 5-9. Figure 5-2 shows the delineated extent of soil containing antimony, arsenic, or lead at concentrations exceeding PCULs. Most of the delineation soil samples where one or more metals were detected at concentrations exceeding the PCUL had a measured pH level that was less than 7.5 SU. The soil pH measured in areas of current or former known contact with high pH water emanating from the LDA (e.g., DU-1, DU-2, DU-3) all exceed a pH of 8.0 SU and average a pH of 8.6 SU. Areas where the impact to soils is attributable to leaching from the CKD generally have high pH levels.

- A deeper soil sample (DS-7D), across the depth interval of 8 to 12 inches, was collected where the highest concentrations of antimony, arsenic, and lead were detected in the near surface (1 to 4 inches) delineation soil sample (DS-7). The concentrations of antimony and lead in this deeper sample were over

10 times lower than in the shallow sample. Only arsenic, at a concentration over 5 times lower than the shallow sample, was reported at a concentration still exceeding PCULs.

- The presence of ASARCO slag in the roadbed material of the Lower Haul Road was reported in Ecology and Environment's 1986 Inspection Report. The presence of slag was later confirmed during Aspect's investigations (Aspect 2017 and 2019b), and slag was detected in RI borehole G-AB-1. Aspect concluded that total arsenic and lead were present in the roadbed soil exceeding MTCA unrestricted cleanup standards (Aspect 2017). The slag was mostly detected within the top 3 feet of the Lower Haul Road, which is above the depth where high pH groundwater flows under the road; as such, it is unlikely that the slag is contributing to groundwater contamination. The high pH water from the LDA migrates beneath the Lower Haul Road at a depth typically deeper than 19 feet below top of the road and is saturated to the top of the sandstone bedrock present at approximately 35 feet below surface near G-AB-1. This area of the Lower Haul Road is comprised of fill (coal mine soils, woody material, and silty sand). The detected COCs in a sample from this fill material were at concentrations that were compliant with the PCULs.

Sediments: The Infiltration Ponds historically received high pH seepage water without treatment, and solids precipitated out of the water and accumulated in the Infiltration Ponds. Since the activation of the full-scale seepage treatment system in January 2019, the Infiltration Ponds have received treated water. Characterization of the precipitates that have accumulated in the Infiltration Ponds was provided through the collection of 10 grab samples throughout the Ponds (see Figure 4-3). Arsenic was the only COC detected at concentrations exceeding sediment PCULs (Table 5-8). The propriety of considering sediment PCULs, with regards to various potential exposure scenarios is discussed further below. Fencing surrounds the Infiltration Ponds.

6.4 Exposure Pathways and Potential Receptors

Based on the nature and extent of contamination described in Section 6.3, the potential exposure pathways and receptors include the following:

- Surface Water - Direct contact by human, terrestrial, and ecological receptors with high pH and metals containing leachate from the LDA is a complete exposure pathway. Ecological receptors can be exposed to surface water containing one or more COCs at concentrations exceeding PCULs at the identified and delineated areas within the Preliminary Site. High pH water is present as surface water along the seepage embankment and seepage collection ditch. Seasonally, high pH groundwater daylights within the South Pond depression and water is present in a small seepage area along the southwest toe of the LDA. Water within the Infiltration Ponds contains concentrations of antimony, arsenic, and/or lead at levels exceeding PCULs. All these areas are currently fenced to restrict access and potential direct contact to impacted surface waters, and crushed rock is used to reduce exposure of high pH water that seasonally seeps from the southwest toe of the LDA. The Reserve Silica site is an active reclamation site with an operating inert waste landfill and a closed limited purpose landfill. Access to the Preliminary Site is currently restricted to authorized personnel only and the site is gated. Recreational or other non-worker trespass is prohibited. Lots 5 and 6, which include the LDA, DSP, and most of the MTCA investigation areas (Figure 2-1), is zoned Mineral-Resources Related (Figure 2-2). The Baja property is zoned Forestry.
- Groundwater - Although the Infiltration Ponds are located overlying the recessional outwash within the 5-year capture zone of the Kent Springs wellfield, groundwater use is not a current complete exposure pathway because the seepage treatment system neutralizes the pH and removes COCs before the treated water is discharged to the Infiltration Ponds. Even without treatment, concentrations of the COCs

attenuate when caustic leachate mixes with neutral groundwater within the recessional outwash. No impacts have been observed in a water well on the Baja property located approximately 500 feet southwest of the Infiltration Ponds. In accordance with WAC 173-161-171(3)(b)(vi), new wells cannot be installed within 1,000 feet from the property boundary of a permitted landfill unless a variance is granted that demonstrates the construction and operation of the well will not further degrade the environment and will not cause a public health risk.

There is no evidence that the bedrock aquifer is impacted based on groundwater quality in bedrock monitoring wells installed in the footprint of the LDA. Continuous sonic cores collected from P-14 and P-15 indicated perched, high pH water occurred on the bedrock surface, but within two feet below the top of the bedrock surface, the bedrock was dry and pH testing of the bedrock was neutral. If the bedrock were a potential source of groundwater, well yields will likely be low because of the interpreted low hydraulic conductivity of the bedrock, which was lower than determined for the shallow groundwater.

- Soils and Sediments - Direct contact by human, terrestrial, and ecological receptors with soil and sediment that contains antimony, arsenic, and lead at concentrations exceeding PCULs. Direct contact by humans is limited as portions of the Preliminary Site are closed landfill and access to open areas of the Preliminary Site are restricted to site workers. The impacted areas of the Preliminary Site are zoned mineral-resource, and future unrestricted land-use is not permitted. Additionally, the delineated areas of impacted soils are either fenced and/or in areas where site workers are not present, and landfill operations do not require the soil to be disturbed.
- Ecological receptors are evaluated following the procedures specified in MTCA Terrestrial Ecological Evaluations (TEE) process. As detailed in TEE under MTCA (Ecology 2023), a site-specific TEE can be conducted by comparing soil analytical results to ecological receptor values listed in Table 749-3 of the WAC 173-340-900. A site-specific TEE was completed by comparing the ecological receptor values to analytical soil sampling results, which are provided in Tables 5-6 through 5-10. The ecological receptor values are conservative as they include risk to ecological receptors (plants, soil biota, and wildlife) without consideration of whether those receptors are present at the site. Site-specific background concentrations were higher than the TEE values for all COCs, except for antimony, where the TEE, which is based on protection of plants, was higher than the background concentration.

7.0 PERMITTED LIMITED PURPOSE LANDFILL BOUNDARY, CLEANUP STANDARDS, AND PROPOSED SITE BOUNDARY

Sampling for various media including groundwater, surface water, soil, and sediment was conducted as a part of the RI to address data gaps identified in the RI/FS workplan. Ecology provided PCULs (Ecology 2024b) for comparison to analytical results obtained during the RI. The PCULs were developed by evaluating various State and Federal potentially applicable and relevant and appropriate requirements (ARARs), and selecting the most stringent (i.e., lowest) value as the PCUL. The ARARs included in the PCUL evaluations included the following:

- **Washington Model Toxics Control Act** (MTCA), (Chapter 70A.305 RCW); and MTCA Cleanup Regulations, (Chapter 173-340 WAC). The procedures for developing CULs for groundwater, surface water, soil, and air are outlined in the MTCA Cleanup Regulation Sections 173-340-720, -730, -740, and -750, respectively. Included in these sections are the specific rules for evaluating cross-media protectiveness.

- The **Clean Water Act** (CWA) (33 USC Section 1251 *et seq*.) requires the establishment of guidelines and standards to control the direct or indirect discharge of pollutants to waters of the United States. Section 304 of the CWA (33 USC 1314) requires the EPA to publish Water Quality Criteria, which are developed for the protection of human health and aquatic life.
- **Washington Water Pollution Control Act** (Chapter 90.48 RCW; Chapter 173-201A WAC). This Act provides for the protection of surface water and groundwater quality. Chapter 173-201A WAC establishes water quality standards for surface waters of the state.
- **Washington Sediment Management Standards (SMS)** (Chapter 173-204 WAC). SMS were developed to reduce and ultimately eliminate adverse effects on biological resources and significant threats to human health from surface sediment contamination. Part V of the SMS addresses sediment cleanup standards.

Chapter 5 of this RI compared sample results to the PCULs including the statistically calculated site-specific soil background concentrations to identify areas that contained COCs exceeding the PCULs. The cumulative evaluation of locations where COC concentrations in samples exceeded the PCULs, combined with other Preliminary Site investigation data (e.g., geophysical studies, historical site data), were used in Chapter 6 to define the nature and extent of impacts to various media, and to refine the CSM. The evaluations completed in this RI are conservative, as the PCULs provided by Ecology generally use the most stringent (i.e., lowest) PCULs listed under various exposure assumptions, without consideration of specific exposure pathways identified as current or potential complete exposure pathways at the Preliminary Site.

Based on the RI data collected, and risk evaluations completed, the following presents revised limited purpose landfill boundaries, CULs, points of compliance, and COCs for surface water, groundwater, soil, and sediment in consideration of the site-specific complete or potentially complete exposure pathways. The Preliminary Site (or RI study area) is refined within this Chapter to identify the proposed Site Boundary as defined under WAC 173-340-200, which includes any site or area where a hazardous substance has been deposited, stored, disposed of, or placed, or otherwise come to be located.

7.1 Permitted Limited Purpose Landfill Boundaries

The boundaries of the LDA and DSP limited purpose landfills were based on historical records, visual inspections, and subsurface investigations consisting of geophysical testing, test pitting and borehole drilling, and the closed landfill permit issued by Public Health.

Lower Disposal Area: Geophysical testing indicated that CKD disposal extends southeast of the previously demarcated boundary of the LDA. Borehole drilling along the southeast side of the LDA confirmed the presence of CKD beyond the extent of the low-permeability soil cover placed over the LDA in 2007. Boreholes were drilled to delineate the extent of CKD along the southeast side of the LDA (see Figures 3-2 and 3-8). Figure 7-1 depicts the revised LDA boundary, which includes the identified lobe of CKD in the southeast portion of the LDA. The FS will develop and evaluate cleanup action alternatives that consider relevant and appropriate requirements for the LDA including the lobe of CKD located beyond the extent of the existing low-permeability soil cover, in accordance with WAC 173-340-351 and 173-340-710.

Dale Strip Pit: Figure 2-1 shows the DSP boundary. The DSP cover was updated in 2010 and 2011 to provide a low-permeability soil cover and positive surface water drainage. The RI activities support the demarcated boundary of the DSP and the applicability of its groundwater monitoring network. As described in the RI, there have been no confirmed releases of contamination from the DSP based on more than 20 years of monitoring groundwater in the bedrock wells and the mine portal. As described in Section 6.2, the DSP appears to meet the functionally stable criteria in WAC 173-304-407(7)(a) and Ecology Publication No. 11-07-006 and its 2013 addendum (Ecology 2013). Based on the evaluation in the RI and nature of the waste disposed in the DSP monitoring of groundwater and surface water, and gases can be safety discontinued, in accordance with WAC 173-304-407(7)(a).

7.2 Proposed Cleanup Standards

This section proposes cleanup standards based on CULs for the COCs and points of compliance for all site media. The COCs identified in Section 6.1 are antimony, arsenic, lead, vanadium, and pH. Under WAC 173-340-200, CULs are defined as the concentrations of hazardous substances that are protective of human health and the environment under specific exposure conditions. PCULs for each medium are protective of other media through the consideration of partitioning and transfer of chemicals between media. For example, groundwater PCULs are protective of drinking water but are also based on protection of groundwater discharge to surface water, and protection of sediments. Soil PCULs are protective of human health and ecological receptors through direct contact and are also established to protect groundwater, surface water, and sediments. The groundwater and surface water PCULs are adjusted for the background concentration of arsenic in the Puget Sound Basin groundwater (Ecology 2022), as allowed under WAC 173-340-720(7)(c) and WAC 173-340-730(5)(c), and the soil and sediment PCULs are adjusted for the site-specific background soil concentrations for arsenic, lead, and vanadium (Table 5-6), as allowed under WAC 173-740(5)(c) and WAC 173-204-560(5). Since arsenic is the only carcinogenic COC, the CULs do not need to be adjusted for total site risk. The PCULs are the applicable CULs for the Site.

The following Sections present the CULs and points of compliance for surface water, groundwater, soil, and sediments at the Preliminary Site, and identify those COCs that were detected in each media at concentrations exceeding the CULs.

7.2.1 Surface Water Cleanup Standards

The surface water risk calculations and associated PCULs are based on direct contact, protection of freshwater aquatic life, and protection of human health from consumption of organisms and water impacted with chemicals. The surface water PCULs are shown in Table 7-1.

The point of compliance for surface water CULs is the point or points at which hazardous substances are released to surface waters of the state (WAC 173-340-730(6)(a)). “Surface waters of the state” includes lakes, rivers, ponds, streams, inland waters, saltwaters, wetlands, and all other surface waters and water courses within the jurisdiction of the state of Washington (WAC 173-201A-020). The point of compliance for surface waters includes the seepage released from the LDA, the South Pond, the Infiltration Ponds, and all surface water drainage pathways to these surface water bodies. MTCA does not provide a conditional point of compliance for surface water. The final State Waste Discharge Permit No. ST0501373 will authorize the collection, treatment and discharge of the seepage to the Infiltration Ponds and provide applicable treatment standards and monitoring requirements.

Direct contact with surface water is a potential exposure pathway for site personnel and ecological receptors. The direct contact exposure pathway is currently minimized by fencing surrounding the seepage area, South Pond, and the Infiltration Ponds, and cover rock in the area where seepage daylights seasonally along the southwest toe of the LDA. Surface waters in the seepage area and South Pond are not used for human consumption and there is insufficient volume of water produced in either of these areas to provide a source of drinking water. Surface water in the Infiltration Ponds is not used for human consumption, but the Infiltration Ponds discharge to groundwater within the 5-year capture zone of the Kent Springs wellfield.

The areas where impacted surface waters are present (seepage area embankment west of the LDA, the South Pond, and the Infiltration Ponds), do not currently serve and would not reasonably serve in the future as complete exposure pathways for protection of aquatic life and protection of human health from consumption of organisms. For example, none of these areas can support fish/shellfish for human consumption. The freshwater PCULs based on protecting aquatic life are also not applicable to the surface water exposure areas of the Preliminary Site, as these areas do not support and are not directly connected to surface water areas that support the aquatic life (fish/shellfish) for which the CULs have been established.

The groundwater CULs are applied to surface water since the South Pond and Infiltration Ponds discharge to groundwater. The groundwater and surface water PCUL of arsenic were adjusted to the 8.0 µg/L Puget Sound Basin background concentration in groundwater, as allowed in WAC 173-340-720(7)(c) and WAC 173-340-740(5).

7.2.2 Groundwater Cleanup Standards

The groundwater PCULs are based on the groundwater ingestion and surface water exposure pathways. The proposed CUL for arsenic is adjusted to the 8.0 µg/L Puget Sound Basin background concentration (Ecology 2022), as allowed under WAC 173-340-720(7)(c). The groundwater CULs for antimony and lead are based on protection of surface water, although the surface water risk assumptions based on consumption of seafood and drinking of surface water are not complete exposure pathways at the Preliminary Site. Impacted groundwater at the Preliminary Site does not discharge to any surface water or tributary to a surface water body that can sustain aquatic life for consumption by humans for which the standards are based. The lead surface water concentration for protection of aquatic life is a potential complete exposure pathway. The proposed groundwater CULs for antimony and lead are based on protection of surface water, because the PCULs are lower than the groundwater ingestion PCUL. The proposed CUL for vanadium is based on the groundwater ingestion PCUL. The proposed CUL for pH is 6.5 to 8.5 SU, consistent with WAC 173-200-040. The proposed groundwater CULs are listed in Table 7-2.

The groundwater point of compliance is the point or points where the groundwater CULs must be attained for a site to be in compliance with the cleanup standards (WAC 173-340-720(8)(a)). The standard point of compliance exists throughout the site from the uppermost level of the saturated zone extending vertically to the lowest-most depth that could be affected by the site (WAC 173-720(8(b)). For landfills regulated under WAC 173-304, the groundwater point of compliance exists beneath the perimeter of the solid waste facilities' active area as that active area would exist at the closure of the facility (WAC 173-304-100(58)). For landfills, the point of compliance exists beyond the containment system, where a release of contamination can be detected. The point of compliance does not exist beneath the landfill because constructing a well through the landfill poses an unacceptable risk to groundwater resources. The groundwater point of compliance at the Preliminary Site is all groundwater beyond the boundaries of the LDA and DSP. The groundwater point of compliance extends to the proposed Site boundary, described in Section 7.3. Figure 7-2 depicts the areas where the concentrations of COCs exceed the groundwater CULs.

Where it can be demonstrated that it is not practicable to meet the cleanup level throughout the site within a reasonable restoration time frame, Ecology may approve a conditional point of compliance for groundwater in accordance with WAC 173-340-720(8)(c) and (d). The application of a conditional point of compliance will be evaluated in the FS and proposed in the draft Cleanup Action Plan.

7.2.3 Soil Cleanup Standards

Table 7.3 lists the soil PCULs for multiple exposure pathways and the soil point of compliance for each exposure pathway. The applicable points of compliance for soil are described below:

- The soil CULs do not apply to the landfill material in a solid waste landfill when hazardous substances in the landfill are contained so that there are no complete exposure pathways. The landfill regulations provide waste acceptance criteria and design standards for lining systems and landfill cover that contain the approved landfill material. Solid waste management units within a landfill are designed, operated, and closed under the applicable regulations at the time. The MTCA CULs apply when there is a release of contamination from the landfill.

- The point of compliance for the direct contact exposure pathway applies throughout a site from the ground surface to 15 feet bgs (WAC 173-340-740(6)(d)). The 15-foot depth represents a reasonable estimate of the depth of soil that could be excavated and distributed at the soil surface as a result of development activities. The direct contact exposure does not apply to the closed landfill cover provided that an environmental covenant is placed on the landfill that restricts the disturbance of the landfill cover.

- The point of compliance for soil PCULs based on the protection of groundwater applies throughout a site (WAC 173-340-740(6)(b). The groundwater CULs are also protective of surface water. Ecology provided additional PCULs that are protective of sediment via groundwater. The soil PCULs based on groundwater are more stringent for the saturated zone than for the vadose zone (i.e., soils above groundwater table) because the governing risk equations apply a dilution factor when infiltrating water mixes with groundwater (MTCA Equation 747-3).

- The point of compliance for terrestrial ecological protection applies for the biologically active soil zone (WAC 173-340-7490(4)(a)). The biologically active zone is assumed to extend to a depth of 6 feet bgs, unless a demonstration is made that identifies a different biologically active zone.

The soil CULs are the lowest PCUL within the applicable point of compliance. The soil CULs should not be set at levels below the natural background concentration of the COCs in soil. The soil PCULs for arsenic, lead, and vanadium were adjusted to the site-specific background concentrations (shown in Table 5-6), as allowed under WAC 173-340-740(5)(c). The soil CUL for antimony is based on the terrestrial ecological protection of plants. No cleanup level is established for soil pH. Table 7-3 summarizes the soil CULs for the COCs. Figure 5-2 shows the delineated areas where concentrations of one or more COCs exceed CULs.

7.2.4 Sediment Cleanup Standards

Table 7-4 lists the sediment PCULs, the site-specific soil background concentrations, and the sediment CULs. Ecology provided conservative sediment PCULs that are protective of the direct contact, seafood consumption, and freshwater benthic organism exposure pathways that are based on simplified, standard risk scenarios in WAC 173-204, Part V (Sediment Cleanup Standards). Consumption of seafood and direct contact exposure pathways are not complete exposure pathways for sediments associated with the South Pond or Infiltration Ponds. No sediment PCULs are established for antimony and vanadium. The sediment PCULs for arsenic and lead are adjusted to the site-specific soil background concentrations, as allowed in WAC 173-204-560(5). The sediment CULs are consistent with the soil CULs for arsenic and lead.

The accumulated precipitates in the Infiltration Ponds are not sediments that would support aquatic species. The Infiltration Ponds are man-made structures that were built to treat the high pH seepage water and remove dissolved solutes prior to the water infiltrating to the underlying groundwater. The South Pond “sediments” are more conservatively compared to soil standards, as the pond is only inundated for the 3 or 4 months during the winter. Figure 7-3 depicts the areas where the concentrations of COCs exceed the groundwater, soil, and surface water and sediment CULs.

7.3 Proposed Site Boundary

Under WAC 173-340-200, a “site or site boundary” means the same as facility, which includes any site or area where a hazardous substance has been deposited, stored, disposed of, or placed, or otherwise come to be located.

The Proposed Site Boundary includes the LDA and the delineated boundary where the concentrations of COCs comply with the cleanup standards. The Proposed Site Boundary includes the seepage collection, conveyance, treatment, and discharge system, including the Infiltration Ponds and the historical surface drainage pathways for the caustic seepage. The Proposed Site Boundary is shown in Figure 7-4.

The Proposed Site Boundary does not include the DSP or the mine portal because there is no evidence of a release of contamination based on more than 20 years of monitoring.

8.0 SUMMARY

8.1 Background

Reclamation and landfilling of silica sand mining pits and historical surface strip coal mining pits have been conducted under DNR and King County permits at the Reserve Silica site since 1971. Filling of the LDA, a former silica sand mining pit, and the DSP, a former surface coal mining pit, included placement of CKD. CKD backfilling was performed in compliance with King County Building and Land Development Permit No, 1122-50, and subsequent King County Department of Public Health Special Landfill Permit, No 17-101 (Ideal 1984). Approximately 175,000 tons of CKD and other material were placed in the LDA between June 1979 and August 1981. The DSP was filled with approximately 250,000 cubic yards of material, a portion of which included CKD. The LDA and DSP were initially capped with several feet of overburden from sand mining operations and a 2-foot layer of clay.

Inspections of the CKD disposal areas conducted in the mid-1980s determined that leachate from the LDA had a pH of approximately 12 SU. Testing of the groundwater emanating from the historical coal mine underlying the DSP did not detect impacts to groundwater from the CKD disposed in the DSP. Numerous environmental investigations were conducted from 1986 through the start of this RI in 2021 to evaluate the nature and extent of impacts to groundwater and surface water from leachate associated with the CKD. During this time, interim actions were also completed at the Preliminary Site to control, capture, and treat the high pH seepage emanating from the LDA. The additional interim actions included:

- Grading to provide positive surface water runoff, surface water diversion ditches, and culverts upgradient of the LDA to prevent stormwater run-on to the LDA, and installation of a low permeability cover across the LDA was completed in 2007. Similarly, grading to provide positive surface water runoff, surface water diversion actions, and placement of a low permeability soil cover was completed for the DSP in 2010 and 2011. These actions were completed to reduce the infiltration of water through the landfill covers and into the CKD disposal areas.

- A shallow groundwater interceptor trench was installed in 2013 along the south end of the LDA to collect and divert groundwater perched on top of the bedrock and prevent the water from entering the LDA. This was a trial system that only extended 220 feet along the south and southeast end of the LDA. This area was selected for the interceptor trench based on hydrogeologic studies of the LDA that indicated perched groundwater was primarily entering the LDA along the south and southeastern areas. In 2018, boreholes were drilled along the anticipated outer edge of the southeast end of the LDA. These boreholes were drilled to evaluate extending the existing interceptor trench further north, along the southeast end of the LDA where geophysics indicated shallow groundwater was entering the LDA. CKD was intercepted in several of these boreholes indicating a pocket of CKD was present in a lobe extending along the southeast side of the capped area of the LDA as shown in Figure 7-1. Additional boreholes were drilled to delineate the extent of the CKD, and groundwater piezometers were installed to evaluate the flow of shallow groundwater into the LDA in this area.
- Test trenches were installed in 2008 along the western toe of the LDA (Test Trench No. 1) and along an embankment west of the LDA (Test Trench No. 2) where several high pH groundwater seeps had been observed. Test Trench No. 1 and 2 locations are shown in Figure 3-2. The test trenches included perforated drainpipe to collect the seepage water and a tightline pipe to direct the water to the Infiltration Ponds. A seepage collection ditch was installed along the entire length of the seepage area along the embankment west of the LDA. The collected seepage water in the ditch entered drop structures and connected to the tightline pipes leading to the Infiltration Ponds.
- A seepage water treatment system was constructed in 2018 and started full-time operation in 2019. Water collected in the trenches and seepage collection ditch is diverted to the treatment system to neutralize the water and reduce the concentration of dissolved solutes from the water prior to discharge to the Infiltration Ponds. Further removal of dissolved solutes occurs within the Infiltration Ponds as the water infiltrates to the underlying groundwater. At the request of Ecology's Water Quality Program, an application for a Washington State Waste Discharge permit was submitted in December 2024 for discharges of the treated water to the Infiltration Pond. In February 2025, Ecology issued State Waste Discharge Temporary Permit No. ST051373 for the Reserve Silica Holcim Treatment Facility. Ecology anticipates issuing the permanent State Waste Discharge Permit in the summer of 2025. Surface water monitoring and sampling of groundwater monitoring wells surrounding the Infiltration Ponds have confirmed that the treatment system is effective in neutralizing the pH and removing dissolved metals to eliminate impacts to groundwater beyond the immediate area of the Infiltration Ponds.

8.2 Remedial Investigation Findings

The RI/FS Work Plan (Golder 2021a) was structured to facilitate a clear understanding of the Preliminary Site history and current conditions, previous investigations, data gaps required to increase the understanding of potential environmental impacts associated with the CKD disposed in the LDA and DSP, the preliminary CSM, and the additional investigations and the data collection needed to evaluate additional remedial actions in the FS. Data collected during the RI indicated the following.

Extent of Groundwater Contamination: Additional geophysical investigations were conducted at the LDA and DSP. The subsurface EM conductivity surveys were shown to have a strong positive correlation with the relative abundance of hydroxide ion (OH-) and other ions that are present in high pH water, increasing the electrical conductivity of the groundwater. The geophysical mapping (see Figures 3-10, 3-11, and 5-1) clearly depicts the areas where CKD impacted groundwater and resultant elevated pH are present. These maps combined with shallow groundwater gradients indicate the flow path of high pH water through the LDA, subsurface seepage out of the LDA, and migration of the high pH groundwater downgradient of the LDA.

Seven additional groundwater monitoring wells were installed to augment the existing groundwater monitoring well network. The RI monitoring wells downgradient of the LDA and Infiltration Ponds confirmed the extent of impacts to groundwater that was indicated by the geophysics investigation. RI boreholes and monitoring wells installed within the LDA provided further data on the presence of CKD and other material disposed within the LDA, the depth of the LDA, impacts associated with the LDA, and the nature of the contaminants present in groundwater within the LDA. The clay-cemented sandstone bedrock that forms the bottom and walls of the LDA serves as an aquitard capturing water within the LDA like a bathtub. Boreholes drilled through the LDA fill material and into the top of the underlying bedrock, determined that the bedrock was not saturated, and groundwater was not migrating vertically beneath the LDA.

A borehole was drilled in the center of the Lower Haul Road, which runs along the western edge of the LDA. The RI borehole, combined with data from other boreholes previously drilled in the Lower Haul Road, confirmed that the sandstone bedrock has a low spot along a portion of this western wall of the LDA. This reported low area is supported by historical information that indicated fill material was used to raise the Lower Haul Road along a portion of the LDA to contain the CKD within the LDA. This low spot in the confining bedrock unit is also where the high pH groundwater seepage occurs along the embankment west of the Lower Haul Road.

Groundwater and surface water monitoring conducted at the Preliminary Site since approximately 2005 continued during the RI and incorporated routine sampling of the new RI wells into the program. Source area wells were initially sampled to evaluate the concentrations of the COPCs. The COPCs included metals, dioxins, and furans that have been associated with CKD and ASARCO slag in other studies. The COCs were selected by identifying the COPCs that exceed the PCULs within the LDA and immediately downgradient of the LDA and Lower Haul Road. As summarized in Section 6.1, the COCs are antimony, arsenic, lead, vanadium, and pH. The groundwater, surface water, soil, and sediment samples collected during the RI were evaluated for these COCs. In addition, when CKD solubilizes in groundwater, two of its constituents dissolve: potassium, which exists in groundwater as the potassium ion (K^+) and hydroxide, which exists in groundwater as the hydroxide ion (OH^-). Elevated potassium concentrations proved to be another strong indicator of impacts associated with dissolution of CKD, which persist in groundwater after the pH neutralizes. As such, all surface water and groundwater samples were also analyzed for potassium.

Evaluation of the long-term groundwater monitoring data confirms that the low-permeability bedrock aquifer underlying the LDA and downgradient of the LDA is not impacted. Bedrock wells MWB-1LDA, MWB-2LDA, and MWB-3LDA are adjacent to the LDA. MWB-2LDA borehole penetrates through the shallow impacted groundwater area and is screened in the underlying bedrock groundwater aquifer. Concentrations of COCs are below PCULs, and the concentrations of potassium and pH levels do not indicate impacts from CKD leachate. The very low yields of MWB-1LDA and MWB-3LDA appear to have impeded well development, and historically elevated arsenic concentrations in these wells appear to be associated with suspended solids and have steadily declined to Puget Sound Basin background concentrations through 20 years of sampling. These two wells do not penetrate shallow impacted areas and there are no traces of high pH or potassium that would indicate impacts from CKD leachate. Boreholes P-14 and P-15, drilled in areas of the LDA where geophysical testing indicated the highest EM reading, were drilled through the CKD and fill material and into the underlying bedrock. The bedrock underlying the LDA was unsaturated, and the sandstone did not have elevated pH levels.

Dale Strip Pit Stability: Data from the DSP monitoring wells and long-term sampling results from the mine portal that drains the bedrock groundwater beneath the DSP indicate that CKD disposed in the DSP is not impacting the groundwater. Unlike the LDA, which is underlain by low permeability sandstone that creates a bathtub effect and allows water that is perched within the landfill to come into contact with the CKD, the DSP is underlain by mined coal seams and underground mine workings that allow water that enters the DSP to drain more freely and discharge through the Dale tunnel to the Portal. Because of the relatively high permeability underlying coal seams, infiltrating water within the DSP is less likely to accumulate and would have less interaction time with the CKD to produce high pH leachate. Although the coal of south King County is considered low-sulfur containing coal, some pH buffering capacity is provided for any CKD leachate transmitted through the remaining coal deposits. Additionally, the DSP is located topographically at a high point in the local area, which limits the area upgradient of the DSP for shallow groundwater to migrate into the DSP. Samples collected for over 20 years from the DSP bedrock wells and from the Portal have not shown indications of impact to groundwater underlying the DSP. Bedrock monitoring well MWB-1SDSP has reported arsenic concentrations exceeding the typical Puget Sound Basin background concentrations, but the pH and potassium concentrations do not indicate the arsenic is attributable to CKD leachate. It is suspected that the elevated arsenic in MWB-1SDSP is a consequence of inadequate well development of a low yield well.

Because there has been no confirmed release of contamination from the DSP based on more than 20 years of sampling the bedrock monitoring wells and mine portal, no further action is warranted under the MTCA regulations. Consequently, the Proposed Site Boundary does not include the DSP. Public Health currently permits post-closure care of the DSP under WAC 173-304. As described in Section 6.2, the DSP appears to meet the functionally stable criteria in WAC 173-304-407(7)(a) and Ecology Publication No. 11-07-006 and its 2013 addendum (Ecology 2013). Based on the evaluation in the RI, monitoring of groundwater, surface water, and gases can be safety discontinued, in accordance with WAC 173-304-407(7)(a).

Lower Disposal Area Releases: During the RI, groundwater levels were recorded using pressure transducers in select wells and measured routinely using handheld water level meters. These routine measurements provided data to evaluate groundwater gradients, flow direction, and the changes in water levels in response to seasonal wet periods and dry seasons. Additional hydraulic testing was performed through slug testing shallow LDA groundwater monitoring wells. Hydraulic parameters calculated from the slug test combined with the aquifer thickness data obtained from the water level measurements and estimated depth to the top of bedrock, were used to estimate the volume of groundwater entering the LDA. This volume was compared to the volume/flow of water captured by the seepage collection ditch to develop a rough water balance. The results of this water balance supported the CSM that most of the shallow groundwater entering the LDA is entering subsurface along the southeast end of the LDA. There is a lag of a few weeks to a month between the start of the rainy season and when the LDA “bathtub” fills up and when the high pH water flowing beneath the Lower Haul Road increases the rate of seepage along the embankment west of the Lower Haul Road. During the wet season, when water levels are highest within the LDA, increases in seepage rates occur nearly simultaneously following large rain events. The nearly concurrent increase in water levels in wells immediately southeast of the LDA and within the LDA, and the increase in seepage discharge rates downgradient of the LDA in response to larger rain events, further support the conclusion that the recharge and flow into the LDA is occurring along the southeast end of the LDA.

Soil and Sediment Contamination: The high pH groundwater that leaches from the LDA contains antimony, arsenic, lead, and vanadium at concentrations that exceed groundwater CULs. These exceedances within the high pH groundwater are partially attributable to the dissolution of metals from the CKD, but they are also caused by the dissolution of these metals from the fill and native soils that the high pH groundwater contacts. When the groundwater migrates or reaches the surface through seeps or the seasonal daylighting in the South Pond, the pH neutralizes from the natural buffering capacity of the soils and dilution from mixing with rainwater and groundwater. As the pH neutralizes, some of the solutes precipitate out of the water. The precipitates are primarily calcium carbonate, which is clearly visible along the embankment west of the LDA where the groundwater seepage occurs. As continued neutralization of the water occurs, the dissolved COCs come out of solution within the calcium carbonate precipitates and are precipitated or adsorbed to minerals and natural organic carbon matter contained in the soil matrix. Soil samples were collected during the RI to evaluate the concentrations of COCs that have accumulated in soils where the high pH seepage water is currently present and in areas where overland flow of the seepage historically occurred before the seepage collection ditch was installed. The primary soil areas investigated include the following decision units:

- DU-1: The area along the bench west of the Lower Haul Road where the high pH seepage daylights prior to entering the seepage collection ditch. Sampling in this area focused on the areas with the highest calcite precipitates, which correlate with the past and/or current high pH groundwater seepage areas.
- DU-2: The wooded area west of the seepage collection trench, where high pH seepage water historically flowed overland prior to the construction of the seepage collection ditch.
- DU-3: The South Pond area, where ephemeral upwelling of high pH groundwater occurs during the annual wet season.
- Infiltration Ponds: Ten samples were collected throughout the Infiltration Ponds to determine the concentration of COPCs in the precipitates and soils within the Ponds.

In addition, soil samples were collected from an area within the Preliminary Site that is outside the area of potential impacts from CKD to determine the site-specific background soil COPC concentrations.

The soil PCULs for arsenic, lead, and vanadium were adjusted to the site-specific natural background concentrations of arsenic, lead, and vanadium, as allowed in WAC 173-340-740(5)(c). The soil PCUL for antimony was not adjusted because the site-specific background soil concentration for antimony is less than the risk based PCULs. The soil PCUL for antimony is based on protection of plants, surface water, and groundwater. Soil sampling analytical results were compared to PCULs. Vanadium was not detected in any soil samples at concentrations exceeding its PCUL. Arsenic was the only COC detected in the seepage area (DU-1) at concentrations exceeding PCULs. Antimony, arsenic, and lead were detected at concentrations exceeding PCULs in the South Pond and the historical overland flow area.

Soil pH was also measured in all soil samples collected. Areas where the impact to soil is attributable to leaching from the CKD have higher pH levels. The soil pH measured in areas of current or former known contact with high pH water emanating from the LDA (e.g., DU-1, DU-2, DU-3) all exceed 8 SU and averaged a pH of 8.6 SU. Most of the background soil samples had a measured pH level that was less than 7.5 SU.

Additional soil samples were collected along the perimeters of the three DU areas to delineate the extent of soil containing COCs at concentrations exceeding background and PCULs. If an initial delineation sample contained one or more COCs at a concentration above background and PCULs, a step-out procedure was used to collect an additional sample further away from the initial sample until the extent of impact was fully delineated. Deeper soil samples (8 to 12 inches bgs) were also collected in the DU-2 historical overland flow area to evaluate the vertical extent of COPCs in soil. The delineation samples confirmed that soils surrounding the South Pond were below background concentrations and were used to refine the locations of exceedances for DU-1 and DU-2. Some of the delineation samples where only arsenic still exceeded the site-specific background had measured pH levels below 7.5 SU. Some of these samples were also in areas where there is no indication of current or former contact with CKD or contact with high pH water, indicating that the COCs in those samples are potentially not attributable to CKD-related impacts. The deeper soil samples collected in DU-2 historical overland flow area confirmed that impacts were primarily in the near surface soils, where dissolution and adsorption likely occurred during the time when the overland flow was occurring. The concentration of COCs in the deeper samples collected in the north end of DU-2, in the area where historically the overland flow water would pond, were lower than the shallow concentrations, but were saturated with groundwater and concentrations of some COCs were still slightly above PCULs.

8.3 Current Exposure Controls

As described in Section 7.3, the Proposed Site Boundary includes the LDA and the delineated boundary where the concentrations of COCs comply with the cleanup standards. The Proposed Site Boundary includes the seepage collection, conveyance, treatment, and discharge system, including the Infiltration Ponds and the historical surface drainage pathways for the caustic seepage. The Proposed Site Boundary does not include the DSP because there has been no confirmed release of contamination after more than 20 years of monitoring bedrock wells and the mine portal. The proposed Site boundary is shown in Figure 7-4.

Lower Disposal Area: The LDA was reclaimed with 175,000 tons of CKD and mining spoils between June 1979 and October 1982 and the cover was revegetated in 1983. The thickness of the mine spoils above the CKD is consistent with the reclamation plans in the June 25, 1981, disposal permit application (see Section 2.3.1.1). The permit application indicated that the property owner, Burlington Northern, wanted at least six feet of soil cover above the CKD to allow reforestation, but indicated that reforestation was not possible in the BPA right-of-way. CKD was first encountered between 10 and 14 feet bgs north of the BPA transmission lines, whereas CKD was first encountered between 1 and 5 feet bgs in borings B-12, B-13, B-14, B-19, and B-19A beneath the BPA transmission lines (see Figure 3-2 and Appendix D). The permit application indicated that the original soil cover averaged 24 inches or less.

The LDA cover was upgraded with a low-permeability soil cover from September to November 2007 (Golder 2008). As described in the Construction Summary Report, a minimum of 2 feet of cover soil was placed over the southern portion of the LDA where CKD was encountered at the surface or where test pits indicated that the existing cover was less than 2 feet thick. The cover soils were specified to have a minimum of 25 percent silts and clays that pass the No. 200 sieve, with the intention of achieving a 10^{-6} centimeter per second permeability based on limited infiltration testing. The low permeability cover is described in soil boring logs for P-3 HSA, P-4A HSA, P-5 HSA, and P-5 Probe, which indicate 2 feet of cover described as:

> Compact to dense, medium brown, mottled, heterogeneous, mix of silty fine to medium SAND and cohesive, low plasticity SILT, little to some organics (rootlets), scattered pockets of fine-grained coal fragments, damp (CL) (FILL LOW PERMEABILITY COVER)

The low permeability cover is also described in the boring logs for P-14 and P-15, which respectively describe 2 feet and 1.5 feet of “topsoil and clay cap”. The low-permeability cover does not extend to the southeast portion of the LDA, where mine spoils are present overlying the CKD in borings B-12, B-13, B-14, B-15, B-16, B-19, B-19A, and B-20.

The reclamation activities for the LDA are generally consistent with the closure standards in WAC 173-301 (Regulations Relating to Minimum Functional Standards for Solid Waste Handling). WAC 173-301 required *sanitary landfills* to be “covered with an equivalent of two feet of compacted soil adequately sloped to allow surface water to runoff.” Ecology implemented WAC 173-304 in October 1985 and repealed WAC 173-301 as an antiquated regulation.

Public Health permits the LDA and DSP as limited purpose landfills under WAC 173-304. The LDA cover was upgraded in 2007 with a minimum of two feet of soil with a gradation specification that was intended to meet a low permeability standard consistent with WAC 173-304-460(3)(e). The soil borings sampled after the cover was upgraded indicate the low permeable cover does not extend over all the CKD waste and the maximum observed thickness was 2 feet. The soil descriptions in the boring logs generally indicate that the cover soil would be anticipated to inconsistently meet the permeability specification in WAC 173-304-460(3).

Limited purpose landfills are regulated under WAC 173-350-400 if they operated after February 2003, which provides more protective cover standards in WAC 173-350-400(4)(f).

The LDA cover provides limited protectiveness for the direct contact and terrestrial ecological exposure pathways. COPC metals within the CKD potentially exceed the PCULs for the terrestrial ecological exposure pathway within its 6-foot deep point of compliance and for the direct contact exposure pathway within its 15-foot deep point of compliance. The 15-foot deep point of compliance represents a reasonable estimate of the depth of soil that could be excavated and disturbed at the soil surface as a result of site development activities (WAC 173-340-740(6)(d)).

The FS will evaluate relevant and appropriate requirements for the LDA that protect these exposure pathways, including prescriptive or alternative cover systems for limited purpose landfills in WAC 173-304-460 and WAC 173-350-400 and environmental covenants that protect and preserve the landfill cover.

Surface Water, Soil, and Sediment: The caustic seepage from the LDA has released contamination to groundwater, surface water, soil, and sediment. Figure 7-1 depicts the areas of where high pH water reaches the surface, which include:

- The seepage embankment area where the seepage is collected into the seepage collection ditch and tightlined to the treatment system;
- the South Pond, where high pH groundwater daylights seasonally during periods of high groundwater; and
- a localized ephemeral seepage area along the southwest toe of the LDA.

Figure 7-3 shows the extent of contamination in groundwater, soil, and surface water and sediment. The seepage at the toe of the LDA is covered with rock and drains to the underlying toe drain to the treatment system. The seepage collection trench intercepts seepage from the LDA, mitigating further releases of contamination. Impacted surface water on the Site is not a tributary to surface water systems outside of the property parcels, because the surface water in the South Pond and the Infiltration Ponds discharge only to groundwater or through evaporative losses.

In 2016 and early 2017, fencing was installed around the seeps and collection trench, around the South Pond, and around the Infiltration Ponds. The fencing restricts access to the caustic water. The fencing was installed as an interim action and is not formalized as an institutional control. Reserve Silica currently restricts access to the operating reclamation site.

Groundwater: As shown in Figures 7-2 and 7-3, groundwater contamination extends in low-permeability Vashon till soil northwest of the seepage area, including along historical drainage pathways. Interim actions have been performed to divert the caustic seepage to the Infiltration Ponds within the recessional outwash formation. The infiltrating caustic surface water was buffered by groundwater within the recessional outwash formation, which resulted in the attenuation of the mobilized metal COCs. The seepage treatment system has operated continuously since 2019 to neutralize the seepage and reduce residual concentrations of COCs from solution prior to discharge to the Infiltration Ponds. The concentrations of COCs have declined below the CULs in the monitoring wells near the Infiltration Ponds as a consequence of leachate treatment.

Groundwater monitoring has been performed in response to the landfill permit, a notice of violation, and the remedial investigation. The state waste discharge permit will provide monitoring requirements to evaluate the performance of the seepage treatment system. The FS and draft Cleanup Action Plan should recommend a groundwater monitoring program that is capable of detecting releases of contamination and evaluates the attenuation of contamination.

Additional groundwater protections are provided by the City of Kent’s Wellhead Protection Program and by restrictions for new wells in WAC 173-160 (Minimum Standards for Construction and Maintenance of Wells). The FS and draft Cleanup Action Plan will include provisions to abide by the City of Kent’s wellhead management strategies, including:

- Notify the City of Kent of pending permits within their wellhead protection area.
- Provide a process for the City of Kent to track the cleanup of the Site.
- Notify the City of Kent of any releases of contamination.

WAC 173-160-171(3)(b) provides minimum setback distances for water wells other than public water supply wells. New wells are not allowed within one thousand feet of a permitted or previously permitted solid waste landfill as defined by the permit, or within one thousand feet from the property boundary of other solid waste landfills. A variance may be granted if documentation demonstrates that the construction and operation of the well adjacent to the landfill will not further degrade the environment and will not cause a public health risk.

8.4 Recommendations

Sufficient data are available to evaluate remedial alternatives in the FS. The focus areas for remedial action should include the following:

- Evaluate and recommend actions to reduce, eliminate, and/or capture and treat high pH seepage water from the LDA.
- Evaluate and recommend actions to reduce the flow of groundwater into the LDA, specifically the flow along the top of the bedrock near the southeast end of the LDA, where most of the water enters the LDA.
- Develop and evaluate cleanup action alternatives that consider relevant and appropriate requirements for the lobe of CKD located beyond the extent of the previously demarcated LDA landfill soil cover.
- Evaluate and recommend alternatives to reduce infiltration through the LDA cover, including areas where the landfill cover was not upgraded in 2007.

- Evaluate and recommend remedial actions necessary to address ecological or human health risks posed by the COCs present in the groundwater, surface water, soil, and sediment at concentrations exceeding the CULs.
- Evaluate and recommend potential improvements to the existing treatment system, to ensure the treatment system is reliable and sustainable and meets Washington State discharge standards.
- Propose a groundwater monitoring program that is capable of detecting releases of contamination and confirms the natural attenuation of contamination. The groundwater monitoring program should be applicable and consistent with the objectives of the landfill permit and the state waste discharge permit.
- Propose relevant and appropriate institutional controls for the Proposed Site Boundary.
- Satisfy the City of Kent's wellhead management strategies pertinent to the Proposed Site Boundary, including notifications of permitting activities, tracking the cleanup of the MTCA sites, and notifications of hazardous materials spills.

Signature Page

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Tables

Table 2-1: Baja Property Water Well Field Parameters and Lab Analytical Data

Sample Area	Sample Location ID	Date Sampled	Field Parameters						Total Metals (µg/L)						Dissolved Metals (µg/L)					
			Temperature (°C)	Conductivity (µmhos/cm)	Dissolved Oxygen (mg/L)	Oxidation Reduction Potential (Rel mV)	Turbidity (NTU)	pH (standard units)	Arsenic	Cadmium	Chromium	Iron	Lead	Manganese	Arsenic	Cadmium	Chromium	Iron	Lead	Manganese
Baja Property	Baja Water Well	4/4/2018	12.7	296.7	6.74	832.3	0.89	6.36	0.249	0.036 J	0.146 J	115	1.57	115	0.221	<0.1	<0.5	11.1 J	0.489	41.3
Primary Drinking Water Standard[a]									10	5	100	-	15	-	10	5	100	-	15	-
Secondary Drinking Water Standard[b]									-	-	-	300	-	50	-	-	-	300	-	50
Preliminary Clean Up Levels (PCULs)[c]									8	0.72	71.98	-	2.5	-	8	0.72	71.98	-	2.5	-

Notes:

a. EPA Primary Maximum Contaminant Level (MCL). 40 CFR Part 141.

b. EPA Secondary Maximum Contaminant Level (SMCL). SMCLs are not enforced, and provide drinking water guidelines on aesthetics, such as taste, odor, or color.

c. Preliminary Cleanup Levels is obtained from Ecology. 2024. Preliminary Cleanup Levels – Excel Workbook, update July 2024.

"-" - Standard not available

J - Data validation code; estimated value

µg/L - micrograms per liter

Rel -Relative voltage

mV - millivolt

µmhos/cm - micromhos per centimeter

Table 2-2: Summary of Group B Water Systems

DOH Water System Number	Water System Name	Number of Connections	Capacity (gpm)	DOH Source Susceptibility Ranking	Location	Well Depth (feet bgs)	Water Bearing Interval (feet bgs)	Well Log	Notes
50391	Dave Svedarsky	6	32	High	T22N/R06E 34 NE	140	147-155	Yes	Till logged from 32 to 125 feet bgs
11121	Industrial Mineral Products	2	10		T22N/R06E 36 SW	25		Test well log	No log for 25 foot deep well. Test well log to 36 feet indicted water from 30 to 36 feet bgs and possible till from 9 to 30 feet bgs
02602	Deep Springs	3	30	High	T22N/R06E 34 NE SE	137	130 to 137	Yes(?)	Well log for D. Olsen in same 1/4 1/4 section and same depth. Till logged from 90 to 130 feet bgs
26327	Maiers, L	2	24	High	T22N/R06E 34	80		No	
56160	Moreno Supply	3		High	T22N/R06E 34 SE	64		No	
39952	Stuth Company	3	28		T22N/R06E 34	70	56 to 70	Yes	Till logged from 23 to 56 feet bgs
03458	Henneberg Water System	2		High	T21N/R06E 02 NW			No	Appears to be mislocated based on location within Black Diamond Natural Area

Notes:

Water system data from https://experience.arcgis.com/experience/9dc3fd45206d450f828ebd7ed9cdf7be, accessed September 6, 2024.

Well log data from https://appswr.ecology.wa.gov/wellconstruction/map/WCLSWebMap/default.aspx accessed September 6, 2024.

Blank - no data

None of the wells had a well tag number associated with the well

Table 3-1: Reserve Silica Lower Haul Road Investigation Summary of Lab Results

Exploration Name	Depth (ft bgs)[1]	Total Metals in Soil		Groundwater Grab Sample	SPLP Extract		
		Arsenic	Lead		Arsenic	Lead	
		(mg/kg)		pH	(mg/L)		pH
AB-5	9	11 U	5.6 U	--	0.40 U	0.20 U	6.5
AB-6	1.5	11 U	5.5 U	7.58	0.40 U	0.20 U	7.5
	14	11 U	5.6 U		0.40 U	0.20 U	9.0
AB-7	1.5	**360**	**710**	6.79	0.40 U	0.20 U	12.0
AB-8	1.5	**96**	**57**	--	0.40 U	0.20 U	6.0
	7.5	12 U	**7.0**		0.40 U	0.20 U	7.0
AB-9	1.0	**75**	**37**	--	0.40 U	0.20 U	7.0
	5	**48**	**97**		0.40 U	0.20 U	12.0
AB-10	10	**24**	**16**	--	0.40 U	0.20 U	7.0
	12	**81**	**32**		0.40 U	0.20 U	10.0
AB-11	1.5	**180**	**71**	12.67	0.40 U	0.20 U	9.0
	5	**38**	**21**		0.40 U	0.20 U	8.5
	10	11 U	**9.1**		--	--	--
	15	**100**	**68**		0.40 U	0.20 U	8.0
AB-12	1.0	**40**	**21**	--	0.40 U	0.20 U	8.0
	5	**36**	**7.5**		0.40 U	0.20 U	--
Natural Background Soil Metals Concentration		**7**	**24**	**NA**	**NA**	**NA**	**NA**
MTCA Method A Soil Cleanup Level (Unrestricted)		**20**	**250**	**NA**	**NA**	**NA**	**NA**
Ecological Indicator Soil Concentrations		**7**	**50**	**NA**	**NA**	**NA**	**NA**

Notes:

Table obtained in its entirety from Aspect's November 2017 Remedial Investigation Report Reserve Silica Ravensdale Site - Table 3.

[1] Depth of soil sample collected in feet below ground surface (ft bgs)

"--" Indicates sample not analyzed/tested

mg/kg = milligrams per kilogram (parts per million)

mg/L = milligrams per liter

MTCA = Model Toxics Control Act

NA = not applicable

SPLP = Synthetic Precipitation Leaching Procedure

U = analyte was not detected at a concentration greater than the indicated laboratory reporting limit.

Bold denotes a detected concentration. Shading indicates a concentration that exceeds the Ecological Indicator Soil Concentration.

Underlining denotes a detected concentration exceeds the MTCA Method A Soil Cleanup Level.

Table 3-2: Reserve Silica Lower Haul Road Data Gaps Investigation Summary of Lab Results

Sample Identification	% Slag by weight	Sample Type	TCLP Metals (pH=12) (mg/L)			
			Arsenic	Lead	Iron	Manganese
ATP-1	53%	Bulk Soil	5.07	1 U	6.75	1 U
		Slag Only	1 U	1 U	5 U	1 U
ATP-2	6%	Bulk Soil	1 U	1 U	--	--
		Slag Only	1 U	1 U	--	--
ATP-3	5%	Bulk Soil	1 U	1 U	9.44	1 U
		Slag Only	1.7	1 U	18.8	1 U
ATP-4	20%	Bulk Soil	1 U	1 U	--	--
		Slag Only	1 U	1 U	--	--

Test Methods:

Aspect collected bulk soil samples from four test pits advanced in the Lower Haul Road, where previous investigation work identified slag fragments mixed in road bed soils. Half of each bulk soil sample was processed in Aspect's geotechnical laboratory to estimate the percent of slag, by weight, in each of the bulk samples. Following processing, slag only samples were collected for separate laboratory processing and analysis.

Friedman & Bruya, Inc. tumbled bulk soil and slag only samples in deionized water, adjusted to pH 12 with sodium hydroxide. After tumbling, the pH was checked and confirmed to still be 12. The liquid was analyzed for TCLP Metals by EPA Method 6020A and 1311 mod.

Table obtained in its entirety from Aspect's May 2019 Summary of RI Data Gaps Investigation Results: Plant Site and Lower Haul Road Reserve Silica, Ravensdale, Washington - Table 4.

Table 3-3: Summary of P-14 and P-11 Groundwater Field Parameters and Laboratory Analytical Results

					Results				
					P-14		P-11		
Analyte	**CAS Number**	**Units**	**Groundwater Screening Level[1]**	**Preliminary Cleanup Levels (PCULs)[2]**	**12/11/2020**		**12/11/2020**		**Percent Difference P-11:P-14**
Water Levels and Elevations									
Depth to Water	-	feet BTOC	-	-	31.09		14.02		-
Groundwater Elevation	-	feet AMSL	-	-	742.23		725.00		-
Screened Interval	-	feet BGS	-	-	40 - 50		14 - 19		-
Field Parameter									
pH	-	pH	-	6.5 - 8.5	13.3		12.67		-
Conductivity	-	µS/cm	-	-	18697		6113		-
Temperature	-	°C	-	-	11.6		11.6		-
Dissolved Oxygen	-	mg/L	-	-	0.12		1.25		-
Oxidation Reduction Potentia	-	mV	-	-	-61.2		15.9		-
Turbidity	-	NTU	-	-	17.9		34.3		-
Total Metals									
Antimony	7440-36-0	µg/L	6.4	6.0	147		201		37%
Arsenic	7440-38-2	µg/L	5.0	8.0	270		1670		519%
Beryllium	7440-41-7	µg/L	32	4.0	2	U	0.76	J	-
Chromium	7440-47-3	µg/L	50	72	5	U	45.1		802%
Copper	7440-50-8	µg/L	640	11	NA		75.5		-
Mercury	7439-97-6	µg/L	2.0	0.012	0.1	U	0.11		-
Lead	7439-92-1	µg/L	15	2.5	18.8		138		634%
Nickel	7440-02-0	µg/L	320	52	36.8		112		204%
Selenium	7782-49-2	µg/L	80	5	11.9		6.41		-46%
Silver	7440-22-4	µg/L	80	3.2	2	U	0.35	J	-
Thallium	7440-28-0	µg/L	0.32	0.06	1	U	0.54	J	-
Vanadium	7440-62-2	µg/L	80	80	23.4		116		396%

Notes:

Results detected above the laboratory reporting limit that exceeded the Groundwater Screening Level (Golder 2021c).

1. Groundwater screening levels used during the initial groundwater sampling for COPCs (Golder 2021c).
2. Preliminary Cleanup Levels obtained from Ecology. 2024. Preliminary Cleanup Levels – Excel Workbook, update July 2024.

- Not available

"U" qualifier - indicates analyte was not detected above reporting limit.

"J" qualifier - indicates analyte was not detected above reporting limit, but was estimated between method detection limit and reporting limit.

AMSL - Above Mean Sea Level

BGS - Below Ground Surface

BTOC - Below Top of Casing

°C - Degree Celsius

CAS - Chemical Abstracts Service

CUL - Cleanup Level

GW - Groundwater

MTCA - Model Toxics Control Act

mg/L - milligrams per liter

mV - millivolts

NA - Not Analyzed

NTU - Nephelometric Turbidity Units

µS/cm - micro siemens per centimeter

µg/L - micrograms per liter

Table 3-4: Summary of P-14 Groundwater Laboratory Analytical Results for Dioxins and Furans

				Results (µg/L)	
				P-14	
Analyte	**CAS Number**	**Preliminary Cleanup Levels (µg/L)[1]**	**Toxicity Equivalency Factor[3]**	**12/11/2020**	
Dioxins/Furans					
2,3,7,8-TCDF	51207-31-9	-	0.1	9.92E-06	U
2,3,7,8-TCDD	1746-01-6	3.40E-06	1	9.92E-06	U
1,2,3,7,8-PeCDF	57117-41-6	-	0.03	9.92E-06	U
2,3,4,7,8-PeCDF	57117-31-4	-	0.3	9.92E-06	U
1,2,3,7,8-PeCDD	40321-76-4	-	1	9.92E-06	U
1,2,3,4,7,8-HxCDF	70648-26-9	-	0.1	4.90E-07	J
1,2,3,6,7,8-HxCDF	57117-44-9	-	0.1	9.92E-06	U
2,3,4,6,7,8-HxCDF	60851-34-5	-	0.1	4.90E-07	J
1,2,3,7,8,9-HxCDF	72918-21-9	-	0.1	9.92E-06	U
1,2,3,4,7,8-HxCDD	39227-28-6	-	0.1	6.80E-07	J
1,2,3,6,7,8-HxCDD	57653-85-7	-	0.1	9.92E-06	U
1,2,3,7,8,9-HxCDD	19408-74-3	-	0.1	9.92E-06	U
1,2,3,4,6,7,8-HpCDF	67562-39-4	-	0.01	9.92E-06	U
1,2,3,4,7,8,9-HpCDF	55673-89-7	-	0.01	9.92E-06	U
1,2,3,4,6,7,8-HpCDD	35822-46-9	-	0.01	9.92E-06	U
OCDF	39001-02-0	-	0.0003	1.98E-05	U
OCDD	3268-87-9	-	0.0003	4.96E-05	U
TEF Sum of Dioxins/Furan Concentrations[2]	-	3.40E-06	-	NA	J

Notes:

1. Preliminary Cleanup Levels is obtained from Ecology. 2024. Preliminary Cleanup Levels – Excel Workbook, update July 2024.

2. Dioxin/Furan - Toxicity Equivalent Factors (TEFs) are calculated using Ecology's methodology and guidance: *Evaluating the Toxicity and Assessing the Carcinogenic Risk of Environmental Mixtures Using Toxicity Equivalency Factors* (Ecology 2007). There were no dioxin or furans detected above the laboratory reporting limit.

"U" qualifier - indicates analyte was not detected above reporting limit.

"J" qualifier - indicates analyte was not detected above reporting limit, but was estimated between method detection limit and reporting limit.

CUL - Cleanup Level

GW - Groundwater

MTCA - Model Toxics Control Act

HpCDD - Heptachlorodibenzo-p-dioxin

HpCDF - 1,2,3,4,6,7,8-Heptachlorodibenzofuran

HxCDD - Hexachlorodibenzo-p-dioxin

HxCDF - 1,2,3,7,8,9-Hexachlorodibenzofuran

OCDF - Octachlorodibenzodioxin

OCDD - Octachlorodibenzodioxin

PeCDF - polychlorinated dibenzofurans

PeCDD - polychlorinated dibenzo-p-dioxins

TEF - Toxicity Equivalency Factor

TCDF - 2,3,7,8-Tetrachlorodibenzodioxin

TCDD - 2,3,7,8-Tetrachlorodibenzo-p-dioxin

Table 4-1: New Borehole and Groundwater Monitoring Well Construction Details

Area	Location ID	Northing	Easting	Date Constructed	Total Well Depth (feet bgs)	Screened Interval (feet bgs)	Bentonite Seal (feet bgs)	Casing Diameter (inches)[1]	TOC Elevation (feet NAVD88)[2,3]
LHR - Borehole	G-AB-1	127080	1352892	9/22/2021	N/A	N/A	N/A	6	739.87*
LDA - Shallow/Alluvial Groundwater Monitoring Wells	MW-7A	128439	1352283	9/22/2021	20	10-20	2-7	2	592.69
	MW-8A	128206	1352128	9/22/2021	26	16-26	2-13	2	601.49
	MW-9A	127023	1352544	9/24/2021	13	8-13	2-5	2	697.29
	MW-10A	127301	1352538	9/21/2021	29	9-29	2-6	2	698.02
Within LDA - Groundwater	P-14	126771	1353075	11/20/2020	52	40-50	3-38	2	773.32
	P-15	127061	1352958	9/23/2021	34	24-34	2-20	2	756.55
LDA - Shallow/Alluvial Piezometers	P-16	127121	1352776	9/21/2021	10	5-10	1-3	2	702.87
	P-17	126190	1353036	9/24/2021	13	8-13	2-5	2	720.32

Notes:

1. All wells constructed of 2-inch diameter PVC, with 2-inch diameter 0.020 slot screen, except for P-14, which was constructed with 0.010 slot screen.
2. Northing and Easting Coordinates provided in Washington State Plane North (NAD 83)
3. G-AB-1 is a borehole. The TOC Elevation is ground surface elevation.

-	Not measured or not available
feet bgs	Feet below ground surface
feet NAVD88	Elevation (feet) in NAVD88 Vertical Datum
LHR	Lower Haul Road
LDA	Lower Disposal Area
TOC	Top of well casing.

Table 4-2: Groundwater and Surface Water Sampling Locations and Frequency

Sample Area	Sample Location ID	Sampling Frequency	Well Data			
			Total Well Depth (feet bgs)	Screened Interval (feet bgs)	Bentonite Seal (feet bgs)	Casing Diameter (inches)
LDA - Shallow/Alluvial Groundwater	MW-1A	Quarterly	44	28-43	2-26	2
	MW-2A	Quarterly	40	25-40	2-23	2
	MW-3A	Quarterly	20	4-20	2-4	2
	MW-4A	Quarterly	20	5-20	2-4	2
	MW-5A	Quarterly	40	25-40	2-23	2
	MW-6A	Quarterly	39	24-39	2-22	2
	MW-7A	Quarterly	20	10-20	2-7	2
	MW-8A	Quarterly	26	16-26	2-13	2
	MW-9A	Quarterly	13	8-13	2-5	2
	MW-10A	Quarterly	29	9-29	2-6	2
	P-16	Quarterly	10	5-10	1-3	2
	P-17	Quarterly	13	8-13	2-5	2
	Still Well	Quarterly	Not Applicable			
Within LDA - Groundwater	P-14	Quarterly	52	40-50	3-38	2
	P-15	Quarterly	34	24-34	2-20	2
LDA - Bedrock Groundwater	MWB-1LDA	Annually	135	115-135	2-105	2
	MWB-2LDA	Annually	125	110-125	2-103	2
	MWB-3LDA	Annually	145	125-145	2-115	2
DSP - Bedrock Groundwater	MWB-1SDSP	Annually	160	150-160	138-148	2
	MWB-1DDSP	Annually	265	255-265	243-253	2
	MWB-2DSP	Annually	258	238-258	-	2
	MWB-4DSP	Annually	43	32-42.8	-	2
	MWB-5DSP	Annually	83	73-83	2-61	2
	MWB-6DSP	Annually	195	120-195	2-108	2
	Mine Portal	semi-annually	Not Applicable			
LDA- Surface Water	South Pond	Quarterly				
	Weir	Quarterly				
	Infiltration Ponds	Quarterly				
	Infiltration Ponds Duplicate (MW-35A)	Quarterly				
LDA-Interceptor Trench	Interceptor Trench	Quarterly				

Notes

-	Not measured or not available
DSP	Dale Strip Pit
feet bgs	Feet below ground surface
feet bmp	Feet below measuring point
feet NAVD88	Feet in NAVD88 datum
LDA	Lower Disposal Area
TOC	Top of casing

Table 4-3: Construction Information for Slug-Tested Wells

Well	Top of Casing Elevation (feet NAVD88)	Screened Interval (feet bgs)	Total Well Depth (feet)	Screened In	Soil Type	DTW at Time of Slug Test (feet)
LDA Monitoring Wells						
P-14	773.32	40-50	52	LDA	Silt and Gravel (Fill with CKD)	29.73
P-15	756.55	24-34	34	LDA	Silt (Fill with CKD)	18.99
Shallow Monitoring Wells						
B-15	775.54	4.5-14.5	14.5	Shallow	Sandy Silt (Mine Spoils)	3.91*
B-21	783.00	9-14	14	Shallow	Clayey Sand, Sandstone from 13.0-14.0 feet bgs.	5.84
B-27	803.40	13-23	23	Shallow	Silty Sand, Sandstone from 22.0-23.0 feet bgs.	17.57
P-16	702.87	5-10	10	Shallow		2.99
Bedrock Monitoring Wells						
P-13	804.63	46.5-56.5	56.5	Bedrock	Siltstone	2.58
MWB-2LDA	741.66	110-125	125	Bedrock	Sandstone and Shale	35.88
MWB-3LDA	744.19	125-145	145	Bedrock	Sandstone	5.45

Notes:

feet bgs	Feet below ground surface
feet NAVD88	Elevation (feet) in NAVD88 Vertical Datum
DTW	Depth to Water (feet below measuring point)

*DTW at B-15 taken 3/15/2023.

Table 4-4: Slug Testing Hvorslev Analysis Results

Well	Screened Interval (Feet bgs)	Soil Type	Test	Type of Test	K (feet/min)	K_{min} (feet/min)[1]	K_{max} (feet/min)[2]	K_{avg} (feet/min)[3]
LDA Monitoring Wells								
P-14	40-50	Silt and Gravel (Fill with CKD)	1	Falling Head	1.9E-03	1.6E-03	1.9E-03	1.7E-03
			2	Rising Head	1.6E-03			
			3	Falling Head	1.6E-03			
			4	Rising Head	1.6E-03			
P-15	24-34	Silt (Fill with CKD)	1	Falling Head	4.1E-04	4.0E-04	7.6E-04	5.0E-04
			2	Rising Head	4.4E-04			
			3	Falling Head	4.0E-04			
			4	Rising Head	7.6E-04			
All Tests			**20**			**4.0E-04**	**1.9E-03**	**1.1E-03**
Shallow Monitoring Wells								
B-15	4.5-14.5	Sandy Silt (Mine Spoils)	1	Falling Head	9.8E-05	--	--	--
B-21	9-14	Clayey Sand, Sandstone from 13.0-14.0 feet bgs.	1	Falling Head	1.6E-03	1.6E-03	1.7E-03	1.7E-03
			2	Rising Head	1.7E-03			
			3	Falling Head	1.6E-03			
			4	Rising Head	1.7E-03			
B-27	13-23	Silty Sand, Sandstone from 22.0-23.0 feet bgs.	1	Rising Head[4]	3.3E-05	--	--	--
P-16[5]	5-10	Silty Sand (Till)	1	Falling Head	7.9E-05	--	--	--
			2	Rising Head	--			
All Tests			**15**			**3.3E-05**	**1.7E-03**	**9.7E-04**
All Tests without B-27			**14**			**7.9E-05**	**1.7E-03**	**1.1E-03**
LDA Bedrock Wells								
P-13	46.5-56.5	Siltstone	1	Falling Head	9.4E-05	6.1E-05	9.4E-05	7.8E-05
			2	Rising Head	6.1E-05			
MWB-2LDA	110-125	Sandstone and Shale	1	Rising Head	2.6E-03	2.5E-03	9.7E-03	4.9E-03
			2	Falling Head	9.7E-03			
			3	Rising Head	2.5E-03			
MWB-3LDA[6]	125-145	Sandstone		Falling Head	--	--	--	--

Notes:
1. K_{min} = minimum hydraulic conductivity.
2. K_{max} = maximum hydraulic conductivity.
3. K_{avg} = average of hydraulic conductivity values calculated in Hvorslev analysis.
4. B-27 tested with disposable bailer only as height of water column in well was not sufficient for testing with slug rod.
5. Rising head test in P-16 not analyzed because of incomplete recovery from prior falling-head test
6. Tests in MWB-3LDA did not recover sufficiently to allow for full Hvorslev analysis; However, the slow rates of recovery relative to shallow wells indicate the bedrock unit behaving as an aquitard.
LDA - Lower Disposal Area
feet/min - Feet per minute

Table 5-1: Borehole G-AB-1 Soil Analytical Data for Total and Leachable Metals

Analyte	Preliminary Cleanup Levels for Soil (PCULs) in mg/kg[1]										Results (mg/kg)	
	Direct Contact - Vadose Zone	Direct Contact - Saturated Zone	Protection of Drinking Water Vadose Zone	Protection of Drinking Water Saturated Zone	Soil Protect Surface Water Vadose Zone	Soil Protect Surface Water Saturated Zone	Protect Sediment Vadose Zone	Protect Sediment Saturated Zone	TEE Eco. Indic. Soil Conc. Unrestricted Land Use[1]	Site-specific natural background	Sample Depth - 3.0 feet bgs	Sample Depth - 23.0 feet bgs
Antimony (µg/L)	32	32	5.42	0.27	5.06	0.25	-	-	5	2.48	1.09 U	0.24 U
Arsenic (µg/L)	0.67	0.67	4.67	0.23	4.67	0.23	41	2	7	24.3	24.9	9.42
Lead (µg/L)	250	250	3000	150	500	25	2480	124	50	124	15.4	4.59
Vanadium (µg/L)	400	400	1600	80	-	-	-	-	2	67.5	48.9	24
Total Organic Carbon	-	-	-	-	-	-	-	-	-	-	17.2% J	0.93%
pH	-	-	-	-	-	-	-	-	-	-	6.47 J	9.4 J

Modified SPLP Extract					Groundwater PCULs (µg/L)
Sample Depth (ft bgs)	3.0		23.0		
Modified SPLP Leaching pH	5	12	5	12	
Analyte					
Antimony (µg/L)	**8**	**23**	3.1	4.6 J	5.6
Arsenic (µg/L)	**6.7**	**29**	**65**	**150**	8
Lead (µg/L)	0.13 U	**7 J**	**3.1**	**12**	2.1
Vanadium (µg/L)	2.3	43	80	**520**	80
Total Organic Carbon	-	-	-	-	-
pH post leaching	6.4	8.7	9.2	11.3	-

Notes:

1. Preliminary Cleanup Levels (PCULs) is obtained from Ecology. 2024. Preliminary Cleanup Levels – Excel Workbook, update July 2024.

For Total Metals - Indicates result exceeds the PCULs including background.

Bold: Indicates the concentration of the analyte detected in the leachate exceeded the Site Groundwater PCULs

"-" Indicates sample not analyzed/tested

1. Ecological Receptor - TEE only applicable to soils to 6 feet bgs

U - Analyte was not detected above the Reporting Limit (RL).

J - Analyte was detected above the Method Detection Limit (MDL) but below the RL. Analyte concentration estimated.

ft bgs - feet below ground surface | µg/L: microgram per liter | mg/kg milligram per kilogram

mg/kg - milligrams per kilograms

PCULs - Preliminary Cleanup Levels

SPLP - Synthetic Precipitation Leaching Procedure - modified to conduct leaching at pH 5 and pH 12

TEE - Terrestrial Ecological Evaluation

Reference:

Ecology. 2024. Preliminary Cleanup Levels – Excel Workbook, update July 2024.

Table 5-2: Borehole P-16 Soil Analytical Data for Total and Leachable Metals

Analyte	Preliminary Cleanup Levels (PCULs) in mg/kg: Direct Contact - Vadose Zone	Direct Contact - Saturated Zone	Protection of Drinking Water Vadose Zone	Protection of Drinking Water Saturated Zone	Soil Protect Surface Water Vadose Zone	Soil Protect Surface Water Saturated Zone	Protect Sediment Vadose Zone	Protect Sediment Saturated Zone	TEE Eco. Indic. Soil Conc. Unrestricted Land Use[1]	Site-specific natural background	Results (mg/kg): Sample Depth - 3.0 feet bgs	Sample Depth - 7.0 feet bgs	Analyte	Modified SPLP Extract: Sample Depth (ft bgs) 3.0, Modified SPLP Leaching pH 5	3.0, pH 12	7.0, pH 5	7.0, pH 12	Groundwater PCULs (µg/L)
Antimony (µg/L)	32	32	5.42	0.27	5.06	0.25	-	-	5	2.48	0.23 U	0.23 U	Antimony (µg/L)	**16**	**27**	3.6	**6.1**	5.6
Arsenic (µg/L)	0.67	0.67	4.67	0.23	4.67	0.23	41	2	7	24.3	4.38	8.38	Arsenic (µg/L)	**30**	**120**	**14**	**130**	8
Lead (µg/L)	250	250	3000	150	500	25	2480	124	50	124	11.80	2.41	Lead (µg/L)	2.1	**7.5**	0.13 J	1.6	2.1
Vanadium (µg/L)	400	400	1600	80	-	-	-	-	2	67.5	9.25	52.3	Vanadium (µg/L)	42	**190**	44	**560**	80
Total Organic Carbon	-	-	-	-	-	-	-	-	-	-	0.15%	0.07%	Total Organic Carbon	-	-	-	-	-
pH	-	-	-	-	-	-	-	-	-	-	9.44 J	8.31 J	pH post leaching	9.6	11.7	8.9	11.5	-

Notes:

For Total Metals - Indicates result exceeds the PCULs including background.

Bold: Indicates the concentration of the analyte detected in the leachate exceeded the Site Groundwater PCULs

"-" Indicates sample not analyzed/tested

1. Ecological Receptor - TEE only applicable to soils to 6 feet bgs

U: Analyte was not detected above the Reporting Limit (RL).

J: Analyte was detected above the Method Detection Limit (MDL) but below the RL. Analyte concentration estimated.

ft bgs: feet below ground surface | µg/L: microgram per liter | mg/kg milligram per kilogram

mg/kg - milligrams per kilograms

PCULs - Preliminary Cleanup Levels

SPLP - Synthetic Precipitation Leaching Procedure - modified to conduct leaching at pH 5 and pH 12

TEE - Terrestrial Ecological Evaluation

µg/L - micrograms per liter

Reference:

Ecology. 2024. Preliminary Cleanup Levels – Excel Workbook, update July 2024.

Table 5-3: Correlation of Potassium Concentrations to pH and Other COCs in Groundwater

Sample Location	Sample Location Relative to Currently or Potential Formerly Impacted Area[b]	Potassium, Total (ug/L)	pH (standard units)	Total Dissolved Solids (mg/L)	Antimony, Total (ug/L)	Arsenic, Total (ug/L)	Lead, Total (ug/L)	Vanadium, Total (ug/L)
	Preliminary Cleanup Level (PCUL)[a]	-	6.5-8.5	-	5.6	8	2.5	80
P-14	Currently Impacted	2,010,000	13.19	5,660	120	188	4.54	11.7
P-15	Currently Impacted	965,000	12.88	3,520	3.54	5.83	106	0.464
P-16	Currently Impacted	818,000	11.99	2,350	8.51	139	9.09	288
Infiltration Ponds	Currently Impacted	471,000	8.17	1370 J	13.3	21.8	2.86	3.16
South Pond	Currently Impacted	435,000	9.9	1,220	3.99	21.6	15.2	75.1
Still Well	Currently Impacted	434,000	12.39	1,700	7.25	50.1	4.7	2.9
MW-6A	Formerly Impacted	359,000	7.59	1070 J	7.92	2.83	0.103 U	0.928
MW-5A	Formerly Impacted	294,000	7.35	984 J	6.37	4.28	0.103 U	1.62
MW-8A	Potential Formerly Impacted	159,000	7.06	622	4.93	6.67	0.103 U	3.44
MW-7A	Potential Formerly Impacted	111,000	7.24	588	3.01	2.14	0.103 U	0.97
MW-2A	Potential Formerly Impacted	71,900	6.87	360 J	2.27	1.39	0.103 U	0.97
MW-3A	Potential Formerly Impacted	66,200	6.74	356	1.55	4.65	0.336	0.604
Mine Portal	Potential Indicator of CKD	22,800	6.83	359	0.202 U	5.51	0.103 U	0.556 U
MW-1A	Not Impacted	13,400	6.56	274 J	0.83	1.02	0.103 U	0.614
P-17	Not Impacted	7,730	6.5	315	1.33	3.92	0.103 U	1.38
MWB-1 SDSP	Not Impacted	5,590	6.81	1,270	0.202 U	16.5	0.103 U	0.556 U
MWB-1DDSP	Not Impacted	3,990	7.19	767	0.202 U	4.74	0.132 J	0.556 U
MWB-5DSP	Not Impacted	2,400	6.97	500	0.202 U	4.95	0.103 U	0.556 U
MW-9A	Not Impacted	1,790	6.89	360	0.202 U	0.436	0.103 U	0.64 J
MWB-6DSP	Not Impacted	1,070	7.24	264	0.202 U	0.966	0.103 U	0.556 U
MW-10A	Not Impacted	777	6.31	106	0.202 U	0.44	0.103 U	0.556 U
MW-4A	Not Impacted	708	6.37	320	0.202 U	0.4 U	0.103 U	1.18
MWB-2DSP	Not Impacted	-	7.75	-	-	-	-	-
MWB-4SDSP	Not Impacted	-	7.82	-	-	-	-	-

Notes

Orange shaded values indicate results exceeds Preliminary Cleanup Level (PCUL)

-	Not measured or not available
a	Preliminary Cleanup Level (PCUL) provided by Ecology July 30 2024
b	Based on the relative concentration of potassium and the concentrations of COCs compared to CULs
U	Data validation code; not detected at the Reporting Limit (RL)
J	Data validation code; estimated value

Data in this Table are from the March 2024 sampling event

Units are micrograms per liter (ug/L); unless noted other wise

Table 5-4: COC Comparison of P-14, P-15 and P-16

Monitoring Well	Potassium, Total (ug/L)	pH (standard units)	Total Dissolved Solids (mg/L)	Antimony, Total (ug/L)	Arsenic, Total (ug/L)	Lead, Total (ug/L)	Vanadium, Total (ug/L)
Preliminary Cleanup Level (PCUL)[a]		6.5-8.5	-	5.6	8	2.5	80
P-14	2,010,000	13.19	5,660	120	188	4.54	11.7
P-15	965,000	12.88	3,520	3.54	5.83	106	0.464
P-16	818,000	11.99	2,350	8.51	139	9.09	288

Notes:

Orange shaded values indicate results exceeds Preliminary Cleanup Level (PCUL)

a Preliminary Cleanup Level (PCUL) provided by Ecology July 30 2024

U Data validation code; not detected at the Reporting Limit (RL)

ug/L mircrograms per liter

J Data validation code; estimated value

mg/L milligrams per liter

Data in this Table are from the March 2024 sampling event

Table 5-5: Summary of Cross-Sectional Flow Calculations

Cross Section Location	Length (feet)	Aquifer Thickness (feet)	Cross-sectional Area of Aquifer (square feet)	Hydraulic Conductivity (ft/min)[b]		Hydraulic Gradient (ft/ft)[a]	Minimum Rate (gpm)	Maximum Rate (gpm)
				Minimum	Maximum			
D-D'	300	5.9	1,778	1E-04	2E-04	0.20	0.27	0.53
D-D'	300	5.9	1,778	1E-04	2E-04	0.30	0.40	0.80
C-C'	350	25	8,750	4E-04	5E-04	0.15	1.1	1.3
C-C'	350	25	8,750	4E-04	5E-04	0.25	6.5	8.2
P-16	140	2.51	351	8E-05	NA	0.35	0.07	NA
Seepage Collection Ditch (Manual Measurements)	NA	NA	NA	NA	NA	NA	5.5	13

Notes:

a. Gradient for C-C' calculated using wells B-12, B-15, and P-5 and gradient for D-D' calculated using wells B-27, B-15,and B-12.

b. Geometric means of hydraulic conductivity data from B-15, P-14, and P-15 used for Section C-C', and geometric means of hydraulic conductivity data from B-21, B-27, and P-13 used for Section D-D'.

ft - feet

gpm - gallons per minute

min - minute

NA - Not Applicable

See Figure 3-2 for Cross-Section Locations and Figures 3-8 and 3-9 for detailed cross sections.

Table 5-6: Site-Specific Background Soil Sample Results

	Preliminary Cleanup Levels (PCULs)																
						Sample ID	BA-1-020123	BA-2-020124	BA-3-020125	BA-4-020126	BA-5-020127	BA-6-020128	BA-7-020129	BA-8-020130	BA-9-020131	BA-10-020132	BA-11-020133
						Collection Date	2/1/2023	2/1/2023	2/1/2023	2/1/2023	2/1/2023	2/1/2023	2/1/2023	2/1/2023	2/1/2023	2/1/2023	2/1/2023
Analyte	Direct Contact	Protection of Drinking Water Vadose Zone	Soil Protect Surface Water Vadose Zone	Protect Sediment Vadose Zone	TEE Eco. Indic. Unrestricted Land Use[1]	Site Specific Natural Background[2]											
Antimony (mg/Kg)	32	5.42	5.06	-	5	2.48	0.186 J-	0.674	1.12	3.45	1.52	1.46	0.912	2.08	1.19	1.54	2.15
Arsenic (mg/Kg)	0.67	4.67	4.67	41	7	24.3	5.14 J	7.31	13.8	22.1	11.1	9.6	19.9	15.9	14.2	14.8	32.8
Lead (mg/Kg)	250	3000	500	2480	50	124	9.57	41.4	62.2	222	79.8	46.5	47.5	106	76	43	57.7
Vanadium (mg/Kg)	400	1600	-	-	2	67.5	50.9	31.2	47.2	30.5	51.8	26	58.1	36.8	56.2	33.4	56.1
Carbon, Total Organic (TOC)	-	-	-	-	-	-	4.47%	12.60%	12%	19.50%	10.80%	31.60%	10.80%	19.60%	17.30%	23.10%	9.87%
Solids, Total	-	-	-	-	-	-	72.80%	53.30%	59.80%	55%	61.20%	40.30%	55%	52.50%	55.60%	29.90%	39.80%
pH	-	-	-	-	-	-	5.5 J	5.43 J	5.86 J	4.74 J	5.56 J	5.61 J	6.54 J	5.21 J	5.83 J	6.44 J	7.57 J

	Preliminary Cleanup Levels (PCULs)															
						Sample ID	BA-12-020134	BA-13-020135	BA-14-020136	BA-15-020137	BA-16-020138	BA-17-020139	BA-18-020140	BA-19-020141	BA-20-020142	BA-20-020143D
						Collection Date	2/1/2023	2/1/2023	2/1/2023	2/1/2023	2/1/2023	2/1/2023	2/1/2023	2/1/2023	2/1/2023	2/1/2023
Analyte	Direct Contact	Protection of Drinking Water Vadose Zone	Soil Protect Surface Water Vadose Zone	Protect Sediment Vadose Zone	TEE Eco. Indic. Unrestricted Land Use[1]	Site Specific Natural Background[2]										
Antimony (mg/Kg)	32	5.42	5.06	-	5	2.48	1.51	0.89	0.411	0.522	1.06	0.151	0.35	0.52	1.18	1.15 J-
Arsenic (mg/Kg)	0.67	4.67	4.67	41	7	24.3	23.5	10.8	8.03	11.2	13.4	4.78	8.8	9.91	27	27.9
Lead (mg/Kg)	250	3000	500	2480	50	124	51.3	28.9	74.8	39.1	60	7.97	9.21	23.6	52.4	48.6
Vanadium (mg/Kg)	400	1600	-	-	2	67.5	46.5	42.6	56.2	60.3	42.8	56	76.6	55	62.4	64.6
Carbon, Total Organic (TOC)	-	-	-	-	-	-	11.70%	12.80%	6.55%	6.60%	14%	1.89%	6.48%	7.97%	13.10%	10.40%
Solids, Total	-	-	-	-	-	-	37%	42.50%	68.10%	64.40%	56.60%	79.70%	31.70%	63.80%	53.50%	58.60%
pH	-	-	-	-	-	-	7.39 J	7.7 J	5.9 J	6.27 J	6.04 J	6.41 J	6.35 J	6.15 J	7.4 J	7.44 J

Notes

Indicates result exceeds at least one of the PCULs.

1. Terrestrial Ecological Evaluation lowest standard for soil for unrestricted land use (Ecology 2023). See Table 5-7 for Plant, Soil Biota, and Wildlife specific TEE values.
2. Resultant background concentrations, from the background soils sample results calculated following procedure described in WAC 173-340-709.

mg/kg - milligrams per kilograms

J - Analyte was detected above the Method Detection Limit (MDL) but below the RL. Analyte concentration estimated.

J-: Analyte concentration estimated and potentially biased low.

TEE - Terrestrial Ecological Evaluation

TOC - Total Organic Carbon

References

Ecology. 2019. Terrestrial Ecological Evaluations (TEE) under Model Toxics Control Act. 19-09-051. February.

Ecology. 2024. Preliminary Cleanup Levels – Excel Workbook, update July 2024.

Table 5-7: Soil Analytical Results for ISM Sampling

								Decision Unit ID	DU-1 (seep area)			DU-2 (historical flow area)			DU-3 (South Pond)		
								Sample ID	ISM1	ISM2	ISM3	ISM1	ISM2	ISM3	ISM1	ISM2	ISM3
								Collection Date	10/19/2021	10/19/2021	10/19/2021	1/25/2022	1/25/2022	1/25/2022	10/19/2021	10/19/2021	10/19/2021
	Preliminary Cleanup Levels (PCULs) in mg/kg																
Analyte	Direct Contact	Protection of Drinking Water Vadose Zone	Soil Protect Surface Water Vadose Zone	Protect Sediment Vadose Zone	TEE Eco. Indic. Soil Conc. Unrestricted Land Use Plants[1]	TEE Eco. Indic. Soil Conc. Unrestricted Land Use Soil biota[1]	TEE Eco. Indic. Soil Conc. Unrestricted Land Use Wildlife[1]	Site Specific Natural Background[2]									
Antimony (mg/kg)	32	5.42	5.06	-	5	-	-	2.48	0.879	0.916	0.86	14.3 J-	14.3	13.4	5.47 J-	4.37	4.94
Arsenic (mg/kg)	0.67	4.67	4.67	41	10	60	7	24.3	65.2	44.4	39.8	87.9	98.8	86.9	58.6	45.6	52.7
Lead (mg/kg)	250	3000	500	2480	50	500	118	124	63.8	64.5	56.1	120	145	130	178	176	164
Vanadium (mg/kg)	400	1600	-	-	2	-	-	67.5	13.5	14.5	12.3	12.8	15.1	13.8	27.4	25.1	27.2
Total Solids	-	-	-	-	-			-	99.6%	99.6%	99.5%	99.3%	99.2%	99.1%	96.7%	94.7%	98.2%
Total Organic Carbon	-	-	-	-	-			-	0.566%	0.883%	0.918%	2.21%	1.76%	1.55%	2.73%	2.73%	1.54%
pH	-	-	-	-	-			-	9.23 J	8.46 J	9.86 J	8.27 J	8.14 J	8.25 J	8.63 J	8.46 J	8.81 J

Notes:

For Total Metals - Indicates result exceeds the PCULs including background.

1. Terrestrial Ecological Evaluation standards for soil for unrestricted land use (Ecology 2023)
2. Background calculated from background soils samples following WAC 173-340-709 procedures

" -" Screening Level not available

ID - Identification

ISM - Incremental Sampling Methodology

J-: Analyte concentration estimated and potentially biased low.

J: Analysis exceeded recommended hold time.

mg/kg: milligram per kilogram

PCULs: Preliminary Cleanup Level: Ecology Provided PCULs tables dated 3 February 2023

References

Ecology. 2019. Terrestrial Ecological Evaluations (TEE) under Model Toxics Control Act. 19-09-051. February.

Ecology. 2024. Preliminary Cleanup Levels – Excel Workbook, update July 2024.

Table 5-8: Soil and Precipitates Analytical Results for Infiltration Pond Sampling

						Sample ID (primary media sampled)	INFIL-POND-S1-0122 (precipitates)	INFIL-POND-S2-0122 (precipitates)	INFIL-POND-S3-0122 (precipitates)	INFIL-POND-S4-0122 (soil)	INFIL-POND-S5-0122 (soil)	INFIL-POND-S6-0122 (precipitates)	INFIL-POND-S7-0122 (precipitates)	INFIL-POND-S8-0122 (precipitates)	INFIL-POND-S9-0122 (sediments/precip)	INFIL-POND-S10-0122 (sediments/precip)
						Collection Date	1/25/2022	1/25/2022	1/25/2022	1/25/2022	1/25/2022	1/25/2022	1/25/2022	1/25/2022	1/25/2022	1/25/2022
Analyte	**Soil Direct Contact**	**SD-1 SMS Lower Tier Beach Play Direct Contact[2]**	**SD-2 SMS Lower Tier Seafood Consumption[2]**	**SD-3 SMS Lower Freshwater Benthic[2]**	**SD-4 Freshwater Natural Background[2]**	**Site Specific Natural Background[1]**										
Antimony (mg/kg)	32	-	-	-	2.5	2.48	1.75 J	3.98	2.76	0.695	5.55	4.99 J	3.11	1.57	1.54	2.2
Arsenic (mg/kg)	0.67	2.1	24.0	14	24	24.3	35.2	35.9	28.5	24.2 J	26.3	47.5 J	21.1	41.3	41.6	26.7
Lead (mg/kg)	250	-	120	360	120	124	154	65.6	62	19.3 J	40.8	55.1 J	52.6	23.1	24.5	28.7
Vanadium (mg/kg)	720	-	-	-	68	67.5	28.7	53.4	39.2	47.7 J	31.8	46.1 J	54.9	61.3	62.1	37.7
Total Solids	-	-	-	-	-	-	67.1%	56.9%	58.7%	66.6%	68.4%	44.7%	51.7%	57.2%	62.6%	66.5%
Total Organic Carbon	-	-	-	-	-	-	2.52%	1.74%	1.75%	6.61%	3.41%	3.97%	1.45%	2.52%	0.87%	0.97%
pH	-	-	-	-	-	-	9.39 J	9.19 J	8.76 J	7.4 J	7.9 J	9.31 J	9.23 J	9.73 J	9.23 J	9.14 J

Notes:
For Total Metals - Indicates result exceeds the PCULs including background.
1. Background calculated from background soils samples following WAC 173-340-709 procedures
2. Ecology. 2024. Preliminary Cleanup Levels – Excel Workbook, update July 2024.
Soil - Soil samples from the infiltration Pond
Sediment - Sediment accumulated in the infiltration Pond
Precipitates - Precipitates accumulated in the infiltration ponds.
" -" Screening Level not available
ID - Identification
J-: Analyte concentration estimated and potentially biased low.
J: Analysis exceeded recommended hold time.
PCULs: Preliminary Cleanup Level: Ecology Provided PCULs tables dated July 30 2024
mg/kg: milligram per kilogram
SMS - Sediment Management Standards (Ecology 2013)

DRAFT

Tabled 5-9: Soil Delineation Sample Results

Analyte	Direct Contact	Protection of Drinking Water Vadose Zone	Soil Protect Surface Water Vadose Zone	Protect Sediment Vadose Zone	TEE Eco. Indic. Soil Conc. Unrestricted Land Use	Site Specific Natural Background[1]	DS-1-013123	DS-2-013123	DS-3-013123	DS-4-013123	DS-5-013123	DS-6-013123	DS-7-013123	DS-7D-041323	DS-8-013123	DS-9-013123	DS-10-013123
Collection Date							1/31/2023	1/31/2023	1/31/2023	1/31/2023	1/31/2023	1/31/2023	1/31/2023	4/12/2023	1/31/2023	1/31/2023	1/31/2023
Antimony (mg/kg)	32	5.42	5.06	-	5	2.48	0.638	0.22	0.487	0.615	0.346	0.691	14.2	2.22	0.544	0.675	8.39 J-
Arsenic (mg/kg)	0.67	4.67	4.67	41	7	24.3	12.4	7.27	12.1	9.37	8.05	13.1	213	40.7	11.8	13.9	58.7
Lead (mg/kg)	250	3000	500	2480	50	124	86	14.1	31.7	24.7	23	38.4	288	24.2	50.6	23.6	38.6
Vanadium (mg/kg)	400	1600	-	-	2	67.5	43.6	62.1	50.9	44.8	44.3	47.6	40.2	43.3	47.4	51.1	31.8
Total Solids	-	-	-	-	-	-	64%	76.40%	68.20%	64.50%	73.50%	75%	57.80%	0.91%	66.80%	59.50%	53.10%
Total Organic Carbon	-	-	-	-	-	-	5.28%	2.91%	7.17%	9.97%	2.06%	2.91%	8.89%	68.00%	7.25%	11%	3.86%
pH	-	-	-	-	-	-	7.73 J	6.66 J	6.22 J	6.18 J	7.85 J	7.6 J	7.68 J	8.13	6.31 J	6.47 J	6.42 J

Analyte	Direct Contact	Protection of Drinking Water Vadose Zone	Soil Protect Surface Water Vadose Zone	Protect Sediment Vadose Zone	TEE Eco. Indic. Soil Conc. Unrestricted Land Use	Site Specific Natural Background[1]	DS-11-013123	DS-12-013123	DS-12-013125D	DS-13-013123	DS-14-013123	DS-15-013123	DS-16-013123	DS-17-013123	DS-18-013123	DS-19-013123	DS-20-013124
Collection Date							1/31/2023	1/31/2023	1/31/2023	1/31/2023	1/31/2023	1/31/2023	1/31/2023	1/31/2023	1/31/2023	1/31/2023	1/31/2023
Antimony (mg/kg)	32	5.42	5.06	-	5	2.48	10.7	1.2	0.841	1.07	4.79	2.09	3.54	3.68	1.37	3.02	2.44
Arsenic (mg/kg)	0.67	4.67	4.67	41	7	24.3	74.7	11.8	10.7	11.6	29.6	21.1	20.5	28.6	52.7	37.1	19
Lead (mg/kg)	250	3000	500	2480	50	124	49.1	9.83	8.91	9	23.3	16.9	13.4	22.6	133	46.8	85.8
Vanadium (mg/kg)	400	1600	-	-	2	67.5	33.1	22.8	23.7	19.4	27.9	18.5	24.2	21.1	16.7	59.8	29.7
Total Solids	-	-	-	-	-	-	78.50%	78.10%	78.10%	73.90%	78.20%	81.20%	65.10%	62.70%	84.30%	71.50%	52.20%
Total Organic Carbon	-	-	-	-	-	-	2.22%	1.80%	1.45%	2.94%	2.40%	1.59%	4.28%	7.96%	0.45%	6.94%	21.40%
pH	-	-	-	-	-	-	6.64 J	6.87 J	6.86 J	6.67 J	7.44 J	7.15 J	7.36 J	7.38 J	9.1 J	7.02 J	5.43 J

Analyte	Direct Contact	Protection of Drinking Water Vadose Zone	Soil Protect Surface Water Vadose Zone	Protect Sediment Vadose Zone	TEE Eco. Indic. Soil Conc. Unrestricted Land Use	Site Specific Natural Background[1]	DS-21-041323	DS-22-041323	DS-23-041323	DS-24-041323	DS-25-041323	DS-26-061923	DS-27-061923	DS-28-061923
Collection Date							4/12/2023	4/12/2023	4/12/2023	4/12/2023	4/12/2023	6/19/2023	6/19/2023	6/19/2023
Antimony (mg/kg)	32	5.42	5.06	-	5	2.48	0.398	0.305	0.255	5	3.58	1.5	1.8	4.8
Arsenic (mg/kg)	0.67	4.67	4.67	41	7	24.3	6.94	8.07	7.66	45.2	28.7	11	18	20
Lead (mg/kg)	250	3000	500	2480	50	124	13.8	11.3	11.9	37.7	37.2	30	7.6	20
Vanadium (mg/kg)	400	1600	-	-	2	67.5	46	50.8	62.2	40.4	26.7	47	32	22
Total Solids	-	-	-	-	-	-	72.6%	68.3%	63.40%	64.50%	85.70%	65.00%	89.00%	87.00%
Total Organic Carbon	-	-	-	-	-	-	4.66%	4.06%	6.06%	5.78%	1.37%	12.00%	1.30%	0.37%
pH	-	-	-	-	-	-	6.2	5.99	6.45	7.53	6.26	5.5	6.6	5.9

Notes:

For Total Metals - Indicates result exceeds the PCULs including background.

1. Background calculated from background soils samples following WAC 173-340-709 procedures

" -" Screening Level not available

ID - Identification

J: Analysis exceeded recommended hold time.

mg/kg: milligram per kilogram

PCULs: Preliminary Cleanup Level: Ecology Provided PCULs tables dated 3 February 2023

TEE - Terrestrial Ecological Evaluation; Lowest of the Plant, Soil Biota, or Wildlife TEE listed (see Table 5-7)

Reference:

Ecology. 2024. Preliminary Cleanup Levels – Excel Workbook, update July 2024.

Table 5-10: DU-2 Deep (8 to 12-inches below ground) Soil Sampling Results

Analyte	Direct Contact	Protection of Drinking Water Vadose Zone	Soil Protect Surface Water Vadose Zone	Protect Sediment Vadose Zone	TEE Eco. Indic. Soil Conc. Unrestricted Land Use	Site Specific Natural Background[1]	DU-1D-013123	DU-2D-013123	DU-3D-013123	DU-4D-013123	DU-5D-013123
	Preliminary Cleanup Levels (PCULs)					Collection Date	1/31/2023	1/31/2023	1/31/2023	1/31/2023	1/31/2023
Antimony (mg/kg)	32	5.42	5.06	-	5	2.48	4.2 J-	3.33	1.96	1.62	2.25
Arsenic (mg/kg)	0.666666667	4.67	4.67	41	7	24.3	14.5	12	5.78	9.54	18.5
Lead (mg/kg)	250	3000	500	2480	50	124	50.7	9.99	6.39	32.1	169
Vanadium (mg/kg)	400	1600	-	-	2	67.5	15.7	7.87	9.91	24.5	17.6
Total Solids	-	-	-	-	-	-	0.38%	0.28%	0.23%	0.39%	0.23%
Total Organic Carbon	-	-	-	-	-	-	84.10%	88.80%	83.40%	84.90%	87.20%
pH	-	-	-	-	-	-	8.35 J	8.38 J	8.51 J	8.38 J	8.45 J

Analyte	Direct Contact	Protection of Drinking Water Vadose Zone	Soil Protect Surface Water Vadose Zone	Protect Sediment Vadose Zone	TEE Eco. Indic. Soil Conc. Unrestricted Land Use	Site Specific Natural Background[1]	DU-6D-013123	DU-7D-013123	DU-7D-013123D	DU-8D-013123	DU-9D-013123	DU-10D-013123
	Preliminary Cleanup Levels (PCULs)					Collection Date	1/31/2023	1/31/2023	1/31/2023	1/31/2023	1/31/2023	1/31/2023
Antimony (mg/kg)	32	5.42	5.06	-	5	2.48	1.63	1.46	1.48	2.12	2.45	9.23
Arsenic (mg/kg)	0.666666667	4.67	4.67	41	7	24.3	4.08	9.65	10.4	14	27.2	91.9
Lead (mg/kg)	250	3000	500	2480	50	124	12.5	9.87	9.55	5.4	6.71	46.4
Vanadium (mg/kg)	400	1600	-	-	2	67.5	10.9	29.6	38	15.9	17.4	32.8
Total Solids	-	-	-	-	-	-	0.45%	1.29%	1.35%	0.31%	0.69%	4.45%
Total Organic Carbon	-	-	-	-	-	-	72.20%	72.40%	66.40%	73.90%	75.10%	51.50%
pH	-	-	-	-	-	-	8.26 J	7.99 J	7.86 J	7.75 J	7.66 J	7.6 J

Notes:

For Total Metals - Indicates result exceeds the PCULs including background.

1. Background calculated from background soils samples following WAC 173-340-709 procedures

" -" Screening Level not available

J-: Analyte concentration estimated and potentially biased low.

J: Analysis exceeded recommended hold time.

mg/kg: milligram per kilogram

PCULs: Preliminary Cleanup Level: Ecology Provided PCULs tables dated 3 February 2023

TEE - Terrestrial Ecological Evaluation; Lowest of the Plant, Soil Biota, or Wildlife TEE listed (see Table 5-7)

Reference:

Ecology. 2024. Preliminary Cleanup Levels – Excel Workbook, update July 2024.

Table 6-1: LDA Bedrock Aquifer Historical Groundwater Elevations

	Groundwater Elevation (feet NAVD88)											
Date Measured	2/10/2015	5/4/2015	8/4/2015	11/4/2015	2/8/2016	5/2/2016	8/22/2016	11/1/2016	1/31/2017	5/30/2017	8/16/2017	11/9/2017
MWB-1LDA	681.45	681.06	679.38	679.33	681.65	681.19	679.68	680.39	681.62	682.23	680.41	680.27
MWB-2LDA	705.96	705.32	703.24	703.85	705.98	705.63	703.74	704.59	705.66	706.22	703.97	704.55
MWB-3LDA	739.57	739.26	736.75	736.05	740.99	740.42	737.38	737.60	740.17	741.87	738.71	738.19

	Groundwater Elevation (feet NAVD88)											
Date Measured	2/28/2018	5/1/2018	8/22/2018	11/6/2018	3/11/2019	5/8/2019	8/27/2019	11/13/2019	2/14/2020	8/13/2020	12/9/2020	3/5/2021
MWB-1LDA	682.64	682.57	680.26	680.11	682.07	682.00	680.14	680.53	682.64	680.76	681.33	682.67
MWB-2LDA	706.71	706.55	703.76	704.00	705.98	705.80	703.81	704.44	706.56	704.45	705.11	706.64
MWB-3LDA	743.06	742.59	738.26	737.41	741.87	741.62	738.43	738.19	742.50	739.60	739.97	743.13

	Groundwater Elevation (feet NAVD88)											
Date Measured	6/10/2021	10/13/2021	1/5/2022	3/17/2022	6/21/2022	9/12/2022	12/12/2022	3/15/2023	6/27/2023	9/6/2023	12/12/2023	3/4/2024
MWB-1LDA	681.51	680.27	682.68	682.79	683.1	681.17	681.17	682.68	681.83	680.54	681.94	683.00
MWB-2LDA	705.37	703.90	706.35	707.14	706.96	704.66	705.25	706.57	705.62	703.92	706.20	707.06
MWB-3LDA	740.73	738.02	743.39	743.99	743.65	740.19	739.71	743.08	741.46	738.98	741.45	744.00

Notes:

feet NAVD88 - Feet NAVD88 Datum

LDA - Lower Disposal Area

Table 6-2: DSP Historical Groundwater Elevations

	Groundwater Elevation (feet NAVD88)											
Date Measured	2/10/2015	5/4/2015	8/4/2015	11/4/2015	2/8/2016	5/2/2016	8/22/2016	11/1/2016	1/31/2017	5/30/2017	8/16/2017	11/9/2017
MWB-1SDSP	900.32	897.62	887.08	879.44	903.27	898.81	886.51	888.80	900.72	901.59	891.97	891.58
MWB-4DSP	911.31	909.76	907.76	908.54	913.02	911.42	907.99	911.10	911.30	913.92	909.83	911.69
MWB-5DSP[1]	919.07	915.00	903.15	903.05	917.92	911.74	900.98	909.01	915.69	917.74	906.92	907.88
MWB-6DSP[1]	898.56	896.78	892.31	891.97	899.21	897.31	892.68	894.59	898.04	903.30	893.87	894.25

	Groundwater Elevation (feet NAVD88)											
Date Measured	2/28/2018	5/1/2018	8/22/2018	11/6/2018	3/11/2019	5/8/2019	8/27/2019	11/13/2019	2/14/2020	8/13/2020	12/9/2020	3/5/2021
MWB-1SDSP	904.25	902.30	888.34	883.35	903.20	901.92	888.41	889.26	905.21	892.30	896.62	901.33
MWB-4DSP	915.32	914.65	Note 2	910.71	914.11	913.32	909.56	910.46	915.81	910.45	911.83	914.72
MWB-5DSP[1]	918.50	917.36	902.42	902.61	916.21	915.30	901.79	902.02	918.35	907.68	910.37	918.14
MWB-6DSP[1]	899.45	899.15	892.48	891.99	898.65	898.18	892.79	894.30	899.86	894.71	896.59	899.09

	Groundwater Elevation (feet NAVD88)											
Date Measured	6/10/2021	10/18/2021	1/5/2022	3/18/2022	6/21/2022	9/13/2022	12/12/2022	3/16/2023	6/26/2023	9/5/2023	12/12/2023	3/8/2024
MWB-1SDSP	893.64	880.32	902.65	898.09	900.83	891.92	893.33	901.81	896.42	888.52	899.06	902.58
MWB-4DSP	910.94	909.19	914.75	915.71	914.46	910.81	913.39	914.95	912.43	Note 2	915.50	916.64
MWB-5DSP[1]	910.37	905.94	918.17	917.91	917.8	907.86	910.74	916.43	912.82	906.16	902.77	917.26
MWB-6DSP[1]	896.10	892.57	899.29	899.95	899.14	Note 4		905.92	900.24	897.097	902.467	902.47

Notes:

1. Groundwater elevations shown in here and in Appendix E.1 in wells MWB-5DSP and MWB-6DSP are corrected with a downward gradient observed in well pair MWB-1SDSP and MWB-1DDSP based upon screen elevations.

2. No readings available from MWB-4DSP due to wasp nest.

3. MWB-6DSP casing was raised by Reserve Silica in between August and November 2019. The New TOC elevation has not been surveyed.

4. MWB-6DSP was found damaged in July 2022. The well was repaired by late December 2022.

DSP - Dale Strip Pit

feet NAVD88 - Feet NAVD88 Datum

TOC - top of casing

Table 7-1: Surface Water Preliminary Cleanup Levels

Analyte	Most Stringent	WA State WQC Aquatic Life Fresh-Chronic WAC 173-201A-240, Table 240	NRWQC Aquatic Life Fresh - Chronic CWA Section 304	WA State WQC Human Health Consumption of Orgs + Water WAC 173-201A-240, Table 240	WA Toxics Rule (WTR) Human Health Consumption of Orgs + Water 40 CFR 131.45	NRWQC Human Health Consumption of Orgs + Water CWA Section 304	Comments
Antimony (ug/L)	**5.6**	-	-	12	6.0	5.6	Consumption of organisms and surface water are not complete exposure pathways at the Site
Arsenic (ug/L)	**0.018**	190	150	10	0.018	0.018	
Lead (ug/L)	**2.5**	2.52	2.5	2.5	-	-	
Vanadium (ug/L)	-	-	-	-	-	-	
pH (SU)	**6.5 to 8.5**				-	-	WAC 173-200 and 201A

Notes:
" -" Screening Level not available
ug/L: microgram per liter
SU = standard units
Reference:
Ecology. 2024. Preliminary Cleanup Levels – Excel Workbook, update July 2024.

Table 7-2: Groundwater Cleanup Levels

Analyte	Proposed Cleanup Level	Protect Drinking Water	Protect Surface Water	Protect Sediment	Puget Sound Basin Natural Background	Cleanup Level Basis
Antimony (ug/L)	**6.0**	6.0	5.60	-	-	Human Health
Arsenic (ug/L)	**8.0**	0.58	0.018	71	8	Natural background
Lead (ug/L)	**2.5**	15	2.5	12.4	-	Human health and freshwater aquatic life
Vanadium (ug/L)	**80**	80	-	-	-	Groundwater ingestion
pH	**6.5 to 8.5**					Water quality

Notes:
" -" Screening Level not available
ug/L: microgram per liter

Reference
Ecology. 2024. Preliminary Cleanup Levels – Excel Workbook, update July 2024.
Ecology. 2022. Natural Background Groundwater Arsenic Concentrations in Washington State, January 2022.

Table 7-3: Soil Cleanup Levels

COC	Soil Cleanup Level	Direct Contact[4]	Protection of Drinking Water Vadose Zone	Soil Protect Surface Water Vadose Zone	Protect Sediment Via Groundwater Vadose Zone	TEE Eco. Indic. Soil Conc. Unrestricted[1,5] Land Use	Site-Specific Natural Background[3]	Cleanup Level Basis
Antimony (mg/kg)	**5.0**	32	5.42	5.06	-	5	2.48	TEE Protect plants
Arsenic (mg/kg)	**24.3**	0.67	4.67	4.67	41	7	24.3	Site-Specific Natural Background
Lead (mg/kg)	**124**	250	3000	500	2480	50	124	Site-Specific Natural Background
Vanadium (mg/kg)	**67.5**	400	1600	-	-	2	67.5	Site-Specific Natural Background

Notes:
1. Terrestrial Ecological Evaluation standards for soil for unrestricted land use (Ecology 2019)
2. Sediment Management Standards, Based on protection of freshwater benthic organisms.
3. Background calculated from background soils samples following WAC 173-340-709 procedures
4. Point of compliance depth interval for protect of human health is surface to a depth of 15.0 feet.
5. Point of compliance depth interval for protect of ecological receptors is surface to a depth of 6.0 feet bgs.
" -" Screening Level not available
COC - Contaminants of Concern
mg/kg: milligram per kilogram

References
Ecology. 2019. Terrestrial Ecological Evaluations (TEE) under Model Toxics Control Act. 19-09-051. February.
Ecology. 2024. Preliminary Cleanup Levels – Excel Workbook, update July 2024.

Table 7-4: Sediment Cleanup Levels

COC	Sediment CUL (mg/kg)	Sediment PCUL for Direct Contact (mg/kg)	Sediment PCUL for Seafood Consumption (mg/kg)	Sediment PCUL for Freshwater Benthic (mg/kg)	Site-Specific Background Concentration	Cleanup Level Basis
Antimony (mg/kg)	**2.48**	-	-	-	2.48	Site-Specific Natural Background
Arsenic (mg/kg)	**24.3**	24.3	0.3	14	24.3	Site-Specific Natural Background
Lead (mg/kg)	**124**	124	0.1	360	124	Site-Specific Natural Background
Vanadium (mg/kg)	**67.5**	-	-	-	67.5	Site-Specific Natural Background

Notes:
1. Background calculated from background soils samples following WAC 173-340-709 procedures
" -" Screening Level not available
COC - Contaminants of Concern
CUL - Cleanup Levels
mg/kg: milligram per kilogram
PCUL - Preliminary Cleanup Levels

References

Ecology. 2024. Preliminary Cleanup Levels – Excel Workbook, update July 2024.