March 2023
Former Reynolds Metals Reduction Plant – Longview

Final Engineering Design Report, Version 2

Prepared for Northwest Alloys, Inc.

This report was prepared by the staff of Anchor QEA, LLC, under the supervision of the Engineer whose seal and signature appears hereon, as required by Chapters 18.43 and 18.220, Revised Code of Washington (RCW).

The finding, recommendations, specifications, or professional opinions are presented within the limits described by the client, in accordance with generally accepted professional engineering practice. No warranty is expressed or implied.

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Prepared for
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Project Number: 210002-04.02
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ABBREVIATIONS

µg/L	micrograms per liter
AKART	All Known, Available, and Reasonable Technologies
AO	Agreed Order
ARAR	Applicable, Relevant, and Appropriate Requirement
AST	aboveground storage tank
Axens AA	ActiGuard F 14×28 activated alumina obtained from Axens Canada Specialty Aluminas Inc.
BFM	bonded fiber matrix
bgs	below ground surface
BMP	Black Mud Pond
CAP	*Cleanup Action Plan*
CARA	Critical Aquifer Recharge Area
CCC	Cowlitz County Code
CD	Consent Decree
CDID	Consolidated Diking Improvement District
CFR	Code of Federal Regulations
cfs	cubic feet per second
cm/sec	centimeters per second
CMCRP	*Compliance Monitoring and Contingency Response Plan*
COC	contaminant of concern
cPAH	carcinogenic polycyclic aromatic hydrocarbon
CQAP	*Construction Quality Assurance Plan*
CVI	Chinook Ventures, Inc.
CWA	Clean Water Act
cy	cubic yard
Draft EDR	*Draft Engineering Design Report*
DRO	diesel range organic
DSR	*Pre-Design Investigation Data Summary Report*
Ecology	Washington State Department of Ecology
ELF Pump Station	East Landfill Pump Station
ESA	Endangered Species Act
Final EDR	*Final Engineering Design Report, Version 2*
Final Revised EDR	*Final Revised Engineering Design Report*
Former Reynolds Plant	former Reynolds Metals Reduction Plant

FOS	factor of safety
GCL	geosynthetic clay liner
H:V	horizontal to vertical
HDPE	high density polyethylene
HPA	Hydraulic Project Approval
HTM	heat transfer media
JARPA	Joint Aquatic Resources Permit Application
MBT-Longview	Millennium Bulk Terminals – Longview, LLC
MCL	maximum contaminant level
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
Mint Farm	Mint Farm Well Field
MSL	mean sea level
MTCA	Model Toxics Control Act
NAVD88	North American Vertical Datum of 1988
NHPA	National Historic Preservation Act
NPDES	National Pollutant Discharge Elimination System
NWP	Nationwide Permit
OHWM	ordinary high water mark
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PDI	pre-design investigation
PDI Work Plan	*Pre-Design Investigation Work Plan*
POC	point of compliance
PRB	permeable reactive barrier
RCW	Revised Code of Washington
Revised EDR	*Revised Engineering Design Report*
Reynolds	Reynolds Metals Company
RI	remedial investigation
RI/FS	*Remedial Investigation and Feasibility Study*
RWMP	*Remediation Water Management Plan*
SED	Shoreline Environmental Designation
SEPA	State Environmental Policy Act
SLSWP	*Sampling Location Study Work Plan*
SMP	Shoreline Master Program
SOW	Schedule of Work and Deliverables

SPL	spent potliner
SQAPP	*Sampling and Quality Assurance Project Plan for Post-Construction Monitoring*
SR	State Route
SSWS	Shoreline of Statewide Significance
SU	site unit
SWPPP	*Stormwater Pollution Prevention Plan*
TDA	Threshold Discharge Area
TPH	total petroleum hydrocarbons
USACE	U.S. Army Corps of Engineers
USC	United States Code
USGS	U.S. Geological Survey
WAC	Washington Administrative Code
WBZ	water-bearing zone
WDFW	Washington Department of Fish and Wildlife
WDNR	Washington State Department of Natural Resources
WLF Pump Station	West Landfill Pump Station
WQC	Water Quality Certification

1 Introduction

This *Final Engineering Design Report, Version 2* (Final EDR) describes the information, concepts, and evaluations used in the design of the cleanup action for the former Reynolds Metals Reduction Plant (Former Reynolds Plant) in Longview, Washington. This Final EDR and its appendices progress the design, construction methods, and schedules to a final 100% design level. The Final EDR also incorporates project permit requirements, which is the document submitted to the Washington State Department of Ecology (Ecology) for design approval.

1.1 Background

This cleanup action will be performed as required under Consent Decree (CD) No. 18-2-01312-08 (Ecology 2018a), fully executed on December 14, 2018, and as described in the *Cleanup Action Plan* (CAP; Ecology 2018b). Millennium Bulk Terminals – Longview, LLC (MBT-Longview), and Northwest Alloys, Inc., are signatories to the CD. The CAP was developed using information presented in the *Remedial Investigation and Feasibility Study* (RI/FS; Anchor QEA 2015) and prepared in accordance with the requirements of the Model Toxics Control Act (MTCA; Ecology 2007), Chapter 70.105D Revised Code of Washington (RCW), administered by Ecology under the MTCA Cleanup Regulation, Chapter 173-340 Washington Administrative Code (WAC). Lighthouse Resources Inc., the parent company of MBT-Longview, filed bankruptcy on December 3, 2020, and MBT-Longview is no longer involved in the cleanup. The cleanup will be performed by Northwest Alloys and will be overseen by Ecology. The following are supporting documents and activities associated with the CD:

- **Cleanup Action Plan.** The CAP was developed following completion of a RI/FS consistent with the requirements of Agreed Order (AO) No. DE-8940 between Ecology, Northwest Alloys, and MBT-Longview (Ecology 2012). The CAP presents Ecology's cleanup decision for the site and describes how that decision was developed. The CAP is Exhibit B to the CD.
- **CD Schedule of Work and Deliverables.** The CD requires the implementation of the CAP and the "Schedule of Work and Deliverables" (SOW; Exhibit C of the CD) and sets a schedule of the work to be completed and a deliverables timeline. A general summary of work under Exhibit C includes the following:
  - **Pre-Design Investigation.** As required per Exhibit C of the CD, the draft *Pre-Design Investigation Work Plan* (PDI Work Plan) was submitted to Ecology on January 13, 2019, within 30 days of the effective date of the CD, and the final PDI Work Plan was submitted to Ecology on March 8, 2019 (Anchor QEA 2019a), within 30 days of receiving Ecology's comments on the draft PDI Work Plan. The PDI Work Plan was approved on March 15, 2019; however, field work could not commence until the U.S. Army Corps of Engineers (USACE) levee authorization was received. USACE authorized pre-design investigation (PDI) work on the levee, and the Consolidated Diking Improvement

District (CDID) issued a levee encroachment permit on January 7, 2020. A PDI Work Plan Addendum was submitted to Ecology on February 4, 2020 (Anchor QEA 2020a), and work commenced on February 10, 2020. The PDI was conducted to collect data necessary to perform engineering evaluations for cleanup action design and to inform the implementation of the cleanup action. The PDI consisted of field explorations, including geotechnical borings with standard penetration testing and cone penetration testing and groundwater sampling for conducting treatability studies for the permeable reactive barriers (PRBs) and reactive backfill. A second PDI mobilization occurred in April 2020 following the approval of a second PDI Work Plan Addendum on April 13, 2020 (Anchor QEA 2020b; Ecology 2020a). A third PDI mobilization occurred in February 2022 following Ecology approval of a third PDI Work Plan Addendum on February 16, 2022 (Anchor QEA 2022a; Ecology 2022a). Details of the PDI are described in the *Pre-Design Investigation Data Summary Report* (DSR) located in Appendix A. A fourth PDI mobilization occurred in October 2022 following Ecology approval of a fourth PDI Work Plan Addendum on September 22, 2022 (Anchor QEA 2022b; Ecology 2022b). Details of the fourth PDI were supplied to Ecology in a separate memorandum on November 7, 2022 (Anchor QEA 2022c).

- **Draft Engineering Design Report.** The *Draft Engineering Design Report* (Draft EDR) described the information, concepts, and evaluations used to advance the design of the cleanup action. The document and its appendices were a 30% to 60% level design deliverable that were submitted to Ecology on August 11, 2020. Ecology provided official comments on the Draft EDR on December 8, 2020 (Ecology 2020b).
- **Revised Engineering Design Report.** The *Revised Engineering Design Report* (Revised EDR) progressed the design, construction methods, and schedules to a 90% (pre-final) level design deliverable. Due to the delay in receiving geotechnical data to advance the landfill designs, the stormwater infrastructure design lagged. The stormwater design was at a 30% level in the Revised EDR. Per Exhibit C of the CD (Ecology 2018a), the Revised EDR was originally due within 60 days of receipt of Ecology's comments on the Draft EDR. Ecology provided comments on December 8, 2020 (Ecology 2020b), which required the Revised EDR to be submitted on February 8, 2021. A request to extend the submittal of the Revised EDR to July 31, 2021, was submitted to Ecology on February 5, 2021, and Ecology approved the extension on February 24, 2021 (Ecology 2021a). The Revised EDR was submitted to Ecology on July 31, 2021. Ecology provided official comments on the Revised EDR on November 9, 2021 (Ecology 2021b).
- **Final Revised Engineering Design Report.** Because the Revised EDR was only able to advance the project's stormwater design to the 30% level, another iteration of design was necessary. The *Final Revised Engineering Design Report* (Final Revised EDR)

advanced all design elements to a near-final 100% level. Ecology comments on the Revised EDR were also addressed. Ecology provided official comments on the Final Revised EDR on November 2, 2022 (Ecology 2022c).

- **Final Engineering Design Report, Version 2**. This Final EDR advances all design elements to a final 100% level and incorporates all project permit conditions as required by Exhibit C of the CD (Ecology 2018a). Ecology's comments on the Final Revised EDR, along with design changes from other agency reviews, have been incorporated into the Final EDR.
- **Sampling Location Study Work Plan.** The *Sampling Location Study Work Plan* (SLSWP) was a concurrent submittal to the Draft EDR submitted to Ecology on August 11, 2020 (Anchor QEA 2020c), and describes site-specific data such as groundwater monitoring data, tidal information, and video documentation of tidal changes and active seeps to be collected and/or evaluated to select post-construction porewater sampling locations and timing. Ecology provided comments on the SLSWP on December 8, 2020 (Ecology 2020b). The final SLSWP that addressed Ecology's December 8, 2020, comments was submitted to Ecology on June 29, 2021 (Anchor QEA 2021). Ecology approved the final SLSWP on March 3, 2022 (Ecology 2022d). The riverbank walks were performed on June 25, 2022, and September 16, 2022. Results from the riverbank walks are summarized in the updated *Compliance Monitoring and Contingency Response Plan* (CMCRP; Anchor QEA 2023).
- **Sampling and Quality Assurance Project Plan for Post-Construction Monitoring.** The *Sampling and Quality Assurance Project Plan for Post-Construction Monitoring* (SQAPP) describes the long-term monitoring program, including methods to be used for conducting post-construction groundwater, surface water, and porewater monitoring. The SQAPP is an appendix to the updated CMCRP that includes all the monitoring components and contingency planning discussed with Ecology between December 2021 and February 3, 2023. Additional details regarding the SQAPP are included in Section 9.3.

1.2 Purpose and Scope

The purpose of this Final EDR is to satisfy the requirements of WAC 173-340-400(4)(a) and those established in the CD and CAP. This Final EDR documents engineering concepts and criteria used during design of the cleanup action and provides the drawings, plans, and procedures necessary to adequately remediate the site. This Final EDR also describes the compliance monitoring that will be used to document site conditions, quality assurance/quality control protocols, and health and safety protocols. Specific information required by WAC 173-340-400(4)(a) and provided in this Final EDR include the following:

- Cleanup action goals and cleanup requirements

- General site information, including a summary of the RI/FS and current conditions
- Owner, operator, and maintenance responsibilities
- Facility maps to show existing conditions and planned cleanup action
- Waste characteristics, quantity, and location of materials to be managed or removed
- Schedule for final design and construction
- Final plan of the planned cleanup action
- Engineering design and operation parameters, including the following:
  - Design criteria, calculations, and assumptions for all cleanup components
  - Treatment, immobilization, and containment efficiencies and associated documentation
  - Demonstration that the cleanup action will achieve compliance with requirements, including treatability study data
- Design features to control hazardous material spills and manage hazardous materials
- Design features to ensure short- and long-term safety of site workers and local residents
- Quality control measures that will be used to demonstrate adequate quality control
- Facility-specific characteristics that may affect design, construction, or operation, including the following:
  - Relationship of the proposed cleanup action to existing facility operations
  - Probability of flooding, seismic activity, temperature extremes, local planning, and development issues
  - Soil characteristics and groundwater system characteristics
- General description of construction testing to demonstrate adequate quality control
- Compliance monitoring measures taken during and after the cleanup to meet WAC 17-340-410 requirements
- Health and safety measures to comply with the safety and health requirements of WAC 173-340-810
- Additional information needed to address the applicable state, federal, and local requirements, including the substantive requirements, for any exempt permits and property access issues that need to be resolved to implement the cleanup action
- Preliminary cost calculations and financial information describing the basis for the amount and form of financial assurance, including a draft financial assurance document
- Institutional controls information, including a listing of required restrictive covenants and a schedule by which those will be filed

1.3 Environmental History Summary for the Former Reynolds Plant

Aluminum production operations began in approximately 1941, with construction and operation of the first aluminum production (i.e., reduction or smelting) and casting operations. In 1967, operations expanded to include additional aluminum production capacity in the North Plant.

Alumina used at the Former Reynolds Plant was received by ship or by rail. Alumina was unloaded and transferred to the alumina storage silos and from there to the potline buildings. Solid alumina was placed in a "pot" and dissolved in a cryolite solution (consisting of sodium, fluoride, and raw aluminum). Electricity was then passed through the material in the pot to produce molten aluminum. The aluminum was then cast into solid form inside the cast houses. A detailed description of the aluminum production process is provided in the RI/FS (Anchor QEA 2015). Aluminum manufacturing ceased in 2001.

One byproduct that is produced during aluminum manufacturing is known as spent potliner (SPL). The potliner consisted of the carbon lining of the pots in which the molten aluminum was produced (Ecology 1982). Over time, this lining eventually became compromised and needed to be replaced.

At the Former Reynolds Plant, a recycling process was operated to recover reusable materials from SPL. This process was conducted in the former Cryolite Recovery Plant located near the Former South Plant. The former Cryolite Recovery Plant was constructed in 1953.

Cryolite recovery involved a multiple-step process. The feedstock consisted of SPL that was stockpiled in the southwestern portion of the Cryolite Recovery Plant. This material was crushed, ground, and blended with underflow solids. The material was then slurried with an alkaline sodium hydroxide solution, which extracted fluoride compounds from the solid materials for reuse. The slurry was pumped to a thickener tank where the liquor was separated from the remaining treated solids, which were composed primarily of residual carbon. During Cryolite Recovery Plant operations, these solids were termed black mud due to the characteristic dark color associated with the carbon present in the solids. Originally, the residual carbon material was placed in a deposit just to the east of the former Cryolite Recovery Plant. An additional fill deposit was constructed along the eastern edge of the property. These fill deposits were excavated at least once, and the materials were placed in the southwestern portion of the property around the industrial landfill (SU1). Placement of residual carbon in these three fill deposits ceased in 1972. These three fill areas were capped with soil in 1988.

Lime was processed at the Cryolite Recovery Plant to produce the sodium hydroxide solution used in the cryolite recovery process. Spent lime (known during plant operations as "white mud," due to its characteristic white color) was generated during this process. This spent lime was initially segregated and managed in a fill deposit located in the eastern corner of the property. After this fill deposit was closed in the 1970s, the spent lime was no longer segregated and was combined and managed with the residual carbon.

Residual carbon or black mud (remaining solids after extraction of reusable fluoride and aluminum) produced at the Former Reynolds Plant after 1972 was managed in an impoundment constructed within the western plant area, known as the Closed Black Mud Pond (BMP). This 33-acre facility was formally closed in 1993, consistent with regulatory requirements under the Washington Dangerous Waste regulations in place at that time.

The Former Reynolds Plant includes three historical on-site landfills, which were used during facility operations for construction debris and other materials and are addressed as part of Ecology's selected cleanup action. The three landfills were the industrial landfill, the floor sweeps landfill, and the construction debris landfill. Use of these three landfills ceased in the 1980s.

To date, extensive work has been conducted to decommission inactive portions of the Former Reynolds Plant, remove industrial materials and wastes from the property, and perform closures and cleanup actions. Additional background information can be found in the RI/FS (Anchor QEA 2015).

1.4 Goals of the Cleanup Action

As described in the CAP (Ecology 2018b), Ecology selected Alternative 4 presented in the RI/FS (Anchor QEA 2015) as the final cleanup action for the site, consistent with MTCA remedy selection criteria (WAC 173-340-360). Alternative 4 includes localized removal and off-site disposal, excavation and consolidation, groundwater treatment, low permeability capping, natural attenuation, and institutional controls. Detailed descriptions of the cleanup action associated with this alternative are included in Section 2. Ecology concluded that Alternative 4, and ultimately the final cleanup, will accomplish the following:

- Comply with MTCA and with other applicable standards and laws.
- Achieve human health and environmental protection in a relatively rapid time frame, compared with the range of alternatives evaluated and to the extent practicable with respect to groundwater restoration.
- Reduce the volume of affected media and waste in the environment.
- Include protective, engineered in situ confinement of residual carbon fill deposits that are not practicable to remove.
- Consolidate impacted soils/solid media remaining on site to the extent practicable, consistent with expectations for remedial alternatives (WAC-173-340-370).
- Have minimal and manageable short-term construction risks, compared with the range of alternatives evaluated.
- Use multiple technologies to provide maximum long-term effectiveness.
- Be protective under the industrial land uses for which the property is zoned.
- Include long-term monitoring and institutional controls to ensure long-term effectiveness in accordance with WAC 173 340-400 and 173 340-410.

1.5 Site Vicinity

The site is located at 4029 Industrial Way near Longview, Washington, in unincorporated Cowlitz County (Figure 1-1). The property and nearby properties are zoned for industrial use. The site is approximately 10 feet above mean sea level (MSL) and bounded by the Columbia River to the south; drainage ditches to the north, west, and east; Industrial Way along the northern boundary; and private property to the east. The drainage ditches are operated by the CDID No. 1, which also manages the levee located within the site along the Columbia River shoreline. The CDID ditches manage surface water and minimize flooding in the City of Longview and other nearby areas. CDID ditches adjacent to the site boundary include CDID Ditch No. 14 to the west, CDID Ditch No. 10 to the north, and CDID Ditch No. 5 to the east.

Industrial Way, also known as State Route (SR) 432, is the nearest transportation corridor, and it extends east-west along the northern boundary of the site. The site includes multiple driveway access points, connections to the Longview Shortline (a rail line that connects the site to the BNSF Railway mainline), and a marine berth and overwater trestle on the Columbia River.

1.6 Site Ownership

Northwest Alloys owns the upland portions of the site and the site assets. The aquatic lands associated with the site are owned by the State of Washington and are managed by the Washington State Department of Natural Resources (WDNR). Northwest Alloys leases the aquatic lands from WDNR.

1.7 Report Organization

The remainder of this report is organized as follows:

- **Section 2 – Description of Cleanup Action** describes the setting of the cleanup action, summarizes the cleanup action objectives and standards, and details the cleanup action activities by site unit (SU).
- **Section 3 – Existing Conditions** summarizes the information and data collected within the cleanup action area that will be used as the basis of the design, including physical, hydrogeologic, and geotechnical conditions.
- **Section 4 – Excavation and Off-Site Disposal** provides the excavation and off-site disposal plan for SU9, SU11, and the Diesel Aboveground Storage Tank (AST) Area.
- **Section 5 – Excavation, On-Site Consolidation, and Low Permeability Caps** provides the conceptual consolidation and capping design, including the basis of design, design approach, containment berm stability, consolidation and settlement, volumes, source materials, and stormwater management.

- **Section 6 – Permeable Reactive Barriers** describes the design and construction considerations for the PRBs to be installed along the northwestern perimeter of the Closed BMP.
- **Section 7 – Remediation Water Management** describes management of remediation water during active construction and between construction seasons.
- **Section 8 – Project Compliance** discusses the regulatory requirements that must be achieved during the implementation of the cleanup action.
- **Section 9 – Compliance Monitoring** describes protection and performance monitoring to be implemented during construction and outlines the long-term monitoring plan, including the installation of new groundwater monitoring wells.
- **Section 10 – Institutional Controls** details the administrative controls required at the conclusion of construction of the cleanup action.
- **Section 11 – Financial Assurance** describes financial assurance that will be sufficient for long-term monitoring and maintenance consistent with the requirements of the WAC.
- **Section 12 – Project Schedule and Reporting** provides the duration and order of the project activities and Completion Report timing.
- **Section 13 – References** includes a list of references cited throughout the report.

Appendices to this document include the following:

- Appendix A – Pre-Design Investigation Data Summary Report
- Appendix B – Geotechnical Summary Report
- Appendix C – Work Plan for Site Unit 9
- Appendix D – Field Sampling and Analysis Plan for Site Unit 11
- Appendix E – Drawings
- Appendix F – Technical Specifications
- Appendix G – Reactive Backfill Report
- Appendix H – Stormwater Design Report
- Appendix I – Treatability Study Report
- Appendix J – Permeable Reactive Barrier Modeling Report
- Appendix K – Remediation Water Management Plan
- Appendix L – Permits and Approvals
- Appendix M – Archaeological Inadvertent Discovery Plan
- Appendix N – Health and Safety Plan
- Appendix O – Construction Quality Assurance Plan
- Appendix P – Work Plan for Removal of Diesel Aboveground Storage Tank

2 Description of Cleanup Action

As mentioned in Section 1.4 and described in the CAP (Ecology 2018b), Ecology selected Alternative 4 presented in the RI/FS (Anchor QEA 2015) as the final cleanup action for the site, consistent with MTCA remedy selection criteria (WAC 173-340-360). This section describes the components of the cleanup action, the cleanup action areas, the cleanup objectives, and the cleanup standards.

2.1 Cleanup Objectives

The following objectives have been identified for cleanup of the site:

- Protection of surface water in the Columbia River and CDID ditches
- Protection of human health and the environment by limiting direct contact with contaminants based on an industrial use scenario
- Protection of human health and the environment by controlling migration of fluoride-impacted groundwater from fill deposits, landfills, and impacted soil
- Protection of terrestrial ecological receptors from exposure to contaminants
- Protection of aquatic and benthic ecological receptors from exposure to contaminants in sediment or surface water

2.2 Cleanup Action Description

A primary goal of the cleanup action is to address two areas of affected groundwater (i.e., the West Groundwater Area and the East Groundwater Area) that were identified during the RI/FS. The selected remedial actions to achieve this goal include construction of a PRB and excavation, consolidation, and on-site containment of materials that have contributed to elevated concentrations of site contaminants of concern (COCs) in groundwater. Upon completion, these actions will achieve the cleanup objectives stated in the CAP and in Section 2.1.

Components of the cleanup action are shown in Figure 2-1, summarized in Tables 2-1 and 2-2, and are described in Sections 2.2.1 through 2.2.5. Figure 2-1 and Table 2-2 have been updated from the RI/FS to best reflect the cleanup action design as described in this Final EDR. Previous cleanup actions at the site have addressed impacted sediment in the vicinity of Outfall 002A (SU12) and a small area of stained soil, identified as localized Total Petroleum Hydrocarbon (TPH) Area (SU13). Those activities are described in Section 2.2.6.

Table 2-1
Components of Cleanup Action

Remedial Action Type	Cleanup Action Component
Institutional Controls	Filing of environmental covenants to prohibit consumption of site groundwater as drinking water and limit activities potentially encountering or disturbing source materials
Natural Attenuation	Natural geochemistry at the site limits migration of fluoride in groundwater to off-site receptors
In Situ Treatment	Construction of a segmented PRB to intercept and treat groundwater
	Backfilling on-site ditches and source removal excavations that intercept groundwater, with an upgrade to reactive backfill within select SUs
Material Consolidation	Focused remedial excavation and on-site consolidation of six SUs
On-Site Containment	Construction of low permeability caps over areas with soils, landfills, and fill deposits exceeding cleanup levels
Off-Site Disposal	Removal and disposal of materials from four SUs where COCs exceed cleanup levels
Other	Long-term monitoring of surface water and groundwater at points of compliance

Table 2-2
Cleanup Action Summary: Remedial Action Area by Site Unit

SU	Description	Remedial Action Area				
		Excavation and Off-Site Disposal	Excavation and On-Site Consolidation	Reactive Backfill	Low Permeability Cap[1]	PRB
SU1	Landfill #2 (industrial)				x[2]	
SU2	Fill Deposit B-3 (residual carbon) (Future West Landfill)		Eastern and western portions[3,4]		Center portion	
SU3	Fill Deposit B-2 (residual carbon)		x[5]	x[3,6]		
SU4	Former Cryolite Area Ditches			x[6,7]		
SU5	Former Stockpile Area		x[5]	x[3,6]		
SU6	Fill Deposit B-1 (residual carbon) (Future East Landfill No. 2)				x	
SU7	Fill Deposit A (spent lime) (Future East Landfill No. 1)				x	

SU	Description	Remedial Action Area				
		Excavation and Off-Site Disposal	Excavation and On-Site Consolidation	Reactive Backfill	Low Permeability Cap[1]	PRB
SU8	Landfill #1 (floor sweeps)		x[8,9]			
SU9	Pitch Tanks	x[5]				
SU10	Landfill #3 (construction debris)		x[8,9]			
SU11	Flat Storage Area	x[6]				
SU12	Vicinity of Outfall 002A	x[10]				
SU13	Localized Area of TPH-Impacted Soil	x[11]				
Other	Segmented PRB adjacent to Closed BMP					x

Notes:

1. Finished operating surface will be hydroseed.
2. Existing soil cover and waste from SU1 will be excavated and graded onto adjacent future West Landfill areas prior to placing a low permeability cap.
3. Excavation will be backfilled with select backfill above the seasonal high groundwater level.
4. Excavated material will be consolidated within the same SU.
5. Excavated material will be transferred to SU6 prior to capping of SU6.
6. Finished operating surface will be gravel.
7. Former cryolite ditches will receive reactive backfill to the seasonal high groundwater level and select backfill above this level.
8. Excavation will be backfilled with compacted select backfill, and the finished operating surface will be vegetated using hydroseed.
9. Excavated material will be transferred to SU7 prior to capping of SU7.
10. Removal of SU12 was completed in late 2016. Removed sediment were managed by off-site disposal.
11. Removal of SU13 was completed in December 2019. Removed material was managed by off-site disposal.

2.2.1 Excavation and Off-Site Disposal Areas

Impacted soils will be excavated and managed by off-site disposal from three areas. These include the pitch tanks (SU9), the flat storage area (SU11), and the Diesel AST Area. At SU9, for pitch removal, the gravel surface within the former containment area will be removed to the existing soil surface, assumed to be approximately 3 feet. The structural piles will be cut off by the demolition contractor to a depth of 5 feet below ground surface (bgs). Soil will be removed to that depth as well, and the ground surface will be sampled to determine if heat transfer media (HTM) oil is present at depth. HTM oil will be removed in two deeper excavation areas where TPH was found during the RI/FS. Gravel and soil removed will be managed for appropriate off-site disposal. Soil removed from SU11 will be disposed at an appropriately permitted facility. Following performance monitoring, SU11 will then be backfilled with general fill after impacted soils have been removed and the area has been remediated. The final surface cover will be composed of gravel in this area. The Diesel AST Area, added to the CD on July 14, 2022 (Ecology 2022e), will be remediated via soil removal in the tank footprint area and off-site disposal following removal of the containment barrier, concrete pad, and empty 200,000-gallon diesel AST. Excavated soil will be profiled for disposal and appropriately managed on site until transported to an approved landfill. Additional details for SU9, SU11, and the Diesel AST Area are included in Section 4.

2.2.2 Excavation and On-Site Consolidation Areas

As described in the RI/FS (Anchor QEA 2015) and CAP (Ecology 2018b), due to natural site conditions (e.g., geochemistry and upward hydraulic gradients) and limited off-site impacts to surface water and groundwater, several of the landfill and fill deposit areas for this site are suitable candidates for excavation and consolidation with the goal of long-term containment. Fill deposits at four of the SUs (SU1, SU2, SU6, and SU7) will be managed using containment, engineering controls, and monitoring to protect human health and the environment by minimizing the potential for direct contact and migration of hazardous substances. The locations of fill deposits to be managed in place are shown in Figure 2-1. Impacted materials from other site areas (SU3, SU5, SU8, and SU10) will be excavated and consolidated with these fill deposits prior to placement of low permeability caps. The consolidation and capping will minimize the potential for direct contact with and infiltration of precipitation through impacted materials and are summarized as follows:

- The eastern and western portions of SU2 will be excavated and consolidated within the same SU. The excavated areas will be filled with reactive backfill to the seasonal high groundwater level and select backfill above this level.
- Materials excavated from SU3 and SU5 will be consolidated within SU6. The excavation area within SU3 will be backfilled with reactive backfill to the seasonal high groundwater level to further immobilize residual fluoride and select backfill above this level. The final grades in these areas will be resurfaced with gravel.
- The SU5 excavation will be filled with compacted select backfill. The pre-existing ditch will receive reactive backfill to the seasonal high groundwater level and select backfill above this level. The final backfilled SU5 area will be graded to prevent future ponding due to seasonal fluctuations in groundwater levels and covered with a gravel mix suitable for light vehicle traffic.
- Materials excavated from SU8 and SU10 will be consolidated within SU7. These excavation areas will be backfilled with compacted select backfill and hydroseeded.

Additional design details for these SUs are included in Section 5.

2.2.3 Low Permeability Caps

Post-consolidation, the three consolidation areas will be covered with a low permeability cap to prevent future exposure to the affected material and reduce surface water infiltration through contaminated materials by retarding the flow of water below the main barrier layer of the cap. The low permeable caps will also reduce the mobility of contaminants located in the unsaturated soil zone and control erosion of contaminated material. SUs that will receive a low permeability cap are SU1, SU2 (post excavation, transfer and consolidation of eastern and western portions from SU2), SU6 (post transfer and consolidation of materials from SU3 and SU5), and SU7 (post transfer and consolidation of materials from SU8 and SU10). The design of the low permeability caps is described in Section 5.

2.2.4 Reactive Backfill

As stated in the RI/FS, COCs at the site can be reliably contained; in fact, natural geochemical processes at the site are effectively doing so under current conditions before implementation of the final cleanup action. However, selected SUs will receive reactive backfill to augment the geochemical and other interactions occurring at the point of exchange between groundwater and ditch water. Reactive backfill will have mineral amendments that will be used in selected areas to reduce residual fluoride concentrations in groundwater flowing through the backfill. Below the average wet weather groundwater elevation, SU2 in the eastern and western areas, SU3, and SU5 will receive reactive backfill post-excavation. Above the average dry weather groundwater elevation, the areas would receive select backfill. The former cryolite ditches (SU4) and the pre-existing ditch within SU5 will also receive reactive backfill to the seasonal high groundwater level and will be backfilled with select backfill above this elevation.

2.2.5 Permeable Reactive Barriers

Groundwater concentrations of fluoride exceed the maximum contaminant level (MCL) in portions of the West and East Groundwater Areas and in an area adjacent to SU10. However, natural geochemical processes occurring in site soils and groundwater limit the migration of fluoride both laterally and vertically; in addition, site hydrogeologic conditions (i.e., upward hydraulic gradients) protect deep groundwater from fluoride contamination. Nevertheless, the selected cleanup action includes groundwater treatment to further protect groundwater and surface water receptors from the migration of site fluoride. Groundwater treatment systems, such as PRBs, will serve to bolster the naturally occurring processes that are preventing migration of fluoride in groundwater and enhance the overall protectiveness of the cleanup action.

Groundwater treatment includes the construction of PRBs—vertical trenches, perpendicular to contaminated groundwater flow, that are backfilled with selected reactive media—to enhance the natural attenuation process and further limit the mass flux of fluoride from groundwater to the CDID ditches. The conceptual locations of the PRBs, from the CAP, are shown in Figure 2-1. PRB width, depth, alignment, and composition depend on a number of factors, including treatment longevity, cost, and other design considerations as discussed in Section 6.

2.2.6 *Completed Cleanup Actions*

2.2.6.1 Site Unit 12

In November 2016, a sediment interim action was completed for SU12. The SU12 remedy included dredging to an approximate depth of 2 feet in a 125-foot by 250-foot area around Outfall 002A. Approximately 3,900 cubic yards (cy) of sediment were dredged and transported by barge upriver to The Dalles, Oregon, for disposal at the Subtitle D Wasco Landfill. A *Sediment Interim Action Completion Report* (Anchor QEA 2017) was submitted to Ecology on August 1, 2017, and was approved by Ecology on August 15, 2017 (Ecology 2017).

2.2.6.2 Site Unit 13

The removal of impacted soils at SU13 (also known as the TPH Area) was completed in October 2019. Approximately 7 cy of soil were removed and disposed of at the Subtitle D Hillsboro Landfill. A Completion Report (Anchor QEA 2019b) was submitted to and approved by Ecology in December 2019 (Ecology 2019a).

2.3 Cleanup Standards

A cleanup standard is defined based on a specified location (i.e., point of compliance [POC]) and the concentration of a hazardous substance (i.e., the cleanup level) that must be met to avoid risks to human health and the environment. The CAP established cleanup levels for surface water, groundwater, and soil as described in Sections 2.3.1 through 2.3.3. Site-specific POCs were set in the CAP for surface water and groundwater.

2.3.1 *Surface Water Cleanup Standard*

As stated in the CAP, the POC for surface water cleanup levels is the point or points at which hazardous substances are released to surface waters of the state (WAC 173-340-730[6]). The CDID regional drainage ditches convey water from various locations within the cities of Kelso and Longview to the Columbia River to prevent flooding of the area. The water contained within the ditches is considered water of the state. Although the CDID ditches themselves are not direct sources of drinking water, they are subject to the same surface water criteria as the river.

The POCs for surface water are in the CDID Ditch No. 14 and Columbia River water column adjacent to the site. Table 2-3 summarizes the cleanup levels and POC for surface water (i.e., the Cleanup Standard).

Table 2-3
Surface Water Cleanup Standards

Contaminant of Potential Concern	Surface Water Cleanup Level	Protection Basis	POC
Fluoride (total)	4 mg/L	State drinking water MCL	CDID Ditch No. 14 and Columbia River
	Narrative Standard	No adverse effects as described in the Narrative Standard	
Free cyanide	5.2 µg/L	WAC 173-201A	

2.3.2 Groundwater Cleanup Standard

Under MTCA, the standard POC for groundwater extends from the uppermost level of the saturated zone to the lowest depth that could be potentially affected by site releases. For fluoride, Ecology has determined that it would not be practicable[1] to meet groundwater cleanup levels throughout the site within a reasonable time frame.

Because it is not practicable to meet the standard POC in groundwater for fluoride, compliance with the fluoride groundwater cleanup level must be measured at conditional POC monitoring points located downgradient from the respective source areas but prior to the property line or discharge to surface water, in accordance with WAC 173-340-720(8)I. Where these monitoring points are located within the existing plumes and an extended time frame (i.e., hundreds of years) is anticipated to comply with site cleanup levels, groundwater remediation levels have been established along with contingency response measures to ensure protection of adjacent surface waters.

For all other constituents, compliance must be evaluated at wells located where remedial action occurs or adjacent to SUs. Table 2-4 summarizes the cleanup levels and POC for groundwater.

[1] Practicability is based on a determination that a more permanent cleanup action is not practicable based on the disproportionate cost analysis in WAC 173-340-360(3)(e) (see Section 7 of the CAP).

Table 2-4
Groundwater Cleanup Standards

Contaminant of Potential Concern	Groundwater Cleanup Level	Protection Basis	POC	Remediation Levels
Fluoride (total)	4 mg/L	State Drinking Water MCL	Conditional POC at property line and groundwater-ditch boundary	Refer to Appendix A of CAP
Free cyanide	200 µg/L	State Drinking Water MCL	Wells adjacent to applicable SUs	Not applicable
cPAHs	0.1 µg/L	MTCA Method A Standard Value		
TPH diesel range	500 µg/L	MTCA Method A Standard Value		
TPH oil range	500 µg/L	MTCA Method A Standard Value		

2.3.3 Soil Cleanup Levels

Soil cleanup levels for industrial uses were developed for fluoride, polycyclic aromatic hydrocarbons (PAHs), TPH, and polychlorinated biphenyls (PCBs) by considering the following potential exposure/risk pathways:

- Human health protection from direct soil contact
- Human health protection from soil-to-groundwater pathway exposure
- Human health protection from soil-to-air pathway exposure
- Terrestrial ecological protection

The final cleanup levels for site soils are summarized in Table 2-5. Development of these cleanup levels is discussed by pathway in the CAP.

Table 2-5
Soil Cleanup Levels

Contaminant of Potential Concern	Soil Cleanup Level	Protection Basis
Fluoride[1]	3,100 mg/kg[1]	Protection of groundwater, Method C
PAHs[2]	18 mg/kg	Method C
PCBs	10 mg/kg	Method A[3]
TPH diesel range	2,000 mg/kg	Method A
TPH heavy oil range	2,000 mg/kg	Method A
TPH mineral oil	4,000 mg/kg	Method A
HTM oil	10,000 mg/kg	Protection of groundwater[4]

Notes:

1. Using Method C, 210,000 mg/kg is protective of human health for direct contact under industrial exposure scenarios (Federal Integrated Risk Information System database). However, this cleanup level was adjusted downward to protect groundwater. Excluding residual carbon or spent lime, site media containing between 3,100 and 210,000 mg/kg fluoride may be reused on site if it can be shown that groundwater will be protected. See CAP Appendix D, *On-Site Media Management Plan* (Ecology 2018b).
2. Cleanup level developed for potentially carcinogenic PAHs based on the approved MTCA toxicity equivalency factor procedure.
3. This is a total value for all PCBs. This value may be used if the PCB-contaminated soils are capped and the cap is maintained as required by 40 CFR 761.61. If this condition cannot be met, the value for unrestricted site use (1 mg/kg) must be used. High occupancy is assumed for the site.
4. As presented in Section 8.5.4 of the RI/FS, the soil-to-air pathway resulted in the most conservative cleanup level for HTM oil. Therefore, 10,000 mg/kg is selected as the soil cleanup level.

2.4 Coordination of the Cleanup with the NPDES Permit

The site's National Pollutant Discharge Elimination System (NPDES) individual permit No. WA 000008-6 was issued by Ecology on February 7, 2018, and the permit became effective March 1, 2018 (Ecology 2018c). The permit is for the discharges currently occurring at the site and for those discharges that will occur during remediation and redevelopment. Permit Condition S1.E of the NPDES permit defines remediation water as "contaminated groundwater from the upper shallow water-bearing zone (WBZ) of the East and West Groundwater Areas and stormwater that comingles with contaminated groundwater and/or contaminated soils." Compliance with the NPDES permit during remediation activities will be performed as described in Section 7.

3 Existing Conditions

This section summarizes the information and data collected within the cleanup action area that will be used as the basis of the design, including physical site characteristics, site geology, hydrologic influences, site hydrogeology, seismicity, and geotechnical conditions. The majority of this information was collected as part of the RI/FS (Anchor QEA 2015) and the PDIs conducted in February and April 2020 and February 2022.

3.1 Physical Site Characteristics

The Former Reynolds Plant is located within a portion of the property owned by Northwest Alloys. Northwest Alloys owns a total of approximately 536 acres of property. Only the southern portion of this property (approximately 436 acres located south of Industrial Way) was included in the historical aluminum manufacturing operations. The Northwest Alloys property located north of Industrial Way remains undeveloped. The Former Reynolds Plant also includes a dock structure within the Columbia River. The Northwest Alloys-owned property extends to the extreme low water mark within the Columbia River.

The Former Reynolds Plant is located within an industrial land use corridor located along Industrial Way/SR 432 and the Columbia River navigation channel. The Former Reynolds Plant and the adjacent properties are zoned for industrial use. Uses at these adjacent properties include the following:

- **Properties to the West.** The majority of the property located to the west of the Former Reynolds Plant has been purchased by the Port of Longview. This property is currently vacant. Other smaller properties located to the west include a closed landfill and a CDID pump station (the Reynolds Pump Station) located on a small CDID-owned parcel located adjacent to the Columbia River.
- **Properties to the East (Nippon Dynawave Packaging Co.).** A Nippon Dynawave Packaging Co. (formerly Weyerhaeuser pulp and paper mill) facility is located immediately to the east (upstream) of the Former Reynolds Plant. The industrial facility is complex and includes multiple affiliated operations.
- **Properties to the North.** The properties located to the northeast include the Mint Farm Well Field (Mint Farm), which is owned by the City of Longview. Other properties located to the north and northwest include several Bonneville Power Administration-owned properties located along Industrial Way/SR 432, a quarry, and other privately owned hillside acreage.

3.2 Site Geology

The site is located within the Longview-Kelso basin, a topographic and structural depression formed by the Cascadia subduction zone (Evarts et al. 2009). The Longview-Kelso basin is primarily composed of Tertiary age bedrock overlain by Quaternary age unconsolidated alluvium. Bedrock units include volcanic rocks of the Grays River formation and thinly interbedded sandstone, siltstone, and shale layers of the Cowlitz Formation (Phipps 1987; Walsh 1987).

The layers of the alluvium include thick sequences of the catastrophic Missoula flood deposits (coarse-grained sand and gravel) overlain by channel and floodplain deposits (silt, fine-grained sand, and clay) of the Columbia and Cowlitz rivers (Swanson et al. 1993; Evarts et al. 2009). This two-layer alluvial system is illustrated in the groundwater conceptual site model (Figure 3-1).

Within the site and beneath most of the Longview area, the upper portion of the alluvium (Upper Alluvium) consists of fine-grained sand, silt, and clay overlying the much deeper sequence of coarser-grained gravels and cobbles (Lower Alluvium). The following provides a summary of the Upper and Lower Alluvium:

- **Upper Alluvium.** The characteristics of the Upper Alluvium vary within the Longview-Kelso basin. However, within the site, the Upper Alluvium consists of fine-grained silt and clay deposits. Analysis of shallow and deep boring logs from the Former Reynolds Plant water supply wells and from studies performed for the City of Longview Mint Farm confirm the Upper Alluvium locally consists of interbedded silt and fine-grained sand layers, with minor fractions of silty sand, sandy silt, and clay interbeds. This fine-grained Upper Alluvium averages approximately 200 feet in thickness beneath the site. The unit is approximately 200 to 300 feet thick along the Columbia River shoreline, thinning to 130 to 190 feet in the northeastern portion of the site.
- **Lower Alluvium.** The Lower Alluvium consists of the deeper, coarse-grained geologic unit containing gravels and cobbles. Many of the water production wells located within the Former Reynolds Plant and on nearby industrial properties (including those of the Mint Farm) are completed within these coarse-grained gravel deposits. Beneath the site and Mint Farm areas, the Lower Alluvium consists of coarse-grained sand and gravel deposits and ranges in thickness from 100 to 350 feet.

Surficial soils within the site can contain other types of soil, including anthropogenic fill deposits, or other disturbances to the Upper Alluvium. Fill, including coarse-grained dredged material from the Columbia River, coarse-grained materials used to construct the CDID levee, and other materials, was placed on the site during its development.

3.3 Hydrologic Influences

The behavior of groundwater within the site is influenced by the area hydrology. Local hydrologic influences include the Columbia River, the surface ditches of the regional CDID ditch system, and those of the on-site ditch system. The influences of these features on groundwater are described in Sections 3.3.1 and 3.3.2.

3.3.1 CDID Ditch System

The site is located in the southeastern corner of the Grays/Elochman Water Resource Inventory Area 25. The average ground surface within the Former Reynolds Plant is approximately 12 feet above MSL, though there is extensive topographic variation at the site.

A network (approximately 35 miles) of drainage ditches is operated throughout the Longview-Kelso basin by the CDID. These ditches were excavated by USACE to drain both stormwater and shallow groundwater from properties within the district and permit development within the floodplain. The CDID ditches are structurally isolated from the Columbia River but ultimately discharge to the Columbia River through a series of pump stations and hydraulic gates. CDID facilities located within or near the Former Reynolds Plant include the following:

- **CDID Levee.** A CDID flood control levee extends along the shoreline of the Columbia River across the full river frontage of the site. This levee is part of a larger network of dikes and levees originally constructed by USACE along the Columbia River shoreline during the 1920s to protect Longview properties from flooding by the Columbia River. Along the Former Reynolds Plant, the height of the levee averages approximately 32 feet above MSL.
- **CDID Ditch No. 14.** The drainage ditch located along the western edge of the site, CDID Ditch No. 14, is located on Northwest Alloys-owned property, with the exception of the CDID-owned and operated pump station (also known as the Reynolds Pump Station) located next to the Columbia River. That pump station is located on CDID-owned property.
- **CDID Ditch No. 5.** The drainage ditch located along portions of Industrial Way and along the eastern corner of the site is CDID Ditch No. 5. This ditch is pumped through an underground discharge pipeline connecting the Industrial Way Pump Station to its outfall at the southern corner of the site.
- **Pump Stations.** The closest pump stations are the Industrial Way Pump Station (located northeast of the Former Reynolds Plant) and the Reynolds Pump Station located at the southwest corner of the Former Reynolds Plant.

The water levels within the CDID ditch system are maintained by active pumping at levels beneath those of the Columbia River. The pumping of the CDID ditches tends to induce groundwater gradients toward the ditch system. For the site, this results in a groundwater gradient from the Columbia River (with its higher water surface elevation) north and west toward the CDID ditches.

3.3.2 Site Drainage Ditch System

In addition to the CDID ditches, numerous on-site ditches collect stormwater runoff. Like the CDID ditch system, these ditches also influence shallow groundwater.

Stormwater runoff within the site is managed by infiltration or evaporation and by a complex stormwater collection and treatment system. Stormwater runoff comprises the largest volume of the discharge managed on the site. Figure 3-2 illustrates the location of key elements, including the following:

- Facility 77 Sump/Pump Station and Thickener Tanks
- Pump Station 004
- Retention Basin, Pump Station C, and Filter Plant (Facility 73)
- Industrial Wastewater Treatment Plant (Facility 71)
- Major industrial Outfall 002A that discharges treated commingled process wastewater and stormwater
- Stormwater-only Outfalls 003C and 006

3.4 Site Hydrogeology

There are several WBZs beneath the site based on information developed as part of the RI/FS (Anchor QEA 2015). These include those of the Lower Alluvium, the Upper Alluvium, and the surficial soils. The on-site water production wells are completed within the Lower Alluvium.

The groundwater monitoring wells developed as part of environmental monitoring programs and the RI/FS are completed within the surficial soils and in some cases within the Upper Alluvium. The depth varies for these wells. The depth of the deepest environmental monitoring well within the network is 38 feet bgs. Generally, the monitoring wells indicated as “shallow” are screened across the first water table encountered, with depths of less than 19 feet bgs. The monitoring wells indicated as “deep” are screened slightly deeper, between 19 and 38 feet bgs. None of these wells penetrate into the Lower Alluvium, which is on average more than 200 feet bgs.

Observations from site hydrogeologic investigations and monitoring well logs indicate that the conditions encountered in the upper soils differ by location due to natural variations in the top of the Upper Alluvium and variations in the history of site development and the composition of surficial soils overlying the Upper Alluvium. Generally, deeper wells and borings within the Former Reynolds Plant encountered discontinuous and interbedded fine-grained sand, silt, and clay layers.

3.4.1 Groundwater Gradients

Groundwater flow in the shallow WBZ of the surficial soils and the Upper Alluvium is influenced primarily by the Columbia River, regional CDID ditch system, and on-site ditches. Precipitation recharge and seasonal fluctuations are noted in this upper zone. Tidal influences are noted in areas near the Columbia River, as described in the RI/FS (Anchor QEA 2015).

Based on dry (October 2012) and wet (December 2012) season groundwater gradients evaluated during the RI/FS, shallow groundwater within this upper WBZ typically flows north and west, away from the Columbia River toward the CDID ditches. The on-site ditches also influence groundwater gradients in some localized areas (i.e., in areas where the water level maintained in the on-site ditches was below that of the nearby groundwater).

Seasonal variations in groundwater elevations were noted in the shallow WBZ. Groundwater elevations were higher (with variation up to 2 feet) in the wet season than during the dry season. This is reasonable given the higher rates of precipitation and estimated groundwater recharge during the wet season and also given the higher Columbia River levels that typically occur during winter months. The extent of seasonal variation differed by well location.

Some of the environmental monitoring wells data evaluated as part of the RI/FS exhibited unusually high groundwater elevations in comparison to adjacent wells. These conditions have been noted at wells G6-S and RLSW-4, which are located along the CDID levee near the Columbia River. The water elevations in these wells also have not correlated well with river stage in comparison to deeper-screened wells in these areas. The observations from these wells suggest that groundwater in this area is perched on low permeability silt and clay layers, as noted in the boring logs for these wells. In December 2012 (and to a certain extent October 2012), relatively high groundwater elevations were observed at wells R-1S, R-4S, and G1-S, which are also located along the CDID levee near the Columbia River.

3.4.2 Hydraulic Conductivities and Vertical Gradients

Hydraulic conductivities were measured in the environmental monitoring wells during the RI/FS to provide a point of comparison to those measured in the Upper and Lower Alluviums during regional studies performed by others. The hydraulic conductivities were measured both during "slug tests," and using the information developed during the tidal study and are summarized as follows:

- **Shallow Water-Bearing Zone.** The hydraulic conductivities within the environmental monitoring wells completed in the shallow WBZ varied by location, and the observed variation is reasonable given the variable nature of the surficial fill soils and the variable contacts with the Upper Alluvium. The measured hydraulic conductivities in the environmental monitoring wells ranged from a low of 0.003 foot to a high of 16 feet per day.
- **Upper Alluvium.** Hydraulic conductivities were measured during the City of Longview's preliminary design studies for the water production wells at the Mint Farm (Kennedy/Jenks 2010). These measurements were performed using laboratory measurements. Of 11 representative samples of the Upper Alluvium, 9 were from silt deposits, with measured conductivities between $3x10^{-4}$ and $3x10^{-5}$ feet per day. Two of 11 samples from the Upper Alluvium were collected from layers containing higher sand content, with measured conductivities ranging from 0.3 to 3 feet per day.

- **Lower Alluvium.** The conductivities of the coarse-grained Lower Alluvium were also reported in the City of Longview's design study (Kennedy/Jenks 2010). The conductivity for this layer was estimated to range between 20 and 2,500 feet per day, with an average of about 725 feet per day (Kennedy/Jenks 2010).

Vertical gradients between the Lower and Upper Alluviums were assessed as part of the City of Longview's preliminary design studies. During June and November 2009, vertical gradients in well pairs completed in each alluvium layer showed the presence of an upward gradient. In most of the paired sentinel wells, groundwater heads measured in the shallow wells were from 2 to 5 feet lower than those in adjacent deep wells. The study concluded that the aquifer within the Lower Alluvium behaved as a confined system near the Columbia River where the silty deposits of the Upper Alluvium were the thickest (Kennedy/Jenks 2010). This includes the area surrounding the site.

3.5 Geotechnical Conditions

Several geotechnical investigations have occurred throughout the property to support the initial construction of the aluminum production facility and other various investigations. The geotechnical conditions were further investigated during the PDI program, which collected data to support the evaluation, analysis, and design of engineered confinement areas for on-site waste excavation and consolidation, as outlined in the PDI Work Plan (Anchor QEA 2019a). To fulfill these objectives, in situ penetration testing and geotechnical borings were conducted at various locations throughout the SUs, along with locations of excavation along the CDID levee. The full data analysis of the PDI program is included in the DSR (Appendix A).

In general, the geotechnical investigations at the site have revealed that subsurface conditions consist of the following major geologic units from the ground surface downward:

- **Existing Landfill Cover.** Within the footprints of each SU, some thickness of cover material or fill was encountered. Cover material overlying waste deposits generally consisted of a very loose, wet, silty, sandy topsoil with a thickness of 0.4 to 10 feet.
- **Waste Material.** Explorations within each SU found waste material consisting of black or white mud or landfill debris. The thickness of waste across the SUs varies, ranging from a few feet to more than 20 feet thick. The waste types have different strength, workability, and compaction characteristics as discussed in Appendix B.
- **Levee Fill (Silty Sand to Sand).** Several investigations were made along or adjacent to the existing CDID levee near SU2, SU8, and SU10. The levee was determined to be composed of loose to medium dense silty sand to relatively clean medium dense sand, topped with a thin gravel base course. It is Anchor QEA's understanding that the existing levee extends landward from its crest at a slope of approximately 6 horizontal to 1 vertical (6H:1V) beneath the

existing grade. The configuration of the riverward side of the levee is variable, ranging from steep 3H:1V slopes with limited extra fill to flatter slopes with 20 to 50 feet of overbuild.

- **Silt.** Native very soft to medium stiff silts with varying percentages of sand were encountered beneath all SUs, generally starting below SU waste or levee fill and persisting to an undetermined depth. The index properties of this unit varied greatly across the site. In the northeast portion of the site, the silt had varying amounts of organic material present, with some interbedded layers of organic silt.
- **Sand.** Native very loose to medium dense sands with varying percentages of fine-grained particles were encountered beneath all SUs, generally starting below an approximate elevation of 0 foot North American Vertical Datum of 1988 (NAVD88) at the southeastern portion of the site and below an elevation of 10 feet NAVD88 at the northwestern portion. The sand unit is at times interbedded within the silt layer.
- **Silty Sand.** The interface between the two preceding units (silt and sand) were often presented through interbedding of very loose to loose silts and sand, as well as through a general mixture of the two. This unit was found generally beneath the silt layer, and deeper sand or silt units, and was observed to vary in thickness across the site.
- **Peat.** A highly organic peat soil was encountered underlying SU7 in the northeast corner of the site. The peat ranged from 2 to 11 feet thick and was found within the top 20 feet of each boring.

The *Geotechnical Summary Report* (Appendix B) provides details regarding the specific lithology observed at each SU, figures that depict the encountered lithologies, and appropriate geotechnical engineering soil parameters used for each layer.

3.6 Seismicity

Much of the state of Washington, including Longview, is designated as a seismic impact zone by the U.S. Geological Survey (USGS). Seismic impact zones are defined as areas in which there is at least a 10% probability that horizontal seismic accelerations equal to or greater than 0.1 gravity (acceleration of gravity at the earth's surface) will occur within a 250-year period. Several active faults exist near the site, with the closest known surficial fault being the St. Helens fault approximately 40 miles to the east. A larger fault zone, the Cascadia subduction zone, lies to the west of the site along the Pacific coast. Using the USGS Hazard Tool, the main contributing fault for the site is the Cascadia subduction zone, which could produce an earthquake with an epicentral distance as close as 30 miles and with a magnitude near 9.0.

Ground shaking is the most widespread effect of earthquakes. The strength of ground shaking at a certain location depends primarily on the magnitude of the earthquake, distance from the source, paths the seismic waves travel through the earth, response characteristics of the rock or soils underlying the site, and topography. In general, relatively flat earth structures, such as the landfills and fill deposits present at the site, are resistant to seismic motions and will move together with the surrounding ground in the event of an earthquake. Nonetheless, federal and state regulations require seismic analysis, based on a relatively severe earthquake event, for the design of landfill cover systems. To better assess the potential impacts to the West Landfill and East Landfills (referred to as SU2, SU6, and SU7 prior to waste consolidation and capping), a deformation analysis was performed to estimate the potential displacement of the waste and landfill cover materials in response to seismic loading and subsequent soil liquefaction. The results are discussed in Section 5.3 and Appendix B.

4 Excavation and Off-Site Disposal

As described in Section 2.2.1, pitch and HTM oil-impacted gravel and soil from SU9, impacted soils from SU11, and diesel range organic (DRO)-impacted soils from the Diesel AST Area will be excavated and managed by off-site disposal. Gravel and soil removed from these areas will be disposed of at an appropriately permitted disposal facility.

Each of these cleanup actions are described in Sections 4.1 through 4.3.

4.1 Site Unit 9

HTM oil was used as part of an enclosed, recirculating heating system associated with the anode and cathode pitch tanks. Pitch is solid at cooler ambient temperatures and must be heated to allow product transfers. During Chinook Ventures, Inc. (CVI), operations at the site (2004 to 2011), a release of HTM oil from the tank heating system's plumbing was discovered within the pitch tanks containment area between the two easternmost pitch storage tanks. Soil sampling was conducted, and CVI removed accessible oil-impacted soils from the release area. Additional soil sampling was conducted in 2011 as part of the RI/FS (Anchor QEA 2015), and that sampling confirmed that no further actions were required to comply with MTCA cleanup levels applicable to the SU9 area (Ecology 2018a).

Isolated surficial pitch deposits were observed to be present near the pitch storage tanks. With the demolition of the pitch tank foundations, containment barrier, and structural pile supports, it should be possible to reach additional pitch and HTM oil. For pitch removal at SU9, the gravel surface within the former containment area will be removed to the existing soil surface, assumed to be approximately 3 feet. The structural piles will be cut off by the demolition contractor to a depth of 5 feet bgs. Soil will be removed to that depth as well, and the ground surface will be sampled to determine if HTM oil is present at depth. HTM oil-impacted soil will be removed in two deeper excavation areas where TPH was found during the RI/FS. Excavated soil and gravel will be managed for off-site disposal as described in the *Work Plan for Site Unit 9* found in Appendix C. In general, the SU9 cleanup will be as follows:

- The gravel surface will be removed to the existing soil surface, assumed to be approximately 3 feet.
- The structural piles will be cut off by others to a depth of 5 feet bgs. Soil will be removed to that depth as well, and the ground surface will be sampled to determine if HTM oil is present at depth.
- Excavation will occur in two additional TPH areas. Soil will be removed in an approximate 5- by 5-foot area down to 6 feet bgs and in a 5- by 5-foot area down to 8 feet bgs, unless groundwater is encountered first.

- Removed gravel and soil will be placed directly into a roll-off box. The roll-off box will be provided with an appropriate liner and cover.
- Excavated soil and gravel will be managed for off-site disposal.
- The excavation areas, including the former tank footprint areas, will be backfilled with general fill and restored for general vehicle use.

4.2 Site Unit 11

The flat storage area was developed by CVI in the western area of the property, between the North Plant potline buildings and the Cable Plant. CVI constructed a pad structure from cement-amended soil for stockpiling bulk products, such as green petroleum coke and coal. Removal of the remaining petroleum coke and decommissioning of the flat storage pad was completed by MBT-Longview in December 2012.

Soil sampling was conducted in 2011, 2012, and 2013 in the flat storage area to determine if PAHs associated with petroleum coke may have leached into underlying soils. The 2013 sampling was conducted as part of the RI/FS to provide improved delineation of an area of PAH contamination in the northwest corner of the former flat storage area. Based on that sampling, a single localized soil sample exceeded the Method C Industrial Soil Cleanup Level for carcinogenic polycyclic aromatic hydrocarbons (cPAHs) (Anchor QEA 2015). This localized area makes up SU11.

The SU11 soil removal and performance monitoring will follow the procedures described in the *Field Sampling and Analysis Plan for Site Unit 11* found in Appendix D. In general, the SU11 cleanup will be as follows:

- cPAH-impacted soil will be removed from an area within the SU11 footprint, down to 2 feet bgs. It is estimated that approximately 185 cy of soil will be removed.
- Removed soil will be placed directly into a roll-off box. The roll-off box will be provided with an appropriate liner and cover.
- The removal of impacted soils will be confirmed by collecting soil samples.
- Confirmation samples will be compared to the PAH cleanup levels defined in the CAP, as described in Section 2.3.3. If comparison of confirmation sample results with cleanup levels does not demonstrate compliance with cleanup levels, additional excavation will be performed, and confirmation samples will be collected until compliance is demonstrated.
- Following confirmation that performance monitoring is compliant with soil cleanup levels, the excavation area will be backfilled with general fill.

4.3 Diesel AST Area

In 1991, Reynolds Metals Company (Reynolds) conducted an independent cleanup action to remove approximately 480 cy of diesel-impacted soils adjacent to the 200,000-gallon diesel AST. Testing of groundwater indicated that the impacts were limited to soil (Reynolds 1993). The excavation removed the impacted soils that could be safely accessed without compromising the integrity of the AST foundation. A deed restriction was filed for the localized area of impacted soils remaining in place under the active tank foundation. The site was restored for use by placing a concrete containment pad and structure around the diesel tank (Reynolds 1993; Anchor QEA 2015). The diesel tank has not been in use for approximately 10 years and is considered a decommissioned closed tank.

The Diesel AST Area will be remediated via soil removal in the tank footprint area and off-site disposal following removal of the containment barrier, concrete pad, and empty 200,000-gallon diesel AST. The Diesel AST Area soil removal will follow the procedures described in the *Work Plan for Removal of Diesel Aboveground Storage Tank* found in Appendix P. In general, the Diesel AST Area removal will be as follows:

- Excavation will occur on a 3H:1V slope from the edge of the existing tank footprint toward the center. It is estimated that approximately 106 cy of DRO-impacted soil will be removed.
- Removed soil will be placed directly into a roll-off box. The roll-off box will be provided with an appropriate liner and cover.
- The removal of impacted soils will be confirmed by collecting soil samples.
- Performance samples will be compared to the TPH diesel range cleanup level defined in the CAP, as described in Section 2.3.3. If comparison of performance sample results with cleanup levels does not demonstrate compliance with cleanup levels, additional excavation will be performed, and performance samples will be collected until compliance is demonstrated.
- Following confirmation that performance monitoring is compliant with soil cleanup levels, the excavation area will be backfilled with general fill with the final cover composed of gravel.

Northwest Alloys sent a request to Ecology for minor modification to the CD on June 22, 2022, to incorporate the Diesel AST Area. Ecology concurred on July 14, 2022, that the soil removal action may be considered a minor modification and that the amendment of the CD would become effective upon Ecology's approval of the work plan submitted with the Final Revised EDR (Ecology 2022e). The deed restriction that was previously filed for the cleanup in the Diesel AST Area must be revised at the same time the additional environmental covenants are filed for the CAP and CD. See Section 10.3 for further discussion on deed restrictions.

5 Excavation, On-Site Consolidation, and Low Permeability Caps

A key goal of the overall site remedy is to reduce the footprint of areas containing impacted materials. Material consolidation reduces areas that will require low permeability caps to prevent infiltration of precipitation through impacted material and to limit direct contact exposures to site contaminants. This section describes the key considerations for design associated with combined excavation, consolidation, and capping activities. It is supported by the detailed Drawings and Technical Specifications included as Appendices E and F, respectively.

5.1 Excavation Design

The CAP requires the excavation and on-site consolidation of impacted materials from five SUs (SU2, SU3, SU5, SU8, and SU10) (Ecology 2018b). Per the CAP and the referenced detailed description of Alternative 4 included in the RI/FS (Anchor QEA 2015), fill removal will be conducted using dry excavation methods. These methods are limited to depths above or immediately below the groundwater table at the time of construction. With the exception of SU3, which is an area where the groundwater table is observed near the ground surface, all excavations are expected to be terminated within 1 to 2 feet of the locally observed dry weather groundwater table elevation.

Sections 5.1.1 through 5.1.5 describe the specific considerations for each excavation area.

5.1.1 Site Unit 2

As described in the RI/FS and Section 1.3 of this Final EDR, the Former Reynolds Plant performed a recycling process called cryolite recovery to recover reusable raw materials from the aluminum manufacturing process. A byproduct of cryolite recovery is residual carbon, also known as black mud.

The SU1/SU2 combined deposit was investigated during the remedial investigation (RI) through the advancement of 30 test pits to determine the vertical and lateral extent of impacted materials. The observations from the test pits, along with information from the CDID regarding construction of the levee, were used to delineate impacted materials. Materials will be excavated from each side of SU2 (Figure 2-1) and then consolidated onto the remaining SU1/SU2 combined fill. The average excavation depth is 6.5 feet, and the total estimated volume is 50,100 cy.

Figure 5-1 shows the bottom elevation of the fill materials in relation to average dry and wet weather groundwater elevations. In areas where excavations are planned (Figure 2-1), it is expected that it will be feasible to complete the excavation work during the relatively dry summer months without the need for dewatering activities. Within SU2, it is expected that all impacted material will be removed and consolidated as a result of the planned excavations.

Historical groundwater depth to water measurements (collected over several decades) were evaluated and form the basis of the high and low (wet and dry) seasonal groundwater elevations.

Water level elevations from groundwater monitoring wells have been measured as part of the quarterly monitoring program conducted by Reynolds from 1988 through 2004; MBT-Longview from 2011 through 2020; and Northwest Alloys in 2021. Water elevation measurements collected during the RI/FS are also included in the dataset, as applicable. For each monitoring location, the arithmetic average, minimum, 10th percentile, maximum, and 90th percentile were calculated and are summarized by SU in Table 5-1. This dataset was used to establish the upper (90th percentile) and lower (10th percentile) elevations that define the seasonal low groundwater level for excavation and the seasonal high groundwater level for placement of the reactive backfill.

Table 5-1
Seasonal Water Level Elevations for Groundwater Monitoring Wells

Site Unit	Monitoring Location	Water Level Elevation (feet)				
		Average	Minimum	10th Percentile	Maximum	90th Percentile
SU2	RL-1S	3.08	1.07	1.65	6.82	4.48
	G6-S	12.39	11.53	11.56	13.6	13.50
	RLSW-2	7.94	5.96	6.27	9.75	9.61
SU3	PZ-1	9.48	9.01	9.07	10.14	9.97
	PZ-3	10.02	9.67	9.73	10.43	10.33
	PZ-4	8.84	8.23	8.31	9.67	9.46
SU4/SU5	PZ-1	9.48	9.01	9.07	10.14	9.97
	R-1S	12.39	8.71	11.04	15.46	14.02
	R-4S	11.02	8.57	9.42	14.67	12.77
SU8	G1-S	13.29	10.18	12.40	14.25	14.11
	G2-S	11.89	11.06	11.18	12.89	12.69

Reactive backfill will be placed to the seasonal high groundwater level within the excavation to further immobilize residual fluoride (refer to Section 5.2 for details of the reactive backfill). The excavated areas will then be backfilled with compacted select backfill to a stable slope configuration that supports the long-term stability of the landfill mass and cover, as well as the CDID levee.

The backfilled areas will be vegetated using similar products specified for the low permeability cap described in Section 5.4. Appendix B includes a detailed evaluation of the stability of this area prior to and after consolidation of impacted material.

5.1.2 Site Unit 3

Like SU2, SU3 was an area associated with the cryolite recovery process where residual carbon was placed. SU3 was investigated during multiple pre-RI and RI field sampling events. A total of 31 push probe borings and test pits were advanced to determine the vertical and lateral extent of impacted materials. The observations from the test pits, along with information from historical site operation documents, were used to delineate impacted materials. Materials will be excavated from SU3 and then consolidated onto SU6, which is a deposit of residual carbon that is currently covered with soil and grass. The average excavation depth is 4 feet, and the total estimated volume is 25,300 cy.

Excavation of SU3 will occur during the late-summer dry months when groundwater elevations have historically been at the seasonal low. This is a sequencing requirement in the Technical Specifications for the Contractor to schedule other construction activities around. Even during dry conditions, it is expected that approximately 40% of the SU3 fill will be below the observed groundwater level by approximately 3 to 5 feet (Figure 5-2). As such, where feasible, the work will be phased to allow for limited excavation below the observed groundwater level at the time of construction without the use of active dewatering methods (e.g., no use of sheeting and active pumping to lower the groundwater table). For waste that extends below the observed groundwater elevation at the time of excavation, the Contractor will be required to remove wastes to a depth of up to 2 feet below the observed groundwater elevation. As material is transferred to SU6, it may be necessary to temporarily stockpile dry excavated material from SU3 so that it can be blended with wet material to facilitate placement and compaction.

As discussed in Section 5.2, to attenuate and treat residual fluoride reactive backfill will be placed from the excavation depths of SU3 to the seasonal high groundwater elevation. The excavated areas above the seasonal high groundwater elevation will be backfilled with compacted select backfill to generally match pre-construction grades. Finally, the area will be covered with a gravel mix suitable for light vehicle traffic.

5.1.3 Site Unit 5

SU5 is the former SPL stockpile area related to the former Cryolite Recovery Plant. This area was remediated by Reynolds in the 1980s under AO No. DE 83-293 issued by Ecology under the authority of RCW 90.48. The remediation work included removal of the stockpiled SPL, removal of impacted soils, and the placement of a soil cap (Anchor QEA 2015). A ditch remains in this area. Due to the presence of the ditch, and the unknown location and specifications of the soil cap, a limited excavation of the surficial soils and the placement of reactive backfill in the ditch is planned to enhance the previous work completed. The excavated material will be removed from the area and consolidated onto SU6.

The SU5 excavation will be filled with reactive backfill to the seasonal high groundwater level (elevation 12.5 feet) and covered with select backfill above this elevation (refer to Section 5.2 for details of the reactive backfill mixture). The final backfilled SU5 area will be graded to prevent future ponding due to seasonal fluctuations in groundwater levels and covered with a gravel mix suitable for light vehicle traffic.

5.1.4 Site Unit 8

SU8 is the floor sweeps landfill. The area was used to place the dry materials swept from the floors in the potlines. These materials included alumina, bath, cryolite, and aluminum fluoride. The deposit is located on the landward side of the CDID levee. Based on the observations of three test pits conducted during the RI, the landfill was also found to contain blocks of concrete, metal rebar, wires and other debris.

Impacted materials within SU8 may be located at or just below the average dry weather groundwater elevation (Figure 5-3). In limited areas excavation may continue below the groundwater table to excavate minor portions of observed contamination that may be present. Similar to the approach for SU3, portions of the SU8 excavation will be sequenced during the later summer months.

The lateral extents are based on the results of the test pit investigations and information from the CDID regarding construction of the levee and a 66-inch-diameter concrete pipe that discharges water from the CDID Industrial Way Pump Station. It is possible that a limited volume of impacted materials is present over the discharge pipe. These materials would remain in place so as not to affect the integrity of the CDID infrastructure. The lateral extents of the waste are based on the results of the test pit landfill investigations, and there is no information on the east side of the pipe that might inform whether there is waste placement near or around this pipe.

Approximately 29,800 cy of impacted materials will be excavated from SU8 and transported to SU7 for consolidation. It is likely that several large blocks of concrete and other inert wastes will be encountered during excavation activities. These large materials will be difficult to consolidate and compact within SU7 and may be segregated by the Contractor for either off-site disposal or decontamination and recycling in accordance with the appropriate solid waste regulations.

The excavated area will be backfilled with compacted select backfill to a stable slope configuration that is consistent with the CDID levee design. The backfilled areas will be vegetated using hydroseed or a pollinator promoting seed mix. Appendix B includes a detailed evaluation of the stability of this area prior to and after restoration of SU8.

5.1.5 Site Unit 10

SU10 is described as the construction debris landfill. Landfilling in this area began sometime during the construction of the North Plant, which occurred after the CDID levee was constructed to its current elevation. The deposit is located on the riverside of the CDID levee and consists of two lobes that are divided by a road. Based on the observations of 10 test pits that were conducted during the RI, the material in the western lobe consists mainly of construction debris. Material in the eastern lobe contains construction debris and other inert plant wastes such as fragments of brick, concrete, metal, plastic, and miscellaneous dry materials.

Impacted materials within SU10 are anticipated to be located above the seasonal high groundwater elevation (Figure 5-3). The observations from the test pits, along with information from the CDID regarding construction of the levee, were used to delineate impacted materials. Approximately 11,100 cy of impacted materials will be excavated from SU10 and transported to SU7 for consolidation. It is likely that several large blocks of concrete and other inert wastes will be encountered during excavation activities. These large materials will be difficult to consolidate and compact within SU7 and may be segregated by the Contractor for either off-site disposal or decontamination and recycling in accordance with appropriate solid waste regulations.

The excavated areas will be backfilled with compacted select backfill to a stable slope configuration that is consistent with the CDID levee design. The backfilled areas will be vegetated using hydroseed or a pollinator promoting seed mix. There will be no need for long-term inspections for this area. Appendix B includes a detailed evaluation of the stability of this area prior to and after restoration of SU10.

5.2 Reactive Backfill Design

Reactive backfill will be placed in SU2, SU3, SU4, and SU5 to enhance natural recovery and attenuation processes that are already occurring at the site by enhancing fluoride removal capacity in the backfill. Key design criteria for the reactive backfill include the following: 1) capacity to remove fluoride from groundwater that will fill the excavations; and 2) the selected reactive media will not impact water quality of adjacent surface waters.

Following excavation, reactive backfill will be placed in SU2 and SU3 to the approximate elevation of the seasonal high water table, followed by select backfill placed to grade. SU2 will be hydroseeded, and SU3 will be covered with a gravel mix suitable for light vehicle traffic.

The SU4 ditches will be filled with reactive backfill to the seasonal high groundwater level. SU4 will then be backfilled with select backfill above the high groundwater elevation. The top of the fill will be graded to generally match pre-construction grades. SU4 backfilled areas will be covered with a gravel mix suitable for light vehicle traffic.

SU5 will also be filled with reactive backfill to the seasonal high groundwater level, covered with compacted select backfill above this elevation, and graded to prevent future ponding of the area. The backfilled areas will be covered with a gravel mix suitable for light vehicle traffic.

The reactive backfill media is based on treatability testing, as described in the *Treatability Study Report* located in Appendix I and summarized in Appendix G. Activated alumina (ActiGuard F 14×28 activated alumina obtained from Axens Canada Specialty Aluminas Inc. [Axens AA]) was selected as the reactive media for the reactive backfill based on treatability testing. The reactive backfill design was determined using the minimum dose of Axens AA (i.e., mass activated alumina per unit dry weight of reactive backfill) to achieve a 90% reduction in fluoride concentrations in site groundwater at each SU by calculating the fluoride uptake isotherm. Sensitivity analyses were performed to assess if variations in post-construction soil conditions (i.e., porosity and density) and initial concentrations of fluoride in groundwater would result in significantly different dose values.

The design doses for each SU are provided in Table 5-2.

Table 5-2
Recommendations for Activated Alumina Dose in Reactive Backfill by SU

Area	Recommended Activated Alumina Dose (% by weight)[1]	Notes
SU2	1	Dose not modified from base calculation
SU3	3.4	Dose increased to account for area at depth with lower compaction[2]
SU4	6	Dose increased to account for area at depth with lower compaction[2]
SU5	5.4	Dose increased to account for area at depth with lower compaction[2]

Notes:
1. Dry weight basis
2. Refer to Appendix G, Attachment G1, for example calculation

The development of the reactive backfill design is further discussed in Appendix G.

5.3 On-Site Consolidation Design

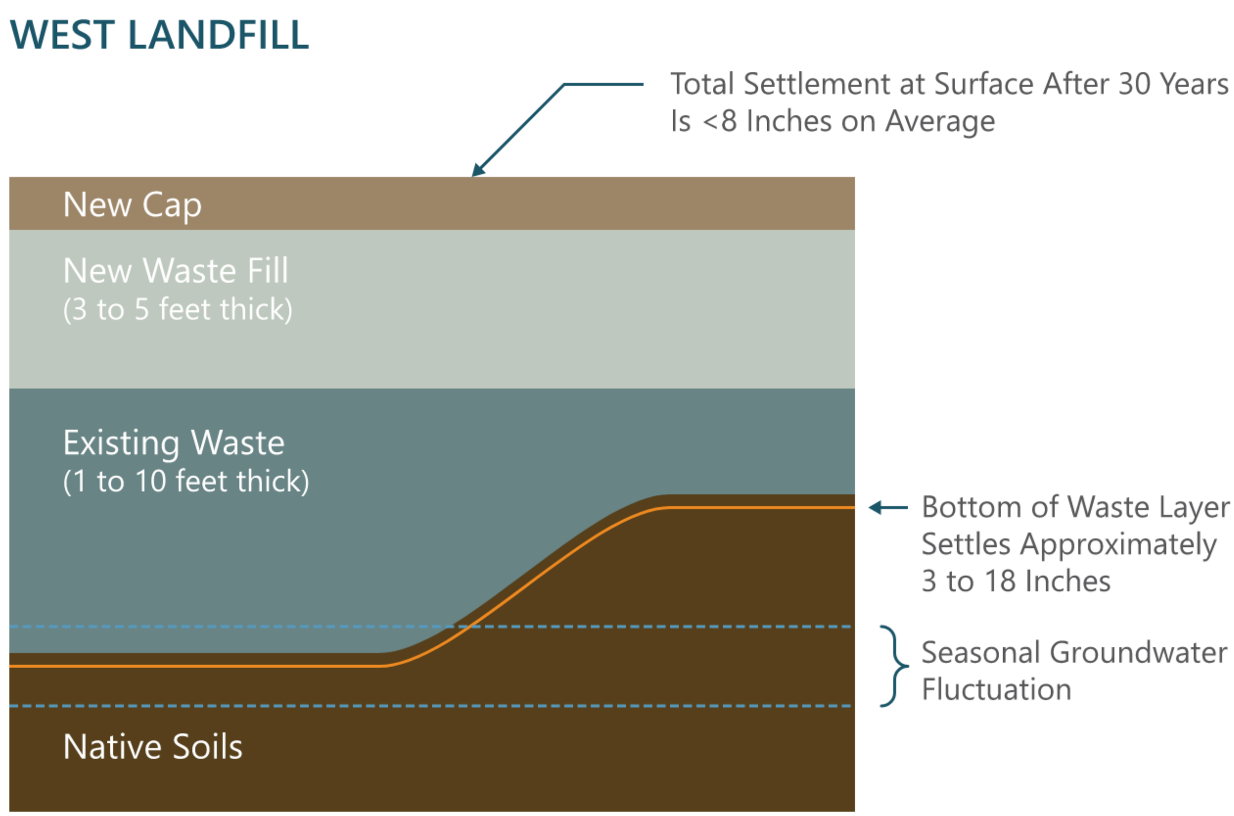
Three existing SUs (SU2, SU6, and SU7) will serve as consolidation landfills and will be renamed the West Landfill, East Landfill No. 2, and East Landfill No. 1, respectively. These landfills are currently covered with soil and vegetation. Each have distinct surface and subsurface considerations that must be taken into account when evaluating long-term stability of the fill material and performance of the low permeability caps. This section documents the geotechnical evaluations performed for each consolidation area.

5.3.1 Site Unit 2 (Future West Landfill)

Prior to the filling of SU2 with residual carbon, the area was semi-enclosed by the berms associated with the CDID levee, perimeter access road, and U-Ditch. The topography of the area is relatively flat with a gentle 2% to 3% grade toward the U-Ditch. Reduction of the SU2 footprint by waste consolidation will increase the height of the landfill by approximately 6 feet after capping. The landfill cover is designed with a maximum elevation of 31 feet NAVD88 and a minimum top slope of 2% away from the CDID levee and into the lined perimeter ditches. The elevation of the south and west perimeters of the landfill is generally level with the surrounding grade; the eastern and northern slopes are designed with maximum slopes of 12H:1V and 5H:1V, respectively. Slope stability analyses were performed to confirm the long-term stability of the perimeter slopes. Seismic deformation analyses were also performed to evaluate the potential damage that could occur during three seismic events (475-year, 975-year, and 2,475-year return periods). The estimated deformation for the shorter return period events is 1 to 5 inches, respectively. The estimated deformation for the most extreme event is 16 inches, and the associated damage is expected to be limited to loss of cover soil over the synthetic low permeability layer.

Over a 30-year period, the landfill cover will settle on average less than 8 inches, and about 60% of the settlement is expected to occur within the first 12 months. The differential settlement is expected to range from 1 to 3 inches over 100 linear feet of cap. The bottom elevation of the waste material is predicted to be an average of 11 inches lower after 30 years. The results of the settlement analysis are summarized in Graphic 5-1. Additional details regarding the assumptions and methods used to assess the stability and settlement of the landfill are included in Appendix B.

Graphic 5-1
Summary of West Landfill Settlement



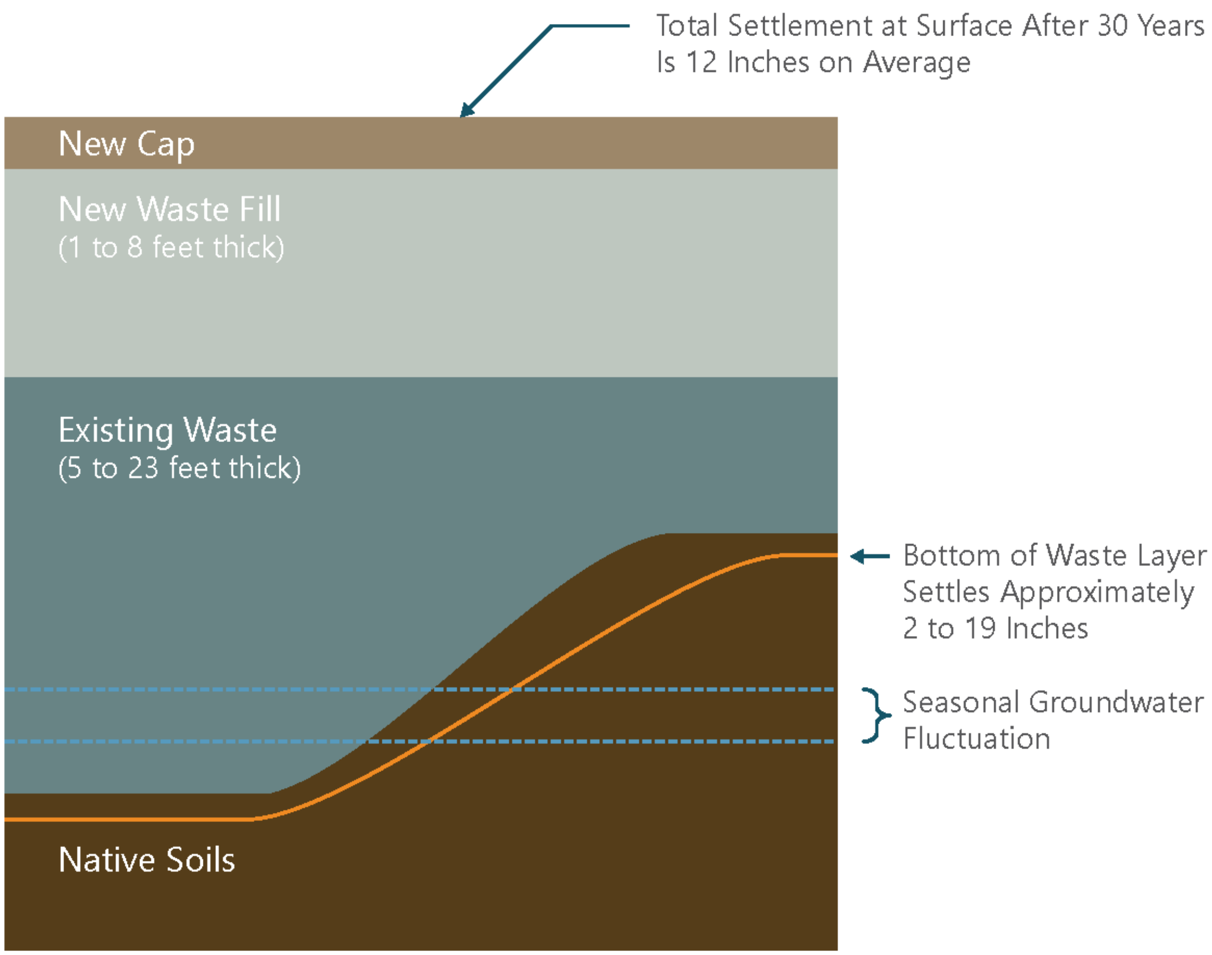
5.3.2 Site Unit 6 (Future East Landfill No. 2)

SU6 was originally configured as two separate bermed areas that could receive slurried residual carbon from the cryolite recovery process. The current height of the landfill is approximately 15 feet above the surrounding grade. The consolidation of material from SU3 and SU5 is expected to raise the height of SU6 by 6 to 8 feet after capping. The landfill cover is designed with a maximum elevation of 32 feet NAVD88 and a minimum top slope of 3% to allow precipitation to flow into the lined perimeter ditches. The current slopes around the perimeter of the landfill area are constructed of relatively loose sand and silty sand established at 3H:1V. Slope stability evaluations determined that this configuration does not meet the minimum static safety factor of 1.4 for long-term stability. Prior to waste consolidation, all landfill slopes will be cut back to 4H:1V in order to achieve an average safety factor of 1.85. Seismic deformation analyses were also performed to evaluate the potential damage that could occur during three seismic events (475-year, 975-year, and 2,475-year return periods). The estimated deformation for the shorter return period events is 1 to 5 inches, respectively. The estimated deformation for the most extreme event is expected to be between 12 and 15 inches depending on whether the origin of the earthquake is north or south of the site. The associated damage is expected to be limited to loss of cover soil over the synthetic low permeability layer; however, there may be areas where the impermeable layer is torn and waste is exposed. Migration of waste from the landfill is not expected to be widespread and would be repairable within a reasonable time frame. If necessary, a temporary cover (e.g., visqueen) can be quickly installed to prevent contact with any exposed waste prior to completing the formal repair.

Over a 30-year period, the landfill cover will settle on average about 12 inches, and about 90% of the settlement is expected to occur within the first 12 months. The differential settlement during the first year is expected to be significant and range from 1 to 18 inches over 100 linear feet of landfill. This magnitude of differential settlement has a high probability of causing stresses that could result in a tear of the geosynthetic components of the low permeability cap if it were to be constructed during the first year of construction. During this time, it is also expected that the crown of the landfill will flatten to a grade that will not be sufficient to convey precipitation to the perimeter ditches. For these reasons, a temporary cover will be placed over the consolidated waste from SU3 and SU5, and the landfill settlement will be monitored over a period of 10 to 12 months prior to constructing the final low permeability cap. The monitoring data will be used to refine the final landfill grading plan so that the remaining expected total and differential settlement can be provided to the Contractor for the final configuration and cover placement. The final placement will be detailed in the Completion Report. The composition of the temporary cover is described in Section 5.4.2.

The bottom elevation of the waste material is predicted to be an average of 10 inches lower after 30 years, with a limited area (less than 2% of the landfill footprint) that may settle up to 19 inches. The results of the settlement analysis are summarized in Graphic 5-2. Additional details regarding the assumptions and methods used to assess the stability and settlement of the landfill are included in Appendix B.

Graphic 5-2
Summary of East Landfill No. 2 Settlement



5.3.3 Site Unit 7 (Future East Landfill No. 1)

During operation, SU7 was maintained as a surface fill with limited perimeter containment. A new retention structure will be required to support the consolidation of material from SU8 and SU10, which will raise the height of SU7 by 12 feet after capping. The landfill cover is designed with a maximum elevation of 20 feet NAVD88 and a minimum top slope of 2% to allow precipitation to flow into the center drainage channel. The soils beneath the landfill consist of layers of very soft clay and peat. In order to prepare the landfill to receive waste from SU8 and SU10, improvements will be required, including subsurface ground improvement and a new engineered berm around the entire landfill perimeter. The subsurface ground improvement includes injecting and mixing of cement material into the existing soils to create a 15-foot-deep and 10-foot-wide zone of soil that has increased strength in order to achieve a minimum long-term stability safety factor of 1.4.

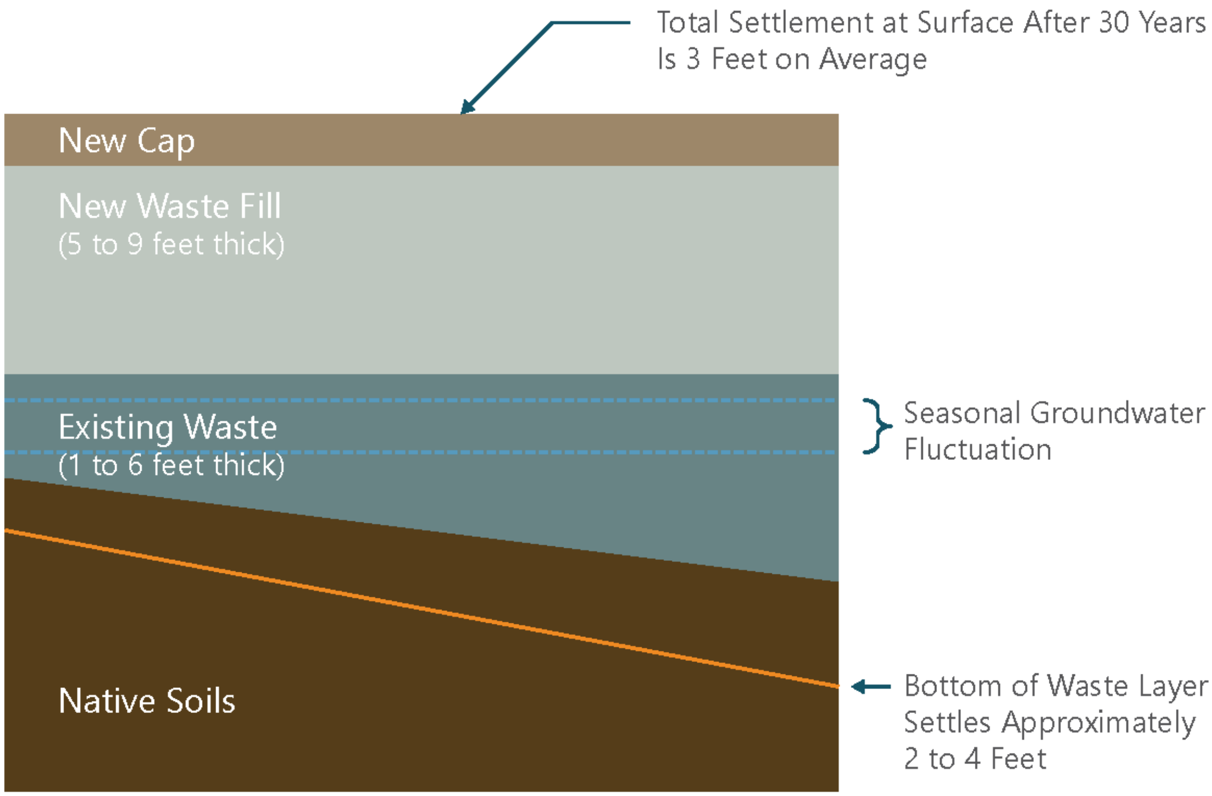
Seismic deformation analyses were also performed to evaluate the potential damage that could occur during three seismic events (475-year, 975-year, and 2,475-year return periods). The estimated deformation for the shorter return period events is 1 to 13 inches, respectively. The estimated deformation for the most extreme event is expected to be between 14 and 36 inches depending on whether the origin of the earthquake is north or south of the site. The associated damage is expected to be limited to loss of cover soil over the synthetic low permeability layer or subsidence to the outer engineered berm. There may be areas where the impermeable layer is torn and waste is exposed, but this is expected to be limited by the presence of the engineered berm. Migration of waste from the landfill is not expected to be widespread and would be repairable within a reasonable time frame. In any case, a temporary cover (e.g., visqueen) can be quickly installed to prevent contact with any exposed waste prior to completing the formal repair.

Over a 30-year period, the landfill cover will settle on average 36 inches, and about 65% of the settlement is expected to occur within the first 12 months. The differential settlement during the first year is expected to be significant and range from 1 to 24 inches over 100 linear feet of landfill. This magnitude of differential settlement has a high probability of causing stresses that could result in a tear of the geosynthetic components of the low permeability cap. For these reasons, a temporary cover will be placed over the consolidated waste from SU8 and SU10, and the landfill settlement will be monitored over a period of 10 to 12 months prior to constructing the final low permeability cap. The monitoring data will be used to refine the final landfill grading plan so that the remaining expected total and differential settlement can be provided to the Contractor for the final configuration and cover placement. The final placement will be detailed in the Completion Report. The composition of the temporary cover is described in Section 5.4.2.

The bottom elevation of the waste material is predicted to be an average of 36 inches lower after 30 years. The waste below the water table will be surrounded by an area of ground improvement that will prevent lateral migration of groundwater through the waste. Therefore, although the more significant settlement will result in a greater mass of waste below the groundwater table, it will not cause an increase of contaminant migration to groundwater.

The results of the settlement analysis are summarized in Graphic 5-3. Additional details regarding the assumptions and methods used to assess the stability and settlement of the landfill are included in Appendix B.

Graphic 5-3
Summary of East Landfill No. 1 Settlement



5.3.4 Slope Stability Analysis Along CDID Levee

The stability of the existing CDID levee was evaluated to determine the effect of additional material placed near or removed from the existing levee profile as part of remedial actions required for SU2, SU8, and SU10. Multiple scenarios were evaluated to assess potential reductions in the factor of safety (FOS) due to temporary conditions that would occur during earthwork activities, long-term increase of fill height adjacent to the levee, fluctuations in groundwater and river stage elevations, and earthquakes. Based on preliminary evaluations, the proposed design is expected to meet acceptable short-term and long-term non-seismic FOS expectations established in guidance produced by USACE. Under seismic conditions, FOSs are expected to be equal or better than pre-remediation conditions with the exception of SU8. The seismic FOS for SU8 decreases slightly following removal of the landfill waste; however, the critical slip surface is toward the landward side of the levee and remains above the target FOS value of 1.05 established in Washington State Department of Transportation guidance. A detailed description of the methodology and results are included in Appendix B.

5.4 Low Permeability Cap Design

This section presents information regarding the design components for the low permeability caps that will be placed over the three fill consolidation areas: SU2 (West Landfill) and SU6 and SU7 (East Landfill No. 2 and East Landfill No. 1, respectively, or collectively referred to as the East Landfills).

5.4.1 Cap System Components

The purpose of the low permeability cap is to minimize infiltration of precipitation through the fill materials and prevent direct contact with impacted materials contained within the fill. To achieve this purpose, the cap will be composed of multiple layers providing for a physical barrier to infiltration, a drainage layer above the barrier, and cover soils for protection of the barrier and drainage layers as well as to promote vegetative growth. The CAP provides minimum performance requirements that must be included in the low permeability cap design. These requirements resulted in an assumed cap system that would include a 12-inch layer of low permeability soil ($1x10^{-6}$ centimeters per second [cm/sec] maximum), overlain by a geocomposite drainage layer topped with 12 inches of topsoil and hydroseed.

As part of the design process, several vendors of natural aggregate and geosynthetics were contacted to assess the availability and market costs of products. At this time, no local, economical source of soil meeting the maximum permeability requirements has been identified. As such, other options that meet or exceed the permeability requirement were considered. Similarly, the assumed geocomposite drainage layer was also reconsidered. Based on a number of factors summarized in Table 5-3, a revised cap system was selected for design. This cap system will be included as the required design that each proposing Contractor will use as the basis for their construction plan and bid.

Table 5-3
Summary of Low Permeability Cap Components

Conceptual Cap System	Designed Cap System	Rationale
Hydroseed (grass)	Self-maintaining flowering vegetation	This would reduce the need for regular mowing and provide pollinator habitat.
12-inch layer of topsoil	6-inch layer of topsoil over 6-inch layer of general fill	A 6-inch topsoil layer is sufficient for supporting vegetation; the 6-inch general fill layer will prevent roots from clogging the drainage layer.
Geocomposite drainage layer	12-inch layer of free-draining sand	This change was made to avoid having two geosynthetic layers against each other in the design.

Conceptual Cap System	Designed Cap System	Rationale
12-inch layer of low permeability soil	GCL	The speed of installation is superior to soil and geomembranes; it reduces the barrier permeability to 1×10^{-9} cm/sec.

Note:
Cap layers are described in order from the top to the bottom of the cap system.

5.4.2 *Temporary East Landfill Covers*

To prevent contact with and erosion of the consolidated waste materials, a temporary cover will be installed over the waste. This cover will consist of a 6-inch layer of sand covered with a hydraulically applied layer of bonded fiber matrix (BFM) mulch. BFM is a continuous layer of elongated fiber strands held together by a water-resistant bonding agent. It eliminates direct rain drop impact on soil and allows no gaps between the product and the soil. The BFM will be supplemented with other erosion protection best management practices along the slopes, and the entire landfill perimeter will be surrounded by silt fencing. These best management practices are included in the "Temporary Erosion and Sediment Control Plans" as part of the Drawings in Appendix E. The site *Stormwater Pollution Prevention Plan* (SWPPP) will also be updated to include these best management practices.

5.4.3 *Final Grading Before Cap Placement*

Based on the results of the settlement monitoring that will occur between construction seasons, a revised grading plan will be prepared that will serve as the subgrade for the geosynthetic clay liner (GCL) and other cap system components. The final grading will be performed in a manner and sequence necessary to limit the particle size of consolidated materials to no more than a 1-inch diameter within the upper 6 inches of material placed directly beneath the GCL.

The final grading of the perimeter ditches will also occur during the following construction season prior to cap placement. The perimeter ditches will be lined similar to the cover system in order to prevent infiltration. The GCL will be extended over the graded ditch. Within ditches, the thickness of drainage sand will be reduced from 12 to 6 inches to accommodate the final surface of the ditch, which will have a small-diameter (i.e., 2-inch-diameter) riprap cover instead of grass for ease of maintenance of the steep side slopes as well as overall erosion control.

5.5 Stormwater Improvements and Cap Runoff Design

The cleanup action will result in modifications to the land cover at the site that will increase the rate and volume of stormwater runoff. The analysis and design of stormwater improvements needed to support the cleanup action are described in detail in the *Stormwater Design Report* (Appendix H).

The *Stormwater Design Report* supports this Final EDR by demonstrating that appropriate stormwater improvements will be implemented with the cleanup action to capture and convey stormwater runoff from the caps in a way that achieves compliance with the minimum requirements for stormwater management outlined in the *Stormwater Management Manual for Western Washington* (Ecology 2019b) and compliance with local (Cowlitz County) permitting requirements.

Hydrologic analyses were completed using the Western Washington Hydrologic Model to evaluate the impact of the cleanup action on the rate and volume of stormwater runoff from each of the existing basins at the site. Hydraulic analyses were completed using PCSWMM hydraulic modeling software to ensure that the proposed stormwater improvements are designed to address deficiencies and prevent flooding at key portions of the existing stormwater system at the site under peak storm conditions. Improvements were evaluated under 25-year storm conditions and under the peak volume storm conditions, which represent the 7-day period that generated the largest stormwater runoff volume from the period of historical rainfall that was modeled with the hydrologic model of the site. Changes in land cover and stormwater cap runoff are summarized in Section 5.5.1, and a summary of the stormwater improvements is provided in Section 5.5.2.

5.5.1 Changes in Land Cover and Stormwater Cap Runoff

Stormwater improvements will be required to accommodate the increased rate and volume of runoff from the low permeability caps. The proposed drainage basins and impervious land cover that will result from the cleanup action are depicted in Figure 5-4. The following summarizes the changes to stormwater runoff that will occur because of the cleanup action and the stormwater improvements that are required to accommodate these changes.

Drainage Basin 2.2. Within Drainage Basin 2.2, the construction of low permeability caps over the East Landfills (i.e., SU6 and SU7) will significantly increase the total runoff from these areas. Due to the nature of the capping system, the runoff from the capped areas will be clean water and will not require treatment prior to discharge. The stormwater improvements will be designed to segregate runoff from these areas and keep it separate from all other site runoff.

The East Landfills will be recategorized as Drainage Basin 2.5. The remaining areas in Drainage Basin 2.2 will continue to be known as Drainage Basin 2.2. The area of Drainage Basin 2.2 will be reduced from 27.9 acres to 13.4 acres. Runoff from the 14.5 acres that comprise the East Landfills will be segregated from the rest of Drainage Basin 2.2 and rerouted through the proposed East Landfill Pump Station (ELF Pump Station) directly to Outfall 002A (as new Drainage Basin 2.5).

The results of the hydrologic model of the site indicate that the peak flow from Drainage Basin 2.2 resulting from a 25-year storm will decrease from 5.67 to 3.14 cubic feet per second (cfs) as a result of these changes. The peak flow from a 100-year storm will decrease from 8.47 to 5.12 cfs.

The ditches that collect and convey runoff from the existing Drainage Basin 2.2 will be modified as part of the construction of the East Landfills. The modifications will result in small roadside swales adjacent to Berth Road that will convey stormwater runoff from Basin 2.2 to existing Pump Station 004. These swales will be separate from and parallel with the GCL-lined perimeter ditches that will collect runoff from the clean caps over the East Landfills. Runoff from the caps over the East Landfills will be connected and conveyed to a new pump station designated as ELF Pump Station. No changes are recommended to Pump Station 004 or its associated force main; they will continue to convey the remaining runoff from Basin 2.2 to the storm drain collection system near the Former South Plant in Drainage Basin 2.1.

Drainage Basin 2.5 (New Drainage Basin). As introduced in the summary of Drainage Basin 2.2, Drainage Basin 2.5 will be created by the consolidation and capping of the East Landfills. The runoff from Drainage Basin 2.5 will be completely segregated from the runoff from adjacent areas within Drainage Basin 2.2 and will not be in contact with groundwater or legacy contaminants.

The results of the hydrologic model of the site indicate that the East Landfills, which will comprise new Drainage Basin 2.5, will generate a peak runoff during a 25-year storm of 8.24 cfs from SU6 and 4.33 cfs from SU7, or a total of 12.57 cfs. The peak runoff from a 100-year storm will be 12.39 cfs from SU6 and 6.52 cfs from SU7, or a total of 18.91 cfs.

The GCL-lined perimeter ditches around the East Landfills will capture and convey runoff from the East Landfills to dedicated manhole structures at the western corner of East Landfill No. 1 (SU7) and the northern corner of East Landfill No. 2 (SU6). Water flowing to these manholes will then be conveyed through 24-inch culverts to the new ELF Pump Station. The ELF Pump Station will deliver water directly through a new 16-inch high density polyethylene (HDPE) force main to Outfall 002A for discharge to the Columbia River.

Drainage Basin 2.6 (New Drainage Basin). Drainage Basin 2.6 will be created by the consolidation and capping of the West Landfill. The runoff from Drainage Basin 2.6 will be completely segregated from the runoff from adjacent areas within Drainage Basin A and will not be in contact with groundwater or legacy contaminants.

The surface of the West Landfill will be graded to drain to GCL-lined perimeter ditches on the north and east sides of the landfill. The GCL-lined perimeter ditches will capture and convey runoff from the West Landfill to a dedicated manhole structure located near the northeast corner of the West Landfill. Water flowing to the manhole structure will then be conveyed through a new 24-inch storm drain to a new pump station referred to as the West Landfill Pump Station (WLF Pump Station), which will be constructed northeast of the West Landfill. The WLF Pump Station will deliver water directly through a new 14-inch HDPE force main to Outfall 002A for discharge to the Columbia River. An overflow structure within the pump station will allow for peak flows from the largest storm events that exceed the capacity of the WLF Pump Station to overflow to the U-Ditch. This overflow to the U-Ditch is anticipated to occur for storms greater than the 5-year storm event. Runoff that overflows from the WLF Pump Station to the U-Ditch will flow through downstream ditches and culverts to Facility 77, where it will commingle with other site stormwater and wastewater. Commingled stormwater and wastewater is then pumped to Facility 73 for treatment prior to discharging to the Columbia River through Outfall 002A.

The results of the hydrologic model of the site indicate that the West Landfill, which will become new Drainage Basin 2.6, will generate a peak runoff during a 25-year storm of 10.92 cfs. The peak runoff from a 100-year storm will be 16.43 cfs.

Drainage Basin A. The remaining areas within Drainage Basin A will continue to be known as Drainage Basin A. Flows from this area will continue to pond, infiltrate, or evaporate on site. Under peak flow conditions, some runoff may overflow to the U-Ditch. The U-Ditch will be cleared of vegetation and regraded to improve maintenance and preserve capacity. The berm between the former leachate ditch and the north branch of the U-Ditch will be removed to reconnect those two segments of the U-Ditch. Each branch of the U-Ditch will also be filled in so that the bottom elevation in each ditch will be higher than the seasonal high groundwater.

Land cover and stormwater runoff volumes, rates, and patterns will be largely unaffected throughout the rest of the site by the cleanup action.

5.5.2 Summary of Stormwater Improvements

The improvements described in Section 5.5.1 are designed to overflow or prevent flooding at key stormwater facilities, including in the U-Ditch and other primary conveyance facilities, at the Facility 77 Sump/Pump Station, at Facility 73, and in Outfall 002A. The improvements are also designed to meet local and state stormwater management requirements. The following provides a short list of the stormwater improvements recommended to support the cleanup action:

- Construction of GCL-lined perimeter ditches and a new manhole to capture and convey stormwater runoff from the West Landfill to a new WLF Pump Station
- Construction of a new WLF Pump Station and a 14-inch force main to convey up to 2,500 gallons per minute (5.6 cfs) from the West Landfill directly to Outfall 002A
- Improvements to the U-Ditch to ease maintenance and preserve storage capacity
- Modification of ditches along Berth Road in Drainage Basin 2.2 to manage stormwater runoff from areas adjacent to the East Landfills

- Construction of GCL-lined perimeter ditches to capture and convey runoff from the East Landfills to manhole structures at the southwest corner of East Landfill No. 1 (SU7) and the northwest corner of East Landfill No. 2 (SU6)
- Construction of new 24-inch storm drains to convey water from the East Landfill ditches to the new ELF Pump Station
- Construction of a new ELF Pump Station and a 16-inch force main to convey up to 2,500 gallons per minute (5.6 cfs) from the East Landfills directly to Outfall 002A

A more detailed description of the basis of these improvements is provided in the *Stormwater Design Report* (Appendix H). It is supported by the detailed Drawings in Appendix E. The *Stormwater Design Report* also summarizes the analysis and design of temporary stormwater control facilities needed to capture and batch remediation water during construction of the cleanup action. However, compliance with the remediation water component of the NPDES permit will be managed under the *Remediation Water Management Plan* (RWMP; Appendix K), which is discussed in Section 7.

6 Permeable Reactive Barriers

A segmented PRB will be constructed along the northwestern perimeter of the Closed BMP and perpendicular to the contaminated groundwater flow to reduce the mobility of fluoride not arrested by the natural geochemical soil conditions at the site. This section describes the design and construction considerations for the PRBs to be installed along the northwestern perimeter of the Closed BMP. It is supported by the detailed Drawings and Technical Specifications included as Appendices E and F, respectively.

6.1 Basis of Design

This section presents the key assumptions and basis for developing the design, plans, and specifications of the PRBs.

6.1.1 Design Criteria

The design criteria for the PRBs are as follows:

- The PRBs will be constructed in the space between the Closed BMP and the CDID Ditch No. 14 within site boundaries.
- The reactive media dose in the PRBs will be sufficient to provide treatment for the duration of groundwater discharge with fluoride concentrations that could result in an exceedance of the fluoride screening level in CDID Ditch No. 14.
- The PRB reactive media will not result in nor contribute to other groundwater quality issues.
- Consideration will be given to long-term monitoring.
- The PRBs will not compromise the structural integrity of the Closed BMP.
- The hydraulic conductivity of the PRBs will be approximately one order of magnitude greater than the hydraulic conductivity of the surrounding native materials.
- Construction of the PRBs will occur during the dry season, which is assumed to end on October 1.

The PRB design is based on vertical and lateral delineation of fluoride concentrations in groundwater along the western perimeter of the Closed BMP, groundwater velocities estimated from the PDI and historical data, and estimated fluoride mass flux. The PDI data are described in detail in the DSR (Appendix A). PDI fluoride screening locations and a cross section summarizing the distribution of fluoride concentrations in groundwater and geological interpretation along the western edge of the Closed BMP are presented in Figures 6-1 and 6-2, respectively. The dose of reactive media in the PRBs is based on the fact that fluoride concentrations in groundwater have been decreasing over time, as the residual plume beneath the Closed BMP is slowly flushed out of the aquifer. Based on observed concentration-time trends, fluoride concentrations are decreasing at a rate of 6% per year, and the mean lifetime for operation of the PRBs to ensure protection of surface water quality was calculated to be 18 years, with a range of 15 to 28 years. Further details are found in Appendix J. The locations of the long-term monitoring wells are also shown in Figure 6-2 and are discussed further in Section 9.4.

6.1.1.1 Fluoride Concentrations

The fluoride concentration data used in the PRB design include dissolved fluoride screening results from the PDI and groundwater sampling results at groundwater monitoring wells along the western perimeter of the Closed BMP (Figure 6-2). The dataset includes 58 results, with fluoride concentrations ranging between 0.2 and 583 milligrams per liter (mg/L), a mean of 53.5 mg/L and a median of 3.95 mg/L.

A threshold concentration of 18 mg/L was used to delineate areas with concentrations that could contribute to an exceedance of the fluoride screening level value of 1.8 mg/L for surface water in the CDID ditch. The threshold value incorporates a dilution-attenuation factor of 10 to account for fluoride attenuation between the groundwater sample locations and the point of discharge to surface water and mixing within the surface water of the ditch. Concentrations on the south side toward the U-Ditch are less than the threshold value except for the shallowest groundwater sample at PDI-PRB-DP-02, which is approximately two times the threshold value. Elevated fluoride concentrations above 18 mg/L are localized in two areas. One area extends from PDI-PRB-DP-10 to PZ-6, and the other extends from PDI-PRB-DP-08 to PDI-PRB-DP-06. In contrast, measured fluoride concentrations outside these two areas are generally low; for example, the fluoride concentrations at PDI-PRB-DP-05 are below 1.1 mg/L at all depths sampled.

Vertically, fluoride concentrations above 18 mg/L are encountered between the seasonal high water table and an elevation of -25 feet NAVD88. This depth interval is within the Upper Alluvium, which consists of fine-grained silt and clay deposits with interbedded silty sand. Fluoride concentrations are highly variable with depth. The relationship between elevated groundwater fluoride concentrations and sediment geology is illustrated by high-resolution profiles of fluoride concentrations and relative hydraulic conductivity collected at PDI2-PRB-DP-09 and PDI2-PRB-DP-10 during the PDI. Elevated fluoride concentrations coincide with depth intervals of high relative hydraulic conductivity, suggesting that fluoride mass loading predominantly occurs in more conductive zones, although higher conductivity zones with low fluoride concentration are also present (e.g., at PDI-PRB-DP-05, PDI-PRB-DP-02, and PDI-PRB-DP-08). These zones contribute low fluoride water to the ditch, diluting the impact of the higher mass flux zones.

6.1.1.2 Groundwater Velocity

Groundwater velocity through the PRBs is estimated from hydraulic conductivity and hydraulic gradient data, as described in detail in Appendix J. The average groundwater velocity used in the design is 4.4 feet per year. For sensitivity analysis, an upper value of 26 feet per year was used.

6.1.1.3 Fluoride Mass Flux

The fluoride concentration data were combined with point estimates of groundwater velocity (from hydraulic conductivity and gradients) to develop spatial (vertical and lateral) estimates of fluoride mass flux toward the CDID ditch along the western margin of the Closed BMP, as described in Appendix J. The fluoride mass flux, which varies both laterally and vertically, was used to refine the PRB alignments.

6.1.2 Design Process

The design process is summarized as follows:

- PRB alignment and depth were selected based on the lateral and vertical distribution of groundwater fluoride concentrations and mass flux estimated from hydraulic conductivity and hydraulic gradients.
- The width of the PRB is 3 feet based on constructability considerations.
- Laboratory treatability studies were used to evaluate candidate treatment media and to select activated alumina as the reactive amendment in the PRBs.
- A one-dimensional geochemical reactive transport model was developed and calibrated to laboratory column study data.
- The reactive transport model was used to simulate the long-term performance of field-scale PRB configurations.
- Representative groundwater flow velocities through the field-scale PRB were estimated from site-specific hydrogeological data.
- Simulated fluoride breakthrough curves were used to design the PRB reactive media dose for an effective PRB lifetime of 30 years.

6.2 Permeable Reactive Barrier Design

The PRBs consist of two trenches backfilled with reactive media that have a minimum width of 3 feet. The northern PRB (Segment 1) is angled and is approximately 525 feet long. The southern PRB (Segment 2) is a straight trench and is approximately 650 feet long. The PRBs are aligned downslope of the western berm of the Closed BMP, as shown in Figure 6-1. The reactive media in the PRBs will be installed between elevations of approximately 7 feet NAVD88 and approximately -25 feet NAVD88. The depth of the PRB segments is shown in profile in Figure 6-2. This section describes the key elements of the PRB design.

6.2.1 Treatability Study

Reactive media for fluoride removal from site groundwater were evaluated in the *Treatability Study Report* (Appendix I). Batch and column tests were performed to rank several reactive media based on fluoride removal rates, removal efficiency, uptake capacity, stability of the sequestered fluoride, and potential secondary water quality effects. The reactive media that were evaluated include activated alumina, calcium phosphates (bone meal, bone char, and rock phosphate), carbonates (calcite and siderite), hydrotalcite, and magnesium oxide. The key conclusions of the *Treatability Study Report* include the following:

- Activated alumina, bone char, bone meal, and hydrotalcite were found to have the best fluoride removal performance.
- Bone meal and bone char were not selected for PRB application due to potential for secondary groundwater quality impacts from release of phosphate.
- Hydrotalcite was also not selected for PRB application due to the very fine grain size of the commercially available material, which would be prone to winnowing out of the PRB with a potential risk of clogging the porous medium downgradient.
- Activated alumina was selected as the reactive media for PRBs based on the results of the treatability testing.
- Fluoride is sequestered by activated alumina due to strong surface complex formation. The potential for remobilization of fluoride from the activated alumina media is very low under reasonably anticipated future site conditions.
- Phosphate removal from groundwater is an additional benefit of activated alumina, which is expected to contribute to improvement of water quality conditions in the CDID ditches over time.

6.2.2 Alignment

The PRB conceptual design presented in the CAP included two PRB segments, one at the northwestern corner of the Closed BMP (northern segment) and the other at the southwestern corner (southern segment). The PRB alignment was refined based on data collected during the PDI. The lateral limits of the PRB segments were defined by the distribution of groundwater fluoride concentrations in borings and monitoring wells adjacent to the CDID ditch. The delineation also considered relative mass flux of fluoride to the ditch at locations where fluoride concentrations greater than 18 mg/L are detected in groundwater. Mass flux was calculated from fluoride concentrations in combination with estimates of hydraulic conductivity and hydraulic gradient, as discussed in Appendix J. The alignments of the PRB segments are shown in Figure 6-1.

The PRB Segment 2 is located to the north relative to the conceptual alignment presented in the CAP. Conceptually, the PRB Segment 2 was aligned to intercept fluoride transported by groundwater from SU2 toward the CDID ditch. Fluoride concentrations in boring PDI-PRB-DP-01, located between the western end of SU2 and the CDID ditch, are all less than 18 mg/L (Figure 6-2) and are considered to contribute minimally to fluoride concentrations in the CDID ditch at present compared to other locations along the PDI transect. Reactive backfill will be placed in SU2, which will further reduce fluoride concentrations in the future. Therefore, a PRB at this location would provide little or no benefit to the CDID ditch water quality.

The refined PRB Segment 2 location is based on the PDI data, which show that fluoride concentrations are consistently less than the selected threshold concentration of 18 mg/L, with only a single exception, between boring PDI-PRB-DP-01 and PZ-7 (Figure 6-2). The one exception is the shallowest (water table) sample from boring PDI-PRB-DP-02, with a fluoride concentration of 38.8 mg/L. Fluoride concentrations from deeper sample intervals (5 to 20 feet below the water table) at this boring location were all less than 1 mg/L, as are the fluoride concentrations in adjacent sample locations (Figure 6-2). In general, flushing of the residual fluoride plume from beneath the Closed BMP is expected to proceed from south to north due to the influence of the ditch on groundwater flow directions; therefore, the sample result at PDI-PRB-DP-02, which is only higher than the threshold concentration for treatment (18 mg/L) by a factor of 2, is most likely of local extent. The estimated fluoride mass flux near the water table is low, more than four orders of magnitude lower than the mass flux at the next deeper sample interval (5 feet below water table), which has a concentration of 1 mg/L. Groundwater at this location therefore does not contribute significantly to the concentrations measured in the CDID ditch, and a PRB at this location would provide no benefit to the ditch water quality.

6.2.3 Depth

The PRBs will be installed to variable depths based on the results of the PDI fluoride screening (Figure 6-2). The RI/FS (Anchor QEA 2015) documented upward vertical hydraulic gradients in well pairs located between the Closed BMP and the CDID ditch due to upwelling of groundwater as it flows toward the ditch. The depth of the PRBs is based on the maximum depth at which fluoride concentrations greater than 18 mg/L are detected along the PRB alignment (31.5 mg/L at RL-2D, which is screened from -14 to -24 feet NAVD88). At other locations along the alignment, the maximum depth of fluoride concentrations greater than 18 mg/L ranges from -7 to -19 feet NAVD88 (Figure 6-2). The upper extent of the reactive media was established as 1 foot above the average wet weather groundwater table elevation.

6.2.4 Width

The width of the PRBs is 3 feet. This width of 3 feet along the principal groundwater flow direction was selected based on constructability considerations.

6.2.5 PRB Media

The PRBs will be backfilled (from bottom to top) with PRB media, geotextile, general fill, and topsoil. The trench will be backfilled with PRB media to an elevation of 7 feet NAVD88, which is approximately 1 foot higher than the average seasonal high water level. This will ensure that impacted groundwater will not bypass the PRB by flowing over the top of the PRB. The trench will be backfilled with general fill to within 6 inches of original ground surface and covered with topsoil to support subsequent hydroseeding. The Drawings, Sheets C-29 and C-30, in Appendix E illustrate the alignment and details of the PRB in profile and cross section.

Axens AA was selected for use in PRB construction. The dosage of activated alumina in the PRBs that will provide for long-term fluoride treatment was determined to be 12.5% by weight (Appendix J). An engineering safety factor of 60% is applied to the activated alumina dose. The PRB media will therefore consist of a mixture of 20% activated alumina, 40% pea gravel, and 40% coarse sand by weight.

6.3 PRB Installation Options

A trenchless technology was selected as the installation method that Contractors will be required to bid on for the project. However, the Contractor will be allowed to submit alternative proposals that capitalize on their experience and available equipment. Possible construction methods include conventional trenching, continuous trenching, and caissons, which are described as follows:

- With a conventional trenching technique, a trench is excavated and held open using a trench box or shoring system. After the trench is backfilled with reactive media, the trench box and shoring system is removed. The advantage is that conventional trench is generally cost-effective and is flexible in trench width. The main disadvantage is that dewatering of the trench is typically required, which would increase construction cost.
- Continuous trenching allows simultaneous excavation and backfilling without an open trench. The main advantage is that no trench support and only limited dewatering is necessary.
- A continuous PRB can be constructed by drilling a series of overlapping large, circular steel caissons into the ground. The native material in each caisson is augured out and replaced with reactive media. The caissons are then removed, allowing reactive media to move into the annular space left by the caisson walls.

Factors in choosing the construction method include the PRB width, available space for construction, and compatibility with site geology. The Contractor may elect to do a pilot test with the chosen construction method during the first construction season before constructing the PRB in the subsequent construction season. Regardless of installation method, the Contractor will be required to implement methods to monitor and control the percentage of activated alumina that is placed within the constructed PRB. The *Construction Quality Assurance Plan* (CQAP; Appendix O) includes methods to verify the material placement.

7 Remediation Water Management

As described in Section 2.4 the cleanup action must coordinate with the site's NPDES permit. Special Condition S1.E. of the NPDES permit requires that water accessed from the shallow WBZ of the East and West Groundwater Areas and stormwater that comingles with contaminated groundwater and/or contaminated soil is considered remediation water and must be managed during the cleanup. The permit states that "contaminated groundwater and contaminated soils are groundwater or soils that have come in contact with legacy pollutants - fluoride, cyanide, or B(a)P and are above site MTCA levels" (Ecology 2018c).

Sections 7.1 and 7.2 summarize the conditions of the permit applicable to remediation water management. Details on how remediation water will be managed in the West and East Groundwater Areas before, during, and between construction seasons; description of infrastructure and conveyance improvements required to manage remediation water; and the responsibilities of the Owner and Contractor associated with remediation water management are described in the RWMP (Appendix K).

7.1 Remediation Water Treatment and Best Management Practices

All remediation water generated at the site must be captured, batched, evaluated, and treated. As described in Condition S1.E.1, each batch of remediation water will be tested for fluoride, and treatment will apply as follows:

- If the fluoride results are at or above 45 mg/L, the remediation water will be routed to Facility 77 and batch-processed through Facility 71 for treatment. The effluent from Facility 71 will be conveyed through Facility 77, treated at Facility 73, and discharged through Outfall 002A.
- If the fluoride results are below 45 mg/L, the remediation will be conveyed through Facility 77, treated at Facility 73, and discharged through Outfall 002A.

An up-to-date log book of estimated volumes, dates, and fluoride test results for all remediation water evaluated for treatment will be kept. This information will be submitted with the corresponding discharge monitoring report.

The site SWPPP will be amended per Permit Condition S10 to include best management practices to be implemented during construction of the site cleanup consistent with Ecology's *Stormwater Management Manual for Western Washington* (Ecology 2019b). These best management practices will be designed to remove and/or reduce sediment and suspended solids in any remediation water generated during the site cleanup.

7.2 Remediation Water AKART Study

The NPDES individual permit requires an All Known, Available, and Reasonable Technologies (AKART) study plan to evaluate the treatment of remediation water at Facility 71. The study plan will be submitted to Ecology for review and approval within 6 months of the planned start date of remediation water processing/treating and include a proposed schedule for sampling and report submittal. The study itself will occur while the first batches of remediation water are being treated.

As described in Condition S1.E.2 of the NPDES permit, the AKART study plan must include, at a minimum, three 24-hour time-based composite samples of influent and effluent per batch of remediation water for three separate batches (i.e., nine samples total). Each sample must be analyzed for total suspended solids, fluoride, free cyanide, and benzo(a)pyrene. The timing of sample collection must be such that each of the effluent samples corresponds to the influent sample, and the resultant analytical results can be effectively used to estimate removal efficiencies across Facility 71.

8 Project Compliance

8.1 Applicable Federal, State, and Local Laws

The cleanup action must comply with elements of other environmental Applicable, Relevant, and Appropriate Requirements (ARARs) and permits. WAC 173-340-710 provides that MTCA cleanup actions must comply with applicable state and federal laws. Though a cleanup action performed under formal MTCA authorities (e.g., an order or CD) is exempt from the procedural requirements of most state and all local environmental laws, the action must nevertheless comply with the substantive requirements of such laws (RCW 70A.305.090 and WAC 173-340-710). Table 8-1 presents action- or location-specific ARARs that apply to the remedial activities.

Table 8-1
Action- or Location-Specific ARARs for the Remedial Actions at the Site

Act/Authority	Criteria/Issue	Citation	Brief Description
CWA (§ 401 and 404)	Discharges of dredge material or placement of fill within waters of the United States	33 USC 1341 and 1344, 40 CFR Part 230	Regulates the placement of dredge and fill material in waters of the United States, including wetlands. The proposed project would likely be authorized under NWP 38.
Civil Works (§ 408)	Consideration of potential risk to the public interest and impairment to the usefulness of a federally authorized project	33 USC 408	Regulates alterations to a federally authorized project (e.g., levees, dams, and federal navigation channels).
NHPA § 106	Consideration of effects on historic properties (i.e., listed, or eligible for listing, in National Register of Historic Places)	54 USC 306101, 36 CFR Part 800	Under Section 106 of the NHPA, federal agencies (e.g., USACE) must consider the effects of their undertakings (for example, issuance of a federal permit) on historic properties.
ESA § 7	Consideration of effects on any species listed under the ESA or designated critical habitat of any listed species	16 USC 1531, 50 CFR Part 402	Under Section 7 of the ESA, federal agencies must consider the effect of proposed activities on threatened or endangered species, or their designated critical habitat.
SEPA	Consideration and analysis of environmental impacts of proposed actions	Chapter 43.21C RCW, Chapter 197-11 WAC	Construction and operation activities associated with implementing a MTCA CAP.
NPDES Construction Stormwater General Permit	Discharge of stormwater to surface waters of the state	40 CFR Part 122, Chapter 90.48 RCW, Chapter 173-226 WAC	Required if clearing, grading, and excavating activities disturb one or more acres and discharge stormwater to surface waters of the state. See Section 2.4 regarding the site's NPDES individual permit No. WA 000008-6.
Washington State Hydraulic Code	Protection of fish and aquatic resources	Chapters 75.20 and 77.55 RCW, Chapter 220-110 WAC	Construction activities that will use, divert, obstruct, or change the natural flow or bed of any of the salt or fresh waters of the state. Exempt from procedural requirements under RCW 77.55.061, WAC 220-660-040(2)(c).

Act/Authority	Criteria/Issue	Citation	Brief Description
Washington State Shoreline Management Act and Cowlitz County Shoreline Management	Requirements for developments within specific waterbodies (such as the Columbia River), shorelands adjacent to these waterbodies (within 200 feet), and associated wetlands	Chapter 90.58 RCW, Chapter 173-27-044 WAC, CCC 19.20	Exempt from procedural requirements under RCW 90.58.355 and WAC 173-340-710(9)(b).
Cowlitz County Critical Areas Ordinance	Protection of critical areas	CCC 19.15	Critical areas, including wetlands, fish and wildlife habitat conservation areas, frequently flooded areas, geologically hazardous areas, and aquifer recharge areas, must be designated to ensure the protection of such areas in accordance with the best available science.
Cowlitz County Grading Ordinance	Procedures for aid in controlling erosion incident to grading activities	CCC 16.35	Regulates excavation, grading, and earthwork activities within the unincorporated area of Cowlitz County designed to aid in controlling erosion incident to grading activity.
Cowlitz County Stormwater Drainage Code	Stormwater management in the unincorporated urbanized area of Cowlitz County	CCC 16.22	Stormwater runoff resulting from earth changes during and after construction activities needs to be controlled.

8.2 Permits and Substantive Requirements

This section identifies the applicable permits or specific federal or state requirements and the permit exemptions. In performing the cleanup action under a CD, Northwest Alloys is exempt from the procedural requirements and any laws requiring or authorizing local government permits or approvals but must comply with the substantive requirements of such permits or approvals.

8.2.1 Applicable Permits and Requirements

Procurement of or compliance with the following permits and environmental reviews are required:

- Clean Water Act (CWA) Section 404 Permit (Nationwide Permit [NWP] 38), including compliance with the following:
  - Endangered Species Act (ESA) Section 7
  - Section 106 of the National Historic Preservation Act (NHPA)
- CWA Section 401 Water Quality Certification (WQC)
- Civil Works Section 408 Permission
- State Environmental Policy Act (SEPA)
- NPDES Permit conditions under NPDES Permit No. WA 000008-6

These permits and reviews are discussed in Sections 8.2.1.1 through 8.2.1.5.

8.2.1.1 Clean Water Act Section 404 Permit

Because the project will involve placement of fill material into waters of the United States, authorization from USACE under Section 404 of the CWA will be required. A Joint Aquatic Resources Permit Application (JARPA) was prepared and submitted to USACE in December 2021 to obtain this authorization. On February 3, 2023, USACE, Seattle District, authorized the work to be completed under an NWP 38. NWP 38 authorizes the placement of fill material into wetlands and other waters for activities required to effect the containment, stabilization, or removal of hazardous or toxic waste materials that are performed, ordered, or sponsored by a government agency with established legal or regulatory authority. As part of the Section 404 Permit process, USACE consulted with the National Marine Fisheries Service and the U.S. Fish and Wildlife Services (collectively, the Services) for proposed activities that have the potential to affect threatened or endangered species or their designated critical habitat. The conditions provided in the permit do not require updates to the engineering design.

The following are requirements of the NWP 38 and the Services for this project:

- Comply with all best management practices and conservation measures outlined in the Biological Evaluation.
- No work below the ordinary high water mark (OHWM) of the Columbia River may occur.

- Comply with the inadvertent discovery plan contained within the NWP 38.
- Use haybales and coir logs in addition to the established best management practices in SU10 to reduce the likelihood of contaminated soils/runoff reaching the Columbia River.
- Work on SU10 would be completed between May 1 and September 30 to coincide with the period of driest weather.

In the event remains or historic artifacts are uncovered, an *Archaeological Inadvertent Discovery Plan* has been written, which specifies monitoring and methods for treating inadvertent archaeological or human remains if discovered. The *Archaeological Inadvertent Discovery Plan* is included as Appendix M.

8.2.1.2 Clean Water Act Section 401 Water Quality Certification

A State 401 Water Quality Certification is granted under the Terms and Conditions (E) of the NWP 38.

8.2.1.3 Civil Works Section 408 Permission

The project has the potential to affect a federally authorized project because excavations (SU8 and SU10) and the West Landfill will overlap into the USACE levee right of way. Written Request for Section 408 Review along with a Federal Encroachment Permit Application was submitted by Grette Associates to CDID No. 1 on December 17, 2021 (Grette 2021). On February 11, 2022, USACE issued a Section 408 Alternation Determination of no alternation, which is included in Appendix L. The Federal Encroachment Permit was issued by CDID on February 22, 2022, and is included in Appendix L. The conditions provided in the permit do not require updates to the engineering design.

8.2.1.4 State Environmental Policy Act

A SEPA environmental checklist was previously submitted for the project, and Ecology issued a Determination of Nonsignificance on January 15, 2015 (Ecology 2015). The project is covered by this Determination of Nonsignificance, which is included in Appendix L.

8.2.1.5 NPDES Permit Conditions

As discussed in Section 7 and required per the site's NPDES individual permit No. WA 000008-6, all remediation water generated at the site must be captured, batched, evaluated, and treated. The treatment method will be based on the fluoride concentration of each collected batch of remediation water. Details on how remediation water will be managed during construction is described in the RWMP in Appendix K.

8.2.2 Permit Exemptions and Substantive Requirements

The cleanup action must comply with the substantive requirements of the following state and local regulations and other requirements, though the cleanup action is procedurally exempt from these permit requirements:

- Washington State Hydraulic Code (WAC 220-660)/Hydraulic Project Approval
- Washington State Shoreline Management Act (RCW 90.58) and Cowlitz County Shoreline Management (Cowlitz County Code [CCC] 19.20) and Shoreline Master Program
- Critical Areas Ordinance (CCC 19.15)
- Cowlitz County Grading Ordinance (CCC 16.35)
- Cowlitz County Stormwater Drainage Code (CCC 16.22) and Cowlitz County Stormwater Drainage Manual

Although the cleanup action is exempt from these requirements, compliance with the substantive requirements of the regulations must be demonstrated. Demonstration of compliance with these regulations is provided in Table 8-2.

Table 8-2
Substantive Compliance with Applicable Regulations

Applicable Regulation	Regulating Agency	Relevant Code Section	Application of Regulation to the Project	Compliance with Regulation
Washington State Hydraulic Code (WAC 220-660)/ HPA	WDFW	WAC 220-660-030(77)	A "hydraulic project" is defined as the construction or performance of work that will use, divert, obstruct, or change the natural flow or bed of any of the salt or fresh waters of the state (WAC 220-660-030[77]).	The cleanup action will not include any work in salt or fresh waters of the state. As such, the proposed work would not be considered a hydraulic project, and WAC 220-660 does not apply to the action. However, because of the proximity of the dredge spoils borrow pit to SU10, initial conversations with WDFW were conducted around the time of the JARPA submittal to update them on the project status. The design identified in this Final EDR and specifications does not include elements that would require an HPA for the project.
Washington State Shoreline Management Act (RCW 90.58) and Cowlitz County Shoreline Management (CCC 19.20) and Shoreline Master Program	Ecology and Cowlitz County	SMP Subsection 3.1 (Applicability)	Per SMP Subsection 3.1(A), the SMP applies to all shorelands and waters within Cowlitz County. The SMP requires development in shorelines of the state, including SSWS, to comply with the rules and policies of the SMP and obtain permits for allowable activities.	The Columbia River is identified as an SSWS by Cowlitz County and regulated under the SMP. For the purposes of the SMP, the SED would be High-Intensity per SMP Subsection 5.4.1. The boundaries of the regulated SSWS area extend 200 feet in all directions from the horizontal plane of the OHWM and include four wetlands on the project site. Two of the proposed SUs (SU2 and SU10) also extend into the 200-foot-wide SSWS area. Proposed work in those areas would be considered a shoreline modification subject to the substantive requirements of the SMP.

Applicable Regulation	Regulating Agency	Relevant Code Section	Application of Regulation to the Project	Compliance with Regulation
Washington State Shoreline Management Act (RCW 90.58) and Cowlitz County Shoreline Management (CCC 19.20) and Shoreline Master Program	Ecology and Cowlitz County	SMP Subsection 3.1.F (Procedural Exemption)	Per SMP Subsection 3.1(F), hazardous substance remedial actions pursuant to a CD, order, or AO issued under RCW 70.105(D) are exempt from all procedural requirements of this program.	The cleanup action is pursuant to a CD under RCW 70.105(D) and is exempt from any laws requiring or authorizing local government permits or approvals for the remedial action per RCW 70A.305.090 and per SMP Subsection 3.1F. As such, the applicant would not be required to obtain a Shoreline Substantial Development Permit or Letter of Exemption from Cowlitz County. However, the substantive requirements of the SMP are still applicable for a designated SSWS (i.e., Columbia River) with High-Intensity SED.
		SMP Subsection 6(1) through (7) (General Shoreline Regulations)	Per SMP Subsection 6(1) through (7), proposed work in all shorelines of the state much comply with multiple general regulations that pertain to no net loss of ecological function; archaeological, cultural and historic resources; critical areas protection; flood prevention and flood damage minimization; public access; vegetation conservation; and water quality and quantity.	The cleanup action would comply with these requirements as much as is practicable based on the requirements of the action.

Applicable Regulation	Regulating Agency	Relevant Code Section	Application of Regulation to the Project	Compliance with Regulation
Critical Areas Ordinance (CCC 19.15)	Cowlitz County	CCC 19.15.030 (Purpose and Intent)	Per CCC 19.15.030, the Washington State Growth Management Act (RCW 36.70A) requires Cowlitz County to designate critical areas and adopt development regulations to ensure the protection of such areas in accordance with the best available science. These critical areas include wetlands, fish, and wildlife habitat conservation areas; frequently flooded areas; geologically hazardous areas; and aquifer recharge areas.	Substantive requirements of Cowlitz County Critical Areas Ordinance are applicable. Critical areas were documented on the project site by Grette Associates, LLC, in a May 19, 2017, critical areas assessment report (Grette 2017a). That report identified five critical areas on the project site: wetlands; fish and wildlife habitat conservation areas; frequently flooded areas; geologically hazardous areas; and aquifer recharge areas.
		CCC 19.15.120 (Wetlands)	Per CCC 19.15.120(A)(1), wetlands must be identified and delineated in accordance with the approved federal wetland delineation manual and applicable regional supplements. Per CCC 19.15.120(A)(2), delineated wetlands must also be rated using the *Washington State Wetland Rating System for Western Washington* (Hruby 2014).	Wetlands at the project site have been delineated and rated, consistent with the requirements of CCC 19.15.120 (A)(1) and (A)(2). The results of those actions are documented in a series of wetland delineation and verification reports prepared by Grette and Associates (Grette 2014a, 2014b, 2014c, 2017b, 2020a, 2020b). All wetlands identified on the site were rated.
			CCC 19.15.120(C)(7) requires that buffers be applied to identified wetland based on their rating category, adjacent land use intensity, and for Category I, II, and III wetland, their habitat score from the wetland rating form, using the buffer widths described in CCC Tables 19.15.120-B and C.	Wetland buffers have been calculated and applied consistent with CCC 19.15.120 (C)(7) and are described and mapped in the wetland delineation and verification reports prepared by Grette Associates (Grette 2014a, 2014b, 2014c, 2017b, 2020a, 2020b).

Applicable Regulation	Regulating Agency	Relevant Code Section	Application of Regulation to the Project	Compliance with Regulation
Critical Areas Ordinance (CCC 19.15)	Cowlitz County	CCC 19.15.120 (Wetlands)	Per CCC 19.15.120(D), compensatory mitigation for alterations to wetlands and their associated buffers will be provided for impacts that cannot be avoided or minimized. Mitigation will be provided based on the wetland mitigation ratios in CCC Table 19.15.120-E. Impacts on buffers will be mitigated at a minimum 1:1 mitigation ratio. Compensatory mitigation will achieve equivalent or greater biological, chemical, and physical functions.	The cleanup action will result in permanent, unavoidable impacts on five wetlands (1.33 acres) and temporary, unavoidable impacts on one wetland (0.4 acre). Wetland buffer impacts will total 10.5 acres. Authorization to place fill material into the impacted wetlands will be obtained from USACE and Ecology under a CWA Section 404 permit and a CWA Section 401 WQC, respectively. Compensatory mitigation will be achieved through the purchase of the appropriate amount of wetland and buffer credits.
		CCC 19.15.140 (Frequently Flooded Areas)	Per CCC 19.15.140(A) and (B), all development within designated frequently flooded areas must comply with Chapter 16.25, Floodplain Management of the CCC.	Only a small section of SU10 is within the 100-year floodplain, a frequently flooded area per CCC 19.15.140(A). Actions in SU10 will not affect floodplain conditions because elevations will be restored after excavation.
		CCC 19.15.150 (Geologically Hazardous Areas)	Per CCC 19.15.150(C), all geologically hazardous areas must comply with a series of general development standards. CCC 19.15.130(D) also includes specific development standards for seismic hazards.	The cleanup action will require the disturbance of existing soils, removal of fill materials, and placement of fill materials in areas of potential seismic hazards. It will not involve the construction of any structures in such areas. All of the proposed activities will be in compliance with CCC 19.15.150(C) and (D).

Applicable Regulation	Regulating Agency	Relevant Code Section	Application of Regulation to the Project	Compliance with Regulation
Critical Areas Ordinance (CCC 19.15)	Cowlitz County	CCC 19.15.160 (Critical Aquifer Recharge Areas)	Per CCC 19.15.160(A)(1), CARAs are those areas with a critical recharging effect on aquifers used for potable water as defined by WAC 365-190-030(2). CCC 19.19.160(B) through (F) contain various requirements and development standards for work in CARAs.	Based on the critical areas assessment report prepared by Grette (2017b), there are no CARAs mapped on the project site by Cowlitz County. The main source of aquifer recharge in the project area is the Columbia River.
		CCC 19.15.170 (Mitigation Requirements)	Per CC 19.15.170(A), unless otherwise provided in the CCC, all critical areas mitigation required pursuant to CCC Chapter 19 must use the best available science in accordance with an approved critical areas assessment, mitigation plan, and SEPA documents so as to result in no net loss of critical area functions and values.	The cleanup action followed the mitigation sequencing requirements stated in CCC 19.15.170(C). Impacts will be mitigated by purchasing credits from the Coweeman River Wetland and Conservation Bank, consistent with CCC 19.15.170(C.6) and 19.15.170(D.3). The remaining requirements in CCC 19.15.170 do not apply because mitigation will be in the form of mitigation bank credits.
Cowlitz County Grading Ordinance (CCC 16.35)		CCC 16.35 (Grading)	CC 16.35 provides uniform procedures authorizing and regulating excavation, grading, and earthwork activities within the unincorporated area of Cowlitz County. These regulations are designed to aid in controlling erosion incident to grading activity and to protect public health, safety, and welfare.	All of the grading permit application requirements (CCC 16.35.060) are provided in this report and associated appendices. All site grading will comply with the grading standards in CCC 16.35.080. A Temporary Erosion and Sedimentation Control Plan will be prepared. All grading will be engineered, and fills will be compacted to a minimum of 90% of maximum density.

Applicable Regulation	Regulating Agency	Relevant Code Section	Application of Regulation to the Project	Compliance with Regulation
Cowlitz County Stormwater Drainage Code (CCC 16.22) and Cowlitz County Stormwater Drainage Manual	Cowlitz County	CCC 16.22 (Stormwater Management in the Unincorporated Urbanized Area)	Per CCC 16.22, stormwater runoff resulting from earth changes during and after construction activities needs to be controlled. The hard surfaces at the project site comprise approximately 26% of the total acreage within the site. Therefore, for the purposes of complying with CCC 16.22.030, the proposed cleanup action would be characterized as "New Development." This requires compliance with the minimum requirements for stormwater management outlined in the Drainage Manual (Cowlitz County 2017).	Appendix H describes the two Threshold Discharge Areas (TDAs) on the project site. The cleanup action will add or replace more than 5,000 square feet of hard surface within TDA 1, so all the minimum requirements outlined in CCC 16.22.060 will apply to stormwater runoff from new and replaced impervious surfaces and converted vegetation areas in TDA 1 (CCC 16.22.040[A.2]). The cleanup action will not impact surfaces or drainage within TDA 2. The cleanup action will comply with all of the minimum requirements in CCC 16.22.060.

8.3 Compensatory Mitigation

The cleanup action will result in unavoidable impacts to wetlands. Federal mitigation policies are established in the following documents:

- General Policies for Evaluating Permit Applications (33 Code of Federal Regulations [CFR] Part 320.4)
- Compensatory Mitigation for Losses of Aquatic Resources Final Rule (33 CFR Part 332)
- General Policies for Evaluating Permit Applications (33 CFR Part 320.4 (r))

Mitigation is also regulated at the state (Ecology) and local (Cowlitz County) level. As with the permits listed in Section 8.2, the cleanup action is exempt from local mitigation requirements.

The cleanup action will mitigate for unavoidable wetland impacts by purchasing credits from a mitigation bank, in compliance with all relevant federal, state, and local regulations. The purchase of compensatory mitigation credits will be documented in the Completion Report.

9 Compliance Monitoring

Compliance monitoring that will be performed during and after construction to meet requirements of WAC 173-340-410 is described in this section.

9.1 Protection Monitoring

A *Health and Safety Plan* was developed to establish health and safety protection monitoring protocols during construction and addresses applicable federal and state worker safety requirements pursuant to WAC 173-340-410(1)(a). The *Health and Safety Plan* is provided in Appendix N. The Contractor will also be required to have their own *Health and Safety Plan*, which will be part of the Contractor submittals as described in Appendix O.

9.2 Performance Monitoring During Construction

Procedures for performance monitoring, or verification of cleanup action activities, are specified in the CQAP (Appendix O), which has been developed in accordance with WAC 173-340-410(1)(b). Verification components specified in the CQAP include but are not limited to the following:

- Verification of excavation to the specified elevations
- Verification of material handling, placement, and compaction
- Verification of import material properties against the required specifications
- Verification of cap components and thicknesses, drainage layer, and geotextile
- Verification of reactive backfill and PRB material properties against the required specifications
- Verification of excavation depth and width and installation of PRB
- Verification of stormwater infrastructure components against required specifications

9.3 Confirmational Monitoring for Long-Term Effectiveness

Confirmational monitoring will be conducted to verify effectiveness of the cleanup action in containing fluoride in shallow groundwater and protecting fish and other aquatic life, as well as effectiveness of the low permeability caps and PRBs (Ecology 2018b). The long-term confirmational monitoring program includes cleanup level and remediation level monitoring components. The CD requires the development of an SQAPP. The SQAPP will describe the methods to be used for conducting long-term groundwater, surface water, and porewater monitoring. Components to be included in the SQAPP include the following:

- Groundwater, surface water, and ditch water monitoring locations, parameters, frequency, analytical methods, and data quality objectives
- Porewater monitoring locations and timing based on results from the SLSWP

- Contingent ditch water and sediment bioassay testing methods, parameters, sample container requirements, and data quality objectives
- Data validation protocols

Discussions regarding the scope of the long-term monitoring program have continued with Ecology during the preparation of this Final EDR. These discussions have focused on incorporating additional means to monitor the long-term effectiveness of the PRBs (i.e., the inclusion of upgradient monitoring wells adjacent to downgradient wells already included in the monitoring program and additional well pairs). It has been agreed that the SQAPP be an appendix to the updated CMCRP, which meets the requirements of WAC 173-340-820 and includes the following monitoring requirements for chemical, biological, and physical components of the implemented cleanup action:

- Conditions for engineered caps constructed as part of the remedial action, including any indications of unanticipated settlement, ponded water, damage, or obstructions to the cap, and other deviations from anticipated conditions
- Conditions for the PRBs, including any indications of ground disturbance that has the potential to disrupt PRB function
- Details of routine performance evaluations for caps and PRBs and triggered maintenance actions and contingencies
- Methods to evaluate reactivity and remaining capacity of the PRB media and determine need for media replacement in sections of the PRBs
- PRB media replacement and/or reactivation methods
- Condition of the groundwater compliance monitoring wells and of the sentinel wells
- Groundwater remediation and cleanup levels and associated monitoring program details
- Surface water cleanup levels and associated monitoring program details
- Porewater monitoring locations and timing based on results from the SLSWP
- Requirements of institutional controls including restrictive covenants to be filed following the cleanup
- Contingency response actions
- Financial assurance update mechanisms triggered by any contingencies

Upon acceptance by Ecology, the updated CMCRP and SQAPP will replace the original CMCRP (Appendix A of the CAP; Ecology 2018b) for long-term effectiveness monitoring and contingency response following the cleanup action.

9.4 Long-Term Groundwater Monitoring Program

Several monitoring wells have been installed across the site to support prior investigations and/or groundwater monitoring programs, including the ongoing interim groundwater monitoring program, which will be superseded by a long-term groundwater monitoring program following implementation of the cleanup action. Following remediation, a total of 17 monitoring wells will make up the long-term groundwater monitoring program. This total includes 16 existing (or relocated) monitoring wells and 1 new well.

Ten new wells will be installed in the vicinities of the PRBs. These wells will be monitored to assess the performance of the PRBs.

The monitoring wells in the long-term groundwater monitoring program, along with the purpose of each monitoring well are listed in Table 9-1. Additional details about the long-term groundwater monitoring and performance monitoring programs are described in the updated CMCRP.

Table 9-1
Long-Term Groundwater Monitoring Program Wells

Groundwater Monitoring Location		Long-Term Monitoring Purpose
West Groundwater Area	RL-2SR[1]	Closed BMP Post-Closure Monitoring and Compliance
	RL-3S[2]	Closed BMP Post-Closure Monitoring and Interior
	PZ-6R[3]	Closed BMP Post-Closure Monitoring and Compliance
	PZ-7R[3]	Closed BMP Post-Closure Monitoring and Compliance
	RLSW2[2]	Interior
	G6-S[2]	Sentinel
	G6-D[2]	Compliance
	G8-S	Closed BMP Post-Closure Monitoring and Compliance
	R-1S	Compliance
East Groundwater Area	R-2	Compliance
	R-4S	Compliance
	G1-S[2]	Compliance
	G2-S[2]	Interior
	G3-S	Interior
	G4-S	Compliance
	G4-D	Sentinel
	SSA7-MW-01	Compliance

Notes:
1. RL-2S may need to be decommissioned due to its proximity to the PRB construction area. If this becomes necessary, a new well to be designated as RL-2SR will be installed following PRB construction.
2. Additional wells may also be disturbed during construction and will be reinstalled as necessary. All practicable efforts will be made to protect wells during construction to avoid reinstallation.
3. PZ-6 and PZ-7 will be relocated after PRB construction and designated as PZ-6R and PZ-7R to serve as compliance monitoring wells in the long-term groundwater monitoring program.

Several existing wells are in or near remediation areas, and others are no longer needed because cleanup levels have been met in those wells. The *Closed BMP Facility Post-Closure Plan Amendment* (Appendix B of the CAP; Ecology 2018b) specified wells that had demonstrated compliance with cleanup levels during post-closure monitoring (RL-1D, RL-3D, RL-4S, RL-4D, and RL-5) and would therefore be abandoned. The following subsections briefly summarize the installation of new (or relocated—indicated by an "R") monitoring wells and the decommissioning or abandonment of wells that have met cleanup levels or have been designated for relocation.

9.4.1 Monitoring Well Installation

Monitoring wells will be installed or relocated in locations adjacent to the upgradient and downgradient sides of the PRBs.

The new monitoring wells will be installed in accordance with the procedures provided in the *Monitoring Well Installation and Decommissioning Plan*, which is a field document. Wells will be constructed to allow the well screens to intersect the water table and areas of high fluoride concentrations at each location.

9.4.2 Monitoring Well Decommissioning

As discussed in Section 9.4.1, monitoring wells that are not included in the long-term monitoring program will be permanently decommissioned. These monitoring wells will be decommissioned after Year 1 construction activities. The monitoring wells to be decommissioned are listed in Table 9-2, and locations are shown in Figures 9-1 through 9-3. Additional wells may also be disturbed during construction and will be reinstalled as necessary. All practicable efforts will be made to protect wells during construction to avoid reinstallation. These locations are shown in Figures 9-1 through 9-2.

Table 9-2
Monitoring Wells to be Permanently Decommissioned

Well ID	Location; Former Use
G1-D	SU8; RI/FS geochemical CSM
G2-D	SU8; RI/FS geochemical CSM
G3-D	SU6; RI/FS geochemical CSM
G5-D	Closed BMP; RI/FS geochemical CSM
G5-S	Closed BMP; RI/FS geochemical CSM
G-7D	Closed BMP; RI/FS geochemical CSM

Well ID	Location; Former Use
R-4D	SU5; former spent potliner area monitoring
RL-1D	Closed BMP; post-closure monitoring
RL-1S	Closed BMP; post-closure monitoring
RL-2D	Closed BMP; post-closure monitoring
RL-3D	Closed BMP; post-closure monitoring/PRB
RL-4D	SU11; post-closure monitoring

Well ID	Location; Former Use
PZ-1	SU3; RI/FS groundwater pressure monitoring
PZ-2	SU3; RI/FS groundwater pressure monitoring
PZ-3	SU3; RI/FS groundwater pressure monitoring
PZ-4	SU3; RI/FS groundwater pressure monitoring
PZ-5	SU5; RI/FS groundwater pressure monitoring
R-1D	SU5; former spent potliner area monitoring
R-3	SU4; former spent potliner area monitoring

Well ID	Location; Former Use
RL-4S	SU11; post-closure monitoring
RL-5	Closed BMP; post-closure monitoring/PRB
RLSW1	West Landfill; historical solid waste pile, investigation monitoring
RLSW3	West Landfill; historical solid waste monitoring, solid waste pile investigation
RLSW4	West Landfill; historical solid waste monitoring, solid waste pile investigation
SSA4-MW-01	SU11; RI/FS groundwater quality investigation
SSA6-MW-01	SU9; RI/FS groundwater quality investigation

Note:

1. Monitoring wells are in the interim or long-term groundwater monitoring programs, and timing of decommissioning is based on timing of remedial activities.

These monitoring wells will be decommissioned or abandoned in accordance with the procedures provided in the *Monitoring Well Installation and Decommissioning Plan*.

10 Institutional Controls

At the conclusion of construction of the cleanup action, environmental covenants must be recorded by Northwest Alloys and attached to the deed at the Cowlitz County Auditor's Office. The environmental covenants will restrict future activities and uses at the site where remedial activity was completed. This will not be required for that portion of the site located north of Industrial Way. The environmental covenants must include the following:

- A description of the affected property areas
- A description of the cleanup action as completed at the site
- Requirements to make provisions for continued monitoring, operation, and maintenance of the remedial action prior to conveying title, easement, lease, or other interest in the site
- Requirements that owners of the property notify all lessees or property purchasers of the restrictions on the use of the property
- Restrictions on uses and activities that would compromise the performance of the remedial action (i.e., low permeability caps and PRBs)
- Requirements that the site remain zoned and used for industrial purposes, unless a change in use is approved by Ecology
- Prohibition of consumptive (i.e., potable) use of groundwater from impacted portions of the upper WBZ (Fill and Upper Alluvium) within the East and West Groundwater Areas

The environmental covenants must run with the land and, as provided by law, must be binding on all parties, including all current and future owners of any interest in the property or a portion of the property. At the conclusion of construction, environmental covenants or deed restrictions will be filed for the site uses and areas in Sections 10.1, 10.2, and 10.3.

10.1 Groundwater

The site is subject to groundwater controls and deed restriction preventing potable water use within the Fill and Upper Alluvium. This restriction does not preclude use of groundwater for industrial purposes or dewatering to facilitate construction and cleanup.

10.2 Land Use

Figure 10-1 shows the portion of the site subject to institutional controls and deed restrictions applicable to remedial actions, which includes future capped landfills at SU1/SU2 (West Landfill), SU6 (East Landfill No. 2), and SU7 (East Landfill No. 1), and the PRBs along the northwestern portion of the site.

10.3 Previous Deed Restrictions (Closed BMP and 20,000-Gallon Diesel Tank)

The deed notice that was previously filed for the Closed BMP must also be revised at the same time the additional deed notices are filed for the CAP and CD for consistency with RCW 64.70. These previous deed restrictions are shown in Figure 10-1. Because impacted soils in the diesel tank area will be excavated and managed by off-site disposal following the demolition of the diesel tank, a deed restriction will no longer be required for that area. The existing deed restriction will be removed from Cowlitz County records.

11 Financial Assurance

As stated in the CD, financial assurance for the corrective action is required by WAC 173-303-64620. Every year, either the Owner or Operator must provide and submit proof of financial assurance consistent with the requirements of WAC 173-303-64620 and WAC 173-303-610(7). The financial assurance will, at all times, cover 30 years of remedial action costs at the site. Ecology's Financial Assurance Officer, on behalf of Ecology, will determine when Owner's actions and submissions meet the requirements of this section and WAC 173-303-64620, both during the yearly review of financial assurance and as a component of the 5-year reviews required for the site by WAC 173-340-420(2)(a).

Cost estimates for financial assurance have been prepared for the chemical, biological, and physical components and monitoring required by the long-term compliance monitoring plan described in Section 9.3. Cost estimates for seismic events that could cause deformation necessitating repair to the landfills were included in the financial assurance cost estimate. Additional performance monitoring has since been added to the program as outlined in the updated CMCRP (Anchor QEA 2023). These cost estimates will be updated and provided under separate cover to Garin Schrieve and Joanna Richards.

12 Project Schedule and Reporting

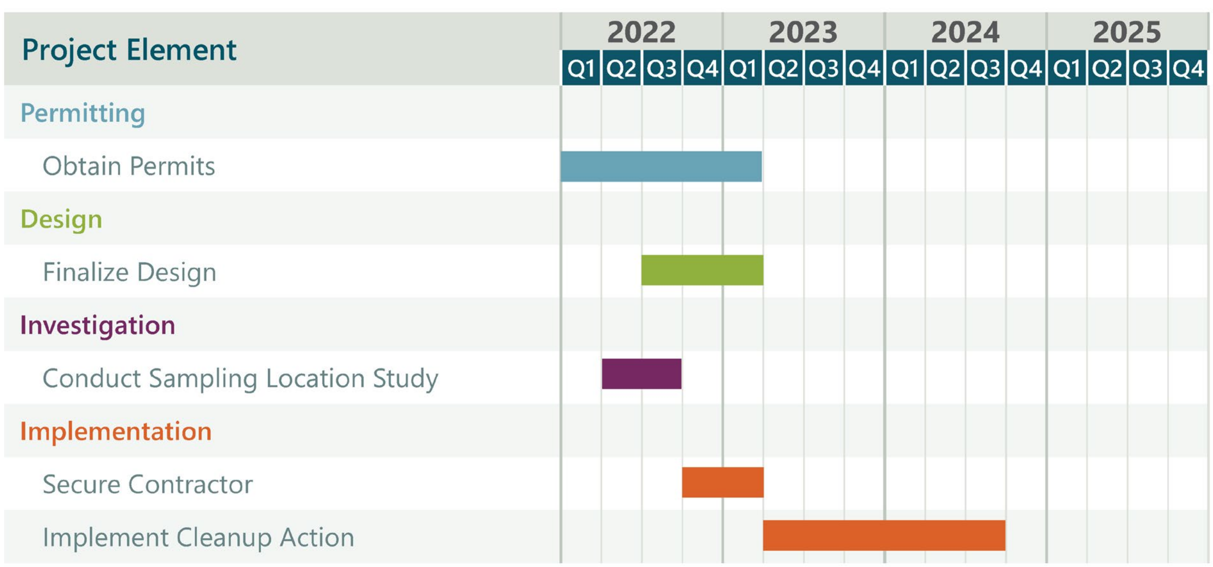
This section provides an overview of the implementation schedule for cleanup construction activities at the site, including associated permitting and investigations. The cleanup implementation schedule is presented in Graphic 12-1.

The excavation, consolidation, and capping activities described in this Final EDR are anticipated to be completed within two construction seasons. Construction will start in spring 2023 and will continue into fall 2024.

The selected Contractor, Envirocon, will be required to prepare a detailed baseline schedule of construction activities that achieves the following goals:

- Provides for a safe work environment for workers
- Provides for implementation of best management practices that protect the environment
- Protects existing facilities from damage
- Accomplishes the work in a timely manner
- Accomplishes the work in a cost-effective manner

Graphic 12-1
Cleanup Implementation Schedule



As specified in the CD SOW, a Completion Report will be submitted to Ecology within 120 days of completion of construction activities. This report will include as-built drawings and provide sufficient information to document construction of the remedial action. The report will also contain an opinion from the engineer as to whether the cleanup action has been constructed in substantial compliance with the plans and specifications and related documents.

13 References

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Figures

SOURCE: Aerial from Google Earth
HORIZONTAL DATUM: Washington State Plane South Zone, NAD83, U.S. Survey Feet
NOTE: BPA property is not included as part of the site.

LEGEND:

Site Boundary

0 2000
Feet

Publish Date: 2023/03/22 9:29 PM | User: chewett
Filepath: 0730-RP-061 (Vicinity - Eng Design Rep).dwg Figure 1-1

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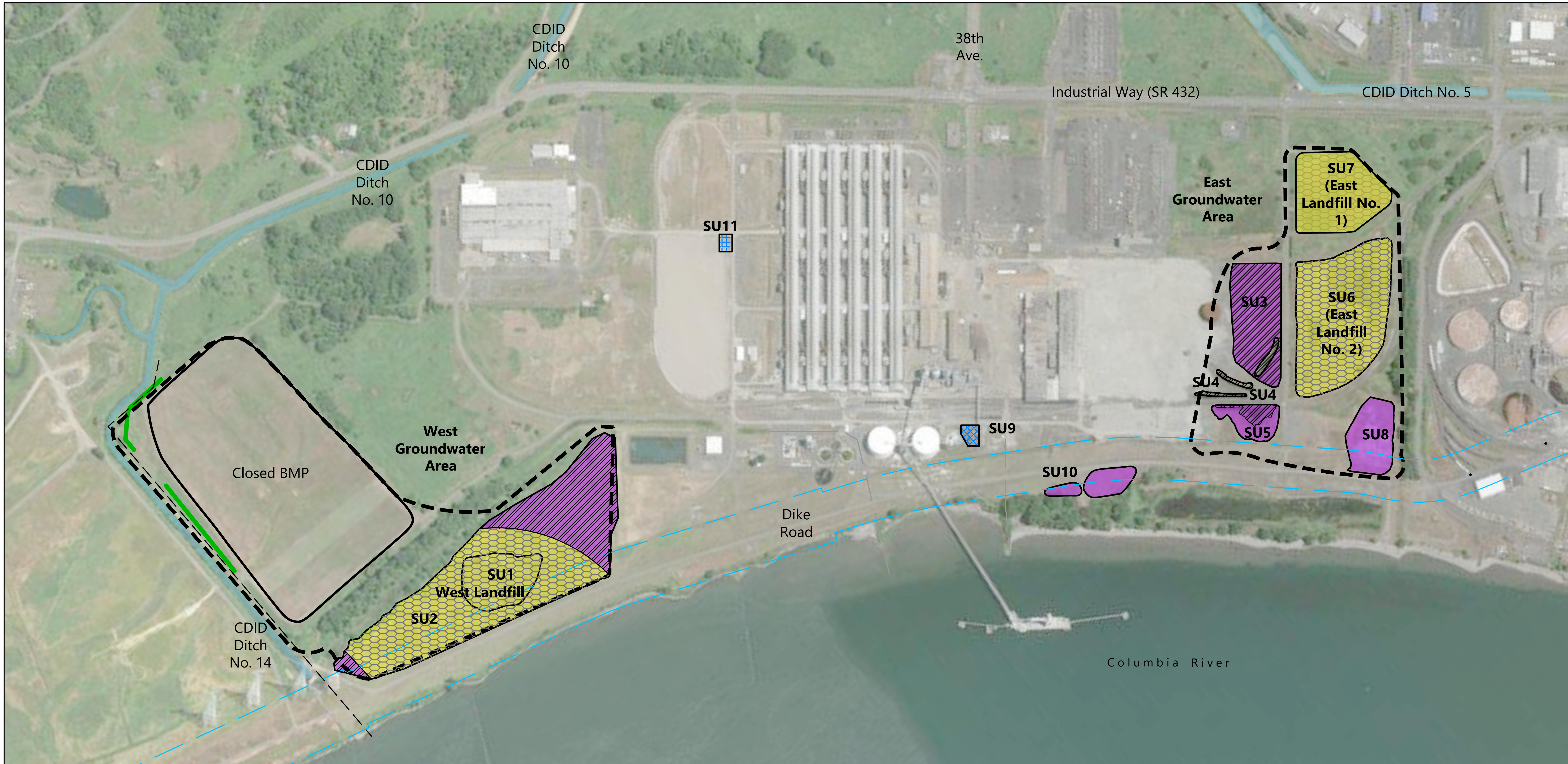
Figure 1-1
Project Vicinity and Site Features

Final Engineering Design Report, Version 2
Former Reynolds Metals Reduction Plant – Longview



SOURCE: Drawing prepared from ALTA Survey (Minister & Glaeser Surveying, Inc.) conducted on November 11, 2010. Aerial image from Bing Maps.
HORIZONTAL DATUM: Washington State Plane South Zone, NAD83, U.S. Survey Feet

LEGEND:

- Low Permeability Cap
- Excavate and Consolidate on Site
- Excavate and Dispose off Site
- Permeable Reactive Barrier
- Excavate and Low Permeability Cap
- Reactive Backfill
- Groundwater Area
- CDID Levee Right-of-Way (ROW)

0 600
Feet

Publish Date: 2023/03/22 9:30 PM | User: chewett
Filepath: 0730-RP-060 (Cleanup Areas - Eng Design Rep).dwg Figure 2-1

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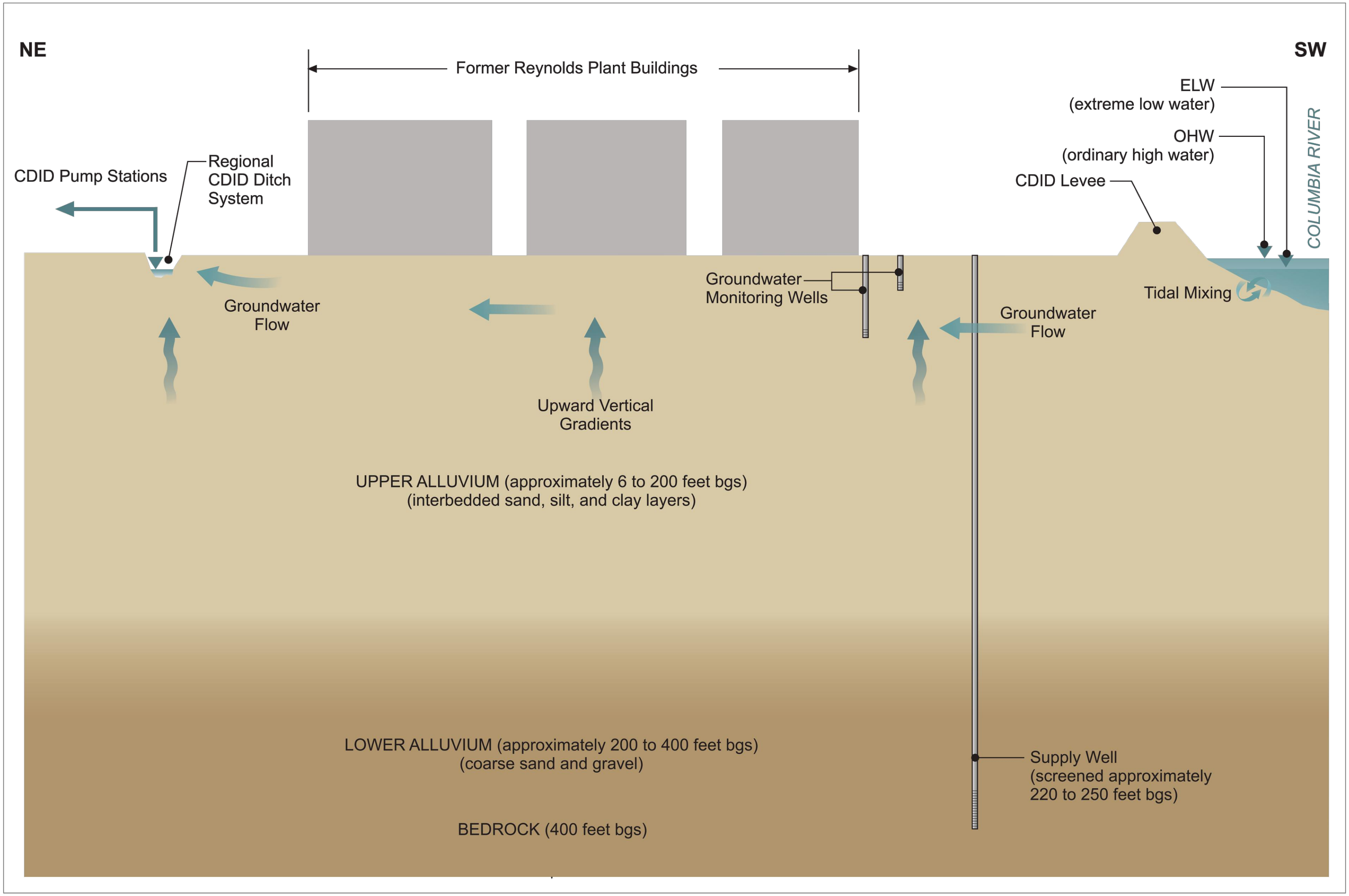
Figure 2-1
Cleanup Action Areas

Final Engineering Design Report, Version 2
Former Reynolds Metals Reduction Plant – Longview



Publish Date: 2023/03/22 9:30 PM | User: chewett
Filepath: 0730-WK-001 (Figure 3-1).dwg Figure 3-1

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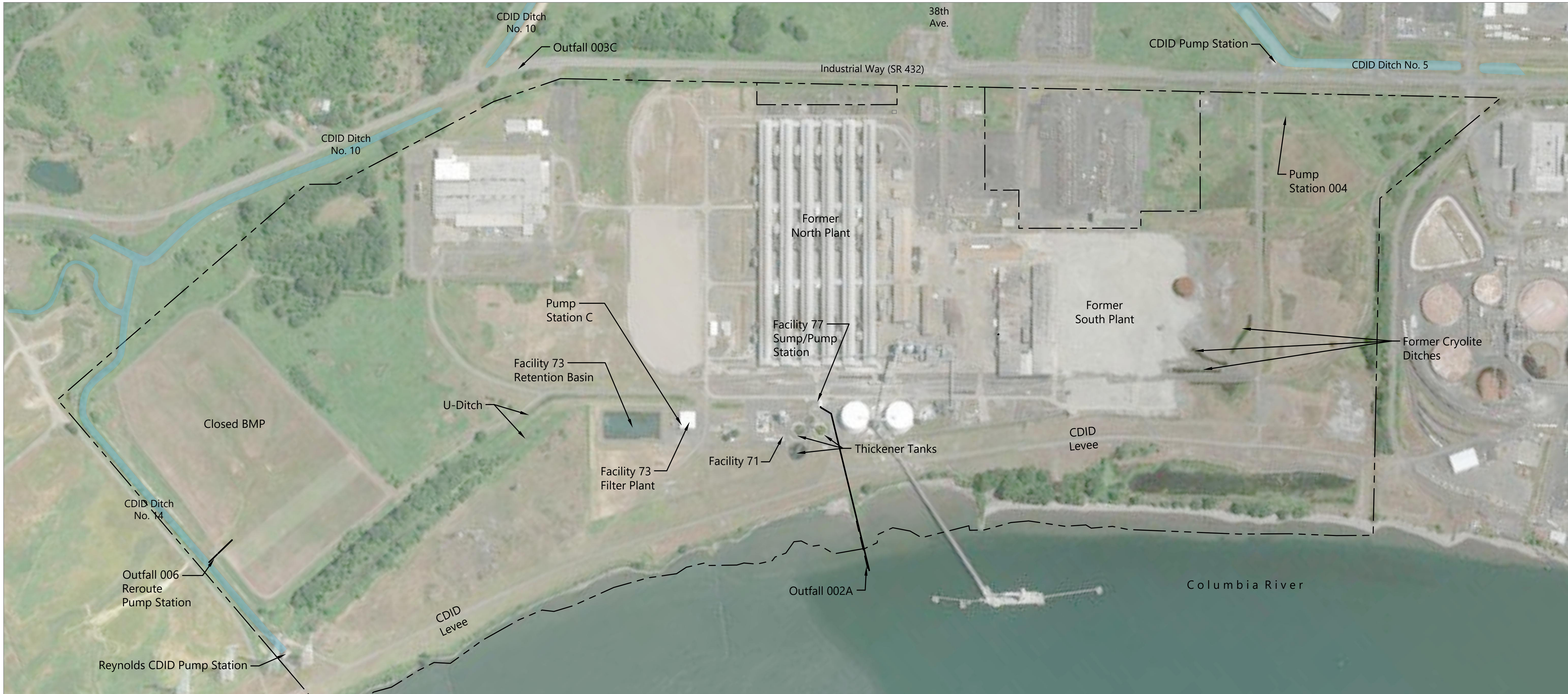
Figure 3-1
Groundwater Conceptual Site Model



SOURCE: Aerial Image from Bing Maps.
HORIZONTAL DATUM: Washington State Plane South Zone, NAD83, U.S. Survey Feet

LEGEND:
Parcel Boundary
CDID Ditch

Publish Date: 2023/03/22 9:30 PM | User: chewett
Filepath: 0730-WK-017-Stormwater.dwg Figure 3-2

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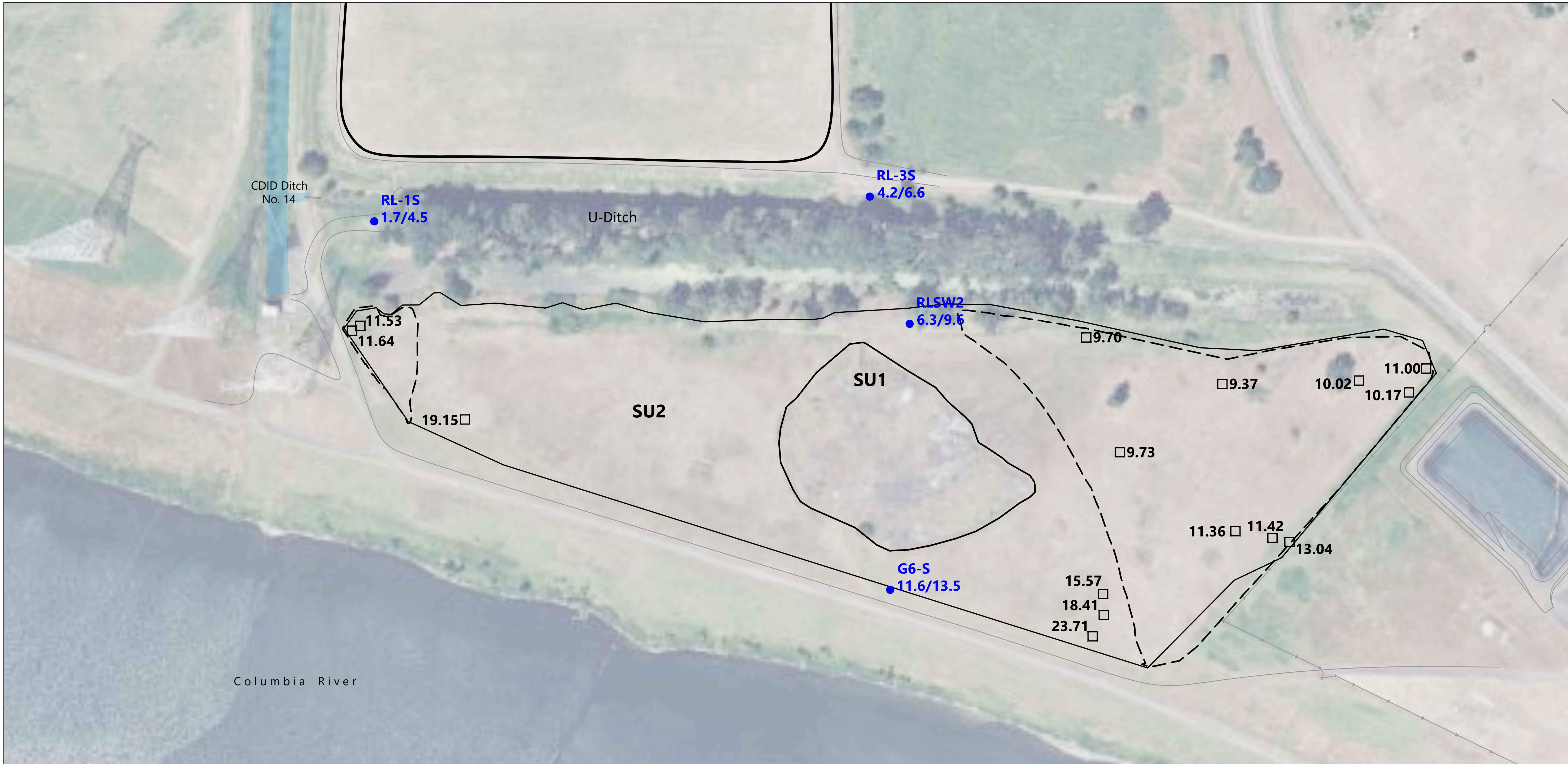
Figure 3-2
Key Elements of the Stormwater Collection and Treatment System



SOURCE: Drawing prepared from ALTA Survey (Minister & Glaeser Surveying, Inc.) conducted on November 11, 2010. Aerial image from Bing Maps.
HORIZONTAL DATUM: Washington State Plane South Zone, NAD83, U.S. Survey Feet
VERTICAL DATUM: NAVD88, Feet

LEGEND:
- Extent of Proposed Excavation
- □25.8 Test Pit Location and Estimated Base of Fill Deposit Elevation in Feet (NAVD88)
- ● G6-S Groundwater Monitoring Location
- 11.6/13.5 Dry Groundwater Elevation (10th Percentile)/Wet Groundwater Elevation (90th Percentile)
- CDID Ditch

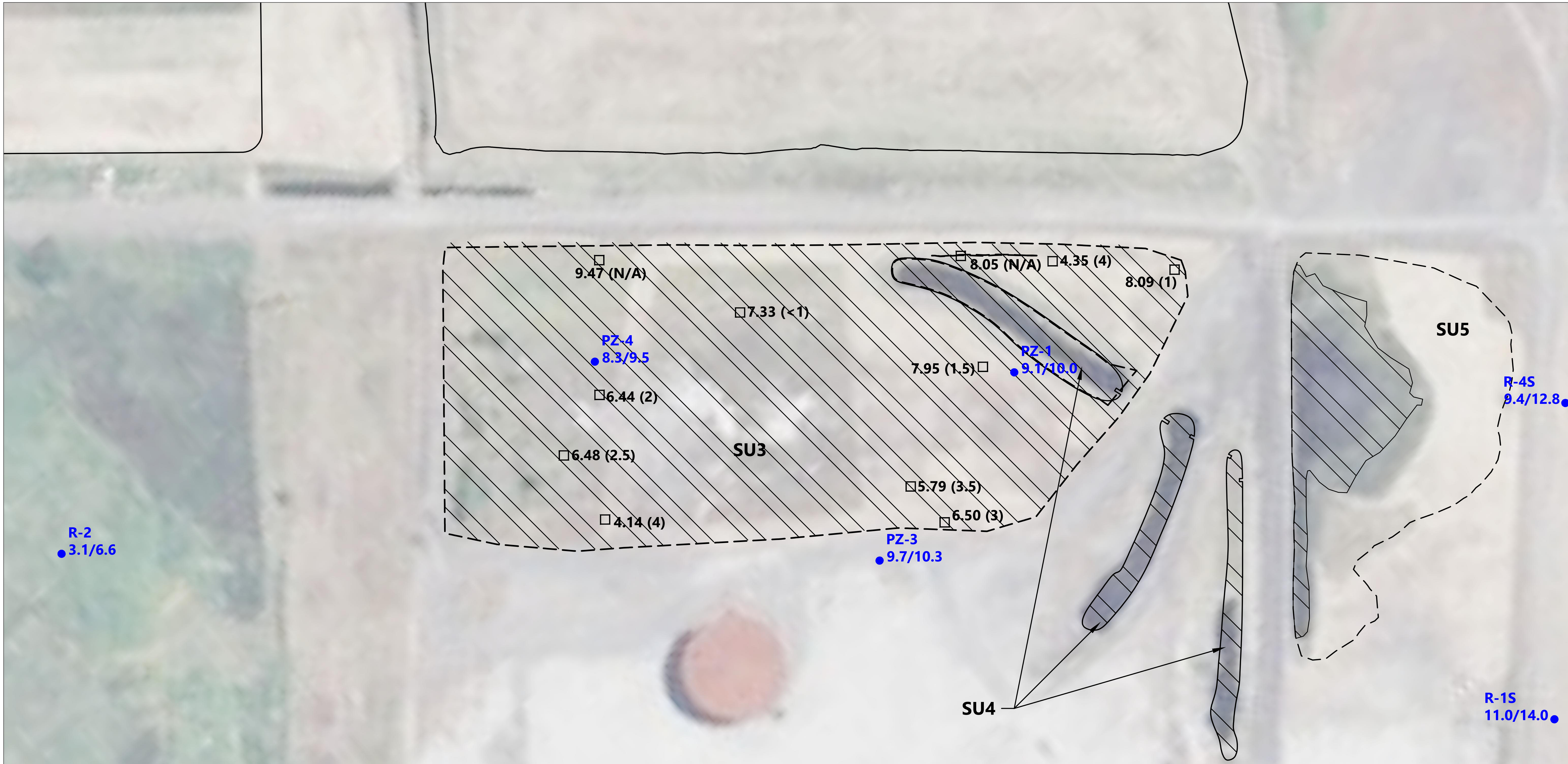
0 200
Feet

Publish Date: 2023/03/22 9:30 PM | User: chewett
Filepath: 0730-RP-069 (Waste and GW).dwg Figure 5-1

ANCHOR QEA

Figure 5-1
SU2: Waste and Local Groundwater Elevations

Final Engineering Design Report, Version 2
Former Reynolds Metals Reduction Plant – Longview



SOURCE: Drawing prepared from ALTA Survey (Minister & Glaeser Surveying, Inc.) conducted on November 11, 2010. Aerial image from Bing Maps.
HORIZONTAL DATUM: Washington State Plane South Zone, NAD83, U.S. Survey Feet
VERTICAL DATUM: NAVD88, Feet

LEGEND:

— — —	Extent of Proposed Excavation
□7.33 (<1)	Test Pit Location, Estimated Base of Fill Deposit Elevation in Feet (NAVD88), and Distance Below Dry Weather Groundwater Elevation (in feet)
● G6-S	Groundwater Monitoring Location
11.6/13.5	Dry Groundwater Elevation (10th Percentile)/Wet Groundwater Elevation (90th Percentile)
(hatched)	Reactive Backfill

0 100
Feet

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Filepath: 0730-RP-069 (Waste and GW).dwg Figure 5-2

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Figure 5-2
SU3: Waste and Local Groundwater Elevations

Final Engineering Design Report, Version 2
Former Reynolds Metals Reduction Plant – Longview

SOURCE: Drawing prepared from ALTA Survey (Minister & Glaeser Surveying, Inc.) conducted on November 11, 2010. Aerial image from Bing Maps.
HORIZONTAL DATUM: Washington State Plane South Zone, NAD83, U.S. Survey Feet
VERTICAL DATUM: NAVD88, Feet

LEGEND:

- – – – – Extent of Proposed Excavation
- □8.26 Test Pit Location and Estimated Base of Fill Deposit Elevation in Feet (NAVD88)
- △<7.36 Test Pit Location Where Base of Fill Deposit Was Not Reached – Estimated Maximum Elevation in Feet (NAVD88)
- ●G6-S 11.6/13.5 Groundwater Monitoring Location, Dry Groundwater Elevation (10th Percentile)/Wet Groundwater Elevation (90th Percentile)
- Reactive Backfill

Publish Date: 2023/03/22 9:30 PM | User: chewett
Filepath: 0730-RP-069 (Waste and GW).dwg Figure 5-3

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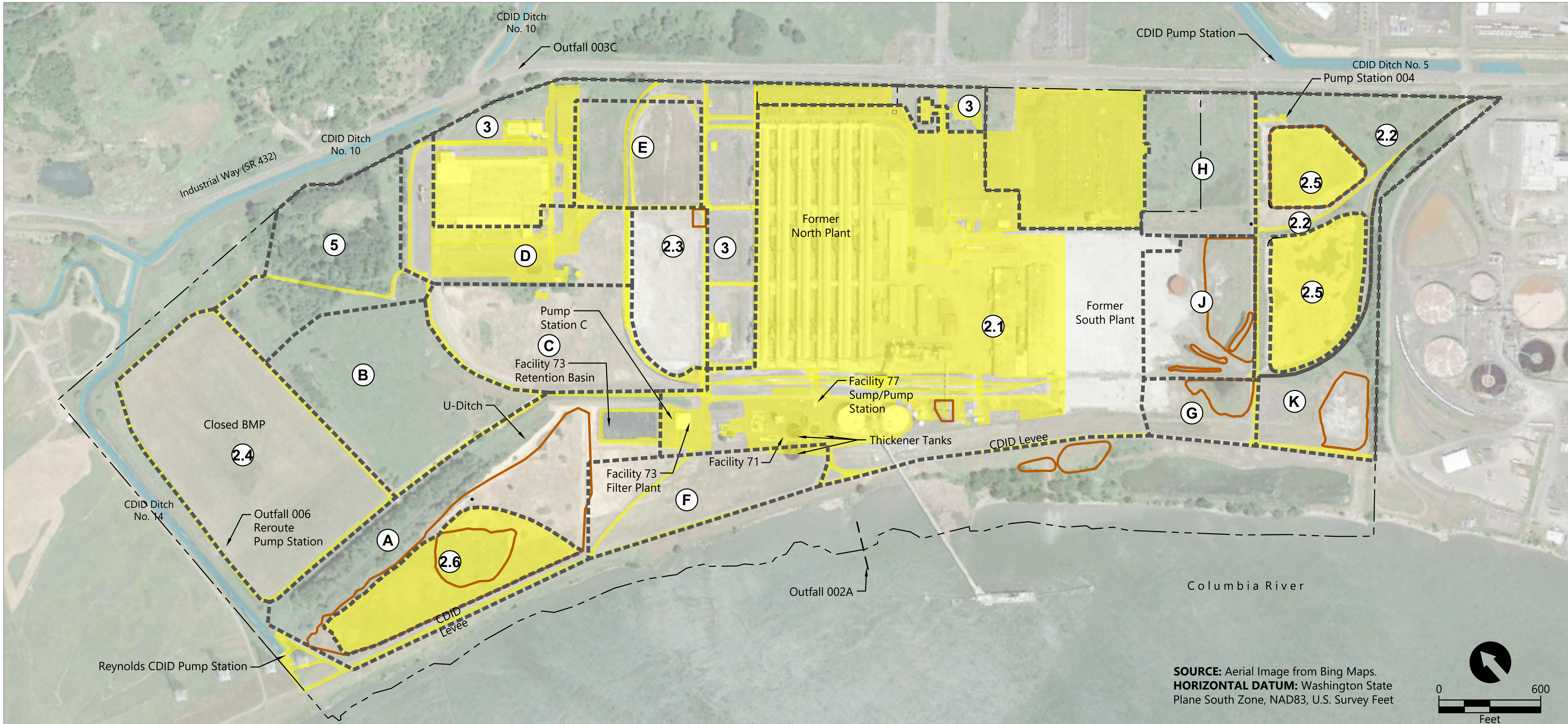
Figure 5-3
SU8 and SU10: Waste and Local Groundwater Elevations

Final Engineering Design Report, Version 2
Former Reynolds Metals Reduction Plant – Longview



LEGEND:

- Parcel Boundary
- Approximate Impervious Area
- (5) Drainage Basin Identification and Approximate Drainage Delineation
- Cleanup Site Unit

Drainage Basin	Impervious Area (in acres)	Pervious Area (in acres)	Total Area (in acres)
Basin 2.1	62.2	26.5	88.7
Basin 2.2	0.9	27.0	27.9
Basin 2.3	0.2	9.2	9.4
Basin 2.4	1.7	31.4	33.1
Basin 3	37.8	19.7	57.5
Basin 5	0.5	16.7	17.2

Drainage Basin	Impervious Area (in acres)	Pervious Area (in acres)	Total Area (in acres)
Basin A	1.5	39.0	40.5
Basin B	0.4	21.0	21.4
Basin C	1.2	16.1	17.3
Basin D	7.0	7.1	14.1
Basin E	1.1	9.6	10.7
Basin F	0.8	12.1	12.9

Drainage Basin	Impervious Area (in acres)	Pervious Area (in acres)	Total Area (in acres)
Basin G	0.2	5.4	5.6
Basin H	0.0	12.7	12.7
Basin J	0.0	12.3	12.3
Basin K	0.5	11.7	12.2

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Filepath: 0730-WK-020-Stormwater-Proposed.dwg Figure 5-4

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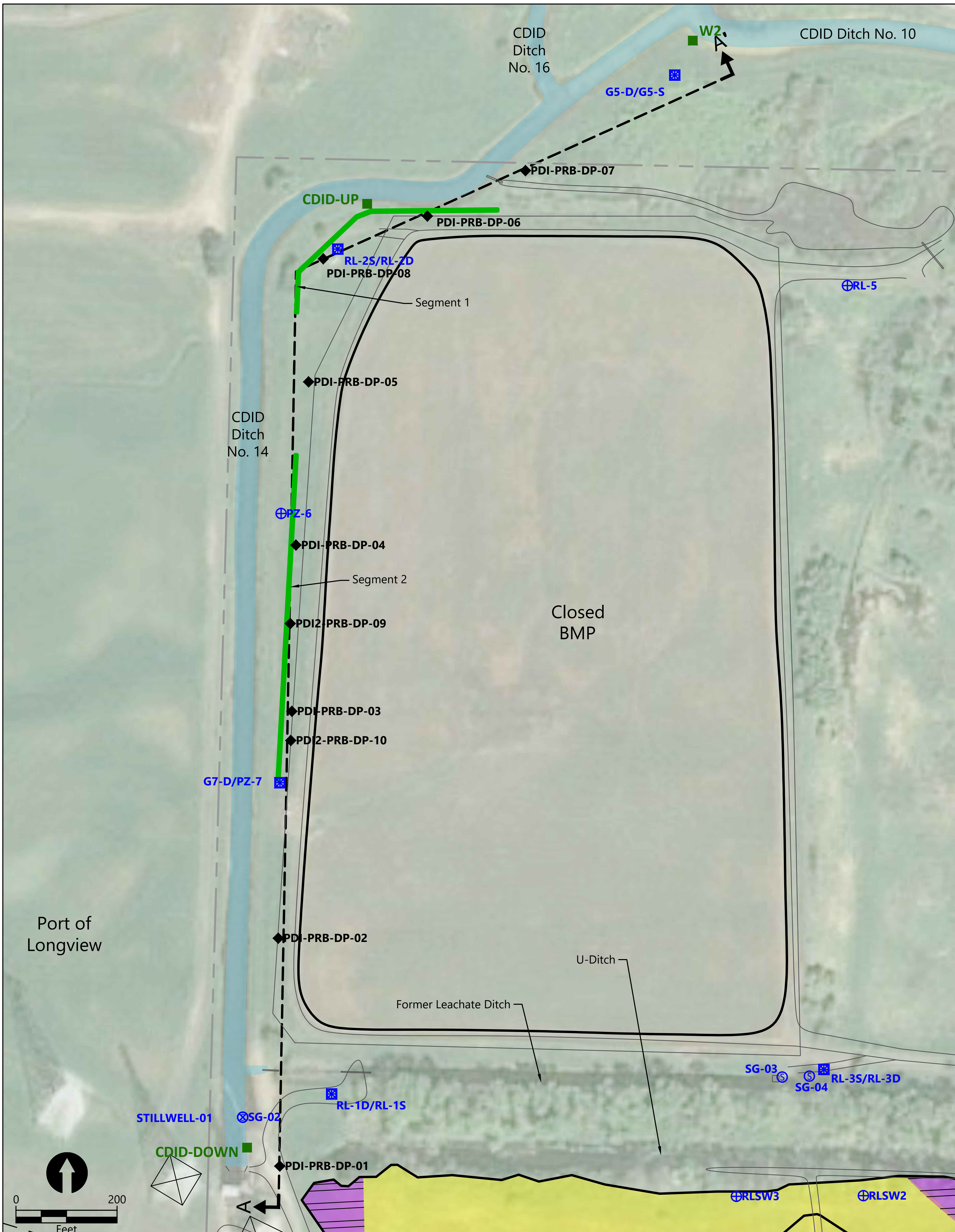
Figure 5-4
Proposed Drainage Basins and Impervious Land Cover



SOURCE: Drawing prepared from ALTA Survey (Minister & Glaeser Surveying, Inc.) conducted on November 11, 2010. Aerial from Bing Maps.
HORIZONTAL DATUM: Washington State Plane South Zone, NAD83, U.S. Survey Feet
VERTICAL DATUM: NAVD88, Feet

LEGEND:
- Contours (2-foot and 10-foot interval)
- Parcel Boundary
- CDID Ditch
- A A' Cross Section Location and Designation
- Permanent Staff Gauge
- Required Surface Water Monitoring Location for Closed BMP Facility

GROUNDWATER WELL LEGEND:
- Groundwater Sampling Location
- Paired Shallow/Deeper Groundwater Sampling Location
- Temporary Stilling Well Instrumented for Tidal Study

LEGEND (SAMPLES):
- PDI Direct Push Probe

CLEANUP ACTION LEGEND:
- Permeable Reactive Barrier

Publish Date: 2023/03/22 9:31 PM | User: chewett
Filepath: 0730-RP-066 (West Groundwater Lithology).dwg Figure 6-1

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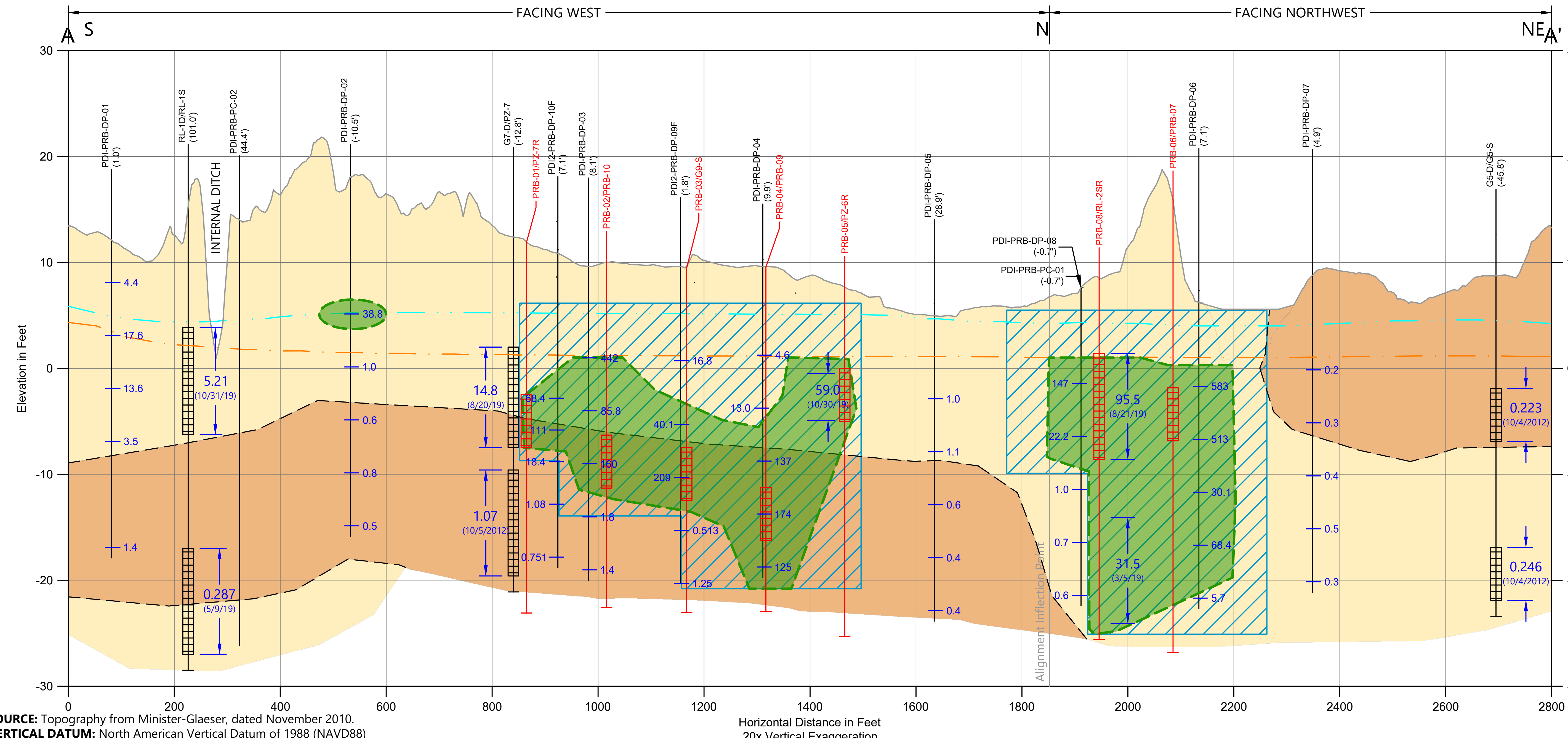
Figure 6-1
Fluoride Screening Locations and Permeable Reactive Barrier Alignments



SOURCE: Topography from Minister-Glaeser, dated November 2010.
VERTICAL DATUM: North American Vertical Datum of 1988 (NAVD88)
NOTES:

1. Highest fluoride value is for wells monitored in 2019. Locations showing N/A are no longer part of these monitoring programs, and fluoride concentrations in these wells, when monitored, have consistently been below 4.0 mg/L.
2. Positive sample offsets indicate offsets toward landfills. Negative sample offsets indicate offsets towards the CDID ditch.
3. PDI borings (DP-01 to DP-08) were installed on February 10 to February 14, 2020. PDI2 borings (DP-09 and DP-10) were installed on April 15 and April 16, 2020.
4. Final monitoring well locations to be field-adjusted to avoid toe of Closed BMP Facility slope.

LEGEND:

- 0.5 Fluoride Concentration (mg/L)
- Approximate Existing Grade (November 2010)
- Lithologic Contact, Dashed Where Inferred
- Historical Dry Season Groundwater Elevation
- Historical Wet Season Groundwater Elevation
- Flouride Concentration Near or Above 10x MCL
- Silt and Sandy Silt
- Sand and Silty Sand
- Permeable Reactive Barrier

Existing Monitoring Well Locations
Sample Name and Offset from Alignment (See Note 2) — PZ-6 (-20.5')
Screened Interval
Bottom of Boring
Highest Fluoride Value (mg/L) (Date Sampled) See Note 1

Proposed Monitoring Well Locations

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Filepath: K:\Projects\0730-MBT-Longview\0730-RP-090.dwg Figure 6-2

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Figure 6-2
Fluoride Concentrations and Permeable Reactive Barrier Profile

SOURCE: Aerial image from Google Earth, dated June 2017.
HORIZONTAL DATUM: Washington State Plane South Zone, North American Datum of 1983 (NAD83), U.S. Survey Feet

LEGEND:

RL-3D⊕ Existing Monitoring Well to be Permanently Decommissioned

RL-2S⊕ Existing Monitoring Well may be Disturbed During Construction and Require Reinstallation

0 250
Feet

Publish Date: 2023/03/30 10:20 AM | User: chewett
Filepath: K:\Projects\0730-MBT-Longview\0730-RP-092.dwg Figure 9-1

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Figure 9-1
Monitoring Well Decommissioning Locations - West Groundwater Area

SOURCE: Aerial image from Google Earth, dated June 2017.
HORIZONTAL DATUM: Washington State Plane South Zone, North American Datum of 1983 (NAD83), U.S. Survey Feet

LEGEND:
R-1D ⊕ Existing Monitoring Well to be Permanently Decommissioned
G1-S ⊕ Existing Monitoring Well may be Disturbed During Construction and Require Reinstallation

0 150
Feet

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Filepath: K:\Projects\0730-MBT-Longview\0730-RP-092.dwg Figure 9-2

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Figure 9-2
Monitoring Well Decommissioning Locations - East Groundwater Area

Final Engineering Design Report, Version 2
Former Reynolds Metals Reduction Plant – Longview

SOURCE: Aerial image from Google Earth, dated June 2017.
HORIZONTAL DATUM: Washington State Plane South Zone, North American Datum of 1983 (NAD83), U.S. Survey Feet

LEGEND:
R-1D ⊕ Existing Monitoring Well to be Permanently Decommissioned

0 250
Feet

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Filepath: K:\Projects\0730-MBT-Longview\0730-RP-092.dwg Figure 9-3

ANCHOR QEA

Figure 9-3
Monitoring Well Decommissioning Locations - Central Portion of Site

SOURCE: Drawing prepared from ALTA Survey (Minister & Glaeser Surveying, Inc.) conducted on November 11, 2010. Aerial image from Bing Maps.
HORIZONTAL DATUM: Washington State Plane South Zone, NAD83, U.S. Survey Feet

NOTES:
1. Institutional controls are not applicable north of Industrial Way, in off-property areas, or in rivers or ditches.
2. The Closed BMP Facility and 20,000-Gallon Diesel Tank are portions of the site subject to existing deed restrictions. After remedial actions, the 20,000-Gallon Diesel Tank deed restriction will no longer be required and will be removed.
3. Site subject to groundwater controls and deed restriction preventing potable water use within the Fill and Upper Alluvium. This restriction does not preclude use of groundwater for industrial purposes or dewatering to facilitate construction and cleanup.
4. The property is limited to industrial use only.

LEGEND
- Low Permeability Cap
- Approximate Future Cap Boundary
- Approximate Future PRB Location Subject to Institutional Controls and Deed Restrictions Following Remedial Actions
- Landfills Subject to Institutional Controls and Deed Restrictions Following Remedial Actions
- Portion of Site Subject to Existing Deed Restrictions
- Site Subject to Groundwater Controls and Deed Restriction Preventing Potable Use Within Fill and Upper Alluvium (See Note 3)

Publish Date: 2023/03/22 9:36 PM | User: chewett
Filepath: 0730-WK-002 (Figure 9-1).dwg Figure 10-1

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Figure 10-1
Areas of Contamination Managed in Place as Part of the Cleanup