REMEDIAL INVESTIGATION/FEASIBILITY STUDY REPORT

Eldridge Municipal Landfill Site
Bellingham, Washington

FINAL DOCUMENT

Prepared for

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ACRONYMS AND ABBREVIATIONS

ARI	Analytical Resources Inc.
ARAR	applicable or relevant and appropriate requirements
BaPE	benzo(a)pyrene equivalent
bgs	below ground surface
BMC	Bellingham Municipal Code
BTC	Bellingham Technical College
CAP	Cleanup Action Plan
City	City of Bellingham
CLARC	cleanup levels and risk calculation
Creek	Little Squalicum Creek
CSM	conceptual site model
CUL	cleanup level
cy	cubic yard
DAF	dilution attenuation factor
DCAP	draft Cleanup Action Plan
Ecology	Washington State Department of Ecology
EDR	engineering design report
EIC	ecological indicator concentration
EML	Eldridge Municipal Landfill
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
IEUBK	integrated exposure/uptake biokinetic model
IHS	indicator hazardous substance
IRIS	integrated risk information system
MCL	maximum contaminant level
MCLG	maximum contaminant level goal
MTCA	Model Toxics Control Act
mg/kg	milligrams per kilogram
NAVD88	North American Vertical Datum 1988
NWTPH	Northwest Total Petroleum Hydrocarbons (laboratory method)
Oeser	Oeser Company
PAH	polycyclic aromatic hydrocarbon
Park	Little Squalicum Park
PLP	potentially responsible person
PQL	practical quantitation limit
PRG	preliminary remediation goal
QAPP	quality assurance project plan
QC	quality control
RAO	remedial action objective
RI/FS	remedial investigation and feasibility study
RL	remediation level
RTP	reconnaissance test pit (sample name prefix)

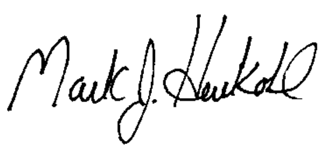
ACRONYMS AND ABBREVIATIONS (cont.)

SAP	sampling and analysis plan
SL	screening level
SVOC	semivolatile organic compound
TCLP	toxicity characteristic leaching procedure
TCP	Toxics Cleanup Program
TEE	terrestrial ecological evaluation
TEF	toxicity equivalency factor
TOC	total organic carbon
TP	test pit (sample name prefix)
TPH	total petroleum hydrocarbons
UCL	upper confidence limit
µg/L	micrograms per liter
USCS	Unified Soil Classification System
UTL	upper tolerance limit
VCP	Voluntary Cleanup Program
VOC	volatile organic compound
WAC	Washington Administrative Code
WQC	water quality criteria

CERTIFICATION

I, Mark J. Herrenkohl, a professional engineering geologist in the State of Washington, certify that I have reviewed the geosciences portions of this document.

Stamp and Signature of Geologist:



Name: Mark J. Herrenkohl, LEG

Date: December 1, 2015

ACKNOWLEDGMENTS

This document was compiled by Herrenkohl Consulting LLC and Integral Consulting Inc. under contract with the City of Bellingham in accordance with the requirements of Contract 2011-0142 and the project work plans (Integral Consulting 2005a,b,c,d,e, Integral Consulting 2006a, b, Herrenkohl Consulting 2012). This project was funded by the City of Bellingham and the Washington State Department of Ecology Remedial Action grant. Mr. Sam Shipp is the City project manager; Ms. Mary O'Herron is the Ecology project manager; and Mr. Mark Herrenkohl is the Herrenkohl Consulting project manager.

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Wilson Engineering LLC	Surveying and graphic support
Cascade Drilling	Drilling operations
Analytical Resources, Inc.	Physical and chemical testing of samples

EXECUTIVE SUMMARY

This document is the remedial investigation/feasibility study (RI/FS) report for the Eldridge Municipal Landfill site (Site) located in Bellingham, Washington. The report describes the environmental setting for the Site, identifies the nature and extent of contamination for affected media, summarizes the results of an interim action, evaluates the protectiveness of post-interim action conditions, and proposes no further remedial action for the Site.

While performing an RI under separate order for the Little Squalicum Park (Park) site, a separate and distinct area of contamination from an old municipal landfill was discovered in the Park. For a few years during the mid- to late-1930s, the City had used a portion of the Park as a "sanitary landfill" for burning and burying local municipal waste hauled by a garbage collection contractor. The landfill area is located on property owned by Whatcom County, which is currently leased by the City of Bellingham (City) for management of the Park.

The initial boundaries of the landfill were delineated in January 2006 as part of the draft Park RI, through the excavation of reconnaissance test pits in which evidence of municipal garbage (glass bottles, metal scraps, ash, ceramics, construction debris, and various indiscernible rusted materials) was found within various fill materials. Six metals (arsenic, cadmium, copper, lead, mercury, zinc) and pentachlorophenol were detected in the landfill at levels determined to pose a threat to human health and the environment. The highest concentrations of metals were found from 2 to 4 feet below ground surface.

In November 2009, the Washington State Department of Ecology (Ecology) listed the landfill area as a separate site and named both the City and County as potentially liable persons. The City and Ecology signed an Agreed Order for completing an RI/FS report and draft cleanup action plan for the Site on November 19, 2010.

In September 2010, the U.S. Environmental Protection Agency (EPA) uncovered additional landfill material during excavations in support of the Little Squalicum Creek removal action at the Park site. In order to allow the EPA work to continue, the City undertook an independent action to investigate, analyze, relocate and secure most of the contaminated soil. Approximately 500 cubic yards (cy) of mixed municipal wastes and soil were removed from a 6,000 ft^2 area, stockpiled, and covered in the landfill Site area.

A draft RI/FS report with a preferred cleanup alternative for the Site was submitted to Ecology in February 2011. The estimated volume of municipal waste and contaminated soil, including the stockpiled soils, was 2,400 cy or 3,800 tons. Human receptors potentially exposed to Site contaminated soils and groundwater included recreational park users, maintenance personnel, and transients. Ecological receptors potentially exposed included terrestrial and wetland plants, soil-dwelling invertebrates, terrestrial animals, and semi-aquatic birds and mammals. The following indicator hazardous substances were identified in the draft RI/FS report:

1. For human health only: arsenic, cadmium, and pentachlorophenol
2. For ecological receptors only: copper and mercury

3. For both receptors: lead and zinc.

After review of the draft RI/FS report by Ecology and further discussion between parties, the City agreed to conduct an interim action for the Site in summer 2011. Also in 2011, EPA completed the removal action of the Little Squalicum Creek site adjacent to the landfill Site.

An amendment to the Agreed Order for the landfill Site was negotiated and signed by the City and Ecology on July 18, 2011. The following remediation levels used to define the removal area were developed based on direct soil contact by humans and terrestrial ecological receptors:

- Arsenic: 10 mg/kg, based on site-specific natural background
- Cadmium: 45 mg/kg, based on direct human contact and adjusted to ensure a hazard index of 1
- Copper: 50 mg/kg, based on the terrestrial ecological evaluation (TEE)
- Lead: 50 mg/kg, based on the TEE
- Mercury: 0.1 mg/kg, based on the TEE
- Zinc: 86 mg/kg, based on natural background
- Pentachlorophenol: 2.5 mg/kg, based on direct human contact.

Interim action remedial activities were conducted by the City's contractor Glacier Environmental Services Inc. from August 22 to October 7, 2011. About 4,290 tons of landfill debris and contaminated soil were excavated from the Site with disposal at a Subtitle D landfill located in Roosevelt, Washington. The excavation was stabilized, backfilled with clean soil, and vegetated by hydroseeding. In addition, a 750 ft^2 depressional wetland was created within the project area. Soils containing pentachlorophenol and metals above the remediation levels were removed from the Site except for locations on steep, unstable slopes and within or adjacent to an existing wetland.

Groundwater concentrations in confirmation samples collected in May 2012 indicate that groundwater complies with cleanup levels and the leaching pathway is not of concern for the Site. No additional confirmation monitoring is required for the Site. However, re-sampling and analyzing for arsenic at MW-03 is appropriate to check the validity of the initial result. This additional sampling and testing does not preclude completing the RI/FS report.

Soil concentrations in performance samples do not comply with the MTCA three-part statistical rule because of a few locations that could not be excavated without threatening steep slopes or the existing wetland. However a site-specific risk assessment concluded that soil concentrations following the interim action are protective of human health and the environment.

The interim action was found to comply with all MTCA threshold criteria and other requirements for selection of a cleanup action. No additional remediation of the Site is warranted. However, for debris and soil contamination remaining under the existing wetland and Cottonwood tree, a restrictive covenant on the property will be required by the City indicating this area is critical habitat. The 750 ft^2 depressional wetland created within the project area will also require additional planting in the future. The groundwater monitoring, wetland planting, and restrictive covenant will be documented and described in a draft cleanup action plan (DCAP) issued under separate cover.

This document is being issued for public review concurrently with the proposed Consent Decree which includes the DCAP.

1 INTRODUCTION

This document is the remedial investigation/feasibility study (RI/FS) for the Eldridge Municipal Landfill site (Site) located in Bellingham, Washington (Figure 1). The RI/FS was conducted in accordance with Agreed Order No. DE 8073 (Agreed Order) between the Washington State Department of Ecology (Ecology) and the City of Bellingham (City). The report describes the environmental setting for the Site, identifies the nature and extent of contamination for affected media, develops remediation levels (RLs) and final cleanup levels (CULs), summarizes the results of an interim action described in an amendment to the Agreed Order, and concludes no further action for the Site. This document was developed using information presented in the *Little Squalicum Park Remedial Investigation Draft Final Report* (Integral 2008) and the *Interim Action Completion Report for the Eldridge Municipal Landfill Project* (Herrenkohl Consulting and Wilson Engineering, 2011b). It has been prepared to satisfy the requirements of the Model Toxics Control Cleanup Act (MTCA), Chapter 70.105D RCW, administered by the Washington State Department of Ecology (Ecology) under the MTCA Cleanup Regulation, Chapter 173-340 Washington Administrative Code (WAC).

Herrenkohl Consulting LLC has written this RI/FS with assistance from Integral Consulting Inc. under Contract No. 2011-0142 (including modifications) with the City of Bellingham Public Works Department (City), and with direction from Ecology's Toxics Cleanup Program (TCP).

1.1 SITE DESCRIPTION AND BACKGROUND

While performing an RI under separate order (Agreed Order No. DE 2016)[1] for the Little Squalicum Park (Park) site, a separate and distinct area of contamination from an old municipal landfill was discovered in the Park. In the mid- to late-1930s, the City had used a portion of the Park as a "sanitary landfill" for burning and burying local municipal waste hauled by a garbage collection contractor. The landfill was operated for only a few years before operations ceased. The landfill area is located on property owned by Whatcom County (Parcel Number: 38022347 32190000), which is currently leased by the City for management of the Park. The remains of the landfill are located west of the Bellingham Technical College (BTC) campus (Figure 1).

The initial boundaries of the landfill were delineated in January 2006 as part of the draft Park RI, through the excavation of reconnaissance test pits in which evidence of municipal garbage was found within various fill materials. The types of municipal garbage observed consisted of glass bottles, metal scraps, ash, ceramics, construction debris, and various indiscernible rusted materials.

[1] The Agreed Order for the Little Squalicum Park site is no longer in effect. The City and Ecology agreed to terminate the original Little Squalicum Park Agreed Order in October 2010. Oversight of most of the non-landfill Little Squalicum Park site was transferred to the United States Environmental Protection Agency (EPA) to become the Little Squalicum Creek Removal Action site.

Upon completion of the draft Park RI in December 2008, the area of the historical landfill was estimated to be approximately 7,100 ft^2. The draft Park RI documented the presence of low levels of polycyclic aromatic hydrocarbons (PAHs), benzoic acid, phthalates, and pentachlorophenol in surface soil samples collected in the landfill area, as well as elevated concentrations of some heavy metals (e.g., lead). Higher levels of metals were detected in subsurface soils.

In November 2009, Ecology listed the landfill area as a separate site (facility site identification number 16195) and named both the City and County as potentially liable persons (PLPs). Soon after, the City and Ecology began negotiating an Agreed Order for completing an RI/FS report and draft cleanup action plan (DCAP) for the Site.

In September 2010, EPA uncovered additional landfill material during excavations in support of the cleanup at the Little Squalicum Creek site (Figure 2). In order to allow the EPA work to continue, the City undertook an independent action to investigate, analyze, relocate and secure most of the contaminated soil in this portion of the landfill.

The contaminated soil that was left in-place was addressed, along with the relocated material, as part of the landfill cleanup. The estimated area of the historical landfill was revised to be approximately 19,000 ft^2 (Figure 2).

The Agreed Order (No. DE 8073) requiring the City to complete an RI/FS report and DCAP for the Site was signed by the City and Ecology on November 19, 2010.

A draft RI/FS report was completed for the Site in February 2011 (Herrenkohl Consulting and Integral Consulting 2011a). After review by Ecology and further discussion between parties, the City agreed to conduct an interim action for the Site in summer 2011.

An amendment to the Agreed Order was negotiated and signed by the City and Ecology on July 18, 2011. The scope of the interim action was described in an interim action work plan (Exhibit B of the Amended Agreed Order) (Herrenkohl Consulting and Integral Consulting 2011b).

The City completed an engineering design report (EDR) on June 24, 2011 for implementing the interim action (Herrenkohl Consulting and Wilson Engineering 2011a). The EDR includes engineering design plans and specifications for the interim action, and ancillary documents (e.g., monitoring plan, wetland restoration plan).

The City advertised the interim action on June 30, 2011. Contractor bids were opened on July 14 with Glacier Environmental Services Inc. (Glacier Environmental) located in Mukilteo, Washington selected as the lowest responsible and responsive bidder.

Remedial activities were conducted from August 22 to October 7, 2011 and included the excavation of about 4,290 tons of landfill debris and contaminated soil from the Site and disposal at a Subtitle D landfill located in Roosevelt, Washington. The excavation was stabilized, backfilled with clean soil, and vegetated by hydroseeding. In addition, a 750 ft^2 depressional wetland was created within the project area.

The cleanup of landfill debris and contaminated soil on the Site was confirmed by the collection and testing of soils as described in the performance monitoring and contingency plan (Herrenkohl Consulting and Wilson Engineering 2011a). Based on the testing results and performance evaluation, soils containing pentachlorophenol and metals above the RLs were removed from the Site except for locations on steep, unstable slopes and within or adjacent to an existing wetland. The interim action construction activities and performance monitoring was summarized in a construction completion report in December 2011 (Herrenkohl Consulting and Wilson Engineering 2011b).

Also in 2011, EPA completed the removal action of the Little Squalicum Creek site adjacent to the landfill Site (CH2M Hill 2012).

In April 2012, the City completed a sampling and analysis plan for conducting additional soil and groundwater characterization at the landfill Site to determine the effectiveness of the interim action (Herrenkohl Consulting 2012). The additional Site characterization was completed in May 2012.

1.2 REGULATORY FRAMEWORK

The RI/FSF for the Eldridge landfill was conducted under MTCA (WAC 173-340), which addresses identification and cleanup of contamination in soils, surface water, and groundwater. For contamination in sediments, MTCA refers to the Sediment Management Standards (SMS) (WAC 173-204), which includes standards for marine sediments. Since standards for freshwater sediment are "Reserved" under WAC 173-204-340, the City coordinated with Ecology to clarify site-specific requirements.

Additional regulations representing applicable or relevant and appropriate requirements (ARARs) include the following:

- Federal Clean Water Act and National Toxics Rule [40 Code of Federal Regulations (CFR) 131], which provide water quality criteria (WQC) for protection of human health and aquatic organisms.

- Water Quality Standards for Surface Water of the State of Washington (WAC 173-201A), which also provides WQC for protection of aquatic organisms.[2]

- Ecology's (2003) Freshwater Sediment Quality Values (SQVs), which cover contamination of freshwater sediments. The SQVs are currently guidelines and do not replace bioassays as the definitive determination of sediment toxicity.

- Federal Safe Drinking Water Act (40 CFR 141), which provides maximum contaminant levels (MCLs) for protection of drinking water.

[2] The SMS are also federally approved water quality standards.

- Washington State Department of Health Rules for Public Water Supplies (WAC 246-290-310), which also provides MCLs.
- Endangered Species Act (16 USC 1531 et seq.; 50 CFR Part 200; 50 CFR Part 402) because listed species are documented in Bellingham Bay (e.g., Bull Trout, Puget Sound Chinook).

Additional ARARs that may apply to the site because of its location or the nature of remedial actions are discussed and referenced in Section 7 (Interim Action) and the feasibility study.

1.3 DOCUMENT ORGANIZATION

This RI/FS report was developed using information presented in the draft Park RI report (Integral 2008) along with recent sampling and testing information in support of the EPA remedial action at the Little Squalicum Creek site (CH2M Hill 2012). Information gathered during and after completion of the 2011 interim action (Herrenkohl Consulting and Wilson Engineering 2011b) is summarized in later sections of the report (Sections 7 and 8).

The purpose of the RI/FS is to provide critical data necessary to understand the nature and extent of any environmental problems at the Site, to assess potential risk to human health and the environment, to determine if cleanup actions are required, and to identify a preferred cleanup alternative. The remaining sections and appendices of this remedial investigation include the following:

Section 2: Site Background and Current Conditions – summarizes the site history and current conditions at the Site.

Section 3: Environmental Setting – describes the physical and ecological setting of the landfill Site and surrounding areas including site geology, hydrogeology, topography, flora and fauna, and cultural resources.

Section 4: Screening Levels and Indicator Hazardous Substances – develops screening levels and identifies indicator hazardous substances (IHSs) for human and ecological exposure pathways and receptors consistent with MTCA requirements.

Section 5: Nature and Extent of Contamination – presents the results of chemical and geotechnical tests performed on samples collected and evaluated for the RI.

Section 6: Fate and Transport Processes – describes and synthesizes available information on sources, transport pathways, potential receptor populations, and potential exposure pathways for IHSs in soils at the Site.

Section 7: Interim Action – includes a summary of the interim action including construction activities and wetland restoration, and compliance monitoring

Section 8: Protection of Human Health and the Environment – evaluates the compliance monitoring results from the interim action to determine whether post-interim action conditions at the Site are protective of human health and the environment.

Section 9: Minimum Requirements for Cleanup Action – evaluates whether the interim action meets the minimum requirements for an overall cleanup action for the Site under MTCA.

Section 10: Summary and Conclusions – summarizes the results of the pre- and post- interim action cleanup with conclusions for the project work.

Section 11: References – lists documents cited in the RI/FS report.

Figures and appendices are presented at the end of the report.

2 SITE BACKGROUND AND CURRENT CONDITIONS[3]

This section describes background information relevant to the cleanup of the Site including a summary of previous site activities and current site conditions before the City's interim action for the landfill Site completed in 2011. It also provides information on other potential contamination sources and cleanup projects adjacent to or near the landfill Site.

2.1 SITE HISTORY

Site historical information was obtained from the Oeser Company RI/FS report (E&E 2002a,b and references therein), the draft Park RI report (Integral 2008), aerial photographs (Mack 1998), and personal communication with City and Whatcom County personnel. Supplemental aerial photographs were obtained from the Whatcom Museum of History and Art (dated 1955, 1963) and City personnel (dated late 1930s, 1961, and 1975) and used to evaluate the Site.

Historically, a construction material landfill operated beneath what is now a portion of the BTC parking lot for an unknown time period. A debris field was documented in the southeast corner of the Park near BTC (E&E 2002a). Based on this earlier information, sampling was conducted in this section of the Park in support of the draft Park RI. A layer of debris containing metals, ash, and garbage was observed between approximately 1 and 4 ft below ground surface (bgs) (Integral 2008). This waste material was believed to be the remains of a 1930s municipal landfill and not part of the construction material landfill[4].

City records indicate that in 1936 the Marietta Township litigated against the City, the City Sanitary Service, and the Razore family (operator of the landfill) over the effect of a municipal landfill, located in the vicinity of the Park, on nearby residential areas and potable spring water (No. 23970; filed June 20, 1936, in the Superior Court in the State of Washington). According to court documents, the landfill material consisted of garbage and tin cans and was operating when the case was litigated in 1936. According to the Findings of Fact and Conclusions of Law (filed August 1, 1936 in the Superior Court in the State of Washington), the garbage in the landfill was to be covered immediately with approximately 2 ft of earth, leaving an exposed end of the landfill not to exceed 25 ft in length and 6 or 7 ft in width.

An article in the Bellingham Herald, dated July 21, 1936, reported that during the proceedings of the lawsuit, landfill owner Jose Razore testified that roughly 25 to 30 cubic yards (cy) of municipal garbage were dumped daily by the company. It is unclear when the landfill closed. It is estimated that it was open for only a few years in the mid- to late 1930's.

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[3] Information on site history and current site conditions includes excerpts from E&E (2002a) and Integral (2008) and is representative of site conditions before EPA's removal action of Little Squalicum Creek and the interim action for the landfill Site completed in 2011.
[4] Based on historical aerial photographs, the construction material landfill is likely located under the BTC parking lot.

From about 1961 until the late 1960s, sand and gravel were extensively mined in the Park including areas near the landfill Site (Integral 2008). In some places within the Park ravine over 20 ft of native soils were mined for sand and gravel. Some of the ditches that were excavated to facilitate drainage remain in place today. Much of the Little Squalicum Creek's original course was diverted into these ditches. The entire ravine was altered substantially from natural conditions with rerouting of the original creek bed and significant changes to the soils and lithology (e.g., backfilling of gravel pit and wash pond excavations, temporary road maintenance, and rail bed and track placement). Temporary basins were dug for gravel washing and reportedly filled with groundwater, both seasonally and, in some cases, year-round. After mining, the land was leased to Mt. Baker Plywood for raw log storage during the early 1970s. Logs were transported by trucks to and from the ravine via the beach.

In 1976, the Whatcom County Park Board acquired 13 acres from the Eiford family, including the majority of the ravine and the 1930s landfill Site. About 0.7 acre was sold to BTC by the County, partly in exchange for trail easements through the BTC campus.

In 1977, the City constructed an underground stormwater pipeline through the upper part of the Park ravine, adjacent to the landfill Site. Stormwater from approximately 3 square miles of the Birchwood neighborhood, including the BTC parking lot, is conveyed through the 36-in. underground pipeline and discharged into the Creek. Since 2002, stormwater from the BTC parking lot is directed through a filtering system (reportedly composted leaf media) before discharging into the Creek. Although water is diverted directly into the Birchwood neighborhood stormwater pipeline during larger rainstorms (greater than 6-month storm), most BTC runoff (approximately 90 percent) is treated before discharging to the Creek (Hunter 2004, pers. comm.).

The City owns 8.7 acres of the Park and leases 12.3 acres of County-owned property, including land occupied by the landfill Site. Currently, a lease agreement between the City Parks and Recreation Department and Whatcom County Parks Department stipulates that the City will manage and operate the area as a park site for 35 years (to about 2025), with a renewal provision for another 35 years.

Additional information on the history and land ownership of Little Squalicum Park is presented in the draft Park RI (Integral 2008).

2.2 UTILITIES, ROADS AND INFRASTRUCTURE

As mentioned above, the City constructed an underground stormwater pipeline adjacent to the landfill Site which conveys stormwater from the Birchwood neighborhood and BTC parking lot. The 36-in. underground pipeline is buried approximately two feet below a gravel access road entering the Park from BTC before discharging into the creek. In 2010, the pipeline was re-routed as part of the EPA Removal Action for Little Squalicum Creek (discussed further in Sections 5 and 7). This is the only known utility located near the landfill Site.

2.3 OTHER POTENTIAL CONTAMINATION SOURCES

There were two cleanup sites under investigation near the landfill Site including the Oeser Company Superfund Site which includes the Little Squalicum Creek Removal Action, and the West Illinois/Timpson Way Street Extension project. A description of each is provided below.

2.3.1 Oeser Company Superfund Site and Little Squalicum Creek Removal Action

The Oeser Superfund site, located north of the landfill Site (Figure 1), is a wood-treatment facility that historically used treating solutions of creosote and pentachlorophenol to preserve utility poles and pilings. The facility currently uses pentachlorophenol in its treatment of wood products. A portion of the Park, located to the west of the landfill Site, was remediated by the Oeser Company under an Agreed Order of Consent with EPA. The remediation of soils and sediments was required due to impacts from Oeser-related historical stormwater and wastewater discharges to the Park.

The EPA Removal Action was completed on September 14, 2011 and included three phases of work (CH2M Hill 2012). Approximately 28,000 tons of creosote- and pentachlorophenol-contaminated soil and sediments was removed from the creek-area and transported to a repository area at the Oeser facility for disposal. The excavated areas were backfilled with clean materials and revegetated. The construction also included re-routing of both the Oeser/Birchwood and Birchwood/BTC storm drains, and re-locating a portion of the historical stream channel and restoring the streamside wetlands.

Although EPA determined the Removal Action was performed in a manner protective of human health and the environment, Oeser-related contamination remains in subsurface soils (>6 ft) and along steep slopes within portions of the Park, but located downgradient of the landfill Site. The location of the known existing Oeser-related contamination is not likely to be a source of contamination to the landfill Site.

2.3.2 West Illinois/Timpson Way Street Extension Project

The City Public Works Department collaborated with the Whatcom County Public Works Department, BTC, and Morse Distribution on the engineering, design, and construction of a new road located directly between Oeser and the Park, connecting West Illinois Street with Marine Drive (Herrenkohl Consulting and Wilson Engineering 2010). The road extension project was located north of the Park and landfill Site (Figure 1). Cleanup activities included the removal of approximately 5,300 tons of arsenic-impacted soil and miscellaneous fill materials from the road extension area and disposal at a Subtitle D landfill located in Roosevelt, Washington. Remedial activities were conducted from approximately May to July 2010.

Soils and potentially groundwater at the road extension site were impacted by contaminates historically released from railroad and wood-treatment activities, including arsenic associated with railroad activities and petroleum hydrocarbons (i.e., creosote and diesel) and pentachlorophenol from Oeser stormwater and wastewater discharges. The source(s) of arsenic was unclear but it was likely associated with either the bedding used to construct the railroad grade or activities by the railroad during its nearly 100 year history along this spur. Oeser-related contaminants appeared to be limited to subsurface soils and groundwater at the southern boundary of the road-extension site, associated with historical discharges through the Oeser/Birchwood stormwater culvert, before discharging into the Park.

The effectiveness of the cleanup activities completed for the road extension project was assessed by implementation of a Compliance Monitoring Plan (Herrenkohl Consulting 2009). The highest arsenic concentration detected in compliance soil samples was 146 mg/kg. Based on the testing results and compliance evaluation, soils containing arsenic above the cleanup level of 20 mg/kg had been removed from the Property. The road extension project is located upgradient of the landfill Site and could be a source of arsenic contamination to Site soil and groundwater.

3 ENVIRONMENTAL SETTING

This section describes the physical and ecological characteristics of the Site and surrounding Park areas including topography, surface water hydrology, geology, and hydrogeology, before the completion of EPA's removal action of Little Squalicum Creek and the interim action for the landfill Site. These site features are important in the context of the nature and extent of contamination as well as the fate and transport of contaminants discussed in later sections of the report.

3.1 TOPOGRAPHY OF SITE AND SURROUNDING AREA

The Site and most of the Park are located within a ravine, with the top of the ravine at about 65 ft North American Vertical Datum 1988 (NAVD 88) and the bottom ranging from 20 to 30 ft NAVD 88. The ravine extends west-northwest for about 550 ft, and then turns to the southwest for about 700 ft, runs south-southwest for about 950 ft beneath the Marine Drive Bridge, and ends at Squalicum Beach on Bellingham Bay (E&E 2002a) (Figures 1 and 2).

The ravine is bounded on the south and east by Bellingham Bay, multiple-residential, single-residential, and public developed lands (BTC). The head of the ravine is bounded on the north by an undeveloped light impact industrial area and West Illinois Street. The area northwest of the ravine to the Marine Drive Bridge is mostly undeveloped, but zoned as light impact industrial. The area south and west of the bridge is a developed urban residential zone (E&E 2002a). A broad relatively flat area extends within the ravine, which was the location of a series of former gravel mining operations.

In the middle of the landfill Site there was a man-made ditch which transported surface water to two depressional Category 3 wetland features (refer to Figure 2). A delineation of the wetlands was completed by Herrenkohl Consulting (2011) which determined the wetlands covered approximately 960 ft^2 (Wetland A) and 750 ft^2 (Wetland B). During the wet season, the ditch and wetlands contained some ponded water but there was no surface runoff to Little Squalicum Creek or other water bodies' offsite.

3.2 SITE SOILS AND GEOLOGY

Surface soils and land surface hydrogeologic units are comprised of coarse-grained (sand/gravel) Vashon recessional (Qvrg) deposits. Landfill refuse and other debris are buried within a sand and gravel seam that is ~10-15 ft. thick based on soil boring logs in other portions of the Park (Integral 2008). This gravel seam is underlain by a relatively thin silty-clay layer (1-2 ft. thick) and a lower sand unit.

A total of 31 test pits [including reconnaissance test pits (RTPs)] were excavated at the landfill Site at depths ranging from 2 to 6.5 ft bgs using a mini track-excavator as part of the draft Park

RI field program (see Figure 2). Information on the test pit reconnaissance survey and test pit soil logs are presented in Appendix A. A photographic log is also presented in Appendix A.

One to two feet of fill materials composed of silty sands and gravels cover much of the landfill debris observed at the Site. The landfill debris layer ranges in thickness from < 0.5 ft to 4 ft and lies above a native silty sandy gravel [Unified Soil Classification System (USCS) GM/GW]. Organic silt was observed below the landfill debris in a few of the RTP locations (RTP-23, -24, -25). Soils in test pits excavated outside the limits of the landfill (TP-03 and TP-24) were described as 1.5 to 2 ft of silt/clay (USCS ML/CL) over native silty sands and gravels (USCS GM/GW).

3.3 GROUNDWATER OCCURRENCE AND DEPTH

In January 2006, groundwater was generally present from approximately 2 to 4 ft bgs at the Site (Appendix A). Surface water ponding was observed in a few areas between the northern boundary of the landfill and station TP-03 where there is a slight depression in the topography (Figure 2). Groundwater was not observed in test pits excavated in early November 2005 suggesting groundwater fluctuates seasonally at the Site.

Additional information on groundwater occurrence and flow velocity in other areas of the Park is presented in the draft Park RI (Integral 2008). Based on information from other areas in the Park, groundwater observed at the Site is likely present to a depth of about 10 ft bgs, separated from deeper groundwater zones by a silty clay layer. The silty clay layer was observed in many soil borings and groundwater monitoring wells located in the western portion of the Park ravine.

3.4 FLORA AND FAUNA

The Park is an undeveloped tract of land bordered by Bellingham Bay, industrial sites (including the Oeser facility), BTC, municipal roads, and abandoned and active railroad tracks. The Park is managed by the City for recreational use and contains upland, lotic, palustrine, and intertidal habitats. Lotic refers to flowing freshwater systems such as rivers and streams. Palustrine refers to non-tidal wetlands dominated by trees, shrubs, persistent emergent macrophytes, emergent mosses, or lichens. The landfill Site is described as mostly upland with seasonal palustrine wetland (Herrenkohl Consulting 2011, E&E 2010, Northwest Ecological Services 2009). While these habitats vary in characteristics such as water regimes and soils, they support similar potential ecological receptors (Integral 2008).

The upland habitat is vegetated with grasses, forbs, horsetails, blackberry and snowberry brush, and dogwood, hawthorn, alder, cherry, and apple trees. Wildlife observed onsite during previously site visits and fieldwork include American robins, barred owls, Cooper’s hawks, red-winged blackbirds, swallows, cottontail rabbits, crows, gulls, grey squirrels, raccoons, and black-tail deer. The moist, organic soils within the palustrine wetland areas of the Site support several invertebrate species, including arthropods such as insects, spiders, millipedes, earthworms, and other soil invertebrates.

No species listed by the state or federal Endangered Species Act (ESA) as endangered, threatened, or candidate species of concern (e.g., bald eagle) were observed in the Park (Integral 2008). The potential presence of other species cannot be ruled out.

3.5 CULTURAL RESOURCES

Archaeological site survey activities within the ravine of the Park indicate that it is a highly disturbed area (Wessen & Associates 2005). Historic gravel mining and other industrial activities have removed much of the Holocene soil and altered the original form and character of the ravine. This portion of the Park ravine has been extensively disturbed, and archaeologists believe that the remaining deposits in these areas have virtually no prospect of containing significant archaeological resources (Wessen & Associates 2005).

The Site and the Park are currently used for recreational activities such as walking, bicycling, play, and birding. The Site provides open space, wildlife habitat, and stormwater conveyance services that are important elements of the City's and County's area parks and public works infrastructure. Since the 1980s, development plans by the County and City have called for enhancing the recreational activities in the Park (including the land occupied by the Eldridge landfill) by constructing trails, water features, and park amenities, and by realigning and day-lighting Creek and stormwater flows within the Park. In 2010, the City completed a Master Plan for the Park establishing a program for park activities, site restoration and resource protection, and including a framework for immediate and long-range facility and site improvements as well as park operations and management (Belt Collins 2010). Many of these improvements, including rerouting the creek, have been incorporated into the EPA cleanup of Oeser-related contamination in soils and sediments at the Park (USEPA 2010a)[5].

[5] The EPA/Oeser Little Squalicum Creek removal action was completed in fall 2011.

4 SCREENING LEVELS AND INDICATOR HAZARDOUS SUBSTANCES

Screening levels were developed and IHSs were identified for human and ecological exposure pathways and receptors consistent with MTCA requirements, based on Site conditions before the completion of EPA's removal action of Little Squalicum Creek and the interim action for the landfill Site. A description of the possible exposure pathways and receptors for the Site are presented in Section 4.1. The development of screening levels, including an evaluation of background concentrations, is provided in Section 4.2. The identification of IHSs for human health and ecological receptors is provided in Section 4.3.

4.1 EXPOSURE PATHWAYS AND RECEPTORS

Receptors that could be exposed to chemicals present at the Site include humans visiting the Park in the vicinity of the landfill, plants growing on the landfill, and a variety of terrestrial animal species living on or near the landfill. Media and potential routes of exposure include direct contact with soil; uptake from soil by plant roots; and consumption of berries, other vegetation, or prey (e.g., worms or small mammals). With the exception of plants, exposures to groundwater below the Site do not occur at present. Because portions of the landfill or land in proximity to the landfill may be considered seasonal Category III/IV depressional wetlands (Herrenkohl Consulting 2011, E&E 2010), the root depth of some plant species may contact groundwater during wet portions of the year. In the future, exposures to groundwater could occur through direct contact or ingestion. However, metals in the landfill showed only a weak tendency to leach (Section 5.2.2) and human use of groundwater is unlikely (as discussed below). At present and in the future, exposures to surface water could occur through direct contact or ingestion. However, metals in the landfill showed only a weak tendency to leach and contaminants in subsurface soil are not available to overland runoff.

Inhalation exposures are not expected to be significant at this site because volatile organic compounds (VOCs) have been detected rarely and at low concentrations throughout the Park and because windblown dust transport is expected to be insignificant. The area is heavily vegetated and is located in a ravine.

4.1.1 Human Exposures

Potential human receptors are expected to be people visiting the Site, which could include the following (Figure 3):

- Recreational Park users, some of whom may be residents near the Park or workers at BTC, Oeser, or other work sites nearby
- Maintenance personnel working in the Park
- Transients living in the Park.

Hunting is not allowed in the Park, so exposures associated with hunting are not included in Figure 3.

Children using the Park constitute a group of special concern because they tend to have higher exposures on a body-weight basis than do adults, particularly for direct contact with soil. Direct contact includes soil contact with skin, with the possibility of chemicals crossing the skin to enter the bloodstream, and incidental or intentional ingestion of soil on the hands. Children usually experience the same exposure pathways as adults but with higher rates of exposure. MTCA Method B soil CULs are designed to reflect a child receptor in a residential setting, where the frequency of exposure is expected to be higher than in a park setting.

Maintenance workers, park users, and transients could be exposed to contaminants in surface soil by direct contact (unintentional ingestion and absorption across the skin). Park users, maintenance workers, and transients could be exposed to contaminants by ingesting local plants (e.g., berries) that have taken up chemicals from the soil.

If park development or maintenance activities uncovered subsurface soil at the Site, maintenance workers, park users, and transients could be exposed to the subsurface soil through direct contact. Exposures to subsurface soil are expected to be infrequent because little digging was expected to occur in the landfill, except for remedial activities.

Ecology considers most groundwater to be potable and protects groundwater for potential future uses. Human ingestion of groundwater is not possible as there were no drinking water wells within the landfill or the Park itself. It appears unlikely that drinking water wells will be completed in the future because land use will likely remain recreational (as a park). The most likely future use of groundwater in the Park is for irrigation of public land. People using irrigated land could be exposed through incidental dermal contact with water, via consumption of irrigated plants, or through contact with soils receiving irrigation.

If Site contaminants reached surface water, either via overland runoff or via groundwater discharge, Park users, maintenance workers, and transients could be exposed through direct contact (dermal contact and incidental ingestion). Transients could also be exposed through intentional ingestion. Site contaminants are not expected to reach surface water, however, because the metals were not found to leach readily to groundwater (see Section 5.2.2) and because the highest concentrations of Site contaminants are found in subsurface soil where they are not available to overland runoff.

If groundwater contaminants reach Bellingham Bay, humans could be exposed directly through contact with water and sediments while collecting shellfish or wading recreationally or indirectly through ingestion of shellfish caught locally.

4.1.2 Ecological Exposures

Potential ecological receptors include the following (see Figure 3):

- Terrestrial and wetland plants (e.g., trees, grasses)
- Soil-dwelling invertebrates (e.g., worms)
- Terrestrial animals, including birds, mammals, and domesticated animals (e.g., dogs)
- Semi-aquatic birds and mammals (e.g., ducks, raccoons).

Terrestrial animals (birds, mammals, and domestic animals) could be exposed to contaminants in surface soil by direct contact (unintentional ingestion and absorption across the skin) with the soil. Terrestrial plants could take up contaminants from surface and shallow subsurface soils. Terrestrial animals could consume contaminated plants or soil-dwelling invertebrates while foraging for food on the Site. The standard depth to which plants and animals are expected to be exposed to soil contaminants is 6 ft [WAC 173-340-7490(4)(a)], though the depth at this Site could be different based on the species present. Exposures to deeper soils are expected to be minor for plants and negligible for vertebrate and invertebrate animals.

Plants may be exposed directly to groundwater, because groundwater has been observed within the active zone (typically 6 ft) during the wet season of the year. Animals are not likely to be successful at constructing burrows when the soils are saturated seasonally, so animals are not likely to contact groundwater.

4.2 SCREENING LEVELS

A statistical comparison of site concentrations with background concentrations was conducted for the draft Park RI (Integral 2008); the results of this evaluation are summarized below (Section 4.2.1). Screening levels addressing human health and terrestrial ecological receptors were developed for metals exceeding background concentrations and other chemicals analyzed in the landfill (Section 4.2.2).

4.2.1 Metals Concentrations Compared to Background

Nine metals were analyzed in soils at the landfill Site (arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc); these metals and additional metals were also analyzed in soils from other areas of the Park (Integral 2008). In the draft Park RI, metals concentrations detected in landfill soils were evaluated to determine if they were elevated above natural or site background concentrations and, therefore, should be considered further in the human health and ecological risk evaluations. Natural background is defined as the concentration of a substance present in the environment that has not been influenced by localized human activities (WAC 173-340-200). In this discussion, the term “natural background” refers to soil metals concentrations identified by Ecology (1994) for 12 metals as natural background concentrations in the Puget Sound region. The term “site background,” which is not a term defined by MTCA, refers to soil samples that were collected during RIs for the Park and Oeser sites in areas that were believed not to be impacted by either site or by any known metals sources. Calcium, potassium, and sodium were excluded from the background evaluation and from risk evaluations because they are trace nutrients not typically associated with human or ecological toxicity.

Based on the statistical comparisons (Integral 2008), the concentrations of chromium, nickel, and silver were found to be consistent with background concentrations; and therefore, these metals were eliminated from further evaluation of the landfill Site. However, the following metals were retained for further consideration in the development of screening levels for the landfill Site: arsenic, cadmium, copper, lead, mercury, and zinc.

4.2.2 Development of Screening Levels

Human Health

Human health screening levels were developed consistent with MTCA requirements (WAC 173-340-740) and are shown in Table B-1 (Appendix B). The screening levels developed for the draft Park RI (Integral 2008) were used without modification, with the exception of arsenic discussed below. The screening levels address direct human contact with soil and protection of groundwater through leaching. MTCA Method B soil screening levels for direct contact were obtained from Ecology's on-line database cleanup levels and risk calculations (CLARC[6]) in July 2007. For chemicals with values for both cancer effects and non-cancer effects, the minimum of the two values was used. If no value was available in CLARC, the USEPA (2004a) Region 9 preliminary remediation goal (PRG)[7] for residential soil was used.

The screening levels for leaching were obtained from Region 9 PRGs, considering a dilution attenuation factor (DAF) of 1, because soils in portions of the landfill are expected to be in contact with groundwater for a portion of the year and because soils at all depths could become saturated during the rainy season. The DAF represents the amount of dilution assumed to occur during the leaching process. Soil pore water in the unsaturated zone will be diluted when it reaches the aquifer, whereas no such dilution occurs when soils are in direct contact with water.

The final human health screening level was the minimum of either the screening level for direct human contact or the screening level for leaching to groundwater. The screening levels for lead, gasoline range hydrocarbons, diesel range hydrocarbons, and motor oil were Method A values (MTCA Table 720-1). If no screening level was available from any of the above sources for a detected analyte, the screening level for a surrogate chemical was used, if it was possible to identify a suitable surrogate, as so noted in Table B-1 (Appendix B).

The screening level for arsenic obtained from the CLARC database was 0.67 mg/kg, based on cancer effects. An evaluation of site background data collected for arsenic indicates that natural background levels in the vicinity of the Site are higher than 0.67 mg/kg. The site background data set contains two samples collected from subsurface soils (9.5-16 ft bgs) in MW-06D located north of the Oeser site and 20 surface samples (0-0.5 ft bgs) collected in the Columbia neighborhood, a residential neighborhood near the Site. These locations are not expected to be impacted by releases from the Oeser facility, the landfill Site, or any known sources of

[6] https://fortress.wa.gov/ecy/clarc/CLARCHome.aspx.
[7] http://www.epa.gov/region09/waste/sfund/prg/index.html. These values have since been superseded by USEPA's regional PRGs available at: http://www.epa.gov/reg3hwmd/risk/human/index.htm. The two sets of PRGs are similar.

metals. The results for the two subsurface samples (4.97 and 4.65 mg/kg) are slightly lower than the mean of the surface samples (5.34 mg/kg), but within the range of the surface samples (3.05-9.09 mg/kg) so they were included in the background data set. A value of 10 mg/kg was calculated for the true 90th percentile of the background data set (WAC 173-340-708(3)(c)) as the one-sided 95 percent upper tolerance limit with 90 percent coverage (95%/90% UTL), using the method described by Howe (1969) and consistent with EPA's ProUCL program (Singh and Singh 2007). The site-specific background value of 10 mg/kg was used to screen arsenic in soils.

Ecological Receptors

Minimum ecological indicator concentrations (EICs) were collated from MTCA Table 749-3 and are summarized in Table B-3 (Appendix B).

4.3 INDICATOR HAZARDOUS SUBSTANCES AND TERRESTRIAL ECOLOGICAL EVALUATION

Because of differences in screening levels, IHSs were selected separately for human health (Section 4.3.1) and ecological receptors (Section 4.3.2). The final, combined list of IHSs is summarized in Section 4.3.3.

4.3.1 Human Health

Data screening to select IHSs for human health was conducted in a two-step process. The first step, selection of preliminary IHSs, was conducted in preparation of the draft Park RI (Integral 2008) and is summarized below. The second step, selection of final IHSs for the landfill Site, is shown in this document.

Preliminary IHSs for Human Health

In the first step, preliminary IHSs were selected for the Park on a site-wide basis using a broad screening approach that considered the following issues (WAC 173-340-703) (Integral 2008):

- toxicological characteristics;
- status as an essential element;
- persistence;
- mobility;
- thoroughness of testing;
- frequency of detection;
- presence of a known source in the vicinity of the site (as discussed in Section 6 and in the Park RI report); and
- degradation byproducts of, or other chemicals associated with, the key constituents.

Toxicological characteristics were considered in the form of risk-based screening levels, discussed above in Section 4.2. The essential elements calcium, magnesium, potassium, and sodium were not analyzed in the landfill Site. The final IHSs selected for the landfill are persistent chemicals associated with landfilling activities and other known historical practices in the vicinity of the landfill. Frequency of detection and thoroughness of testing were evaluated in combination, as discussed below.

The maximum concentration of each analyte detected anywhere in the Park was compared with the screening level. If the maximum site concentration exceeded the screening level, the analyte was retained as a preliminary IHS and was considered further in the second step. Otherwise it was eliminated from further consideration. Details of the first screening step are provided in Appendix F of the draft Park RI (Integral 2008) and the resulting preliminary IHSs are summarized in Table B-2 (Appendix B).

Final IHSs for Human Health

In the second step, the preliminary IHSs selected for the Park (Table B-2) were screened separately for surface and subsurface soils in the landfill. Not all of the preliminary IHSs selected for the Park were detected in the landfill, but all of them were evaluated in the second step. For nondetected analytes, maximum detection limits were compared to screening levels. For detected analytes, a data set was constructed for each preliminary IHS and was evaluated to determine the size of the data set and the shape of the distribution. Upper one-sided 95 percent confidence limits on the means (95UCLs) were calculated for data sets with at least 11 samples and were used for the second screening step. When the 95UCL exceeded the maximum detected value in the data set, or when the data set had fewer than 11 samples, the maximum value was used for the second screening step.

To calculate 95UCLs, distributions were tested for normality and lognormality using the Shapiro Wilkes test. If a sample set had a lognormal distribution, the 95UCL was the H-statistic using Land's method. If not, and the distribution was normal, the 95UCL was calculated using Student's *t* statistic. If the distribution fit neither a normal nor a lognormal distribution, the 95UCL was chosen based on the recommendation indicated in EPA's statistical software, ProUCL.

Preliminary IHSs were evaluated considering the three-part statistical rule. If the data set met all of the following criteria, the preliminary IHS was eliminated from further consideration [WAC 173-340-740(7)(d)(i), -(e)(i), and –(e)(ii)]:

- The 95UCL was less than the soil screening level
- No single sample concentration was greater than two times the soil screening level
- Fewer than 10 percent of the sample concentrations exceeded the soil screening level.

If the data set failed any one of the above criteria, the preliminary IHS was retained as a final IHS. Details of the second step of the screening process are provided in Table B-4. The results are summarized in Table B-6.

The data set used to calculate the frequency with which the screening level was exceeded (third bullet above) included both detected and nondetected results. In the case of arsenic, one of the results causing the 10 percent criterion to be exceeded was a nondetected result. Including nondetected results in the calculation of frequency of exceedance is a conservative approach to screening that includes consideration of the adequacy of detection limits.

Several analytes were not screened for human health IHSs. Conventional parameters [e.g., alkalinity and total organic carbon (TOC)] were not screened because screening levels are not available and these parameters are not usually associated with human toxicity. Individual carcinogenic PAHs were not screened because they are included in the benzo(a)pyrene equivalent (BaPE) summation. The BaPE for a sample was calculated by applying toxicity equivalency factors (TEFs) to seven carcinogenic PAHs and summing the adjusted values. The TEF represents the toxicity of a carcinogenic PAH in relation to benzo(a)pyrene. The BaPE represents the toxicity of a carcinogenic PAH mixture as if all of the carcinogenic PAHs were present in the form of benzo(s)pyrene.

The final IHSs for human health are arsenic, cadmium, lead, zinc, and pentachlorophenol (Table B-6). There is no evidence that pentachlorophenol was ever used at the Eldridge landfill site and the one low detection of pentachlorophenol in area surface soils is thought to be the result of dumping or some other unknown source within this area of the Park. The metals are consistent with landfill activities and urban runoff from neighboring residential areas and roads.

4.3.2 Ecological Receptors

IHSs for ecological receptors were selected in a two-step fashion consistent with the approach used for human health. The first step, selection of preliminary IHSs, was conducted in preparation of the draft Park RI (Integral 2008) and is summarized below. The second step, selection of final IHSs for the landfill Site, is shown in this document.

Preliminary IHSs for Ecological Receptors

In the first step, maximum detected values in soil data for the entire Park were screened against minimum available EICs (Table B-3) to develop a list of preliminary IHSs for ecological receptors. Soil data for some areas of the Park (e.g., historical creek) were screened against both soil and sediment EICs because of the planned re-routing Little Squalicum Creek. In the landfill, however, soil data were screened only against soil EICs because Park plans did not include re-routing of the creek into the landfill (Belt Collins 2010). Chemicals with maximum detected values exceeding soil EICs were designated preliminary IHSs (Table B-2). Details of the first screening step are provided in Appendix G of the draft Park RI (Integral 2008).

Final IHS's for Ecological Receptors

In the second step, the preliminary IHSs selected for the Park (Table B-2) were screened for surface soils in the landfill. 95UCLs were calculated as described above for human health (Section 4.3.1) and were used in the final screen if they were less than the maximum value and when there were 11 or more values available for comparison. If the 95UCL exceeded the maximum concentration, or if there were fewer than 11 values in the data set, the maximum value was used for screening in the second step. Details of the second step of the screening process are shown in Table B-5 (Appendix B). Copper, lead, mercury, and zinc were selected as final IHSs for ecological receptors (Table B-6). These metals are consistent with the historical landfill activities.

4.3.3 Final Site IHSs

The following 7 chemicals were selected as final IHSs for the landfill (Table B-6):

- For human health only: arsenic, cadmium, and pentachlorophenol
- For ecological receptors only: copper and mercury
- For both receptors: lead and zinc.

The nature and extent of these chemicals are described further in Section 5.

5 NATURE AND EXTENT OF CONTAMINATION

This section presents the results of chemical and physical tests performed on samples collected and evaluated for the RI before completion of EPA's removal action of Little Squalicum Creek and the City's interim action of the landfill Site. These analyses were necessary to evaluate the type, distribution, transport, and fate of chemicals at the Site. Geotechnical tests (e.g., grain size) were conducted to evaluate the engineering properties of soils.

Validation of the analytical laboratory data collected during the draft Park RI was completed by EcoChem using EPA's Laboratory Data Validation Functional Guidelines for evaluating both organic and inorganic analyses (USEPA 1999, 2002) and followed data quality requirements presented in the QAPP (Integral 2005b). Data quality was deemed acceptable for use in this evaluation (Integral 2008). Analytical data collected for the 2010 Birchwood/BTC channel excavation and soil confirmation sampling was reviewed for data quality by Herrenkohl Consulting using EPA guidelines and deemed acceptable for use in this evaluation.

The landfill was estimated to cover 19,000 ft^2. In September 2010, approximately 6,000 ft^2 (volume of 500 cy) of material was removed from within a portion of the Site boundaries and stockpiled (Figure 2). The remaining area of the landfill Site was estimated to be approximately 13,000 ft^2 with a volume of approximately 1,900 cy, which together with the stockpiled materials, totaled approximately 2,400 cy of contaminated soils.

The following sections summarize in chronological order the sources of data used in the RI and delineate the preliminary boundaries of the landfill based on field observations and testing results. Analytical testing results for final Site IHS's are presented in Figure 4.

5.1 2005 LANDFILL BOUNDARY SURVEY

In November 2005, test pits TP-1 and TP-2, located at the northeast corner of the Park near the BTC parking lot, were excavated, and municipal garbage and debris were observed in the upper 4 ft of soils in both test pits (see Figure 2; test pit logs are provided in Appendix A). Materials encountered included intact bottles dating back to the 1920s and 1930s, unidentifiable metal fragments, ash materials, and construction debris, among other materials. Material typical of municipal waste was observed to be more extensive in TP-1, including a distinct "garbage odor" in the upper portions of the excavation. A third test pit TP-3 was excavated outside the known limits of the landfill area. No debris was observed in TP-3. After consultation with City Parks and Recreation Department and Attorney's office personnel, this area of the Park was tentatively identified as the Razore City Landfill before renaming it the Eldridge Municipal Landfill.

In January 2006, a total of 25 RTPs were excavated to delineate the boundary of the historical landfill with no samples collected or analyzed[8] (see Figure 2). The RTPs were initially

[8] Reconnaissance test pits (e.g., RTP-1) were not used to collect samples but for delineating the landfill boundary through field observations. Test pits (e.g., TP-1) were used to collect samples for chemical analyses.

excavated on 50-ft centers around test pit TP-1, where evidence of municipal garbage was first discovered. Additional test pits were excavated at the discretion of the field geologist to delineate the lateral extent of the historical landfill, including the area around test pit TP-2. The RTPs were excavated to a depth of approximately 2 to 6.5 ft bgs. Field notes were taken with regard to whether or not municipal garbage or debris was encountered, but the soils were not logged or collected for chemical analysis. Observations from the reconnaissance test pits are presented in Table A-1 (Appendix A).

Evidence of municipal garbage was found in RTP-2, -3, -5, -6, -10, -16, -17, -18, -19, -22, and -24 (see Figure 2 and Table A-1). The types of municipal garbage observed consisted of glass bottles, metal scraps, drywall, rust, charcoal, ash, and ceramics. Municipal garbage was observed from approximately 0.5 to 5 ft bgs. At the time of the reconnaissance test pit sampling, the area of the historical landfill was estimated to be approximately 7,000 ft^2, based on visual observations of the contents from the reconnaissance test pits.

Also in January 2006, test pits TP-22 and TP-23 were excavated within the estimated boundaries of the historical landfill for collection of soil samples for analysis (see Figure 2; test pit logs are provided in Appendix A). Metal and glass debris were encountered from 0.5 to 4.5 ft bgs and 2.5 to 4 ft bgs in test pits TP-22 and TP-23, respectively (see photographs in Appendix A). A third test pit TP-24 was excavated outside the preliminary limits of the landfill area for confirmation purposes. No debris was observed in TP-24.

5.2 LANDFILL SOIL

In addition to delineating the extent of landfill materials with RTPs, soil samples were collected in 2005 and 2006 for analysis from six test pit locations (TP-1 to TP-3 and TP-22 to TP-24) within or near the Site as shown on Figure 2. Petroleum hydrocarbons were relatively low in concentration, generally below the screening level of 200 mg/kg, but several soil samples contained elevated levels of lead, mercury, and zinc. The nature and extent of detected chemicals in surface and subsurface soil within the Site are discussed below and presented in Figure 4.

5.2.1 Surface Soil

Six surface soil samples were collected from six test pits within the Site and analyzed for petroleum hydrocarbons and metals. Only one surface soil sample, from TP-23, exceeded the screening level (soil EIC) of 200 mg/kg for motor oil (230 mg/kg). This sample was analyzed for semivolatile organic compounds (SVOCs). Low levels of PAHs, benzoic acid, phthalates, and pentachlorophenol (0.350 mg/kg) were detected in the surface soil sample from TP-23.

Surface soils in TP-23 also had some of the highest detected metals concentrations including cadmium (1.2 mg/kg), copper (113 mg/kg), lead (285 mg/kg), mercury (0.26 mg/kg), and zinc (505 mg/kg). Arsenic was not detected in surface soil samples and the highest nickel concentration (44 mg/kg) was detected in TP-03 located outside the limits of the landfill (Table C-1, Appendix C).

TOC concentrations ranged from 2.66 to 6.09 percent (TP-1).

5.2.2 Subsurface Soil

Seventeen subsurface soil samples were analyzed from the six test pits excavated on or near the Site. Sixteen of the 17 samples were analyzed for petroleum hydrocarbons with one sample (TP-23 at 3.5 to 4 ft bgs) above the soil EIC of 200 mg/kg. This sample was analyzed for SVOCs. Low levels of PAHs and phthalate compounds were detected in the sample. Pentachlorophenol was not detected in this subsurface soil sample (Figure 4 and Table C-1 in Appendix C).

Chromium, copper, lead, nickel, and zinc were detected in each sample analyzed. Elevated metals were detected in one or more samples from TP-01, TP-22, and TP-23. In general, the highest concentrations of metals (arsenic, cadmium, copper, lead, mercury, nickel, and zinc) were detected in soils from 1 to 4 ft bgs in these test pits (Table C-1 in Appendix C). Soils at this depth were composed of ash (burnt) and “rusted” granular materials. Numerous bottles and other municipal wastes were also observed at this depth.

The highest concentrations of cadmium, copper, lead, mercury, and zinc were detected at the following stations:

Station	Depth (ft bgs)	Cadmium	Copper	Lead	Mercury	Zinc
TP-01	1–2	3.1	124	1,270	0.36	1,230
TP-22	1.7–2.2	8.0	282	3,970	1.20	2,960
TP-23	3.5–4	10	409	1,290	1.62	3,060

Note: Concentrations in mg/kg.

The highest arsenic (13 mg/kg) and nickel (120 mg/kg) concentrations in subsurface soils were detected in TP-22 (0.5-1.7 ft) and TP-23 (3.5-4.0 ft), respectively.

The samples from TP-22 and TP-23 with elevated total metals were further evaluated using the toxicity characteristic leaching procedure (TCLP) to determine the leachability of these metals and their potential impacts to surface water and groundwater[9]. Cadmium (0.02 mg/L in both), copper (0.025 and 0.04 mg/L), lead (0.66 and 0.28 mg/L), nickel (0.07 and 0.08 mg/L), and zinc (8.005 J and 5.37 J mg/L) were detected in the tests, respectively (Table C-2, Appendix C). Table C-2 also presents a comparison of the total and TCLP metal concentrations. The TCLP concentrations are two to four orders-of-magnitude lower than the total metals concentrations, indicating a relatively weak tendency of the metals at the Site to leach to surface water and groundwater. Moreover, TCLP concentrations are below the Washington State Dangerous Waste Criteria for these metals (Chapter 173-303 WAC).

[9] The TCLP test was designed to model a theoretical scenario in which municipal solid waste is placed in an unlined landfill. The acetic acid solution used in the TCLP method is designed to simulate the result of rainwater infiltrating the landfill, reacting with the municipal solid waste, and then leaching through the waste being tested.

TOC concentrations in the nine soil samples ranged from 0.953 to 9.04 percent (TP-01 at 2 to 3 ft bgs).

5.3 BIRCHWOOD/BTC CHANNEL EXCAVATION AND SOIL CONFIRMATION

In September 2010 during construction of a new Birchwood/BTC stormwater channel, the contractor for the Oeser Company encountered miscellaneous municipal wastes in fill materials located northwest of the previous identified landfill footprint. Oeser was working with EPA on the cleanup of Oeser-related contamination in other areas of the Park as part of a removal action (USEPA 2010a). Approximately 500 cy of fill materials including municipal garbage was excavated from the new Birchwood/BTC channel and stockpiled onsite. The area of the excavation was approximately 6,000 ft^2 (125 ft long and up to 50 ft wide) with municipal wastes observed to a depth of 4 ft bgs. Reconnaissance test pits beneath the stockpile location confirmed the presence of landfill materials in this area of the Site (Figure 2).

Confirmation sampling of the bottom and sidewalls of the excavation was accomplished during two separate sampling events. The first sampling was conducted on September 6, 2010 after excavation of the channel and eastern slope (refer to Figure 2). Approximately 150 cy of fill was excavated and stockpiled onsite. Confirmation composite soil samples were collected from 7 stations (LSC-HA-01 to LSC-HA-04 and LSC-HA-06, LSC-HA-08, LSC-HA-09) at the base of the excavation to a depth of 0.5 ft. using a stainless steel hand auger. Confirmation composite samples were also collected from the eastern sidewall (LSC-HA-05 and LSC-HA-07). Each sample was analyzed for petroleum hydrocarbons and metals. A summary of the results is presented in Table C-3 (Appendix C).

Petroleum hydrocarbon concentrations were below the soil screening level of 200 mg/kg in all samples[10]. Lead and mercury were detected above screening levels in several confirmation samples with the highest lead concentration (269 mg/kg) reported in station LSC-HA-05. Station LSC-HA-05 was located along the sidewall of the excavation which contained some landfill materials (e.g., ash, rusted metals). After excavation, Oeser contractors covered the sidewall with plastic and backfilled to the design grade for the slope of channel (refer to Figure 2).

On September 29, approximately 350 cy of additional fill and municipal wastes were excavated from the western sidewall of the BTC channel. This material was stockpiled with the other material excavated earlier in the month. Confirmation composite soil samples were collected from 4 locations representing the slope of the channel and analyzed for metals. Results are summarized in Table C-3 (Appendix C). Only lead from station LSC-HA-12 (70 mg/kg) was above the screening level.

Soil was excavated by the contractor until no municipal wastes (e.g., bottles, brick, metal fragments) were observed in the excavation. Excavated soils and debris were placed on 30 Mil

[10] Semivolatile organic compounds (including pentachlorophenol) were not analyzed on the soil samples because petroleum hydrocarbons concentrations were below the screening level (Integral Consulting 2008).

plastic and then covered with 15 Mil plastic held down with sandbags. A silt fence was then constructed around the stockpile (refer to pictures in Appendix A). The approximate extent of the remaining landfill Site based on observed refuse and chemical results of soil samples, including the area where the stockpile was located, was estimated at 13,000 ft^2 as shown on Figure 2.

5.4 PRELIMINARY SITE BOUNDARY

The preliminary Site boundary was estimated to be 19,000 ft^2 based on the following information (Figure 2):

- visual observations from the 2005 landfill boundary survey as part of the Park RI;
- soil sampling and testing conducted in 2006 as part of the Park RI; and
- visual observations, soil sampling and testing during construction of the new Birchwood/BTC stormwater channel as part of the EPA Removal Action in 2010.

6 FATE AND TRANSPORT PROCESSES

As previously discussed, a municipal landfill was in operation on the northeastern portion of the Park during the 1930s. Based on visual information obtained from test pits and soil sampling in 2005, 2006, and 2010, the historical landfill materials are covered with approximately 0.5 to 3 ft (generally 2 ft) of soil (fill). Native soils are generally present at the base of the landfill materials (~3 to 4 ft bgs). No impermeable liner was observed at the base of the landfill materials and no impermeable cap was observed on top of the landfill materials. As use of the landfill was discontinued prior to 1940, there is no new source of contaminants to this area of the Park. However, the buried landfill wastes did present a potential ongoing source of contamination.

A conceptual site model diagram of contaminant transport in the vicinity of the landfill is presented in Figure 5. During the dry season, the water table was expected to be beneath the bottom of the landfill materials based on field observations in early November 2005 (refer to test pit logs in Appendix A). When precipitation occurs, contaminants (principally metals) may be leached from the landfill materials by infiltrating water and transported to the capillary fringe and groundwater zones. During the wet season, the water table was expected to be in direct contact with the lower portion of the landfill materials based on field observations in January 2006 (Appendix A). In 2010, EPA/Oeser constructed a new Birchwood/BTC stormwater channel located adjacent to the presumed boundary of the landfill (Figure 2). Although landfill wastes and contaminated soils located adjacent to the new creek channel were excavated, stockpiled, and covered with 30 Mil plastic, there was a potential for Site contaminants to be transported via surface water runoff and groundwater infiltration to the new channel. It should be noted however, that leaching of metals from soils to surface water and groundwater was not considered to be an important transport pathway at the Site based on TCLP results (refer to Section 5.2.2).

Contaminants present in overland stormwater runoff (i.e., industrial/homeowner chemicals, automotive waste) may also be transported downward toward groundwater or down slope to the Birchwood/BTC stormwater channel. Once overland runoff contaminants reach the Birchwood/BTC stormwater channel, they would likely be transported downgradient (to the southwest toward Bellingham Bay in the case of the Birchwood/BTC stormwater channel and presumably also in the case of groundwater) by the processes described for dissolved contaminant transport in surface water and groundwater (Integral 2008). Contaminant fate and transport in the dissolved phase is the result of advection, hydrodynamic dispersion, and biological/chemical reactions (including oxidation, biodegradation, sorption, etc.).

7 INTERIM ACTION

A draft RI/FS report with a preferred cleanup alternative was issued to Ecology for their review in February 2011 (Herrenkohl Consulting and Integral Consulting 2011a) (Figure 6). After review by Ecology and further discussion between parties, the City agreed to conduct an interim action for the Site in summer 2011. The interim action was conducted under an amendment to Agreed Order No. DE 8073 between the City and Ecology and included removal of the stockpiled fill materials and the excavation of the upper four feet or more of municipal waste and the soil from the Site that exceeded remediation levels (RLs) developed in Appendix D (Table D-1) and specified below.

- Arsenic: 10 mg/kg, based on natural background
- Cadmium: 45 mg/kg, based on direct human contact and adjusted to ensure a HI of 1
- Copper: 50 mg/kg, based on the TEE
- Lead: 50 mg/kg, based on the TEE
- Mercury: 0.1 mg/kg, based on the TEE
- Zinc: 86 mg/kg, based on natural background
- Pentachlorophenol: 2.5 mg/kg, based on direct human contact

The point of compliance for each of the proposed Site RLs, all of which are based on direct contact with soil for either human or ecological receptors, is 15 ft bgs[11].

The amendment to the Agreed Order, which describes the interim action, was available for public review and comment from June-July 2011 and became effective on July 18, 2011. Applicable permits and substantive requirements for the interim action were summarized in the Agreed Order and include:

- Nationwide 38 permit (Required for impact to wetlands during the interim action pursuant to Section 404 of the Clean Water Act, 33 U.S.C. § 1344 (with Section 106 Review of the National Historic Preservation Act, 16 U.S.C. § 470f).
- State Environmental Policy Act Integrated Compliance (RCW 43.21C.036 and WAC 197-11-250 through 259).
- City of Bellingham Fill and Grade Permit (BMC 16.70.070).
- City of Bellingham Construction Stormwater Permit (BMC 15.42).
- City of Bellingham Land Clearing Permit (BMC 16.60.060).
- City of Bellingham Critical Area Ordinance (BMC 16.55.420).

The results of the interim action are provided below including a summary of the construction activities and wetland restoration and compliance monitoring. Additional details on the

[11] Some of the direct contact RLs were adjusted up to natural background concentrations per WAC 173-340-740(5)(c).

engineering design and construction are provided in the engineering design and construction completion reports (Herrenkohl Consulting and Wilson Engineering 2011a,b), respectively.

7.1 CONSTRUCTION

A total of about 4,290 tons of landfill debris and contaminated soil was removed from the Site in support of the interim action and transported to Roosevelt Regional Landfill in Washington State for proper disposal. Construction was conducted from August 22 to October 7, 2011. A brief description of the interim action is provided below.

7.1.1 Interim Action Area

As designed in the engineering design report (EDR), approximately 2,300 cy (~3,500 tons *in situ*) of landfill debris and contaminated soil was removed from the Site at depths ranging from 2-ft to 7-ft bgs (Figure 7). After the excavation in each designated area (Areas 1 and 2), confirmation sampling was completed as required in the performance monitoring plan (Herrenkohl Consulting and Wilson Engineering 2011a).

Excavated landfill debris and contaminated soil was loaded into containers onsite and transferred by truck and trailer (Ferndale Ready Mix & Gravel, Inc.) to Ferndale for loading on rail and transport to the Roosevelt landfill. Approximately 575 tons of the total debris and contaminated soils excavated from the Site was transported by truck and trailer (Harlow Construction Company, Inc.) from the Site to Republic Service's Seattle facility where it was transferred to containers for transport by rail to the Roosevelt Landfill.

7.1.2 Stockpile Area

Approximately 500 cy (~750 tons) of landfill debris and contaminated soil stockpiled in summer 2010 during the EPA cleanup of Little Squalicum Creek was also loaded into containers and transferred to Ferndale for loading on rail and transport to the Roosevelt landfill. The excavation was completed by EPA in support of re-routing the Birchwood/BTC storm channel and Little Squalicum Creek.

7.1.3 Backfilling, Top Soil, and Hydroseeding

After confirmation sampling was completed, the excavation was backfilled with about 4,310 tons of clean sand with gravel. The fill material originated from the Polaris borrow pit (pit run south wall), a glacial outwash deposit of the Kendall complex (WDNR 2001) operated by Ferndale Ready Mix and located in Whatcom County. Fill was initially stockpiled onsite and then spread over the Site in 1-2 ft lifts with a bulldozer and compacted using a roller as required by the project specifications.

Approximately 770 tons of top soil was spread over the fill base at a thickness of 4 inches as required by the project specifications. Top soil (sandy loam) was provided by Cowden Gravel and Ready Mix, located in Whatcom County. Once graded, the Site was hydroseeded using a mulch, seed, and fertilizer mixture. A series of straw wattles were installed throughout the newly graded area to reduce erosion. Also, a silt fence was installed between the Site and the Birchwood/BTC storm channel for temporary erosion control.

7.1.4 Trail Construction

The quarry-spall access road was left in-place for possible future access to the Eldridge Site and the Park. However, a walking trail was constructed over the quarry spalls for public use. A woven geotextile was applied overtop the quarry spalls before adding a 6-inch layer of crushed surfacing base course and a final 3-inch layer of crushed limestone. Coarse mulch was placed along the edges of the trail to cover any remaining quarry spalls.

7.2 WETLAND RESTORATION

From October 3-6, 2011, an approximate 750 ft^2 wetland was created in accordance with the Wetland Restoration Plan (Herrenkohl Consulting and Wilson Engineering 2011a) (Figure 8). The wetland creation site was prepared by excavating an area previously backfilled, followed by placement of a 6-inch low permeability layer, and then covered with 9-inches of topsoil. Approximately 33 tons of low permeability soil, provided by Ferndale Ready Mix, was compacted using the excavator bucket. Shelterbelt Inc. installed the wetland plants and placed a 3- to 6-inch mulch layer over the entire creation area.

7.3 FINISH GRADING PLAN

The finish grading plan after completion of the interim action is shown in Figure 8. The Site was evenly graded to ensure positive drainage with no concentrated flow paths. New grades match existing grades along limits of the work area with the exception of two areas along the southern slope where additional fill material was placed for increased coverage and stability. The reconstructed wetland was vegetated in accordance with the Wetland Restoration Plan (Herrenkohl Consulting and Wilson Engineering 2011a). Outside the reconstructed wetland, all disturbed areas were graded and hydroseeded. In addition, crushed limestone was applied to the access road with mulch along its perimeter for a walking trail into the Park.

7.4 COMPLIANCE MONITORING

Compliance monitoring was evaluated to assure the effectiveness of the interim action and included: performance soil monitoring of the interim action in meeting RLs, and confirmation groundwater monitoring of the long-term effectiveness of the interim action. The compliance monitoring completed for the interim action is discussed below (also see Figures 9-11).

7.4.1 Performance Monitoring

Performance monitoring and contingency responses were implemented for the Site in accordance with WAC 173-340-410 as described in the performance monitoring plan (Herrenkohl Consulting and Wilson Engineering 2011a). The objective of the monitoring was to confirm that soil RLs were achieved by the interim action for the Site. Construction contingency responses were also defined in the monitoring plan and included additional removal of soil above RLs from the excavation bottom or sidewall(s). The results of the performance monitoring for the interim action are summarized below and provided in Appendix E.

In Area 1, soil samples were collected from 15 bottom samples (e.g., A1B)[12] and 12 sidewall samples (e.g., A1S). Results for six sidewall and two bottom sample locations were above the RLs for one or more metals, requiring additional removal of soils. For three of the sidewall samples (A1S, A2S, A8S), additional removal was not possible due to steep, unstable slopes. Minor exceedances of RLs for lead and zinc also occurred at stations A6S and A7B, respectively. After this final removal, compliance sampling and testing met the requirements of the monitoring plan with exceptions stated above (Figure 7).

In Area 2, soil samples were collected from 15 bottom samples (e.g., B1B) and 9 sidewall samples (e.g., B1S). Results for seven sidewall and 4 bottom sample locations were above the RLs for one or more metals, requiring additional removal of soils at these locations. For three of the sidewall samples, additional removal was not possible due to encroachment into a wetland (Wetland A) or under a large Cottonwood tree. Additional compliance sampling indicated 4 sidewall locations were still above the RLs for one or more metals. The City and Ecology decided to excavate additional soil from these locations until no obvious landfill debris was observed in the soils or there were encroachment or engineering (e.g., slope stability) concerns. After this final removal, compliance sampling and testing indicated that a total of 6 sidewall locations in Area 2 (B3S2, B5S2, B6S2, B9S, B12S, B16S) were above RLs (Figure 7). Additional removal was not possible due to either steep, unstable slopes or encroachment into Wetland A or the Cottonwood tree. Three other performance sample locations (B2S, B5B2, B10B) had minor exceedance of RLs but there was no obvious visual signs of landfill debris. The contractor scraped clean these areas but no other sampling was conducted.

7.4.2 Confirmation Monitoring

Confirmation groundwater monitoring was implemented for the Site to determine the effectiveness of the interim action as described in the Ecology-approved sampling and analysis plan (SAP) (Herrenkohl Consulting 2012). Soil borings and groundwater monitoring wells were installed at 4 locations onsite and one upgradient location on adjacent BTC property (Figure 9, Table F-1). The results of the monitoring are provided below.

[12] Confirmation sample identifications begin with EML-IA- (Eldridge Municipal Landfill-Interim Action-)

Soil Investigation

The soil investigation consisted of completing 5 soil borings within and adjacent to the landfill Site (Figures 9 and 10). Each of the soil borings was advanced to the top of a gray or tan, silty clay layer, considered to be the confining layer of a perched groundwater zone at the same depth as and immediately below the landfill materials. The soil borings were used to collect soil samples for laboratory chemical analysis and to further characterize Site lithology. Soil boring logs are provided in Appendix F. The number of soil samples and the sample depth intervals collected for laboratory analysis at each location were largely determined based on the sampling strategy described in the SAP (Herrenkohl Consulting 2012) with the following exceptions:

- At location SB-03[13], a soil sample was collected from a depth of 7.5-9 ft below ground surface (bgs) instead of between 10 to 15 ft bgs because there was no sample recovery[14] for samples below this depth (10-11.5 ft and 11.5 -13 ft) and the clay layer was encountered at the base of the boring (12.5-13 ft).
- At location SB-04, a soil sample was not collected from the depth zone of 10 to 15 ft bgs because the base of the boring was 7.5 ft.
- At location SB-05, samples were not collected from the upper 2 ft and 10 to 15 ft depth because of poor sample recovery within these depth ranges. Samples were collected and analyzed from 5-6.5 ft and 15-16.5 ft.

In accordance with the SAP, selected soil samples were analyzed for metals, pentachlorophenol, and PAHs (Table F-2).

Groundwater Investigation

Each soil boring was converted to a groundwater monitoring well following procedures described in the SAP (Herrenkohl Consulting 2012). Monitoring well as-built information is provided in Appendix F.

The new monitoring wells were developed to remove formation material from the well borehole and the filter pack prior to groundwater level measurement and sampling. Each well was developed by surging the well with a surge block (i.e., the Typhoon pump acted as a surge block) and purging the well until there were consistent measurements of pH, temperature, conductivity, and turbidity as required in the SAP. Purge volumes were greater than 10 casing volumes for all wells.

Groundwater levels for evaluating groundwater flow direction across the Site were measured at each well on May 28, 2012 during the groundwater sampling event (Figure 10). Each groundwater level was measured from a surveyed reference point (located on a marked edge of the top of the PVC well casing) to the top of the groundwater using a hand-held water level

[13] Soil boring and monitoring well identifications begin with EML- (Eldridge Municipal Landfill-)
[14] No or poor sample recover for some sample depths was due to the coarse-nature (i.e., gravels) of the material at these locations.

indicator. These measurements were recorded to the nearest 0.01 ft. Groundwater elevation measurements are provided in the well construction logs located in Appendix F.

Groundwater samples were collected from the monitoring wells on May 28 and 29, 2012. Prior to sampling, each well was purged with a peristaltic pump using dedicated purge and sample collection tubing except for well MW-05. For this station, a dedicated Teflon bailer was used to purge and sample the well because the depth of the well was beyond the efficient operating depth of the peristaltic pump (refer to Appendix F). Field parameters, including pH, temperature, conductivity, dissolved oxygen, and turbidity were regularly measured and recorded during purging. Purging was considered complete when these field parameters became stable as specified in the SAP with one exception. Turbidity measurements for station MW-05 were highly variable because of the use of a bailer for sampling (refer to Table F-3 in Appendix F).

Groundwater samples were collected into appropriate sample containers provided by the laboratory. In accordance with the SAP, groundwater samples were analyzed for total metals, dissolved metals, pentachlorophenol, PAHs, and conventional parameters (nitrite, nitrate, ammonia). Groundwater for dissolved metals analyses was collected and filtered in the laboratory using a 0.45-micron, disposable filters. This was a change from the SAP (refer to field change forms in Appendix F).

Groundwater Flow

The uppermost groundwater at the landfill Site occurs as a 5- to 10-ft thick unconfined or perched water-bearing zone within a gravelly sand fill and native silty sands and gravels. The base of this water-bearing zone appears to be a relatively continuous silty clay bed located across the Site. To evaluate the groundwater flow direction at the site, the depths to groundwater measured on May 28, 2012 were converted to groundwater level elevations, plotted on a Site map, and contoured (Figures 9-10). As shown on the figure, Site groundwater flows to the southwest toward Bellingham Bay. The groundwater elevation likely varies seasonally, and may rise to near land surface in the winter based on previous observations (refer to Section 3.3).

Groundwater elevations measured at MW-01 and MW-02 (34.81 ft and 33.76 ft, respectively) were at or near the surface elevation of the Birchwood/BTC stormwater channel (approximately 33 ft based on earlier surveying of this feature). Consequently, it can be assumed that surrounding groundwater also flows to this channel and out to Bellingham Bay.

Data Quality

Data quality was assessed by performing a data validation review on all the analytical results for the compliance monitoring. The data were validated using guidance and quality control (QC) criteria documented in the analytical methods, the SAP (Herrenkohl Consulting 2012), and the National Functional Guidelines for Organic and Inorganic Data Review (USEPA 1999, 2004b, 2009). Soil and groundwater samples were analyzed by Analytical Resources, Inc. (ARI) of Tukwila, Washington. The results reported by the laboratory were 100% complete for the soil and groundwater analyses. No qualifications were recommended in the data set except for the following:

- Pentachlorophenol in groundwater for station MW-05 was analyzed less than 24 hours outside the recommended holding time. The result was qualified as an estimate (UJ).

Additional details on the data quality review are provided in Appendix F.

8 PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

This section presents an evaluation of the compliance monitoring results from the interim action to determine whether post-interim action conditions at the Site are protective of human health and the environment.

The RLs used in the interim action were based on direct contact with soil by humans and ecological receptors. The leaching pathway was not considered, pending results of confirmation groundwater sampling following the interim action. Confirmation groundwater results demonstrate that groundwater is in compliance with groundwater cleanup levels, as discussed in Section 8.1. This means that the RLs used in the interim action can be accepted as the final cleanup levels (CULs) for the Site.

In Section 8.2, performance sampling results for soil are evaluated to determine whether soil is in compliance with soil CULs according to the three-part statistical rule [WAC 173-340-740(7)]. Because performance sampling results for some of the IHSs do not comply with the three-part rule, a risk assessment was conducted to determine whether post-interim action conditions are protective of human health and the environment [WAC 173-340-357] (Section 8.3).

8.1 CONFIRMATION MONITORING RESULTS FOR GROUNDWATER

Groundwater RLs were not derived for the interim action, so risk-based groundwater CULs were developed based on an evaluation of ARARs for surface water (Tables G-1 and G-2) and drinking water (Table G-3). Groundwater sampling results were compared to the risk-based CULs for all IHSs except arsenic, which was evaluated based on natural background as discussed below (Table G-4). Groundwater field parameters with available primary or secondary maximum contaminant levels (MCLs) or ambient water quality criteria (AWQC) were also evaluated (Table G-5).

8.1.1 Groundwater Cleanup Levels

For each IHS, the minimum of the following applicable or relevant and appropriate requirements (ARARs) was identified as the CUL for protection of surface water (Table G-1):

- EPA water quality criterion, considering protection of freshwater receptors and human health via consumption of water and organisms[15];
- Washington State water quality standard (WQS), considering protection of freshwater receptors[16]; and

[15] Available at: http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm.
[16] Available at: https://fortress.wa.gov/ecy/publications/summarypages/wac173201a.html.

- National Toxics Rule, considering protection of freshwater receptors and human health via consumption of water and organisms[17].

The state WQS for cadmium, copper, lead, and zinc are dependent on hardness and the WQS for pentachlorophenol is dependent on pH. These values were calculated using site-specific data (Table G-3).

The cancer risks and hazard quotients associated with the minimum ARARs were evaluated using MTCA Equations 730-2 and 730-1, respectively. Each of the minimum surface water ARARs was associated with a cancer risk of less than $1x10^{-5}$ and a hazard quotient of less than 1, so no adjustments were made [WAC 173-340-730(5)(b)].

For each IHS, the minimum of the following ARARs was identified for protection of drinking water (Table G-3):

- EPA maximum contaminant level (MCL)[18]
- EPA MCL goal (MCLG)
- Washington State MCL[19].

The cancer risks and hazard quotients associated with the minimum ARARs were evaluated using MTCA Equations 720-2 and 720-1, respectively. The cancer risk associated with the minimum MCL for arsenic exceeded $1x10^{-5}$, so the value was adjusted down to achieve a cancer risk of $1x10^{-5}$ [WAC 173-340-720(7)(b)]. The hazard quotient associated with the minimum MCL for copper exceeded 1, so the value was adjusted down to achieve a hazard quotient of 1.

The CULs for protection of surface water were lower than the CULs for protection of drinking water, so the CULs for protection of surface water were selected as the risk-based groundwater CULs (Table G-3). The natural background concentration of 5 µg/L for arsenic in groundwater [MTCA Table 720-1 footnote b] is higher than the risk-based CUL of 0.018 µg/L, so the groundwater CUL for arsenic was adjusted up to 5 µg/L (Table G-4) [WAC 173-340-720(7)(c)].

8.1.2 Groundwater Compliance

One round of groundwater compliance samples was collected in May 2012. The results for the IHSs are shown in Table G-4. The results for field parameters with available primary or secondary MCLs or AWQC are shown in Table G-5.

Some of the field parameters did not comply with primary and secondary MCLs. Total iron concentrations ranged from 3,770 (MW-05) to 9,320 (MW-03) µg/L, all of which are well above the secondary MCL of 300 µg/L. Total manganese concentrations ranged from 930 (MW-05) to

[17] Available at: http://www.ecfr.gov/cgi-bin/text-idx?c=ecfr&sid=5fca8b93bdd6cb15306ea1b735a4ff62&rgn=div8&view=text&node=40:23.0.1.1.18.4.16.6&idno=40
[18] Available at: http://water.epa.gov/drink/contaminants/index.cfm
[19] Available at: http://apps.leg.wa.gov/wac/default.aspx?cite=246-290-310.

3,370 (MW-04) µg/L, all of which are well above the secondary MCL of 50 µg/L. These results suggest that the shallow groundwater in this area would not be suitable for drinking. Nevertheless, because the groundwater has not been declared non-potable, groundwater CULs were developed considering protection of drinking water, as discussed above.

Nitrite concentrations were not detected, with detection limits below the MCL of 1 mg/L, in all wells. Nitrate concentrations were below the MCL in all of the wells. Ammonia concentrations were below the AWQC in all of the wells. pH values ranged from 5.91 (MW-04) to 6.50 (MW-05), which are below or at the lower end of the range listed in the primary MCL. Turbidity was absent in all of the wells except MW-05, where it measured 376 NTU. This value is well above the MCL of either 1 or 5 NTUs, depending on the type of filtration used in the water delivery system. The turbidity in MW-05 was caused by sampling with a dedicated bailer.

Concentrations of lead, mercury, zinc, and pentachlorophenol were below their respective CULs in all five wells.

The concentrations of total cadmium (0.3 µg/L) and total copper (22.7 µg/L) were above their CULs (0.25 and 9.0 µg/L, respectively) in MW-05, which is located side-gradient of the Site beneath the BTC parking lot. No landfill debris was observed during the installation of this well and these concentrations are not considered to be associated with the Site.

The concentration of total arsenic (17.7 µg/L) exceeded its CUL (5 µg/L) in MW-03, which is located in the middle of the Site. Although the arsenic concentration detected in groundwater from MW-03 was elevated in comparison to the other stations including upgradient and side-gradient wells, it's probably not associated with the landfill for the following reasons:

- Soil samples collected and analyzed for arsenic from this location and the upgradient station MW-04 were below both the CUL of 10 mg/kg (refer to Table F-2 and Section 7.4.2) as well as the Puget Sound background of 7 mg/kg (Ecology 1994);

- All performance monitoring soil results from the interim action were below the CUL for arsenic (refer to Table E-1 and Section 7.4.2);

- Elevated arsenic levels were detected in groundwater at other locations in the Park (e.g., 25.9 µg/L at SB-23 and 14.0 µg/L at SB-25 in the upper creek area located approximately 400 ft west of the landfill Site), indicating the potential for elevated levels of arsenic in groundwater in the area, likely from other source(s) (Integral Consulting 2008); and

- Elevated arsenic levels were detected in soil samples at the W. Illinois Street Site (Herrenkohl Consulting and Wilson Engineering 2010), located north and potentially upgradient of the Eldridge Municipal Landfill Site[20].

[20] The City completed a voluntary cleanup of arsenic-contaminated soils in support of extending West Illinois Street and Timpson Way (refer to Section 2.3.2).

MW-03 should be re-sampled to verify this apparently anomalous result, but such sampling need not preclude the completion of the RI/FS report.

The concentrations of all of the IHSs were below their CULs in MW-01 and MW-02, which are located at the downgradient edge of the Site where groundwater flows into the storm channel. Because there are no observed impacts at the downgradient edge of the landfill, groundwater is considered to be protected and the leaching pathway is not of concern. The soil RLs for the interim action, based on direct contact with soil by human and ecological receptors, are the final soil CULs for the Site.

8.2 PERFORMANCE SAMPLING RESULTS FOR SOIL

The performance soil data set was developed by combining soil sample results from the initial site characterization sampling at locations from which soil had not been removed during the interim action, performance sampling conducted following completion of the interim action, and soil sampling conducted during installation of wells located within the landfill.

Of the hand auger samples collected during the initial site characterization (Section 5.3), 12 samples were located in the landfill area and were not removed during the interim action. These samples were analyzed for arsenic, cadmium, lead, and mercury but not copper, zinc, or pentachlorophenol. A total of 54 performance soil samples were collected at the completion of the interim action representing the final excavation (Section 7.4.1). These samples were analyzed for all of the IHSs. Three of the wells installed for compliance monitoring are located within the landfill (MW-01, -02, and -03) (Figure 10). Soil samples from these borings were analyzed for all of the IHSs. The full performance soil data set includes 55 samples analyzed for pentachlorophenol; 57 samples analyzed for copper and zinc; and 69 samples analyzed for arsenic, cadmium, lead, and mercury.

Soil compliance with the CULs was evaluated using the MTCA three-part statistical rule [WAC 173-340-740(7)(b)]:

- The upper one-sided 95 percent confidence limit on the mean (95UCL) shall be less than the CUL,
- The maximum concentration shall not be greater than twice the CUL, and
- Fewer than 10 percent of the results shall be greater than the CUL.

Mean and 95UCL values were calculated using USEPA's (2013) ProUCL 5.0 (Table G-7). ProUCL determined that the compliance data sets for arsenic and copper were normally distributed, and the 95UCL's for these metals were calculated using the Student's t statistic. The compliance data sets for the other metals fit neither normal nor lognormal distributions, so the 95UCLs were calculated using nonparametric statistics.

Pentachlorophenol was not detected in any of the samples, with detection limits below the CUL (Table G-6). The performance soil data sets for arsenic and cadmium comply with all three parts of the rule. The data sets for copper and mercury are out of compliance on both the frequency of exceedance and maximum detected value. The data sets for lead and zinc are out of compliance for all three parts of the rule.

8.3 RISK ASSESSMENT OF POST-INTERIM ACTION CONDITIONS

The soil data sets not in compliance with the three-part statistical rule (copper, lead, mercury, and zinc) after completion of the interim action were evaluated further to determine if they indicate a risk to human health or the environment [WAC 173-340-357] (Table G-6).

8.3.1 Human Health

To evaluate protection of human health, the data sets were evaluated against the Method B equation values for direct human contact using the three-part statistical rule. The Method B equation values are 300, 250, 24, and 24,000 mg/kg for copper, lead, mercury, and zinc, respectively. The data sets for copper, mercury, and zinc comply with all three parts of the rule (Table G-6).

For the lead data set, the following summary statistics are relevant to the three-part rule:

- The 95UCL of 95 mg/kg is below the CUL of 250 mg/kg by a factor of 2.6
- The maximum of 536 mg/kg is greater than the CUL by a factor of 2.1
- 3 of 69 (4%) sample results are greater than the CUL (i.e., 310, 477, and 536 mg/kg).

Lead is in compliance with the first and third parts of the rule and only marginally out of compliance with the second part.

The CUL for lead was derived using EPA's Integrated Exposure Uptake Biokinetic (IEUBK) model (USEPA 1994). USEPA guidance explains that risk-based soil action levels derived with the IEUBK model are intended to be protective of long-term average exposures of children to lead in soil. More specifically, the soil lead concentration term used to estimate long-term average intake from outdoor soil ingestion is typically defined by the sample mean (or conservatively the 95UCL) rather than the maximum concentration.

At this Site, the sample size is relatively large (n=69), providing good spatial coverage; the data set is expected to be reasonably representative of subareas of high and low concentrations. The single maximum concentration that is only marginally greater than 500 mg/kg is unlikely to be representative of long-term average exposures. Furthermore, the sample is from soil adjacent to a Cottonwood tree, which will be considered critical habitat (see Section 8.3.2 below) and, therefore, will not be accessible for direct contact by humans. Considering all elements of the sampling design and lead concentrations measured in soil, the post-interim action conditions at the Site are considered protective of human health via direct contact with soil.

8.3.2 Ecological

A step-wise approach was used to address potential ecological risks from residual metals concentrations present in soils located on the Site. Figure 7 shows that confirmation soil samples exceeding remediation levels may exist on the flat and unstable slope areas of the landfill as well as at the BTC/Birchwood storm channel area. Although a clean soil cover[21] was placed over the flat and slope areas of the landfill, the depth of the cover is variable (i.e., 2 to 7 feet thick) and residual soil concentrations exceeding the CULs for copper, lead, mercury, and zinc are present within the conditional point of compliance (i.e., 0 to 6 feet). Remedial actions in the BTC/Birchwood storm channel area were conducted prior to remedial actions on the flat and slope areas of the landfill. In the storm channel area, soil containing visible landfill debris was initially excavated. Confirmation sampling was then conducted and additional soil was excavated to the depth of a clay layer to address residual contamination. Confirmation sampling was not conducted within the BTC/Birchwood storm channel area following the second excavation because it was assumed that virtually all residual contamination was removed. The confirmation samples collected following the initial excavation of the storm channel area were used in this evaluation and show concentrations of lead and mercury exceeding the CULs may be present within the conditional point of compliance[22].

The ecological risks from residual metals concentrations were reviewed and used to design the 4-step process described below. Ecological risks associated with residual metals concentrations at each sample location may be eliminated at any step of the process and need not be carried through the entire 4-step process.

For the residual metal contamination remaining under the old wetland and the cottonwood tree (as represented by performance stations B3S2, B9S, B12S, B16S), this area will be classified as a critical habitat by the City. Upon Ecology review, an environmental covenant or restrictive covenant may also be required by the City. No additional evaluation was conducted on these samples.

STEP 1: Depth-weighted Soil Concentrations

Use of a single subsurface soil sample to represent ecological exposures at a sample location is not necessarily representative of potential exposure, particularly when the subsurface soil sample is covered by a layer of clean fill material. At each sample location containing residual metals concentrations above the CUL, a depth-weighted exposure point concentration was calculated. Depth-weighted concentrations were estimated for soil within the conditional point of compliance (POC) which extends from the surface to a depth of 6 feet. The 90th percentile natural background concentration for Puget Sound (Ecology 1994)[23] was used to represent

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[21] “Clean” cover material does not mean zero contaminant concentrations. Contaminant concentrations in the cover material were represented at background levels for this evaluation.

[22] It is important to note that use of confirmation sample data collected following the initial excavation probably over-estimates concentrations currently present in the BTC/Birchwood storm channel area.

[23] Puget Sound background values were used because the origin of soil samples in this sample set are described as glacial outwash and till material which is similar to the cover material used at the landfill Site (WDNR 2001).

metals concentrations in the clean cover layer and the residual site soil concentration was used to represent the concentration in soil below the cover layer. Cover layer thickness was estimated at each sample location using ground elevation data determined before soil excavation/removal and after cover placement. The depth-weighted soil concentration was calculated as shown in Equation 1.

Equation 1:

$$C_{dw} = \left((C_c \times D_c) + (C_r \times D_r)\right) / D_{poc}$$

Where:

C_{dw} = depth-weighted soil metal concentration (mg/kg)
C_c = soil cover metal concentration (mg/kg)
D_c = depth of soil cover (feet)
C_r = residual soil metal concentration (mg/kg)
D_r = depth of residual soil layer (feet); equals $D_{poc} - D_c$
D_{poc} = depth of point of compliance (feet); equals 6 feet
Note: When $D_c \geq D_{poc}$, $C_{dw} = C_c$

Depth-weighted soil concentrations were calculated as described above and then compared to ecological CULs (Table H-1). Copper, lead, mercury, and zinc exceed CULs at one or more stations:

- Copper exceeds the CUL (50 mg/kg) in 1 of 10 stations (A8S);
- Lead exceeds the CUL (50 mg/kg) in 6 of 17 stations (A1S, A6S2, A8S, HA-03, HA-07, HA-12);
- Mercury exceeds the CUL (0.1 mg/kg) in 6 of 17 stations (A8S, HA-01, HA-02, HA-03, HA-06, HA-07);
- Zinc exceeds the CUL (86 mg/kg) in 4 of 10 stations (A1S, A8S, B5S2, B6S2).

STEP 2: Alternative Ecological Soil Cleanup Levels

U.S. EPA has developed ecological soil screening levels (Eco-SSLs) protective of plants, soil biota, and wildlife[24]. Eco-SSLs are available for copper, lead, and zinc, but not mercury. The Eco-SSLs for wildlife are not suitable alternatives for the wildlife indicator soil concentrations presented in Table 749-3 of MTCA because they were derived for receptors other than the vole, shrew, and robin used in MTCA and were calculated using different toxicological endpoints (i.e., MTCA uses the lowest-observed-adverse-effect-levels while the Eco-SSLs use the no-observed-adverse-effect-levels). However, the plant and soil biota Eco-SSLs are suitable alternative soil CULs because they include more recent and comprehensive toxicological datasets and were derived using more critical statistical methods. Therefore, the Eco-SSLs for plants and soil biota were used as alternative CULs for copper, lead, and zinc in evaluating remaining stations after STEP 1.

[24] Available online at http://www.epa.gov/ecotox/ecossl/.

The depth-weighted soil concentrations derived in STEP 1 that exceed CULs were compared to alternative CULs (i.e., Eco-SSLs) and these results are provided in Table H-2. Copper doesn't exceed the alternative CUL for plants or invertebrates. Mercury results do not change from STEP 1 because there are no Eco-SSLs for mercury. Lead and zinc exceed the alternative cleanup levels for plants at one or more stations:

- Lead concentrations exceed the alternative plant CUL (120 mg/kg) in two station (A8S and HA-07);
- Zinc concentrations exceed the alternative plant CUL (160 mg/kg) in two stations (A1S, A8S);
- Zinc concentrations exceed the alternative soil biota CUL (120 mg/kg) in three stations (A1S, A8S, B6S2).

STEP 3: Exposure-adjusted Soil Concentrations

Ecological receptors (e.g., plants, soil biota, and wildlife) are not homogeneously exposed to soil within the conditional POC (i.e., 0-6 feet). For example, roots of grasses typically occur within the upper one or two feet of soil. If residual metals are only present below the upper two feet, grasses are unlikely to be exposed to these metals. Therefore, exposure-adjusted soil concentrations were calculated to provide an improved estimate of ecological exposures.

Following completion of STEPS 1 and 2, receptors and metals associated with residual risks were identified at each sample location. Site-specific information was used to identify specific target receptors likely to inhabit the site. Since no site-specific information is available concerning the rooting depth of plants or burrowing depth of soil biota, literature surveys were conducted to identify appropriate information for estimating rooting and burrowing depths. The estimates of rooting and burrowing depths as well as information from the depth-weighted concentration step (STEP 1) were then used to estimate exposure adjusted soil concentrations at each sample location as shown in Equation 2.

Equation 2:

$$C_{ea} = (C_c \text{ x } P_c) + (C_r \text{ x } P_r)$$

Where:

C_{ea} = exposure-adjusted soil metal concentration (mg/kg)
C_c = soil cover metal concentration (mg/kg)
P_c = proportion of root or soil biota in soil cover layer (percentage)
C_r = residual soil metal concentration (mg/kg)
P_r = proportion of root or soil biota in residual soil layer (feet)

Exposure-adjusted soil concentrations were then compared to alternative soil CULs (STEP 2). Plant rooting depths were evaluated for three groups of plants (as required): grasses, shrubs, and trees. Jackson et al. (1996) developed root depth models for grasses, shrubs, and trees based upon empirical data obtained from a comprehensive review of the scientific literature. Suter et al. (2000) recommends the use of these rooting models to estimate plant exposure in ecological risk assessments. The models from Jackson et al. (1996) were used to estimate the exposure-adjusted soil concentrations for plants.

For soil biota, literature reviews were conducted to estimate the normal burrowing depths of soil macro-invertebrates likely to inhabit the site. The macro-invertebrate groups (e.g., earthworms, ants, beetles) with the deepest burrows were used to evaluate potential exposure of soil biota to residual metals concentrations in soil underlying the clean soil cover.

Results presented in Table H-2 show the receptors, metals, and sample stations associated with residual risks requiring further evaluation include:

- Plants, lead, station A8S
- Wildlife, lead, station A8S (evaluated in STEP 4)
- Plants and wildlife, lead, station HA-07 (evaluated in STEP 4)
- Soil biota, mercury, station A8S
- Soil biota, mercury, stations HA-01, HA-02, HA-03, HA-06, and HA-07 (evaluated in STEP 4)
- Plants, zinc, stations A1S and A8S
- Soil biota, zinc, station A1S, A8S, and B6S2

Remedial activities on the flat and unstable slope areas of the landfill that were completed in 2011 included backfilling excavations with a sand/gravel mixture (classified as poorly graded sand), adding a four-inch cover of top soil, and hydroseeding with a mixture of grasses and clover. The City Parks Department maintenance activities for this area include periodic mowing and weed-whacking to control the establishment of exotic plants (e.g., blackberry) and native shrubs and trees. The 2010 Little Squalicum Park Master Plan indicates the flat and unstable slope areas of the landfill will be used as a gathering area, primarily for students from BTC (Belt Collins 2010). There are currently no trees or shrubs growing on or directly adjacent to sample stations that require further evaluation.

The Birchwood/BTC storm channel area is an ephemeral drainage which typically contains water following rain events. Remedial activities included an initial excavation/removal of visible landfill debris. Confirmation sampling was then conducted showing some areas with soil metals contamination. A second action was conducted to address this contamination where excavation/removal was conducted down to an underlying silty clay layer. This second excavation/removal action occurred across the entire channel area to provide proper drainage. The storm channel area was then covered with a 0.5 to 1-foot thick impermeable silty clay layer and a 0.5 to 1-foot gravel layer. Much of the area was then covered with beauty bark and landscaped using a variety of shrubs and trees (CH2M Hill 2012).

For plants, exposure-adjusted soil concentrations were derived using the rooting depth model developed by Jackson et al. (1996). This model estimates the fraction of the root mass of major plant types (i.e., grasses, shrubs, and trees) that typically occur in the soil profile at varying depths. The model is shown in Equation 3.

Equation 3:

$$Y = 1 - \beta^d$$

Where:

Y = cumulative root fraction (percent) from soil depth *d* (cm)
β = extinction coefficient

The extinction coefficients provided in Jackson et al. (1996) are 0.952 for grasses, 0.978 for shrubs, and 0.97 for trees. The models predict the following cumulative root fractions (Figure H-1):

- Grasses – 50% in upper 14 cm (0.46 feet) and 90% in the upper 47 cm (1.55 feet)
- Shrubs – 50% in the upper 31 cm (1 foot) and 90% in the upper 104 cm (3.4 feet)
- Trees – 50% in the upper 23 cm (0.75 feet) and 90% in the upper 76 cm (2.5 feet)

It is unlikely shrubs or trees will become established on the flat and unstable slope areas of the landfill Site. Since the rooting depth of grasses is significantly less than shrubs and trees, it is unlikely grasses will be exposed to residual soil metals at sample stations A1S or A8S. Nevertheless, for the purposes of this evaluation it was conservatively assumed that shrubs and trees may become established at some point in the future.

Results of the exposure-adjusted soil concentrations evaluation for plants at stations A1S and A8S located on the unstable slope area of the landfill (Figure 7) are shown in Table H-3. Since the exposure-adjusted soil concentrations for grasses, shrubs, and trees potentially growing on or near stations A1S and A8S are below the alternative plant CULs, it is concluded that plants are not at risk.

No site-specific information is available characterizing the macro-invertebrate communities that may inhabit soil on and near sample stations A1S, A8S, and B6S2 which are located on the unstable slope area of the former landfill (Figure 7). However, we can use site-specific information on soil properties and published information on habitat requirements for groups of soil macro-invertebrates to help characterize the community that will likely populate the area and the burrowing depths of these groups.

The minimum cover depths[25] for sample stations of concern are 4.5 feet at station A1S, 3 feet at station A8S, and 5.5 feet at station B6S2 (Table H-2). The cover consists of 4 inches of top soil overlaying a sand/gravel mixture layer of variable depth (classified as poorly graded sand).

[25] The differences in elevation reported in Table H-2 were calculated as the differences between the before and after cleanup elevations. However, it is likely the station locations were excavated below the before cleanup elevation in some locations to remove landfill debris and contaminated soil. Therefore, the differences in elevation reported in Table H-2 are considered to represent the minimum cover depth.

Also, it is predicted that 90 percent of the root mass of grasses (the current and likely future vegetative cover on the site) will occur in the upper 1.5 feet on the soil profile (Figure H-1).

Many soil macro-invertebrates are herbivorous, feeding on live or decaying plant material (e.g., earthworms, crane fly larvae, beetle larvae, ants). These herbivorous animals tend to live either at the soil surface where organic matter is plentiful or in the portion of the soil profile that contains decaying vegetation or supports plant roots. For the area around stations A1S, A8S, and B6S2 this appears to be restricted to the upper 1.5 feet where 90 percent of grass roots are expected to occur. Carnivorous soil macro-invertebrates (e.g., centipedes, ants, spiders) tend to inhabit portions of the soil profile that contain potential prey, which is also typically within the upper 1.5 feet.

Several species of non-native earthworms inhabit the Bellingham area and may potentially occur on the Site. These species have a variety of feeding and burrowing strategies. While some earthworm species live and feed in the surface organic matter layer (e.g., red wiggler (*Eisenia fetida*)), others live in deep vertical burrows and come to the surface to forage at night or during rain events (e.g., night crawler (*Lumbricus terrestris*)). Earthworms are found in all but the driest and coldest land areas of the world (Lee 1985; Satchell 1983). Earthworms have basic environmental requirements that include adequate and suitable food supplies, adequate moisture, suitable temperature, adequate respiratory exchange, protection from light, suitable soil texture, and suitable pH and electrolyte concentrations (Lee 1985). Variation in these physical and chemical characteristics controls the presence, abundance, and diversity of earthworm populations in soils. Earthworms are absent or rare in soils with very coarse texture. The abrasiveness of coarse textured soil and the earthworm's susceptibility to drought limit the species composition and abundance of earthworms. For example, Hendrix et al. (1992) found that earthworm density dropped from 255 - 301 worms/m^2 in finer textured soils (55-65% sand/10-20% clay/25% silt) to 60 worms/m^2 in soil with relatively coarse texture (80% sand/15% clay/5% silt). The sand/gravel layer of the cover material placed on the landfill was reported to be 44% gravel, 55% sand, and 1% silt based on the contractor's submittal during construction (Herrenkohl Consulting and Wilson Engineering 2011b). This information suggests the sand/gravel layer of the cover will act as a barrier preventing earthworm exposure to residual metals concentrations present in the underlying soils. Therefore, it is concluded that earthworms will not be present in the area around stations A1S, A8S, and B6S2.

Considering the local climate and vegetative cover present on the flat and unstable slopes of the former landfill, soil- and ground-dwelling macro-invertebrates likely to inhabit this area include white grubs, crane fly larvae, grasshoppers, ants, centipedes, millipedes, pill/sow bugs, spiders, slugs or snails. The ability of these groups of macro-invertebrates to burrow into the soil is discussed in the following paragraphs.

White grubs are common soil-dwelling invertebrates typically associated with turfgrass in Western Washington. White grubs are the larvae of a number of different species of scarab beetle. The most common white grubs in the Pacific Northwest include *Aphodius granaris*, *A.*

pardalis, and May/June beetles (*Polyphaga* spp. and *Phyllophaga* spp.)[26] May/June beetle species typically have 2 to 4 year life-cycles where they spend most of the time as larvae in the soil feeding on plant material. Larvae typically feed within the upper 5 to 15 cm (2 to 6 in) during the summer months and may descend to 30 to 100 cm (12 to 39 in) during the winter months depending on moisture and temperature (Carpinera 2001). In Washington State, mature grubs of the tenlined June beetle feed in the upper one foot of soil, while smaller/younger grubs feed on finer roots at greater depth[27]. In Oregon, June beetles grubs (*Polyphylla spp.*) burrow 20 to 55 cm (8 to 22 in) into the soil in the winter and remain inactive until the following spring[28]. This information suggests that white grubs will not become exposed to residual metals found in soil below the minimum three feet of clean cover present in the area around stations A1S, A8S, and B6S2.

The European crane fly is a serious pest in lawns, pastures, and hayfields of northwestern Washington (Jackson and Campbell 1975). Eggs are laid in August and September and larvae emerge within two weeks feeding on plant roots until pupation begins in mid-July of the following year. Adults emerge in mid-August through September. Larvae inhabit the upper four inches of the soil profile (Jackson and Campbell 1975). Therefore, crane fly larvae will not become exposed to residual metals found in soil below the minimum three feet of clean cover present in the area around stations A1S, A8S, and B6S2.

Several species of grasshoppers may occur within the Bellingham area including red-winged, meadow, Carolina, red-legged, two-stripped, migratory, and red-shanked grasshoppers[29]. They are commonly associated with grassland or grassland/shrub habitats where nymph and adult stages may be observed feeding on vegetation. Eggs are deposited in the shallow soil during summer and fall. Eggs over-winter in the soil and hatch the following spring when the nymphs emerge. The grasshopper life cycle precludes exposure to residual metals present at depths of three feet or more.

Many ant species construct their nests under rocks, fallen woody material, or other material that provides protection from rain and predators. However, many other species construct subterranean nests. Subterranean ant nests typically consist of several more or less vertical shafts and several more or less horizontal chambers (Tschinkel 2005). Two relevant studies were found characterizing the nest depths of ants. Both studies were in Florida and were conducted on sandy soils which presumably did not limit nesting depth. Tschinkel (2005) found the depth of 24 nests of *Camponotus socius* to range from 21 cm (8 in) to 60 cm (approximately 2 feet). Williams and Lofgren (1988) found the nest depth of seven different species of ants to vary from 3 cm (approximately 1 in) to 47 cm (approximately 1.5 feet). Based upon this information the maximum subterranean nest depth for ants at the Site is expected to be

[26] The Pacific Northwest Insect Management Handbook available online at http://pnwhandbooks.org/insect/hort/turfgrass/turfgrass-white-grub
[27] Washington State University Orchard Pest Management Online available at http://jenny.tfrec.wsu.edu/opm/displayspecies.php?pn=640
[28] *www.rngr.net/publications/ghs/**june-beetle**-white-grubs/at.../file*
[29] U.S. Department of Agriculture Grasshoppers website available online at http://www.sidney.ars.usda.gov/grasshopper/index.htm

approximately 2 feet. Since the minimum depth of clean soil cover at sample stations A1S, A8S, and B6S2 is three feet, it is concluded that ants will not be exposed to residual metals concentrations in the soil underlying the clean cover.

Several other groups of macro-invertebrates including centipedes, millipedes, sow/pill bugs, spiders, slugs, and snails are commonly observed living in close contact with the soil. These invertebrates are more often found under logs, rocks, and other debris or within rotting logs and other organic debris where they are protected from predators and dehydration. While many groups are herbivorous (e.g., millipedes and pill/sow bugs), some are predatory (e.g., centipedes and spiders). Some groups such as centipedes and slugs can lay their eggs in the soil, while others like the sow/pill bugs hold their eggs in brood pouches. Following hatching, the young of all these groups take on their adult life styles living on or near the soil surface. None of these macro-invertebrates will be exposed to residual metals found in soils at depths of three feet or greater.

Based on the preceding information, soil-dwelling macro-invertebrates likely to occur around sample station A1S, A8S, and B6S2 include white grubs, crane fly larvae, grasshoppers, ants, centipedes, millipedes, pill/sow bugs, spiders, slugs or snails. The coarse texture of the sand/gravel mixture cover should inhibit the establishment of earthworm populations at depth in these areas. The preceding information indicates that white grubs and ants have the greatest ability to burrow deeply into the soil. However, it is unlikely they will reach the minimum depth of three feet where they might become exposed to residual metals concentrations in soils at or near sample station A1S, A8S, and B6S2. Therefore, it is concluded that soil-dwelling macro-invertebrates are not at risk in the areas represented by these locations.

STEP 4: Other Considerations

Sample station A8S with a depth-weighted lead concentration of 167 mg/kg (Table H-2) is a potential concern for wildlife because it exceeds the MTCA ISC of 118 mg/kg. However, the lead concentration of 167 mg/kg is less than 2-times the ISC of 118 mg/kg and less than 10 percent of Site soil samples that exceed the 118 mg/kg concentration[30]. So, the Site meets the MTCA three-part cleanup requirement and no further remedial action is required to address the residual lead present in soil at sample station A8S[31].

Sample station HA-07 is located within the Birchwood/BTC storm channel and has a soil concentration of lead (222 mg/kg) exceeding the plant Eco-SSL of 120 mg/kg and the wildlife ISC of 118 mg/kg. The 222 mg/kg lead concentration is a worst-case estimate of the residual soil lead concentration at station HA-07 because additional excavation (0.5 ft) occurred at this location after this sample was collected and it is likely that all excess lead was removed. Nonetheless, these results indicate the Site complies with the 3-part cleanup requirement in that the concentration of lead at station HA-07 (222 mg/kg) is less than 2-times the plant Eco-SSL

[30] Data presented in Table G-6 and amended with the depth-weighted concentrations in Table H-2 shows that less than 10 percent of Site samples have lead concentrations greater than 118 mg/kg.
[31] The three part rule is the 95% UCL is less than the CUL (see Table G-7), no sample can be greater than 2-times the CUL, and less than 10 percent of samples can be greater than the CUL.

(120 mg/kg) and less than 2-times the wildlife ISC (118 mg/kg), less than 10 percent of Site soil samples exceed the CULs, and the 95% UCL for the Site is less than the CULs (see preceding paragraph for details). Therefore, no further remedial action is required to address lead at sample station HA-07.

Concentrations of mercury at sample stations HA-01, HA-02, HA-03, HA-06, and HA-07 located within the Birchwood/BTC storm channel excavation range from 0.11 to 0.19 mg/kg and are above the soil biota ISC of 0.1 mg/kg, but below the plant ISC of 0.3 mg/kg and wildlife ISC of 5.5 mg/kg (Table H-2). Mercury is not considered to pose a risk to soil macro-invertebrates in the BTC/Birchwood storm channel area because:

- The mercury concentrations for these stations (Table H-2) are worst-case estimates of the residual mercury present in the soil because additional soil excavation/removal (from 0.5 to 5.0 ft) occurred after these samples were collected and it is likely that all or most of the excess mercury was subsequently removed.

- The storm channel was covered with a 0.5 to 1.0-foot impermeable silty clay layer and a 0.5 to 1.0-foot layer of sandy gravel following excavation/removal of visible landfill debris and contaminated soil. This cover does not provide habitat conducive to the establishment and maintenance of a diverse and abundant macro-invertebrate community.

- Although EPA did not provide Eco-SSLs for mercury, the Canadian Council of Ministers of the Environment (CCME) derived an environmental soil quality guideline (SQG) of 12 mg/kg which is considered to be protective of soil invertebrates, plants, and wildlife (CCME 1999). Mercury concentrations shown in Table H-2 for sample stations HA-01, HA-02, HA-03, HA-06, and HA-07 are well below the CCME environmental SQG.

Uncertainties and Conclusions

Major uncertainties associated with the post-interim action ecological risk assessment include:

- The depth-weighted concentrations calculated for the flat and unstable slope areas of the landfill described in STEP 1 likely overestimate exposure concentrations within the conditional POC (0-6 feet) because they do not account for the depth of excavation below the original soil surface. It is therefore likely that the depth of the cover layer is deeper then shown in Tables H-1 and H-2.

- Alternative CULs for plants and soil biota were used in STEP 2 (i.e., Eco-SSLs). MTCA allows for substitute values to be considered under WAC 173-340-7493(6).

- In STEP 3, it was assumed that grasses, shrubs, and trees might become established on the flat and unstable slope areas of the landfill. However, currently the vegetative cover consists of grasses and clover, and landscape management practices are implemented to maintain the grass/clover vegetative cover. Since grasses have much shallower roots systems then shrubs or trees, exposures and risks to plants are likely to be over-estimated.

- In STEP 3, information is presented that demonstrates that soil macro-invertebrates likely to inhabit the flat and unstable slope areas of the landfill Site will not burrow deep enough to become exposed to residual metals in the underlying soil (e.g., soil located below a depth of three feet). Although one cannot be absolutely sure of this conclusion, it is consider highly unlikely that soil macro-invertebrates would be significantly exposed to residual metals concentrations.

- In STEP 4, potential risks to soil macro-invertebrates from mercury in the Birchwood/BTC storm channel were addressed using a qualitative exposure assessment and supplemental toxicity assessment. Although there is a moderate degree of uncertainty associated with this evaluation, confidence in the conclusion that soil macro-invertebrates are not at risk is high.

In conclusion, this post interim action ecological risk assessment provides sufficient information to conclude that ecological receptors will not be at risk from residual soil metals concentrations present or potentially present on the landfill Site. The Site complies with the MTCA 3-part cleanup requirement demonstrating that no further cleanup action is required to address ecological risks.

9 MINIMUM REQUIREMENTS FOR CLEANUP ACTION

The interim action meets the minimum requirements for an overall cleanup action for the Site under WAC 173-340-360(2)[a] and [b] as summarized below.

- Site soil conditions post-interim action are protective of human health and the environment as described in Section 8.3 above.
- Site groundwater complies with CULs. Groundwater concentrations in confirmation samples collected after completion of the interim action are in compliance with CULs and the leaching pathway is not of concern for the Site.
- The interim action complied with applicable laws and substantive requirements as required in the amendment to the Agreed Order and described in the EDR and construction completion report.
- Compliance monitoring conducted as part of the interim action including performance soil sampling during construction and confirmation groundwater monitoring after completion (refer to Section 7.4).
- Municipal wastes and contaminated soils were removed from the Site preventing further risk from direct contact by both humans and ecological receptors and potential contamination of surface water and groundwater, and providing long-term effectiveness and permanence (refer to Sections 8.1 and 8.3).
- The interim action provided the shortest restoration time frame by permanent removal of the landfill debris and contaminated soil, without changing the current Site use (i.e., Public Park) or affecting surrounding property use.
- The public was invited to review and provide comments on the amendment to the Agreed Order describing the interim action for the Site. The 30-day review and comment period was accomplished in June and July 2011. No public comments were received. The public will also be invited to review and provide comments (30-day period) on this public review draft RI/FS report.

10 SUMMARY AND CONCLUSIONS

The RI/FS conducted for the Eldridge Municipal Landfill Site resulted in the following findings:

- In the mid- to late-1930s, the City had used a portion of the Park as a sanitary landfill for burning and burying local municipal waste hauled by a garbage collection contractor. The landfill was operated for only a few years before operations ceased.
- The remains of the landfill were located in the northeastern portion of the Park west of the BTC campus parking lot. The landfill was discovered during the field investigation in support of the draft Park RI.
- The types of municipal garbage observed consisted of glass bottles, metal scraps, ash, ceramics, construction debris, and various indiscernible rusted materials.
- Elevated levels of heavy metals (e.g., lead) were detected in the soils with the highest concentrations observed from 2 ft to 4 ft bgs. Six metals (arsenic, cadmium, copper, lead, mercury, zinc) and pentachlorophenol were detected in the landfill at levels determined to pose a threat to human health and the environment.
- Based on soil investigations from 2005 to 2010, the lateral distribution of municipal wastes and contaminated soil was estimated at 19,000 ft^2. The vertical distribution was observed to a depth of up to 4 ft bgs.
- In the summer of 2010, approximately 500 cy of mixed municipal wastes and soil were removed from a 6,000 ft^2 area and stockpiled (with cover) onsite in support of constructing a new creek channel in the Park by EPA.

A draft RI/FS report for the landfill Site, with a preferred cleanup alternative, was submitted to Ecology for their review in February 2010. After review by Ecology and further discussion between parties, the City agreed to conduct an interim action for the Site in summer 2011. The interim action was conducted under an amendment to Agreed Order No. DE 8073 between the City and Ecology and included removal of the stockpiled fill materials and the excavation of the upper four feet (in some areas more) of municipal waste and the soil from Site areas that exceed RLs.

After completion of the interim action for the landfill Site, the following findings and conclusions are made:

- A total of about 4,290 tons of landfill debris and contaminated soil was removed from the Site in support of the interim action and transported to Roosevelt Regional Landfill in Washington State for proper disposal. The excavation was stabilized, backfilled with clean soil, and vegetated by hydroseeding. In addition, a 750 ft^2 depressional wetland was created within the project area.

- Performance monitoring conducted during the interim action showed most of the landfill materials had been removed from the Site except for a few locations either on steep, unstable slopes or encroaching into Site wetlands. Soil concentrations in performance samples, with the exception of soil adjacent to an existing wetland and Cottonwood tree, and surrounding steep slopes, were determined to be protective of human health via direct contact with soil and protective of soil biota, plants, and wildlife.

- Groundwater concentrations in confirmation samples collected after completion of the interim action indicate that groundwater complies with CULs and the leaching pathway is not of concern for the Site. No additional confirmation monitoring is required for the Site. However, re-sampling and analyzing for arsenic at MW-03 and possibly other site monitoring wells is appropriate to check the validity of the initial results. The additional sampling and testing does not preclude completing this RI/FS report.

- Site conditions post-interim action are protective of human health and the environment and meet MTCA minimum requirements for an overall cleanup action. No additional remediation of the Site is required. For the residual metal contamination remaining under the old wetland and the Cottonwood tree, this area will be classified as a critical habitat by the City and a restrictive covenant will be required for the property.

- A DCAP is required for the Consent Decree to address long-term care of the site with residual metal contamination. The DCAP will include a requirement for additional groundwater monitoring to confirm the arsenic concentrations in Site groundwater and a restrictive covenant for the property as described above. It will also include a requirement for additional wetland planting for the 750 ft^2 depressional wetland created as part of the interim action.

The revised site boundary is estimated to be approximately 32,000 ft^2 as shown in Figure 12. The revision is based on visual observations and performance monitoring sampling and testing conducted during the Birchwood/BTC channel excavation and interim action. It assumes the following:

- Landfill debris and contaminated soils lie under the existing wetland (wetland A) and the Cottonwood tree located at the northwestern portion of the landfill Site.

- The access road (currently a crushed limestone covered trail), adjacent to the existing wetland and Cottonwood tree, is the landfill Site northern boundary based on visual observations made during re-construction of this road in support of the EPA Removal Action.

- The Birchwood/BTC storm drain excavation is the western boundary of the landfill Site. This is based on visual observations, sampling and testing results, and additional soil excavation conducted by the EPA contractor after performance monitoring sampling had been concluded as part of the final channel construction.

- Additional soil and debris are located on the slopes along the southern boundary of the final excavation.

This document is being issued for public review concurrently with the proposed Consent Decree and DCAP (legal agreement).

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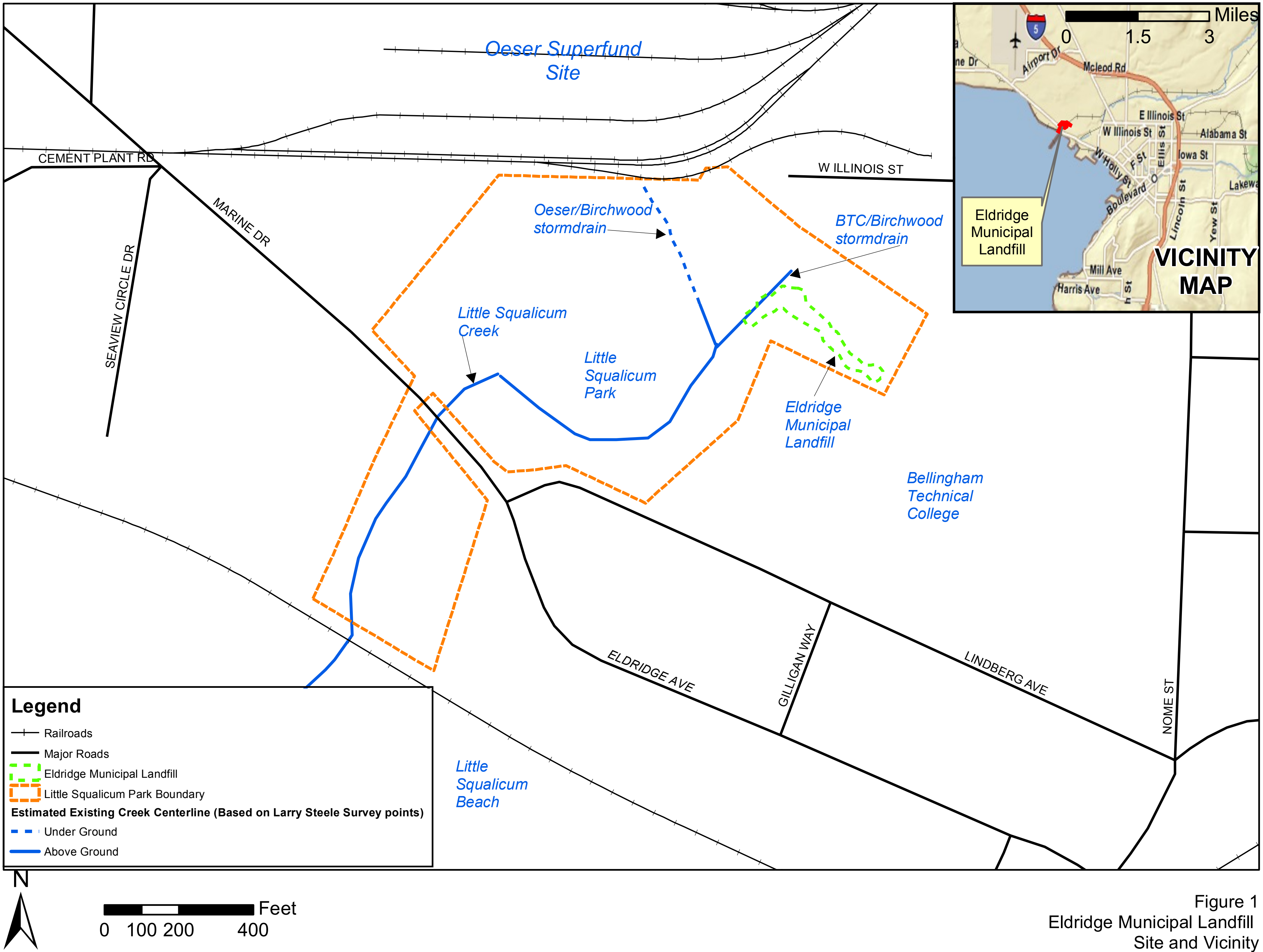
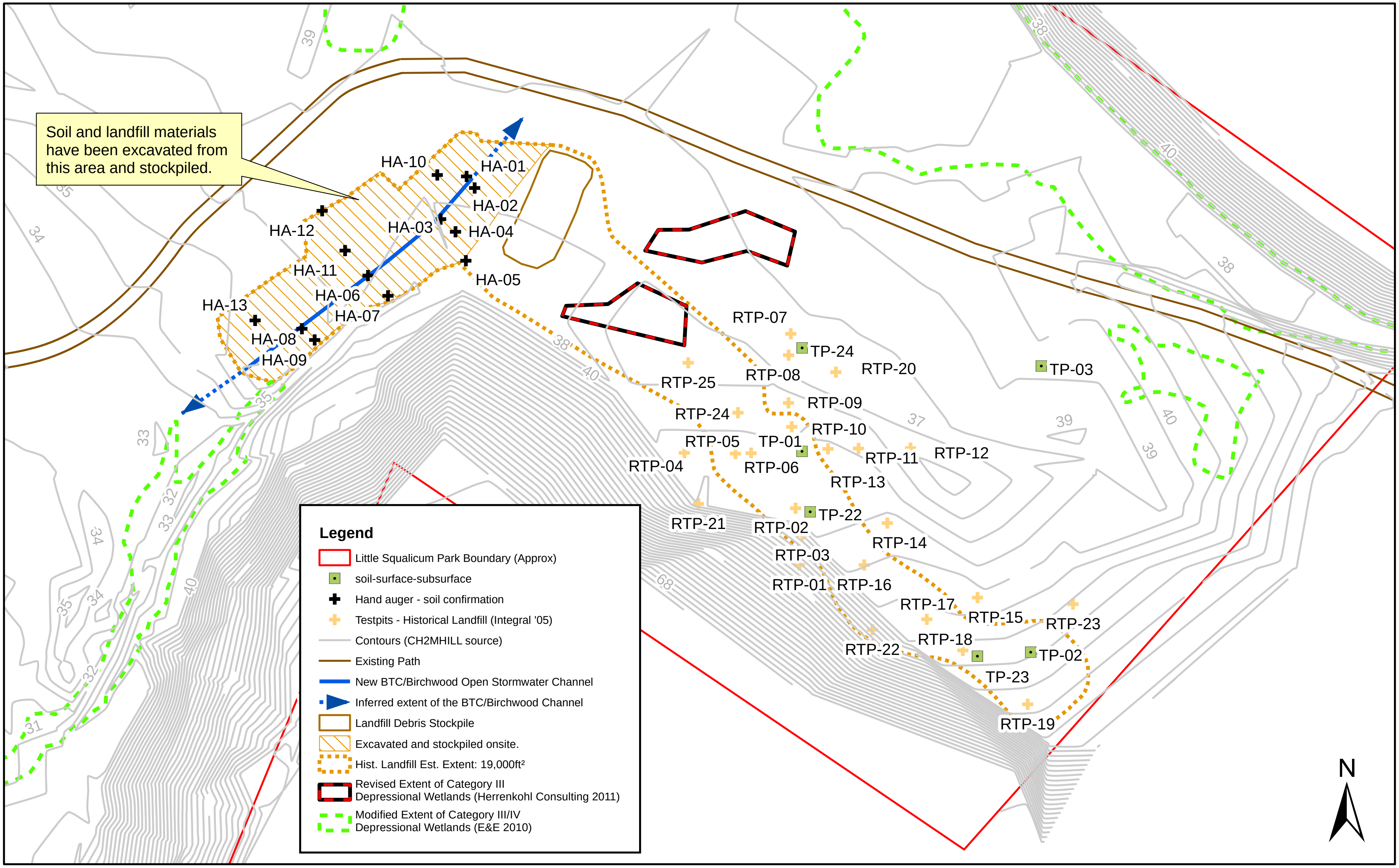


Figure 1
Eldridge Municipal Landfill
Site and Vicinity
Bellingham, WA



Herrenkohl Consulting LLC

0 30 60 120 180 Feet

1 in = 60 ft

Figure 2
Eldridge Municipal Landfill
Base Map

*Survey data horizontal datum is WA State Plane 1983, WA-North, NAD83-HARN, US Feet
*Survey data vertical datum is NAVD88
*Topographic contour lines were provided by CH2M Hill from the Little Squalicum Park Topographic Survey completed by White Shield, Inc dated August 21, 2008.
* Wetlands delineation completed by Ecology and Environment 2010 for CH2M Hill and EPA in support of Little Squalicum Creek removal action.
* Revised wetland delineation completed by Herrenkohl Consulting Feb 2011.

Receptors of Concern

Exposure Medium	Exposure Pathway	Human Receptors: Park Workers	Human Receptors: Park Visitors	Human Receptors: Transients	Terrestrial Receptors: Terrestrial Plants	Terrestrial Receptors: Soil Invertebrates	Terrestrial Receptors: Terrestrial Birds	Terrestrial Receptors: Terrestrial Mammals[a]
Surface soil	Ingestion	■	■	■	x	■	■	■
	Contact	■	■	■	■	■	■	□
Subsurface soil	Ingestion	■	□	□	x	□	x	□
	Contact	■	□	□	■	□	x	□
Groundwater	Ingestion	x	x	x	x	x	x	x
	Contact	x	x	x	x	x	x	x
Surface water	Ingestion	x	x	x	x	x	x	x
	Contact	x	x	x	x	x	x	x
Air	Inhalation	□	□	□	x	x	□	□
Terrestrial plants	Ingestion	x	■	■	x	x	□	■
	Contact	□	□	□	x	x	□	□
Terrestrial animals	Ingestion	x	x	x	x	□	■	■

LEGEND

■ = Complete and potentially important exposure pathway

□ = Complete but not likely important exposure pathway

x = Incomplete exposure pathway

NOTE

[a] Terrestrial mammals include domestic pets.

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Figure 3. Conceptual Site Model for Receptors and Exposure Pathways

TP-22 (ft)	0-0.5	0.5-1.7	1.7-2.2
As	10 U	13	40 U
Cd	0.1 U	0.6	8
Cu	57.7	104	282
Pb	134.5	222	3970
Hg	0.18	0.33	1.2
Zn	197	244	2960
PCP	--	--	--

TP-01 (ft)	0-1	1-2	2-3	3-4	4-5
As	0.9 U	2 U	8	6	0.9 U
Cd	0.65	3.1	1.9	0.4	0.05 U
Cu	49.7	124	106	61.9	22
Pb	121.5	1270	107	18	3
Hg	0.185	0.36	0.2	0.17	0.003 U
Zn	163	1230	638	87.4	44.6
PCP	--	--	--	--	--

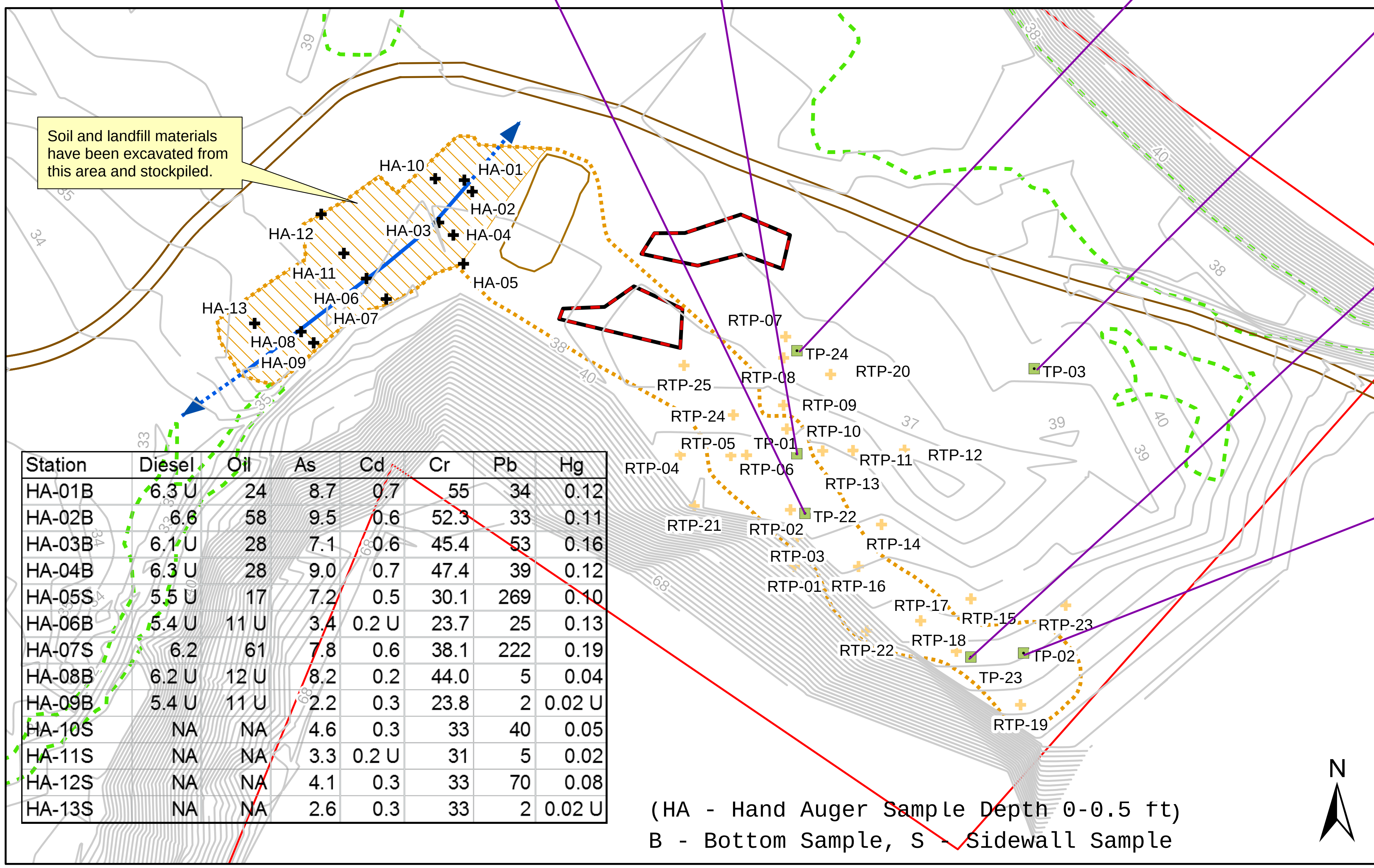
TP-24 (ft)	0-1.5	> 1.5
As	6	1 U
Cd	0.05 U	0.06 U
Cu	52.1	64.3
Pb	50	160
Hg	0.08	0.16
Zn	80.7	178
PCP	--	--

TP-03 (ft)	0-1	1-2
As	1 U	9
Cd	0.6	0.05 U
Cu	22.7	31.3
Pb	19	23
Hg	0.004 U	0.05
Zn	96.7	81.3
PCP	--	--

Key	
Units	mg/kg
As	Arsenic
Cd	Cadmium
Cu	Copper
Pb	Lead
Hg	Mercury
Zn	Zinc
PCP	Pentachlorophenol
--	Not analyzed
U	Not detected
J	Estimate value

TP-23 (ft)	0-2	2-3.5	3.5-4	4-4.5	4.5-5
As	10	2 U	10 U	8	0.9 U
Cd	1.2	1.3	10	1	0.04 U
Cu	113	126	409	104	23.7
Pb	285	371	1290	32	5
Hg	0.26	0.24	1.62	0.22	0.003 U
Zn	505	440	3060	200	204
PCP	0.35 J	--	0.046 UJ	--	--

TP-02 (ft)	0-1	1-1.6	1.6-2.9	2.9-3.7	3.7-4.2	4.2-5.3
As	1 U	7	0.9 U	1 U	11	0.8 U
Cd	0.7	0.7	0.4	0.8	1	0.4
Cu	42.35	63.2	21.2	50.4	92.6	23.8
Pb	106.5	74	15	233	43	7
Hg	0.065	0.07	0.002 U	0.18	0.19	0.003 U
Zn	110.5	128	61.6	168	235	74.3
PCP	--	--	--	--	--	--



Station	Diesel	Oil	As	Cd	Cr	Pb	Hg
HA-01B	6.3 U	24	8.7	0.7	55	34	0.12
HA-02B	6.6	58	9.5	0.6	52.3	33	0.11
HA-03B	6.1 U	28	7.1	0.6	45.4	53	0.16
HA-04B	6.3 U	28	9.0	0.7	47.4	39	0.12
HA-05S	5.5 U	17	7.2	0.5	30.1	269	0.10
HA-06B	5.4 U	11 U	3.4	0.2 U	23.7	25	0.13
HA-07S	6.2	61	7.8	0.6	38.1	222	0.19
HA-08B	6.2 U	12 U	8.2	0.2	44.0	5	0.04
HA-09B	5.4 U	11 U	2.2	0.3	23.8	2	0.02 U
HA-10S	NA	NA	4.6	0.3	33	40	0.05
HA-11S	NA	NA	3.3	0.2 U	31	5	0.02
HA-12S	NA	NA	4.1	0.3	33	70	0.08
HA-13S	NA	NA	2.6	0.3	33	2	0.02 U

Map Legend

- soil-surface-subsurface
- Contours (CH2MHILL source)
- Existing Path
- Hand auger - soil confirmation
- Testpits - Historical Landfill (Integral '05)
- Landfill Debris Stockpile
- New BTC/Birchwood Open Stormwater Channel
- Excavated and stockpiled onsite.
- Hist. Landfill Est. Extent: 19,000ft²
- Revised Extent of Category III Depressional Wetlands (Herrenkohl Consulting 2011)
- Modified Extent of Category III/IV Depressional Wetlands (E&E 2010)
- Little Squalicum Park Boundary (Approx)

Herrenkohl Consulting LLC

0 30 60 120 180 Feet

1 in = 60 ft

*Survey data horizontal datum is WA State Plane 1983, WA-North, NAD83-HARN, US Feet
*Survey data vertical datum is NAVD88
*Topographic contour lines were provided by CH2M Hill from the Little Squalicum Park Topographic Survey completed by White Shield, Inc dated August 21, 2008.
* Wetlands delineation completed by Ecology and Environment 2010 for CH2M Hill and EPA in support of Little Squalicum Creek removal action.
* Revised wetland delineation completed by Herrenkohl Consulting Feb 2011.

Figure 4
Eldridge Municipal Landfill
Data Summary of Proposed Final IHSs in Soils

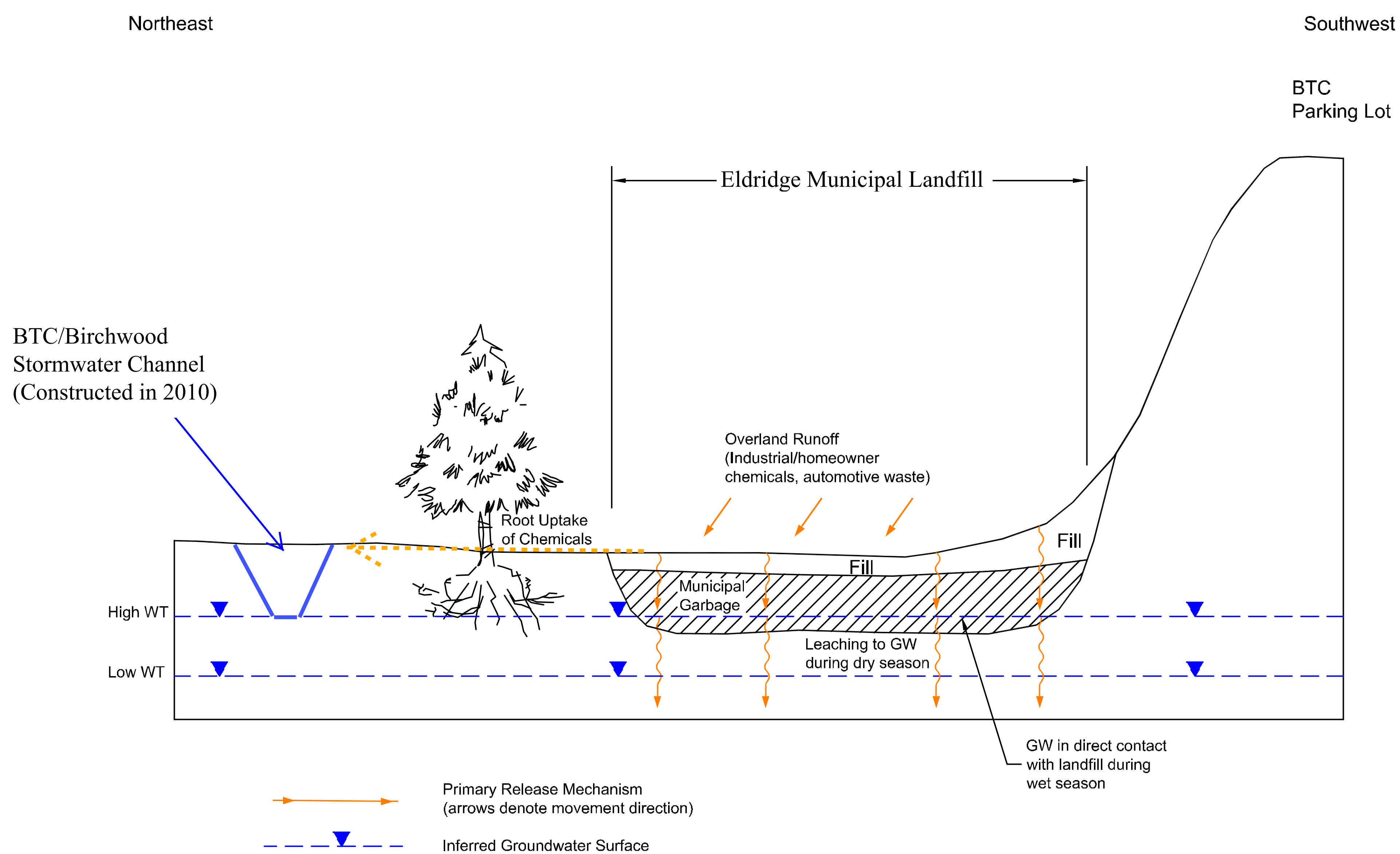


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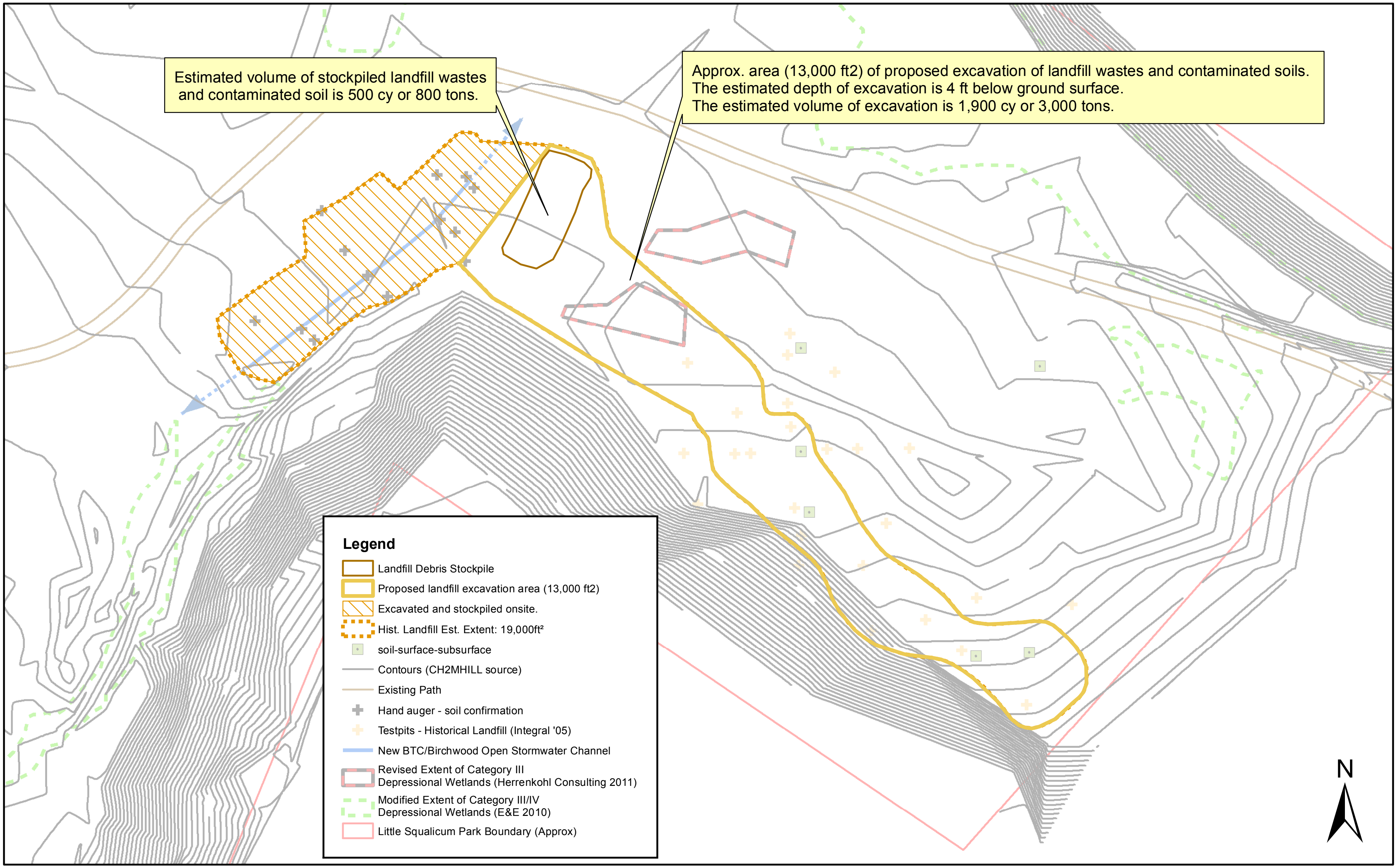
Figure 5

Conceptual Site Model of Contaminant Transport in the Vicinity of the Historical Landfill



Herrenkohl Consulting LLC

0 30 60 120 180 Feet

1 in = 60 ft

*Survey data horizontal datum is WA State Plane 1983, WA-North, NAD83-HARN, US Feet
*Survey data vertical datum is NAVD88
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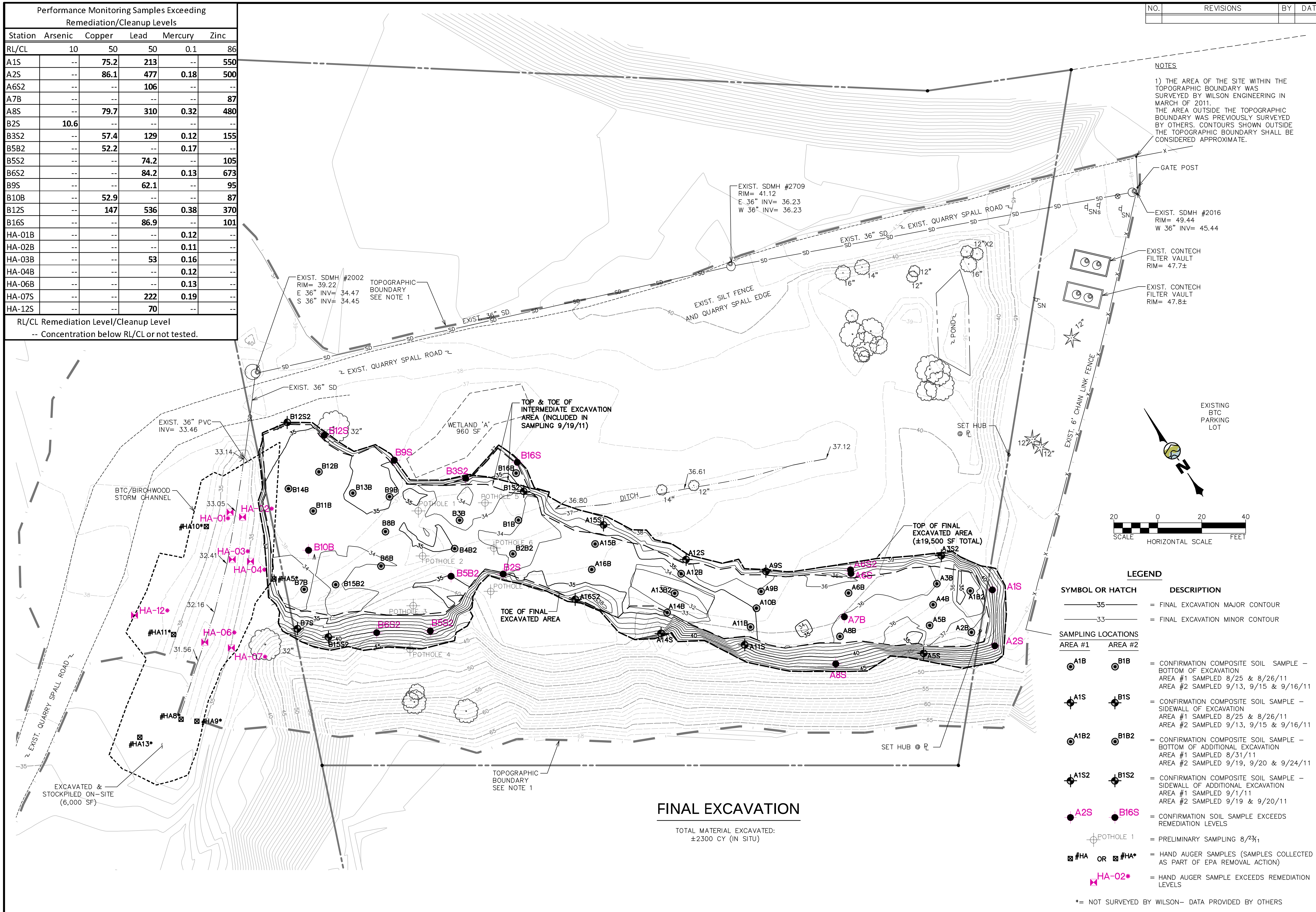
* Revised Wetland delineation completed by Herrenkohl Consulting Feb 2011

Figure 6
Eldridge Municipal Landfill
Design Concept, Preferred Cleanup Alternative

Performance Monitoring Samples Exceeding Remediation/Cleanup Levels

Station	Arsenic	Copper	Lead	Mercury	Zinc
RL/CL	10	50	50	0.1	86
A1S	--	75.2	213	--	550
A2S	--	86.1	477	0.18	500
A6S2	--	--	106	--	--
A7B	--	--	--	--	87
A8S	--	79.7	310	0.32	480
B2S	10.6	--	--	--	--
B3S2	--	57.4	129	0.12	155
B5B2	--	52.2	--	0.17	--
B5S2	--	--	74.2	--	105
B6S2	--	--	84.2	0.13	673
B9S	--	--	62.1	--	95
B10B	--	52.9	--	--	87
B12S	--	147	536	0.38	370
B16S	--	--	86.9	--	101
HA-01B	--	--	--	0.12	--
HA-02B	--	--	--	0.11	--
HA-03B	--	--	53	0.16	--
HA-04B	--	--	--	0.12	--
HA-06B	--	--	--	0.13	--
HA-07S	--	--	222	0.19	--
HA-12S	--	--	70	--	--

RL/CL Remediation Level/Cleanup Level
-- Concentration below RL/CL or not tested.



FINAL EXCAVATION

TOTAL MATERIAL EXCAVATED: ±2300 CY (IN SITU)

NO.	REVISIONS	BY	DATE

WILSON ENGINEERING, LLC
805 DUPONT STREET
BELLINGHAM, WA 98225
(360) 733-6100 • FAX (360) 647-9061
www.wilsonengineering.com
Wilson SURVEY/ENGINEERING

DESIGNED BY | DRAWN BY RDN | CHECKED BY

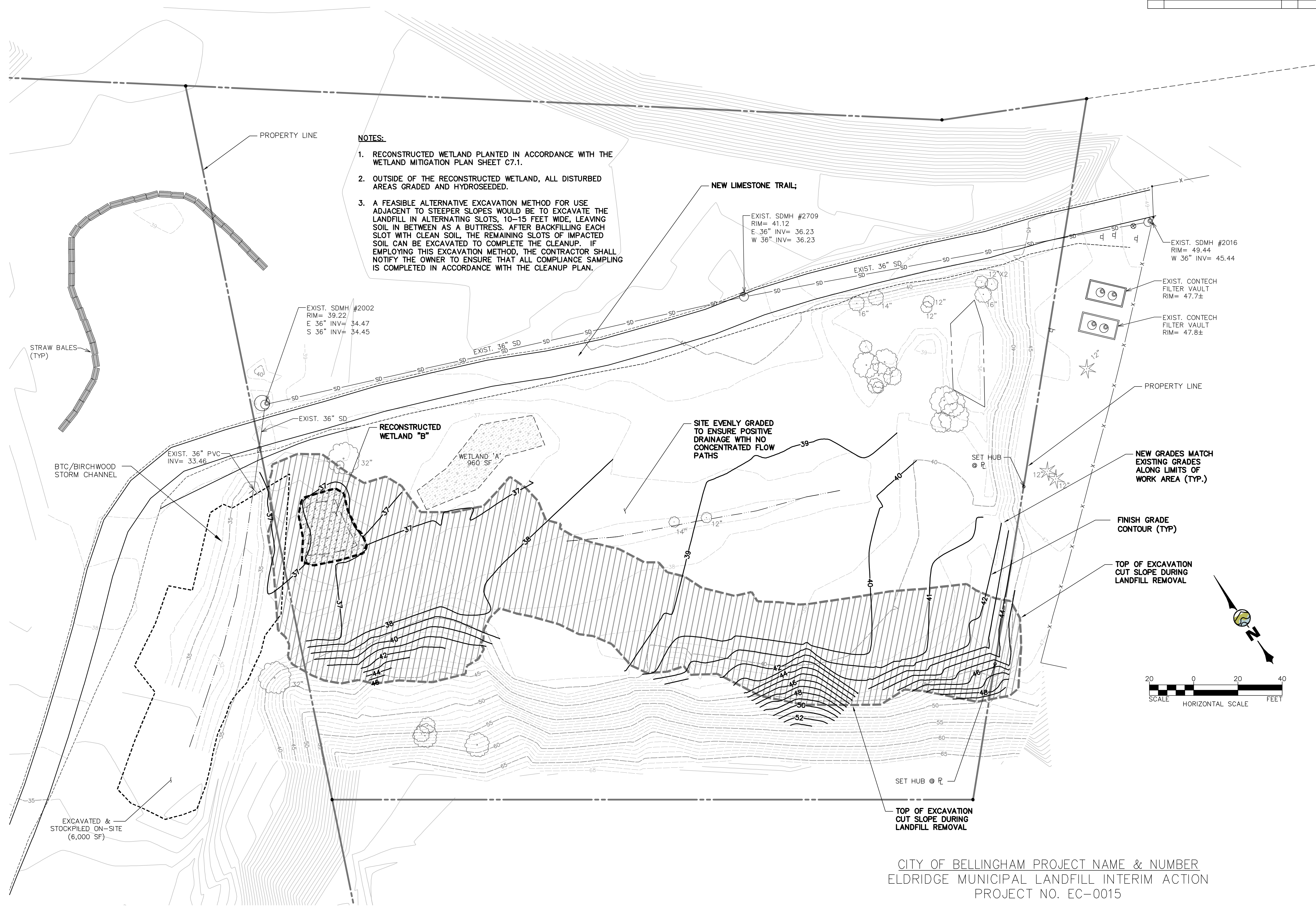
CITY OF BELLINGHAM

BELLINGHAM WASHINGTON

ELDRIDGE MUNICIPAL LANDFILL INTERIM ACTION PERFORMANCE MONITORING SAMPLED LOCATIONS AND RESULTS

DATE FEBRUARY 2014 | SCALE AS SHOWN | JOB NUMBER 2014-016

SHEET FIG 7 OF -



NOTES:

1. RECONSTRUCTED WETLAND PLANTED IN ACCORDANCE WITH THE WETLAND MITIGATION PLAN SHEET C7.1.
2. OUTSIDE OF THE RECONSTRUCTED WETLAND, ALL DISTURBED AREAS GRADED AND HYDROSEEDED.
3. A FEASIBLE ALTERNATIVE EXCAVATION METHOD FOR USE ADJACENT TO STEEPER SLOPES WOULD BE TO EXCAVATE THE LANDFILL IN ALTERNATING SLOTS, 10–15 FEET WIDE, LEAVING SOIL IN BETWEEN AS A BUTTRESS. AFTER BACKFILLING EACH SLOT WITH CLEAN SOIL, THE REMAINING SLOTS OF IMPACTED SOIL CAN BE EXCAVATED TO COMPLETE THE CLEANUP. IF EMPLOYING THIS EXCAVATION METHOD, THE CONTRACTOR SHALL NOTIFY THE OWNER TO ENSURE THAT ALL COMPLIANCE SAMPLING IS COMPLETED IN ACCORDANCE WITH THE CLEANUP PLAN.

CITY OF BELLINGHAM PROJECT NAME & NUMBER
ELDRIDGE MUNICIPAL LANDFILL INTERIM ACTION
PROJECT NO. EC–0015

NO.	REVISIONS	BY	DATE

WILSON ENGINEERING, LLC
805 DUPONT STREET
BELLINGHAM, WA 98225
(360) 733-6100 • FAX (360) 647-9061
www.wilsonengineering.com
Wilson SURVEY/ENGINEERING

ANNE STERLING ELIZABETH · STATE OF WASHINGTON · REGISTERED PROFESSIONAL ENGINEER

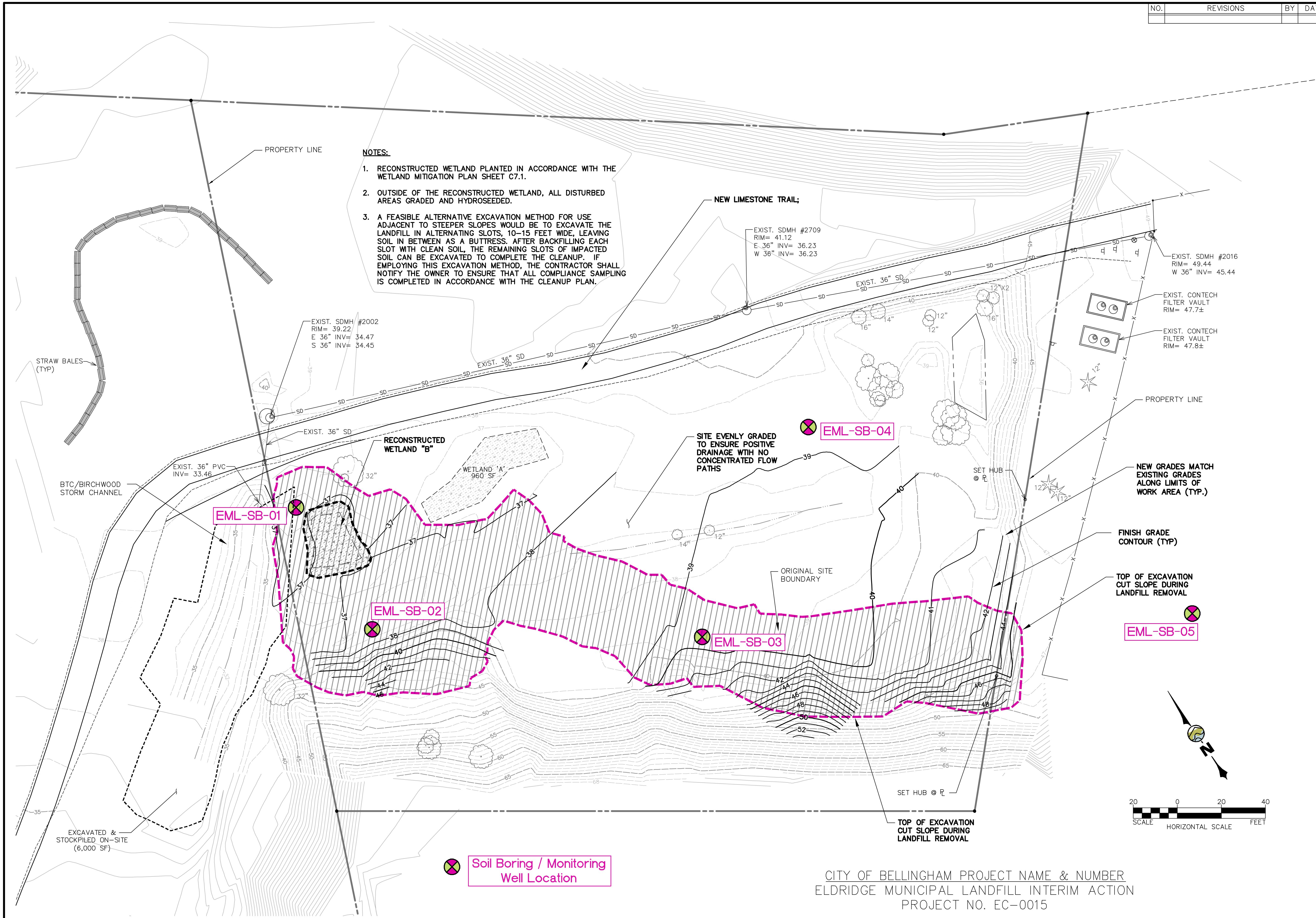
DESIGNED BY EAS
DRAWN BY JGS/BAH/RDN
CHECKED BY

CITY OF BELLINGHAM
BELLINGHAM WASHINGTON
ELDRIDGE MUNICIPAL LANDFILL INTERIM ACTION
FINISH GRADING PLAN

DATE FEBRUARY 2014
SCALE AS SHOWN
JOB NUMBER 2014-016

SHEET FIG 8 OF -

W:\2014\2014-016 Herrenkohl Consulting - Eldridge Municipal Landfill RI-FS Report\Dwg\Exhibits\Fig8 Finish GRADING PLAN.dwg, 2/20/2014 9:55:04 AM, PDF-XChange for AcroPlot Color Pres.pc3, RDN



NOTES:

1. RECONSTRUCTED WETLAND PLANTED IN ACCORDANCE WITH THE WETLAND MITIGATION PLAN SHEET C7.1.
2. OUTSIDE OF THE RECONSTRUCTED WETLAND, ALL DISTURBED AREAS GRADED AND HYDROSEEDED.
3. A FEASIBLE ALTERNATIVE EXCAVATION METHOD FOR USE ADJACENT TO STEEPER SLOPES WOULD BE TO EXCAVATE THE LANDFILL IN ALTERNATING SLOTS, 10–15 FEET WIDE, LEAVING SOIL IN BETWEEN AS A BUTTRESS. AFTER BACKFILLING EACH SLOT WITH CLEAN SOIL, THE REMAINING SLOTS OF IMPACTED SOIL CAN BE EXCAVATED TO COMPLETE THE CLEANUP. IF EMPLOYING THIS EXCAVATION METHOD, THE CONTRACTOR SHALL NOTIFY THE OWNER TO ENSURE THAT ALL COMPLIANCE SAMPLING IS COMPLETED IN ACCORDANCE WITH THE CLEANUP PLAN.

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ELDRIDGE MUNICIPAL LANDFILL INTERIM ACTION
PROJECT NO. EC–0015

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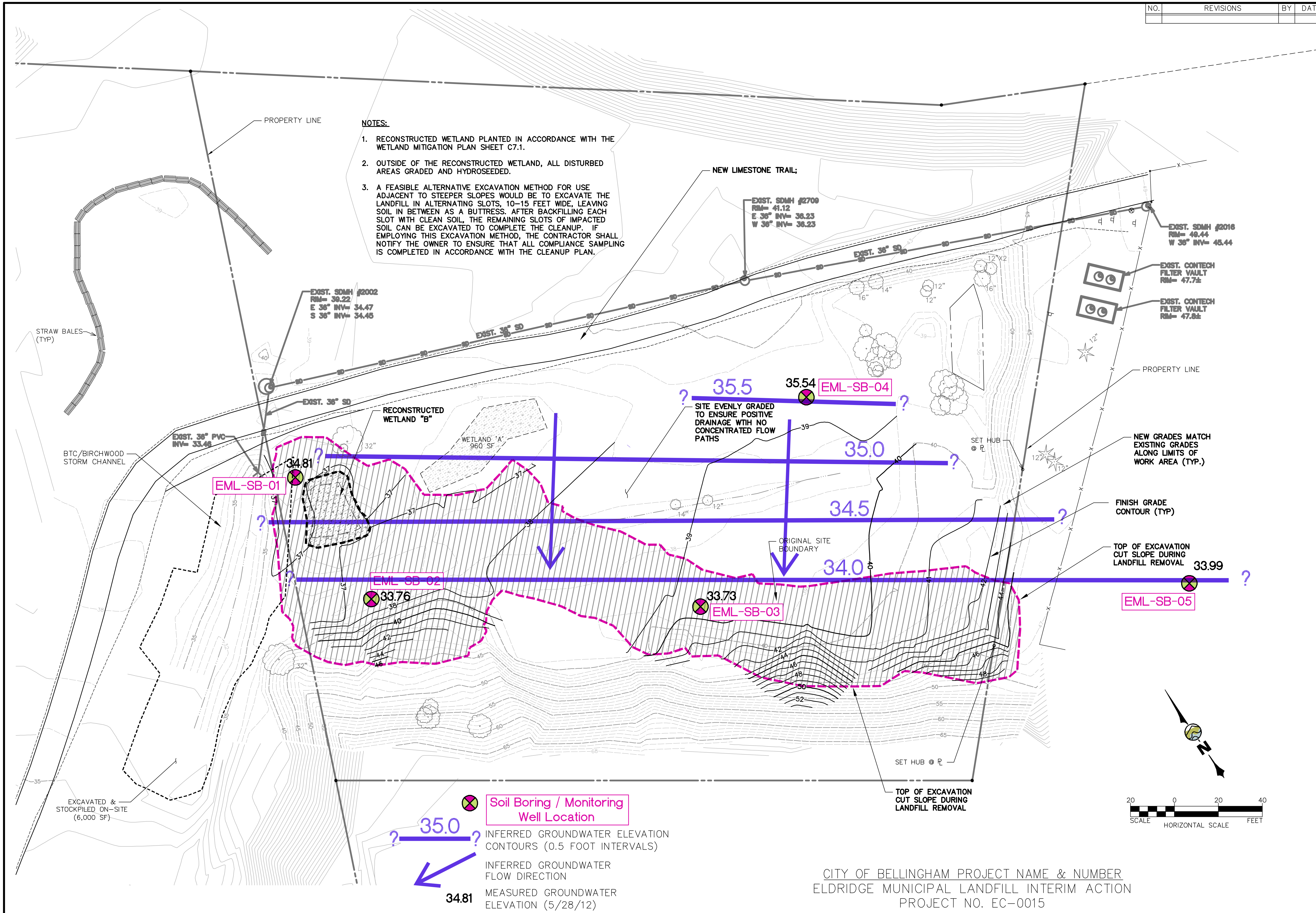
CITY OF BELLINGHAM
BELLINGHAM WASHINGTON
ELDRIDGE MUNICIPAL LANDFILL RI/FS
SOIL BORING/MONITORING WELL LOCATIONS

DATE FEBRUARY 2014
SCALE AS SHOWN
JOB NUMBER 2014-016
SHEET FIG 9 OF -



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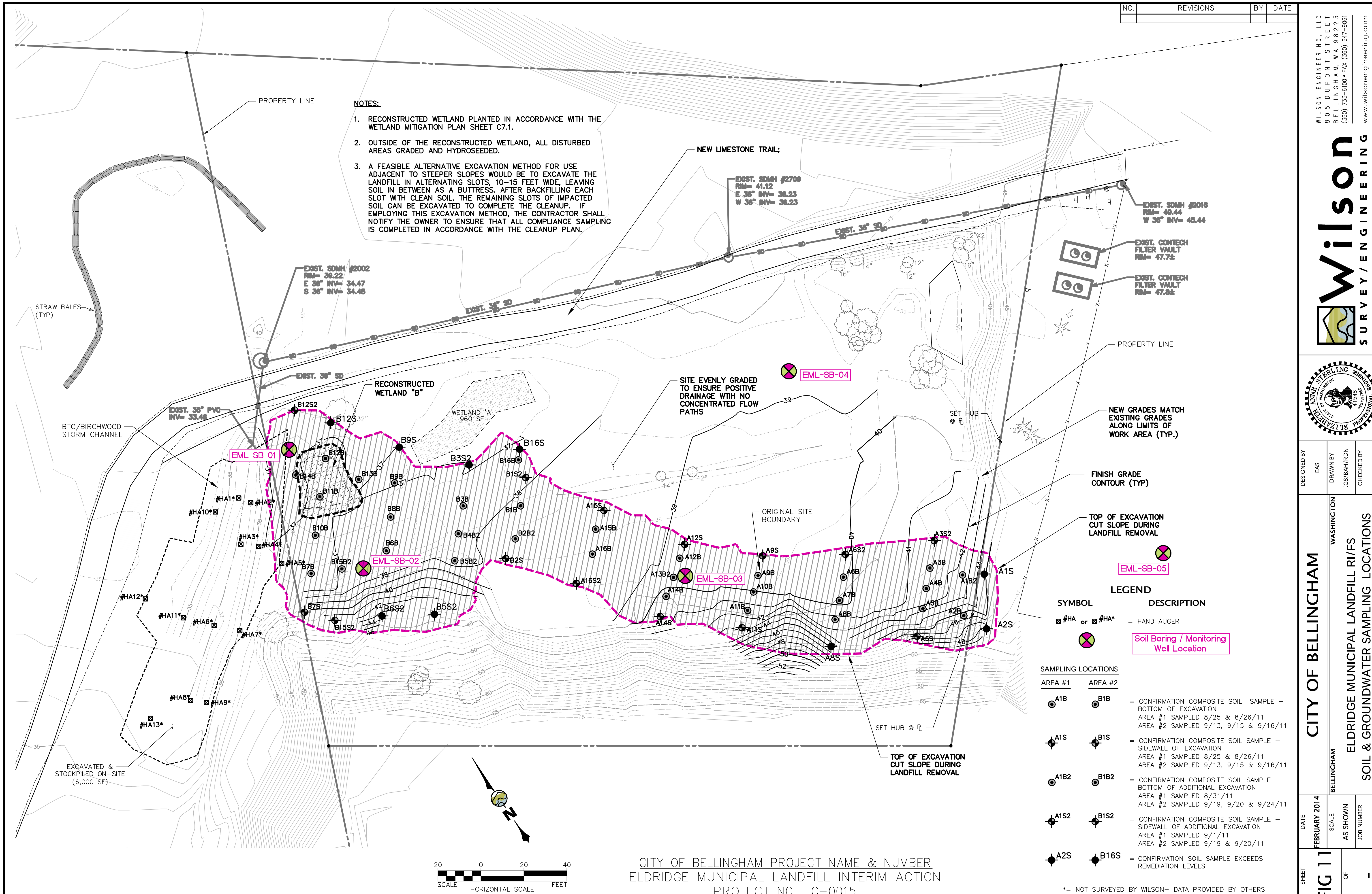
BELLINGHAM, WASHINGTON

ELDRIDGE MUNICIPAL LANDFILL RI/FS
GROUNDWATER SURFACE MAP, MAY 2012

SHEET FIG 10 OF - | DATE FEBRUARY 2014 | SCALE AS SHOWN | JOB NUMBER 2014-016



NO. | REVISIONS | BY | DATE
PROPERTY LINE
NOTES:
1. RECONSTRUCTED WETLAND PLANTED IN ACCORDANCE WITH THE WETLAND MITIGATION PLAN SHEET C7.1.
2. OUTSIDE OF THE RECONSTRUCTED WETLAND, ALL DISTURBED AREAS GRADED AND HYDROSEEDED.
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NEW LIMESTONE TRAIL;
EXST. SDMH #2709 RIM= 41.12 E 36" INV= 36.23 W 36" INV= 36.23
EXST. SDMH #2016 RIM= 49.44 W 36" INV= 45.44
EXST. CONTECH FILTER VAULT RIM= 47.7±
EXST. CONTECH FILTER VAULT RIM= 47.8±
EXST. SDMH #2002 RIM= 39.22 E 36" INV= 34.47 S 36" INV= 34.45
EXST. 36" SD
STRAW BALES (TYP)
EXST. 36" PVC INV= 33.46
RECONSTRUCTED WETLAND "B"
WETLAND 'A' 960 SF
SITE EVENLY GRADED TO ENSURE POSITIVE DRAINAGE WITH NO CONCENTRATED FLOW PATHS
PROPERTY LINE
SET HUB @ ℄
NEW GRADES MATCH EXISTING GRADES ALONG LIMITS OF WORK AREA (TYP.)
FINISH GRADE CONTOUR (TYP)
TOP OF EXCAVATION CUT SLOPE DURING LANDFILL REMOVAL
BTC/BIRCHWOOD STORM CHANNEL
ORIGINAL SITE BOUNDARY
EML-SB-01
EML-SB-02
EML-SB-03
EML-SB-04
EML-SB-05
EXCAVATED & STOCKPILED ON-SITE (6,000 SF)
SET HUB @ ℄
TOP OF EXCAVATION CUT SLOPE DURING LANDFILL REMOVAL
LEGEND
SYMBOL | DESCRIPTION
#HA or #HA* = HAND AUGER
Soil Boring / Monitoring Well Location
SAMPLING LOCATIONS
AREA #1 | AREA #2
A1B | B1B = CONFIRMATION COMPOSITE SOIL SAMPLE – BOTTOM OF EXCAVATION AREA #1 SAMPLED 8/25 & 8/26/11 AREA #2 SAMPLED 9/13, 9/15 & 9/16/11
A1S | B1S = CONFIRMATION COMPOSITE SOIL SAMPLE – SIDEWALL OF EXCAVATION AREA #1 SAMPLED 8/25 & 8/26/11 AREA #2 SAMPLED 9/13, 9/15 & 9/16/11
A1B2 | B1B2 = CONFIRMATION COMPOSITE SOIL SAMPLE – BOTTOM OF ADDITIONAL EXCAVATION AREA #1 SAMPLED 8/31/11 AREA #2 SAMPLED 9/19, 9/20 & 9/24/11
A1S2 | B1S2 = CONFIRMATION COMPOSITE SOIL SAMPLE – SIDEWALL OF ADDITIONAL EXCAVATION AREA #1 SAMPLED 9/1/11 AREA #2 SAMPLED 9/19 & 9/20/11
A2S | B16S = CONFIRMATION SOIL SAMPLE EXCEEDS REMEDIATION LEVELS
*= NOT SURVEYED BY WILSON– DATA PROVIDED BY OTHERS
20 0 20 40
SCALE HORIZONTAL SCALE FEET
CITY OF BELLINGHAM PROJECT NAME & NUMBER
ELDRIDGE MUNICIPAL LANDFILL INTERIM ACTION
PROJECT NO. EC-0015
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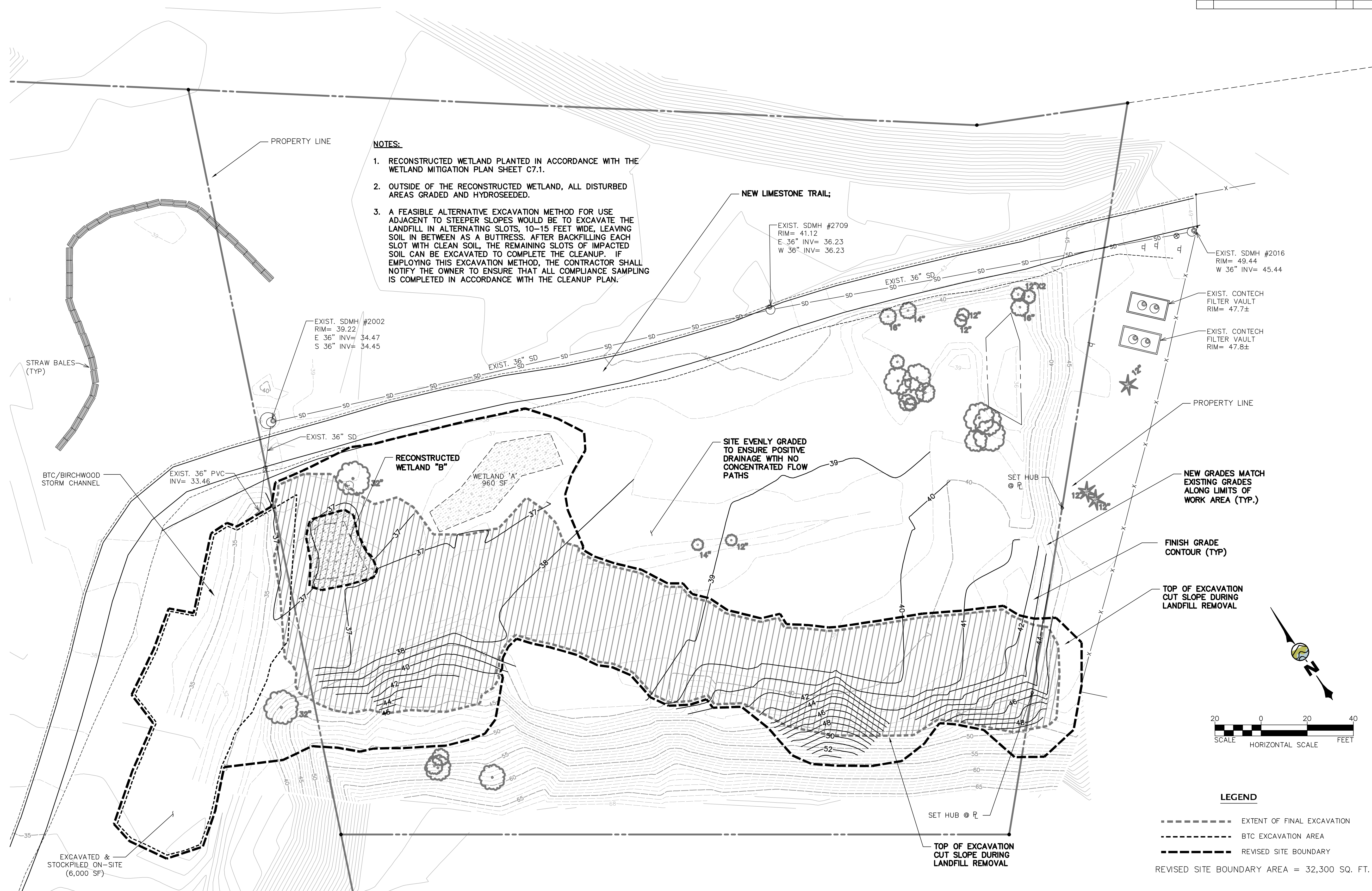
BELLINGHAM WASHINGTON
ELDRIDGE MUNICIPAL LANDFILL RI/FS
SOIL & GROUNDWATER SAMPLING LOCATIONS
SHEET FIG 11 OF 1
DATE FEBRUARY 2014
SCALE AS SHOWN
JOB NUMBER 2014-016



CITY OF BELLINGHAM PROJECT NAME & NUMBER
ELDRIDGE MUNICIPAL LANDFILL INTERIM ACTION
PROJECT NO. EC-0015

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Wilson SURVEY/ENGINEERING

ANNE ELIZABETH STERLING — STATE OF WASHINGTON — REGISTERED PROFESSIONAL ENGINEER

DESIGNED BY EAS | DRAWN BY JGS/BAH/RDN | CHECKED BY

CITY OF BELLINGHAM

BELLINGHAM WASHINGTON

ELDRIDGE MUNICIPAL LANDFILL RI/FS
REVISED SITE BOUNDARY

SHEET FIG 12 OF - | DATE FEBRUARY 2014 | SCALE AS SHOWN | JOB NUMBER 2014-016

W:\2014\2014-016 Herrenkohl Consulting - Eldridge Municipal Landfill RI-FS Report\Dwg\Exhibits\Fig12 Revised Site Bndry.dwg, 2/20/2014 9:55:17 AM, PDF-XChange for AcroPlot Color Pros.pc3, RDN

APPENDIX A

HISTORICAL LANDFILL BOUNDARY SURVEY, TEST PIT LOGS, AND PHOTOGRAPHIC LOG

APPENDIX A

HISTORICAL LANDFILL BOUNDARY SURVEY AND TEST PIT LOGS

The historical landfill was delineated by excavating 25 small reconnaissance test pits (RTP) approximately 2 to 6.5 ft deep and the width of the track-hoe bucket (approximately 18 in.). Each test pit was excavated using a mini track-mounted excavator.

The excavated material was examined by a field geologist for the presence of municipal garbage and debris. The reconnaissance test pits were initially excavated on 50 ft centers around Test Pit TP-01. Additional test pits were excavated at the discretion of the field geologist to delineate the lateral extent of the historical landfill, including the area around Test Pits TP-1 and TP-2. Field notes were taken with regard to whether or not municipal garbage or debris was encountered, but the soils were not logged or collected for chemical analysis from the reconnaissance test pits. Observations from the reconnaissance test pits are provided in Table A-1. Photographs of selected reconnaissance test pits are also provided below.

Once each reconnaissance test pit was completed, it was backfilled and a labeled stake was placed at the location indicating whether or not the landfill was encountered. Each location was surveyed by a licensed land surveyor. Based on the results of the reconnaissance test pit survey, three test pits (TP-22, TP-23, and TP-24) were excavated for the collection of samples for analysis.

Table A-1. Reconnaissance Test Pit Survey Results

Recon. Test Pit No.	Depth Excavated (ft bgs)	Depth Subsurface Municipal Garbage/Debris Observed (ft bgs)	Subsurface Municipal Garbage/Debris Description	Notes
RTP-1	5	None observed.	None observed.	Test pit located on a shelf that is a few feet higher in elevation than TP-01.
RTP-2	2.5	0.5–2.5	Bottles (22 recovered intact), rust, charcoal.	
RTP-3	3	2–3	Metal and glass debris.	Orange soil at bottom of test pit
RTP-4	3	None observed.	None observed.	
RTP-5	3	Not noted.	One broken bottle observed.	Groundwater at 2.5 ft bgs.
RTP-6	3	Approx 2.5	Rust, possible ash, a small amount of metal, two bottles, and one brush.	Groundwater at 2.5 ft bgs.

Table A-1. Reconnaissance Test Pit Survey Results

Recon. Test Pit No.	Depth Excavated (ft bgs)	Depth Subsurface Municipal Garbage/Debris Observed (ft bgs)	Subsurface Municipal Garbage/Debris Description	Notes
RTP-7	3	Not noted.	One small piece of glass and metal.	Groundwater at 2-2.5 ft bgs.
RTP-8	3	None observed.	None observed.	Groundwater at 2.3 ft bgs.
RTP-9	3	None observed.	None observed.	Groundwater at 2 ft bgs.
RTP-10	3	Not noted.	One small bottle, trace of glass and metal.	Orange layer observed at 1.5 ft bgs.
RTP-11	3	None observed.	None observed.	Groundwater observed at 2 ft bgs.
RTP-12	3	None observed.	None observed.	Groundwater observed at 1.8 ft bgs.
RTP-13	3.5	None observed.	None observed.	Groundwater observed at 3 ft bgs.
RTP-14	3	None observed.	None observed.	Groundwater observed at 2.5 ft bgs.
RTP-15	4	Not noted.	One piece of black slag observed.	Groundwater observed at 4 ft bgs.
RTP-16	4	1.8–4	Orange soil, ash, bottles (12 intact), brick, mirror, ceramics, metal.	Groundwater observed at 4 ft bgs.
RTP-17	4.5	Not noted. Orange soil and ash observed at approx. 3–3.5 ft bgs.	Bottles (seven intact), ceramics, metal, melted glass, ash, and orange soil.	Groundwater observed at 4.5 ft bgs.
RTP-18	3.5	2.5–3.5	Mostly metal debris, with some glass (including one intact bottle).	Groundwater observed at 3.5 ft bgs. Orange soil/ash layer 2.8–3 ft bgs. Slight diesel/oil-like odor observed.
RTP-19	5	2.8–5	Glass (10 intact bottles), some metal.	Orange soil and rust observed 1.8 to 5 ft bgs.
RTP-20	3	None observed.	None observed.	Groundwater observed at 3 ft bgs.
RTP-21	4.5	None observed.	None observed.	Groundwater observed at 3 ft bgs.
RTP-22	6.5	3.0–4.5	Drywall, ash, and metal.	

Table A-1. Reconnaissance Test Pit Survey Results

Recon. Test Pit No.	Depth Excavated (ft bgs)	Depth Subsurface Municipal Garbage/Debris Observed (ft bgs)	Subsurface Municipal Garbage/Debris Description	Notes
RTP-23	4.7	0–3.5	Some asphalt and one red brick.	Organic-rich silt observed at 4 ft bgs (native).
RTP-24	2.4	None observed.	None observed.	Organic-rich silt observed at 2 ft bgs (native).
RTP-25	2	0–1.5	Three small pieces of glass.	Organic-rich silt observed at 1.5 ft bgs (native).

Major Divisions			Symbols		Typical Names
Coarse Grained Soils (More than 1/2 of soil >No. 200 sieve size)	**Gravels** (More than 50% coarse fraction > no. 4 sieve		GW		Well-graded gravels or gravel-sand mixtures, little to no fines
			GP		Poorly-graded gravels or gravel-sand mixtures, little to no fines
			GM		Silty gravels, gravel-sand-silt mixtures
			GC		Clayey gravels or gravel-sand-clay mixtures
	Sands (Less than 50% coars fraction > no. 4 sieve)		SW		Well-graded sands or gravel-sand mixtures, little to no fines
			SP		poorly-graded sands or gravelly sands, little to no fines
			SM		Silty sands, sand-silt mixtures
			SC		Clayey sands, sand-clay mixtures
Fine Grained Soils (More than 1/2 of soil <No. 200 sieve size)	**Silts & Clays** Liquid limit* less than 50%		ML		Inorganic silts and very fine sands, silty or clayey fine sands or clayey silts with slight plasticity
			CL		Inorganic clays of low to medium plasticity, gravelly clays, sandy or silty clays, lean clays
			OL		Organic silts and organic silty clays of low plasticity
	Silts & Clays Liquid limit* greater than 50%		MH		Inorganic silts, micaceous or ditomaceous fine sand or silty soils, elastic silts
			CH		Inorganic clays of high plasticity, fat clays
			OH		Organic clays of medium to high plasticity, organic silty clay, organic silts
Highly Organic Soils			Pt		Peat or other highly organic soils

*Liquid limit represents the moisture contnet (in percent) of a soil at which point the soil no longer behaves like a plastic and starts to behave like a liquid.

Boring Log Symbols

Sample Interval

Groundwater, First Observed

Groundwater, Static

Sample Types

SS	Split Spoon
G	Grab
ST	Shelby Tube
GS	Geoprobe Sampler

Sheen Types

NS	No Sheen Observed
SS	Slight Sheen observed (Spotty coverage of sheen pan, no
MS	Moderate Sheen (Full Coverage)
HS	Heavy Sheen (Full Coverage, Irredescent)

Sample Moisture

Dry	No Moisture, dry to touch
Moist	Damp but no visible moisture
Wet	Visible free water

Sample Plasticity (Fine-Grained Soils)

Non-Plastic -	Cannot be rolled at any moisture content
Low -	Barely rolled, lump cannot be formed when drier than plastic limit
Medium -	Easily rolled, lump crumbles when drier than plastic limit
High -	Easily rolled yet takes considerable time to reach the plastic limit, lump can be formed without crumbling when drier than the plastic limi

Partical Size Range (Course-Grained Soils)

Gravel -	Fine, Course
Sand -	Fine, Medium, Coarse

Integral Consulting, Inc.
2817 NE 22nd Avenue
Portland, Oregon 97212
503-284-5545
503-284-5755 (Fax)

Based on Unified Soil Classification System and ASTM Standard D2487 and D2488

integral consulting inc.

integral consulting inc.

1201 Cornwall Avenue, Suite 208
Bellingham, WA 98225
(360) 756-9296 FAX (360) 756-7914

TEST PIT NUMBER	TP-1
PROJECT	Little Squalicum Park RI/FS
LOCATION	Bellingham, Washington
PROJECT NUMBER	C075-02
LOGGED BY	M. Herrenkohl, P.E.G.
DATE	November 9, 2005

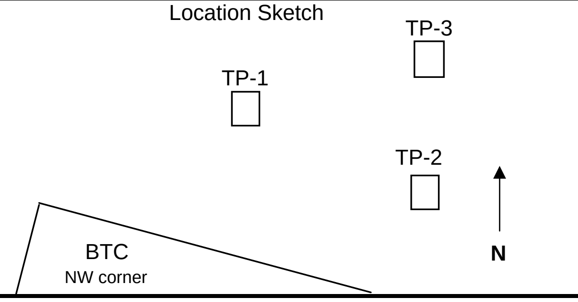
SAMPLE INFORMATION								DESCRIPTION
Sample ID	Sample Time	FID (ppm)	Sheen		Sample Depth (ft)	Depth (ft)	STRATA	USCS group name, color, grain size range, minor constituents, plasticity, odor, sheen, moisture content, texture, weathering, cementation, geologic interpretation, etc.
LSP0059	1435	1.4	NS		0-1		GM/SM	Sandy gravel w/fines, light brown, some earthworms observed (fill).
LSP0060*	1440				0-1			
LSP0061	1450	3.3	NS		1-2		Debris	Black layer, burnt garbage ash, metal debris, bones (fill).
						2--		
LSP0062	1455	2.3	LS		2-3		Debris	Orange (rusted) with white (ash) layer, garbage odor (fill).
							Debris	Black layer simlar to above with metal parts, bottles, and glass (fill).
LSP0063	1447	2.8	LS		3-4		Debris	Orange layer, clays/sand/gravel matrix, similar to above with less debris (fill).
						4--		
LSP0064	1445	9.5	NS		4-5		GM	Silty sandy fine to coarse gravel w/clay, gray (10 YR 6/1 - 5/1), 65-70% gravel.
*Duplicate							—	Bottom of test pit at 5' bgs.

ADDITIONAL NOTES / SKETCHES

Samples collected from west and south side walls.
Materials encountered from 1' to 4' bgs appear to be municipal landfill materials in a soil matrix with a "garbage odor".
Landfill materials decreasefrom 3-4' bgs, and are absent below 4' bgs.

EXCAVATING CONTRACTOR	Wilder Construction
EXCAVATION METHOD	Backhoe - John Deere 310
SAMPLING EQUIPMENT	Stainless Steel Spoon/Shovel/Bowl
COORDINATES	Northing: 649016.90 ft
	Easting: 1235609.38 ft
SURFACE ELEVATION	38.24 ft
DATUMS	Horizontal: NAD 83/91
	Vertical: NAVD 88

Location Sketch



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Bellingham, WA 98225
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TEST PIT NUMBER	TP-2
PROJECT	Little Squalicum Park RI/FS
LOCATION	Bellingham, Washington
PROJECT NUMBER	C075-02
LOGGED BY	M. Herrenkohl, P.E.G.
DATE	November 10, 2005

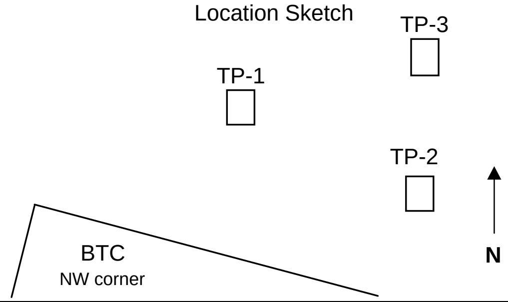
SAMPLE INFORMATION								DESCRIPTION
Sample ID	Sample Time	FID (ppm)	Sheen		Sample Depth (ft)	Depth (ft)	STRATA	USCS group name, color, grain size range, minor constituents, plasticity, odor, sheen, moisture content, texture, weathering, cementation, geologic interpretation, etc.
LSP0065	0830	**	NS		0-1		GM	Sand/gravel/clay/silt matrix, reddish dark brown (5YR 3/2) , no odor (fill).
LSP0066*	0840				0-1			
LSP0067	0850	**	NS		1-1.6		Debris	Black ash/burned materials mixed into similar matrix observed above.
LSP0071	1000	**	NS		1.6-2.9	2--	Debris	Rust zone with metal debris in a silty sand matrix, some white material of unkown
								source and large piece of concrete.
LSP0070	0950	**	NS		2.9 - 3.7			
							GM	Clayey sandy gravel w/silt, dark brown (7.5 YR 3/2) (fill).
LSP0069	0940	**	LS		3.7- 4.2	4--	Debri	As above, mixed with black ashy material (fill).
LSP0068	0855	**	NS		4.2- 5.3		G	
								Gravel w/fines, tan to light brown (10 YR 5/2 - 5/3) (Fill?)
*Duplicate							—	
**Problems calibrating PID/FID								Bottom of test pit at 5.3 ft bgs.

ADDITIONAL NOTES / SKETCHES

Large 1 ft x 1 ft concrete "block" observed at approximately 2 - 2.5 ft bgs.
Chrome stripping from car was observed at approximatley 2 ft bgs.
No municipal waste was observed in the test pit.

EXCAVATING CONTRACTOR	Wilder Construction
EXCAVATION METHOD	Backhoe - John Deere 310
SAMPLING EQUIPMENT	Stainless Steel Spoon/Shovel/Bowl
COORDINATES	Northing: 648930.22 ft
	Easting: 1235708.04 ft
SURFACE ELEVATION	40.61 ft
DATUMS	Horizontal: NAD 83/91
	Vertical: NAVD 88

Location Sketch



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TEST PIT NUMBER	TP-3
PROJECT	Little Squalicum Park RI/FS
LOCATION	Bellingham, Washington
PROJECT NUMBER	C075-02
LOGGED BY	M. Herrenkohl, P.E.G.
DATE	November 10, 2005

SAMPLE INFORMATION								DESCRIPTION
Sample ID	Sample Time	FID (ppm)	Sheen		Sample Depth (ft)	Depth (ft)	STRATA	USCS group name, color, grain size range, minor constituents, plasticity, odor, sheen, moisture content, texture, weathering, cementation, geologic interpretation, etc.
LSP0075	1300	**	NS		0-1		CL	Silty clay with gravel and sand to gravelly silty clay with sand, dark brown,
								(7.5 YR 3/4), (fill).
LSP0074	1250	**	NS		1-2			Sand and gravel content increasing with depth.
						2--	GM	Clayey silty sandy gravel, dark brown (7.5 YR 3/2), fines decreasing with depth.
LSP0073	1240	**	NS		2-3			
							GM/GP	Grading to sandy gravel w/ silt, grayish brown (10YR 5/2), 80% gravel, 20% sand,
LSP0072	1230	**	NS		>3			>5% fines (Native?).
								Bottom of test pit at 3 ft bgs.
						4--		
**Problems calibrating PID/FID								
No obvious odors								

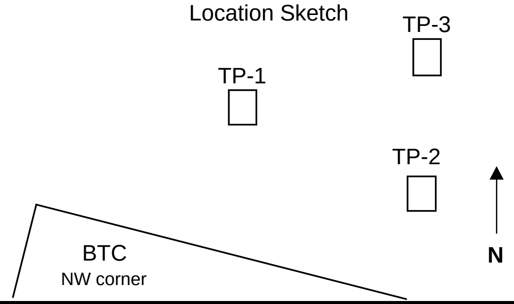
ADDITIONAL NOTES / SKETCHES

Scrap metal (rusted bucket) observed at ~1 ft bgs.

Note: This station was moved 54 ft 060° (magnetic north) from its surveyed location. N 48.7672°, W 122.51147°.

EXCAVATING CONTRACTOR	Wilder Construction
EXCAVATION METHOD	Backhoe - John Deere 310
SAMPLING EQUIPMENT	Stainless Steel Spoon/Shovel/Bowl
COORDINATES	Northing: 649053.78 ft
	Easting: 1235712.67 ft
SURFACE ELEVATION	38.42 ft
DATUMS	Horizontal: NAD 83/91
	Vertical: NAVD 88

Location Sketch



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(360) 756-9296 FAX (360) 756-7914

TEST PIT NUMBER	TP-22
PROJECT	Little Squalicum Park RI/FS
LOCATION	Bellingham, Washington
PROJECT NUMBER	C075-02
LOGGED BY	Eron Dodak, R.G.
DATE	January 31, 2006

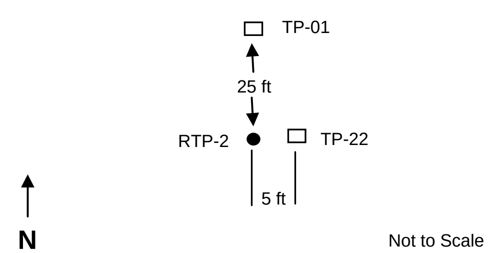
SAMPLE INFORMATION					Depth (ft)	STRATA	DESCRIPTION
Sample ID	Time	PID/FID	Sheen	Sample Depth			USCS group name, color, grain size range, minor constituents, plasticity, odor, sheen, moisture content, texture, weathering, cementation, geologic interpretation, etc.
LSP0105	0950	5.8/0	NS	0-0.5		GW	Sandy gravel w/ silt, dark brown (7.5 YR 3/2), fine to 3" dia. gravel
(1015 for VOC sample)						SM/ ML	(40%), sand (30%), silt (30%), no garbage, moist, no odor (fill).
LSP0106	0940	6.0/0	NS	0.5-1.7			Silty sand/sandy silt w/gravel, v. dark gray (7.5 YR 3/1), 15% bottles/metal,
LSP0107	0930	10.2/0	NS	1.7-2.2	2--	GW ▼	10% charcoal, 30% silt, 30% sand, 15% gravel, moist, no odor (fill).
(1040 for VOC sample)							Gravel w/ sand, reddish brown (5 YR 4/4), 15% bottles/glass, 30% sand,
							55% gravel, moist to wet, no odor (fill).
					4--		
						—	Bottom of test pit at 4.5' bgs. Sampled to 2.2' bgs.

ADDITIONAL NOTES / SKETCHES

Water seeping into excavation at 2.2 ft bgs.
Glass pieces, intact bottles, metal debris encountered from 0.5' to 4.5' bgs (bottom of test pit).
A total of 31 intact bottles were removed from test pit (13 were collected for identification).

EXCAVATING CONTRACTOR	Wilder Construction
EXCAVATION METHOD	Track Hoe
SAMPLING EQUIPMENT	SS Spoons/bowls
COORDINATES	Northing: 648990.85 ft
	Easting: 1235612.97 ft
SURFACE ELEVATION	38.70 ft
DATUMS	Horizontal: NAD 83/91
	Vertical: NAD 88

Location Sketch



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(360) 756-9296 FAX (360) 756-7914

TEST PIT NUMBER	TP-23
PROJECT	Little Squalicum Park RI/FS
LOCATION	Bellingham, Washington
PROJECT NUMBER	C075-02
LOGGED BY	Eron Dodak, R.G.
DATE	January 31, 2006

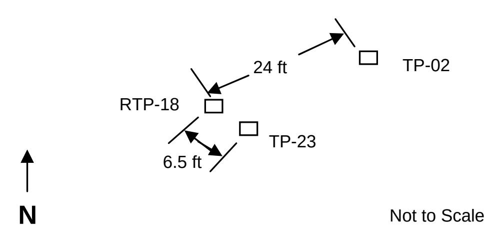
SAMPLE INFORMATION					Depth (ft)	STRATA	DESCRIPTION
Sample ID	Time	PID/FID	Sheen	Sample Depth			USCS group name, color, grain size range, minor constituents, plasticity, odor, sheen, moisture content, texture, weathering, cementation, geologic interpretation, etc.
LSP0108	1210	2.6	NS	0-2.0		ML	Sandy Silt w/ gravel, brown (10 YR 4/2), ~15% sand, 25% fine to 8" dia.
							gravel, ~60% silt, moist, no odor, no garbage observed (fill).
					2--		Sandy silt w/ gravel, very dark gray brown (10 YR 3/2), ~15% debris (glass,
LSP0104	1155	2.4	NS	2.0-3.5			bottles, metal), ~25% sand, ~25% fine to 3" gravel, ~35% silt, moist, no odor (fill).
							Mixture of gravel w/ sand, silt, and debris, reddish brown (5 YR 4/4), orange stained,
LSP0110	1145	3	NS	3.5 - 4.0	4--	GW	~30% debris (glass, metal), v. moist, no odor (fill).
LSP0111	1140	3.2	NS	4.0		ML	Organic-rich silt w/ gravel, black (5 YR 2.5/1), slight sulfur odor, moist (native).
LSP0112	1310	6.0	NS	4.5-5.0		SW ▼	Sand w/ gravel, dark gray (7.5 YR 4/1), 15-25% F-C gravel, trace silt, v. moist to
						—	wet, no odor (native).
							Bottom of test pit at 5.2 ft bgs.

ADDITIONAL NOTES / SKETCHES

Metal and glass debris observed from 2.5 ft to 4 ft bgs.
Water seeping into excavation at 5.2 ft bgs.
A total of 16 intact bottles were removed from test pit (13 were collected for identification).
No diesel odor observed (diesel odor was observed in RTP-18).

EXCAVATING CONTRACTOR	Wilder Construction
EXCAVATION METHOD	Track Hoe
SAMPLING EQUIPMENT	SS Spoons/bowls
COORDINATES	Northing: 648928.50 ft
	Easting: 1235685.09 ft
SURFACE ELEVATION	40.59 ft
DATUMS	Horizontal: NAD 83/91
	Vertical: NAVD 88

Location Sketch



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TEST PIT NUMBER	TP-24
PROJECT	Little Squalicum Park RI/FS
LOCATION	Bellingham, Washington
PROJECT NUMBER	C075-02
LOGGED BY	Eron Dodak, R.G.
DATE	January 31, 2006

SAMPLE INFORMATION							DESCRIPTION
Sample ID	Time	PID/FID	Sheen	Sample Depth	Depth (ft)	STRATA	USCS group name, color, grain size range, minor constituents, plasticity, odor, sheen, moisture content, texture, weathering, cementation, geologic interpretation, etc.
LSP0113	1410	4.8/0	NS	0-1.5		ML	Silt with gravel, dark brown (7.5 YR 3/2), ~15% fine to corase gravel, ~5-10%
							sand, trace roots, moist, no odor (fill?). No debris/garbage encountered.
						▼	
LSP0114	1415	5.8/0	NS	1.5	2--	GW	Gravel w/ sand, gray (10 YR 5/1), 35% sand, 5-10% silt, fine to 4" dia gravel, wet,
							no odor (native). No debris/garbage encountered.
						—	
					4--		Bottom of test pit at 3.2 ft bgs.

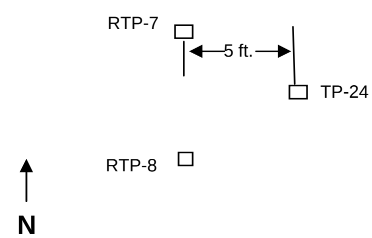
ADDITIONAL NOTES / SKETCHES

Standing water in test pit at 1.5 ft bgs.

Excavated to 3.2 ft bgs; could not excavate deeper due to sluffing gravel.

EXCAVATING CONTRACTOR	Wilder Construction
EXCAVATION METHOD	Track Hoe
SAMPLING EQUIPMENT	SS Spoons/bowls
COORDINATES	Northing: 649061.59 ft
	Easting: 1235609.45 ft
SURFACE ELEVATION	38.00 ft
DATUMS	Horizontal: NAD 83/91
	Vertical: NAVD 88

Location Sketch



Not to Scale

Photographic Log of 2006 Sampling
Eldridge Municipal Landfill RI/FS & CAP

Small track excavator used to excavate test pits. Reconnaissance test pit RTP-13 is shown in the photo.

Bottles and metal debris recovered from test pit TP-22.

Photographic Log of 2006 Sampling
Eldridge Municipal Landfill RI/FS & CAP

TP-22 Sampling at 1.7-2.2 ft bgs

Photographic Log of 2006 Sampling
Eldridge Municipal Landfill RI/FS & CAP

TP-22 West Sidewall

TP-22 South Sidewall

Photographic Log of 2006 Sampling
Eldridge Municipal Landfill RI/FS & CAP

TP-23 Sampling at 4 ft bgs

Photographic Log of 2006 Sampling
Eldridge Municipal Landfill RI/FS & CAP

TP-23 South Sidewall at 5 ft bgs

Photographic Log of 2010 Confirmation Sampling
Eldridge Municipal Landfill RI/FS & CAP

Confirmation sampling locations at base of new BTC/Birchwood channel and eastern sidewall/slope.

Confirmation sampling locations from western sidewall/slope of BTC/Birchwood Channel.

Stockpile covered with surrounding silt fence.

APPENDIX B

SCREENING LEVELS AND INDICATOR HAZARDOUS SUBSTANCES

Table B-1. Soil Screening Levels for Human Health

		Leaching SL (mg/kg)	Direct Contact SLs (mg/kg)					
CAS Number	Analyte	EPA Region 9 Preliminary Remediation Goal for Leaching DAF=1[a] (PRG-DAF1)	MTCA Direct Contact Carcinogen (MTCA-S-C)[b]	MTCA Direct Contact Noncarcinogen (MTCA-S-N)[b]	EPA Region 9 Preliminary Remediation Goals Residential Soil (PRG-Resid)[c]	Final Direct Contact Screening Level (DC)[d]	**Human Health Screening Level Saturated Soil & Sediment (SL-Sat) (mg/kg)[e]**	Basis for SL-Sat
Metals								
7429-90-5	Aluminum	NV	NV	NV	7.61E+04	7.61E+04	**7.61E+04**	PRG residential soil
7440-36-0	Antimony	3.00E-01	NV	3.20E+01		3.20E+01	**3.00E-01**	Leaching
7440-38-2	Arsenic	1.00E+00	6.70E-01	2.40E+01		6.70E-01	**1.00E+01**	Site-specific background
7440-39-3	Barium	8.20E+01	NV	1.60E+04		1.60E+04	**8.20E+01**	Leaching
7440-41-7	Beryllium	3.00E+00	NV	1.60E+02		1.60E+02	**3.00E+00**	Leaching
7440-43-9	Cadmium	4.00E-01	NV	8.00E+01		8.00E+01	**4.00E-01**	Leaching
7440-47-3	Chromium (assumed hexavalent for screening)	2.00E+00	NV	2.40E+02	NV	2.40E+02	**2.00E+00**	Leaching
7440-48-4	Cobalt	NV	NV	NV	9.03E+02	9.03E+02	**9.03E+02**	PRG residential soil
7440-50-8	Copper	NV	NV	3.00E+03		3.00E+03	**3.00E+03**	Direct contact noncarcinogen
7439-92-1	Lead	NV	NV	NV	4.00E+02	4.00E+02	**2.50E+02**	Method A
7439-96-5	Manganese	NV	NV	1.10E+04		1.10E+04	**1.10E+04**	Direct contact noncarcinogen
7439-97-6	Mercury	NV	NV	2.40E+01		2.40E+01	**2.40E+01**	Direct contact noncarcinogen
7440-02-0	Nickel	7.00E+00	NV	1.60E+03		1.60E+03	**7.00E+00**	Leaching
7782-49-2	Selenium	3.00E-01	NV	4.00E+02		4.00E+02	**3.00E-01**	Leaching
7440-22-4	Silver	2.00E+00	NV	4.00E+02		4.00E+02	**2.00E+00**	Leaching
7440-28-0	Thallium	NV	NV	5.60E+00		5.60E+00	**5.60E+00**	Direct contact noncarcinogen
7440-62-2	Vanadium	3.00E-02	NV	5.60E+02		5.60E+02	**3.00E-02**	Leaching
7440-66-6	Zinc	6.20E+02	NV	2.40E+04		2.40E+04	**6.20E+02**	Leaching
SVOCs								
62-53-3	Aniline	NV	1.80E+02	NV		1.80E+02	**1.80E+02**	Direct contact carcinogen
106-50-3	1,4-Benzenediamine	NV	NV	1.50E+04		1.50E+04	**1.50E+04**	Direct contact noncarcinogen
92-87-5	Benzidine	NV	4.30E-03	2.40E+02		4.30E-03	**4.30E-03**	Direct contact carcinogen
65-85-0	Benzoic acid	2.00E+01	NV	3.20E+05		3.20E+05	**2.00E+01**	Leaching
100-51-6	Benzyl alcohol	NV	NV	2.40E+04		2.40E+04	**2.40E+04**	Direct contact noncarcinogen
111-91-1	bis(2-Chloroethoxy)methane	NV	NV	NV	NV	NV	**NV**	--
111-44-4	bis(2-Chloroethyl)ether	2.00E-05	9.10E-01	NV		9.10E-01	**2.00E-05**	Leaching
39638-32-9	bis(2-chloroisopropyl)ether	NV	NV	3.20E+03		3.20E+03	**3.20E+03**	Direct contact noncarcinogen
108-60-1	Bis(2-chloro-1-methylethyl) ether	NV	1.40E+01			1.40E+01	**1.40E+01**	Direct contact carcinogen
117-81-7	bis(2-Ethylhexyl)phthalate	NV	7.10E+01	1.60E+03		7.10E+01	**7.10E+01**	Direct contact carcinogen
101-55-3	4-Bromophenyl-phenylether	NV	NV	NV	NV	NV	**NV**	--
85-68-7	Butylbenzylphthalate	8.10E+02	NV	1.60E+04		1.60E+04	**8.10E+02**	Leaching
86-74-8	Carbazole	3.00E-02	5.00E+01	NV		5.00E+01	**3.00E-02**	Leaching
106-47-8	4-Chloroaniline	3.00E-02	NV	3.20E+02		3.20E+02	**3.00E-02**	Leaching
59-50-7	4-Chloro-3-Methylphenol	NV	NV	NV	NV	NV	**NV**	--
91-58-7	2-Chloronaphthalene	NV	NV	NV	4.94E+03	4.94E+03	**4.94E+03**	PRG residential soil
95-57-8	2-Chlorophenol	2.00E-01	NV	4.00E+02		4.00E+02	**2.00E-01**	Leaching
7005-72-3	4-Chlorophenyl-phenylether	NV	NV	NV	NV	NV	**NV**	--
194-59-2	7H-Dibenzo(c,g)carbazole	NV	NV	NV	NV	NV	**NV**	--
132-64-9	Dibenzofuran	NV	NV	1.60E+02		1.60E+02	**1.60E+02**	Direct contact noncarcinogen
95-50-1	1,2-Dichlorobenzene	9.00E-01	NV	7.20E+03		7.20E+03	**9.00E-01**	Leaching
541-73-1	1,3-Dichlorobenzene	NV	NV	NV	5.31E+02	5.31E+02	**5.31E+02**	PRG residential soil
106-46-7	1,4-Dichlorobenzene	1.00E-01	4.20E+01	NV		4.20E+01	**1.00E-01**	Leaching
91-94-1	3,3'-Dichlorobenzidine	3.00E-04	2.20E+00	NV		2.20E+00	**3.00E-04**	Leaching
120-83-2	2,4-Dichlorophenol	5.00E-02	NV	2.40E+02		2.40E+02	**5.00E-02**	Leaching

Table B-1. Soil Screening Levels for Human Health

CAS Number	Analyte	Leaching SL (mg/kg): EPA Region 9 Preliminary Remediation Goal for Leaching DAF=1[a] (PRG-DAF1)	Direct Contact SLs (mg/kg): MTCA Direct Contact Carcinogen (MTCA-S-C)[b]	MTCA Direct Contact Noncarcinogen (MTCA-S-N)[b]	EPA Region 9 Preliminary Remediation Goals Residential Soil (PRG-Resid)[c]	Final Direct Contact Screening Level (DC)[d]	**Human Health Screening Level Saturated Soil & Sediment (SL-Sat) (mg/kg)[e]**	Basis for SL-Sat
84-66-2	Diethylphthalate	NV	NV	6.40E+04		6.40E+04	**6.40E+04**	Direct contact noncarcinogen
105-67-9	2,4-Dimethylphenol	4.00E-01	NV	1.60E+03		1.60E+03	**4.00E-01**	Leaching
131-11-3	Dimethylphthalate	NV	NV	8.00E+04		8.00E+04	**8.00E+04**	Direct contact noncarcinogen
84-74-2	di-n-Butylphthalate	2.70E+02	NV	8.00E+03		8.00E+03	**2.70E+02**	Leaching
534-52-1	4,6-Dinitro-2-methylphenol	NV	NV	NV	6.11E+00	6.11E+00	**6.11E+00**	PRG residential soil
51-28-5	2,4-Dinitrophenol	1.00E-02	NV	1.60E+02		1.60E+02	**1.00E-02**	Leaching
121-14-2	2,4-Dinitrotoluene	4.00E-05	NV	1.60E+02		1.60E+02	**4.00E-05**	Leaching
606-20-2	2,6-Dinitrotoluene	3.00E-05	NV	8.00E+01		8.00E+01	**3.00E-05**	Leaching
117-84-0	di-n-Octylphthalate	1.00E+04	NV	1.60E+03		1.60E+03	**1.60E+03**	Direct contact noncarcinogen
122-66-7	1,2-Diphenylhydrazine	NV	1.30E+00	NV		1.30E+00	**1.30E+00**	Direct contact carcinogen
118-74-1	Hexachlorobenzene	1.00E-01	6.30E-01	6.40E+01		6.30E-01	**1.00E-01**	Leaching
87-68-3	Hexachlorobutadiene	1.00E-01	1.30E+01	1.60E+01		1.30E+01	**1.00E-01**	Leaching
77-47-4	Hexachlorocyclopentadiene	2.00E+01	NV	4.80E+02		4.80E+02	**2.00E+01**	Leaching
67-72-1	Hexachloroethane	2.00E-02	7.10E+01	8.00E+01		7.10E+01	**2.00E-02**	Leaching
78-59-1	Isophorone	3.00E-02	1.10E+03	1.60E+04		1.10E+03	**3.00E-02**	Leaching
90-12-0	1-Methylnaphthalene	NV	NV	NV	NV	NV	**4.00E+00**	Naphthalene as surrogate
95-48-7	2-Methylphenol	8.00E-01	NV	4.00E+03		4.00E+03	**8.00E-01**	Leaching
108-39-4	3&4-Methylphenol	NV	NV	4.00E+03		4.00E+03	**4.00E+03**	Direct contact noncarcinogen
106-44-5	4-Methylphenol	NV	NV	4.00E+02		4.00E+02	**4.00E+02**	Direct contact noncarcinogen
88-74-4	2-Nitroaniline	NV	NV	NV	1.83E+02	1.83E+02	**1.83E+02**	PRG residential soil
99-09-2	3-Nitroaniline	NV	NV	NV	1.83E+01	1.83E+01	**1.83E+01**	PRG residential soil
100-01-6	4-Nitroaniline	3.00E-02	NV	NV	2.32E+01	2.32E+01	**3.00E-02**	Leaching
98-95-3	Nitrobenzene	7.00E-03	NV	4.00E+01		4.00E+01	**7.00E-03**	Leaching
88-75-5	2-Nitrophenol	NV	NV	NV	NV	NV	**NV**	--
100-02-7	4-Nitrophenol	NV	NV	NV	NV	NV	**NV**	--
552-43-0	1-Nitropyrene	NV	NV	NV	NV	NV	**NV**	--
62-75-9	n-Nitrosodimethylamine	NV	2.00E-02	NV		2.00E-02	**2.00E-02**	Direct contact carcinogen
86-30-6	N-nitrosodiphenylamine	6.00E-02	2.00E+02	NV		2.00E+02	**6.00E-02**	Leaching
621-64-7	n-Nitroso-di-n-propylamine	2.00E-06	1.40E-01	NV		1.40E-01	**2.00E-06**	Leaching
87-86-5	Pentachlorophenol	1.00E-03	8.30E+00	2.40E+03		8.30E+00	**1.00E-03**	Leaching
108-95-2	Phenol	5.00E+00	NV	4.80E+04		4.80E+04	**5.00E+00**	Leaching
110-86-1	Pyridine	NV	NV	8.00E+01		8.00E+01	**8.00E+01**	Direct contact noncarcinogen
4901-51-3	2,3,4,5-Tetrachlorophenol	NV	NV	NV	NV	NV	**2.40E+03**	2,3,4,6-Tetrachlorophenol as surrogate
58-90-2	2,3,4,6-Tetrachlorophenol	NV	NV	2.40E+03		2.40E+03	**2.40E+03**	Direct contact noncarcinogen
935-95-5	2,3,5,6-Tetrachlorophenol	NV	NV	NV	NV	NV	**2.40E+03**	2,3,4,6-Tetrachlorophenol as surrogate
25167-83-3	Tetrachlorophenols	NV	NV	NV	NV	NV	**2.40E+03**	2,3,4,6-Tetrachlorophenol as surrogate
87-61-6	1,2,3-Trichlorobenzene	NV	NV	NV	NV	NV	**NV**	--
120-82-1	1,2,4-Trichlorobenzene	3.00E-01	NV	8.00E+02		8.00E+02	**3.00E-01**	Leaching
95-95-4	2,4,5-Trichlorophenol	1.40E+01	NV	8.00E+03		8.00E+03	**1.40E+01**	Leaching
88-06-2	2,4,6-Trichlorophenol	8.00E-03	9.10E+01	NV		9.10E+01	**8.00E-03**	Leaching
PAHs								
83-32-9	Acenaphthene	2.90E+01	NV	4.80E+03		4.80E+03	**2.90E+01**	Leaching
208-96-8	Acenaphthylene	NV	NV	NV	NV	NV	**2.90E+01**	Acenaphthene as surrogate
120-12-7	Anthracene	5.90E+02	NV	2.40E+04		2.40E+04	**5.90E+02**	Leaching
86-73-7	Fluorene	2.80E+01	NV	3.20E+03		3.20E+03	**2.80E+01**	Leaching

Table B-1. Soil Screening Levels for Human Health

		Leaching SL (mg/kg)	Direct Contact SLs (mg/kg)					
CAS Number	Analyte	EPA Region 9 Preliminary Remediation Goal for Leaching DAF=1[a] (PRG-DAF1)	MTCA Direct Contact Carcinogen (MTCA-S-C)[b]	MTCA Direct Contact Noncarcinogen (MTCA-S-N)[b]	EPA Region 9 Preliminary Remediation Goals Residential Soil (PRG-Resid)[c]	Final Direct Contact Screening Level (DC)[d]	**Human Health Screening Level Saturated Soil & Sediment (SL-Sat) (mg/kg)[e]**	Basis for SL-Sat
91-20-3	Naphthalene	4.00E+00	NV	1.60E+03		1.60E+03	**4.00E+00**	Leaching
85-01-8	Phenanthrene	NV	NV	NV	NV	NV	**5.90E+02**	Anthracene as surrogate
91-57-6	2-Methylnaphthalene	NV	NV	NV	NV	NV	**4.00E+00**	Naphthalene as surrogate
56-55-3	Benzo(a)anthracene	8.00E-02	1.40E-01	NV		1.40E-01	**8.00E-02**	Leaching
50-32-8	Benzo(a)pyrene	4.00E-01	1.40E-01	NV		1.40E-01	**1.40E-01**	Direct contact carcinogen
205-99-2	Benzo(b)fluoranthene	2.00E-01	1.40E-01	NV		1.40E-01	**1.40E-01**	Direct contact carcinogen
207-08-9	Benzo(k)fluoranthene	2.00E+00	1.40E-01	NV		1.40E-01	**1.40E-01**	Direct contact carcinogen
218-01-9	Chrysene	8.00E+00	1.40E-01	NV		1.40E-01	**1.40E-01**	Direct contact carcinogen
53-70-3	Dibenzo(a,h)anthracene	8.00E-02	1.40E-01	NV		1.40E-01	**8.00E-02**	Leaching
206-44-0	Fluoranthene	2.10E+02	NV	3.20E+03		3.20E+03	**2.10E+02**	Leaching
193-39-5	Indeno(1,2,3-cd)pyrene	7.00E-01	1.40E-01	NV		1.40E-01	**1.40E-01**	Direct contact carcinogen
129-00-0	Pyrene	2.10E+02	NV	2.40E+03		2.40E+03	**2.10E+02**	Leaching
191-24-2	Benzo(g,h,i)perylene	NV	NV	NV	NV	NV	**2.10E+02**	Fluoranthene as surrogate
192-65-4	Dibenzo(a,e)pyrene	NV	NV	NV	NV	NV	**NV**	--
189-64-0	Dibenzo(a,h)pyrene	NV	NV	NV	NV	NV	**NV**	--
189-55-9	Dibenzo(a,i)pyrene	NV	NV	NV	NV	NV	**NV**	--
191-30-0	Dibenzo(a,l)pyrene	NV	NV	NV	NV	NV	**NV**	--
57-97-6	7,12-Dimethylbenz(a)anthracene	NV	NV	NV	NV	NV	**NV**	--
TEQBAPCAR1/2	BaPE (ND=1/2DL)	NV	NV	NV	NV	NV	**1.40E-01**	Benzo(a)pyrene
Petroleum								
GRH	Gasoline Range Hydrocarbons	NV	NV	NV	NV	NV	**3.00E+01**	Method A
DRH	Diesel Range Hydrocarbons	NV	NV	NV	NV	NV	**2.00E+03**	Method A
MOTOR OIL	Motor Oil	NV	NV	NV	NV	NV	**2.00E+03**	Method A
TPH	TPH	NV	NV	NV	NV	NV	**2.00E+03**	Method A for diesel range

Notes:
DAF = dilution attenuation factor
NV = no value available
PAH = polycyclic aromatic hydrocarbon
PRG = preliminary remediation goal
SL = screening level
SVOC = semivolatile organic compound
[a]Source: http://www.epa.gov/region09/waste/sfund/prg/index.html.
[b]Source: https://fortress.wa.gov/ecy/clarc/CLARCHome.aspx Ecology (2007)
[c]Source: http://www.epa.gov/region09/waste/sfund/prg/index.html
[d]Minimum of MTCA-S-C, MTCA-S-N, and PRG-Resid
[e]Minimum of PRG-DAF1 and mMTCA-S

Table B-2. Preliminary Indicator Hazardous Substances

Structural Chemical Category	Chemical	CAS_RN	Human Health	Ecological
Metals[a]	Arsenic	7440-38-2	X	X
	Cadmium	7440-43-9	X	X
	Chromium	7440-47-3		X
	Lead	7439-92-1	X	X
	Mercury	7439-97-6		X
	Zinc	7440-66-6	X	X
Phenols	2,4,6-Trichlorophenol	88-06-2	X	
	Pentachlorophenol	87-86-5	X	X
SVOCs	2,4-Dinitrotoluene	121-14-2	X	
	2,6-Dinitrotoluene	606-20-2	X	
	Carbazole	86-74-8	X	
PAHs	1-Methylnaphthalene	90-12-0	X	
	2-Methylnaphthalene	91-57-6	X	
	Acenaphthene	83-32-9	X	
	Benzo[g,h,i]perylene	191-24-2	X	
	Benzo[a]pyrene	50-32-8		X
	Fluoranthene	206-44-0	X	
	Fluorene	86-73-7	X	
	Naphthalene	91-20-3	X	
	Phenanthrene	85-01-8	X	
	Pyrene	129-00-0	X	
	BaPE	--	X	
VOCs	m&p-Xylenes	179601-23-1	X	
Petroleum	Gasoline range organics	--	X	
	Diesel range organics	--	X	
	Motor oil	--	X	

Notes:
BaPE = benzo[a]pyrene toxicity equivalents
CAS-RN = Chemical Abstract Services registry number
PAH = polycyclic aromatic hydrocarbon
SVOC = semivolatile organic compound
VOC = volatile organic compound
[a] The following metals exceeded EICs but were removed from further consideration after the background analysis: aluminum, antimony, iron, manganese, selenium, silver, and vanadium.

Table B-3. EIC Values for Soils (all units are mg/kg)

Structural Chemical Categories	Chemical	CAS RN	Plants	Biota	Wildlife	Min. EIC
Metals	Aluminum	7429-90-5	50			50
	Antimony	7440-36-0	5			5
	Arsenic	7440-38-2	10	60	7	7
	Arsenic III	22541-54-4			7	7
	Arsenic V	17428-41-0	10	60	132	10
	Barium	7440-39-3	500		102	102
	Beryllium	7440-41-7	10			10
	Boron	7440-42-8	0.5			0.5
	Bromine	7726-95-6	10			10
	Cadmium	7440-43-9	4	20	14	4
	Chromium	7440-47-3	42	42	67	42
	Cobalt	7440-48-4	20			20
	Copper	7440-50-8	100	50	217	100
	Fluorine	16984-48-8	200			200
	Iodine	7553-56-2	4			4
	Lead	7439-92-1	50	500	118	50
	Lithium	7439-93-2	35			35
	Manganese	7439-96-5	1100		1500	1100
	Mercury	7439-97-6	0.3	0.1	5.5	0.1
	Molybdenum	7439-98-7	2		7	2
	Nickel	7440-02-0	30	20	980	20
	Selenium	7782-49-2	1	70	0.3	0.3
	Silver	7440-22-4	2			2
	Technetium	7440-26-8	0.2			0.2
	Thallium	7440-28-0	1			1
	Tin	7440-31-5	50			50
	Uranium	7440-61-1	5			5
	Vanadium	7440-62-2	2			2
	Zinc	7440-66-6	86	200	360	86
Pesticides	Aldrin	309-00-2			0.1	0.1
	Benzene hexachloride (including lindane)	58-89-9			6	6
	Chlordane	57-74-9		1	2.7	1
	DDT/DDD/DDE (total)	DDX1/2			0.75	0.75
	Dieldrin	60-57-1			0.07	0.07
	Endrin	72-20-8			0.2	0.2
	Hexachlorobenzene	118-74-1			17	17
	Heptachlor/heptachlor epoxide (total)	THPCL1/2			0.4	0.4
	Pentachlorophenol	87-86-5	3	6	4.5	3
Other Chlorinated Organics	1,2,3,4-Tetrachlorobenzene	634-66-2		10		10
	1,2,3-Trichlorobenzene	87-61-6		20		20

Table B-3. EIC Values for Soils (all units are mg/kg)

Structural Chemical Categories	Chemical	CAS RN	Plants	Biota	Wildlife	Min. EIC
	1,2,4-Trichlorobenzene	120-82-1		20		20
	1,2-Dichloropropane	78-87-5		700		700
	1,4-Dichlorobenzene	106-46-7		20		20
	2,3,4,5-Tetrachlorophenol	4901-51-3		20		20
	2,3,5,6-Tetrachloroaniline	3481-20-7	20	20		20
	2,4,5-Trichloroaniline	636-30-6	20	20		20
	2,4,5-Trichlorophenol	95-95-4	4	36		4
	2,4,6-Trichlorophenol	88-06-2		10		10
	2,4-Dichloroaniline	554-00-7		100		100
	3,4-Dichloroaniline	95-76-1		20		20
	3,4-Dichlorophenol	95-77-2	20	400		20
	3-Chloroaniline	106-47-8	20	30		20
	3-Chlorophenol	108-43-0	7	10		7
	2,3,7,8-TCDD	TEQDF051/2M			0.000002	0.000002
	Chloroacetamide	79-07-2		2		2
	Chlorobenzene	108-90-7		40		40
	Hexachlorocyclopentadiene	77-47-4	10			10
	PCB mixtures (total)	TARO1/2	40		0.65	0.65
	Pentachloroaniline	527-20-8		100		100
	Pentachlorobenzene	608-93-5		20		20
Other Nonchlorinated Organics	2,4-Dinitrophenol	51-28-5	20			20
	4-Nitrophenol	100-02-7		7		7
	Acenaphthene	83-32-9	20			20
	Benzo[a]pyrene	50-32-8			12	12
	Biphenyl	92-52-4	60			60
	Diethyl phthalate	84-66-2	100			100
	Dimethyl phthalate	131-11-3		200		200
	Dibutyl phthalate	84-74-2	200			200
	Fluorene	86-73-7		30		30
	Furan	110-00-9	600			600
	Nitrobenzene	98-95-3		40		40
	Nitrosodiphenylamine [N-]	86-30-6		20		20
	Phenol	108-95-2	70	30		70
	Styrene	100-42-5	300			300
	Toluene	108-88-3	200			200
	Gasoline Range Organics	GRH		100	5000	100
	Diesel Range Organics	DRH		200	6000	200

Notes:
EIC = ecological indicator concentration
Source: Ecology 2001 Table 749-3

Table B-4. Final Indicator Hazardous Substances for Human Health (all concentrations in mg/kg)

Preliminary IHS	No. of Samples Analyzed[a]	No. of Data Points[b]	No. of Samples Detected	Percent Detected Data Points	Min. Detection Limit	Max. Detection Limit	Max. Detected Value	Human Health Screening Level[c], ppm	Ratio of Max. DL to SL	No. of DL Exceedances	Freq. of DL Exceedance	Ratio of Max. Detect to SL	No. of Detected Exceedances	Freq. of Detected Exceedance	Total Freq. of Exceedance Detected & DL	95UCL[d]	Min. of 95UCL and Max. Value	95UCL[e] > SL?	Max. Detect > 2xSL?	> 10% Values[f] Exceed SL?	Final IHS?	Reason for Exclusion
Surface Soil																						
Metals																						
Arsenic	6	6	2	33	9.00E-01	1.00E+01	1.30E+01	1.00E+01	1.00E+00	0	0	1.30E+00	2	22	13	NC	1.30E+01	Y	N	Y	Y	
Cadmium	6	6	4	67	5.00E-02	1.00E-01	1.20E+00	4.00E-01	2.50E-01	0	0	3.00E+00	4	100	67	NC	1.20E+00	Y	Y	Y	Y	
Lead	6	6	6	100	NA	NA	2.85E+02	2.50E+02	0.00E+00	0	--	1.14E+00	1	17	17	NC	2.85E+02	Y	N	Y	Y	
Zinc	6	6	6	100	NA	NA	5.05E+02	6.20E+02	0.00E+00	0	--	8.15E-01	0	0	0	NC	5.05E+02	N	N	N	N	Complies with three part statistical rule
SVOCs																						
Carbazole	1	1	0	0	2.00E-02	2.00E-02	--	3.00E-02	6.67E-01	0	0	0.00E+00	0	--	0	NC	--	--	--	N	N	FOD less than 5%
2,4-Dinitrotoluene	1	1	0	0	1.00E-02	1.00E-02	--	4.00E-05	2.50E+02	1	100	0.00E+00	0	--	100	NC	--	--	--	Y	N	FOD less than 5%
2,6-Dinitrotoluene	1	1	0	0	1.20E-02	1.20E-02	--	3.00E-05	4.00E+02	1	100	0.00E+00	0	--	100	NC	--	--	--	Y	N	FOD less than 5%
1-Methylnaphthalene	1	1	0	0	2.00E-02	2.00E-02	--	4.00E+00	5.00E-03	0	0	0.00E+00	0	--	0	NC	--	--	--	N	N	FOD less than 5%
Pentachlorophenol	1	1	1	100	NA	NA	3.50E-01	1.00E-03	0.00E+00	0	--	3.50E+02	1	100	100	NC	3.50E-01	Y	Y	Y	Y	
2,4,6-Trichlorophenol	1	1	0	0	8.60E-03	8.60E-03	--	8.00E-03	1.08E+00	1	100	0.00E+00	0	--	100	NC	--	--	--	Y	N	FOD less than 5%
PAHs																						
Acenaphthene	1	1	0	0	1.00E-02	1.00E-02	--	2.90E+01	3.45E-04	0	0	0.00E+00	0	--	0	NC	--	--	--	N	N	FOD less than 5%
Fluorene	1	1	0	0	1.10E-02	1.10E-02	--	2.80E+01	3.93E-04	0	0	0.00E+00	0	--	0	NC	--	--	--	N	N	FOD less than 5%
Naphthalene	1	1	0	0	1.10E-02	1.10E-02	--	4.00E+00	2.75E-03	0	0	0.00E+00	0	--	0	NC	--	--	--	N	N	FOD less than 5%
Phenanthrene	1	1	1	100	NA	NA	1.30E-01	5.90E+02	0.00E+00	0	--	2.20E-04	0	0	0	NC	1.30E-01	N	N	N	N	Complies with three part statistical rule
2-Methylnaphthalene	1	1	0	0	1.80E-02	1.80E-02	--	4.00E+00	4.50E-03	0	0	0.00E+00	0	--	0	NC	--	--	--	N	N	FOD less than 5%
Fluoranthene	1	1	1	100	NA	NA	1.70E-01	2.10E+02	0.00E+00	0	--	8.10E-04	0	0	0	NC	1.70E-01	N	N	N	N	Complies with three part statistical rule
Pyrene	1	1	1	100	NA	NA	1.70E-01	2.10E+02	0.00E+00	0	--	8.10E-04	0	0	0	NC	1.70E-01	N	N	N	N	Complies with three part statistical rule
Benzo(g,h,i)perylene	1	1	1	100	NA	NA	1.80E-02	2.10E+02	0.00E+00	0	--	8.57E-05	0	0	0	NC	1.80E-02	N	N	N	N	Complies with three part statistical rule
BaPE (ND = 1/2 DL)	1	1	1	100	NA	NA	9.81E-02	1.40E-01	0.00E+00	0	--	7.01E-01	0	0	0	NC	9.81E-02	N	N	N	N	Complies with three part statistical rule
Petroleum																						
Gasoline Range Hydrocarbons	3	3	0	0	5.00E-03	7.00E-03	--	3.00E+01	2.33E-04	0	0	0.00E+00	0	--	0	NC	--	--	--	N	N	FOD less than 5%
Diesel Range Hydrocarbons	6	6	3	50	5.00E-01	6.00E-01	3.40E+01	2.00E+03	3.00E-04	0	0	1.70E-02	0	0	0	NC	3.40E+01	N	N	N	N	Complies with three part statistical rule
Motor Oil	6	6	6	100	NA	NA	2.10E+02	2.00E+03	0.00E+00	0	--	1.05E-01	0	0	0	NC	2.10E+02	N	N	N	N	Complies with three part statistical rule
Subsurface Soil																						
Metals																						
Arsenic	17	17	7	41	8.00E-01	4.00E+01	1.30E+01	6.70E-01	5.97E+01	10	100	1.94E+01	7	100	100	1.21E+01	1.21E+01	Y	Y	Y	Y	
Cadmium	17	17	13	76	4.00E-02	6.00E-02	1.00E+01	4.00E-01	1.50E-01	0	0	2.50E+01	10	77	59	NC	1.00E+01	Y	Y	Y	Y	
Lead	17	17	17	100	NA	NA	3.97E+03	2.50E+02	0.00E+00	0	--	1.59E+01	4	24	24	6.73E+03	3.97E+03	Y	Y	Y	Y	
Zinc	17	17	17	100	NA	NA	3.06E+03	6.20E+02	0.00E+00	0	--	4.94E+00	4	24	24	1.47E+03	1.47E+03	Y	Y	Y	Y	
SVOCs																						
Carbazole	1	1	0	0	2.00E-02	2.00E-02	--	3.00E-02	6.67E-01	0	0	0.00E+00	0	--	0	NC	--	--	--	N	N	FOD less than 5%
2,4-Dinitrotoluene	1	1	0	0	1.00E-02	1.00E-02	--	4.00E-05	2.50E+02	1	100	0.00E+00	0	--	100	NC	--	--	--	Y	N	FOD less than 5%
2,6-Dinitrotoluene	1	1	0	0	1.20E-02	1.20E-02	--	3.00E-05	4.00E+02	1	100	0.00E+00	0	--	100	NC	--	--	--	Y	N	FOD less than 5%
1-Methylnaphthalene	1	1	0	0	2.00E-02	2.00E-02	--	4.00E+00	5.00E-03	0	0	0.00E+00	0	--	0	NC	--	--	--	N	N	FOD less than 5%
Pentachlorophenol	1	1	0	0	4.60E-02	4.60E-02	--	1.00E-03	4.60E+01	1	100	0.00E+00	0	--	100	NC	--	--	--	Y	N	FOD less than 5%
2,4,6-Trichlorophenol	1	1	0	0	8.60E-03	8.60E-03	--	8.00E-03	1.08E+00	1	100	0.00E+00	0	--	100	NC	--	--	--	Y	N	FOD less than 5%
PAHs																						
Acenaphthene	1	1	0	0	1.00E-02	1.00E-02	--	2.90E+01	3.45E-04	0	0	0.00E+00	0	--	0	NC	--	--	--	N	N	FOD less than 5%
Fluorene	1	1	0	0	1.10E-02	1.10E-02	--	2.80E+01	3.93E-04	0	0	0.00E+00	0	--	0	NC	--	--	--	N	N	FOD less than 5%
Naphthalene	1	1	0	0	1.20E-02	1.20E-02	--	4.00E+00	3.00E-03	0	0	0.00E+00	0	--	0	NC	--	--	--	N	N	FOD less than 5%
Phenanthrene	1	1	1	100	NA	NA	1.40E-02	5.90E+02	0.00E+00	0	--	2.37E-05	0	0	0	NC	1.40E-02	N	N	N	N	Complies with three part statistical rule
2-Methylnaphthalene	1	1	0	0	1.80E-02	1.80E-02	--	4.00E+00	4.50E-03	0	0	0.00E+00	0	--	0	NC	--	--	--	N	N	FOD less than 5%
Fluoranthene	1	1	1	100	NA	NA	3.20E-02	2.10E+02	0.00E+00	0	--	1.52E-04	0	0	0	NC	3.20E-02	N	N	N	N	Complies with three part statistical rule
Pyrene	1	1	1	100	NA	NA	5.00E-02	2.10E+02	0.00E+00	0	--	2.38E-04	0	0	0	NC	5.00E-02	N	N	N	N	Complies with three part statistical rule
Benzo(g,h,i)perylene	1	1	1	100	NA	NA	2.50E-02	2.10E+02	0.00E+00	0	--	1.19E-04	0	0	0	NC	2.50E-02	N	N	N	N	Complies with three part statistical rule
BaPE (ND = 1/2 DL)	1	1	1	100	NA	NA	4.36E-02	1.40E-01	0.00E+00	0	--	3.12E-01	0	0	0	NC	4.36E-02	N	N	N	N	Complies with three part statistical rule
Petroleum																						
Gasoline Range Hydrocarbons	10	10	0	0	4.00E-03	1.00E-02	--	3.00E+01	3.33E-04	0	0	0.00E+00	0	--	0	NC	--	--	--	N	N	FOD less than 5%
Diesel Range Hydrocarbons	16	16	7	44	4.00E-01	6.00E-01	5.20E+01	2.00E+03	3.00E-04	0	0	2.60E-02	0	0	0	4.85E+01	4.85E+01	N	N	N	N	Complies with three part statistical rule
Motor Oil	16	16	8	50	1.10E+01	1.50E+01	2.30E+02	2.00E+03	7.50E-03	0	0	1.15E-01	0	0	0	1.09E+02	1.09E+02	N	N	N	N	Complies with three part statistical rule

Notes: [a]Field duplicate and replicate samples are excluded from counts. Their results have been averaged with corresponding normal sample results.
[b]No. of Data Points might be different from the No. of Samples Analyzed for metals if they were analyzed by more than one method.
[c]SLs based on the leaching pathway were calculated using a dilution attenuation factor of 1.
[d]95UCLs were calculated for data sets of at least 11 samples.
[e]Defaults to the Max. detected value when the 95UCL is larger than the Max. detected value.
[f]Refers to all values including both detected values and detection limits.
DL = detection limit
FOD = frequency of detection
IHS = indicator hazardous substance
NC = not calculated
SL = screening level
SVOC = semivolatile organic chemical
95UCL = upper 95 percent confidence limit on the mean
-- = not available

Table B-5. Soil Exposure Point Concentrations (mg/kg) and Hazard Quotients (dimensionless)

	Statistics				Soil EICs and HQs					
Preliminary IHS	n	Mean	SD	EPC[a]	Plant	PlantHQ	Invert.	Invert.HQ	Wildlife	Wildlife HQ
Arsenic	7	3.6	3.6	6.3	10	6.3E-01	60	1.0E-01	7	9.0E-01
Cadmium	6	5.4E-01	4.4E-01	9.0E-01	4	2.3E-01	20	4.5E-02	14	6.4E-02
Chromium	7	3.7E+01	5.2	4.1E+01	42	9.7E-01	42	9.7E-01	67	6.1E-01
Copper	6	5.6E+01	3.0E+01	8.1E+01	100	8.1E-01	50	1.6	217	3.7E-01
Lead	6	1.2E+02	9.2E+01	2.0E+02	50	3.9	500	3.9E-01	118	1.7
Mercury	6	1.3E-01	9.5E-02	2.1E-01	0.3	6.9E-01	0.1	2.1	5.5	3.8E-02
Nickel[b]	6	3.9E+01	4.9	4.3E+01	30	1.4	20	2.1	980	4.3E-02
Zinc	6	1.9E+02	1.6E+02	4.5E+02	86	5.2	200	2.2	360	1.2
Acenaphthene	2	3.7E-02	4.5E-02	6.8E-02	20	3.4E-03				
Acenaphthylene	2	4.7E-02	3.0E-02	6.8E-02						
Anthracene	2	4.5E-02	3.3E-02	6.8E-02						
Fluorene	2	3.7E-02	4.4E-02	6.8E-02			30	2.3E-03		
Naphthalene	2	3.0E-02	3.5E-02	5.5E-02						
Phenanthrene	2	9.8E-02	4.5E-02	1.3E-01						
2-Methylnaphthalene	2	3.9E-02	4.2E-02	6.8E-02						
Benz[a]anthracene	2	7.0E-02	2.8E-03	7.2E-02						
Benzo[a]pyrene	2	1.0E-01	4.4E-02	1.4E-01					12	1.1E-02
Chrysene	2	8.9E-02	3.0E-02	1.1E-01						
Dibenz[ah]anthracene	2	7.3E-02	8.9E-02	1.4E-01						
2,4-Dimethylphenol	2	3.9E-02	4.1E-02	6.8E-02						
2-Methylphenol	2	3.9E-02	4.1E-02	6.8E-02						
Phenol	2	3.7E-02	4.4E-02	6.8E-02	70	9.7E-04	30	2.3E-03		
Pentachlorophenol	2	3.4E-01	7.8E-03	3.5E-01	3	1.2E-01	6	5.8E-02	4.5	7.8E-02
Bis[2-ethylhexyl]phthalate	2	4.7E-01	1.9E-01	6.1E-01						
Butylbenzylphthalate	2	7.3E-02	8.9E-02	1.4E-01						
Dimethylphthalate	2	3.9E-02	4.1E-02	6.8E-02			200	3.4E-04		
BenzoicAcid	2	4.9E-01	5.6E-01	8.8E-01						
BenzylAlcohol	2	5.5E-02	6.7E-02	1.0E-01						
Dibenzofuran	2	3.8E-02	4.2E-02	6.8E-02						

Notes:
EIC = ecological indicator concentration
EPC = exposure point concentration
HQ = hazard quotient
IHS = indicator hazardous substance
SD = standard deviation
[a] EPCs were maximum values, Student's t-test UCL95s, or UCL95s calculated by Land's method, depending on the data distribution and UCL values.
[b] Nickel was eliminated by the background evaluation but was still included in screening for information purposes

Table B-6. Final Indicator Hazardous Substances

Analyte	Human Health		Ecological
	Surface Soil	Subsurface Soil	Soil
Metals			
Arsenic	X	X	
Cadmium	X	X	
Copper			X
Lead	X	X	X
Mercury			X
Zinc		X	X
SVOCs			
Pentachlorophenol	X		

APPENDIX C

SUMMARY OF CHEMICAL TESTING RESULTS

Table C-1A. Sample Collection and Analysis Summary — Little Squalicum Park RI (Integral 2008)

Test Pit (TP) Soil Samples

Sample Number	Sample Location	Sample Depth (ft bgs)	Date	Total Organic Carbon	Total Solids	Physical Testing	Total Metals	TCLP Metals	NWTPH-GRO	NWTPH-VPH	NWTPH-DRO+RRO	SVOCs	PCBs	Archived
Nov-05														
LSP0059	TP-01	0-1	9-Nov-05	X	X	X	X		X		X			
LSP0060	TP-01 DUP	0-1	9-Nov-05	X	X	X	X		X		X			
LSP0061	TP-01	1-2	9-Nov-05	X	X		X		X		X		X	
LSP0062	TP-01	2-3	9-Nov-05	X	X		X		X		X		X	
LSP0063	TP-01	3-4	9-Nov-05	X	X		X		X		X			
LSP0064	TP-01	4-5	9-Nov-05	X	X		X		X		X			
LSP0065	TP-02	0-1	10-Nov-05	X	X		X		X		X			
LSP0066	TP-02 DUP	0-1	10-Nov-05	X	X		X		X		X			
LSP0067	TP-02	1-1.6	10-Nov-05	X	X		X		X		X			
LSP0071	TP-02	1.6-2.9	10-Nov-05	X	X		X		X		X			
LSP0070	TP-02	2.9-3.7	10-Nov-05	X	X		X		X	X	X			
LSP0069	TP-02	3.7-4.2	10-Nov-05	X	X		X		X		X			
LSP0068	TP-02	4.2-5.3	10-Nov-05	X	X	X	X		X		X			
LSP0075	TP-03	0-1	10-Nov-05	X	X		X		X		X			
LSP0074	TP-03	1-2	10-Nov-05		X		X							
LSP0073	TP-03	2-3	10-Nov-05											X
LSP0072	TP-03	3-Bottom	10-Nov-05			X								X
Jan-06														
LSP0105	TP-22	0-0.5	31-Jan-06		X		X				X			
LSP0106	TP-22	0.5-1.7	31-Jan-06		X		X				X			
LSP0107	TP-22	1.7-2.2	31-Jan-06		X		X	X	X		X			
LSP0108	TP-23	0-2	31-Jan-06		X		X				X	X		
LSP0109	TP-23	2-3.5	31-Jan-06		X		X				X			
LSP0110	TP-23	3.5-4	31-Jan-06		X		X	X			X	X		
LSP0111	TP-23	4	31-Jan-06		X		X				X			
LSP0112	TP-23	4.5-5.0	31-Jan-06		X		X				X			
LSP0113	TP-24	0-1.5	31-Jan-06		X		X				X			
LSP0114	TP-24	1.5	31-Jan-06		X		X				X			

Notes:

TCLP = Toxicity Characteristics Leaching Procedure
NWTPH-GRO = Northwest Total Petroleum Hydrocarbons - Gas Range Organics
NWTPH-VPH = Northwest Total Petroleum Hydrocarbons - Volatile Petroleum Hydrocarbons
DRO + RRO = Diesel-Range Organics and Residual-Range Organics
SVOCs = Semivolatile Organic Compounds
PCBs = Polychlorinated biphenyls

Table C-1B. Summary of Analytes Detected in Soil (Integral 2008)

Analyte	No. of Samples Analyzed	No. of Data Points	No. of Detected Data Points	Percent of Detection	Freq. of Detection	Min. Detection Limit	Max. Detection Limit	Min. Detected Value	Max. Detected Value	Location of Max. Detected Value	Samples with Max. Detected Value
Landfill Surface Soil											
Metals, mg/kg											
Arsenic	6	6	2	33	0.3	0.9	10	6	10	TP-23	LSP0108
Cadmium	6	6	4	67	0.7	0.05	0.1	0.6	1.2	TP-23	LSP0108
Chromium	6	6	6	100	1.0	NA	NA	31.8	44.4	TP-23	LSP0108
Copper	6	6	6	100	1.0	NA	NA	22.7	113	TP-23	LSP0108
Lead	6	6	6	100	1.0	NA	NA	19	285	TP-23	LSP0108
Mercury	6	6	5	83	0.8	0.004	0.004	0.065	0.26	TP-23	LSP0108
Nickel	6	6	6	100	1.0	NA	NA	30	44	TP-03	LSP0075
Silver	6	6	1	17	0.2	0.05	0.1	0.35	0.35	TP-01	LSP0059
Zinc	6	6	6	100	1.0	NA	NA	80.7	505	TP-23	LSP0108
SVOCs, mg/kg											
Benzoic Acid	1	1	1	100	1.0	NA	NA	0.094	0.094	TP-23	LSP0108
Bis(2-ethylhexyl)phthalate	1	1	1	100	1.0	NA	NA	0.61	0.61	TP-23	LSP0108
di-n-Butylphthalate	1	1	1	100	1.0	NA	NA	0.066	0.066	TP-23	LSP0108
Pentachlorophenol	1	1	1	100	1.0	NA	NA	0.35	0.35	TP-23	LSP0108
Retene	1	1	1	100	1.0	NA	NA	0.035	0.035	TP-23	LSP0108
2,3,4,6-Tetrachlorophenol	1	1	1	100	1.0	NA	NA	0.087	0.087	TP-23	LSP0108
PAHs, mg/kg											
Acenaphthylene	1	1	1	100	1.0	NA	NA	0.025	0.025	TP-23	LSP0108
Anthracene	1	1	1	100	1.0	NA	NA	0.022	0.022	TP-23	LSP0108
Phenanthrene	1	1	1	100	1.0	NA	NA	0.13	0.13	TP-23	LSP0108
Benzo(a)anthracene	1	1	1	100	1.0	NA	NA	0.072	0.072	TP-23	LSP0108
Benzo(a)pyrene	1	1	1	100	1.0	NA	NA	0.073	0.073	TP-23	LSP0108
Benzo(b)fluoranthene	1	1	1	100	1.0	NA	NA	0.074	0.074	TP-23	LSP0108
Benzo(k)fluoranthene	1	1	1	100	1.0	NA	NA	0.07	0.07	TP-23	LSP0108
Chrysene	1	1	1	100	1.0	NA	NA	0.11	0.11	TP-23	LSP0108

Table C-1B. Summary of Analytes Detected in Soil (Integral 2008)

Analyte	No. of Samples Analyzed	No. of Data Points	No. of Detected Data Points	Percent of Detection	Freq. of Detection	Min. Detection Limit	Max. Detection Limit	Min. Detected Value	Max. Detected Value	Location of Max. Detected Value	Samples with Max. Detected Value
Fluoranthene	1	1	1	100	1.0	NA	NA	0.17	0.17	TP-23	LSP0108
Indeno(1,2,3-cd)pyrene	1	1	1	100	1.0	NA	NA	0.014	0.014	TP-23	LSP0108
Pyrene	1	1	1	100	1.0	NA	NA	0.17	0.17	TP-23	LSP0108
Benzo(g,h,i)perylene	1	1	1	100	1.0	NA	NA	0.018	0.018	TP-23	LSP0108
Petroleum, mg/kg											
Diesel Range Hydrocarbons	6	6	3	50	0.5	0.5	0.6	7.15	34	TP-23	LSP0108
Motor Oil	6	6	6	100	1.0	NA	NA	21	210	TP-23	LSP0108
Conventionals, Percent											
Liquid Limit	1	1	1	100	1.0	NA	NA	51.5	51.5	TP-01	LSP0059
Percent Moisture	1	1	1	100	1.0	NA	NA	14.085	14.085	TP-01	LSP0059
Plastic Limit	1	1	1	100	1.0	NA	NA	39.9	39.9	TP-01	LSP0059
Plasticity Index	1	1	1	100	1.0	NA	NA	11.6	11.6	TP-01	LSP0059
Total Organic Carbon	3	3	3	100	1.0	NA	NA	2.66	6.09	TP-01	LSP0059
Total Solids	3	3	3	100	1.0	NA	NA	71.95	82.15	TP-01	LSP0059
Conventionals, Std Units											
Specific Gravity	1	1	1	100	1.0	NA	NA	2.625	2.625	TP-01	LSP0059
Landfill Subsurface Soil											
Metals, mg/kg											
Arsenic	17	17	7	41	0.4	0.8	40	6	13	TP-22	LSP0106
Cadmium	17	17	13	76	0.8	0.04	0.06	0.4	10	TP-23	LSP0110
Chromium	17	17	17	100	1.0	NA	NA	27.6	155	TP-24	LSP0114
Copper	17	17	17	100	1.0	NA	NA	21.2	409	TP-23	LSP0110
Lead	17	17	17	100	1.0	NA	NA	3	3970	TP-22	LSP0107
Mercury	17	17	13	76	0.8	0.002	0.003	0.05	1.62	TP-23	LSP0110
Nickel	17	17	17	100	1.0	NA	NA	28	120	TP-23	LSP0110
Silver	17	17	2	12	0.1	0.04	0.6	0.6	1.4	TP-01	LSP0061
Zinc	17	17	17	100	1.0	NA	NA	44.6	3060	TP-23	LSP0110

Table C-1B. Summary of Analytes Detected in Soil (Integral 2008)

Analyte	No. of Samples Analyzed	No. of Data Points	No. of Detected Data Points	Percent of Detection	Freq. of Detection	Min. Detection Limit	Max. Detection Limit	Min. Detected Value	Max. Detected Value	Location of Max. Detected Value	Samples with Max. Detected Value
SVOCs, mg/kg											
Bis(2-ethylhexyl)phthalate	1	1	1	100	1.0	NA	NA	0.15	0.15	TP-23	LSP0110
Diethylphthalate	1	1	1	100	1.0	NA	NA	0.012	0.012	TP-23	LSP0110
di-n-Butylphthalate	1	1	1	100	1.0	NA	NA	0.015	0.015	TP-23	LSP0110
Retene	1	1	1	100	1.0	NA	NA	0.037	0.037	TP-23	LSP0110
PAHs, mg/kg											
Acenaphthylene	1	1	1	100	1.0	NA	NA	0.012	0.012	TP-23	LSP0110
Phenanthrene	1	1	1	100	1.0	NA	NA	0.014	0.014	TP-23	LSP0110
Benzo(a)anthracene	1	1	1	100	1.0	NA	NA	0.02	0.02	TP-23	LSP0110
Benzo(a)pyrene	1	1	1	100	1.0	NA	NA	0.03	0.03	TP-23	LSP0110
Benzo(b)fluoranthene	1	1	1	100	1.0	NA	NA	0.038	0.038	TP-23	LSP0110
Benzo(k)fluoranthene	1	1	1	100	1.0	NA	NA	0.046	0.046	TP-23	LSP0110
Chrysene	1	1	1	100	1.0	NA	NA	0.034	0.034	TP-23	LSP0110
Fluoranthene	1	1	1	100	1.0	NA	NA	0.032	0.032	TP-23	LSP0110
Indeno(1,2,3-cd)pyrene	1	1	1	100	1.0	NA	NA	0.019	0.019	TP-23	LSP0110
Pyrene	1	1	1	100	1.0	NA	NA	0.05	0.05	TP-23	LSP0110
Benzo(g,h,i)perylene	1	1	1	100	1.0	NA	NA	0.025	0.025	TP-23	LSP0110
Petroleum, mg/kg											
Diesel Range Hydrocarbons	16	16	7	44	0.4	0.4	0.6	13	52	TP-23	LSP0110
Motor Oil	16	16	8	50	0.5	11	15	26	230	TP-23	LSP0110
Conventionals, Percent											
Percent Moisture	2	2	2	100	1.0	NA	NA	9.9	17.04	TP-03	LSP0072
Total Organic Carbon	9	9	9	100	1.0	NA	NA	0.953	9.04	TP-01	LSP0062
Total Solids	9	9	9	100	1.0	NA	NA	69.2	89.7	TP-02	LSP0068
Conventionals, Std Units											
Specific Gravity	2	2	2	100	1.0	NA	NA	2.51	2.75	TP-02	LSP0068

Table C-2. Comparison of Total and TCLP Metal Concentrations in Samples Collected from the Historical Landfill Area

TP-23, 3.5–4.0 ft bgs							
	Total Metals			**TCLP Metals**			**Total/TCLP**
Arsenic	10	U	mg/kg	0.03	U	mg/L	NA
Cadmium	10		mg/kg	0.02		mg/L	500
Chromium	78	J	mg/kg	0.006	U	mg/L	13000
Copper	409		mg/kg	0.04		mg/L	10225
Lead	1290		mg/kg	0.28		mg/L	4607
Nickel	120		mg/kg	0.08		mg/L	1500
Silver	0.6	U	mg/kg	0.002	U	mg/L	NA
Zinc	3060		mg/kg	5.37	J	mg/L	570

TP-22, 1.7–2.2 ft bgs							
	Total Metals			**TCLP Metals**			**Total/TCLP**
Arsenic	40	U	mg/kg	0.03	U	mg/L	NA
Cadmium	8		mg/kg	0.02		mg/L	400
Chromium	75	J	mg/kg	0.006	U	mg/L	12500
Copper	282		mg/kg	0.025		mg/L	11280
Lead	3970		mg/kg	0.66		mg/L	6015
Nickel	62		mg/kg	0.07		mg/L	886
Silver	0.3	U	mg/kg	0.002	U	mg/L	NA
Zinc	2960		mg/kg	8.005	J	mg/L	370

Notes: bgs = below ground surface
NA = not applicable since the analytes were undetected
J = estimated
U = undetected at detection limit shown
mg/kg = milligrams per kilogram
mg/L = milligrams per liter

Table C-3. Confirmation Sample Testing Results (Concentrations in mg/kg)

Station	Depth (ft)	Northing (ft)	Easting (ft)	Date Collected	Diesel	Motor Oil	Arsenic	Barium	Cadmium	Chromium	Lead	Mercury	Selenium	Silver
LSC-HA-01	0.5	649135.71	1235464.72	9/6/2010	6.3 U	24	8.7	137	0.7	55	34	0.12	0.6 U	0.2 U
LSC-HA-02	0.5	649130.76	1235468.21	9/6/2010	6.6	58	9.5	142	0.6	52.3	33	0.11	0.6 U	0.2 U
LSC-HA-03	0.5	649117.29	1235453.58	9/6/2010	6.1 U	28	7.1	146	0.6	45.4	**53**	**0.16**	0.6 U	0.2 U
LSC-HA-04	0.5	649111.90	1235459.95	9/6/2010	6.3 U	28	9.0	144	0.7	47.4	39	0.12	0.6 U	0.2 U
LSC-HA-05	0.5	649099.27	1235464.40	9/6/2010	5.5 U	17	7.2	599	0.5	30.1	**269**	0.10	0.5 U	0.9
LSC-HA-06	0.5	649092.93	1235422.20	9/6/2010	5.4 U	11 U	3.4	135	0.2 U	23.7	25	0.13	0.5 U	0.2 U
LSC-HA-07	0.5	649084.09	1235430.79	9/6/2010	6.2	61	7.8	216	0.6	38.1	**222**	**0.19**	0.5 U	0.3
LSC-HA-08	0.5	649069.86	1235393.67	9/6/2010	6.2 U	12 U	8.2	104	0.2	44.0	5	0.04	0.6 U	0.2 U
LSC-HA-09	0.5	649065.02	1235399.19	9/6/2010	5.4 U	11 U	2.2	43.1	0.3	23.8	2	0.02 U	0.5 U	0.2 U
LSC-HA-10	0.5	649136.36	1235452.11	9/28/2010	--	--	4.6	148	0.3	33	40	0.05	0.5 U	0.2 U
LSC-HA-11	0.5	649103.77	1235412.32	9/28/2010	--	--	3.3	99.9	0.2 U	31	5	0.02	0.5 U	0.2 U
LSC-HA-12	0.5	649120.95	1235402.46	9/28/2010	--	--	4.1	113	0.3	33	**70**	0.08	0.5 U	0.2 U
LSC-HA-13	0.5	649073.46	1235373.51	9/28/2010	--	--	2.6	44.0	0.3	33	2	0.02 U	0.5 U	0.2 U

-- Not analyzed.
269 Exceeds Screening Level.

APPENDIX D

INTERIM ACTION CLEANUP REQUIREMENTS

APPENDIX D
INTERIM ACTION CLEANUP REQUIREMENTS

This section describes the interim action cleanup requirements proposed for the Site. It includes information on remediation levels, points of compliance, and remedial action objectives.

D.1 SITE REMEDIATION LEVELS

The screening levels (SLs) used to identify the final indicator hazardous substances (IHSs) for human health and ecological receptors were compiled and the minimum screening levels [i.e., lesser of human health and terrestrial ecological evaluation (TEE)] were identified. The minimum screening levels were adjusted to develop remediation levels (RLs) by considering the following issues:

- Updates to toxicity parameter values
- Leaching pathway
- Practical quantitation limits (PQLs)
- Natural background concentrations

Additional consideration was given to additive risks and final adjustments were made as necessary to ensure that the RLs were consistent with target risk requirements of MTCA. Each of these issues is discussed below. The screening levels and RLs are shown in Table D-1.

D.1.1 Toxicity Values

The human health toxicity data available in USEPA's Integrated Risk Information System (IRIS) was checked for each of the final human health IHSs to determine whether they had been updated since the SLs were compiled in 2008. Toxicity values for pentachlorophenol were updated in IRIS in September 2010. The previous oral reference dose was 0.03 mg/kg-day, while the updated value is 0.005 mg/kg-day. The previous oral slope factor was 0.12 per mg/kg-day, while the updated value is 0.4 per mg/kg-day. The MTCA Method B equation values for direct contact with soil that were used for screening (2,400 and 8.3 mg/kg for noncancer and cancer effects, respectively) were adjusted to reflect the revised toxicity values. The revised direct contact SLs for pentachlorophenol are 400 and 2.5 mg/kg for noncancer and cancer effects, respectively. The minimum direct contact SL of 2.5 mg/kg is shown in Table D-1. No toxicity values have been updated for the other final human health IHSs since 2008.

D.1.2 Leaching Pathway

The final human health SLs used for cadmium, zinc, and pentachlorophenol were based on the leaching pathway because it produced lower SLs than did the direct contact pathway. However, based on a review of multiple lines of evidence discussed below, it was concluded that the leaching pathway is not a primary transport route for these chemicals at the Site. The RLs for these chemicals were based on direct human contact or the TEE, rather than the leaching pathway (Table D-1).

Pentachlorophenol

Per MTCA Section 747(9), an "empirical demonstration" may be conducted in order to establish a site-specific cleanup level. The proposed site-specific soil pentachlorophenol RL is 2.5 mg/kg (based on the soil ingestion pathway). Based upon the field evidence, it is believed that remnant soil pentachlorophenol does not pose a significant threat to underlying groundwater. This conclusion was drawn from the following multiple lines-of-evidence:

- For the landfill area, pentachlorophenol was only detected in one surface soil sample (0.350 mg/kg at TP-23). However, at this same location (TP-23), pentachlorophenol was not detected at depth (to ~ 4 ft. bgs).

- Pentachlorophenol is an ionizing organic and has a range of soil organic carbon-water partitioning coefficient (K_{oc}) values (MTCA Table 747-2). Pentachlorophenol is less mobile at lower pH (<5) and more mobile at more neutral pH (~7). Ecology's 1994 study of background soil metals concentrations found that average soil pH levels (by two methods, 1Molar CaCl and 1:1 soil-to-water) were 4.8 and 5.8, respectively. This implies that pentachlorophenol will likely be less mobile as it is anticipated that landfill soil pH is < 5-6.

- It's unlikely that site groundwater will be used for drinking water (now or in the future).

- There is no evidence that pentachlorophenol was ever used within the confines of the Eldridge landfill.

Metals

Per MTCA Section 747(7)(b)(ii), the toxicity characteristic leaching procedure (TCLP) leach test (EPA Method 1311) may be used to demonstrate that soil metals levels are protective of groundwater. The TCLP test was used on two soil samples (refer to Section 5.2.2 in report). Maximum TCLP leachate concentrations were 0.02, 0.66, 8, and <0.03 mg/L for cadmium, lead, zinc, and arsenic, respectively. The concentrations detected in the leachate were much lower than the TCLP limits that define a waste as exhibiting the toxicity characteristic (5, 1, and 5 mg/L for cadmium, lead and arsenic, respectively; there is no TCLP limit for zinc). In summary, the TCLP test results indicate that elevated soil metals levels are not likely to impact groundwater.

D.1.3 Practical Quantitation Limits and Natural Background Concentrations

Because the minimum SL for arsenic was lower than its natural background concentration, the natural background concentration was selected as the RL (Table D-1) (Ecology 1994). The TEE SL for zinc was based on its natural background concentration. None of the minimum screening levels was lower than its PQL so no adjustments were made on that basis.

D.1.4 Additive Risks

The total noncancer hazards and cancer risks associated with the RLs were calculated using MTCA Equations 740-1 and 740-2, respectively. These equations model a residential exposure scenario. The target for total Site noncancer hazards is 1 (WAC 173-340-740(5)(b)). The hazard quotient for each final IHS was calculated by dividing the RL by the direct contact SL based on noncancer effects (Table B-1 in Appendix B). The total of the noncancer hazard quotients (hazard index) associated with the final RLs was 1.4, so the RL for cadmium was adjusted down from 80 mg/kg to 45 mg/kg, at which point the hazard index was 1 (Table D-1). Cadmium was selected for this adjustment because it was the largest contributor to the hazard index.

The target for total Site cancer risks is $1x10^{-5}$ (WAC 173-340-740(5)(b)). The cancer risk associated with the natural background concentration of arsenic is $1.5x10^{-5}$ and the cancer risk associated with the direct contact RL for pentachlorophenol is $1x10^{-6}$ (Table D-1). The other final IHSs are not considered carcinogens so they do not contribute to total Site cancer risk. The total Site cancer risk associated with the RLs is $1.6x10^{-5}$, which is higher than the MTCA target. It is not practical to adjust the RL for arsenic below its natural background concentration. Site concentrations of pentachlorophenol, however, are expected to be much lower than the target RL. The one detected concentration of pentachlorophenol is 0.350 mg/kg, which is almost an order of magnitude lower than the RL (2.5 mg/kg). Pentachlorophenol is not expected to contribute substantially to total Site cancer risk, so no adjustment was made to the RL. Total Site cancer risk under actual exposure conditions is expected to be substantially lower than the value shown in Table D-1 due to the very limited detection of pentachlorophenol within the Site.

D.1.5 Proposed Remediation Levels

The RLs for the final IHSs are as follows (refer to Table D-1):

- Arsenic: 10 mg/kg, based on site-specific natural background (refer to Section 4.2.2 in the report)
- Cadmium: 45 mg/kg, based on direct human contact and adjusted to ensure a HI of 1
- Copper: 50 mg/kg, based on the TEE
- Lead: 50 mg/kg, based on the TEE
- Mercury: 0.1 mg/kg, based on the TEE
- Zinc: 86 mg/kg, based on natural background
- Pentachlorophenol: 2.5 mg/kg, based on direct human contact

The standard point of compliance for each of the Site RLs[1], all of which are based on direct contact with soil for either human or ecological receptors, is 15 ft bgs.

These concentrations were considered when establishing remedial action objectives for the site (Section D.2).

[1] Some of the direct contact RLs were adjusted up to natural background concentrations per WAC 173-340-740(5)(c).

D.2 REMEDIAL ACTION OBJECTIVES

Remedial action objectives (RAOs) are narrative statements about the types of actions that must be performed to address issues defined in the Conceptual Site Model. The RAOs for the landfill Site were the following:

- To reduce direct contact with contaminated soil by humans and ecological receptors;
- To minimize contamination of surface water; and
- To minimize migration of contaminants from soil to groundwater.

A cleanup action may comply with the RLs and these RAOs if the selected remedy is permanent to the maximum extent practicable, protective of human health and the environment, and provides institutional controls and compliance monitoring, if necessary.

REFERENCES

Ecology. 1994. Natural background soil metals concentrations in Washington State. Publ. No. 94-115. Washington Department of Ecology, Olympia WA.

MTCA. Model Toxics Control Act (Chapter 173-340). Prepared by the Washington State Department of Ecology, Toxics Cleanup Program. Last Updated November 2007.

Table D-1. Soil Remediation Levels for Eldridge Landfill

Final Indicator Hazardous Substance	Human Health Direct Contact Screening Level[a] (mg/kg)	Terrestrial Ecological Evaluation Screening Level (mg/kg)	Natural Background[b] (mg/kg)	Practical Quantitation Limit[c] (mg/kg)	Method B Remediation Level (mg/kg)	Basis for Remediation Level (mg/kg)	Human Health Hazard Quotient at Remediation Level[d] (unitless)	Human Health Cancer Risk at Remediation Level[e] (unitless)
Arsenic	0.67	NA	10	0.5	10	Site-Specific Background	0.42	1.5E-05
Cadmium	80	NA	1	0.2	45	Direct contact[f]	0.6	--
Copper	NA	50	36	0.2	50	TEE	NA	--
Lead	250	50	17	0.5	50	TEE	NA	--
Mercury	NA	0.1	0.07	0.05	0.1	TEE	NA	--
Zinc	24,000	86	86	> 0.66[g]	86	Background	0.0036	--
Pentachlorophenol	2.5	NA	NA	0.1	2.5	Direct contact	0.0063	1.0E-06
						Total:	1.0	1.6E-05

Notes:
-- = no value calculated because chemical isn't a carcinogen
HI = hazard index, sum of hazard quotients
IHS = indicator hazardous substance
MDL = method detection limit
NA = not applicable because the chemical isn't an IHS for this receptor, there is no natural background value, or a hazard quotient cannot be calculated
PCP = pentachlorophenol
TEE = terrestrial ecological evaluation

[a]Value shown is lowest of MTCA direct contact screening level values (carcinogen or noncarcinogen) per Table B-1 in Appendix B, with the exceptions of lead (Method A value is shown) and pentachlorophenol (updated per Section D.1.2).

[b]Obtained from Ecology (1994).

[c]Obtained from Ecology's "Draft LDW ARARs & CULs v12" spreadsheet.

[d]Calculated, consistent with MTCA Equation 740-1, using the following simplified equation: Hazard Quotient = Remediation Level / Noncancer Direct Contact Screening Level.

[e]Calculated, consistent with MTCA Equation 740-2, using the following simplified equation: Cancer Risk = Remediation Level x $1x10^{-6}$ / Cancer Direct Contact Screening Level.

[f]Direct contact remediation level was adjusted down to ensure HI=1.

[g]Value shown is a method detection limit, which is lower than a practical quantitation limit.

APPENDIX E

PERFORMANCE MONITORING RESULTS

Table E-1. Summary of Testing Results for Performance Monitoring Soil Samples (mg/kg dw)
Interim Action, Eldridge Municipal Landfill Site

Station	Arsenic	Cadmium	Copper	Lead	Mercury	Zinc	PCP	PAHs	BaP TEQ
RLs	10	45	50	50	0.1	86	2.5	NA**	***
EML-IA-A1S	5.9	1.7	75.2	213	0.10	550	0.190 U		
EML-IA-A1B	3.6	0.2	19.4	5.2	0.02 U	117	0.190 U		
EML-IA-A1B2						61			
EML-IA-A2S	8.1	3.3	86.1	477	0.18	500	0.190 U	0.019 U - 0.078	0.042
EML-IA-A2B	5.0	0.2	26.9	6.9	0.04	76	0.190 U		
EML-IA-A3S	4.9	0.5	43.2	15.6	0.05	107	0.190 U		
EML-IA-A3S2						53			
EML-IA-A3B	3.4	0.1	22.4	5.1	0.03	63	0.190 U		
EML-IA-A4B	4.7	0.2	30.9	5.5	0.05	65	0.180 U		
EML-IA-A4BD	4.8	0.2	33.5	5.9	0.05	72	0.180 U		
EML-IA-A5B	5.3	0.2	41.5	4.2	0.05	70	0.190 U	0.019 U	--
EML-IA-A5S	2.6	0.3	19.9	5.7	0.04	69	0.190 U		
EML-IA-A6S	5.8	0.5	34.9	106	0.08	162	0.570 U		
EML-IA-A6S2						84			
EML-IA-A6B	4.6	0.2	28.7	10.7	0.04	86	0.180 U		
EML-IA-A7B	5.3	0.2	30.5	5.4	0.05	87	0.180 U		
EML-IA-A8B	4.7	0.2	22.0	3.0	0.04	61	0.200 U	0.020 U	--
EML-IA-A8BD	5.1	0.2	24.9	3.1	0.04	64	0.180 U	0.018 U	--
EML-IA-A8S	9.8	1.4	79.7	310	0.32	480	0.560 U		
EML-IA-A9S	4.4	0.2	31.8	13.3	0.06	73	0.190 U	0.019 U	--
EML-IA-A9B	5.7	0.1	26.1	3.3	0.04	54	0.180 U		
EML-IA-A10B	3.6	0.1	28.5	4.9	0.03	79	0.190 U		
EML-IA-A11B	2.3	0.1	16.9	3.3	0.02	62	0.190 U		
EML-IA-A11S	4.4	0.2	25.0	3.6	0.03	53	0.190 U		
EML-IA-A12S	7.5	0.3	43.3	17.9	0.08	74	0.180 U		
EML-IA-A12B	4.6	0.1 U	25.4	2.6	0.03	42	0.190 U		
EML-IA-A13B	2.7	0.4	46.1	11.3	0.09	145	0.190 U		
EML-IA-A13B2						63			
EML-IA-A14B	1.9	0.1 U	18.1	2.7	0.03	59	0.190 U		
EML-IA-A14S	7.1	0.2	25.7	16.8	0.03	69	0.190 U		
EML-IA-A15S	5.0	0.1	39.4	9.6	0.05	50	0.190 U		
EML-IA-A15B	3.0	0.1 U	18.4	3.6	0.02 U	64	0.190 U	0.019 U	--
EML-IA-A16B	1.8	0.1	18.5	2.9	0.03	85	0.190 U		
EML-IA-A16S	7.3	0.5	26.1	18.2	0.04	112	0.190 U		
EML-IA-A16S2						68			
EML-IA-B1S	5.5	0.2	37.2	52.4	0.14	116	0.190 U		
EML-IA-B1S2				104	0.21	135			
EML-IA-B1B	2.9	0.1	21.8	4.4	0.03	76	0.200 U		
EML-IA-B2B	4.9	0.2	21.7	19.1	0.03	100	0.180 U	0.018 U	--
EML-IA-B2B2						84			
EML-IA-B2S	10.0	0.2	24.2	42.2	0.04	62	0.180 U		
EML-IA-B2SD	11.2	0.2	26.1	46.6	0.04	66	0.180 U		

Table E-1. Summary of Testing Results for Performance Monitoring Soil Samples (mg/kg dw)
Interim Action, Eldridge Municipal Landfill Site

Station	Arsenic	Cadmium	Copper	Lead	Mercury	Zinc	PCP	PAHs	BaP TEQ
RLs	10	45	50	50	0.1	86	2.5	NA**	***
EML-IA-B3S	5.8	0.7	134	222	0.43	233	0.190 U		
EML-IA-B3S2			57.4	129	0.12	155			
EML-IA-B3B	3.9	0.1	25.8	15.3	0.02	64	0.190 U	0.019 U	--
EML-IA-B4B	5.9	0.3	30.3	24.4	0.04	138	0.200 U		
EML-IA-B4B2						61			
EML-IA-B5B	12.3	0.4	65	50.3	0.22	83	0.190 U		
EML-IA-B5B2	4.3		52.2	13.3	0.17				
EML-IA-B5S	9.5	0.4	41.7	63.1	0.06	117	0.190 U	0.019 U - 0.048	0.029
EML-IA-B5S2				74.2		105			
EML-IA-B6S	6.9	0.5	46.5	108	0.13	190	0.190 U		
EML-IA-B6S2				84.2	0.13	673*			
EML-IA-B6B	1.3	0.1 U	31.2	9.7	0.08	75	0.200 U		
EML-IA-B7S	2.8	0.2	17.2	6.8	0.04	82	0.190 U	0.019 U - 0.037	0.019
EML-IA-B7B	2.5	0.1	43.1	3.8	0.06	47	0.180 U		
EML-IA-B7BD	2.2	0.1	37.0	2.9	0.05	41	0.200 U		
EML-IA-B8B	3.0	0.1 U	13.8	2.9	0.02	46	0.190 U		
EML-IA-B9B	4.0	0.1 U	14.4	2.9	0.02	41	0.180 U		
EML-IA-B9S	4.4	0.2	34.1	62.1	0.06	95	0.200 U		
EML-IA-B10B	2.4	0.2	52.9	5.4	0.10	87	0.200 U		
EML-IA-B11B	1.7	0.1 U	16.7	2.9	0.02 U	51	0.200 U		
EML-IA-B12B	1.2	0.1 U	15.4	2.1	0.02 U	50	0.180 U		
EML-IA-B12S	8.2	1.0	147	536	0.38	370	0.580 U	0.035 J - 0.076	0.046
EML-IA-B12S2	5.4	0.1	32.8	4.4	0.03	53			
EML-IA-B13B	1.7	0.1	29.5	4.3	0.02	44	0.190 U		
EML-IA-B14B	1.4	0.1 U	18.1	3.5	0.03	51	0.190 U		
EML-IA-B15B	6.6	0.5	112	28.8	0.43	263	0.190 U		
EML-IA-B15B2			14.2		0.03	79			
EML-IA-B15S	4.1	0.5	33.6	14.2	0.1	187	0.180 U		
EML-IA-B15S2						62			
EML-IA-B16S	5.4	0.4	36.1	86.9	0.07	101			
EML-IA-B16B	4.2	0.2	29.2	13.5	0.03	75			

Notes:

673* = average value of triplicate analysis (680, 690, 650 mg/kg)

[orange] Exceeds Corresponding RL

[yellow] Second Confirmation Sample Result below RL

NA** There is no RL for PAHs in the interim action.

*** A screening level of 0.14 mg/kg for BaP toxicity equivalents (Method B equation value) was used for comparison only.

APPENDIX F

GROUNDWATER CONFIRMATION MONITORING RESULTS

APPENDIX F
LABORATORY DATA VALIDATION

The data were validated using guidance and quality control (QC) criteria documented in the analytical methods; the Sampling and Analysis Plan (Herrenkohl Consulting 2012), and the National Functional Guidelines for Organic and Inorganic Data Review (USEPA 1999, 2004, 2009). Soil and groundwater samples were analyzed by Analytical Resources, Inc. (ARI) of Tukwila, Washington. Samples submitted to ARI were analyzed for one or more of the following:

Test	Method
Arsenic, Cadmium, Copper, Lead, Zinc	EPA 200.8
Mercury	SW 7470A/7471A
Pentachlorophenol	SW 8270D low level
Polycyclic Aromatic Hydrocarbons	SW 8270D low level
Nitrite, Nitrate in Groundwater Only	EPA 300.0
Ammonia in Groundwater Only	EPA 350.1M
Calcium, Iron, Manganese, Magnesium in Groundwater Only	EPA 200.8

Sample data are presented in the following sample delivery groups (SDGs):

Laboratory Sample Delivery Group	Samples
UV92	EML-SB-05-5-6.5, -15-16.5
UW00	EML-SB-01-10-11; EML-SB-02-10-11; EML-SB-03-7.5-9; EML-SB-04-0-1.5, -5-6
UW44/UW45	EML-MW-01, -02, -03, -04, -05

Summary data packages and electronic data deliverables (EDD) are available upon request (compact disk).

A partial data review was completed for all data packages which included review of the following:

- Data package completeness
- Analytical holding time and sample preservation
- Reporting limits
- Blank contamination
- Accuracy (compound recovery)
- Precision (replicate analyses)

F.1 DATA PACKAGE COMPLETENESS

Completeness is defined as the total number of usable results (results that were not rejected during data validation) divided by the total results reported by the laboratory. The results reported by the laboratory were 100% complete for the soil and groundwater analyses. No qualifications are recommended in the data set except for the following:

- Pentachlorophenol in groundwater for station EML-MW-05 was analyzed less than 24 hours outside the recommended holding time. The result is qualified as an estimate (UJ).

F.2 HOLDING TIME AND SAMPLE PRESERVATION

With the exception of the pentachlorophenol result for EML-MW-05, the time between sample collection, extraction (if applicable), and analysis was determined to be within method and project-specified holding times. No other qualifications of the data are necessary.

The initial sample preservation requirement (cooler temperature of 4°C ±2°) was met for all samples upon receipt by the laboratory.

F.3 REPORTING LIMITS

Reporting limits were at or below target reporting limits for the project.

F.4 BLANK CONTAMINATION

At least one method blank was analyzed with each batch of samples for each analysis. No contamination was detected in any of the method blanks except for the following:

SDG	Analysis	Compound
UW44, UW45	Metals	Calcium

Groundwater sample concentrations were ten times greater than the calcium concentration detected in blank. No qualification of the data was necessary.

F.5 ACCURACY

<u>Surrogate Compound Recoveries</u>

Surrogate compounds were added to samples analyzed for organics by EPA method SW8270D. The surrogate recoveries reported by the laboratory met the criteria for acceptable performance.

<u>Matrix Spike Recoveries</u>

Matrix spike and/or matrix spike duplicate (MS/MSD) analyses were performed at the proper frequency for conventionals (e.g., nitrate), metals, and organic analyses. All spike recoveries reported by the laboratory for MS/MSD analyses met the criteria for acceptable performance.

Laboratory Control Spike Recoveries

Laboratory control sample/laboratory control sample duplicate (LCS/LCSD) analyses were performed at the proper frequency for metals and organic analyses of samples. All of the recoveries reported by the laboratory for LCS/LSCD analyses met the criteria for acceptable performance.

Standard Reference Material Recoveries

Standard reference materials were analyzed for nitrite, nitrate, and ammonia in groundwater (SDGs UW44/UW45). The sample recovery met the criteria for acceptable performance.

F.6 PRECISION

MS/MSD, LCS/LCSD, and laboratory replicate analyses were evaluated for laboratory precision. All of the relative percent difference (RPD) values for MS/MSD, laboratory replicate, and LCS/LCSD analyses met the criteria for acceptable performance except for the following:

SDG	Sample	Replicate Analysis	Compound
UV92	EML-SB-05-5-6.5	MS/MSD RPD	Zinc

No qualifications of the data are recommended because the RPD result (21.3%) was slightly outside the control limit of ±20% and other data used for assessing precision (e.g., LCS/LCSD) in this sample was considered acceptable.

F.7 REFERENCES

EPA. 2009. Guidance for Labeling Externally Validated Laboratory Analytical Data for Superfund Use. OSWER No. 9200.1-85 EPA 540-R-08-005. U.S. Environmental Protection Agency. January.

EPA. 2004. USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review. EPA-540/R-04-004. U.S. Environmental Protection Agency. Office of Superfund Remediation and Technology Innovation (OSRTI). Washington, D.C. October.

EPA. 1999. USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review. EPA-540/R-99-008. U.S. Environmental Protection Agency. Office of Emergency and Remedial Response. Washington, D.C. October.

Herrenkohl Consulting. 2012. Sampling and Analysis Plan, Eldridge Municipal Landfill RI/FS. Prepared for the City of Bellingham, Public Works Department, Bellingham, WA. Prepared by Herrenkohl Consulting LLC, Bellingham,

Table F-1. Sample Location Information.

Location	Northing (ft)	Easting (ft)	Elevation (ft)
EML-MW-01 TOP PIPE	649141.40	1235496.70	37.53
EML-MW-01 LID	649141.40	1235496.70	37.93
EML-MW-01 GS	649141.00	1235497.00	37.72
EML-MW-02 TOP PIPE	649076.20	1235494.60	37.49
EML-MW-02 LID	649076.20	1235494.60	37.89
EML-MW-02 GS	649076.00	1235495.00	37.59
EML-MW-03 TOP PIPE	648989.80	1235617.10	39.08
EML-MW-03 LID	648989.80	1235617.10	39.66
EML-MW-03 GS	648990.00	1235617.00	39.33
EML-MW-04 TOP PIPE	649042.10	1235710.20	38.84
EML-MW-04 LID	649042.10	1235710.20	39.27
EML-MW-04 GS	649042.00	1235710.00	39.17
EML-MW-05 TOP PIPE	648874.70	1235807.70	48.17
EML-MW-05 LID	648874.70	1235807.70	48.55
EML-MW-05 GS	648875.00	1235808.00	48.37

Horizontal Datum NAD 83/98 (WA State North)
Vertical Datum NAVD88
Surveyed by Wilson Engineering LLC on June 5, 2012

Table F-2. Soil Sample Testing Results (**mg/kg dw**).

Station	Arsenic	Cadmium	Copper	Lead	Mercury	Zinc	PCP	PAHs
Remedial Levels	10	45	50	50	0.1	86	2.5	NA*
EML-SB-01-10-11	1.4	0.1 U	18.5	1.8	0.03 U	34	0.180 U	0.018 U
EML-SB-02-10-11	3.5	0.2	25.7	2.4	0.03	46	0.190 U	0.019 U
EML-SB-03-7.5-9	3.1	0.1	25.5	2.2	0.03	41	0.190 U	0.019 U
EML-SB-04-0-1.5	6.1	0.3	32.5	64	0.07	96	0.200 U	0.030**
EML-SB-04-5-6	2.6	0.1 U	26.5	2.1	0.03 U	40	0.180 U	0.018 U
EML-SB-05-5-6.5	2.9	0.1	20.9	2.4	0.02 U	42	0.190 U	0.019 U
EML-SB-05-15-16.5	3.8	0.2	27.9	2.9	0.03 U	40	0.180 U	0.018 U

Notes: 64 Exceeds Remediation Level (highlighted)
* There is no remediation level for PAHs in the interim action.
** A screening level of 0.14 mg/kg for BaP toxicity equivalents (Method B equation value) was used for comparison.

Table F-3. Groundwater Sample Testing Results.

Station	**N-Nitrite**	**N-Nitrate** (Units = mg-N/L)	**Ammonia**	**Arsenic**		**Cadmium**		**Calcium**		**Copper**		**Iron**		**Lead** (Units = ug/L)		**Magnesium**		**Manganese**		**Mercury**		**Zinc**		**PCP**	**PAHs**
				TM	DM	TM	DM	TM	DM	TM	DM	TM	DM	TM	DM	TM	DM	TM	DM	TM	DM	TM	DM		
EML-MW-01	0.1 U	0.1 U	0.129	1.8	1.6	0.1 U	0.1 U	18000	16500	4.1	0.6	6690	4350	0.4	0.1 U	12000	10100	1570	1670	0.0026 U	0.0026 U	4	4 U	0.16 U	0.0027 - 0.0099 U
EML-MW-02	0.1 U	1.1	2.29	1.4	1.2	0.1 U	0.1 U	63200	59000	1.2	1.0	6380	4770	0.1 U	0.1 U	20700	17600	987	918	0.0026 U	0.0026 U	4 U	12	0.16 U	0.0027 - 0.0099 U
EML-MW-03	0.1 U	0.1 U	0.364	17.7	14.7	0.1 U	0.1 U	46400	44800	1.3	0.8	9320	6610	0.1 U	0.1 U	23000	18500	2090	2010	0.0026 U	0.0026 U	4 U	4 U	0.16 U	0.0027 - 0.0099 U
EML-MW-04	0.1 U	0.1 U	0.082	1.9	1.9	0.2	0.2	36100	36600	2.2	1.7	4230	4140	0.1 U	0.1 U	14800	16500	3370	3420	0.0026 U	0.0026 U	70	5	0.16 U	0.0027 - 0.0099 U
EML-MW-05	0.1 U	2.6	0.023	1.3	0.2 U	0.3	0.1 U	19300	15200	22.7	0.9	3770	30	2.5	0.1 U	12000	8970	930	282	0.0026 U	0.0026 U	24	4 U	0.16 UJ	0.0027 - 0.0099 U

Notes:

*Groundwater samples from monitoring wells EML-MW-1 through EML-MW-4 were collected on May 29, 2012.
*Groundwater sample from monitoring well EML-MW-5 was collected on May 28, 2012
<u>Metal results are reported as total (TM) and dissolved (DM) metals.</u>
Detection limits for PCP and PAHs are method detection limits reported by laboratory.
PAH - polycyclic aromatic hydrocarbons
PCP - pentachlorophenol
NTU - nephelometric turbidity units
mS/cm = milli Siemens per centemeter

Final Field Parameter Data, Groundwater Sample Collection

Station	**pH**	**Temp**	**Cond**	**DO**	**Turb**
	(-)	(^{o}C)	(mS/cm)	(mg/L)	(NTU)
EML-MW-01	6.30	10.36	0.309	0.41	0
EML-MW-02	6.06	11.00	0.655	0.36	0
EML-MW-03	6.07	13.65	0.504	0.34	0
EML-MW-04	5.91	11.95	0.462	0.40	0
EML-MW-05	6.50	13.40	0.257	13.75	376

SOIL BORING LOG KEY

Major Divisions		Symbols	Typical Names
Coarse Grained Soils (More than 1/2 of soil >No. 200 sieve size)	**Gravels** (More than 50% coarse fraction > no. 4 sieve	GW	Well-graded gravels or gravel-sand mixtures, little to no fines
		GP	Poorly-graded gravels or gravel-sand mixtures, little to no fines
		GM	Silty gravels, gravel-sand-silt mixtures
		GC	Clayey gravels or gravel-sand-clay mixtures
	Sands (Less than 50% coars fraction > no. 4 sieve)	SW	Well-graded sands or gravel-sand mixtures, little to no fines
		SP	poorly-graded sands or gravelly sands, little to no fines
		SM	Silty sands, sand-silt mixtures
		SC	Clayey sands, sand-clay mixtures
Fine Grained Soils (More than 1/2 of soil <No. 200 sieve size)	**Silts & Clays** Liquid limit* less than 50%	ML	Inorganic silts and very fine sands, silty or clayey fine sands or clayey silts with slight plasticity
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy or silty clays, lean clays
		OL	Organic silts and organic silty clays of low plasticity
	Silts & Clays Liquid limit* greater than 50%	MH	Inorganic silts, micaceous or ditomaceous fine sand or silty soils, elastic silts
		CH	Inorganic clays of high plasticity, fat clays
		OH	Organic clays of medium to high plasticity, organic silty clay, organic silts
Highly Organic Soils		Pt	Peat or other highly organic soils

*Liquid limit represents the moisture contnet (in percent) of a soil at which point the soil no longer behaves like a plastic and starts to behave like a liquid.

Boring Log Symbols

Sample Interval

Groundwater, First Observed

Groundwater, Static

Sample Types

SS	Split Spoon
G	Grab
ST	Shelby Tube
GS	Geoprobe Sampler

Sheen Types

NS	No Sheen Observed
SS	Slight Sheen observed (Spotty coverage of sheen pan, no irridescence)
MS	Moderate Sheen (Full Coverage)
HS	Heavy Sheen (Full Coverage, Irredescent)

Sample Moisture

Dry	No Moisture, dry to touch
Moist	Damp but no visible moisture
Wet	Visible free water

Sample Plasticity (Fine-Grained Soils)

- Non-Plastic - Cannot be rolled at any moisture content
- Low - Barely rolled, lump cannot be formed when drier than plastic limit
- Medium - Easily rolled, lump crumbles when drier than plastic limit
- High - Easily rolled yet takes considerable time to reach the plastic limit, lump can be formed without crumbling when drier than the plastic limit

Partical Size Range (Course-Grained Soils)

- Gravel - Fine, Course
- Sand - Fine, Medium, Coarse

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Based on Unified Soil Classification System and ASTM Standard D2487 and D2488

35-35.5* * Indicates sample was selected for analysis

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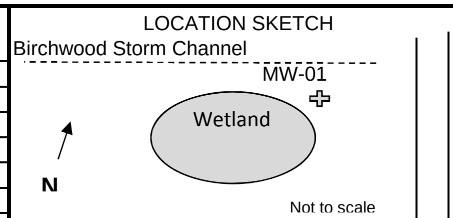
BOREHOLE NUMBER	EML-SB-01
PROJECT	Eldridge Municipal Landfill RI/FS
LOCATION	Little Squalicum Park
PROJECT NUMBER	HCL026
LOGGED BY	Mark Herrenkohl, LEG
DATE AND TIME	May 22, 2012 1015

SAMPLE INFORMATION									DESCRIPTION
Sample ID	Time	Blow Counts	% Recovery	PID	Sheen	Sample Depth (ft)	Depth (ft)	STRATA	USCS group name, moisture content and plasticity, color, minor and MAJOR constituents with grain size range, odor, sheen, texture, weathering, cementation, geologic interpretation, etc.
									2-inch root zone
								SM	Wet, (loose), tan to brown, silty SAND (F-C) with F Gravels (FILL)
0-1.5	1015	2/6/5	67	--	N	0-1.5	1--		
								ML	Damp, (soft), tan to brown clayey SILT (FILL)
							2--		
							3--		
	1020	2/3/3	0	--	N	2.5.-4		SM/	V. Wet, (loose), tan to brown, silty gravelly (F), SAND (F-C) to
								GM	silty sandy (F-C) Fine Gravel (FILL)
							4--		
								∇ ?	
							5--		
5-6.5	1027	6/15/14	67	--	N	5-6.5		SM	V. Wet/saturated, (loose), brown to gray, SAND (F-M) with fine gravels
							6--		
							7--		
							8--		
7.5-9	1036	2/4/8	87	--	N	7.5-9		SM	Saturated, (loose), tan to gray, silty SAND (F-M)
									(Sample may be mostly sluff from flowing sands)
							9--		

DRILLING CONTRACTOR	Cascade Drilling
DRILLING METHOD	Hollow-Stem Auger, Limited Access
SAMPLING EQUIPMENT	Split-Spoon
COORDINATES	N 649141.4
(Top-of-PVC)	W 1235496.7
SURFACE ELEVATION	37.53 ft
DATUM	NAVD

LOCATION SKETCH

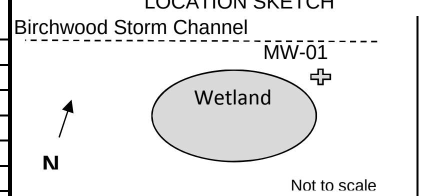


HERRENKOHL CONSULTING LLC	
321 Summerland Road Bellingham, WA 98229 (360) 319-0721 FAX (360) 647-6980	BOREHOLE NUMBER: EML-SB-01 PROJECT: Eldridge Municipal Landfill RI/FS LOCATION: Little Squalicum Park PROJECT NUMBER: HCL026 LOGGED BY: Mark Herrenkohl, LEG DATE AND TIME: May 22, 2012 1015

SAMPLE INFORMATION									DESCRIPTION
Sample ID	Time	Blow Counts	% Recovery	PID	Sheen	Sample Depth (ft)	Depth (ft)	STRATA	USCS group name, moisture content and plasticity, color, minor and MAJOR constituents with grain size range, odor, sheen, texture, weathering, cementation, geologic interpretation, etc.
								SM	Wet, (loose), gray to mottled orange, silty SAND (F-M) (Native)
10-11*	1045	10/7/6	67	--	N	10-11.5	11		
									(Transition at 11.2 ft)
								CL	Moist, (m.stiff), light brown, silty CLAY (Native)
							12		Base of Boring @ 11.5 ft.
							13		
							14		
							15		
							16		
							17		
							18		
							19		

DRILLING CONTRACTOR	Cascade Drilling
DRILLING METHOD	Hollow-Stem Auger, Limited Access
SAMPLING EQUIPMENT	Split-Spoon
COORDINATES	N 649141.4
(Top-of-PVC)	W 1235496.7
SURFACE ELEVATION	37.53 ft
DATUM	NAVD

LOCATION SKETCH



Herrenkohl Consulting LLC

As-Built Well Completion Form

Exploration No.: EML-SB-01

Well No. (If different than Expl. No.): MW-01

Client/Owner: COB Project No.: HCL026

Project Name: Eldridge Municipal Landfill

Drilling Co.: Cascade Drilling

Rep(s): James Goble

Installation Start Date: 5/22/12 Hour: 1015

Installation Finish Date: 5/22/12 Hour: 1145

Well Type: [X] Single ☐ Nested ☐ Clustered

BORING AND WELL DIMENSIONS AND INSTALLATION DETAILS

DOE Unique Well No.: BHE 658

Number of Pipes in Boring: 1

Boring Diameter at Top of Hole: 8-inch

Does Diameter of Hole Change? No

Boring Diameter at First Step Down: --

Depth of First Step Down: --

Boring Diameter at Second Step Down: --

Depth of Second Step Down: --

Well Completion Date: 5/22/12

Elevation of Well Cover: 37.93 (ft NAVD)

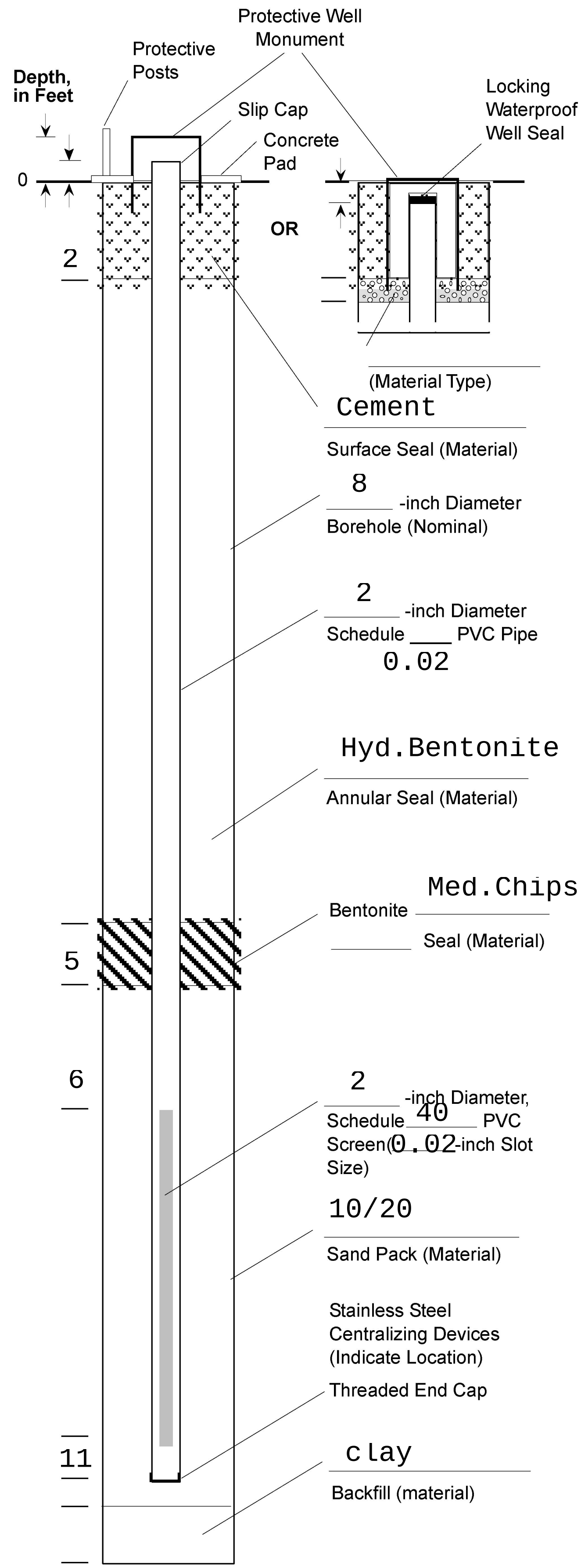
Elevation of Top of Well Pipe: 37.53 (ft NAVD)

Depth to Water: 34.81 ft

Date: 5/28/12 Time: 1250

MATERIALS USED

3.5	Sacks of 10/20 Sand
4	Sacks of cement Concrete/Cement
--	Sacks of ____ Grout Mix Used
1	Sacks of Bentonite Chips
6	Feet of 2-inch PVC Blank Casing
5	Feet of 0.02-inch PVC Slotted Screen
1	Threaded End Cap
1	Waterproof Well Seal/Slip Cap
1	Flush Mount/Aboveground Protective Monument
--	Protective Posts



HERRENKOHL CONSULTING LLC

321 Summerland Road
Bellingham, WA 98229

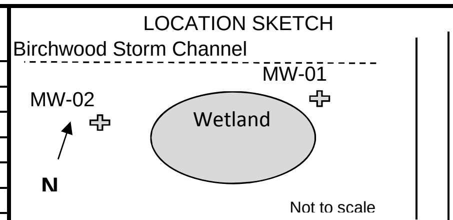
(360) 319-0721 FAX (360) 647-6980

BOREHOLE NUMBER	EML-SB-02
PROJECT	Eldridge Municipal Landfill RI/FS
LOCATION	Little Squalicum Park
PROJECT NUMBER	HCL026
LOGGED BY	Mark Herrenkohl, LEG
DATE AND TIME	May 22, 2012 1205

SAMPLE INFORMATION									DESCRIPTION
Sample ID	Time	Blow Counts	% Recovery	PID	Sheen	Sample Depth (ft)	Depth (ft)	STRATA	USCS group name, moisture content and plasticity, color, minor and MAJOR constituents with grain size range, odor, sheen, texture, weathering, cementation, geologic interpretation, etc.
								SM	Damp to moist, (v. loose), tan, silty gravelly (F), SAND (F-C) (FILL)
0-1.5	1205	3/6/7	53	--	N	0-1.5	1--		
							2--		
							3--	∇ ?	
2.5-4	1210	3/6/16	60	--	N	2.5.-4		SM/	Wet, (v. loose), tan to gray, silty gravelly (F), SAND (F-C) to silty,
								GM	sandy (F-C), GRAVEL (F) (FILL)
							4--		
							5--		
5-6.5	1215	6/4/6	33	--	N	5-6.5		GM	Saturated, (v. loose), tan to gray, silty sandy (F-C), GRAVEL (F) (FILL)
							6--		(Gravel blocked sample shoe, piling driving and low recovery)
							7--		
							8--		
7.5-9	1221	5/10/12	80	--	N	7.5-9		SM	Saturated, (loose), gray, silty SAND (F-M) (Native?)
							9--		

DRILLING CONTRACTOR	Cascade Drilling
DRILLING METHOD	Hollow-Stem Auger, Limited Access
SAMPLING EQUIPMENT	Split-Spoon
COORDINATES	N 649076.2
(Top-of-PVC)	E 1235494.6
SURFACE ELEVATION	37.49 ft
DATUM	NAVD

LOCATION SKETCH

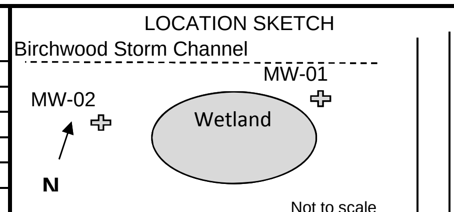


HERRENKOHL CONSULTING LLC	BOREHOLE NUMBER: EML-SB-02
321 Summerland Road	PROJECT: Eldridge Municipal Landfill RI/FS
Bellingham, WA 98229	LOCATION: Little Squalicum Park
(360) 319-0721 FAX (360) 647-6980	PROJECT NUMBER: HCL026
	LOGGED BY: Mark Herrenkohl, LEG
	DATE AND TIME: May 22, 2012 1205

SAMPLE INFORMATION							Depth (ft)	STRATA	DESCRIPTION
Sample ID	Time	Blow Counts	% Recovery	PID	Sheen	Sample Depth (ft)			USCS group name, moisture content and plasticity, color, minor and MAJOR constituents with grain size range, odor, sheen, texture, weathering, cementation, geologic interpretation, etc.
								SM	Saturated, (loose), gray, silty SAND (F-M) (Native?)
10-11*	1226	5/7/10	67	--	N	10-11.5	11		
									(Transition at 11.2 ft)
								CL/ML	Moist, (m.stiff), light brown, silty CLAY to sandy clayey, SILT (Native)
11.5-12.5	1232	3/7/14	67	--	N	11.5-13	12		(clay/silt layer is approximately 1.2 ft thick)
								SM	Moist to damp, gray, silty SAND (F) (Native)
							13		Base of Boring @ 13 ft.
							14		
							15		
							16		
							17		
							18		
							19		

DRILLING CONTRACTOR	Cascade Drilling
DRILLING METHOD	Hollow-Stem Auger, Limited Access
SAMPLING EQUIPMENT	Split-Spoon
COORDINATES	N 649076.2
(Top-of-PVC)	E 1235494.6
SURFACE ELEVATION	37.49 ft
DATUM	NAVD

LOCATION SKETCH



Herrenkohl Consulting LLC

As-Built
Well Completion Form

Exploration No.: EML-SB-02

Well No. (If different than Expl. No.): MW-02

Client/Owner: COB Project No.: HCL026

Project Name: Eldridge Municipal Landfill

Drilling Co.: Cascade Drilling

Rep(s): James Goble

Installation Start Date: 5/22/12 Hour: 1205

Installation Finish Date: 5/22/12 Hour: 1340

Well Type: [X] Single [ ] Nested [ ] Clustered

BORING AND WELL DIMENSIONS AND INSTALLATION DETAILS

DOE Unique Well No.: BHE 659

Number of Pipes in Boring: 1

Boring Diameter at Top of Hole: 8-inch

Does Diameter of Hole Change? No

Boring Diameter at First Step Down: --

Depth of First Step Down: --

Boring Diameter at Second Step Down: --

Depth of Second Step Down: --

Well Completion Date: 5/22/12

Elevation of Well Cover: 37.89 (ft NAVD)

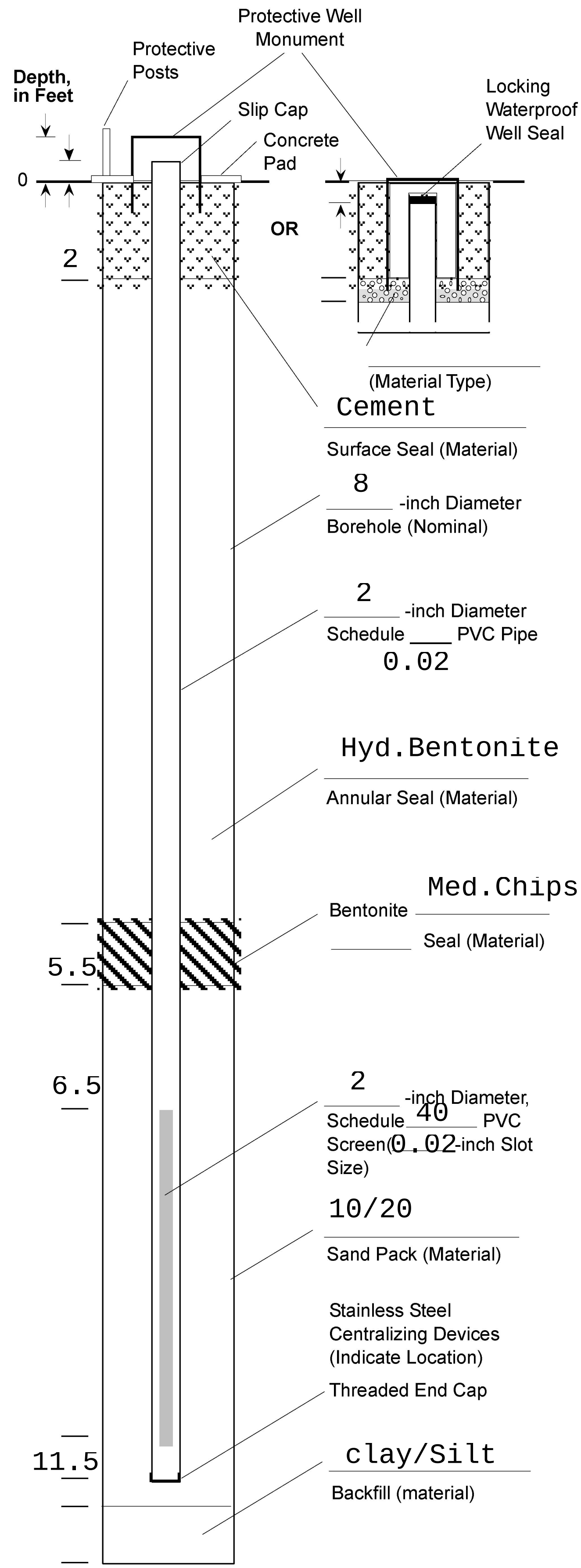
Elevation of Top of Well Pipe: 37.53 (ft NAVD)

Depth to Water: 33.76 ft

Date: 5/28/12 Time: 1252

MATERIALS USED

3	Sacks of 10/20 Sand
4	Sacks of cement Concrete/Cement
--	Sacks of ______ Grout Mix Used
1	Sacks of Bentonite Chips
6.5	Feet of 2-inch PVC Blank Casing
5	Feet of 0.02-inch PVC Slotted Screen
1	Threaded End Cap
1	Waterproof Well Seal/Slip Cap
1	Flush Mount/Aboveground Protective Monument
--	Protective Posts

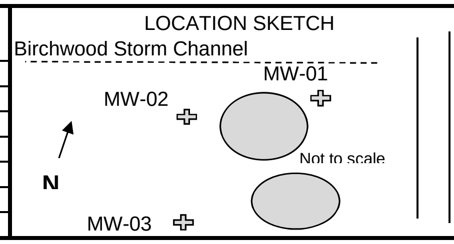


HERRENKOHL CONSULTING LLC 321 Summerland Road Bellingham, WA 98229 (360) 319-0721 FAX (360) 647-6980	BOREHOLE NUMBER: EML-SB-03 PROJECT: Eldridge Municipal Landfill RI/FS LOCATION: Little Squalicum Park PROJECT NUMBER: HCL026 LOGGED BY: Mark Herrenkohl, LEG DATE AND TIME: May 22, 2012 1350

SAMPLE INFORMATION									
Sample ID	Time	Blow Counts	% Recovery	PID	Sheen	Sample Depth (ft)	Depth (ft)	STRATA	DESCRIPTION USCS group name, moisture content and plasticity, color, minor and MAJOR constituents with grain size range, odor, sheen, texture, weathering, cementation, geologic interpretation, etc.
									(2-inch grass plug on surface)
								SM	Moist, (v. loose), tan to light brown, silty, SAND (F-C) with increasing gravels at bottom of sampler (FILL)
0-1.5	1350	4/9/12	67	--	N	0-1.5	1--		
							2--		
							3--		
2.5-4	1355	4/7/14	47	--	N	2.5.-4			Moist, (v. loose), tan to light brown, silty, gravelly (F), SAND (F-C) (FILL)
							4--		
							5--	∇ ?	
5-6.5	1400	5/7/18	60	--	N	5-6.5			Wet/saturated, (loose), tan to brown, silty, gravelly (F), SAND (F-C) (FILL)
							6--		
							7--		
							8--		
7.5-9*	1405	3/7/8	73	--	N	7.5-9		SM	Saturated, (loose), gray, silty SAND (F-M) (Native?)
							9--		

DRILLING CONTRACTOR	Cascade Drilling
DRILLING METHOD	Hollow-Stem Auger, Limited Access
SAMPLING EQUIPMENT	Split-Spoon
COORDINATES	N 648989.8
(Top-of-PVC)	E 1235617.1
SURFACE ELEVATION	39.08 ft
DATUM	NAVD

LOCATION SKETCH



HERRENKOHL CONSULTING LLC

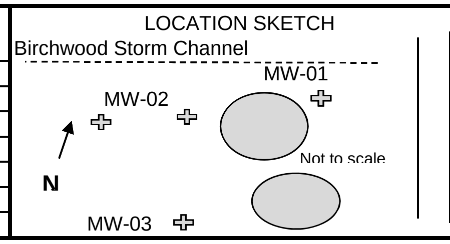
321 Summerland Road
Bellingham, WA 98229
(360) 319-0721 FAX (360) 647-6980

BOREHOLE NUMBER	EML-SB-03
PROJECT	Eldridge Municipal Landfill RI/FS
LOCATION	Little Squalicum Park
PROJECT NUMBER	HCL026
LOGGED BY	Mark Herrenkohl, LEG
DATE AND TIME	May 22, 2012 1350

Sample ID	Time	Blow Counts	% Recovery	PID	Sheen	Sample Depth (ft)	Depth (ft)	STRATA	DESCRIPTION: USCS group name, moisture content and plasticity, color, minor and MAJOR constituents with grain size range, odor, sheen, texture, weathering, cementation, geologic interpretation, etc.
								SM	Wet, (loose), gray, silty, SAND (F-M) (Native?)
10-11.5	1410	8/13/20	100	--	N	10-11.5	11		
	1416	9/37/50	50-5in		N	11.5-13	12		No Recovey.
								CL	Damp, gray, silty CLAY (Native) - at bottom of sampler
							13		Base of Boring @ 13 ft.
									Note: clay layer may begin @ 11.5 ft but was unable to sample because of sand heave filling sampler.
							14		
							15		
							16		
							17		
							18		
							19		

DRILLING CONTRACTOR	Cascade Drilling
DRILLING METHOD	Hollow-Stem Auger, Limited Access
SAMPLING EQUIPMENT	Split-Spoon
COORDINATES	N 648989.8
(Top-of-PVC)	E 1235617.1
SURFACE ELEVATION	39.08 ft
DATUM	NAVD

LOCATION SKETCH



Herrenkohl Consulting LLC

As-Built Well Completion Form

Exploration No.: EML-SB-03

Well No. (If different than Expl. No.): MW-03

Client/Owner: COB Project No.: HCL026

Project Name: Eldridge Municipal Landfill

Drilling Co.: Cascade Drilling

Rep(s): James Goble

Installation Start Date: 5/22/12 Hour: 1350

Installation Finish Date: 5/22/12 Hour: 1540

Well Type: ☒ Single ☐ Nested ☐ Clustered

BORING AND WELL DIMENSIONS AND INSTALLATION DETAILS

DOE Unique Well No.: BHE 660

Number of Pipes in Boring: 1

Boring Diameter at Top of Hole: 8-inch

Does Diameter of Hole Change? No

Boring Diameter at First Step Down: --

Depth of First Step Down: --

Boring Diameter at Second Step Down: --

Depth of Second Step Down: --

Well Completion Date: 5/22/12

Elevation of Well Cover: 39.66 (ft NAVD)

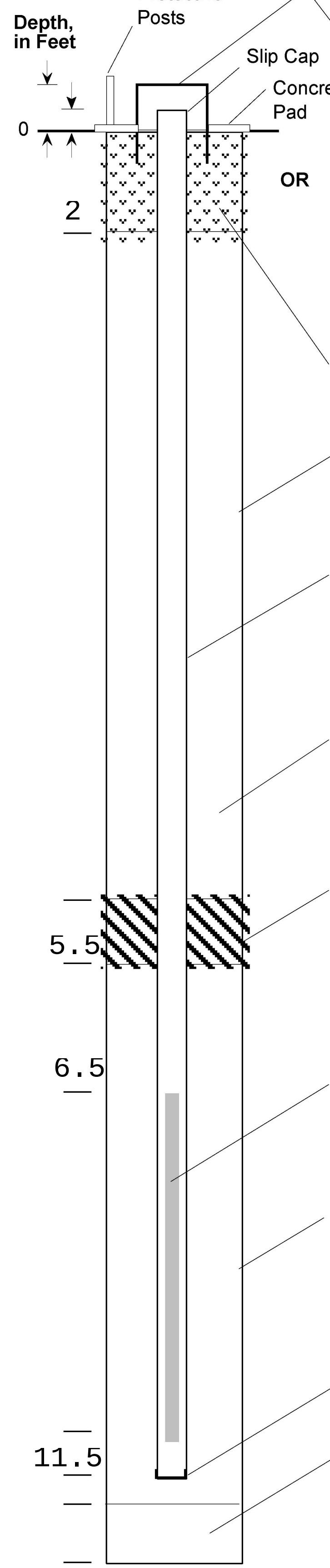
Elevation of Top of Well Pipe: 39.08 (ft NAVD)

Depth to Water: 33.73 ft NAVD

Date: 5/28/12 Time: 1255

MATERIALS USED

3	Sacks of 10/20 Sand
2.5	Sacks of cement Concrete/Cement
--	Sacks of ____ Grout Mix Used
1.5	Sacks of Bentonite Chips
6.5	Feet of 2-inch PVC Blank Casing
5	Feet of 0.02-inch PVC Slotted Screen
1	Threaded End Cap
1	Waterproof Well Seal/Slip Cap
1	Flush Mount/Aboveground Protective Monument
--	Protective Posts



(Material Type) Cement

Surface Seal (Material)

8 -inch Diameter Borehole (Nominal)

2 -inch Diameter Schedule ____ PVC Pipe 0.02

Hyd.Bentonite

Annular Seal (Material)

Bentonite Med.Chips Seal (Material)

2 -inch Diameter, Schedule 40 PVC Screen (0.02-inch Slot Size)

10/20

Sand Pack (Material)

Stainless Steel Centralizing Devices (Indicate Location)

Threaded End Cap

clay

Backfill (material)

HERRENKOHL CONSULTING LLC

321 Summerland Road
Bellingham, WA 98229

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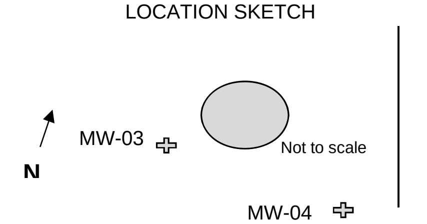
BOREHOLE NUMBER	EML-SB-04
PROJECT	Eldridge Municipal Landfill RI/FS
LOCATION	Little Squalicum Park
PROJECT NUMBER	HCL026
LOGGED BY	Mark Herrenkohl, LEG
DATE AND TIME	May 22, 2012 1545

Sample ID	Time	Blow Counts	% Recovery	PID	Sheen	Sample Depth (ft)	Depth (ft)	STRATA	DESCRIPTION: USCS group name, moisture content and plasticity, color, minor and MAJOR constituents with grain size range, odor, sheen, texture, weathering, cementation, geologic interpretation, etc.
								CL	Damp to moist, (soft), brown, sandy (F-M), silty, CLAY with root fragments and thin layer of sand (F-M) in upper 6-inches and bottom
0-1.5*	1545	3/2/4	73	--	N	0-1.5	1		of sampler. 1 fine gravel in composite (FILL)
									(2 attempts to sample 0-1.5 sample at this location)
							2		
2.5-4	1555	32/29/22	87	--	N	2.5.-4	3	GM	Damp, (loose), gray, sandy (F-C) GRAVEL (F) (FILL?)
							4	∇ ?	
							5		
5-6*	1607	14/11/11	67	--	N	5-6.5			Wet/saturated, (loose), gray, silty, sandy (F-C) GRAVEL grading to
							6	SM	silty, SAND (F-M) @ 5.5 ft (Native?)
							7		
							8		
7.5-9.5	1612	1/1/1/1	90	--	N	7.5-9.5		CL	Damp, (v. soft), gray, silty, CLAY with fine sand (Native)
									(Sampler driven 2 ft due to softness of soil)
							9		
									Base of boring @ 9.5 ft.

DRILLING CONTRACTOR	Cascade Drilling
DRILLING METHOD	Hollow-Stem Auger, Limited Access
SAMPLING EQUIPMENT	Split-Spoon
COORDINATES	N 649042.1
(Top-of-PVC)	E 1235710.2
SURFACE ELEVATION	38.84 ft.
DATUM	NAVD

LOCATION SKETCH



Herrenkohl Consulting LLC

As-Built Well Completion Form

Exploration No.: EML-SB-04

Well No. (If different than Expl. No.): MW-04

Client/Owner: COB Project No.: HCL026

Project Name: Eldridge Municipal Landfill

Drilling Co.: Cascade Drilling

Rep(s): James Goble

Installation Start Date: 5/22/12 Hour: 1545

Installation Finish Date: 5/22/12 Hour: 1715

Well Type: ☒ Single ☐ Nested ☐ Clustered

BORING AND WELL DIMENSIONS AND INSTALLATION DETAILS

DOE Unique Well No.: BHE 661

Number of Pipes in Boring: 1

Boring Diameter at Top of Hole: 8-inch

Does Diameter of Hole Change? No

Boring Diameter at First Step Down: --

Depth of First Step Down: --

Boring Diameter at Second Step Down: --

Depth of Second Step Down: --

Well Completion Date: 5/22/12

Elevation of Well Cover: 39.27 (ft NAVD)

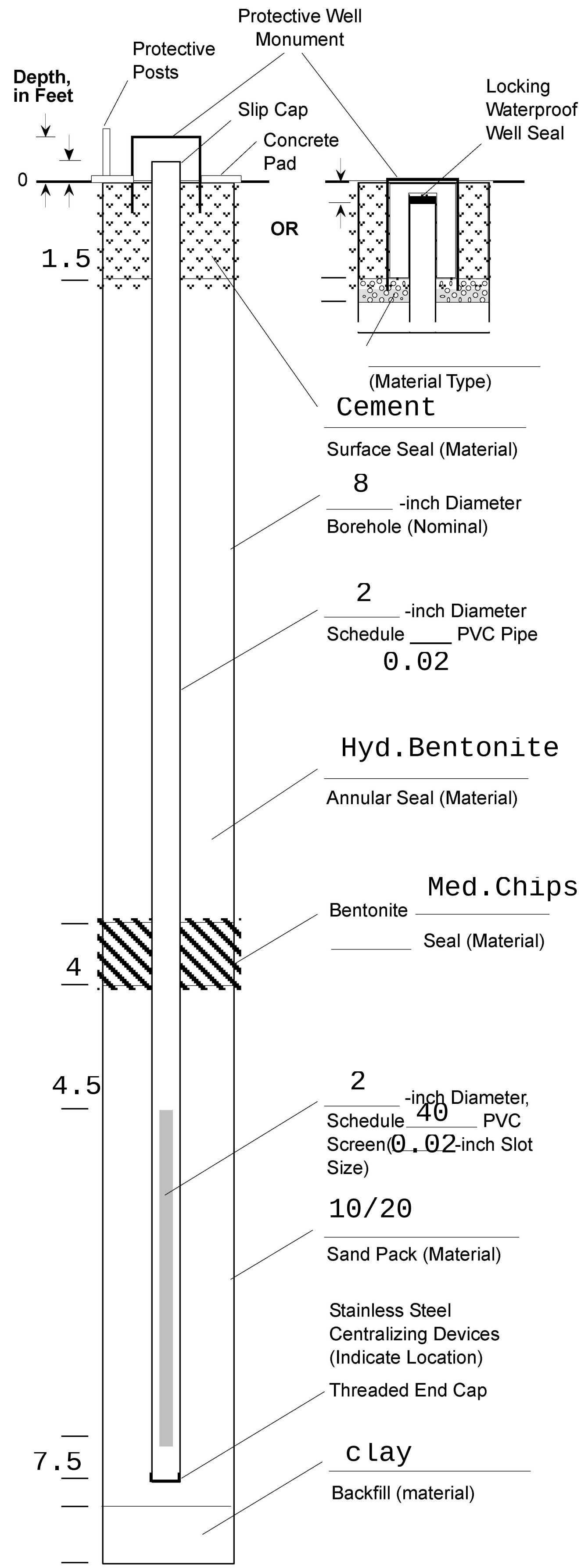
Elevation of Top of Well Pipe: 38.84 (ft NAVD)

Depth to Water: 35.54 ft NAVD

Date: 5/28/12 Time: 1257

MATERIALS USED

2	Sacks of 10/20 Sand
3	Sacks of cement Concrete/Cement
--	Sacks of ____ Grout Mix Used
1	Sacks of Bentonite Chips
4.5	Feet of 2-inch PVC Blank Casing
3	Feet of 0.02-inch PVC Slotted Screen
1	Threaded End Cap
1	Waterproof Well Seal/Slip Cap
1	Flush Mount/Aboveground Protective Monument
--	Protective Posts



HERRENKOHL CONSULTING LLC

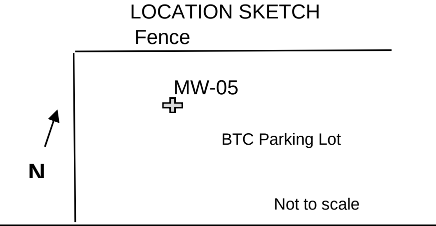
321 Summerland Road
Bellingham, WA 98229
(360) 319-0721 FAX (360) 647-6980

BOREHOLE NUMBER	EML-SB-05
PROJECT	Eldridge Municipal Landfill RI/FS
LOCATION	Little Squalicum Park
PROJECT NUMBER	HCL026
LOGGED BY	Mark Herrenkohl, LEG
DATE AND TIME	May 23, 2012 0856

SAMPLE INFORMATION									DESCRIPTION
Sample ID	Time	Blow Counts	% Recovery	PID	Sheen	Sample Depth (ft)	Depth (ft)	STRATA	USCS group name, moisture content and plasticity, color, minor and MAJOR constituents with grain size range, odor, sheen, texture, weathering, cementation, geologic interpretation, etc.
									(0.2 ft grass over 0.4 ft of asphalt removed)
								GM	Damp, (loose), reddish brown, silty sandy (F-C) GRAVEL (F) with
									asphalt, brick, and rock fragments (FILL)
0.5-2	856	7/9/10	47	--	N	0.5-2	1--		
							2--		
							3--		
2.5-4	902	50-5in	20	--	N	2.5.-4		GM	Damp, (loose), brown to reddish brown, sandy (F-M), GRAVEL (F-C)
									with silt (FILL)
							4--		
							5--		
5-6.5*	907	13/17/21	67	--	N	5-6.5		GM	Moist to wet, (loose), broken fragmented rock in a silty SAND (F-C) to
							6--		sandy GRAVEL (F-C) matrix (FILL?)
									(Left out gravels in sample for analysis)
							7--		
							8--		
7.5-9	917	20/28/29	47	--	N	7.5-9		GM	Moist to wet, (loose), broken fragmented rock in a silty SAND (F-C) to
									sandy GRAVEL (F-C) matrix (FILL?)
							9--		

DRILLING CONTRACTOR	Cascade Drilling
DRILLING METHOD	Hollow-Stem Auger, Limited Access
SAMPLING EQUIPMENT	Split-Spoon
COORDINATES	N 648874.7
(Top-of-PVC)	E 1235807.7
SURFACE ELEVATION	48.17 ft
DATUM	NAVD

LOCATION SKETCH



HERRENKOHL CONSULTING LLC

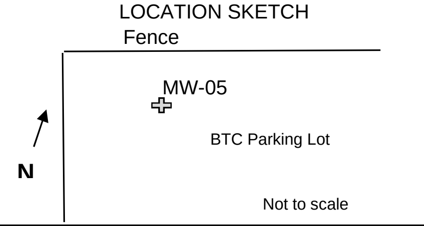
321 Summerland Road
Bellingham, WA 98229
(360) 319-0721 FAX (360) 647-6980

BOREHOLE NUMBER	EML-SB-05
PROJECT	Eldridge Municipal Landfill RI/FS
LOCATION	Little Squalicum Park
PROJECT NUMBER	HCL026
LOGGED BY	Mark Herrenkohl, LEG
DATE AND TIME	May 23, 2012 0856

SAMPLE INFORMATION									
Sample ID	Time	Blow Counts	% Recovery	PID	Sheen	Sample Depth (ft)	Depth (ft)	STRATA	DESCRIPTION USCS group name, moisture content and plasticity, color, minor and MAJOR constituents with grain size range, odor, sheen, texture, weathering, cementation, geologic interpretation, etc.
								GM	Moist to wet, (loose), broken fragmented rock in a silty SAND (F-C) to sandy GRAVEL (F-C) matrix (FILL?)
10-11.5	926	17/40/38	20	--	N	10-11.5	11--		
							12--		
12.5-14	940	8/12/11	0	--	N	12.5-14	13--	GM	No Recovery, except for 2 broken rock fragments in catcher.
							14--		
							15--		
15-16.5*	957	15/33/19	47	--	N	15-16.5		GM	Saturated, (loose), tan to brown with reddish brown mottling, silty, sandy (F-C) GRAVEL (F-C) (Native?)
							16--		(Fines and sand increasing at depth)
							17--		
17.5-18.5	1002	13/50-6in	33	--	N	17.5-18.5	18--	GM	Saturated, (loose to m. dense), brown to olive brown, silty sandy (F-C) GRAVEL (F) (Native)
							19--		

DRILLING CONTRACTOR	Cascade Drilling
DRILLING METHOD	Hollow-Stem Auger, Limited Access
SAMPLING EQUIPMENT	Split-Spoon
COORDINATES	N 648874.7
(Top-of-PVC)	E 1235807.7
SURFACE ELEVATION	48.17 ft
DATUM	NAVD

LOCATION SKETCH



HERRENKOHL CONSULTING LLC

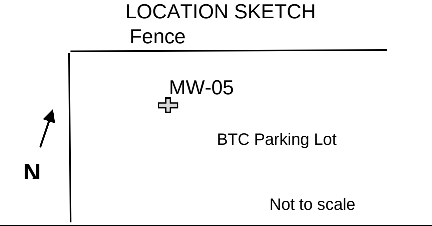
321 Summerland Road
Bellingham, WA 98229
(360) 319-0721 FAX (360) 647-6980

BOREHOLE NUMBER	EML-SB-05
PROJECT	Eldridge Municipal Landfill RI/FS
LOCATION	Little Squalicum Park
PROJECT NUMBER	HCL026
LOGGED BY	Mark Herrenkohl, LEG
DATE AND TIME	May 23, 2012 0856

SAMPLE INFORMATION									DESCRIPTION
Sample ID	Time	Blow Counts	% Recovery	PID	Sheen	Sample Depth (ft)	Depth (ft)	STRATA	USCS group name, moisture content and plasticity, color, minor and MAJOR constituents with grain size range, odor, sheen, texture, weathering, cementation, geologic interpretation, etc.
								SM	Transition approximately 20 ft bgs.
									Saturated, (loose), reddish brown/orange brown, silty SAND (F-M)
20-21.5	1010	11/15/32	87	--	N	20-21.5			(2-3 mottled lenses in color) (Native)
							21		grading to saturated, (loose), tan, silty SAND (F-M) (Native)
							22		
22.5-24	1022	6/12/10	87	--	N	22.5-24			
							23		
								CL	Damp, (soft), tan, silty CLAY (Native)
							24		
									Base of Boring @ 24 ft.
							25		
							26		
							27		
							28		
							29		

DRILLING CONTRACTOR	Cascade Drilling
DRILLING METHOD	Hollow-Stem Auger, Limited Access
SAMPLING EQUIPMENT	Split-Spoon
COORDINATES	N 648874.7
(Top-of-PVC)	E 1235807.7
SURFACE ELEVATION	48.17 ft
DATUM	NAVD

LOCATION SKETCH



Herrenkohl Consulting LLC

As-Built Well Completion Form

Exploration No.: EML-SB-05

Well No. (If different than Expl. No.): MW-05

Client/Owner: COB Project No.: HCL026

Project Name: Eldridge Municipal Landfill

Drilling Co.: Cascade Drilling

Rep(s): James Goble

Installation Start Date: 5/23/12 Hour: 0856

Installation Finish Date: 5/23/12 Hour: 1200

Well Type: ☒ Single ☐ Nested ☐ Clustered

BORING AND WELL DIMENSIONS AND INSTALLATION DETAILS

DOE Unique Well No.: BHE 662

Number of Pipes in Boring: 1

Boring Diameter at Top of Hole: 8-inch

Does Diameter of Hole Change? No

Boring Diameter at First Step Down: --

Depth of First Step Down: --

Boring Diameter at Second Step Down: --

Depth of Second Step Down: --

Well Completion Date: 5/23/12

Elevation of Well Cover: 48.55 (ft NAVD)

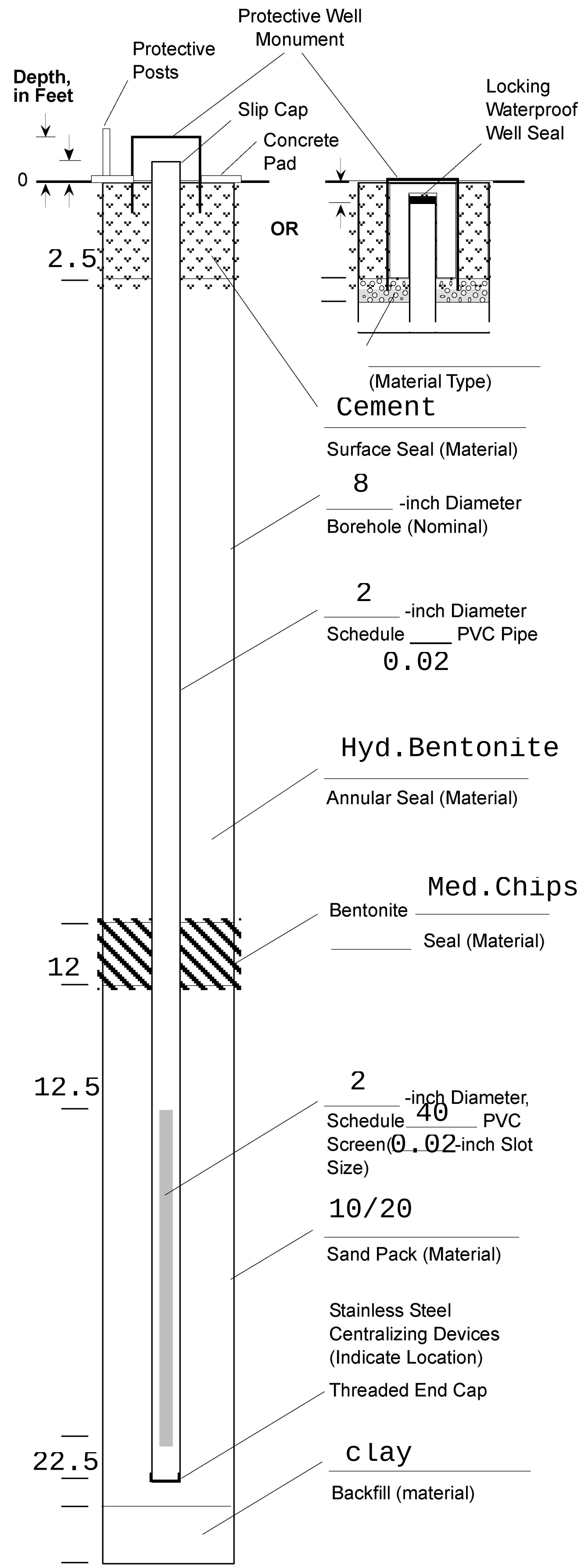
Elevation of Top of Well Pipe: 48.17 (ft NAVD)

Depth to Water: 33.99 ft NAVD

Date: 5/28/12 Time: 1315

MATERIALS USED

5	Sacks of 10/20 Sand
4	Sacks of cement Concrete/Cement
--	Sacks of ____ Grout Mix Used
2	Sacks of Bentonite Chips
12.5	Feet of 2-inch PVC Blank Casing
10	Feet of 0.02-inch PVC Slotted Screen
1	Threaded End Cap
1	Waterproof Well Seal/Slip Cap
1	Flush Mount/Aboveground Protective Monument
--	Protective Posts



FIELD CHANGE REQUEST (FCR) FORM (TYPICAL)

Project Name: Eldridge Municipal Landfill RI/FS Project No.: HCL026
Client: City of Bellingham – Public Wks Request No.: FCR-01

To: Project Files Date: 5/28/12

Field Change Request Title: Groundwater Sample Nomenclature

Description:
Monitoring wells were labeled EML-MW-# instead of EML-GW-# as described in SAP

Reason for Change:
For consistency the groundwater samples collected from the well would only require "MW", the same as well identification

Recommended Disposition:
Make change.

Field Operations Lead (or designee) Signature Date

Disposition:

Mark Herrenkohl [signature] 5/28/12
Project Manager Signature Date

Approval:

Project Manager Signature Date

Distribution:
Client Project Manager
Herrenkohl Consulting Project Manager
Field Operations Lead
QA Officer
Project File
Other:

FIELD CHANGE REQUEST (FCR) FORM (TYPICAL)

Project Name: Eldridge Municipal Landfill RI/FS   Project No.: HCC026
Client: City of Bellingham - Public Works   Request No.: FCR-02

To: Project Files   Date: 5/28/12

Field Change Request Title: Bailer used for EML-MW-05

Description:
A bailer (disposable) was used to purge and sample EML-MW-05 instead of a peristaltic pump as described in the SAP

Reason for Change:
The water depth was too great for an peristaltic pump to work efficiently/properly

Recommended Disposition:
Use Bailer acceptable. Care should be given when lowering and raising bailer during sampling to reduce turbidity.

Field Operations Lead (or designee)   Signature   Date

Disposition:

Mark Herrenkohl   [signature]   5/28/12
Project Manager   Signature   Date

Approval:

Project Manager   Signature   Date

Distribution:
Client Project Manager
Herrenkohl Consulting Project Manager
Field Operations Lead
QA Officer
Project File
Other:

FIELD CHANGE REQUEST (FCR) FORM (TYPICAL)

Project Name: Eldridge Municipal Landfill RI/FS Project No.: HCC026
Client: City of Bellingham - Public Wks Request No.: FCR- 03

To: Project Files Date: 5/29/12

Field Change Request Title: Turbidity in Sample EML-MW-05

Description:
The laboratory was requested to allow sample bottles for EML-MW-05 to settle before sampling for analysis.

Reason for Change:
Excessive turbidity due to collection with bailer.

Recommended Disposition:
The laboratory was informed of this change and will describe in laboratory report including direction

Field Operations Lead (or designee) Signature Date

Disposition:
Agree.

Mark J. HERRENKOHL [signature] 5/29/12
Project Manager Signature Date

Approval:

Project Manager Signature Date

Distribution:
Client Project Manager
Herrenkohl Consulting Project Manager
Field Operations Lead
QA Officer
Project File
Other:

FIELD CHANGE REQUEST (FCR) FORM (TYPICAL)

Project Name: Eldridge Municipal Landfill RI/FS Project No.: HCC026

Client: City of Bellingham - Public Works Request No.: FCR-04

To: Project Files Date: 5/28/12

Field Change Request Title: Field Filtering for Dissolved Metals in Groundwater

Description:

For groundwater sampling, samples for dissolved metals will be filtered in the laboratory instead of the field. Samples were collected in un-preserved bottles.

Reason for Change:

Convenience and less chance of cross-contamination during preparation of samples.

Recommended Disposition:

Change approved, for the reasons stated.

Field Operations Lead (or designee) Signature Date

Disposition:

Project Manager Signature Date

Approval:

Mark Herrenkohl [signature] 5/28/12

Project Manager Signature Date

Distribution:

Client Project Manager

Herrenkohl Consulting Project Manager

Field Operations Lead

QA Officer

Project File

Other:

APPENDIX G

POST-INTERIM ACTION RISK ASSESSMENT

Table G-1. Method B Surface Water Cleanup Levels
Eldridge Municipal Landfill

Chemical	USEPA Water Quality Criteria [a]		State Water Quality Stnds		National Toxics Rule [a]		Minimum	Method B Equation		Associated Risk		Final SW CUL	
	Value	Basis	Value	Basis	Value	Basis	WQC	Cancer	Noncancer	CR	HQ	Value	Basis
Arsenic	0.018	HH-fish & water	190.0	Freshwater	0.018	HH-fish & water	0.018	0.0982	17.7	1.8E-07	0.0010	0.018	WQC / NTR
Cadmium	0.25	Freshwater	1.5	Freshwater CrIII	1.0	Freshwater	0.25	nv	40.5	--	0.0062	0.25	WQC
Copper	9.0	Freshwater	16.9	Freshwater	11	Freshwater	9.0	nv	2,880	--	0.0031	9.0	WQC
Lead	2.5	Freshwater	4.2	Freshwater	2.5	Freshwater	2.5	nv	nv	--	--	2.5	WQC / NTR
Mercury	0.77	Freshwater	0.012	Freshwater	0.012	Freshwater	0.012	nv	nv	--	--	0.012	WQS / NTR
Zinc	120	Freshwater	154.9	Freshwater	100	Freshwater	100	nv	16,548	--	0.0060	100	NTR
Pentachlorophenol	0.27	HH-fish & water	2.5	Freshwater	0.28	HH-fish & water	0.27	1.47	1,180	1.8E-07	0.00023	0.27	WQC

Notes:
Concentrations in µg/L.

CR - cancer risk
CUL - cleanup level
HH - human health
HQ - hazard quotient
NTR - National Toxics Rule
nv - no value available
SW - surface water
TEQ - toxicity equivalency
WQC - USEPA water quality criterion
WQS - Washington State water quality standard
[a] Lower of chronic criterion for protection of freshwater receptors and criterion for protection of human health via consumption of water and organisms.

Table G-2. Hardness- and pH-Dependent Water Quality Standards

Hardness and pH Data

Station	Calcium (mg/L)	Magnesium (mg/L)	Hardness [a] (mg/L $CaC0_3$)	pH (unitless)
EML-MW-01	18	12	94.2	6.30
EML-MW-02	63.2	20.7	242.87	6.06
EML-MW-03	46.4	23	210.3	6.07
EML-MW-04	36.1	14.8	150.93	5.91
EML-MW-05	19.3	12	97.45	6.50
Average			159.2	6.17
Natural logarithm (ln)			5.07	

Notes:

[a] Hardness = 2.5 [Calcium] + 4.1 [Magnesium]

Site-Specific Water Quality Standards

IHS	Conversion Factor (CF)		Water Quality Standard	
	Equation	Value (unitless)	Equation	Value (µg/L)
Cadmium	1.101672 - [(ln hardness) 0.041838]	0.890	CF x e^{0.7852[ln(hardness) - 3.490}	1.5
Copper	*not hardness dependent*	0.960	CF x e^{0.8545[ln(hardness)] - 1.465}	16.9
Lead	1.46203 - [(ln hardness) 0.145712)]	0.723	CF x e^{1.273[ln(hardness)] - 4.705}	4.2
Zinc	*not hardness dependent*	0.986	CF x e^{0.8473[ln(hardness)] + 0.7614}	154.9
PCP	*not pH dependent*	--	e^{1.005(pH) - 5.290}	2.5

Table G-3. Method B Groundwater Cleanup Levels
Eldridge Municipal Landfill

Chemical	USEPA MCL Value	USEPA MCL Basis	State MCL Value	State MCL Basis	Minimum MCL	Method B Equation Cancer	Method B Equation Noncancer	Associated Risk CR	Associated Risk HQ	Drinking Water CUL	SW CUL	Risk-Based Groundwater CUL Value	Risk-Based Groundwater CUL Basis
Arsenic	10	MCL	10	MCL	10	0.0583	4.8	1.7E-04	2.1	0.583	0.018	0.018	Protection of SW
Cadmium	5	MCLG	5	MCL	5	nv	16	--	0.31	5	0.25	0.25	Protection of SW
Copper	1,300	MCLG	nv	MCL	1300	nv	640	--	2.0	640	9.0	9.0	Protection of SW
Lead	15	MCL action level	nv	MCL	15	nv	nv	--	--	15	2.5	2.5	Protection of SW
Mercury	2	MCLG	2	MCL	2	nv	nv	--	--	2	0.012	0.012	Protection of SW
Zinc	nv	--	5,000	Secondary MCL	5000	nv	4,800	--	1.0	5000	100	100	Protection of SW
Pentachlorophenol	1	MCL	nv	--	1	0.219	80	4.6E-06	0.013	1	0.27	0.27	Protection of SW

Notes:
Concentrations in µg/L.

CR - cancer risk
CUL - cleanup level
HQ - hazard quotient
MCL - maximum contaminant level
MCLG - MCL goal
nv - no value available
SW - surface water
TEQ - toxicity equivalency

Table G-4. Compliance Evaluation for Groundwater Results
Eldridge Municipal Landfill

Station	Arsenic	Cadmium	Copper	Lead	Mercury	Zinc	Pentachlorophenol
Cleanup Level	5	0.25	9.0	2.5	0.012	100	0.27
Basis for CUL	Natural background [a]	WQC	WQC	WQC / NTR	WQS / NTR	NTR	WQC
Sample Results							
EML-MW-01	1.8	0.1 U	4.1	0.4	0.0026 U	4	0.16 U
EML-MW-02	1.4	0.1 U	1.2	0.1 U	0.0026 U	4 U	0.16 U
EML-MW-03	**17.7**	0.1 U	1.3	0.1 U	0.0026 U	4 U	0.16 U
EML-MW-04	1.9	0.2	2.2	0.1 U	0.0026 U	70	0.16 U
EML-MW-05 [b]	1.3	**0.3**	**22.7**	2.5	0.0026 U	24	0.16 UJ

Notes:
Results are reported as µg/L total metals.
Boldface indicates a result exceeding the applicable cleanup level.
[a] The natural background concentration of arsenic in groundwater for the State of Washington is 5 µg/L (MTCA Table 720-1, footnote b)
[b] EML-MW-05 was sampled using a dedicated bailer resulting in elevated DO and turbidity in sample.

CUL - cleanup level
NTR - National Toxics Rule
U - undetected result; associated value is method detection limit
WQC - federal water quality criterion
WQS - state water quality standard

Table G-5. Compliance Evaluation for Groundwater Field Parameters
Eldridge Municipal Landfill

Station	Iron (µg/L)	Manganese (µg/L)	Nitrite (mg-N/L)	Nitrate (mg-N/L)	Ammonia (mg-N/L)	pH (unitless)	Turbidity (NTU)
Criterion	300	50	1	10	7.3 [a]	6.5-8.5	1 / 5 [b]
Basis for Criterion	Secondary MCL	Secondary MCL	MCL	MCL	AWQC [c]	Secondary MCL	MCL
Sample Results							
EML-MW-01	**6690**	**1570**	0.1 U	0.1 U	0.129	**6.30**	0.0
EML-MW-02	**6380**	**987**	0.1 U	1.1	2.29	**6.06**	0.0
EML-MW-03	**9320**	**2090**	0.1 U	0.1 U	0.364	**6.07**	0.0
EML-MW-04	**4230**	**3370**	0.1 U	0.1 U	0.082	**5.91**	0.0
EML-MW-05 [d]	**3770**	**930**	0.1 U	2.6	0.023	6.50	**376**

Notes:
Boldface indicates a result not in compliance with the applicable criterion.

[a] The pH and temperature in groundwater are outside the range shown in the AWQC table of criteria. Based on the pattern in the table, the criterion is expected to be larger than 7.3.

[b] MCL is 1 for systems using conventional or direct filtration and 5 for other systems.

[c] Table N-8 in USEPA's (2013) Aquatic Life Ambient Water Quality Criteria for Ammonia—Freshwater (EPA 822-R-13-001)
[d] EML-MW-05 was sampled using a dedicated bailer resulting in elevated DO and turbidity in sample.

MCL - maximum contaminant level
mg-N/L - milligrams nitrogen per liter
NTU - nephelometric turbidity units

Table G-6. Compliance Evaluation for Soil Results
Eldridge Municipal Landfill

Station	Arsenic	Cadmium	Copper	Lead	Mercury	Zinc	Pentachlorophenol
Sample Results							
EML-IA-A1S	5.9	1.7	**75.2**	**213**	0.10	**550**	0.190 U
EML-IA-A1B2	3.6	0.2	19.4	5.2	0.02 U	61	0.190 U
EML-IA-A2S	8.1	3.3	**86.1**	**477**	**0.18**	**500**	0.190 U
EML-IA-A2B	5.0	0.2	26.9	6.9	0.04	76	0.190 U
EML-IA-A3S2	4.9	0.5	43.2	15.6	0.05	53	0.190 U
EML-IA-A3B	3.4	0.1	22.4	5.1	0.03	63	0.190 U
EML-IA-A4B [a]	4.8	0.2	32.2	5.7	0.05	68.5	0.180 U
EML-IA-A5B	5.3	0.2	41.5	4.2	0.05	70	0.190 U
EML-IA-A5S	2.6	0.3	19.9	5.7	0.04	69	0.190 U
EML-IA-A6S2 [c]	5.8	0.5	34.9	**106**	0.08	84	0.570 U
EML-IA-A6B	4.6	0.2	28.7	10.7	0.04	86	0.180 U
EML-IA-A7B	5.3	0.2	30.5	5.4	0.05	**87**	0.180 U
EML-IA-A8B [a]	4.9	0.2	23.5	3.1	0.04	62.5	0.190 U
EML-IA-A8S	9.8	1.4	**79.7**	**310**	**0.32**	**480**	0.560 U
EML-IA-A9S	4.4	0.2	31.8	13.3	0.06	73	0.190 U
EML-IA-A9B	5.7	0.1	26.1	3.3	0.04	54	0.180 U
EML-IA-A10B	3.6	0.1	28.5	4.9	0.03	79	0.190 U
EML-IA-A11B	2.3	0.1	16.9	3.3	0.02	62	0.190 U
EML-IA-A11S	4.4	0.2	25.0	3.6	0.03	53	0.190 U
EML-IA-A12S	7.5	0.3	43.3	17.9	0.08	74	0.180 U
EML-IA-A12B	4.6	0.1 U	25.4	2.6	0.03	42	0.190 U
EML-IA-A13B2	2.7	0.4	46.1	11.3	0.09	63	0.190 U
EML-IA-A14B	1.9	0.1 U	18.1	2.7	0.03	59	0.190 U
EML-IA-A14S	7.1	0.2	25.7	16.8	0.03	69	0.190 U
EML-IA-A15S	5.0	0.1	39.4	9.6	0.05	50	0.190 U
EML-IA-A15B	3.0	0.1 U	18.4	3.6	0.02 U	64	0.190 U
EML-IA-A16B	1.8	0.1	18.5	2.9	0.03	85	0.190 U
EML-IA-A16S2	7.3	0.5	26.1	18.2	0.04	68	0.190 U
EML-IA-B1B	2.9	0.1	21.8	4.4	0.03	76	0.200 U
EML-IA-B2B	4.9	0.2	21.7	19.1	0.03	84	0.180 U
EML-IA-B2S [a]	**10.6**	0.2	25.15	44.4	0.04	64	0.180 U
EML-IA-B3S2	5.8	0.7	**57.4**	**129**	**0.12**	**155**	0.190 U
EML-IA-B3B	3.9	0.1	25.8	15.3	0.02	64	0.190 U
EML-IA-B4B2	5.9	0.3	30.3	24.4	0.04	61	0.200 U
EML-IA-B5B2	4.3	0.4	**52.2**	13.3	**0.17**	83	0.190 U
EML-IA-B5S2	9.5	0.4	41.7	**74.2**	0.06	**105**	0.190 U
EML-IA-B6S2 [b]	6.9	0.5	46.5	**84.2**	**0.13**	**673**	0.190 U
EML-IA-B6B	1.3	0.1 U	31.2	9.7	0.08	75	0.200 U

Table G-6. Compliance Evaluation for Soil Results
Eldridge Municipal Landfill

Station	Arsenic	Cadmium	Copper	Lead	Mercury	Zinc	Pentachlorophenol
Sample Results							
EML-IA-B7S	2.8	0.2	17.2	6.8	0.04	82	0.190 U
EML-IA-B7B [a]	2.35	0.1	40.05	3.35	0.055	44	0.190 U
EML-IA-B8B	3.0	0.1 U	13.8	2.9	0.02	46	0.190 U
EML-IA-B9B	4.0	0.1 U	14.4	2.9	0.02	41	0.180 U
EML-IA-B9S	4.4	0.2	34.1	**62.1**	0.06	**95**	0.200 U
EML-IA-B10B	2.4	0.2	**52.9**	5.4	0.10	**87**	0.200 U
EML-IA-B11B	1.7	0.1 U	16.7	2.9	0.02 U	51	0.200 U
EML-IA-B12B	1.2	0.1 U	15.4	2.1	0.02 U	50	0.180 U
EML-IA-B12S	8.2	1.0	**147**	**536**	**0.38**	**370**	0.580 U
EML-IA-B12S2	5.4	0.1	32.8	4.4	0.03	53	0.580 U
EML-IA-B13B	1.7	0.1	29.5	4.3	0.02	44	0.190 U
EML-IA-B14B	1.4	0.1 U	18.1	3.5	0.03	51	0.190 U
EML-IA-B15B2	6.6	0.5	14.2	28.8	0.03	79	0.190 U
EML-IA-B15S2	4.1	0.5	33.6	14.2	0.1	62	0.180 U
EML-IA-B16S	5.4	0.4	36.1	**86.9**	0.07	**101**	--
EML-IA-B16B	4.2	0.2	29.2	13.5	0.03	75	--
EML-SB-01-10-11	1.4	0.1 U	18.5	1.8	0.03 U	34	0.180 U
EML-SB-02-10-11	3.5	0.2	25.7	2.4	0.03	46	0.190 U
EML-SB-03-7.5-9	3.1	0.1	25.5	2.2	0.03	41	0.190 U
LSC-HA-01	8.7	0.7	--	34	**0.12**	--	--
LSC-HA-02	9.5	0.6	--	33	**0.11**	--	--
LSC-HA-03	7.1	0.6	--	**53**	**0.16**	--	--
LSC-HA-04	9.0	0.7	--	39	**0.12**	--	--
LSC-HA-06	3.4	0.2 U	--	25	**0.13**	--	--
LSC-HA-07	7.8	0.6	--	**222**	**0.19**	--	--
LSC-HA-08	8.2	0.2	--	5	0.04	--	--
LSC-HA-09	2.2	0.3	--	2	0.02 U	--	--
LSC-HA-10	4.6	0.3	--	40	0.05	--	--
LSC-HA-11	3.3	0.2 U	--	5	0.02	--	--
LSC-HA-12	4.1	0.3	--	**70**	0.08	--	--
LSC-HA-13	2.6	0.3	--	2	0.02 U	--	--
No. samples (n)	69	69	57	69	69	57	55
Mean (from ProUCL)	4.8	0.3	33.7	43.8	0.07	107	--

Table G-6. Compliance Evaluation for Soil Results
Eldridge Municipal Landfill

Station	Arsenic	Cadmium	Copper	Lead	Mercury	Zinc	Pentachlorophenol
Sample Results							
Compliance with Cleanup Level							
Cleanup level	10	45	50	50	0.1	86	2.5
Basis for CUL	natural background	direct contact	TEE	TEE	TEE	natural background	direct contact
No. exceedances	1	0	7	13	12	11	0
Percent exceedances	1%	0%	**12%**	**19%**	**17%**	**19%**	--
Max detect	10.6	3.3	**147**	**536**	**0.38**	**673**	--
Max exceedance factor	1.1	0.1	**3**	**11**	**4**	**8**	--
95UCL	5.2	0.6	38.5	**94.9**	0.1	**183**	--
Compliance with Human Health Direct Contact Screening Level							
Screening level	--	--	300	250	24	24000	--
No. exceedances	--	--	0	3	0	0	--
Percent exceedances	--	--	0%	4%	0%	0%	--
Max detect	--	--	147	**536**	0.38	673	--
Max exceedance factor	--	--	0.5	2	0.02	0.03	--
95UCL	--	--	38.5	94.9	0.1	183	--

Notes:
Results reported as mg/kg.
Boldface among individual sample results indicates a result exceeding the applicable CUL.
Boldface in the compliance sections indicates a result not in compliance with the three-part statistical rule [WAC 173-340-740(7)]:
- 95UCL < CUL
- Maximum concentration <= 2xCUL
- < 10% of results > CUL.

[a] Average of duplicate results.
[b] The zinc result for this sample is an average of triplicate results.
[c] The lead result from soil sample collected from EML-IA-A6S exceeded cleanup level (not analyzed for sample -A6S2)
-- - not analyzed or not applicable
95UCL - upper one-sided 95 percent confidence limit on the mean, calculated using ProUCL
CUL - cleanup level
TEE - terrestrial ecological evaluation
Sample naming conventions:
A - area
B - bottom
HA - hand auger sample from remedial investigation
IA - interim action performance sample
S - slope
SB - soil boring sample collecting during well drilling

Table G-7. ProUCL Output for IHS Metals
Eldridge Municipal Landfill

IHS	Recommended Distribution	Recommended UCL (mg/kg)	Mean (mg/kg)
Arsenic	95% Student's-t	5.232	4.762
Cadmium	95% KM (Chebyshev)	0.592	0.332
Copper	95% Student's-t	38.54	33.72
Lead	95% Chebyshev	94.93	43.8
Mercury	95% KM (Chebyshev)	0.1	0.065
Zinc	95% Chebyshev	183.4	107

UCL Statistics for Data Sets with Non-Detects

User Selected Options	
Date/Time of Computation	2/19/2014 5:24:04 PM
From File	C707_ProUCL_Input_20140219.xls
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Arsenic

General Statistics

Total Number of Observations	69	Number of Distinct Observations	48
		Number of Missing Observations	0
Minimum	1.2	**Mean**	**4.762**
Maximum	10.6	Median	4.4
SD	2.339	Std. Error of Mean	0.282
Coefficient of Variation	0.491	Skewness	0.598

Normal GOF Test

Shapiro Wilk Test Statistic	0.942	Shapiro Wilk GOF Test
5% Shapiro Wilk P Value	0.0056	Data Not Normal at 5% Significance Level

Lilliefors Test Statistic	0.0972	Lilliefors GOF Test	
5% Lilliefors Critical Value	0.107	Data appear Normal at 5% Significance Level	
Data appear Approximate Normal at 5% Significance Level			
Assuming Normal Distribution			
95% Normal UCL		95% UCLs (Adjusted for Skewness)	
95% Student's-t UCL	5.232	95% Adjusted-CLT UCL (Chen-1995)	5.247
		95% Modified-t UCL (Johnson-1978)	5.235
Gamma GOF Test			
A-D Test Statistic	0.23	Anderson-Darling Gamma GOF Test	
5% A-D Critical Value	0.755	Detected data appear Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.0482	Kolmogrov-Smirnoff Gamma GOF Test	
5% K-S Critical Value	0.108	Detected data appear Gamma Distributed at 5% Significance Level	
Detected data appear Gamma Distributed at 5% Significance Level			
Gamma Statistics			
k hat (MLE)	3.992	k star (bias corrected MLE)	3.828
Theta hat (MLE)	1.193	Theta star (bias corrected MLE)	1.244
nu hat (MLE)	550.9	nu star (bias corrected)	528.3
MLE Mean (bias corrected)	4.762	MLE Sd (bias corrected)	2.434
		Approximate Chi Square Value (0.05)	476
Adjusted Level of Significance	0.0465	Adjusted Chi Square Value	474.9
Assuming Gamma Distribution			
95% Approximate Gamma UCL (use when n>=50))	5.286	95% Adjusted Gamma UCL (use when n<50)	5.297
Lognormal GOF Test			
Shapiro Wilk Test Statistic	0.958	Shapiro Wilk Lognormal GOF Test	
5% Shapiro Wilk P Value	0.0578	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.0799	Lilliefors Lognormal GOF Test	
5% Lilliefors Critical Value	0.107	Data appear Lognormal at 5% Significance Level	
Data appear Lognormal at 5% Significance Level			
Lognormal Statistics			

Minimum of Logged Data	0.182	Mean of logged Data	1.43
Maximum of Logged Data	2.361	SD of logged Data	0.537

Assuming Lognormal Distribution

95% H-UCL	5.462	90% Chebyshev (MVUE) UCL	5.807
95% Chebyshev (MVUE) UCL	6.256	97.5% Chebyshev (MVUE) UCL	6.879
99% Chebyshev (MVUE) UCL	8.102		

Nonparametric Distribution Free UCL Statistics

Data appear to follow a Discernible Distribution at 5% Significance Level

Nonparametric Distribution Free UCLs

95% CLT UCL	5.226	95% Jackknife UCL	5.232
95% Standard Bootstrap UCL	5.238	95% Bootstrap-t UCL	5.257
95% Hall's Bootstrap UCL	5.23	95% Percentile Bootstrap UCL	5.233
95% BCA Bootstrap UCL	5.233		
90% Chebyshev(Mean, Sd) UCL	5.607	95% Chebyshev(Mean, Sd) UCL	5.99
97.5% Chebyshev(Mean, Sd) UCL	6.521	99% Chebyshev(Mean, Sd) UCL	7.564

Suggested UCL to Use **95% Student's-t UCL 5.232** As

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002)
and Singh and Singh (2003). However, simulations results will not cover all Real World data sets.
For additional insight the user may want to consult a statistician.

Cadmium

General Statistics

Total Number of Observations	69	Number of Distinct Observations	11
Number of Detects	57	Number of Non-Detects	12
Number of Distinct Detects	11	Number of Distinct Non-Detects	2
Minimum Detect	0.1	Minimum Non-Detect	0.1
Maximum Detect	3.3	Maximum Non-Detect	0.2

Variance Detects	0.246	Percent Non-Detects	17.39%
Mean Detects	0.4	SD Detects	0.496
Median Detects	0.2	CV Detects	1.24
Skewness Detects	4.16	Kurtosis Detects	21.41
Mean of Logged Detects	-1.288	SD of Logged Detects	0.792

Normal GOF Test on Detects Only

Shapiro Wilk Test Statistic	0.566	Normal GOF Test on Detected Observations Only
5% Shapiro Wilk P Value	0	Detected Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.273	Lilliefors GOF Test
5% Lilliefors Critical Value	0.117	Detected Data Not Normal at 5% Significance Level

Detected Data Not Normal at 5% Significance Level

Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs

Mean	0.348	Standard Error of Mean	0.056
SD	0.461	95% KM (BCA) UCL	0.451
95% KM (t) UCL	0.441	95% KM (Percentile Bootstrap) UCL	0.445
95% KM (z) UCL	0.44	95% KM Bootstrap t UCL	0.51
90% KM Chebyshev UCL	0.516	95% KM Chebyshev UCL	0.592
97.5% KM Chebyshev UCL	0.698	99% KM Chebyshev UCL	0.905

Gamma GOF Tests on Detected Observations Only

A-D Test Statistic	2.498	Anderson-Darling GOF Test
5% A-D Critical Value	0.769	Detected Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.207	Kolmogrov-Smirnoff GOF
5% K-S Critical Value	0.12	Detected Data Not Gamma Distributed at 5% Significance Level

Detected Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics on Detected Data Only

k hat (MLE)	1.491	k star (bias corrected MLE)	1.424
Theta hat (MLE)	0.268	Theta star (bias corrected MLE)	0.281
nu hat (MLE)	170	nu star (bias corrected)	162.4
MLE Mean (bias corrected)	0.4	MLE Sd (bias corrected)	0.335

Gamma Kaplan-Meier (KM) Statistics

k hat (KM)	0.569	nu hat (KM)	78.52
Approximate Chi Square Value (78.52, α)	59.1	Adjusted Chi Square Value (78.52, β)	58.74
95% Gamma Approximate KM-UCL (use when n>=50)	0.462	95% Gamma Adjusted KM-UCL (use when n<50)	0.465

Gamma ROS Statistics using Imputed Non-Detects

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs

GROS may not be used when kstar of detected data is small such as < 0.1

For such situations, GROS method tends to yield inflated values of UCLs and BTVs

For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

Minimum	0.01	**Mean**	**0.332**
Maximum	3.3	Median	0.2
SD	0.474	CV	1.427
k hat (MLE)	0.781	k star (bias corrected MLE)	0.757
Theta hat (MLE)	0.425	Theta star (bias corrected MLE)	0.439
nu hat (MLE)	107.8	nu star (bias corrected)	104.4
MLE Mean (bias corrected)	0.332	MLE Sd (bias corrected)	0.382
		Adjusted Level of Significance (β)	0.0465
Approximate Chi Square Value (104.41, α)	81.83	Adjusted Chi Square Value (104.41, β)	81.4
95% Gamma Approximate UCL (use when n>=50)	0.424	95% Gamma Adjusted UCL (use when n<50)	0.426

Lognormal GOF Test on Detected Observations Only

Lilliefors Test Statistic	0.184	Lilliefors GOF Test	
5% Lilliefors Critical Value	0.117	Detected Data Not Lognormal at 5% Significance Level	

Detected Data Not Lognormal at 5% Significance Level

Lognormal ROS Statistics Using Imputed Non-Detects

Mean in Original Scale	0.34	Mean in Log Scale	-1.587
SD in Original Scale	0.469	SD in Log Scale	0.987
95% t UCL (assumes normality of ROS data)	0.434	95% Percentile Bootstrap UCL	0.438
95% BCA Bootstrap UCL	0.479	95% Bootstrap t UCL	0.501
95% H-UCL (Log ROS)	0.436		

DL/2 Statistics

DL/2 Normal		DL/2 Log-Transformed	
Mean in Original Scale	0.341	Mean in Log Scale	-1.565

SD in Original Scale	0.469	SD in Log Scale	0.948
95% t UCL (Assumes normality)	0.435	95% H-Stat UCL	0.423

DL/2 is not a recommended method, provided for comparisons and historical reasons

Nonparametric Distribution Free UCL Statistics

Data do not follow a Discernible Distribution at 5% Significance Level

Suggested UCL to Use — **95% KM (Chebyshev) UCL 0.592** — Cd

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

<u>Copper</u>

General Statistics

Total Number of Observations	57	Number of Distinct Observations	53
		Number of Missing Observations	0
Minimum	13.8	**Mean**	**33.72**
Maximum	147	Median	28.5
SD	21.79	Std. Error of Mean	2.886
Coefficient of Variation	0.646	Skewness	3.08

Normal GOF Test

Shapiro Wilk Test Statistic	0.715	Shapiro Wilk GOF Test
5% Shapiro Wilk P Value	4.55E-14	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.198	Lilliefors GOF Test
5% Lilliefors Critical Value	0.117	Data Not Normal at 5% Significance Level

Data Not Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		95% UCLs (Adjusted for Skewness)	
95% Student's-t UCL	38.54	95% Adjusted-CLT UCL (Chen-1995)	39.72

	95% Modified-t UCL (Johnson-1978) 38.74

Gamma GOF Test

A-D Test Statistic 1.458	Anderson-Darling Gamma GOF Test
5% A-D Critical Value 0.754	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic 0.126	Kolmogrov-Smirnoff Gamma GOF Test
5% K-S Critical Value 0.118	Data Not Gamma Distributed at 5% Significance Level

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE) 3.968	k star (bias corrected MLE) 3.771
Theta hat (MLE) 8.496	Theta star (bias corrected MLE) 8.941
nu hat (MLE) 452.4	nu star (bias corrected) 429.9
MLE Mean (bias corrected) 33.72	MLE Sd (bias corrected) 17.36
	Approximate Chi Square Value (0.05) 382.8
Adjusted Level of Significance 0.0458	Adjusted Chi Square Value 381.7

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50)) 37.86	95% Adjusted Gamma UCL (use when n<50) 37.98

Lognormal GOF Test

Shapiro Wilk Test Statistic 0.948	Shapiro Wilk Lognormal GOF Test
5% Shapiro Wilk P Value 0.0292	Data Not Lognormal at 5% Significance Level
Lilliefors Test Statistic 0.085	Lilliefors Lognormal GOF Test
5% Lilliefors Critical Value 0.117	Data appear Lognormal at 5% Significance Level

Data appear Approximate Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data 2.625	Mean of logged Data 3.387
Maximum of Logged Data 4.99	SD of logged Data 0.48

Assuming Lognormal Distribution

95% H-UCL 37.42	90% Chebyshev (MVUE) UCL 39.72
95% Chebyshev (MVUE) UCL 42.71	97.5% Chebyshev (MVUE) UCL 46.87
99% Chebyshev (MVUE) UCL 55.04	

Nonparametric Distribution Free UCL Statistics

Data appear to follow a Discernible Distribution at 5% Significance Level

Nonparametric Distribution Free UCLs

95% CLT UCL	38.46	95% Jackknife UCL	38.54
95% Standard Bootstrap UCL	38.36	95% Bootstrap-t UCL	40.59
95% Hall's Bootstrap UCL	42.73	95% Percentile Bootstrap UCL	38.61
95% BCA Bootstrap UCL	39.47		
90% Chebyshev(Mean, Sd) UCL	42.37	95% Chebyshev(Mean, Sd) UCL	46.3
97.5% Chebyshev(Mean, Sd) UCL	51.74	99% Chebyshev(Mean, Sd) UCL	62.43

Suggested UCL to Use	**95% Student's-t UCL**	**38.54**	Cu

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002)
and Singh and Singh (2003). However, simulations results will not cover all Real World data sets.
For additional insight the user may want to consult a statistician.

<u>Lead</u>

General Statistics

Total Number of Observations	69	Number of Distinct Observations	58
		Number of Missing Observations	0
Minimum	1.8	**Mean**	**43.8**
Maximum	536	Median	9.6
SD	97.45	Std. Error of Mean	11.73
Coefficient of Variation	2.225	Skewness	3.738

Normal GOF Test

Shapiro Wilk Test Statistic	0.474	Shapiro Wilk GOF Test
5% Shapiro Wilk P Value	0	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.333	Lilliefors GOF Test
5% Lilliefors Critical Value	0.107	Data Not Normal at 5% Significance Level

Data Not Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		95% UCLs (Adjusted for Skewness)	
95% Student's-t UCL	63.36	95% Adjusted-CLT UCL (Chen-1995)	68.73
		95% Modified-t UCL (Johnson-1978)	64.24

Gamma GOF Test

A-D Test Statistic	4.994	Anderson-Darling Gamma GOF Test
5% A-D Critical Value	0.817	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.203	Kolmogrov-Smirnoff Gamma GOF Test
5% K-S Critical Value	0.114	Data Not Gamma Distributed at 5% Significance Level

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.497	k star (bias corrected MLE)	0.485
Theta hat (MLE)	88.12	Theta star (bias corrected MLE)	90.29
nu hat (MLE)	68.58	nu star (bias corrected)	66.94
MLE Mean (bias corrected)	43.8	MLE Sd (bias corrected)	62.89
		Approximate Chi Square Value (0.05)	49.11
Adjusted Level of Significance	0.0465	Adjusted Chi Square Value	48.78

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	59.7	95% Adjusted Gamma UCL (use when n<50)	60.1

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.904	Shapiro Wilk Lognormal GOF Test
5% Shapiro Wilk P Value	1.31E-05	Data Not Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.161	Lilliefors Lognormal GOF Test
5% Lilliefors Critical Value	0.107	Data Not Lognormal at 5% Significance Level

Data Not Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	0.588	Mean of logged Data	2.5
Maximum of Logged Data	6.284	SD of logged Data	1.473

Assuming Lognormal Distribution

95% H-UCL	54.31	90% Chebyshev (MVUE) UCL	60.04
95% Chebyshev (MVUE) UCL	71.41	97.5% Chebyshev (MVUE) UCL	87.18
99% Chebyshev (MVUE) UCL	118.2		

Nonparametric Distribution Free UCL Statistics

Data do not follow a Discernible Distribution (0.05)

Nonparametric Distribution Free UCLs

95% CLT UCL	63.09	95% Jackknife UCL	63.36
95% Standard Bootstrap UCL	62.73	95% Bootstrap-t UCL	75.86
95% Hall's Bootstrap UCL	75.48	95% Percentile Bootstrap UCL	64.92
95% BCA Bootstrap UCL	70.43		
90% Chebyshev(Mean, Sd) UCL	78.99	95% Chebyshev(Mean, Sd) UCL	94.93
97.5% Chebyshev(Mean, Sd) UCL	117.1	99% Chebyshev(Mean, Sd) UCL	160.5

Suggested UCL to Use **95% Chebyshev (Mean, Sd) UCL** **94.93** Pb

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002)
and Singh and Singh (2003). However, simulations results will not cover all Real World data sets.
For additional insight the user may want to consult a statistician.

<u>Mercury</u>

General Statistics

Total Number of Observations	69	Number of Distinct Observations	19
Number of Detects	62	Number of Non-Detects	7
Number of Distinct Detects	19	Number of Distinct Non-Detects	2
Minimum Detect	0.02	Minimum Non-Detect	0.02
Maximum Detect	0.38	Maximum Non-Detect	0.03
Variance Detects	0.00449	Percent Non-Detects	10.14%
Mean Detects	0.0712	SD Detects	0.067

Median Detects	0.045	CV Detects	0.941
Skewness Detects	2.711	Kurtosis Detects	9.018
Mean of Logged Detects	-2.926	SD of Logged Detects	0.708

Normal GOF Test on Detects Only

Shapiro Wilk Test Statistic	0.696	Normal GOF Test on Detected Observations Only
5% Shapiro Wilk P Value	1.11E-16	Detected Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.228	Lilliefors GOF Test
5% Lilliefors Critical Value	0.113	Detected Data Not Normal at 5% Significance Level

Detected Data Not Normal at 5% Significance Level

Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs

Mean	0.066	Standard Error of Mean	0.00787
SD	0.0649	95% KM (BCA) UCL	0.0813
95% KM (t) UCL	0.0791	95% KM (Percentile Bootstrap) UCL	0.0792
95% KM (z) UCL	0.079	95% KM Bootstrap t UCL	0.0833
90% KM Chebyshev UCL	0.0896	95% KM Chebyshev UCL	0.1
97.5% KM Chebyshev UCL	0.115	99% KM Chebyshev UCL	0.144

Gamma GOF Tests on Detected Observations Only

A-D Test Statistic	2.446	Anderson-Darling GOF Test
5% A-D Critical Value	0.764	Detected Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.183	Kolmogrov-Smirnoff GOF
5% K-S Critical Value	0.115	Detected Data Not Gamma Distributed at 5% Significance Level

Detected Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics on Detected Data Only

k hat (MLE)	1.914	k star (bias corrected MLE)	1.832
Theta hat (MLE)	0.0372	Theta star (bias corrected MLE)	0.0389
nu hat (MLE)	237.3	nu star (bias corrected)	227.1
MLE Mean (bias corrected)	0.0712	MLE Sd (bias corrected)	0.0526

Gamma Kaplan-Meier (KM) Statistics

k hat (KM)	1.036	nu hat (KM)	142.9
Approximate Chi Square Value (142.93, α)	116.3	Adjusted Chi Square Value (142.93, β)	115.8

95% Gamma Approximate KM-UCL (use when n>=50)	0.0811	95% Gamma Adjusted KM-UCL (use when n<50)	0.0815

Gamma ROS Statistics using Imputed Non-Detects

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs

GROS may not be used when kstar of detected data is small such as < 0.1

For such situations, GROS method tends to yield inflated values of UCLs and BTVs

For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

Minimum	0.01	**Mean**	**0.065**
Maximum	0.38	Median	0.04
SD	0.0661	CV	1.017
k hat (MLE)	1.524	k star (bias corrected MLE)	1.467
Theta hat (MLE)	0.0426	Theta star (bias corrected MLE)	0.0443
nu hat (MLE)	210.3	nu star (bias corrected)	202.5
MLE Mean (bias corrected)	0.065	MLE Sd (bias corrected)	0.0537
		Adjusted Level of Significance (β)	0.0465
Approximate Chi Square Value (202.51, α)	170.6	Adjusted Chi Square Value (202.51, β)	170
95% Gamma Approximate UCL (use when n>=50)	0.0772	95% Gamma Adjusted UCL (use when n<50)	0.0774

Lognormal GOF Test on Detected Observations Only

Lilliefors Test Statistic	0.161	Lilliefors GOF Test
5% Lilliefors Critical Value	0.113	Detected Data Not Lognormal at 5% Significance Level

Detected Data Not Lognormal at 5% Significance Level

Lognormal ROS Statistics Using Imputed Non-Detects

Mean in Original Scale	0.0651	Mean in Log Scale	-3.086
SD in Original Scale	0.066	SD in Log Scale	0.83
95% t UCL (assumes normality of ROS data)	0.0784	95% Percentile Bootstrap UCL	0.0785
95% BCA Bootstrap UCL	0.0803	95% Bootstrap t UCL	0.0818
95% H-UCL (Log ROS)	0.0798		

DL/2 Statistics

DL/2 Normal		DL/2 Log-Transformed	
Mean in Original Scale	0.0651	Mean in Log Scale	-3.09
SD in Original Scale	0.0661	SD in Log Scale	0.834
95% t UCL (Assumes normality)	0.0783	95% H-Stat UCL	0.0799

DL/2 is not a recommended method, provided for comparisons and historical reasons

Nonparametric Distribution Free UCL Statistics

Data do not follow a Discernible Distribution at 5% Significance Level

Suggested UCL to Use	95% KM (Chebyshev) UCL	0.1	Hg

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

<u>Zinc</u>

General Statistics

Total Number of Observations	57	Number of Distinct Observations	39
		Number of Missing Observations	0
Minimum	34	**Mean**	**107**
Maximum	673	Median	68.5
SD	132.3	Std. Error of Mean	17.53
Coefficient of Variation	1.237	Skewness	3.147

Normal GOF Test

Shapiro Wilk Test Statistic	0.467	Shapiro Wilk GOF Test
5% Shapiro Wilk P Value	0	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.402	Lilliefors GOF Test
5% Lilliefors Critical Value	0.117	Data Not Normal at 5% Significance Level

Data Not Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		95% UCLs (Adjusted for Skewness)	
95% Student's-t UCL	136.3	95% Adjusted-CLT UCL (Chen-1995)	143.6
		95% Modified-t UCL (Johnson-1978)	137.5

Gamma GOF Test

A-D Test Statistic	8.48	Anderson-Darling Gamma GOF Test	
5% A-D Critical Value	0.766	Data Not Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.343	Kolmogrov-Smirnoff Gamma GOF Test	
5% K-S Critical Value	0.12	Data Not Gamma Distributed at 5% Significance Level	

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	1.724	k star (bias corrected MLE)	1.645
Theta hat (MLE)	62.03	Theta star (bias corrected MLE)	65.01
nu hat (MLE)	196.6	nu star (bias corrected)	187.6
MLE Mean (bias corrected)	107	MLE Sd (bias corrected)	83.39
		Approximate Chi Square Value (0.05)	156.9
Adjusted Level of Significance	0.0458	Adjusted Chi Square Value	156.2

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	127.9	95% Adjusted Gamma UCL (use when n<50)	128.5

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.729	Shapiro Wilk Lognormal GOF Test	
5% Shapiro Wilk P Value	1.82E-13	Data Not Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.274	Lilliefors Lognormal GOF Test	
5% Lilliefors Critical Value	0.117	Data Not Lognormal at 5% Significance Level	

Data Not Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.526	Mean of logged Data	4.355
Maximum of Logged Data	6.512	SD of logged Data	0.647

Assuming Lognormal Distribution

95% H-UCL	114.1	90% Chebyshev (MVUE) UCL	122.3
95% Chebyshev (MVUE) UCL	134.4	97.5% Chebyshev (MVUE) UCL	151.1
99% Chebyshev (MVUE) UCL	184		

Nonparametric Distribution Free UCL Statistics

Data do not follow a Discernible Distribution (0.05)

Nonparametric Distribution Free UCLs

95% CLT UCL	135.8	95% Jackknife UCL	136.3
95% Standard Bootstrap UCL	135.2	95% Bootstrap-t UCL	151.5
95% Hall's Bootstrap UCL	135.6	95% Percentile Bootstrap UCL	138.9
95% BCA Bootstrap UCL	144.6		
90% Chebyshev(Mean, Sd) UCL	159.6	95% Chebyshev(Mean, Sd) UCL	183.4
97.5% Chebyshev(Mean, Sd) UCL	216.4	99% Chebyshev(Mean, Sd) UCL	281.4

Suggested UCL to Use **95% Chebyshev (Mean, Sd) UCL** **183.4** **Zn**

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002)
and Singh and Singh (2003). However, simulations results will not cover all Real World data sets.
For additional insight the user may want to consult a statistician.

APPENDIX H

SUPPLEMENTAL APPROACH FOR ECOLOGICAL RISK EVALUATION

Table H-1. Depth-Weighted Metals Calculations for Performance Monitoring Samples Using Puget Sound Background Values

Station	Elevation Before Cleanup (ft)	Elevation After Cleanup (ft)	Difference in Elevation (ft)	Difference in Elevation Rounded to Nearest 0.5 ft[1]	Residual Soil Depth to 6 ft[2]	Copper (mg/kg)	Copper Depth-Weighted	Lead (mg/kg)	Lead Depth-Weighed	Mercury (mg/kg)	Mercury Depth-Weighted	Zinc (mg/kg)	Zinc Depth-Weighted
Cleanup Level						50		50		0.1		86	
Puget Sound Background 90%UCL (Ecology 1994)						36		24		0.07		85	
A1S	40.28	45.0	4.7	4.5	1.5	**75.2**	46	**213**	**71**	0.10	0.1	**550**	**201**
A2S	40.98	48.0	7.0	6.0	0.0	**86.1**	36	**477**	24	**0.18**	0.1	**500**	85
A6S2	37.52	40.0	2.5	2.5	3.5	34.9	35	**106**	**72**	0.08	0.1	84	84
A7B	36.05	40.0	4.0	4.0	2.0	30.5	34	5.4	18	0.05	0.1	**87**	86
A8S	41.91	45.0	3.1	3.0	3.0	**79.7**	**58**	**310**	**167**	**0.32**	**0.2**	**480**	**283**
B2S	35.82	38.5	2.7	2.5	3.5	25.15	30	44.4	36	0.04	0.1	64	73
B3S2	36.22	37.0	0.8	1.0	5.0	**57.4**	**54**	**129**	**112**	**0.12**	0.1	**155**	**143**
B5B2	35.08	38.0	2.9	3.0	3.0	**52.2**	44	13.3	19	**0.17**	0.1	83	84
B5S2	38.66	44.0	5.3	5.5	0.5	41.7	36	**74.2**	28	0.06	0.1	**105**	**87**
B6S2	37.98	43.5	5.5	5.5	0.5	46.5	37	**84.2**	29	**0.13**	0.1	**673**	**134**
B9S	36.34	37.0	0.7	0.5	5.5	34.1	34	**62.1**	**59**	0.06	0.1	**95**	**94**
B10B	34.13	37.0	2.9	3.0	3.0	**52.9**	44	5.4	15	0.10	0.1	**87**	86
B12S	36.07	37.0	0.9	1.0	5.0	**147**	**129**	**536**	**451**	**0.38**	**0.3**	**370**	**323**
B16S	36.75	37.0	0.3	0.5	5.5	36.1	36	**86.9**	**82**	0.07	0.1	**101**	**100**
HA-01	35.61	33.5	-2.1	-2.0	--	NA	--	34	--	**0.12**	--	NA	--
HA-02	35.69	33.0	-2.7	-2.5	--	NA	--	33	--	**0.11**	--	NA	--
HA-03	35.14	32.5	-2.6	-2.5	--	NA	--	**53**	--	**0.16**	--	NA	--
HA-04	35.22	35.5	0.3	0.5	5.5	NA	--	39	37.8	**0.12**	0.1	NA	--
HA-05	Removed with Interim Action[3]												
HA-06	36.96	32.0	-5.0	-5.0	--	NA	--	25	--	**0.13**	--	NA	--
HA-07	35.30	35.0	-0.3	-0.5	--	NA	--	**222**	--	**0.19**	--	NA	--
HA-12	36.37	37.5	1.1	1.0	5.0	NA	--	**70**	**62.3**	0.08	0.1	NA	--
TP-24	Removed with Interim Action[3]												

Table Notes:

[1] Difference in sample elevation is based on comparison between elevation during sampling and elevation at approximate location after finish grade (accuracy 0.5 ft).

[2] For stations with more than 6 ft fill cover, a depth of 6 ft is used for the calculations. For stations with difference in elevation in -ft, depth-weighted calculations were not completed for these stations.

[3] Soil represented by stations HA-05 and TP-24 were excavated during the interim action.

B9S Station is located near wetland or Cottonwood tree and considered critical habitat. Residual soil metals concentrations at these stations will be left in-place to protect the existing critical habitat

-- Depth-weighted concentrations not calculated because additional soil had been excavated after sampling and thus, these concentrations are not likely representative of current conditions

NA Metal not analyzed for this sample.

58 Metal concentration exceeds cleanup level.

Table H-2. Depth-Weighted Metals Calculations for Performance Monitoring Samples Compared to Eco-SSL Values

Station	Elevation Before Cleanup (ft)	Elevation After Cleanup (ft)	Difference in Elevation (ft)	Difference in Elevation Rounded to Nearest 0.5 ft[1]	Residual Soil Depth to 6 ft[2]	Copper (mg/kg)	Copper Depth-Weighted	Lead (mg/kg)	Lead Depth-Weighed	Mercury (mg/kg)	Mercury Depth-Weighted	Zinc (mg/kg)	Zinc Depth-Weighted
Eco-SSL Values (Plants, Invertebrates)						70, 80		120, 1700		None		160, 120	
Puget Sound Background 90%UCL (Ecology 1994)						36		24		0.07		85	
A1S	40.28	45.0	4.7	4.5	1.5	**75.2**	46	**213**	71	0.10	0.1	**550**	**201**
A2S	40.98	48.0	7.0	6.0	0.0	**86.1**	36	**477**	24	**0.18**	0.1	**500**	85
A6S2	37.52	40.0	2.5	2.5	3.5	34.9	35	106	72	0.08	0.1	84	84
A7B	36.05	40.0	4.0	4.0	2.0	30.5	34	5.4	18	0.05	0.1	87	86
A8S	41.91	45.0	3.1	3.0	3.0	**79.7**	58	**310**	**167**	**0.32**	**0.2**	**480**	**283**
B2S	35.82	38.5	2.7	2.5	3.5	25.15	30	44.4	36	0.04	0.1	64	73
B3S2	36.22	37.0	0.8	1.0	5.0	57.4	54	**129**	112	**0.12**	0.1	**155**	**143**
B5B2	35.08	38.0	2.9	3.0	3.0	52.2	44	13.3	19	**0.17**	0.1	83	84
B5S2	38.66	44.0	5.3	5.5	0.5	41.7	36	74.2	28	0.06	0.1	105	87
B6S2	37.98	43.5	5.5	5.5	0.5	46.5	37	84.2	29	**0.13**	0.1	**673**	**134**
B9S	36.34	37.0	0.7	0.5	5.5	34.1	34	62.1	59	0.06	0.1	95	94
B10B	34.13	37.0	2.9	3.0	3.0	52.9	44	5.4	15	0.10	0.1	87	86
B12S	36.07	37.0	0.9	1.0	5.0	**147**	**129**	**536**	**451**	**0.38**	**0.3**	**370**	**323**
B16S	36.75	37.0	0.3	0.5	5.5	36.1	36	86.9	82	0.07	0.1	101	100
HA-01	35.61	33.5	-2.1	-2.0	--	NA	--	34	--	**0.12**	--	NA	--
HA-02	35.69	33.0	-2.7	-2.5	--	NA	--	33	--	**0.11**	--	NA	--
HA-03	35.14	32.5	-2.6	-2.5	--	NA	--	53	--	**0.16**	--	NA	--
HA-04	35.22	35.5	0.3	0.5	5.5	NA	--	39	37.8	**0.12**	0.1	NA	--
HA-05	Removed with Interim Action[3]												
HA-06	36.96	32.0	-5.0	-5.0	--	NA	--	25	--	**0.13**	--	NA	--
HA-07	35.30	35.0	-0.3	-0.5	--	NA	--	**222**	--	**0.19**	--	NA	--
HA-12	36.37	37.5	1.1	1.0	5.0	NA	--	70	62.3	0.08	0.1	NA	--
TP-24	Removed with Interim Action[3]												

Table Notes:

[1] Difference in sample elevation is based on comparison between elevation during sampling and elevation at approximate location after finish grade (accuracy 0.5 ft).

[2] For stations with more than 6 ft fill cover, a depth of 6 ft is used for the calculations. For stations with difference in elevation in -ft, depth-weighted calculations were not completed for these stations.

[3] Soil represented by stations HA-05 and TP-24 were excavated during the interim action.

B9S Station is located near wetland or Cottonwood tree and considered critical habitat. Residual soil metals concentrations at these stations will be left in-place to protect the existing critical habitat.

-- Depth-weighted concentrations not calculated because additional soil had been excavated after sampling and thus, these concentrations are not likely representative of current conditions.

NA Metal not analyzed for this sample.

Table H-3. Exposure-adjusted Soil Concentrations for Plants

Station	Metal	Soil Layer Depth (feet)		Soil Layer Metal Concentration (mg/kg)		Proportion of Roots in Clean Cover and Residual Soil Layers (%)[1]						Exposure-adjusted Soil Concentration (mg/kg)[2]			Alternative Plant CUL (mg/kg)
						Trees		Shrubs		Grasses					
		Clean Cover	Residual Soil	Clean Cover	Residual Soil	Clean Cover	Residual Soil	Clean Cover	Residual Soil	Clean Cover	Residual Soil	Trees	Shrubs	Grasses	
A8S	Lead	3.0	3.0	24	310	0.94	0.06	0.87	0.13	0.99	0.01	41	61	27	120
A1S	Zinc	4.5	1.5	85	550	0.98	0.02	0.95	0.05	1	0	94	108	85	160
A8S	Zinc	4.5	1.5	85	283	0.98	0.02	0.95	0.05	1	0	89	95	85	160

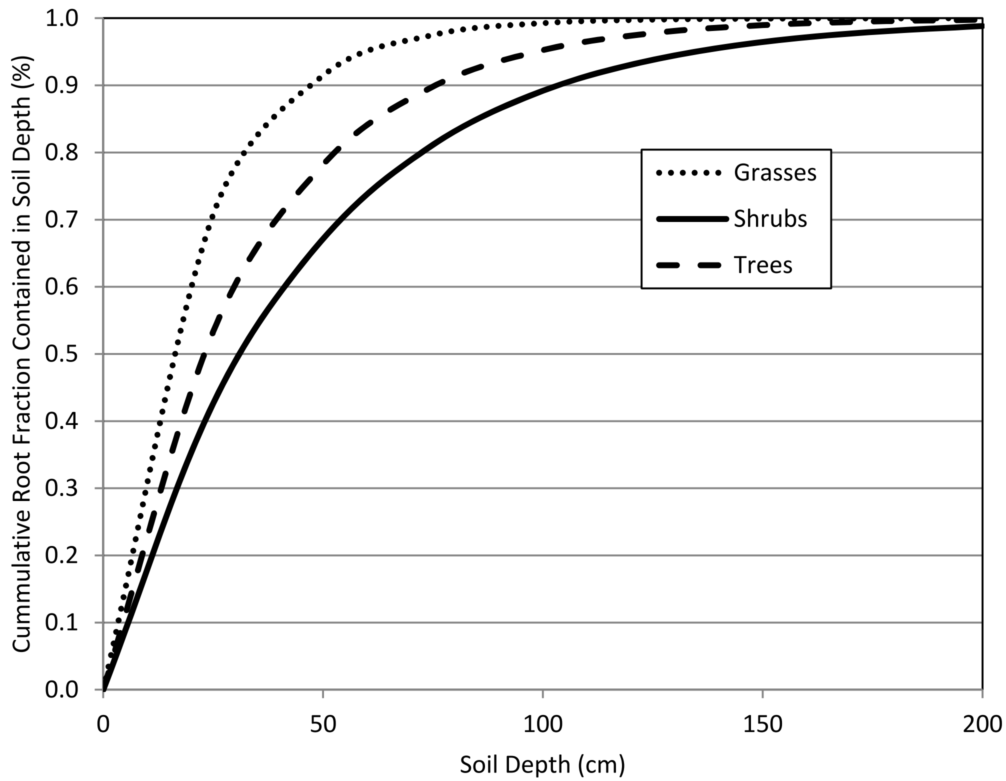
Notes:

[1] Derived using Equation 3.

[2] Derived using Equation 2.

CUL - clean up level

Figure H-1. Cummulative Root Fraction Model Curves for Major Plant Types



ADDENDUM 1

BASIS FOR SELECTION OF THE PREFERRED CLEANUP ACTION

Basis for Selection of the Preferred Cleanup Action

Addendum to the Remedial Investigation/Feasibility Study
Eldridge Municipal Landfill Site

Final Document

Prepared for
City of Bellingham, Public Works Department
210 Lottie Street
Bellingham, WA 98225

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December 2015

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ACRONYMS AND ABBREVIATIONS

BTC	Bellingham Technical College
City	City of Bellingham
CUL	cleanup level
Cy	cubic yard
DCAP	Draft Cleanup Action Plan
Ecology	Washington State Department of Ecology
MTCA	Model Toxics Control Act
Park	Little Squalicum Park
RI/FS	remedial investigation and feasibility study
SAP	sampling and analysis plan
TCP	Toxics Cleanup Program
WAC	Washington Administrative Code
WISHA	Washington Industrial Safety and Health Act

CERTIFICATION

I, Mark J. Herrenkohl, a professional engineering geologist in the State of Washington, certify that I have reviewed the geosciences portions of this document.

Stamp and Signature of Geologist:

State of Washington
Engineering Geologist
2286
Licensed Geologist
Mark J. Herrenkohl

Name: Mark J. Herrenkohl, LEG Date: 12/01/2015

I, Elizabeth Sterling, a professional engineer in the State of Washington, certify that I have reviewed the engineering portions of this document.

Stamp and Signature of Engineer:

Elizabeth Anne Sterling
State of Washington
41548
Registered
Professional Engineer

Name: Elizabeth Sterling, PE Date: 12/01/2015

1 PURPOSE AND SCOPE

This addendum to the remedial investigation/feasibility study (RI/FS) provides the basis for selection of the preferred cleanup action for the Eldridge Municipal Landfill Site (Site), including a description of the alternatives and applied technologies, evaluated in accordance with MTCA remedy selection criteria (WAC 173-340-350 and -360). WAC 173-340-360(2)(a) lists four threshold requirements for cleanup actions including:

- Protect human health and the environment,
- Comply with cleanup standards,
- Comply with applicable laws, and
- Provide for compliance monitoring.

The project alternatives and applied technologies contained in this evaluation are designed to meet these threshold requirements.

When selecting from alternatives that meet the threshold requirements listed above, the selected action must also address the following three criteria (WAC 173-340-360[2][b]):

- Use permanent solutions to the maximum extent practicable,
- Provide for a reasonable restoration time frame, and
- Consider public concerns.

The MTCA analysis of disproportionate costs is used to evaluate which cleanup alternatives are "permanent to the maximum extent practicable." This analysis compares the relative benefits and costs of cleanup alternatives proposed for the Site. Six criteria are used in the disproportionate cost analysis for the Site as specified in WAC 173-340-360(3)(f) including protectiveness, permanence, cost, long-term effectiveness, short-term risk management, implementability, and consideration of public concerns. The qualitative analysis presented in the following sections compares the relative benefits of each alternative against those provided by the most permanent alternative. Many of these criteria are environmentally based while others are related but non-environmental (e.g., implementability).

Herrenkohl Consulting LLC has written this addendum to the RI/FS with assistance from Wilson Engineering, LLC under Contract No. 2011-0142 (including modifications) with the City of Bellingham Public Works Department (City), and with direction from the Washington State Department of Ecology (Ecology) Toxics Cleanup Program.

This document and the RI/FS report are being issued for public review concurrently with the proposed Consent Decree which includes the draft cleanup action plan (DCAP).

2 PROPOSED CLEANUP TECHNOLOGIES

The following proposed cleanup technologies were considered in the evaluation of two remedial alternatives for the Site:

- **Shoring and Slope Stability:** Sheet-pile or soldier-pile installation upslope of residual contaminated areas to stabilize soils before excavation commences.
- **Removal by Excavation:** Excavation of soil by appropriate land-based equipment including excavator, bulldozer, and dump trucks.
- **Subtitle D Landfill Disposal:** Disposal of impacted material generated from removal operations at a permitted off-site Subtitle D disposal facility.
- **Institutional Controls:** Limits or prohibitions on activities that could interfere with the integrity of the cleanup action or result in exposure to impacted soils.

More information on each of these technologies is presented in the following subsections. These technologies are also considered in the evaluation of the two remedial alternatives presented in Section 3 below and summarized in Table 1 at the end of Section 4.

2.1 SHORING AND SLOPE STABILITY

Shoring refers to the process of supporting a structure or unstable slope to prevent collapse during an excavation. The most common temporary shoring used for deeper excavations are driven sheet pile or soldier pile (steel H-piles with wooden lagging) walls.

Sheet pile walls are constructed by hammer-driving or vibrating prefabricated, steel sections into the ground. The complete sheet pile wall is formed by connecting the joints of adjacent sheet pile sections in sequential installation. The main advantages of shoring with sheet piles:

- Light weight and provide high resistance to driving stresses;
- Provide long service life above or below the water table with modest protection; and
- Easy to adapt pile length by either welding or bolting, and joints are less apt to deform during driving.

The major disadvantages of sheet piles:

- Installation is difficult in soils with boulders or cobbles impacting the desired wall depths;
- The shape of the excavation may be controlled by the sheet pile section and connections; and

- Sheet pile driving may cause neighborhood disturbance and potential settlement in adjacent properties due to installation vibrations.

Soldier pile walls are some of the oldest forms of retaining systems used in deep excavations. The steel H-piles are hammer-driven or vibrated into the ground and connected with wooden lagging.

The main advantages of shoring with soldier piles:

- Typically the least expensive shoring system; and
- Allows excavating in small stages while backfilling and compacting the void space behind the lagging.

The major disadvantages are:

- Cannot be used in high water table conditions without extensive dewatering; and
- Not as stiff as other retaining systems.

2.2 EXCAVATION, TRANSPORT, AND OFF-SITE DISPOSAL OF REMAINING CONTAMINATED SOIL

Excavation followed by off-site disposal is a widely-used technique for disposal of non-hazardous and hazardous soil. Experience with many types of wastes and numerous clean-up situations has shown that impacted soils can be safely excavated and transported to an off-site disposal location. This technology was used in the successful removal and disposal of about 4,290 tons of landfill debris and contaminated soil in support of the Site interim action in 2011. The materials were transported to Roosevelt Regional Landfill in Washington State for proper disposal. Off-site disposal of remaining Site soil would involve shoring slopes (refer to Section 2.1), removal of vegetation (e.g., cottonwood trees), excavation of the impacted soil from unstable slopes and an existing wetland, loading the solids into dump trucks and/or rail cars, and transportation to the receiving facility for proper disposal. The excavation would be stabilized by placement of clean fill and hydroseeded. In addition, a ~1,000 ft^2 depressional wetland would be created within the project area to replace the impacted, existing wetland.

Excavation and transport are accomplished by standard techniques and equipment. The field personnel, though, need to be health and safety trained under the Washington Industrial Safety and Health Act (WISHA) to perform work dealing with contaminated soils. Excavation of remaining contaminated soil with off-site disposal offers several advantages:

- The source of future surface water and groundwater contamination from the Site is eliminated by removal of the residual contaminated soil.

- Removal of remaining landfill debris and contaminated soils eliminates all risk to human health and the environment at the Site.

The disadvantages with off-site disposal may include:

- The wastes are not destroyed. The safety of waste disposal is dependent on the long-term integrity of the off-site disposal site. If the off-site disposal facility loses integrity, the facility owner and the facility users may become responsible for remedial work at the site.
- Excavation of impacted soil increases potential for contaminant release while excavation is conducted.
- Transportation of the wastes may create a risk to human safety and the local environment along the transportation route.
- The method of cleanup is dependent on the availability of acceptable off-site disposal sites.

Two Subtitle D landfills have been identified as being able to accept the remaining contaminated soil from the Eldridge Landfill. The Roosevelt Regional Landfill facility in Klickitat County, Washington and the Wenatchee Landfill facility near Wenatchee, Washington can accept all remaining soils. Transport of the soils to the landfills would be accomplished through Allied Waste (Rabanco) and Recycling and Disposal Services, respectively.

2.3 INSTITUTIONAL CONTROLS

Institutional controls in the form of restrictive covenants on the property would be required if residual contaminated soils remain at the Site. The restrictive covenants would document the nature and extent of impacted soils and the remedial action completed for the Site. They may also limit uses of the area, and prohibit the modification without the prior written approval of Ecology. In addition, the restrictive covenants may require owners of the Property to notify all lessees or property purchasers of the restrictions on the use of the Property. The restrictive covenants may also require the owners of the property to provide for continued monitoring and operation and maintenance of the remedial action prior to conveying title, easement, lease or other interest in the Property. The restrictive covenants would be subject to Ecology's approval before being recorded.

3 EVALUATION OF REMEDIAL ALTERNATIVES

This section presents an analysis of the remedial alternatives and applied technologies developed for the Eldridge Landfill Site. The evaluation of each alternative considers the six criteria used in the disproportionate cost analysis listed in Section 1. "No Action" is not considered in this evaluation of remedial alternatives. Table 1 presented at the end of Section 4 provides a comparison of remedial alternatives and applied technologies in relation to the MTCA threshold requirements and six criteria. A narrative for each alternative is presented in the following subsections.

3.1 ALTERNATIVE 1 – WETLAND PLANTING, COMPLIANCE MONITORING, AND INSTITUTIONAL CONTROLS

As described in the RI/FS report, an interim action was completed at the Site in 2011. The interim action consisted of excavating 4,290 tons of landfill materials and contaminated soils and disposing of them at a permitted disposal facility. However, implementation of the interim action resulted in residual contaminated soils being left in a few locations around the periphery of the former landfill, including steep, unstable slopes and within an existing wetland area (Figure 1). Alternative 1 includes the additional measures of wetland planting, compliance groundwater monitoring, and institutional controls to address these areas of residual soil contamination.

Site conditions post-interim action are protective of human health and the environment and meet MTCA minimum requirements for an overall cleanup action (Herrenkohl Consulting and Integral Consulting 2014). Alternative 1 relies on institutional actions to reduce intrusive activities that may disturb the residual contaminated soils. Protection will require maintenance (i.e., grass cutting and removal of invasive plants and tree-starts) and deed restrictions on the property and groundwater monitoring using existing wells within the former landfill footprint. It is recommended that groundwater sampling be conducted during the wet season for two consecutive years. A full review for the need of additional monitoring would be conducted at the end of year 2.

Alternative 1 will also include a requirement for additional wetland planting for the 750 ft^2 depressional wetland created as part of the interim action. Fencing and signs indicating "critical habitat" would be placed around the two wetlands and adjacent cottonwood tree.

The estimated total cost for Alternative 1 is $237,000 (refer to Table 1 and Appendix A).

3.2 ALTERNATIVE 2 – SHORING, EXCAVATION, OFF-SITE TRANSPORT AND DISPOSAL

Alternative 2 includes shoring for slope stability and excavation of residual landfill material and contaminated soil at the Eldridge Landfill Site (Wilson Engineering 2015). As shown in Figure

2, the four areas of excavation total ~9,800 square ft for a total volume of impacted soil removal of approximately 2,950 cy (5,458 tons assuming 1.85 tons/cy). The size and volume estimates for each area are based on previous confirmation sampling upon completion of the interim action in 2011 and includes excavation of clean soil to meet shoring requirements for slope stability during excavation. Following excavation, the soils would be transported to a Subtitle D landfill for disposal.

The closest landfills are in Roosevelt and Wenatchee, Washington. Based on the concentrations of metals in soils removed during the interim action, no treatment will be required prior to disposal.

The excavation and off-site disposal alternative for all soils exceeding the MTCA cleanup levels (CULs) for metals is designed to be protective of human health and the environment. Residual soils of concern would be removed from the Site preventing possible risk from direct contact and potential contamination of surface water and groundwater, and providing the most long-term effectiveness and permanence of the two alternatives considered. Risks related to metals contamination would be transferred to an off-site disposal facility.

The off-site disposal alternative is implementable but has the greatest short-term risk to humans and the environment from disturbance of impacted soils during excavation activities. This includes the requirement for shoring of unstable slopes for Areas 2-4, adjacent to buildings on the Bellingham Technical College campus. Once shoring is established, there is no unusual difficulty expected with excavation, transport, and disposal. The equipment necessary to implement Alternative 2 is also readily available.

The estimated total cost for Alternative 2 is $1,413,000 to manage unstable slopes, excavate, and dispose of a total of 5,458 tons of residual contaminated soils off-site without treatment (refer to Appendix A). The estimated operation and maintenance costs are zero, since the remaining residual soils are removed from the Site; however, watering of the created wetland would be required during the dry summer months until wetland plants are established (about 2 years). No restrictive covenants are required for the property.

4 COMPARISON OF ALTERNATIVES AND TECHNOLOGIES: REMEDY COSTS AND BENEFITS

A summary of the disproportionate cost analysis is presented in Table 1. Appendix A contains a detailed cost breakdown for each alternative. The probable costs of the alternatives range from a low value of $237,000 for Alternative 1 to a high value of $1,413,000 for Alternative 2, each with a 30% added contingency. These costs are expressed in 2015 dollars without adjustments for future cost inflation and without present value discounting of future costs.

Alternative 1 is identified as the preferred alternative, based on a qualitative review of the MTCA analysis of disproportionate costs (Table 1). This alternative combines compliance monitoring and institutional actions while remaining practicable in overall cost. Alternative 1 is permanent to the maximum extent practicable under MTCA, and is identified as the preferred alternative.

Alternative 2 would receive a high benefit ranking, but as clearly identified in Table 1 the cost compared with the benefits gained is significantly greater and is therefore considered impracticable. The additional site preparation, removal, and disposal activities conducted in Alternative 2 expand the soil removal area and disposal volume, but apply these additional efforts to soils with lower metals levels that are safely managed using technologies included in Alternative 1.

Table 1. Detailed Evaluation of Alternatives and Applied Technologies		
Alternative Number, Description, and Ranking	**Alternative 1** Compliance Monitoring and Institutional Controls	**Alternative 2** Shoring, Excavation, Off-Site Transport, and Disposal
Volume of Soil Removal (cy)	0	2,950
Core Costs (Including contingency, refer to Appendix A)	$237,000 (2015$)	$1.413 million (2015$)
Compliance with MTCA Threshold Criteria		
Protection of Human Health and the Environment	Yes – Alternative will protect human health and the environment.	Yes – Alternative will protect human health and the environment.
Compliance with Cleanup Standards	Yes – Institutional controls are used for soils not complying with cleanup standards.	Yes – Active remedial measure (removal) is used for soils not complying with cleanup standards.
Compliance with Applicable State and Federal Laws	Yes – Alternative complies with applicable laws.	Yes – Alternative complies with applicable laws.
Provision for Compliance Monitoring	Yes – Alternative includes provisions for compliance monitoring (i.e., groundwater monitoring).	Yes – Alternative includes provisions for compliance monitoring (i.e., compliance soil sampling during removal).
Restoration Time Frame	Restoration time frame is 1 year for construction of fencing and signage. Groundwater monitoring of 2 years or more may be required to ensure compliance. Landscape maintenance is required for future (30 years).	Restoration time frame is 1 to 2 years for design and construction. Maintenance (e.g., watering) of the restored wetland will be required during the drier summer months until plants are established (~2 years).

Table 1. Detailed Evaluation of Alternatives and Applied Technologies		
Alternative Number, Description, and Ranking	**Alternative 1** Compliance Monitoring and Institutional Controls	**Alternative 2** Shoring, Excavation, Off-Site Transport, and Disposal
Evaluation of Permanence using MTCA Disproportionate Cost Analysis		
Protectiveness:	This alternative will achieve overall protection.	This alternative will be most protective for the Property.
Permanence:	Residual contaminated soils are generally isolated by fill material placed during interim action or isolated using institutional controls. This alternative is not as permanent as Alternative 2.	Alternative eliminates the volume of impacted material by completely removing, to greatest degree technically feasible, impacted surface and subsurface soils throughout the Site.
Long-Term Effectiveness:	Alternative makes most use of containment by fill placement during interim action and institutional controls.	Alternative makes greatest use of removal and off-site disposal.
Short-Term Risk Management:	Less disturbance of residual contaminated soils, most effective short-term.	Most disturbance of residual contaminated soils, least effective short-term.
Implementability:	Most Implementable; access restrictions will be required over portions of the Site permanently.	Implementable; it may require temporary access restrictions during shoring and soil excavation.
Consideration of Public Concerns:	Lower ranking relative to complete removal of residual soils – contaminated material remains onsite	Higher ranking – residual contaminated material removal from site

Notes: Refer to Section 3 for detailed description of each alternative.

5 DESCRIPTION OF THE PREFERRED CLEANUP ACTION

<u>Alternative 1 has been selected as the preferred cleanup action for the Eldridge Municipal Landfill Site</u>. This alternative combines removal of the highest concentrations of metals in soils (interim action) with compliance groundwater monitoring and institutional controls (refer to Section 3.1). The following sections provide additional details of the preferred cleanup action including compliance monitoring, contingency responses, and institutional controls.

5.1 TYPES, LEVELS, AND AMOUNTS OF CONTAMINATION REMAINING ONSITE

As presented in Section 8.3.2 of the RI/FS report, a stepwise approach was used to address potential ecological risks from the residual metal concentrations that exceeded remediation levels after completion of the interim action. The specific metals involved consisted of copper, lead, mercury, and zinc. This stepwise approach involved first calculating depth-weighted soil concentrations, then developing alternative ecological soil cleanup levels, and finally developing exposure-adjusted soil concentrations.

Based on the results of this evaluation, it was determined that the post interim action ecological risk assessment provides sufficient information to conclude that ecological receptors should not be at risk from residual soil metals concentrations present on the landfill site. This determination is based on the clean cover soils and underlying contaminated soils remaining undisturbed. Long-term care is therefore required to maintain these existing conditions in the following specific areas (refer to Figure 1):

- Area 1: Contaminated soils under existing wetland A and the cottonwood tree are below a depth of 0.5 ft to 1.0 ft and contain copper, lead, mercury, and zinc concentrations exceeding the CULs protective of terrestrial species, and lead exceeding a value protective of human direct contact.

- Area 2: Contaminated soils at the base of the steep slope in the southwestern corner of the Site are below a depth of 0 ft to 5.5 ft , and contain lead, mercury, and zinc concentrations exceeding cleanup levels protective of terrestrial species.

- Area 3: Contaminated soils at the base of the steep slope along the southeastern edge of the Site are below a depth of 3.0 ft to 4.0 ft and contain copper, lead, mercury and zinc concentrations exceeding cleanup levels protective of terrestrial species, and lead exceeds a value protective of human direct contact.

- Area 4: Contaminated soils at the eastern end of the Site are below a depth of 4.5 ft to 6.0 ft and contain copper, lead, mercury, and zinc concentrations exceeding cleanup levels protective of terrestrial species, and lead exceeds a value protective of human direct contact.

As also indicated in the RI/FS, the uppermost groundwater potentially impacted by landfill leachate occurs as an unconfined water-bearing zone extending from near land surface to a depth of about 10 feet. The saturated thickness in this water-bearing zone is typically between 6 and 8 feet, and the groundwater in it is separated from deeper aquifers by a silty clay aquitard. None of the compounds or metals analyzed in groundwater samples obtained following the interim action exceeded cleanup levels or were higher than background levels, except for the metals arsenic and iron. Because arsenic and iron in Site groundwater do not currently meet CULs, additional compliance monitoring is required as part of this cleanup action.

5.2 COMPLIANCE MONITORING

Compliance monitoring will be implemented for the Site in accordance with WAC 173-340-410. Compliance groundwater monitoring will be performed as described in Section 6 and with methods presented in the SAP (Herrenkohl Consulting 2012). The objective of the monitoring is to confirm that CULs have been achieved and to confirm the long-term effectiveness of the cleanup action for the Site.

5.3 INSTITUTIONAL CONTROLS

Institutional controls will be required as part of the cleanup action, and will include an environmental covenant, an operations and maintenance plan for the Site, and special boundary fencing and signage. The purpose of these institutional controls will be to protect valuable habitat, to prevent human exposure to residual soil contamination, and to protect terrestrial wildlife at the Site.

The restrictive covenants will be subject to Ecology’s approval before being recorded.

6 IMPLEMENTATION OF THE PREFERRED CLEANUP ACTION

The design and implementation of the cleanup action for the Site will be completed over a period of approximately one year, with additional time to complete compliance monitoring, as necessary. The expected schedule for design and implementation of the cleanup action is described below.

- **Wetland Planting** – Additional wetland planting and installation of a boundary fence and signage will be completed in the fall/winter of 2015. Upon completion of the planting, the plants will be watered once per month during the summer months (July, August, and September) over two consecutive years.

- **Compliance Monitoring** – Groundwater monitoring will be performed to track and confirm the expected decline of arsenic and iron concentrations in Site groundwater. Groundwater samples will be collected during the wettest season (December – March) over two years of monitoring. The samples will be obtained from wells EML-SB-01, -02, -03, and -04, and analyzed for arsenic and iron (dissolved only) following methods described in the sampling and analysis plan (SAP, Herrenkohl Consulting 2012). Standard field parameters (pH, temperature, conductivity, and the redox potential) will also be measured during each sampling event.

- **Designation of Especially Valuable Habitat -** The designation process is expected to take place by the end of 2015.

- **Recording of Environmental Covenant** – An environmental covenant restricting property use and protection of Wetland A and the cottonwood tree will be recorded upon finalization of the Consent Decree. These controls will remain in place indefinitely unless removal is approved by Ecology. Recording is expected to occur by the end of 2015.

- **Preparation of Operations and Maintenance Plan**– Preparation of this document will be completed by the end of 2015.

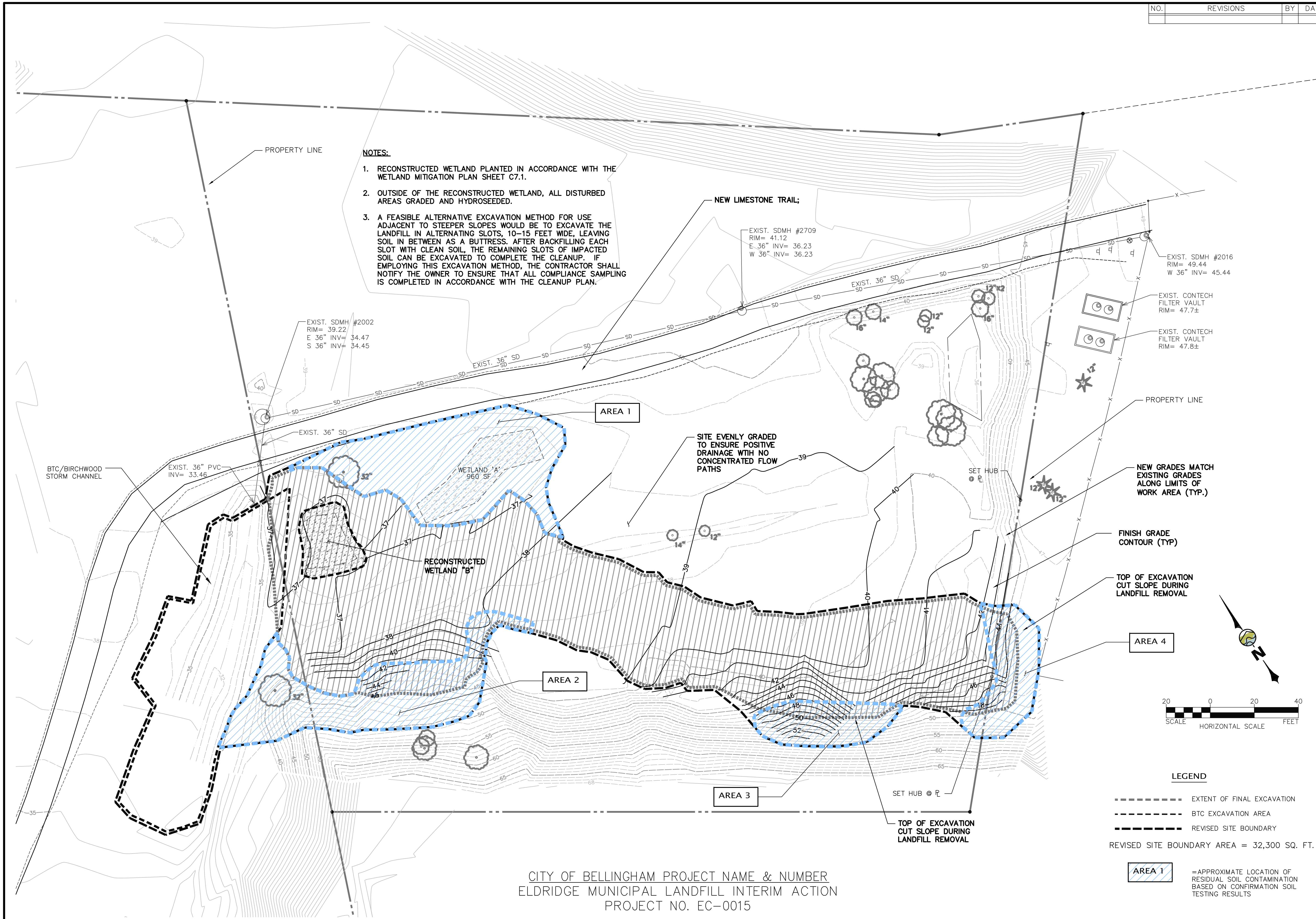
7 REFERENCES

Herrenkohl Consulting. 2012. Sampling and Analysis Plan, Groundwater Site Characterization, Eldridge Municipal Landfill RI/FS. Prepared for the City of Bellingham, Public Works Dept., Bellingham, WA. Prepared by Herrenkohl Consulting LLC, Bellingham, WA. April 27.

Herrenkohl Consulting and Integral Consulting. 2014. Public Review Draft Remedial Investigation/Feasibility Study, Eldridge Municipal Landfill Project, Bellingham, WA. Prepared for the City of Bellingham Public Works Department, Bellingham, WA. Prepared by Herrenkohl Consulting LLC of Lopez Island, WA in association with Integral Consulting Inc of Seattle, WA. April 18.

MTCA. Model Toxics Control Act (Chapter 173-340). Prepared by the Washington State Department of Ecology, Toxics Cleanup Program. Last Updated November 2007.

Wilson Engineering. 2015. Memorandum – Civil Engineering & Construction Cost Estimate, Alternative No. 2 – Shoring, Excavation, Off-Site Transport & Disposal, Eldridge Municipal Landfill. Prepared for Mark Herrenkohl, LEG, Herrenkohl Consulting LLC, Lopez Island, WA. Prepared by Elizabeth Sterling, PE, Wilson Engineering LLC, Bellingham, WA. August 31.



NOTES:

1. RECONSTRUCTED WETLAND PLANTED IN ACCORDANCE WITH THE WETLAND MITIGATION PLAN SHEET C7.1.
2. OUTSIDE OF THE RECONSTRUCTED WETLAND, ALL DISTURBED AREAS GRADED AND HYDROSEEDED.
3. A FEASIBLE ALTERNATIVE EXCAVATION METHOD FOR USE ADJACENT TO STEEPER SLOPES WOULD BE TO EXCAVATE THE LANDFILL IN ALTERNATING SLOTS, 10–15 FEET WIDE, LEAVING SOIL IN BETWEEN AS A BUTTRESS. AFTER BACKFILLING EACH SLOT WITH CLEAN SOIL, THE REMAINING SLOTS OF IMPACTED SOIL CAN BE EXCAVATED TO COMPLETE THE CLEANUP. IF EMPLOYING THIS EXCAVATION METHOD, THE CONTRACTOR SHALL NOTIFY THE OWNER TO ENSURE THAT ALL COMPLIANCE SAMPLING IS COMPLETED IN ACCORDANCE WITH THE CLEANUP PLAN.

LEGEND

- EXTENT OF FINAL EXCAVATION
- BTC EXCAVATION AREA
- REVISED SITE BOUNDARY

REVISED SITE BOUNDARY AREA = 32,300 SQ. FT.

AREA 1 =APPROXIMATE LOCATION OF RESIDUAL SOIL CONTAMINATION BASED ON CONFIRMATION SOIL TESTING RESULTS

CITY OF BELLINGHAM PROJECT NAME & NUMBER
ELDRIDGE MUNICIPAL LANDFILL INTERIM ACTION
PROJECT NO. EC-0015

NO.	REVISIONS	BY	DATE

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Wilson SURVEY / ENGINEERING

ELIZABETH ANNE STERLING, STATE OF WASHINGTON, REGISTERED PROFESSIONAL ENGINEER

DESIGNED BY EAS | DRAWN BY JGS/RDN | CHECKED BY

CITY OF BELLINGHAM
BELLINGHAM WASHINGTON
ELDRIDGE MUNICIPAL LANDFILL
SITE BOUNDARY & AREAS WITH RESIDUAL CONTAMINATION

DATE DECEMBER 2015 | SCALE AS SHOWN | JOB NUMBER 2015-101

SHEET FIG 1 OF 1

KEYED NOTES

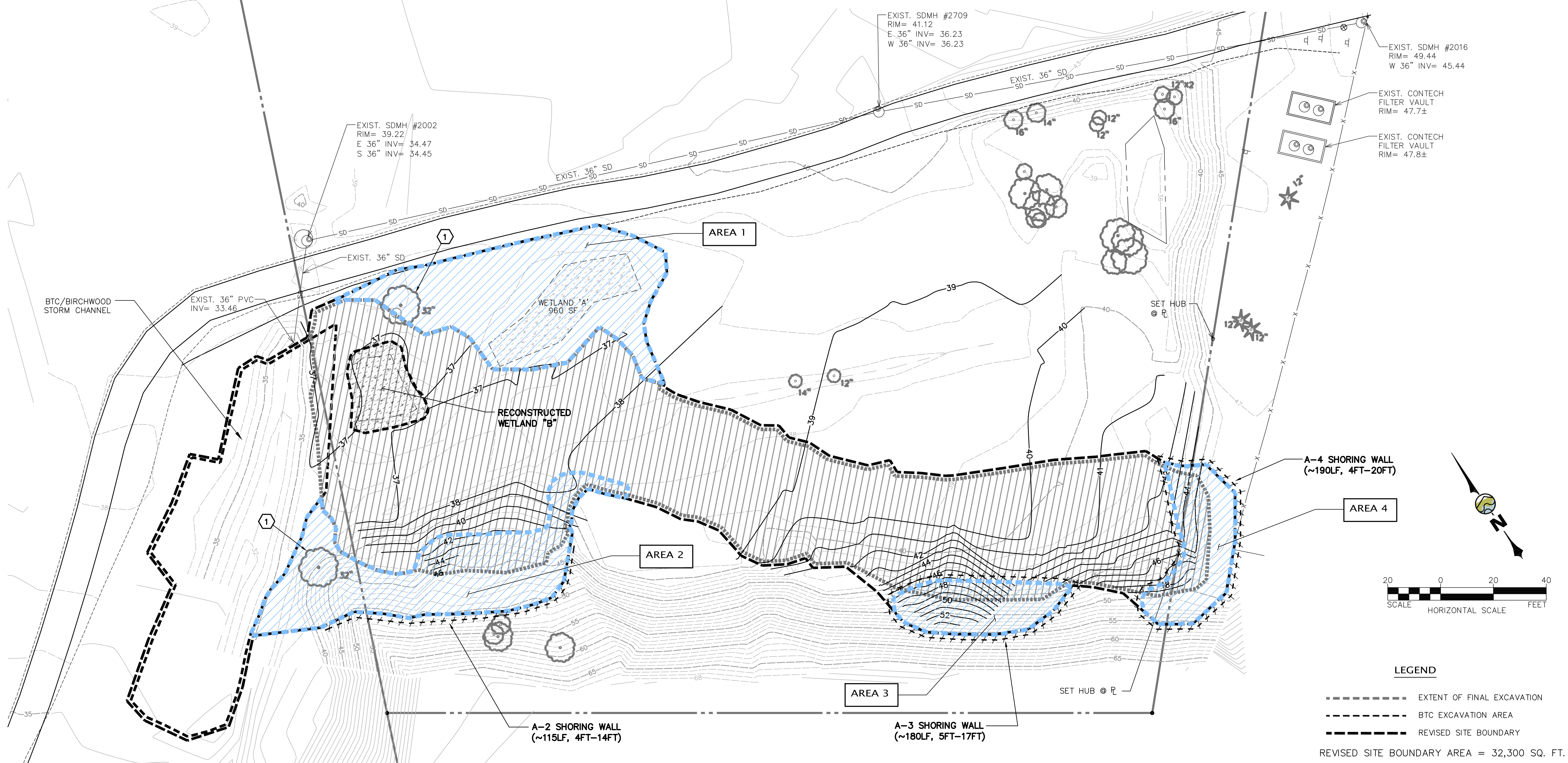
(1) = REMOVE EXISTING TREE

SUMMARY OF SHORING, EXCAVATION, AND BACKFILL QUANTITIES

AREA	PLAN AREA	SHORING WALL LENGTH (FT)	HEIGHT (FT)	AREA (SF)	BOTTOM OF EXCAVATION (SEE NOTE 1)	EXCAVATION (1) VOLUME (CY) (SEE NOTES 2 & 3)	BACKFILL (2) VOLUME (CY) (SEE NOTE 4)
1	4032	0	0	0	EL. 34.00	523	TOPSOIL– 94 GRAVEL– 623
2	3378	115	4FT–14FT	1435	EL. 37.00	1126	TOPSOIL– 80 GRAVEL– 1477
3	1091	100	5FT–17FT	1890	EL. 40.00	566	TOPSOIL– 26 GRAVEL– 758
4	1322	190	4FT– 20FT	3040	EL. 38.00	735	TOPSOIL– 31 GRAVEL– 907
TOTALS	9823			6365		2950	TOPSOIL– 231 GRAVEL– 3845

NOTES:

1. THE BOTTOM OF EXCAVATION FOR EACH AREA IS BASED ON PREVIOUS CONFIRMATION SAMPLING AT THE COMPLETION OF THE 2011 INTERIM ACTION.
2. EXCAVATED VOLUME IS CALCULATED AS BANK (IN-PLACE) VOLUME.
3. EXCAVATED VOLUME LIKELY INCLUDES CLEAN SOIL TO MEET SHORING REQUIREMENT FOR SLOPE STABILITY DURING EXCAVATION.
4. BACKFILL VOLUME IS CALCULATED AS LOOSE (UNCOMPACTED) VOLUME



LEGEND

EXTENT OF FINAL EXCAVATION

BTC EXCAVATION AREA

REVISED SITE BOUNDARY

REVISED SITE BOUNDARY AREA = 32,300 SQ. FT.

AREA 1 =APPROXIMATE LOCATION OF RESIDUAL SOIL CONTAMINATION BASED ON CONFIRMATION SOIL TESTING RESULTS

SHORING WALL

CITY OF BELLINGHAM PROJECT NAME & NUMBER
ELDRIDGE MUNICIPAL LANDFILL INTERIM ACTION
PROJECT NO. EC–0015

NO.	REVISIONS	BY	DATE

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Wilson SURVEY / ENGINEERING

DESIGNED BY EAS
DRAWN BY JGS/RDN
CHECKED BY

CITY OF BELLINGHAM
BELLINGHAM WASHINGTON
ELDRIDGE MUNICIPAL LANDFILL
ALTERNATIVE No. 2 – SHORING, EXCAVATION, OFF-SITE HAUL, AND DISPOSAL EXHIBIT

DATE DECEMBER 2015
SCALE AS SHOWN
JOB NUMBER 2015-101
SHEET FIG 2 OF 1

APPENDIX A

PRELIMINARY ENGINEERS COST ESTIMATES

Preliminary Engineer's Cost Estimate	
For Compliance Monitoring and Institutional Controls	
Eldridge Municipal Landfill RI/FS	
Bellingham, WA	
Prepared by: Mark Herrenkohl, LEG	
Herrenkohl Consulting LLC	
Revision Date: 09/09/15 **REMEDIAL ALTERNATIVE NO. 1**	
Costs Updated: City of Bellingham	
CONSTRUCTION COST ESTIMATE ASSUMPTIONS AND CALCULATIONS	
DIRECT COSTS	
PROJECT MANAGEMENT AND ENGINEERING	$ 11,070
City project management, engineering and administration	
Assume 5% of total direct and indirect costs (rounded).	
Also includes $2,500 for Operations & Maintenance Plan	
PROJECT SURVEYING	$ 2,500
Survey and mapping of fenced areas (Wetlands and Cottonwood Tree)	
Wilson Engineering LLC Proposal Dated 07/29/15	
FENCE AND SIGN INSTALLATION	$ 18,400
120 ft x 60 ft of 2-rail cedar fence	
360 linear ft at $50/ft. 4 Signs at $100 each installed on fence, no posts	
Based on Gina Austin, City of Bellingham email dated 0724/15	
WETLAND PLANTING	$ 5,000
Includes cost of plants (30 native plants), installation, and watering for 3 years	
Based on Element Solutions proposal dated 09/10/14	
TOTAL ESTIMATED DIRECT COSTS:	**$ 36,970**
INDIRECT COSTS	
SITE MAINTENANCE	$ 122,500
Site Clearing includes grass cutting, removal of invasives and tree-starts (30 years).	
Assume twice each year by City at $7,000 for first 5 years.	
Maintenance requirements of area will decrease after 5 years. Assume $3,500 x 25 years.	
Based on Marvin Harris, City of Bellingham estimate dated 08/21/15.	
Note: cost for grass cutting of open field within site included with other areas of park.	
COMPLIANCE GROUNDWATER MONITORING	$ 23,000
Groundwater monitoring for 2 years (4 onsite wells analyzed for dissoloved arsenic and iron)	
Includes annual report (2 reports).	
Based on Herrenkohl Consulting proposal dated 07/29/15	
TOTAL ESTIMATED INDIRECT COSTS:	**$ 145,500**
TOTAL ESTIMATED DIRECT + INDIRECT COSTS:	**$ 182,470**
Recommended Contingency (Assume 30% of Direct + Indirect Costs)	**$ 54,741**
TOTAL ESTIMATED PROJECT COST:	**$ 237,000**

Preliminary Engineer's Cost Estimate
For Shoring, Excavation, Off-Site Transport & Disposal
Eldridge Municipal Landfill RI/FS
Bellingham, WA

Engineering Prepared by: Elizabeth Sterling, PE of Wilson Engineering LLC
Indirect Cost and Summary Prepared by: Mark Herrenkohl, LEG, Herrenkohl Consulting LLC
Revision Date: 09/09/15

REMEDIAL ALTERNATIVE NO. 2

CONSTRUCTION COST ESTIMATE ASSUMPTIONS AND CALCULATIONS

DIRECT COSTS	Quantity	Unit	Unit Price	Amount
PROJECT MANAGEMENT AND ENGINEERING				
Project Management	--	--	--	$ 4,260
Engineering, Permitting, Survey, & Design	--	--	--	$ 34,641
Bidding, Construction Staking & Construction Management	--	--	--	$ 27,872
Subtotal - PM & Engineering				**$ 66,773**
MOBILIZATION (~10% of total direct costs)	1	LS	$ 70,000	**$ 70,000**
TEMPORARY EROSION CONTROL				
Silt Fencing	250	LF	$ 8	$ 2,000
Compost Berm	150	LF	$ 6	$ 900
Construction Entrance	225	SY	$ 25	$ 5,625
Subtotal - Temporary Erosion Control				**$ 8,525**
SITE DEMOLITION & SHORING				
Tree Removal	1	LS	$ 12,000	$ 12,000
Clearing & Grubbing - (assume grubbing to a depth of 6-inches)	10000	SF	$ 1	$ 10,000
Dewatering	3	Mo.	$ 2,500	$ 7,500
Shoring				
Shoring Installation	6365	SF	$ 30	$ 190,950
Shoring Removal	6365	SF	$ 5	$ 31,825
Subtotal - Site Demolition & Shoring				**$ 252,275**
SITE EARTHWORK				
Excavation				
Area 1	523	CY	$ 20	$ 10,460
Area 2	1126	CY	$ 20	$ 22,520
Area 3	566	CY	$ 20	$ 11,320
Area 4	735	CY	$ 20	$ 14,700
Disposal of Spoils				
Area 1	968	ton	$ 70	$ 67,760
Area 2	2083	ton	$ 70	$ 145,810
Area 3	1047	ton	$ 70	$ 73,290
Area 4	1360	ton	$ 70	$ 95,200
Embankment				
Area 1				
Gravel Backfill	1152	ton	$ 22	$ 25,344
Top soil	188	ton	$ 60	$ 11,280
Area 2				
Gravel Backfill	2732	ton	$ 22	$ 60,104
Top soil	160	ton	$ 60	$ 9,600
Area 3				
Gravel Backfill	1402	ton	$ 22	$ 30,844
Top soil	52	ton	$ 60	$ 3,120
Area 4				
Gravel Backfill	1826	ton	$ 22	$ 40,172
Top soil	62	ton	$ 60	$ 3,720
Finish Grading	1500	SY	$ 3	$ 4,500
Hydroseeding	13500	SF	$ 0.50	$ 6,750
Wetland Restoration	1000	SF	$ 7.50	$ 7,500
Landscape Restoration	1	LS	$ 5,000	$ 5,000
Subtotal - Site Earthwork				**$ 648,994**
TOTAL ESTIMATED DIRECT COSTS:				**$ 1,046,567**
INDIRECT COSTS				
ENVIRONMENTAL CONSTRUCTION OVERSIGHT				$ 20,000
Assume two weeks of oversight work for field personnel (2 persons). Includes performance sampling during construction of each area.				
PERFORMANCE MONITORING (SAMPLING AND TESTING)				$ 5,000
Five samples collected from each area (4 areas). Samples tested for total metals only.				
CONSTRUCTION COMPLETION REPORT				$ 15,000
Report documents results of construction including final volumes, grade, and performance sampling results. City and Ecology deliverable.				
TOTAL ESTIMATED INDIRECT COSTS:				**$ 40,000**
TOTAL ESTIMATED DIRECT + INDIRECT COSTS:				**$ 1,086,567**
Recommended Contingency (Assume 30% of Direct + Indirect Costs)				**$ 325,970**
TOTAL ESTIMATED PROJECT COST:				**$ 1,413,000**