REPORT

Remedial Investigation/Feasibility Study Work Plan Reserve Silica Reclamation Site

Ecology Facility Site No. 2041/Cleanup Site No 4728

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ACRONYMS AND ABBREVIATIONS

Agreed Order	Agreed Order No. DE 16052
ARARs	applicable and relevant or appropriate requirements
bgs	below ground surface
BPA	Bonneville Power Administration
cm/sec	centimeters per second
CKD	cement kiln dust
DCA	Disproportionate Cost Analysis
DCAP	Draft Cleanup Action Plan
DDES	Department of Development and Environmental Services
DPER	Department of Permitting and Environmental Review
DO	dissolved oxygen
DSP	Dale Strip Pit
Ecology	Washington State Department of Ecology
EM	Electromagnetic induction
EPA	United States Environmental Protection Agency
FS	Feasibility Study
Golder	Golder Associates, Inc.
gpm	gallons per minute
Holcim	Holcim (US) Inc.
Ideal	Ideal Basic Industries, Inc.
IMP	Industrial Mineral Products Inc.
LDA	Lower Disposal Area
mg/L	milligrams per liter
msl	mean sea level
MTCA	Model Toxics Control Act
ORP	oxidation-reduction potential
pg/g	picogram per gram
Plant Site	Reserve Silica Sand Processing Plant
PLP	Potentially Liable Person
Public Health	Public Health - Seattle & King County
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RAO	Remedial Action Objective
RCW	Revised Code of Washington
Reserve Silica	Reserve Silica Corporation
RI	Remedial Investigation
SHA	Site Hazard Assessment
Site	Reserve Silica Reclamation Site
Smith Bros.	Smith Bros. Silica Sand, Inc.
SPLP	Synthetic Precipitation Leaching Procedure
TCLP	toxicity characteristic leaching procedure
TDS	total dissolved solids

TEE	Terrestrial Ecological Evaluation
TESI	Tacoma Environmental Sciences Inc.
USGS	United States Geological Survey
WAC	Washington Administrative Code
WRIA	Water Resource Inventory Area

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1.0 INTRODUCTION

This document is the Work Plan to conduct a Remedial Investigation (RI) and Feasibility Study (FS) at the Reserve Silica Reclamation site (Site) located in Ravensdale, Washington. Figure 1-1 shows the Site location. The Reserve Silica Reclamation site does not include the adjoining Reserve Silica Plant site north of Black Diamond-Ravensdale Road. Reserve Silica Corporation (Reserve Silica) and Holcim (US) Inc. (Holcim) entered into Agreed Order No. DE 16052 (Agreed Order) with the Washington State Department of Ecology (Ecology) for the Reserve Silica Reclamation site. BNSF Railway was also notified by Ecology of its status as a Potentially Liable Person (PLP) for the Site, but BNSF Railway declined to participate in the Agreed Order. This RI/FS Work Plan and attached support plans have been prepared to meet the requirements of the Agreed Order and complete the RI/FS in accordance with Revised Code of Washington (RCW) 70.105D.050(1) and the Washington State Model Toxics Control Act (MTCA) Cleanup Regulations. References to the "Site" in this Work Plan includes the area defined by Ecology in the Agreed Order as the Preliminary Site. Ecology indicated the final site, defined as the area where hazardous substances have come to be located, will be delineated by the results of the RI.

1.1 Objective and Purpose

The RI/FS will be conducted in accordance with the MTCA requirements for conducting an RI/FS, which are defined in Chapter 173-340-350 of the Washington Administrative Code (WAC). The objective of the RI/FS 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. Additional data are required 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.

The Site has been the subject of numerous environmental investigations and interim remedial actions completed under the approval of an interagency group consisting of Ecology and Public Health - Seattle & King County (Public Health). Routine groundwater and surface water monitoring has been conducted at the Site since 2006 under the requirements of Limited Purpose Landfill (Post-Closure) Annual Permits issued by Public Health. Additional information on the Site geology, hydrogeology, and disposal activities during reclamation are available from historical records and documents produced during the mining operations at the Site and during post-closure activities. Combined, these historical sources of Site data provide a strong and sufficient basis for development of a preliminary Conceptual Site Model (CSM). This Work Plan provides a summary of pertinent data collected from these various historical Site investigations and studies and identifies the areas where additional investigations and data collection are needed (i.e., data gaps) to complete the Conceptual Site Model and meet the objectives of the RI/FS.

1.2 Work Plan Organization

This RI/FS Work Plan has been structured in accordance with Exhibit B to the Agreed Order, Scope of Work and Schedule, to facilitate a clear understanding of the 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 will be completed. The remaining sections of this Work Plan are organized as follows:

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

- Section 3 – Previous Site Investigations and Environmental Quality. Presents a summary of the previous investigations completed at the Site including geophysical testing, groundwater, surface water, soil, and sediment sampling and analyses.
- Section 4 – Previous Remedial Actions. Describes interim remedial actions that have been implemented to mitigate environmental impacts at the Site, protect human health and the environment, and provided for ongoing water treatment for the protection of groundwater and surface water.
- Section 5 – Preliminary Conceptual Site Model, Identification of Data Gaps, and Preliminary Screening Levels. Uses the extensive amount of Site data provided from historical records, previous environmental investigations and remedial actions, and from current groundwater and surface water monitoring to identify the potential sources of contamination, potential environmental media impacted, and the potential contaminant exposure pathways and receptors. This section identifies the data gaps where additional investigations are needed to complete the CSM to meet the objectives of the MTCA RI/FS. This section also presents a discussion on the screening levels against which surface water, groundwater, soil, and sediment data will be compared to identify constituents of concern during the RI.
- Section 6 – Proposed Remedial Investigation Tasks. Presents the tasks and methodology proposed to collect data necessary to fill the identified data gaps for completion of the RI/FS.
- Section 7 – Feasibility Study Approach. Describes the approach to develop and evaluate the Site cleanup action alternatives in accordance with MTCA.
- Section 8 – Project Organization and Schedule. Presents the overall project organizational structure and schedule for carrying out the RI/FS activities consistent with the Agreed Order schedule and required deliverables.
- Section 9 – References. Includes citations for the references used to prepare this Work Plan.

Appendices to the Work Plan include the following:

Appendix A – Historical Photographs and Maps. Provides copies of historical aerial photographs and maps with data or information pertinent to the scoping and completion of the Site RI/FS.

Appendix B – Data Summary Tables. Provides historical data referenced in the development of this Work Plan and in development of the preliminary CSM.

Appendix C – Site Borehole Logs. Presents borehole logs and well construction information for historical boreholes, piezometers, and monitoring wells that will be used during the RI.

Appendix D – Sampling and Analysis Plan (SAP). Identifies the sampling locations and provides a discussion of the methods and procedures that will be used to conduct the RI.

Appendix E – Quality Assurance Project Plan (QAPP). Identifies the field and laboratory quality assurance/quality control (QA/QC) procedures that will be used during the RI for making accurate measurements and obtaining representative, accurate, and precise analytical data.

Appendix F – Health and Safety Plan (HASP). Identifies the project tasks, contaminants and hazards, and the safety procedures for addressing hazards. Procedures for addressing potential emergencies associated with the project are also discussed in the Health and Safety Plan.

2.0 SITE BACKGROUND AND ENVIRONMENTAL SETTING

The Site was first used for 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 deep pits are oriented along the “strike” or geographic orientation of the coal and sandstone bedrock units. Reclamation of the surface coal and sand pits on the Site started in 1971 and included landfilling the pits with mine spoils (the non-economical soil and rock produced during mining) from the Site and with imported fill material including cement kiln dust (CKD).

CKD was placed in two former mine pits at the Site: the Lower Disposal Area (LDA) and the Dale Strip Pit (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 PR0015708. The North Pit, Upper Pit, Lower Pit, Tan Sand Pit, and Middle Pit which are 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 #PR0082027. Locations of the LDA, DSP, and other historic sand mining pits are shown on Figure 2-1.

2.1 Site Location and Surrounding Land Use

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

1) 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.

2) 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 Landfill Lot, which contains both the LDA and the DSP.

3) 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. A portion of the Infiltration Ponds and 2 of the existing Site groundwater monitoring wells are located within the boundaries of the Baja Property

The 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 and south.
- 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 feet wide Bonneville Power Administration (BPA) easement transects the Site from east to west and contains three sets of transmission towers and overhead electrical lines.

2.2 Site History

The earliest identified uses of the Site are coal mining activities, dating back to the early 1900s and continued through at least 1947. Records indicate underground and surface strip coal mining was conducted by various operators during that time period. A review of available aerial photograph coverage and historical maps are included in Appendix A and indicate the following:

- 1928 – A facility map of the Dale Coal Company and N.W. Briquetting Company shows coal mine processing and loading facilities on the northern portion of the Site and extending north across Black Diamond-Ravensdale Road.
- 1931 – A coal mine map dated 1925 / revised 1931 shows active mining of the Dale Mine No. 1, a portion of which is beneath the DSP. The Dale tunnel, which originally provided mine dewatering and access to the underground coal seams and now drains groundwater from the mine workings, is evident extending from Dale No. 7 Seam and the Dale No. 4 Seam leading north to the mine portal (Figure 2-3).
- 1936 –A 1924/revised 1936 coal mine map indicates that the Dale No. 4 and Dale No. 7 seams had been 'mined out' by this time. Additional mining of the Dale No. 7 seam was performed through the Anderson Mine Portal on the southern portion of the seam from 1945 to 1948 (Ideal 1984).
- 1944 – The 1944 aerial photograph shows a road from north to south through the Site and coal mine processing facilities in the vicinity of the northern end of the Site, including the mine portal, machine shop, water tank, and tipple. This photo also shows the transport of coal tailings across the current alignment of Black Diamond-Ravensdale Road.
- 1952 – The aerial photograph shows recent strip mining of coal from the DSP, which was reportedly conducted between 1946 and 1950. Although underground mining ceased in 1948, the majority of the coal processing facilities remain on the northern portion of the Site at the time of this aerial photo. The 1952 aerial photograph shows the locations of the Dale Coal Company and N.W. Briquetting Company facilities and rail spurs shown in the 1928 facility map, before their decommissioning in the mid-1950s.
- 1957 – Coal processing facilities are not evident on this aerial photograph, indicating that they were likely demolished and removed between 1952 and 1957, including railroad lines that were located on the south side of Black Diamond-Ravensdale Road.
- 1968 – This aerial photograph shows the east-west trending BPA powerline easement for the first time, including a linear, deforested area with access roads on the ground and power lines overhead.
- 1979 and 1980 – The LDA appears fully deforested with significant ground disturbance. The DSP, still open in 1979, appears vegetated except for that portion in the powerline easement. Ground disturbance is also evident between the LDA and the DSP.
- 1990 – The LDA and DSP appear to have been filled and reclaimed, as evidenced by cover vegetation evident in this aerial photograph. Linear ground disturbance is evident extending north onto the Site from the south-adjacent sandstone mining activities. This map clearly shows the Infiltration Ponds, located at the northwest corner of the Site, for the first time.
- 2006 and 2009 – Ongoing fill and reclamation of the sandstone pits is evident and those portions of the Upper Pit and North Pit that extend onto the Site appear filled in the 2006 aerial, although surficial grading appears ongoing.

- 2013 and 2017 – Vegetation covers all the previously mined areas on the Site, indicating complete restoration of those areas. Filling and reclamation of the Upper Pit, Lower Pit, Tan Sand Pit, North Pit and Middle Pit is ongoing.

Currently, ongoing operations at the Site consist of landfilling of the inert waste landfill at the former silica sand pit mines on Lot 5 and ongoing monitoring activities required under the Closed Landfill Permit associated with the LDA and DSP on Lot 6.

Based on information available from historical documents, the following sections present additional details of the historical mining, filling, and restoration activities conducted at the Site.

2.2.1 Site Owner and Operator History

The Northwestern Improvement Company, a subsidiary of Northern Pacific Railway, conducted coal mining and strip mining at the Site from the early 1900s until 1947 (Ecology & Environment 1986). Between 1947 and 1968 no operations are known to have been conducted on the Site (Ecology & Environment 1986). Northern Pacific merged with Great Northern and several other railways on March 2, 1970, to form Burlington Northern (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 the Site 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, Burlington Northern Railroad Company (aka Northern Pacific Railway). The Site was then leased by Industrial Mineral Products, Inc. (IMP), which took over from Smith Bros. in 1972. L-Bar Products, Inc. then began leasing the Site from IMP on January 1, 1986. In May 1991, L-Bar Products, Inc. changed its name to Reserve Silica Corporation and Reserve Silica continued leasing the Site for sand mining operations at this time. In 1997, Reserve Silica purchased the Site from Glacier Park Company (EDR 2020). Glacier Park Company was originally a subsidiary of Great Northern (Mayes 1990) and later became a subsidiary of Burlington Northern after the March 2, 1970 merger. Sand mining and processing was conducted at the 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, beginning in 1979, to the Dale Strip Pit Reclamation Project, which appears to have included both the LDA and the DSP, for disposal. In 1991, Ideal was purchased and merged with several other companies to become Holnam, Inc., which subsequently became Holcim (US) Inc. in the early 2000s.

2.2.2 Mining History

Surface and underground coal mining were conducted on portions of the Site between the early 1900s and approximately 1947. Sandstone mining began in approximately 1968 and continued until 2008. Several historical mining pits were located on the Site:

- The DSP is a former surface strip coal mine that was mined in the late 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 and sandstone mining wastes (TESI 2000) and/or rejected clay and sand batches and glass cullet waste (Ideal 1984).
- The LDA is a former sand mine that mined sandstone in the late 1960s/early 1970s. CKD was disposed in the LDA between June 1979 and October 1982 (Ideal 1984).
- Sand mining of the Upper Pit, North Pit, Lower Pit, Tan Sand Pit, and Middle Pit occurred between the late 1980s and 2007. Most 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 is ongoing under an inert waste landfill permit.

2.2.2.1 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 coal in this district is also low sulfur containing coal (Vine 1969). 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 and 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). Due to the low levels of sulfur in coal deposits of King County, AMD is not a factor at the Site.

The coal mines in the Ravensdale district were opened in 1899 by the Seattle and San Francisco Railway and Navigation Property 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 the Site consisted of surface strip mining of the DSP and 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) (Figure 2-3; Appendix A). Beyond the 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 Site, to the Dale Coal Mine processing area located on the northern portion of the Site (Figure 2-3). The Dale Coal Mine processing area included a washery, Sulphur storage, cooler and drying room, tipple, and machine shops with a generator room (Figure 2-4; Appendix A; 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 provides maps and aerial photographs showing historical coal mining activities on and adjacent to the Site.

2.2.2.2 Coal Mining Methods

Both surface (strip) and underground coal mining occurred at the Site. A conceptual section of the mining methods utilized for mining the Dale Mine No. 1 coal seams is included as Figure 2-5. The section view is roughly parallel to the bed of the coal seam; the line of the conceptual cross-section is shown on Figure 2-3. 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 at least 1932. 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 located to the southeast of the 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 located approximately 2,000 feet northwest of the DSP at elevation 635 feet above mean sea level (msl; Figure 2-3). The Dale Tunnel was advanced up an unknown coal seam overlying the Dale No. 4 seam (Metropolitan Engineers 1972). The Dale Tunnel inclined gradually to a maximum elevation of 670 feet msl at the southern end, corresponding to depths of 240 to 270 feet below ground surface (bgs), to facilitate gravity drainage of groundwater. Groundwater from the Dale No. 4 and No. 7 seams continues to gravity drain to the mine portal.

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 Site are depicted by the green hatched boundaries shown on 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, averaged 140 feet wide, east to west, and 40 feet deep with sloping sides (Metropolitan Engineers 1972). The extent of the DSP is shown on Figure 2-3. 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 2-4). The railroad tracks and tipple were located near the present-day Black Diamond-Ravensdale Road, with disposal of non-saleable coal to the north of the Site (where the former Reserve Silica Plant Site was located), as evidenced by historical aerial photographs (Appendix A). Coal mining-related operations and structures on the northern portion of the 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, the facilities associated with coal mining and processing were removed from the Site between 1952 and 1957 (Appendix A).

2.2.2.3 Sand Mining History

Mining of silica sand began at the Site in approximately 1968 with the LDA pit and continued in other portions of the Site until production ceased in November of 2008. The raw material occurred as 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 located north of the 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 depth of the sand mining operations was limited by the presence of water in the strip pit. 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 to this 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 approximately 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 on 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 prevented pooled water and shallow groundwater in the 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 Work Plan. The reclamation is being conducted under an active Inert Waste Landfill permit, which allows for acceptance and disposal of inert waste including cured concrete, asphaltic materials, brick and masonry, ceramic materials, glass, stainless steel and aluminum, and soil that meets specified chemical criteria.

2.2.3 Reclamation and Landfilling

Reclamation and landfilling have been conducted under county grading permits since 1971, including a King County Department of Permitting and Environmental Review Grading Permit (#L7061122; Bennett 2014) and later the King County Building and Land Development Grading Permit (No. 1122-58; Ideal 1984). King County required Reserve Silica to obtain landfill permits from Public Health, beginning in 2012. 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). A 2014 Interim Reclamation Plan describes the reclamation activities for the Lower and North Pits (Bennett 2014), as described further below.

2.2.3.1 Limited Purpose Landfill

Beginning in 2012, Public Health approved a closed, limited purpose landfill permit for the LDA and DSP. The permit is updated annually. A summary of the reclamation of the LDA and DSP is provided below.

Lower Disposal Area. The LDA was filled with approximately 175,000 cubic yards of CKD between June 1979 and August 1981. The original excavated area measured approximately 3.5 acres, was 40 feet deep, 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 (P-14, see Figure 3-12), indicated that the LDA extends approximately 60 feet below the current ground surface of the LDA where sandstone bedrock is encountered (Golder 2021). The surface cover - including a 2 feet thick layer of clay underneath a 7 feet layer of overburden from sand mining operations and revegetation of the LDA—was completed by the fall of 1983. In 2008, 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 (Golder 2008).

Dale Strip Pit Area. 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 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 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 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. Initial capping of the DSP was completed in the early 1990s (TESI 2000). The cap of the DSP consists of a 4 feet layer of clay soil underneath three feet of sand overburden from sand mining operations (Hart Crowser 1989). 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).

2.2.3.2 Inert Waste Landfill

Beginning in 2012, Public Health approved an inert waste disposal permit for reclamation and landfilling of the Lower and North Pits (Public Health 2012a). The Upper Pit had already been reclaimed by this time. 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 #L70G1122 and reclaimed with inert fill in the 2000s.

Lower and North Pits. Currently, the Lower Pit and the North Pit are undergoing backfilling under the Inert Waste Landfill Permit #PR0082027, issued by Public Health. 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).

The following information was stated in the *Lot 6 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 and 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 (Interim Reclamation Plan Bennett 2014). 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 and the fill is certified to meet restrictions for inert waste. There are no post-closure monitoring or financial assurance requirements for inert waste landfills.

Roadway Areas. IMP reportedly accepted processed slag from the ASARCO smelting facility in Tacoma, Washington. Slag was reportedly used to improve traction on slippery haul roads at the Site (Ecology and Environment 1986, and investigations completed by TESI reported "…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).

2.3 Physical Setting

2.3.1 Topography

The Site is located on the southwest flank and at the base of a glacially carved bedrock high, 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 located 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 Site ranges from approximately 600 feet NAVD88 on the northern portions of the 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.

2.3.2 Land Use

The current land use of the Site is varied as discussed throughout this Work Plan. The Closed Landfill will be managed in accordance with applicable state regulations (Minimum Functional Standards for Solid Waste Handling, WAC 173-304). The currently applicable regulations for the Inert Waste Landfill are the Solid Waste Handling Standards, WAC 173-350. Once reclamation of the Inert Waste Landfill is complete, it will transition to management under a closed landfill permit. The landfill will be maintained under appropriate land use designations, in accordance with the applicable landfill regulations, in perpetuity.

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

2.3.3 Geology and Hydrogeology

2.3.3.1 Regional Geology

The 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 13,000 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).

2.3.3.2 Site Geology

Three geologic units have been identified at the Site, in addition to artificial fill soil, and include (1) Eocene age sedimentary bedrock units of the Puget Group-Renton Formation, (2) Vashon-age lodgment silty sand and gravel till, and (3) Vashon recessional outwash gravel (SubTerra 2006). A surface geologic map of the Site is provided in Figure 2-8.

The Puget Group-Renton Formation forms the sedimentary bedrock core of the northwest trending ridge that underlies the 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 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.

The Vashon-age lodgment till occurs as a 5 to 15 feet thick mantle at the land surface, except for the bedrock highs, 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 Site is evident by standing water that ponds on top of the till.

Vashon recessional outwash gravel is documented to the northwest of Black Diamond-Ravensdale Road 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 Site, and in the area of the former processing plant and underlying the settling ponds on the adjoining Reserve Silica Plant site.

2.3.3.3 Hydrogeology

Three aquifers are identified near the Site according to studies by SubTerra (SubTerra 2006):

1) The uppermost aquifer is an unconfined aquifer in glacial deposits that appears connected to surface water features in the area, including Ravensdale Lake and Wetland A. Surface water runoff from north of the power line drainage divide, as well as groundwater that drains from the DSP 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 lodgment till) confining layer separates the uppermost aquifer from a lower aquifer, which is located within glacial outwash sands and gravels and preglacial sediments that are up to 200 feet

thick (SubTerra 2006). This middle, glacial outwash aquifer is identified to the west but is absent beneath the Site (SubTerra 2006).

3) Bedrock aquifer that 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, and water wells completed within it 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 on the north end of the 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 historic 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).

Shallow perched groundwater, present in localized areas within the unconsolidated soils and fill soils at the 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 located west of the Site.

2.3.4 Groundwater Use

SubTerra presented a summary of domestic water supply wells within 1-mile upgradient and 2-miles downgradient of the Site at the time the SubTerra report was prepared in 2006 (SubTerra 2006). The Subterra study indicated that the nearest domestic wells are community water supply wells that provide water supply to the Maple Ridge Highlands community, located to the northwest. The wells range in total depth from 74 to 209 feet bgs. The community of Ravensdale, located north and northeast of the Site, has municipal water service through the Evergreen Water and Improvement Association from a supply well located more than 5,000 feet from the Site.

A review of water wells from Ecology's database indicated 69 private wells were found within a 1-mile radius of the Site. The closest private well is the Baja Property private well located approximately 500 feet southwest of the Infiltration Ponds. The Baja Property private well was sampled for pH, total and dissolved arsenic, cadmium, chromium, lead, iron, and manganese on April 4, 2018 (Golder 2018a). 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. Figure 2-7 shows the approximate locations of water wells found from Ecology's database, including the Baja Property private well.

A well log from 1988 documents the construction of test well somewhere in the vicinity of the 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 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 (Appendix A).

2.3.5 Surface Water

The Site is located within the Lake Sawyer drainage basin, which is part of the Lower Green-Duwamish River Watershed of the Duwamish-Green Water Resource Inventory Area (WRIA) 9. A local surface water divide roughly correlates to the BPA power transmission lines near the center of the 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 to the south of the Site.

Ravensdale Lake is located north of the Site and is reportedly fed by springs and surface water. Ravensdale Lake drains to Ravensdale Creek, 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 Site and is supplied by precipitation and groundwater from the LDA (SubTerra 2006). Water in the South Pond is present intermittently, depending on seasonality, and is completely dry for several months of the year. Surface water sampling of the South Pond has been conducted on a regular basis since February 2005 for field parameters, general chemistry, and dissolved metals. The pH of surface water in the South Pond has been measured to range from 9.2 to 13.1 and is typically between 10 and 12, which exceed the surface water standard of 6.5 to 8.5. 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).

A series of three interconnected infiltration ponds are located to the northwest of the LDA, near the northwest corner of the Site. 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 Site 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 that is captured in the seep collection ditch is piped to the seepage treatment facility installed in 2018. Following treatment, the water is piped to the Infiltration Ponds. Surface water sampling of the Infiltration Ponds has been conducted on a regular basis since February 2015 for field parameters, general chemistry, and dissolved metals. Prior to the installation of the seepage treatment system in 2018, pH of surface water in the infiltrations ponds ranged from 9 to greater than 12.5. Since the start of the treatment system in 2018, pH of the Infiltration Ponds water has continued to attenuate and since November 2019 is consistently below 9.0. The discharge to the Infiltration Ponds is covered under the Ecology Sand and Gravel General Permit (WAG503029; Ecology, 2016). The current flow of surface water at the Site during the wet season is shown on Figure 2-9.

3.0 PREVIOUS SITE INVESTIGATIONS AND ENVIRONMENTAL QUALITY

Numerous environmental investigations, monitoring activities, evaluations of remedial alternatives, and remedial actions have occurred at the Site starting in the early 1970s and continuing to the present. This section provides an overview of the most relevant Site monitoring and environmental investigations completed to evaluate and address environmental impacts associated with permitted disposal activities that historically occurred at the Site. Figure 3-1 provides the locations of the existing piezometers and monitoring wells at the Site. Figure 3-2 provides the locations of all previous boreholes, piezometers, and test pits completed by Golder in addition to the existing monitoring wells at the Site. Figure 3-3 provides a closer view at the previous boreholes, piezometers, and test pits installed by Golder to investigate the subsurface conditions of the LDA.

3.1 Previous Field Investigations

Numerous investigations have been conducted at the Site since 1972 to evaluate and characterize environmental conditions and potential impacts associated with mining and permitted disposal activities that historically occurred at the Site. Many of these historical site investigation and evaluation reports are available for downloading and viewing on Ecology's Site electronic documents repository (https://apps.ecology.wa.gov/gsp/CleanupSiteDocuments.aspx?csid=4728). Relevant data and evaluations from historical reports have been incorporated into this RI Work Plan and used to develop the preliminary CSM. Below is an annotated summary of the key reports that were evaluated in the development of this RI Work Plan:

- Metropolitan Engineers, 1972, Final Report Geologic and Hydrologic Conditions. This report summarizes the coal mining activities, early sand mining activities, geologic and hydrogeologic interpretations of the Site, and includes the earliest summary of environmental conditions at the Site.
- Ideal Basic Industries, 1984, Individual Exemption to Petition for Cement Kiln Dust Designation. This report discussed 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 & Environment, 1986, Site Inspection Report. This report discusses the results of a file review and site inspection conducted by Ecology & Environment (E&E) on behalf of the United States Environmental Protection Agency (EPA) at the Site, which was at the time under ownership of L-Bar Products. The site inspection was conducted to collect additional information on the nature and extent of past waste disposal activities at the 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 upon the reported location of this catch basin (Figure 2; Ecology & Environment 1986), a portion of the catch basin may have been converted in what is today known as the Infiltration Pond.
  - Section 11 of the report 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 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 report 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 report indicated pH was approximately 12 standard units and lead concentrations varied from 1 to 2 mg/L. The elevated pH of the surface water was determined to be 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). 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 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 Site topographic, hydrologic, hydrogeologic and geologic conditions; a summary of compliance groundwater and surface water monitoring activities conducted at the 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 was resulting 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 4 of this Work Plan, 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 Site geology, hydrogeology, environmental impacts associates with the CKD disposal areas, and 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 are presented in this Work Plan (Figures 3-4, 3-5). Analytical data collected between 2002 and 2006 from 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 metals 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 infiltrating from the surface 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 $1x10^{-5}$ 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 west of the 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 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 non-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 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 of 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 was 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, siltstone and sandstone of the Puget Group were encountered extending to the depths explored. The composition of the bedrock varied across the 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 3-6). 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 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 located at the south end of the LDA and extending to the observed seep discharge area along the northwest boundary.
  - Groundwater does not flow across or around 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 remedial activities for the Reserve Silica Plant site are not discussed in this Work Plan. Investigations were conducted along the portion of the Lower Haul Road that is located west of the LDA to evaluate the potential presence 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 northern most 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 for Synthetic Precipitation Leaching Procedure (SPLP), which measures potential leachability of metals under natural conditions[1]. 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 3-7 and 3-8 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 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 two 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 C of this Work Plan[2].
  - As shown on Table 3-1, concentrations of total arsenic and lead are present in surface and shallow subsurface fill soil along the Lower Haul Road. The reported 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. The SPLP testing did not detect leachable concentrations of arsenic and lead. Despite the presence of slag and detectable concentrations of total arsenic and lead in fill soil, arsenic and lead do not appear to be leachable under neutral pH conditions, and would therefore be, immobile under neutral pH conditions (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 3-7, Appendix C) were excavated along the Lower Haul Road in the general area of the soil borings completed 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

[1] The SPLP method (1312) provides extraction fluid specifications based on the material being tested and the region from which the sample was collected. The samples collected as part of this investigation were treated with Extraction Fluid #2, per Method 1312, to determine leachability of soil from a site west of the Mississippi River, using a fluid with a pH of 5.00 +/- 0.05, intended to simulate leaching under natural conditions given the pH of rainfall for a region.
[2] Borings AB-01 to AB-04 were collected on the Reserve Silica Plant site and are not included in Appendix C.

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 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 milligrams per liter [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).

- Golder, 2018b, Interceptor Trench Investigation Summary and Recommendations. As detailed in Section 4 of this RI Work Plan, 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 indicate 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 along the access road located along the southeast side of the LDA. CKD was encountered in several of these boreholes, and 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 3-3 shows the location of the boreholes, and Figure 3-9 depicts cross-section showing the material encountered in the boreholes. Borehole logs are included in Appendix C.
  - 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 on Figure 3-3, 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 3-10 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 3-6 shows the areas surveyed in 2010 and 2019 combined onto 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 conductivities 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 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

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 this 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 to Ecology (Golder 2020). Results of the 2020 survey (provided in Figures 3-11 and 3-12) 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 on Figure 3-7. 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 kV BPA power lines transect the DSP and is 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.

- Golder, 2021, 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 C:
  - 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 two 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 located 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 COPCs: antimony, arsenic, beryllium, chromium, lead, mercury, nickel, selenium, silver, thallium, vanadium, and 2,3,7,8-substituted dioxins & furans. The purpose of analyzing for this expanded list of COPCs in P-14 was to evaluate the presence and concentrations of these compounds in groundwater located 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 that copper also be analyzed for in the P-11 sample, 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 Site. Analyzing groundwater samples from wells P-14 and P-11 for a similar list of COPCs allows for a preliminary evaluation of groundwater quality within and downgradient of the LDA.

Table 3-4A presents a summary of the field parameters and laboratory metals analytical results for the groundwater samples collected from P-14 and P-11. Table 3-4B 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 MTCA cleanup levels.
- Vanadium was detected in P-11 at a reported concentration that exceeded MTCA cleanup level. Vanadium was also detected in P-14 but at a reported concentration that was below the MTCA cleanup level.
- The estimated concentration of thallium reported in P-11 was slightly above the MTCA cleanup level, but the reported 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 reported in P-11 were significantly higher (more than 200% higher) than the concentrations reported in P-14.
- There were no dioxins or furans compounds detected above the laboratory reporting limits.

3.2 Groundwater and Surface Water Monitoring

Quarterly surface water and groundwater monitoring has been conducted at the 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.

In addition to the monitoring conducted under the closed landfill permits, groundwater and surface water monitoring have been conducted at various locations on the Site since 2002. Figure 3-1 shows well locations and groundwater and surface water sampling locations. Table 3-3 provides the construction details for the DSP and LDA groundwater monitoring wells. Arcadis performed monthly and quarterly monitoring activities from 2006 through the second quarter of 2009. Golder assumed responsibility for monitoring activities in August 2009 and conducted groundwater and surface water monitoring until April 2014. GeoEngineers performed groundwater and surface monitoring from May to December 2014. Golder resumed the groundwater and surface monitoring in February 2015 and is currently performing the monitoring. Monitoring frequency for various sampling locations has varied dependent on data needs. Historical monitoring frequency is summarized as follows:

- Groundwater monitoring of the shallow/alluvial monitoring wells generally occurred on a quarterly schedule from July 2005 to September 2008. After the seep collection test trenches were installed, groundwater monitoring frequency for the four wells around the Infiltration Ponds was increased to monthly through September 2009. At the end of the formal test trench monitoring program in October 2009, the sampling frequency for these four wells returned to quarterly.
- Surface water monitoring of the Infiltration Ponds, Weir, South Pond, and Still Well generally occurred on a monthly schedule, unless dry, from February 2005 to June 2008 and then was reduced to the current quarterly schedule.
- Groundwater monitoring of wells MWB-1SDSP and MWB-1DDSP generally occurred on a quarterly schedule starting in December 2002. Monitoring of well MWB-5DSP generally occurred on a monthly schedule from December 2006 to June 2008, and then monitoring was reduced to quarterly. Groundwater monitoring of well MWB-6DSP generally occurred on a quarterly schedule starting in December 2006. Groundwater levels and field parameters are measured in wells MWB-2DSP and MWB-4SDSP on a quarterly schedule. Surface water monitoring of the mine portal discharge generally occurred on a quarterly schedule starting in March 2002.

A variance to reduce the monitoring frequency of the DSP wells was granted by Public Health on March 15, 2012 and renewed on April 17, 2016 and on October 10, 2019 (Public Health 2012b, 2016b, 2019). The reduction in monitoring frequency was supported by the following:

- The DSP monitoring wells (MWB-1SDSP, MWB-1DDSP, MWB-2DSP, MWB-4SDSP, MWB-5DSP, and MWB-6DSP), the DSP mine portal, and the LDA bedrock wells (MWB-1LDA, MWB-2LDA, and MWB-3LDA) were sampled numerous times with some wells sampled since 2002. Quarterly sampling of DSP wells MWB-1SDSP, MWB-1DDSP, occurred from 2003 until 2012. DSP wells MWB-5DSP and MWB-6DSP were sampled monthly in 2007, quarterly from 2008 to 2012, and semi-annually since 2012. The LDA wells were sampled quarterly since December 2006. At the time the initial variance was granted in 2012, all wells and the mine portal had significantly more than 8 quarters of groundwater monitoring and several years of additional data under various monthly and quarterly sampling plans.

- Sufficient groundwater analytical data were collected to evaluate the nature of bedrock groundwater in the vicinity of the DSP and the LDA. These evaluations were presented to Public Health and Ecology in quarterly monitoring reports. The groundwater data from the DSP and LDA wells indicate that no groundwater impacts have occurred in the bedrock wells. Impacts from the LDA were observed in select shallow groundwater wells and surface water locations. All LDA shallow groundwater wells and surface water sampling locations remained on a quarterly monitoring frequency.
- The historical groundwater analytical data for the DSP wells and mine portal and the LDA bedrock wells support that bedrock groundwater has not been impacted by CKD. Specifically, pH levels are near neutral, and the arsenic concentrations are consistent with those typically seen in groundwater in this area. Additionally, the arsenic concentrations and pH levels are much lower than those detected in wells with known CKD impact.
- Statistical trend analysis and background evaluation of arsenic in the bedrock groundwater indicated groundwater concentration trends in the bedrock wells were predominantly steady or decreasing and did not indicate impacts to the bedrock groundwater from the DSP or LDA.
- The soil cover upgrade at the DSP was completed in 2011, and the LDA cover was completed in 2007. Therefore, groundwater monitoring data collected quarterly was no longer needed for characterization of the Site or to support selection of measures to reduce the potential for future impacts. The upgrades included increasing the cover thickness in some areas, grading to provide positive drainage on the cover surfaces, and the construction of drainage ditches along the perimeter of the covers to direct surface water away from the cover areas. Therefore, annual sampling was determined adequate to evaluate any changes to bedrock groundwater quality.
- The groundwater analytical data did not indicate seasonal variations in groundwater concentrations of arsenic or potassium (the key indicator analytes) in any of the DSP or LDA bedrock wells or the DSP. Furthermore, there were no short-term temporal trends that could be identified in the data. Since there are no seasonal variations, and long-term concentration trends can be evaluated with less frequent monitoring, annual sampling was determined to be sufficient to monitor groundwater quality in the DSP and LDA bedrock groundwater.

The current groundwater and surface water monitoring being conducted at the Site to fulfill the requirements of the 2021 Post-Closure Care and Maintenance Permit (PR0015708) includes the following:

- Quarterly collection of groundwater samples from six on-site shallow/alluvial groundwater monitoring wells (MW-1A, MW-2A, MW-3A, MW-4A, MW-5A, and MW-6A) as part of the LDA monitoring program.
- Annual collection of groundwater samples from three on-site bedrock groundwater monitoring wells (MWB-1LDA, MWB-2LDA, and MWB-3LDA) as part of the LDA monitoring program.
- Annual collection of groundwater samples from four on-site bedrock groundwater-monitoring wells (MWB-1SDSP, MWB-1DDSP, MWB-5DSP, MWB-6DSP) as part of the DSP monitoring program.
- Semi-annual measurement of water levels and field parameters in monitoring wells MWB-2DSP and MWB-4SDSP as part of the DSP monitoring program.

- Quarterly collection of surface water samples from the Infiltration Ponds, Weir (or the constructed wetlands located upstream if the Weir is dry), South Pond, and Still Well as part of the LDA surface water sampling program.
- Annual collection of water samples from the culvert that discharges from the former mine portal as part of the DSP sampling program.
- Measurement of field parameters in water purged from the groundwater monitoring wells, and in water sampled directly from the surface water areas. Field parameters include groundwater level readings (in wells only), pH, conductivity, temperature, dissolved oxygen (DO), oxidation-reduction potential (ORP), and turbidity.
- Analysis of the groundwater, surface water, and quality control samples for dissolved arsenic, lead, iron, manganese, potassium, and total dissolved solids (TDS).
- Quarterly Interceptor Trench monitoring for instantaneous flow volume and sampling for pH, TDS, and turbidity.

Monitoring data collected during these routine monitoring events are reported to Ecology, Public Health, and King County Department of Permitting and Environmental Review in quarterly monitoring reports submitted following receipt and validation of analytical results from the laboratories. Appendix B provides summary tables of historical surface water and groundwater sampling data.

The groundwater and surface water data collected at the Site since 2005 support the following findings:

- There have been no observed impacts to surface water or groundwater associated with the CKD in the DSP. This is based on over 10 years of groundwater and surface water sampling and analyses collected from groundwater monitoring wells screened directly beneath the DSP and hydraulically upgradient and downgradient of the DSP. Additionally, over 15 years of samples collected from the DSP mine portal have not indicated impacts to groundwater from acid mine drainage from the Dale No. 1 coal mine or impacts related to the CKD disposal in the DSP. The mine portal drains groundwater from those portions of the historical mine workings located directly beneath the CKD disposal area in the DSP.
- Shallow groundwater present within the LDA disposal area and glacial deposits overlying the bedrock located hydrologically downgradient (west to northwest) of the LDA are impacted by high pH and dissolved arsenic and lead concentrations above preliminary screening levels (PSLs). Samples collected from the bedrock groundwater monitoring wells downgradient of the LDA are not impacted.
- Surface water samples collected from an area west of the LDA, where the shallow groundwater daylights through seeps, is also impacted by high pH and dissolved arsenic and lead. In addition, the South Pond is a topographic low point located west of the LDA. During the wet season impacted shallow groundwater daylights in the South Pond creating an ephemeral surface water ponding. The water is high pH and elevated in dissolved arsenic and lead. The South Pond area and the seep area are completely fenced to prevent access to areas where impacted surface waters are present.
- The three interconnected Infiltration Ponds exhibited elevated pH after the LDA seepage was captured and directed to the ponds (as early as 1987). Since the seepage treatment system began operating in 2018, pH levels in the Infiltration Ponds have been consistently decreasing, stabilizing around a pH of 8 to 8.9 pH units. The Infiltration Ponds are fenced with security fencing to prevent unauthorized access.

- As shown on Figure 3-1, there are 4 shallow groundwater monitoring wells surrounding the Infiltration Ponds (MW-1A, MW-2A, MW-5A, and MW-6A). Prior to the start of the seepage treatment system, groundwater in MW-5A and MW-6A, which are located along the west side of the Infiltration Ponds, seasonally contained elevated pH and dissolved arsenic. There have been no impacts detected in groundwater samples collected from MW-1A and MW-2A, which are located on the north and east sides of the infiltration pond, respectively. Impacts observed in shallow groundwater monitoring wells MW-5A and MW-6A, but not observed in MW-1A and MW-2A, indicate that water infiltrating from the Infiltration Ponds was impacting shallow groundwater beneath and immediately east of the Infiltration Ponds. Since the ponds have started receiving treated water from the treatment system, the elevated pH and dissolved metals concentrations are attenuating in the shallow groundwater of MW-5A and MW-6A.

4.0 PREVIOUS REMEDIAL ACTIONS

Since the early 2000s Holcim has taken numerous actions at the 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 ultimately treat high pH water detected in seeps west of the LDA. This section presents a summary of the actions completed.

4.1 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 meet the landfill closure requirements of WAC 173-304. Specific activities included: re-grading 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 compacted to achieve a permeability of $1x10^{-6}$ cm/sec 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).

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, placing low permeability soil to provide a minimum 2-foot-thick layer compacted to $1x10^{-6}$ 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 3-1 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 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.

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

Various actions were historically conducted at the 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 located on the bench immediately to the west of the LDA, 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. 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 and 3-1 show the locations of the interceptor trench, seepage trenches, and seepage collection discharge pipe system.

In 2016 and early 2017 as part of a response to a Notice of Violation (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 restrict access to these areas by wildlife. Additionally, rip-rap rock was placed along the southwestern toe of the LDA to reduce potential exposure.

Further, in 2018, a seepage treatment system was constructed. The high pH water collected from the LDA and collected 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. Since the seepage treatment system began operating in 2018, modifications have been and 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 and the pH of the water in the Infiltration Ponds has attenuated to around a pH of 8 to 8.9 pH units. 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 B.

5.0 PRELIMINARY CONCEPTUAL SITE MODEL AND IDENTIFICATION OF DATA GAPS

This section presents the preliminary CSM. The extensive amount of available historical data, investigations, and remedial actions already completed at the Site, allow for the development of a comprehensive preliminary CSM. Development of the CSM is an important step in describing potential sources of contaminants, potential migration pathways, environmental media where the contaminants are detected, and identifying the environmental receptors and potential exposure pathways by which the receptors could be exposed. The preliminary CSM is used to identify data gaps and to develop the scope of RI activities proposed to collect the data necessary to fill those data gaps.

5.1 Contaminants and Potential Sources

CKD is the primary by-product of cement manufacturing. CKD is a very fine material emitted from the heating process used to make cement from various raw materials (including limestone and other calcium-containing materials). CKD is produced as a very fine dust, or flue “ash,” which is captured in dust collection systems attached to the rotary heating kilns. Dust control devices such as baghouse filters are used to capture and collect the fine dust from the hot gases of the heating operation.

Much research had been completed by both the EPA, Ecology, and scholars in the US and abroad on the characteristics of CKD. Two of the most comprehensive and applicable documents regarding CKD are the EPA 1993 Report to Congress on Cement Kiln Dust and the Leidos 2015 Cement Kiln Dust: Summary of Existing Information for the Lower Duwamish Waterway, which in turn, reference numerous other studies.

The historical research agrees that CKD is usually very alkaline (pH 10.5 to 12), and often contains trace constituents that may represent the content of the raw materials used in the cement manufacture. Primary bulk characteristics of CKD are silicates, calcium oxide, carbonates, potassium oxide, sulfates, chlorides, various metal oxides, and sodium oxide (EPA 1993). All cement kilns generate CKD; the quantities and characteristics of the CKD depend on operational factors and the characteristics of the input material (Leidos 2015).

Specific to assessing the Site risks, the RI must evaluate contaminants that are known to potentially leach from CKD. Direct contact with CKD is controlled by the capping previously completed at the Site. As discussed above, there has been significant research and studies completed related to the characteristics of CKD, typical environmental impacts observed at CKD disposal sites, and contaminants that can potentially leach from CKD. This external research combined with empirical data historically collected at the Site was used to assist in finalizing the list of contaminants of potential concern (COPCs) at the Site. Ecology, in their January 2020 Responsiveness Summary Report (Ecology 2020), recommended the following list of COPCs:

- CKD COPCs should include antimony, arsenic, barium, beryllium, cadmium, chromium (total), lead, mercury, nickel, selenium, silver, thallium, and vanadium. Ecology cited EPA’s recommendation that these COPCs should be sampled in groundwater when a release from a CKD landfill is suspected (EPA 1998).
- Dioxin and furans should be analyzed in the most-impacted leachate sample to confirm that the concentration is below groundwater and surface water cleanup levels, although dioxin is presumed to have limited solubility and very limited mobility in groundwater.
- The COPCs for the roadbed slag include arsenic, lead, copper, cadmium, chromium, and mercury. The RI should summarize previous and additional evaluations of the leaching potential of the roadbed slag under natural and caustic groundwater pH conditions.

Ecology also recommended that potential impacts from historic coal mining and CKD in the DSP include analysis for pH, metals, and sulfate. Potential impacts associated with CKD disposed in the DSP and groundwater migration pathways associated with the former coal mine workings are included in the RI. High pH and metals are potential impacts associated with CKD and are included in the list of COPCs as described below. Sulfate is a potential indicator compound for acid mine drainage but is not a potential contaminant associated with CKD; therefore, sulfate is not included as a COPC.

Based on historical research and monitoring completed at the Site, the following discusses the applicability of the COPCs Ecology recommended for the Site RI:

- Antimony
  - EPA indicates leach testing showed antimony leach concentrations may exceed the 6.4 µg/L MTCA groundwater cleanup standard. EPA recommends additional studies into antimony in groundwater (EPA 1993).
  - Antimony was not tested in CKD samples at sites in the Lower Duwamish waterway study (Leidos 2015).
  - Given the lack of consistent data from historical studies and the potential to leach from CKD, antimony analysis is recommended for targeted Site samples from the highest impacted groundwater.
- Arsenic
  - Arsenic is one of the key COCs that has been monitored at the Site. Arsenic will continue to be monitored for groundwater and surface water samples collected.
- Barium
  - Groundwater monitoring prior to August 2008 analyzed for barium in DSP bedrock, LDA bedrock, LDA shallow, and LDA surface water. No concentrations were found above the WAC 173-200 standard of 1,000 µg/L.
  - Ecology, Public Health, and King County Department of Development and Environmental Services agreed to remove barium as a COC on June 12, 2008 (*Request to Modify Groundwater and Surface Water Monitoring Programs, and Response to Comments on Draft Post-Closure Plan*).
  - Barium is relatively immobile under high pH conditions expected for CKD leachate (EPA 1993).
  - Barium is not recommended to be included in the list of COPCs.
- Beryllium
  - Beryllium is relatively immobile under high pH conditions expected for CKD leachate (EPA 1993).
  - There is a general lack of data on beryllium concentrations from CKD leachate from historical studies. Given the lack of data from historical site studies, beryllium analysis is recommended for targeted Site samples from the highest impacted groundwater.
- Cadmium
  - Arcadis monitoring (2008 Q2 and previous) analyzed for cadmium in DSP bedrock and from the mine portal. No concentrations were detected above 10 µg/L (WAC 173-200 standard).
  - In consideration of the absence of detections, Ecology, Public Health, and King County Department of Development and Environmental Services agreed to remove cadmium as a COC on June 12, 2008 (*Request to Modify Groundwater and Surface Water Monitoring Programs, and Response to Comments on Draft Post-Closure Plan*).

  - Cadmium does not readily leach from CKD and is relatively immobile under high pH conditions expected for CKD leachate (EPA 1993).
  - Cadmium is not recommended to be included in the list of COPCs.
- Chromium (Total)
  - Chromium sampling data for sites in the Lower Duwamish waterway indicate chromium is typically found significantly below (2 orders of magnitude lower) the MTCA Method A cleanup level of 2,000 mg/kg for trivalent chromium in CKD samples. Groundwater data was inconsistent; some data were found at levels above the 50 µg/L MTCA cleanup standard for total chromium, but most groundwater results were found below the 50 µg/L standard.
  - Chromium was found to be potentially leachable from CKD, as TCLP and SPLP leaching tests completed by EPA indicated chromium leachate concentrations higher than the 50 µg/L standard (EPA 1993).
  - Given the lack of consistent data from historical Site studies, chromium is recommended to be analyzed in the most-impacted groundwater sample.
- Lead
  - Lead is one of the key COCs that has been monitored at the Site. Lead will continue to be monitored in Site groundwater and surface water samples.
- Mercury
  - Groundwater and seep sampling data for sites in the Lower Duwamish waterway indicate mercury may be found above the MTCA cleanup standards (Leidos 2015). However, mercury does not readily leach from CKD and is relatively immobile under high pH conditions expected for CKD leachate (EPA 1993).
  - Mercury is recommended to be analyzed in the most-impacted groundwater sample.
- Nickel
  - The majority of fill, groundwater, and surface water sampling data for sites in the Lower Duwamish waterway indicate nickel was not found above the MTCA cleanup standards (Leidos 2015). Nickel does not readily leach from CKD and is also relatively immobile under high pH conditions expected for CKD leachate (EPA 1993).
  - Given the lack of data from historical Site studies, nickel is recommended to be analyzed in the most-impacted groundwater sample.
- Selenium
  - Selenium was found in seep/creek samples at the Puget Park & MacFarland Property in the Lower Duwamish waterway. However, selenium concentrations in groundwater were not above the MTCA cleanup standards of 80 µg/L (Leidos 2015).
  - Given the lack of data from historical Site studies, selenium is recommended to be analyzed in the most-impacted groundwater sample.

- Silver
  - Silver sampling data for sites in the Lower Duwamish waterway indicate silver is typically found significantly below (2 orders of magnitude lower) the MTCA Method B direct contact cleanup level of 400 mg/kg and the MTCA cleanup level protective of groundwater (for vadose zone soil) of 140 mg/kg in CKD samples.
  - Surface water/seepage sampling data for the Washington Federal Savings and Loan site in the Lower Duwamish indicate silver is not detected above 30 µg/L (Leidos 2015). Detected concentrations are below the MTCA groundwater cleanup standard of 80 µg/L.
  - Given the lack of data from historical Site studies, silver is recommended to be analyzed in the most-impacted groundwater sample.
- Thallium
  - There is a general lack of thallium related sampling data from historical studies.
  - Thallium is relatively immobile under high pH conditions expected for CKD leachate (EPA 1993).
  - Given the lack of data from historical studies, thallium is recommended to be analyzed in the most-impacted groundwater sample.
- Vanadium
  - There is a general lack of vanadium related sampling data from historical studies.
  - Surface water/seepage sampling data for the Washington Federal Savings and Loan site in the Lower Duwamish indicate vanadium is not detected above 10 µg/L (Leidos 2015). Detected concentrations are below the MTCA groundwater cleanup standard of 80 µg/L.
  - Given the lack of data from historical studies, vanadium is recommended to be analyzed in the most-impacted groundwater sample.
- 2,3,7,8-substituted dioxins & furans
  - EPA also analyzed dioxins and furans in CKD samples from 11 cement manufacturing facilities. Dioxin and furan compounds were detected in CKD generated by both hazardous and nonhazardous waste fuel burning facilities, but EPA indicated they were present at very low concentrations. EPA does not believe leachable dioxins and furans should be considered further due to the extremely insoluble nature of dioxins and furans, as indicated by the toxicity characteristic leaching procedure (TCLP) leaching study of dioxins and furans (EPA 1993).
  - Dioxins and furans are a byproduct of combustion (e.g., motor vehicles, forest fires, incineration of wastes), as such, low levels of these compounds are ubiquitous in the environment. Ecology indicates an appropriate background soils concentration in Washington State for dioxins and furans of 5.2 nanograms per kilogram (ng/Kg) (Ecology 2010).
  - Sampling data for CKD, sediment, and precipitate at the Puget Park and the McFarland Property in the Lower Duwamish Basin indicated total dioxin and furan (2,3,7,8-TCDD) toxic equivalent concentrations above the 5.2 ng/Kg background concentration for Washington State (Leidos 2015).

  - Given the lack of data from historical Site studies, dioxins and furans are recommended to be analyzed in the most-impacted groundwater sample.

- In addition to the COPCs list described above, pH level, which is likely the leading indicator of impacts to water from CKD, will be included in all groundwater and surface water samples collected. Potassium and TDS are also potential indicators of CKD impacts, and while not COPCs, will be analyzed in select samples during the RI to help delineate impacts. Sediment samples will also include total organic carbon (TOC) analysis, as it can affect the bioavailability and uptake of contaminants.

Historically, manganese and iron have been analyzed in groundwater and surface water samples collected at the Site in association with the Closed Landfill Permit monitoring requirements. Manganese and iron are not constituents associated with CKD. Except for periodic detections of manganese in well MW-3A, the concentrations of manganese and iron reported in groundwater and surface water samples at the Site are all below MTCA cleanup levels. Manganese and iron are not detected above MTCA cleanup levels in samples collected from locations (groundwater wells and surface water locations) that are known to be impacted by CKD leachate. The pH in MW-3A is near neutral and the concentrations of all other analytes reported in MW-3A are consistent with concentrations observed in the background wells. Manganese and iron are not COPCs at the Site and will not be included in RI groundwater and surface water sampling program.

A summary of the COPCs that will be included in the RI Sampling Activities include the following:

- Primary COPCs and indicator compounds that are known to be present at the Site: pH, arsenic, lead, potassium, TDS.
- Targeted COPCs that can be associated with CKD but are not known to be present at the Site: antimony, beryllium, chromium, mercury, nickel, selenium, silver, thallium, vanadium, 2,3,7,8-substituted dioxins & furans.
- The COPCs for the roadbed slag and fill material include arsenic, lead, copper, cadmium, chromium, and mercury.

5.2 Nature and Extent of Contamination

As described in Sections 3 and 4 of this Work Plan, the nature and extent of impacts on the Site have been generally defined. This section presents the current understanding of the nature and extent of contamination for various environmental media at the Site.

- **DSP Bedrock Groundwater** - Over 10 years of 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 have not shown detections that indicate impacts to groundwater are occurring in association with CKD disposed in the DSP. The arsenic concentration detected in bedrock groundwater collected from well MWB-1SDSP is slightly higher than the MTCA Method A cleanup level, 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. This is also supported by sampling and analyses of the mine portal that drains groundwater from the former coal mine workings beneath the DSP, where there have been no detections that indicate impacts to groundwater from the DSP. Historical groundwater elevations after correcting for vertical gradients observed in MWB-1SDSP and MWB-1DDSP 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 at the mine portal. Table 5-1 provides historical DSP bedrock groundwater elevations.

Figure 5-1 provides a conceptual north-south cross-section of the DSP, and Figure 5-2 provides a series of graphs of the historical DSP groundwater elevations. Figure 5-7 provides a conceptual groundwater contour map of the bedrock groundwater flow at the DSP. Additional evaluations of the hydrogeologic properties of the bedrock aquifer will be provided in the RI.

- LDA Bedrock Groundwater - Over 10 years of groundwater sampling data collected from monitoring wells installed within the bedrock formation underlying the LDA have not detected any contaminants that would indicate impacts are currently occurring to the bedrock groundwater in association with 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 0.160 mg/L to 0.027 mg/L, with the concentrations attenuating with each year following well installation. Arsenic concentrations in MWB-1LDA have been less than 0.020 mg/L since 2012 and have been around 0.010 mg/L since 2017. The pH and other parameters monitored in this well and the other LDA bedrock wells do not indicate impacts are occurring from the CKD leachate from the LDA. Further assessment of the potential for impacts to the bedrock aquifer beneath the LDA will be provided in the RI. Bedrock groundwater beneath the LDA flows along the strike of the bedrock in a general south to the north direction. Table 5-2 provides historical LDA bedrock groundwater elevations, and Figure 5-3 provides a graph of historic LDA bedrock groundwater elevations. Figure 5-6 provides a conceptual groundwater contour map of the bedrock groundwater flow at the LDA. The extended historical monitoring data from LDA and DSP bedrock monitoring wells and from the mine portal that drains the groundwater beneath the DSP confirm that bedrock groundwater has not been impacted by CKD disposed at the Site.
- **Shallow Groundwater** - Impacts to shallow groundwater present within the LDA and to the west and northwest of the LDA are confirmed by elevated pH, arsenic and lead levels detected in groundwater samples. Shallow groundwater was not encountered southwest of the LDA in boring P-10 (near well MWB-3LDA) south of the topographic divide near the BPA transmission line (see Figure 3-2). As depicted on 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 and from groundwater seepage areas confirms the geophysical delineation, but additional groundwater monitoring wells are required to provide groundwater samples that confirm the extent of impacts are bounded.
- **Surface Water** - Surface water impacts are detected at the Site in areas where groundwater from the LDA discharges to the surface through seeps, and in areas where those seeps are collected in remediation collection ditches and flow to Infiltration Ponds. Surface water pH measurements are readily made in the field with handheld pH meters. The extent of surface water impacts has been delineated. Additional analyses and evaluations will be conducted during the RI to determine if the contaminant concentrations and exposure pathways associated with impacted surface waters present a risk and if additional remedial actions are necessary to address those risks.
- **Soils** - CKD disposed in the LDA and DSP was covered with several feet of soil and capped with low-permeability soil caps that are minimally 2 feet thick, in accordance with WAC 173-304-407 performance standards. CKD was also observed beyond the LDA landfill in localized areas beneath the Lower Haul Road immediately west of the LDA (Aspect 2017) and was detected adjacent to the southeast portion of the LDA

during the 2018 Interceptor Trench borehole investigation (Golder 2018b). At both locations, the CKD is not present near the surface. Potential future risks associated with the CKD present outside of the LDA and DSP will be determined during the RI.

- Calcium carbonate precipitation occurs along the embankment west of the Lower Haul Road where the high pH seepage occurs prior to collection in the seepage collection ditch. Additionally, prior to installation of the seepage collection ditch, high pH seepage water would flow west to the area immediately north of the South Pond and precipitation of calcium carbonates would occur. Although the calcium carbonate precipitates are generally inert and are non-toxic, metals associated with CKD or that potentially leached from other fill materials that the high pH water migrated through could be present in the near surface of these areas from dissolution of those metals from the seepage water. The presence of reactive materials and COPC metals in these two areas, shown as DU-1 and DU-2 on Figure 6-4, will be evaluated during the RI.

- The presence of ASARCO slag in the roadbed material of the Lower Haul Road was reported in Ecology and Environment's 1986 Inspection Report and was confirmed during Aspect's investigations (Aspect 2017 and 2019b). The investigation concluded that total arsenic and lead were present in the roadbed soil exceeding MTCA residential cleanup standards. Samples of the roadbed slag were tested for leaching potential under high pH conditions, similar to the pH levels present in the CKD impacted groundwater. Arsenic was detected in two of the high pH leachability study test samples but was not detected in three of the four high pH leachability tests performed on slag-only samples. Additional assessment and testing related to the slag and other fill material present in the Site roadbed will be conducted in the RI to evaluate if metals are leaching from the slag at concentrations that exceed cleanup levels for the Site.

- **Sediments** - The South Pond water reflects the shallow groundwater elevation and seasonally dries up during the summer and early fall when groundwater levels are lower than the elevation of the pond bottom. There is no surface water outflow from the South Pond. The Infiltration Ponds historically received the high pH seepage water that is collected in the seepage collection ditches located west of the LDA. Since the activation of the seepage treatment system in September 2018, the Infiltration Ponds receive treated water. Historically, surface water samples collected from the South Pond and the Infiltration Ponds have contained high pH levels and elevated concentrations of arsenic and lead. During the RI, soil and sediments in the South Pond and the settled solids present in the Infiltrations Ponds will be characterized to evaluate if COPCs are potentially present at concentrations exceeding PSLs.

5.3 Exposure Pathways and Potential Receptors

Direct contact with CKD disposed at the Site is not a current complete exposure pathway, because the CKD disposal areas are covered with several feet of soil, including the low-permeability soil caps installed on the DSP and LDA. The trace lenses of CKD observed in the Lower Haul Road boreholes, and the CKD located immediately southeast of the LDA are also both covered with several feet of soil. The RI will evaluate potential future exposure pathways and receptors associated with the buried CKD located outside of the LDA and DSP. Direct exposure to CKD that may potentially be experienced by workers during any RI activities is addressed in the HASP (Appendix F). The following potential exposure pathways and potential receptors are identified for the purpose of establishing PSLs for the Site:

- Surface water – Impacted groundwater from the LDA daylights to the surface in seeps along the side hill west of the Lower Haul Road where it is collected into the seepage water collection ditch. Seasonally when the shallow groundwater in the recessional gravels is at its highest, high pH groundwater daylights in the South Pond, which is a topographic low area west of the seepage area. There is no surface water outflow from the South Pond. Prior to construction and operation of the treatment system, the high pH water from the seepage area was diverted to the Infiltration Ponds, where the water infiltrated to the underlying groundwater within the recessional gravels. Impacted surface water is not known to discharge from the Site. Impacted surface water areas at the Site are all currently surrounded by fencing to prevent direct contact by humans and larger animals. Potential receptors to impacted surface water at the Site include ecological receptors. The remedial investigation will include completion of a terrestrial ecological evaluation (TEE) completed in accordance with WAC 173-340-7493 and evaluation of potential impacts to aquatic and benthic organisms potentially present at the Site.
- On-Site migration of impacted groundwater – Impacted shallow groundwater is present west of the LDA. The extent has been evaluated with geophysical testing, which indicated that the impacted shallow groundwater does not migrate off the Site. Recall that in this RI-FS Work Plan the Site refers to the area defined by Ecology in the AO as the Preliminary Site, and the final Site will be determined based upon the delineated extent of the area where hazardous substances are located during the RI. Additional groundwater monitoring wells will be installed during the RI to confirm the extent of impacts to shallow groundwater west of the LDA. Prior to the start of the seepage water treatment system, untreated water infiltrating in the Infiltration Ponds resulted in impacts to the shallow groundwater beneath the ponds. The impacted shallow groundwater migrates towards the west-northwest, which was indicated by samples collected from groundwater monitoring wells that are installed around the Infiltration Ponds. The geophysical testing indicated that the extent of impacted groundwater is less than 50 feet downgradient of the Infiltration Ponds before attenuating to background levels. Additional groundwater monitoring wells will be installed during the RI to confirm the extent of impacts downgradient of the Infiltration Ponds. There are no current human receptors to impacted shallow groundwater at the Site because groundwater at the Site is not used for any purpose other than monitoring.
- Off-Site migration of impacted groundwater – There are currently no indications that impacted groundwater extends off the Site. The extent of impacts to groundwater will be confirmed during the RI. The closest active groundwater well to the Site, the Baja Well, was sampled as described in Section 2.3.4 of this Work Plan and is not impacted. The potential for future off-Site migration of impacted groundwater and potential for impacts to off-Site receptors in the future will be evaluated in the RI.
- Surficial soils and sediments - Precipitation of calcium carbonates and potentially COPC metals occurs along the embankment west of the Lower Haul Road where the high pH seepage occurs, and historically occurred west of the seepage collection trench in the area immediately north of the South Pond. Dissolution of solids also occurs in the South Pond and within the Infiltration Ponds. The entire embankment where the high pH seepage occurs is fenced and the South Pond and Infiltration Ponds are fenced. Assessment is required to determine if the shallow soils and sediments in these areas present a potential direct contact exposure pathway for human and ecological receptors.

5.4 Preliminary Screening Levels

Preliminary Screening Levels (PSLs) are numerical screening levels against which sample analytical data are compared for identifying constituents of concern during the Site RI. The PSLs do not necessarily represent values that will be equivalent to Site cleanup levels that will be calculated under MTCA during the FS. PSLs applicable to the Site potential exposure pathways will be based on MTCA Method A and B surface water, groundwater, and soil cleanup levels. Ecological PSLs will be based on TEE tables contained in WAC 173-340-900 and applicable sediment management standards from Washington State Sediment Management Standards defined in Chapter 173-204 WAC.

Under MTCA, the standard point of compliance for groundwater cleanup level is throughout the Site groundwater (WAC 173-340-720(8)(b)). Where it can be demonstrated under the MTCA process 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). During the RI, data from each well will be compared to PSLs. Applicability of establishing conditional points of compliance will be evaluated in the development of remedial alternatives in the FS. PSLs developed for this Site are provided in Table 5-3.

5.5 Identification of Data Gaps

Historical investigations, testing, remedial actions, and current Site monitoring data were used to develop the preliminary CSM. Areas where additional data are needed to complete the RI and obtain sufficient data to define the nature and extent of contamination, evaluate risks to human health and the environment, and determine appropriate remedial actions under the FS process include the following:

- **Extent of the Site** - The AO established a preliminary Site boundary for purposes of developing this Work Plan. Further, the AO indicates that the Site, defined as the area where hazardous substances have come to be located, will be delineated by the results of the RI. A delineation data gap exists and defining the Site based on the results of the RI is needed. Defining the extent of impacts to shallow groundwater at the Site is the primary data gap needed to define the extent of the Site.

  Once the Site has been defined, its areal extent will be evaluated against the locations of historical coal facilities and visual surveillance will be completed to survey for potential releases of hazardous substances associated with those facilities. If there are visual indications of releases attributable to former coal mining facilities, additional work may be necessary to evaluate them.

- **LDA Shallow Groundwater** – The conceptual model of the LDA is analogous to a bathtub that is filled with CKD and capped at the top. The low-permeability sandstone/siltstone bedrock that was excavated during the silica sand mining operations created a depression where infiltrating water pools, effectively filling the bathtub. The contact time between the perched groundwater and the CKD increases the pH of the water as calcium oxides (quicklime) and other base constituents react with the water producing hydroxides and other alkaline compounds. The alkaline water also liberates metals like arsenic and lead into solution. Site investigations indicate that groundwater is entering the LDA along the southeast side as infiltrating rainwater perches on top of the bedrock upgradient of the LDA and flows along the top bedrock and into the LDA excavated depression. Although the LDA is capped with a low permeability soil cap, there is also some minor direct infiltration of rainwater that likely occurs through the cap. The eastern bedrock LDA sidewall is higher in elevation than the western sidewall, so as the LDA bathtub fills, groundwater discharges from the LDA along the low elevation areas along the west side of the LDA. The groundwater coming from the LDA flows along the top of the bedrock through the fill material beneath the Lower Haul Road, and daylights as seeps present west of the LDA. In the area of the South Pond the high pH groundwater from the LDA seasonally daylights as the groundwater table elevations rise above the topographic low point that was created by the South Pond.

An important clarification to the bathtub analogy, is that groundwater flowing through the LDA does not fill the bathtub uniformly or flow through the CKD within the LDA uniformly. The CKD deposits form blocks or areas of unsaturated, extremely low permeability material that groundwater flows around and along preferential pathways. This was observed during the LDA hydrogeologic investigation (Golder 2013b), where some boreholes drilled into the CKD were completely dry and others were saturated. The geophysical survey figure (Figure 3-6) depicting the subsurface areas of identified high conductivity groundwater conceptually illustrate this flow pattern. Figure 5-4 provides a conceptual cross-section that depicts shallow groundwater flowing into the LDA from the southeast and the subsequent LDA bathtub filling and discharge. Figure 5-5 provides a conceptual groundwater contour map of the shallow groundwater flow at the Site in and around the LDA.

Additional data are needed to further quantify the flow of groundwater through the LDA and determine if reasonable measures to reduce the flow into the LDA are feasible. This information can be utilized during the FS to help evaluate remedial alternatives. Additionally, testing of the impacted groundwater within the LDA is required for the list of COPCs identified in Section 5.1 of this Work Plan.

- **Extent of Groundwater Impacts Downgradient of the South Pond** – Geophysical testing conducted in the areas of the South Pond indicated that the high pH groundwater extends approximately 50 feet downgradient (west) of the South Pond. The property line is located approximately 400 feet west of the South Pond. Groundwater flow within the recessional gravels beneath the South Pond is generally towards the northwest (Figure 5-5). Additional groundwater monitoring wells are needed west and northwest of the South Pond to provide empirical data to delineate the extent of groundwater impacts and confirm that impacts do not extend beyond the property. The additional groundwater monitoring wells will also further define the groundwater gradient and flow direction in the recessional gravels.

- **Extent of Groundwater Impacts Downgradient of the Infiltration Ponds** – Prior to installation of the treatment system, the seepage collection ditch captured the high pH seepage water from the LDA and discharged it directly to the Infiltration Ponds. This action reduced the area impacted by the high pH seepage water by concentrating the bulk of the discharges in a single area. The soil and groundwater beneath the Infiltration Ponds have a natural buffering capacity that neutralizes the high pH and allows removal of dissolved metals through adsorption and precipitation. Seasonally, when flows to the Infiltration Ponds and infiltration to the underlying groundwater exceeded the natural buffering capacity, elevated pH and arsenic concentrations were detected in two of the groundwater monitoring wells located immediately west and southwest of the Infiltration Ponds. Currently, the collected seepage water is treated prior to discharge to the Infiltration Ponds to reduce the pH and dissolved metals concentrations. These actions have also allowed the natural buffering capacity of the underlying soil and groundwater to begin to naturally attenuate the groundwater to acceptable pH and metals concentrations. Geophysical testing was conducted during a period when the Infiltration Ponds were receiving untreated water[3], and the extent of impact to groundwater beneath the ponds would be the greatest. The geophysics indicated that the high conductivity water only extended approximately 50 feet downgradient of the Infiltration Ponds. Additional groundwater

[3] The treatment system startup was first initiated in late September 2018 and operated to early January 2019. The system was shut down from January 2019 to May 2019 to repair and replace pipes/parts due to scaling and to upgrade the carbon dioxide supply tank to a larger size. The geophysical testing was conducted in April 2019, when the treatment system was not operating for over 3 months.

monitoring wells are needed downgradient of the Infiltration Ponds to provide groundwater monitoring points that confirm the extent of impacts to groundwater, including under conditions if the Infiltration Ponds were receiving untreated water. These additional wells will also help further define the groundwater gradient and flow direction downgradient of the Infiltration Ponds.

- **Contaminants of Potential Concern** – The extensive sampling and analyses completed at the Site confirm that the primary contaminants related to the CKD disposal include high pH, arsenic, and lead. Published studies related to CKD composition indicate a list of COPCs for which there is currently insufficient testing completed at the Site to evaluate if these compounds are present at concentrations of potential concern. A discussion of these additional COPCs was presented in Section 5.1 of this Work Plan. Additional testing that includes an expanded list of analytes is a data gap.
- **Characterization of Roadbed Slag** – Historical records indicate that ASARCO slag was used as one of the materials to build portions of the Site haul roads. Boreholes and test pitting completed by Aspect confirmed the presence of slag in portions of the Lower Haul Road located immediately west of the LDA. Testing of the slag indicated that total arsenic and lead are present in slag but leaching of these metals under natural pH conditions did not occur. However, investigation results show that arsenic is leaching from the slag when it comes into contact with high pH liquid and further investigation is required to define the extent of high pH leachate to determine where it is in contact with slag or other roadbed fill material resulting in excess metals leaching.
- **Soils** – Dissolution of solids consisting primarily of calcium carbonates from the high pH groundwater is currently occurring downgradient of the LDA along the embankment west of the Lower Haul Road where groundwater seepage to the surface is occurring. Prior to the installation of the seepage collection ditch, the high pH seepage water flowed west of the embankment to the topographic low area north of the South Pond. Characterization of the surface and subsurface soils in these two areas for comparison to PSLs is a data gap.
- **Pond Sediments** – Although fencing surrounds both the South Pond and the Infiltration Ponds to prevent trespass by humans and animals, the sediments/soils in the South Pond and the settled solids/CKD precipitates in the Infiltration Ponds will be characterized for comparison to PSLs and evaluated against site exposure scenarios to determine risks and evaluate if remedial actions are required.

6.0 PROPOSED REMEDIAL INVESTIGATION TASKS TO ADDRESS DATA GAPS

This section describes the investigations proposed to collect data necessary to fill the data gaps discussed in the previous section. The methods, technical procedures, and safety measures that will be used to complete the investigations are presented in the Sampling and Analysis Plan (SAP), Quality Assurance Project Plan (QAPP), and the Health and Safety Plan (HASP), included in Appendix D, E, and F of this Work Plan; respectively.

6.1 Geophysical Investigation

Geophysical investigations conducted at the Site in 2010, 2019, and 2020 showed a strong correlation between subsurface EM conductivity and the presence of high pH groundwater. Figure 3-6 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 Figure 3-11 shows the results of these geophysical surveys. The geophysical survey completed in 2020 at the LDA confirms the results of the 2010 and 2019 geophysical surveys. A detailed discussion of the results of the geophysical survey conducted in 2020 at the DSP will be provided in the RI Report.

If future geophysical surveys are required to further confirm historical results or to outline subsurface areas of high apparent conductivity, a geophysical survey will be performed using a combination of two instruments: The GEONICS® EM-31, which will be used to survey shallower depths (approximately 0 to 15 feet), and the GEONICS® EM-34, which will be 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 Site where the BPA overhead power lines are close to the ground surface (e.g., in the DSP area).

6.2 Installation of Groundwater Monitoring Wells

This section discusses the proposed installation of additional groundwater monitoring wells at the Site. Data collected from these additional groundwater data points combined with data collected from existing groundwater monitoring wells are intended to delineate the extent of groundwater impacts, and thus, help define the extent of the Site.

Groundwater monitoring wells will be drilled and installed, by a Washington State licensed driller, using roto-sonic drilling methods. The roto-sonic drilling method collects continuous cores. A Golder geologist will inspect the cores to evaluate the soil lithology, create the borehole log, and evaluate the depth when groundwater is first encountered. The wells will be drilled, logged, and installed in accordance with Golder Technical Guidelines TG-1.2-12 *Monitoring Well Drilling and Installation* and TG-1.2-6 *Soil Description System*. These technical procedures are controlled confidential documents and are available to Ecology for review upon request. For most locations, drilling will extend approximately 10 to 15 feet into the water table for construction of the monitoring wells. Stratigraphic and groundwater data will be obtained, and boreholes will be completed as 2-inch diameter Schedule 40 PVC wells with approximately 10 to 15 feet of 0.020-inch slotted screen. Each monitoring well annulus will be backfilled with silica sand to approximately 2 feet above the slotted screen. The borehole annulus above each screen section will be sealed with bentonitic cement grout or a bentonite clay seal to land surface. A protective lockable steel monument will be installed for secured access. Refer to Figure 6-1 for a generalized well diagram. The following sections describes the additional monitoring wells that will be installed as part of the remedial investigation tasks. The approximate proposed locations of the monitoring wells are shown on Figure 6-2. Well depths and screened intervals may be adjusted at the time of installation depending on conditions encountered during drilling.

6.2.1 LDA Monitoring Well

Prior to November 2020, there were four piezometers/monitoring wells installed within the LDA (P-1, P-3, P-4B and P-5). Following completion of the geophysical survey conducted in October 2020 which confirmed the high EM conductivity areas within the LDA, an additional groundwater monitoring well (P-14) was installed within the LDA. P-14 was installed in November 2020 along the apparent center line of the high pH groundwater flow within the LDA, as confirmed by the geophysical survey. A summary of the drilling and installation of this well was provided in Section 3.1 of this Work Plan.

Two additional monitoring wells (P-15, P-16) are proposed along the apparent center line of the high pH groundwater flow from the LDA. The approximate drilling locations are shown on Figures 6-2 and 6-3. These additional monitoring wells will serve to provide the following data:

- P-15: Will be installed within the LDA and at a location immediately east of the Lower Haul Road and immediately east of exiting well P-11. P-15 location is within the area where the geophysics indicated high pH groundwater is present. P-15 will allow collection of groundwater to analyze for COPCs in groundwater just before that groundwater migrates out of the LDA and through the Lower Haul Road. Data from P-15 will be compared to groundwater data collected from P-11 (located on the apparent downgradient side of the Lower Haul Road) to evaluate the changes in COPC concentrations as the high pH groundwater from the LDA migrates through the Lower Haul Road fill material. In addition, a borehole (identified as G-AB-1 on Figure 6-2) will be 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 depth to bedrock at that location. Soil samples will be collected from G-AB-1 in the vadose zone and the saturated zone, and analyzed for total metals, TOC, and pH. Leach testing will also be performed on the soil samples. Using EPA Method 1313, leachable concentrations of COPCs at two different pH levels will be determined. Each extract will be analyzed for total arsenic, lead, antimony, and vanadium, and pH. Further details on the soil sampling and analyses are provided in the SAP (Appendix D).

- P-16 will be installed within the area where the geophysics indicated high pH groundwater is present and west of the seepage collection ditch, between the seepage collection ditch and the South Pond. Groundwater samples collected from P-16 will provide data to evaluate the change in groundwater chemistry west of the seepage area prior to the impacted groundwater entering the groundwater within the recessional gravels. Soil samples will be collected from P-16 in the vadose zone and the saturated zone, and analyzed for total metals, TOC, and pH. Leach testing will also be performed on the soil samples. Using EPA Method 1313, leachable concentrations of COPCs at two different pH levels will be determined. Each extract will be analyzed for total arsenic, lead, antimony, and vanadium, and pH. Further details on the soil sampling and analyses are provided in the SAP (Appendix D).
- Groundwater elevation data from these wells will also help to further refine groundwater gradient and flow within the LDA and immediately downgradient of the LDA, evaluate groundwater response to rain events, and evaluate seasonal fluctuations in groundwater elevations. Groundwater elevation data from P-16 and surface water elevation data from the staff gauge installed in the South Pond, will also help determine whether the ephemeral nature of the surface water at the South Pond is reflective of groundwater upwelling to the surface.

6.2.2 Downgradient of South Pond Monitoring Wells

Two groundwater monitoring wells will be installed west to northwest of the South Pond (MW-9A and MW-10A). As shown on Figure 6-2, the addition of these two wells will create a line of wells that parallels the western property boundary running from the upgradient well MW-4A to downgradient well MW-3A. This line of wells will provide data points to establish that impacts to groundwater have not migrated to the property boundary. Geophysics survey of the areas surrounding the South Pond indicated impacts to groundwater are limited to the general area of the South Pond and do not extend more than 50 feet west of the South Pond. These wells will also confirm the extent of impacts to groundwater downgradient of the South Pond has been delineated. In combination with the LDA monitoring wells (P-14, P-15, P-11, P-16), this network of monitoring wells will provide data within the area where the geophysics indicated high pH groundwater is present and show the attenuation of groundwater with distance downgradient of the LDA and prior to reaching the property boundary. These data points are being installed as monitoring wells to allow routine monitoring to evaluate seasonal fluctuations in groundwater quality and to provide long-term confirmation that groundwater impacts never extend to the property boundary.

6.2.3 Infiltration Ponds Monitoring Wells

Groundwater monitoring data from MW-5A and MW-6A, and the EM conductivity surveys indicate that, when the Infiltration Ponds are receiving untreated water, high pH impacts to groundwater occur along the west (MW-6A) and southwest (MW-5A) side of the Infiltration Ponds. Like the South Pond, geophysics surveys indicate a rapid decrease in apparent conductivity with distance, attenuating to background levels approximately 50 feet downgradient of the ponds. Monitoring wells installed west-southwest and southwest of the Infiltration Ponds and MW-5A and MW-6A will delineate the extent of high pH and arsenic in groundwater. Three wells downgradient of the Infiltration Ponds will serve to delineate the extent of groundwater impacts. One of the three wells (AMW-1) is already installed northwest of the Infiltration Ponds. This well was installed in association with the independent remedial actions being conducted on the Reserve Silica Plant site, located northwest of Black Diamond Ravensdale Road SE. Two additional wells are proposed to be installed (MW-7A and MW-8A; Figure 6-2). MW-8A will be located west to southwest of the Infiltration Ponds on Reserve Silica Property, along the opposing side of Black Diamond Ravensdale Road SE. The third well will be located to the southwest, between the Infiltration Ponds, MW-5A and the Baja Property private well. Site access and approval to install this well will need to be obtained from the Baja Property owner. Locations of these wells are provided in Figure 6-2. These wells combined with the existing groundwater monitoring wells adjacent to the Infiltration Ponds will provide data to delineate any impacts to groundwater and ensure that impacted groundwater associated with the Site will not reach any current or potential future receptors.

6.3 Groundwater Monitoring Program

Groundwater monitoring conducted during the RI will include the following.

6.3.1 Periodic Monitoring Requirements

This section describes the groundwater monitoring that will be conducted in association with the MTCA RI under the Agreed Order. The RI groundwater monitoring presented herein also substantially meets the requirements of the Post-Closure Care and Maintenance Permit (closed landfill permit). The RI monitoring program includes a larger list of monitoring wells than required under the closed landfill permit. The RI groundwater monitoring program includes the following:

- Quarterly collection of groundwater samples from 14 shallow/alluvial groundwater monitoring wells and piezometers (MW-1A, MW-2A, MW-3A, MW-4A, MW-5A, MW-6A, MW-7A, MW-8A, MW-9A, MW-10A, P-14, P-15, P-16, and AMW-1) as part of the LDA monitoring program. MW-7A, MW-8A, MW-9A, MW-10A, P-15, and P-16 are new monitoring wells that will be installed during the RI.
    - Two of the initial sampling rounds from LDA groundwater monitoring wells (P-14, P-11) will include analyses for an extended list of parameters. The first of these two sampling events was completed in December 2020, as described in Section 3.1 of this Work Plan. Ecology will be consulted on the results of these initial rounds and the data collected will be used to refine the list of COPCs for future sampling events.
- Semi-annual measurement of field parameters and annual collection of groundwater samples from three on-site bedrock groundwater monitoring wells (MWB-1LDA, MWB-2LDA, and MWB-3LDA) as part of the LDA monitoring program.

- Semi-annual measurement of field parameters and annual collection of groundwater samples from four on-site bedrock groundwater-monitoring wells (MWB-1SDSP, MWB-1DDSP, MWB-5DSP, MWB-6DSP) as part of the DSP monitoring program.
- Semi-annual measurement of field parameters in monitoring wells MWB-2DSP and MWB-4SDSP as part of the DSP monitoring program.
- Quarterly collection of surface water samples from the Infiltration Ponds, Weir (or the constructed wetlands located upstream if the Weir is dry), South Pond, and Still Well as part of the LDA surface water sampling program.
- Annual collection of water samples from the culvert that discharges from the former mine portal as part of the DSP sampling program.
- Measurement of field parameters in water purged from the groundwater monitoring wells, and in water sampled directly from the surface water areas. Field parameters include groundwater level readings (in wells only), pH, conductivity, temperature, dissolved oxygen (DO), oxidation-reduction potential (ORP), and turbidity.
- Analysis of the groundwater, surface water, and quality control samples for total arsenic, lead, potassium, and TDS. Because there is a potential of high bias of metals concentrations that can be introduced from highly turbid unfiltered samples, dissolved metals will also be collected and placed on hold. Dissolved metals analysis can be performed if the total metals results appear anomalously high and potentially correlated with high turbidity samples.
- Quarterly Interceptor Trench monitoring for instantaneous flow volume and sampling for pH, TDS, and turbidity.

6.3.2 Contribution of Chemicals of Potential Concern to Groundwater

Groundwater entering the LDA contacts CKD disposed in the LDA, which results in the increased alkalinity and correlated increased pH of the groundwater. The increased pH of the groundwater can also increase the dissolution of metals into the groundwater from the solid matrix through which the groundwater flows. The extent and nature of the dissolution of solutes into the high pH groundwater is a direct function of the presence and solubility of those solutes within the solids in contact with the high pH water. Continuous cores of the material within the LDA (during P-14 drilling) observed CKD, mine waste silts and gravels, and some areas of debris (glass fragments and paper). P-14 well was installed in the area of the LDA where geophysics indicated groundwater with some of the highest pH at the Site was present. The high pH of the groundwater in P-14 was confirmed during sampling, where a pH of 13.3 was measured in P-14. Analysis for the Site COPCs in P-14 would be expected to indicate the highest dissolution of solutes to groundwater from the CKD and other materials present in the LDA relative to the rest of the Site.

As the high pH groundwater migrates from the LDA, in an apparent westerly direction, it migrates through the fill material that was used to construct the Lower Haul Road. Previous investigations (Aspect 2017 and 2019b) observed various fill material including ASARCO slag, mine waste soil (silty sand and gravel, coal fragments), brick fragments, lenses of CKD, and woody debris in test pits and boreholes drilled in the Lower Haul Road. To evaluate if dissolution of excess metals to groundwater occurs as the groundwater migrates through this Lower Haul Road fill material, groundwater samples from well P-11 located on the apparent downgradient (western) side of the Lower Haul Road will be collected.

As detailed in Section 3.1 above, an initial round of sampling and analyses were completed on wells P-14 and P-11 in December 2020. The results of that initial round indicated significantly higher concentrations of arsenic, chromium, lead, nickel, and vanadium reported in P-11 (more than 200% higher) than the concentrations reported in P-14 (Golder 2021). An additional round, anticipated to occur in June 2021, of samples will be collected from P-14 and P-11 for further comparison of the results. The analytical results from these two wells will be compared to PSLs to help refine the Site COPC list. The percent difference in the solute concentrations in each well will also be compared to evaluate if excess metals are being contributed to groundwater from the fill material present in the Lower Haul Road.

Because there is nearly 300 feet of distance between P-14 and P-11, well P-15, described above in Section 6.2.1, will be installed within the LDA at a location immediately east of P-11. Groundwater samples collected from P-15 will also be compared to analytical results from P-11 and P-14 to evaluate contribution of solutes to groundwater along this apparent high pH groundwater flow path. Existing groundwater data from areas of the Site where high pH groundwater was in contact with native soils (e.g., MW-5A and MW-6A, prior to the start of the treatment system), will also be evaluated to determine the tendency for metals to leach from native soils at the Site under high pH conditions. These evaluations of empirical data from the Site may be supplemented by laboratory solubility testing to determine or indicate the specific media from which excess metals are being liberated. A Work Plan amendment will be provided to Ecology for review and approval if laboratory leachability testing of specific media is planned.

6.4 Pond Sediments and Seepage Area Soil Sampling

As discussed previously in this Work Plan, calcium carbonate and other precipitates are present at the surface in areas where the high pH groundwater daylights and historically flowed overland. Testing described in this section is specifically designed to estimate the true average concentrations of COPCs in the Site areas where impacted groundwater daylighted to the surface and deposited precipitates. The soils and precipitates in these areas would be expected to contain the highest COPCs potentially present in surface soils at the Site.

Soil and sediment will be sampled using Incremental Sampling Methodology (ISM). ISM sampling will be 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). Sampling methodologies and techniques are further discussed in the SAP (Appendix D).

Three Decision Units (DUs) will be established in the areas where the highest probability of impacts to surficial soils and sediments are present on the Site. The three DUs will include the following:

- 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 this area will focus on the areas with the highest precipitates, which correlate with the past and/or current high pH groundwater seepage areas.
- DU-2 is the low land area west of the seepage collection trench, where high pH seepage water historically flowed 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.

The locations of these three DUs are shown on Figure 6-4.

Each ISM sample in DU-1 and DU-3 will be an aggregate of 30 increments. The increments will be collected along a randomly started systematic grid within DU-1 and DU-3. Each ISM sample in DU-2 will be an aggregate of 50 increments collected along a randomly started systematic grid. ISM samples from DU-2 include a greater number of increments because DU-2 area is larger than DU-1 and DU-3. At each increment location, approximately 50 grams of soil will be collected and added to the respective sampling container for the DU sample. The total mass of each ISM sample from DU-1 and DU-3 will equal approximately 1,500 grams (30 increments times 50 grams per increment); and the total mass of each ISM sample from DU-2 will equal approximately 2,500 grams (50 increments times 50 grams per increment). Each ISM sample collected from each of the DUs will be labeled and delivered to the analytical laboratory for further ISM processing and analysis. The locations of the DUs and the proposed sampling locations is provided in Figure 6-4.

Triplicate ISM samples will be completed at each DU, meaning three replicate ISM samples per DU will be collected and shipped to the analytical laboratory for processing and analysis. The collection of three replicate samples allows for the calculation of the relative standard deviation (RSD) and coefficient of variation (CV) between the three samples collected from each DU. The RSD and CV values indicate repeatability in the results (i.e., the results similar), which provides confidence that the results represent the true average concentrations with the DU. If the RSD is greatly different (greater than 35%), or the CV is greatly different (greater than 3) in the majority of sample results, poor correlation is indicated and an alternate sampling strategy may be needed to reduce variability (e.g., a reduction in sampling area, an increase in increments, etc.). To provide conservative estimates of the mean chemical concentrations for comparison to screening levels, 95% upper confidence limits (UCLs) on the mean will be calculated using the triplicate sample results for each DU.

Increment sampling locations will be loaded into a handheld GPS unit. Field staff will navigate to the pre-determined locations and collect a 50-gram increment from the top 4 inches of soil/sediment/precipitates using appropriate tools (e.g., small hand shovel or ISM sampling device). For sediments, the sampling depth (approximately 10 centimeters) is a representative biologically active zone for assessing exposure scenarios for freshwater benthic invertebrates (Ecology 2008). This uppermost soil layer is also representative of potential human exposure by incidental trespass. Additionally, if contaminants were deposited in these areas from the precipitation and dissolution of solids from high pH groundwater, the highest concentrations would be near the surface. The collected increment will be transferred into a sample container that contains all the increments for the DU. The second and third replicate sample from each DU will be collected in a manner identical to the primary sample. The second replicate increment locations will be collected approximately 3 feet west of the first replicate increment locations. The third replicate increment locations will be collected approximately 3 feet south of the first replicate increment locations.

Each sample will be analyzed for arsenic, lead, antimony, vanadium, pH, and TOC[4]; TOC is analyzed as it can affect the bioavailability and uptake of contaminants. Soil pH is analyzed to assess impacted area and partitioning of naturally occurring metals. If the preliminary screening of COPCs in groundwater (see Section 6.3.2) indicates additional COPCs are present in water at concentrations that could precipitate and accumulate to concentrations exceeding PSLs, those metals will be added to the soil and sediment characterization samples following consultation with Ecology.

[4] Antimony and vanadium were added because their concentrations exceeded the groundwater screening level in samples collected from P-14 and P-11 on the December 11, 2020.

The Infiltration Ponds are an active component of the seepage treatment system. Treated water is discharged to the Infiltration Ponds where the water infiltrates into the underlying recessional gravels groundwater. Additional precipitation of solutes not removed in the treatment system occurs within the Infiltration Ponds prior to the water infiltrating to the underlying groundwater. Groundwater monitoring wells surrounding the Infiltration Ponds are monitored to confirm that the treatment system and Infiltration Ponds are preventing impacts to groundwater migrating downgradient of the Infiltration Ponds. Because the Infiltration Ponds are a component of the overall treatment system, characteristics of sediments within the Infiltration Ponds are likely to change over time. As such, a limited evaluation of the concentrations of COPCs within the Infiltration Ponds sediments is proposed during the RI. Further evaluation may be conducted in the future when evaluating final remedial alternatives. The RI evaluation will include the collection of 10 grab samples distributed throughout accessible areas of the ponds. Six of the 10 samples will be collected from the sediments near the area where the seepage water collection pipe discharges to the Infiltration Ponds. This area visually contains the greatest concentration of precipitates and would be expected to contain the highest COPC concentrations if present within the precipitates. One of the samples will be collected in the south area of the infiltration ponds where the natural drainage channel enters the pond. The remaining three samples will be distributed throughout the accessible areas of the ponds. The grab samples collected from the Infiltration Pond sediments will be analyzed for arsenic, lead, antimony, vanadium, soil, and TOC. If the preliminary screening of COPCs in groundwater (see Section 6.3.2) indicates additional COPCs are present in water at concentrations that could precipitate and accumulate to concentrations exceeding PSLs, those metals will be added to the sediment samples following consultation with Ecology.

7.0 FEASIBILITY STUDY APPROACH

The FS will identify and evaluate remedial alternatives that protect human health and the environment by eliminating, reducing, or otherwise controlling risks posed by environmental conditions at the Site. Remedial alternatives will be developed consistent with ongoing high seepage water cleanup and source control activities and property use planning and development. The FS is intended to provide sufficient data, analysis, and engineering evaluations to enable the selection of a cleanup action alternative, which is protective of human health and the environment and considers local development plans. A phased approach will be taken, whereby remedial alternatives are developed and screened, followed by a detailed analysis of remedial alternatives in accordance with the MTCA cleanup regulations, WAC 173-340-360. Prior to beginning the FS, a FS planning meeting will be held to review applicable or relevant and appropriate requirements (ARARs), potential remedial alternatives and establish points of compliance.

The FS Report will contain the primary elements described in the following sections.

7.1.1 Introduction and Objectives

The first section of the FS Report will include an introduction and describe the objectives of the document. Reference will be made to previous work done at the Property. Additional work completed to support the FS Report will also be described in this section.

7.1.2 Determination of Cleanup Standards

Site-specific cleanup standards will be established in this section. Cleanup standards will include cleanup levels and points of compliance. MTCA requires evaluation of cleanup action alternatives that meet cleanup levels at both standard and conditional points of compliance. If necessary, conditional points of compliance will be established in the FS in accordance with WAC 173-340-320 to -360. Cleanup levels will be proposed in the RI to assist the interpretation of RI data. MTCA (WAC 173-340-350) states that the purpose of the FS is to develop and evaluate cleanup alternatives to enable a cleanup action to be selected. Cleanup levels will be recommended for chemicals of concern in each medium and for each complete pathway using WAC 173-340-700 to -760.

7.1.3 Identify Applicable or Relevant and Appropriate Requirements (ARARs)

MTCA requires cleanup actions comply with applicable local, state, and federal laws. Applicable local, state, and federal laws for the Site will be identified in this section of the FS, and their compliance requirements evaluated.

7.1.4 Remedial Action Objectives

Remedial Action Objectives (RAOs) that will impact remedial alternatives evaluation will be identified. This section will discuss ongoing cleanup and source control considerations for the Site, which will influence screening of potential remedial alternatives. The RAO section will then describe the applicable and relevant or appropriate requirements (ARARs) that will be used in determining appropriate RAOs and the selected remedial alternative.

7.1.5 Develop Remedial Alternatives

The remedial alternatives screening is intended to narrow the list of potential alternatives that will be evaluated in detail. When alternatives are being developed, individual remedial technologies would be screened primarily on their ability to meet the RAO for the Site. The screening process will develop and present the shortlisted remedial alternatives that will be carried forward as part of the detailed evaluation of alternatives in the FS.

The screening will broadly consider effectiveness, implementability, cost, and potential applicability to the Site. Each alternative carried forward will meet the threshold requirement of protection of human health and the environment. Only alternatives that are determined to be viable will be carried forward to the more detailed evaluation in the FS, while those that cannot be implemented will be discarded from further evaluation.

7.1.6 Detailed Evaluation of Remedial Alternatives

This section in the FS Report will evaluate shortlisted alternatives. The detailed evaluation will further define the alternatives, as necessary, analyze the alternatives against MTCA and other evaluation criteria, and compare the alternatives against one another. The remedial alternatives will be evaluated for compliance with the requirements of WAC 173-340-360. The following minimum threshold criteria will be considered in the detailed evaluation of remedial alternatives:

- Compliance with cleanup standards and applicable laws
- Protection of human health
- Protection of the environment
- Provision for a reasonable restoration time frame
- Use of permanent solutions to the maximum extent practicable
- Degree to which recycling, reuse, and waste minimization are employed
- Short-term effectiveness
- Long-term effectiveness
- Net environmental benefit

- Implementability
- Provision for compliance monitoring
- Cost-effectiveness
- Prospective community acceptance

7.1.7 Disproportionate Cost Analysis

Each alternative will be compared and contrasted for each of the following criterion (WAC 173-340-360(3)(f):

- Protectiveness
- Permanence
- Cost
- Long Term Effectiveness
- Management of Short-Term Risks
- Technical and Administrative Implementability
- Consideration of Public Concerns

The Disproportionate Cost Analysis (DCA) will provide the basis for selection of a preferred remedial alternative, Preference will be given to the remedial alternative that uses permanent solutions to the maximum extent practicable. If the preferred remedial alternative is clearly the most permanent, a DCA may not be necessary.

7.1.8 Recommended Remedial Alternative

The remedial alternative that is determined to best satisfy the evaluation criteria will be identified. Justification for the selection will be provided, and the recommended remedial alternative will be further developed in the ensuing Draft Cleanup Action Plan.

8.0 PROJECT ORGANIZATION AND SCHEDULE

8.1 Project Organization

Reserve Silica and Holcim have the primary responsibility for managing the work completed at the Site. Aspect is the primary consultant for Reserve Silica activities, and Golder is the primary consultant for Holcim activities. The consultants are responsible for the respective company activities associated with implementing the RI/FS work. These activities include preparing necessary project plans and reports for submittal to Ecology and other involved parties, as well as attending project meetings, performing field work, evaluating data generated during the RI, and overseeing subcontractors as necessary to complete the RI/FS in accordance with the Agreed Order. A project organization chart is provided in the QAPP.

8.2 Project Schedule

Exhibit B of the Agreed Order establishes the general RI/FS schedule and reporting requirements. Based on an Agreed Order effective date of December 16, 2019, the following schedule is estimated:

Task	Deliverables	Due Dates[a]
1	Draft RI Work Plan to Agency	The draft RI Work Plan was submitted to Ecology on June 30, 2020. Ecology submitted a list of comments on the draft RI Work Plan on September 30, 2020, and verbally approved additional remedial investigation tasks to be performed in December 2020.
2	Final RI Work Plan	July 2021
3	Commencement of RI Field Work	Preliminary sampling conducted in November 2020. RI field activities scheduled to occur during summer and fall of 2021.
4	Completion of RI Field Work – With the exception of continued groundwater and surface water monitoring	Assumed to require 6 to 9 months (Estimated March 2022)
5	Submittal of Draft RI Report	90 calendar days following receipt of final validated data (Estimated June 2022)
6	Agency Review Draft RI Report	45 calendar days following receipt of draft RI report (Estimated August 2022)
7	Public Review Draft RI Report	45 calendar days following receipt of Ecology comments on Agency Review Draft RI Report (Estimated October 2022)
8	Final RI Report	30 calendar days following receipt of Ecology comments, subsequent to public comment (Estimated November 2022)
9	Agency Review Draft FS Report	90 calendar days following Ecology approval of Public Review Draft RI Report (Estimated February 2023)
10	Public Review Draft FS Report	45 calendar days following receipt of Ecology's comments on the Agency Review draft FS Report (Estimated April 2023)
11	Final FS Report	30 calendar days following receipt of Ecology comments, subsequent to public comment (Estimated May 2023)
12	Agency Review preliminary Draft Cleanup Action Plan (DCAP)	90 calendar days following approval of Final FS Report (Estimated August 2023)

Notes:
[a] Due dates shown are for initial draft and final deliverables. This schedule assumes only a single revised document will be submitted following receipt of comments from Ecology. Documents become final only upon approval by Ecology.

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https://golderassociates.sharepoint.com/sites/119026/project files/6 deliverables/ri fs work plan/_ri work plan to ecology/2021-ri-workplan/2021-07/152030402-r-rev1-ri workplan_to_ecology_072221.docx

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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 (mg/L)						Dissolved Metals (mg/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	0.000249	0.000036 J	0.000146 J	0.115	0.00157	0.115	0.000221	<0.0001	<0.0005	0.0111 J	0.000489	0.0413
Primary Drinking Water Standard[a]									0.01	0.005	0.1	-	0.015	-	0.01	0.005	0.1	-	0.015	-
Secondary Drinking Water Standard[b]									-	-	-	0.3	-	0.05	-	-	-	0.3	-	0.05

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.

J - Data validation code; estimated value

"-" - Standard not available

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

Exploration Name	Depth (ft bgs)[1]	Total Metals in Soil: Arsenic (mg/kg)	Total Metals in Soil: Lead (mg/kg)	Groundwater Grab Sample pH	SPLP Extract: Arsenic (mg/L)	SPLP Extract: Lead (mg/L)	SPLP Extract: 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 Concentrations		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

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

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

Table 3-2: 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.

Golder Notes:

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: Site Monitoring Well and Piezometer Construction Details

Area	Location ID	Northing	Easting	Date Constructed	Total Well Depth (feet bgs)	Screened Interval (feet bgs)	Bentonite Seal (feet bgs)	Well Construction Material	Casing Diameter (inches)	TOC Elevation (feet msl NAVD88)
LDA - Shallow/Alluvial Groundwater Monitoring Wells	MW-1A	128365	1352450	7/11/2005	44	28-43	2-26	PVC	2	613.44
	MW-2A	128506	1352436	7/12/2005	40	25-40	2-23	PVC	2	607.21
	MW-3A	127623	1352636	7/12/2005	20	4-20	2-4	PVC	2	689.11
	MW-4A	126738	1352641	7/13/2005	20	5-20	2-4	PVC	2	705.45
	MW-5A	128293	1352305	7/13/2005	40	25-40	2-23	PVC	2	611.23
	MW-6A	128410	1352323	7/14/2005	39	24-39	2-22	PVC	2	608.95
Within LDA - Groundwater	P-14	126771	1353075	11/20/2020	52	40-50	3-38	PVC	2	773.32
LDA - Bedrock Groundwater Monitoring Wells	MWB-1LDA	127892	1352842	12/5/2006	135	115-135	2-105	PVC	2	704.68
	MWB-2LDA	127091	1352874	12/5/2006	125	110-125	2-103	PVC	2	741.66
	MWB-3LDA	126223	1353144	12/5/2006	145	125-145	2-115	PVC	2	744.19
DSP - Bedrock Groundwater Monitoring Wells	MWB-1SDSP	126511	1354193	12/9/2002	160	150-160	138-148	PVC	2	936.29
	MWB-1DDSP	126501	1354192	12/9/2002	265	255-265	243-253	PVC	2	935.37
	MWB-2DSP	126478	1354471	2/1985	258	238-258	-	PVC	2	934.82
	MWB-4SDSP	126859	1353976	4/1985	42.8	32-42.8	-	PVC	2	932.41
	MWB-5DSP	127194	1353890	11/29/2006	83	73-83	2-61	PVC	2	935.05
	MWB-6DSP	125454	1354568	11/30/2006	195	120-195	2-108	PVC	2	920.65

Table 3-3: Site Monitoring Well and Piezometer Construction Details

Area	Location ID	Northing	Easting	Date Constructed	Total Well Depth (feet bgs)	Screened Interval (feet bgs)	Bentonite Seal (feet bgs)	Well Construction Material	Casing Diameter (inches)	TOC Elevation (feet msl NAVD88)
LDA - Shallow/Alluvial Piezometers	P-1	127554	1353012	11/29/2010	55	50-55	4-47	PVC	2	757.50
	P-3	126860	1353133	11/16/2010	65	60-65	5-57	PVC	2	784.47
	P-4B	126534	1353042	11/30/2010	25	20-25	4-17	PVC	2	738.41
	P-5	126586	1353166	11/17/2010	50	45-50	3-42	PVC	2	773.30
	P-11	127088	1352871	11/15/2010	20	14-19	3-11	PVC	2	739.02
	P-12	126325	1353263	12/13/2011	34	24-34	3-21	PVC	2	757.07
	P-13	126303	1353400	12/12/2011	56.5	46.5-56.5	3-43.5	PVC	2	804.63
	B-12	126354	1353239	10/25/2016	19	9-19	2-7	PVC	2	758.80
	B-15	126528	1353232	10/25/2016	14.5	4.5-14.5	1-3	PVC	2	775.54
	B-21	126239	1353336	12/11/2017	14	9-14	2-7	PVC	2	783.00
	B-24	126464	1353353	12/11/2017	17	7-17	2-5	PVC	2	809.76
	B-27	126342	1353360	12/12/2017	23	13-23	2-11	PVC	2	803.40

Notes:

Northing and Easting Coordinates provided in Washington State Plane North (NAD 83)

-	Not measured or not available
feet bgs	Feet below ground surface
feet msl	Feet above mean sea level
TOC	Top of well PVC casing

Table 3-4A: Summary of P-14 and P-11 Field Parameters and Laboratory Analytical Results for Metals

				Results				
				P-14		P-11		
Analyte	**CAS Number**	**Units**	**MTCA Applicable GW CUL[1]**	**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	-	13.30		12.67		-
Conductivity	-	µS/cm	-	18697		6113		-
Temperature	-	°C	-	11.6		11.6		-
Dissolved Oxygen	-	mg/L	-	0.12		1.25		-
Oxidation Reduction Potential	-	mV	-	-61.2		15.9		-
Turbidity	-	NTU	-	17.9		34.3		-
Total Metals								
Antimony	7440-36-0	µg/L	6.4	147		201		37%
Arsenic	7440-38-2	µg/L	5	270		1670		519%
Beryllium	7440-41-7	µg/L	32	2	U	0.76	J	-
Chromium	7440-47-3	µg/L	50	5	U	45.1		802%
Copper	7440-50-8	µg/L	640	NA		75.5		-
Mercury	7439-97-6	µg/L	2	0.1	U	0.11		-
Lead	7439-92-1	µg/L	15	18.8		138		634%
Nickel	7440-02-0	µg/L	320	36.8		112		204%
Selenium	7782-49-2	µg/L	80	11.9		6.41		-46%
Silver	7440-22-4	µg/L	80	2	U	0.35	J	-
Thallium	7440-28-0	µg/L	0.32	1	U	0.54	J	-
Vanadium	7440-62-2	µg/L	80	23.4		116		396%

Notes:

1 - Applicable MTCA CUL is either the MTCA Method A CUL or the lower of either the MTCA Method B Cancer or Non-Cancer CULs.

"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.

BTOC - Below Top of Casing | AMSL - Above Mean Sea Level | BGS - Below Ground Surface | MTCA - Model Toxics Control Act | GW - Groundwater | CUL - Cleanup Level | µS/cm - microsiemens per centimeter | mV - millivolts | NA - Not Analyzed | NTU - Nephelometric Turbidity Units

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

				Results (µg/L)	
				P-14	
Analyte	**CAS Number**	**MTCA Applicable GW CUL (µg/L)[1]**	**Toxicity Equivalency Factor[2]**	**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	6.70E-07	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]	-	6.70E-07	-	1.66E-07	-

Notes:

1 - Applicable MTCA CUL is either the MTCA Method A CUL or the lower of either the MTCA Method B Cancer or Non-Cancer CULs.

2 - Dioxin/Furan cleanup levels will be calculated using Ecology's Toxicity Equivalent Factors calculation methodology and guidance. *Evaluating the Toxicity and Assessing the Carcinogenic Risk of Environmental Mixtures Using Toxicity Equivalency Factors* (Ecology 2007).

"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.

MTCA - Model Toxics Control Act | GW - Groundwater | CUL - Cleanup Level

Table 5-1: DSP Historical Groundwater Elevations

	Groundwater Elevation (feet amsl)											
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	896.72	894.02	883.48	875.84	899.67	895.21	882.91	885.20	897.12	897.99	888.37	887.98
MWB-4DSP	892.50	890.95	888.95	889.73	894.21	892.61	889.18	892.29	892.49	895.11	891.02	892.88
MWB-5DSP[1]	905.06	901.03	889.95	890.30	903.71	897.98	887.90	894.58	901.81	903.89	893.47	893.61
MWB-6DSP[1]	900.16	898.36	893.50	892.94	900.91	898.79	893.81	896.40	899.57	904.82	895.19	895.98

	Groundwater Elevation (feet amsl)								
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
MWB-1SDSP	900.65	898.70	884.74	879.75	899.60	898.32	884.81	885.66	901.61
MWB-4DSP	896.51	895.84	Note 2	891.90	895.30	894.51	890.75	891.65	897.00
MWB-5DSP[1]	904.82	903.51	889.36	889.51	902.47	901.87	902.47	888.34	904.65
MWB-6DSP[1]	900.88	900.67	893.60	893.13	900.12	899.49	893.80	Note 3	

Notes:

1	Groundwater elevations shown in Table 5-1 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.
feet amsl	feet above mean sea level
TOC	top of casing

GOLDER

Table 5-2: LDA Bedrock Aquifer Historical Groundwater Elevations

	Groundwater Elevation (feet amsl)											
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	677.85	677.46	675.78	675.73	678.05	677.59	676.08	676.79	678.02	678.63	676.81	676.78
MWB-2LDA	702.36	701.72	699.64	700.25	702.38	702.03	700.14	700.99	702.06	702.62	700.37	700.95
MWB-3LDA	735.97	735.66	733.15	732.45	737.39	736.82	733.78	734.00	736.57	738.27	735.11	734.59

	Groundwater Elevation (feet amsl)								
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
MWB-1LDA	679.04	678.97	676.66	676.51	678.47	678.40	676.54	676.93	679.04
MWB-2LDA	703.11	702.95	700.16	700.40	702.38	702.20	700.21	700.84	702.96
MWB-3LDA	739.46	738.99	734.66	733.81	738.27	738.02	734.83	734.59	738.90

Notes:
feet amsl feet above mean sea level

Table 5-3: Preliminary Screening Levels

SOIL[1]										
Analytes	MTCA Soil Method A Human Health Direct Ingestion Cleanup Level (mg/kg)[2]	MTCA Soil Method B Human Health Non-Cancer Direct Ingestion Cleanup Level (mg/kg)[2]	MTCA Soil Method B Human Health Cancer Direct Ingestion Cleanup Level (mg/kg)[2]	Natural Background (mg/kg)[4]	Site Soil Human Health Preliminary Screening Level (mg/kg)	MTCA TEE EISC for Protection of Terrestrial Plants and Animals (mg/kg)[3]			Natural Background (mg/kg)[4]	Site Soil Ecological Preliminary Screening Level (mg/kg)
						Plants	Soil Biota	Wildlife		
Metals										
Antimony	-	32	-	-	32	5	Note 5	Note 5	-	5
Arsenic	20	24	0.67	7	20	10	60	132	7	10
Beryllium	-	160	-	2	160	10	Note 5	Note 5	2	10
Chromium (total)	2000	120000	-	42	2000	42	42	67	42	42
Lead	250	-	-	17	250	50	500	118	17	50
Mercury	2	-	-	0.07	2	0.3	0.1	5.5	0.07	0.1
Nickel	-	1600	-	38	1600	30	200	980	38	38
Selenium	-	400	-	-	400	1	70	0.3	-	0.3
Silver	-	400	-	-	400	2	Note 5	Note 5	-	2
Thallium	-	0.8	-	-	0.8	1	Note 5	Note 5	-	1
Vanadium	-	400	-	-	400	2	Note 5	Note 5	-	2

Notes:

[1] The Site Soil Human Health Preliminary Screening Levels (PSLs) are selected based on a comparison of the MTCA direct ingestion cleanup levels and natural background. The Site Soil Ecological PSLs are selected based on a comparison of the TEE EISC and natural background.

[2] The Method A Cleanup Level used in comparison if a Method A Cleanup Level exists for the analyte. Otherwise, the lower of the Method B Non-Cancer or Method B Cancer Cleanup Level is selected for use in the comparison.

[3] Screening Levels selected as the lowest between Plants, Soil Biota, and Wildlife levels on Table 5.1 of Ecology's TEE Guidance (https://fortress.wa.gov/ecy/publications/documents/1909051.pdf)

[4] Statewide natural background concentrations obtained from Ecology's October 1994 *Natural Background Soil Metals Concentrations in Washington State* (https://apps.ecology.wa.gov/publications/documents/94115.pdf). If a cleanup level is below the natural background, the PSL defaults to the natural background concentration.

[5] For hazardous substances where a value is not provided, plant and soil biota indicator concentrations shall be based on a literature survey conducted in accordance with WAC 173-340-7493(4) and calculated using methods described in the publications listed in footnotes c and d of Table 5.1 of Ecology's TEE Guidance. Methods to be used for developing wildlife indicator concentrations are described in MTCA Tables 749-4 and 749-5.

EISC - Ecological Indicator Soil Concentrations | MTCA - Model Toxics Control Act | TEE - Terrestrial Ecological Evaluation

"-" - Not applicable

Where applicable, assumes arsenic is Arsenic-V. Assumes all chromium is trivalent chromium (Chromium-III).

Table 5-3: Preliminary Screening Levels

SEDIMENT		
Analytes	**MTCA Freshwater Sediment Cleanup Objective Level Fresh Benthic (mg/kg)[1]**	**Site Sediment Preliminary Screening Level (mg/kg)**
Metals		
Antimony	-	-
Arsenic	14	14
Beryllium	-	-
Chromium (total)	72	72
Lead	360	360
Mercury	0.66	0.66
Nickel	26	26
Selenium	11	11
Silver	0.57	0.57
Thallium	-	-
Vanadium	-	-

Notes:

[1] Screening levels obtained from MTCA Sediment Management Standards Table VI. (https://fortress.wa.gov/ecy/publications/publications/1309055.pdf)

No beach play or subsistence clam digging/net fishing are anticipated in the area with affected sediments.

MTCA - Model Toxics Control Act

"-" - Not applicable

Where applicable, assumes arsenic is Arsenic-V. Assumes all chromium is trivalent chromium (Chromium-III).

Table 5-3: Preliminary Screening Levels

SURFACE WATER LIST A (based on the most stringent applicable law from WAC 173-201A-240, CWA 304(a), and 40 CFR 131.45 (including the withdrawn criteria)[1]

Analytes	MTCA SW Aquatic Life Fresh Water Acute Cleanup Level 173-201A WAC (µg/L)	MTCA SW Aquatic Life Fresh Water Acute Cleanup Level CWA §304 (µg/L)	MTCA SW Human Health Fresh Water Cleanup Level 173-201A WAC (µg/L)[2]	EPA SW Human Health Fresh Water Cleanup Level CWA §304 (µg/L)[2]	EPA SW Human Health Fresh Water Cleanup Level 40 CFR 131.45 (µg/L)[2]	Site Surface Water Preliminary Screening Level List A (µg/L)
Metals						
Antimony	-	-	12	5.6	6	5.6
Arsenic	360	340	10	0.018	0.018	0.018
Beryllium	-	-	-	-	-	-
Chromium (total)	550	570	-	-	-	550
Lead	65	65	-	-	-	65
Mercury	2.1	1.4	-	-	-	1.4
Nickel	1400	470	150	610	80	80
Selenium	20	-	120	170	60	20
Silver	3.4	3.2	-	-	-	3.2
Thallium	-	-	0.24	0.24	1.7	0.24
Vanadium	-	-	-	-	-	-
pH	pH screening levels for water are set to be 6.5 - 8.5 pH units, obtained from WAC 173-200-040.					

SURFACE WATER LIST B (based on the most stringent applicable law from WAC 173-201A-240, CWA 304(a), and the remaining federal applicable law in 40 CFR 131.45 (methylmercury, bis(2-chloro1-methylethyl)ether, and arsenic)[1]

Analytes	MTCA SW Aquatic Life Fresh Water Acute Cleanup Level 173-201A WAC (µg/L)	MTCA SW Aquatic Life Fresh Water Acute Cleanup Level CWA §304 (µg/L)	MTCA SW Human Health Fresh Water Cleanup Level 173-201A WAC (µg/L)[2]	EPA SW Human Health Fresh Water Cleanup Level CWA §304 (µg/L)[2]	EPA SW Human Health Fresh Water Cleanup Level 40 CFR 131.45 (µg/L)[2]	Site Surface Water Preliminary Screening Level List B (µg/L)
Metals						
Antimony	-	-	12	-	-	12
Arsenic	360	340	10	0.018	0.018	0.018
Beryllium	-	-	-	-	-	-
Chromium (total)	550	570	-	-	-	550
Lead	65	65	-	-	-	65
Mercury	2.1	1.4	-	-	-	1.4
Nickel	1400	470	150	-	-	150
Selenium	20	-	120	-	-	20
Silver	3.4	3.2	-	-	-	3.2
Thallium	-	-	0.24	-	-	0.24
Vanadium	-	-	-	-	-	-
pH	pH screening levels for water are set to be 6.5 - 8.5 pH units, obtained from WAC 173-200-040.					

Notes:

[1] Screening levels developed using Ecology Interim Policy 730 (Jan 11, 2021). Two sets of surface water PSLs were developed. List A is based on the most stringent applicable law from WAC 173-201A-240, CWA 304(a), and 40 CFR 131.45 (including the withdrawn criteria). List B is based on the most stringent applicable law from WAC 173-201A-240, CWA 304(a), and the remaining federal applicable law in 40 CFR 131.45 (methylmercury, bis(2-chloro1-methylethyl)ether, and arsenic). The PSLs will be refined as appropriate during the RI if EPA's decision to withdraw the 40 CFR 131.45 values is overturned by the courts (or is maintained), or if there are any other changes to the applicable laws.

[2] Human Health Cleanup Levels calculated using 10^{-6} risk for carcinogens, for consumption of water and organisms.

MTCA - Model Toxics Control Act | SW - Surface Water

"-" - Not applicable

Where applicable, assumes arsenic is Arsenic-V. Assumes all chromium is trivalent chromium (Chromium-III).

Table 5-3: Preliminary Screening Levels

GROUNDWATER[1]						
Analytes	**MTCA GW Method A Direct Ingestion Cleanup Level (µg/L)**	**MTCA GW Method B Non-Cancer Direct Ingestion Cleanup Level (µg/L)**	**MTCA GW Method B Cancer Direct Ingestion Cleanup Level (µg/L)**	**Federal Maximum Contaminant Level 40 CFR 141 (µg/L)**	**WA State Maximum Contaminant Level 246-290 WAC (µg/L)**	**Site Groundwater Preliminary Screening Level (µg/L)**
Metals						
Antimony	-	6.4	-	6	6	6
Arsenic	5	4.8	0.058	10	10	5
Beryllium	-	32	-	4	4	4
Chromium (total)	50	-	-	100	100	50
Lead	15	-	-	15	15	15
Mercury	2	-	-	2	2	2
Nickel	-	320	-	-	100	100
Selenium	-	80	-	50	50	50
Silver	-	80	-	-	-	80
Thallium	-	0.16	-	2	2	0.16
Vanadium	-	80	-	-	-	80
Dioxins and Furans						
2,3,7,8-TCDD	-	1.10E-05	6.70E-07	3.00E-05	3.00E-05	6.70E-07
Total Dioxin/Furan Toxicity Equivalency (TEQ)	-	1.10E-05	6.70E-07	3.00E-05	3.00E-05	6.70E-07
pH	pH screening levels for water are set to be 6.5 - 8.5 pH units, obtained from WAC 173-200-040.					

Notes:

[1] The Site Groundwater PSLs are selected based on a comparison of the cleanup level of a comparison of the MTCA direct ingestion cleanup levels, the federal maximum contaminant level (MCL), and the state MCL.

MTCA - Model Toxics Control Act | GW - Groundwater

"-" - Not applicable

Where applicable, assumes arsenic is Arsenic-V. Assumes all chromium is trivalent chromium (Chromium-III).