Pre-Remedial Design Investigation Project Plans – Upland

R.G. Haley Site
Bellingham, Washington

for
City of Bellingham

August 22, 2018

GeoEngineers
Earth Science + Technology

Pre-Remedial Design Investigation Project Plans – Upland

R.G. Haley Site
Bellingham, Washington

for
City of Bellingham

August 22, 2018

GeoEngineers

2101 4th Avenue, Suite 950
Seattle, Washington 98121
206.728.2674

Pre-Remedial Design Investigation
Project Plans - Upland

R.G. Haley Site
Bellingham, Washington

File No. 0356-114-08

August 22, 2018

Prepared for:

City of Bellingham
210 Lottie Street
Bellingham, Washington 98225

Attention: Craig Mueller

Prepared by:

GeoEngineers, Inc.
2101 4th Avenue, Suite 950
Seattle, Washington 98121
206.728.2674

Sydney Bronson
Project Manager

Richard Moore, LEG, LHG
Associate

SS:RFM:leh

Disclaimer: Any electronic form, facsimile or hard copy of the original document (email, text, table, and/or figure), if provided, and any attachments are only a copy of the original document. The original document is stored by GeoEngineers, Inc. and will serve as the official document of record.

GeoEngineers

Table of Contents

ABBREVIATIONS AND ACRONYMS

AO	Agreed Order
bgs	below ground surface
CAP	Cleanup Action Plan
City	City of Bellingham
Cornwall Site	Cornwall Avenue Landfill Site
Ecology	Washington State Department of Ecology
ENR	enhanced natural recovery
GPR	ground penetrating radar
Haley	R.G Haley International Corp
HASP	Health and Safety Plan
IHS	indicator hazardous substances
ISS	in-situ soil solidification
LNAPL	light non-aqueous phase liquid
mg/kg	milligrams per kilogram
MNR	monitored natural recovery
MTCA	Model Toxics Control Act
OHWM	ordinary high water mark
PAHs	polycyclic aromatic hydrocarbons
PCP	pentachlorophenol
Port	Port of Bellingham
PRDI	Pre-Remedial Design Investigation
QAPP	Quality Assurance Project Plan
RCW	Revised Code of Washington
RI/FS	Remedial Investigation/Feasibility Study
SAP	Sampling and Analysis Plan
Site	R.G Haley Site
TPH	total petroleum hydrocarbons
WAC	Washington Administrative Code

1.0 INTRODUCTION

A Pre-Remedial Design Investigation (PRDI) is planned at the R.G. Haley Site (Site) to obtain additional upland site data to support design of the Site cleanup action. The general location of the Site south of the downtown business district in Bellingham, Washington is shown on Figure 1-1. Wood products for commercial use were treated with pentachlorophenol between approximately 1948 and 1985. Cleanup actions will be completed pursuant to requirements of the Washington State Model Toxics Control Act (MTCA), Chapter 70.105D of the Revised Code of Washington (RCW) and Chapter 173-340 of the Washington State Administrative Code (WAC). Design and permitting activities supporting Site cleanup will be conducted under Agreed Order (AO) No. DE 15776, (Ecology, 2018a) between the Washington State Department of Ecology (Ecology) and the City of Bellingham (City).

The AO for the R.G. Haley Site requires developing PRDI Project Plans that describe additional information needs to support the engineering analysis and design efforts. The PRDI Project Plans presented in this document include summary descriptions for upland field work activities to obtain the Site information needed, as follows:

- Refine the extent of light non-aqueous phase liquid (LNAPL) to select the footprint of in-situ soil solidification (ISS);
- Debris survey to evaluate ISS constructability;
- Delineate the northern extent of upland contamination; and
- One site-wide sampling event to refresh the 2012 groundwater data set.

Planned field and analytical testing activities for each work element are summarized in subsequent sections following additional site background information presented in Sections 1.1, 1.2, and 1.3. Additional field and laboratory testing details are presented in the Sampling and Analysis Plan (SAP; Appendix A) and Quality Assurance Project Plan (QAPP; Appendix B). A Health and Safety Plan (HASP) is provided in Appendix C.

1.1. General Site Description

The R.G. Haley International Corp (Haley) wood treatment facility was formerly located at the foot of a steep bluff on the eastern shore of Bellingham Bay (Figure 1-1). The wood treatment facility operated in an upland, filled area adjacent to Bellingham Bay. The Site is subdivided into two units that are separated by the ordinary high water mark (OHWM) (Figure 1-2). The Marine Unit boundary is approximate, based on extrapolation from and interpolation between available data points. The Upland Unit boundary is based on existing RI data, although that data does not fully delineate the extent of all Site contaminants. The Upland Unit boundary would be further evaluated in the future as a separate action.

The upland portion of the Site is currently fenced and vacant. A vertical sheet pile barrier is present along a portion of the shoreline. The shoreline is covered with armoring, sparse vegetation, gravel and debris. Remnant timber pilings and debris associated with former overwater structures remain in the intertidal zone.

Historical land uses at or near the Site included railroad activities, lumber mill operations, wood treatment and storage, disposal of municipal waste at the Cornwall Avenue Landfill, and pulp and paper mill activities. Upland and in-water areas are impacted by contaminant releases from the former wood-treating operations. Fill beneath the Site includes wood waste from historical mill operations and construction debris.

1.2. Relationship to Adjacent MTCA Cleanup Sites

The Whatcom Waterway Site to the west and the Cornwall Avenue Landfill Site (Cornwall Site) to the south overlap the Haley Site (Figure 1-2). Cleanup activities for these adjacent sites are being completed as separate MTCA actions under agreements between Ecology, the Port of Bellingham (Port) and other parties. The Port is the performing party for these cleanup actions. The Haley, Cornwall and Whatcom Waterway cleanups will be coordinated to assure compatibility. In general, the upland caps and nearshore sediment actions associated with the Haley and Cornwall Sites will be designed to provide seamless coverage. In deeper subtidal waters, the overlapping cleanups for the Haley and Whatcom Waterway Sites are nearly identical, with monitored natural recovery selected as the remedy for both. This is also anticipated to be the remedy for the Cornwall Site if its boundary is extended further from shore.

1.3. Cleanup Action Summary

The components of the selected Site cleanup action are summarized below and presented on Figure 1-2:

- In-situ soil solidification (ISS) will be performed within the area of potentially mobile LNAPL near the shoreline.
- A low-permeability cap will be constructed throughout most of the upland unit, at locations where soil exceeds cleanup levels. The cap will include a gas collection layer to prevent build-up of pressure below the low-permeability layer. The cap also will be designed to reduce stormwater infiltration and convey runoff to surface water.
- LNAPL-impacted sediment in the intertidal zone adjacent to the shoreline will be excavated. Sediment remaining at the base of the excavation will be capped with clean sand and armored as necessary to prevent erosion. Design will evaluate the potential use of amendments in the cap material to enhance chemical containment if engineering analysis and modeling indicate that such amendments may be needed. The excavated sediment will be consolidated under the upland cap.
- Outside of the sediment removal area, an armored sediment cap will be placed in remaining intertidal and shallow subtidal areas where surface sediment concentrations exceed cleanup levels. This includes areas immediately west of the former Haley wood treatment facility where sediment concentrations exceed benthic criteria, and locations further north (Pine Street Beach area) where bioaccumulative constituents exceed cleanup levels.
- Natural recovery methods will be used in areas where contaminants in surface sediment exceed cleanup levels but would be expected to achieve cleanup levels within 10 years as a result of ongoing natural deposition of sediment. This primarily consists of monitored natural recovery (MNR) over the expanded footprint of the marine unit. Enhanced natural recovery (ENR), involving placement of a relatively thin layer of clean sand to help promote natural recovery, will be used between the proposed MNR area and the shallow subtidal sediment cap.

The cleanup action is described in further detail in the Final Cleanup Action Plan (CAP; Ecology, 2018b).

2.0 IN-SITU SOIL SOLIDIFICATION OVERVIEW

The 2018 CAP identified cleanup action components for the Site including the proposed ISS footprint shown on Figure 2-1. ISS was selected as the preferred technology to solidify soils containing potentially mobile (free phase) LNAPL, as described in the Final Remedial Investigation/Feasibility Study Report (RI/FS, GeoEngineers, 2016). The ISS footprint proposed in the FS included an area of potentially mobile LNAPL (also referred to as the LNAPL plume) located on the upland side of a vertical barrier that was installed along the shoreline in 2001 and 2002 as an interim action. The ISS footprint also extended south of the vertical barrier, where monitoring well observations and Site analytical data suggest mobile LNAPL may be present.

2.1. Basis for Refining the ISS Footprint

The lateral and vertical extent of ISS will be refined during remedial design based, in part, on total petroleum hydrocarbon (TPH) concentrations in soil. Soil near the shoreline that has TPH concentrations greater than approximately 18,000 milligrams per kilogram (mg/kg) will be considered for ISS. Petrophysical testing conducted during the RI estimated that LNAPL at the Site is not likely mobile at TPH concentrations below this value. The footprint of ISS will be further refined based on visual indications of mobile LNAPL observed in explorations, and LNAPL occurrence in groundwater monitoring wells. Collectively, these three criteria will be used to evaluate the extent of potentially mobile LNAPL, and select the lateral and vertical footprint of ISS application.

Existing soil TPH data and historical LNAPL occurrences in monitoring wells were reviewed to identify additional data needs to refine the footprint of ISS application. Based on this, several soil borings are proposed within and around the perimeter of the ISS footprint presented in the FS. These borings will be completed using direct-push drilling equipment. Direct-push drilling was selected to provide cost effective coverage of the area, collect continuous cores for subsurface observation, and provide flexibility to collect soil samples for laboratory analysis of TPH.

LNAPL observations and analytical data from the proposed soil borings, combined with information from past investigations, will be used to select the final ISS footprint during remedial design. No additional sampling to refine the ISS footprint will be performed during remedial construction.

2.2. Proposed Soil Borings to Support ISS Design

Approximately 20 direct push borings (including two contingent borings) are identified on Figure 2-1 to address ISS footprint data gaps. The number of borings and locations may be adaptively modified in the field based on observations and the conditions encountered. During previous investigations, LNAPL indicators and elevated TPH concentrations were observed in soil borings to a maximum depth of approximately 12 feet below the ground surface (bgs). Each proposed soil boring will be advanced to a depth of approximately 20 feet bgs to confirm soil conditions below the future ISS treatment zone. Continuous soil cores will be obtained from the direct-push borings to observe subsurface conditions and conduct field screening for the presence of LNAPL.

An estimated total of 60 soil samples will be collected for laboratory analysis of TPH based on field screening results. Soil samples from the two contingent borings will be analyzed only if elevated TPH concentrations are observed in the nearest borings to the north. For planning purposes, it is estimated that three soil samples will be collected for chemical analysis from each boring. The mid-depth sample will characterize soil with the most prevalent field indicators of potentially mobile LNAPL to inform 'worst case' conditions for ISS design. A shallower and deeper sample will be collected from each boring with the goal of selecting the vertical extent of ISS application. It is anticipated the depth of the shallower soil sample will be near the groundwater table. This conceptual sampling framework will be modified, as needed, based on conditions encountered in the field (e.g. if two distinct horizons of LNAPL-impacted soil are observed).

Approximately six to eight samples collected from mid to deeper depth intervals will be analyzed for Total Organic Carbon (TOC), polycyclic aromatic hydrocarbons (PAHs) and pentachlorophenol (PCP). Analytical data from these samples will be used to support technical analyses needed for engineering design and remedy modeling.

3.0 ISS DEBRIS AND CONSTRUCTABILITY SURVEY OVERVIEW

The presence of subsurface debris and other obstructions has been documented in previous field investigations at the Site, including the test pits completed in 2016 to support ISS bench-scale treatability testing and mix design. The subsurface debris includes the following:

- Remnant piling that supported the historical sawmill;
- Remnant underground foundations or structures associated with all historical on-Site facilities;
- Waste wood materials from historical sawmill operations (sawdust and dimensional lumber);
- Construction debris incorporated in Site fill during historic tideland filling;
- Municipal landfill waste in the area where the Haley and Cornwall sites overlap; and
- Remnant underground utilities and/or equipment associated with the former Haley wood treatment facility.

The presence of subsurface debris may impact the selection of ISS implementation methodology and the production rate of ISS during construction. Additional investigation will be conducted to further evaluate the extent of debris. This information will be used to provide design guidance for ISS contructability.

3.1. Debris Survey Using Geophysical Methods

Geophysical methods are planned to evaluate the types and extent of subsurface debris. The most cost-effective geophysical method may be ground penetrating radar (GPR). The effectiveness of GPR or a different technology (if recommended by a geophysical contractor) will be evaluated by testing it at the Site.

Preliminary assessments using GPR or other geophysical methods will be performed at the locations identified on Figure 3-1 near treatability study test pit TP-TTWP-N that encountered a high density of wood debris, and along the southern shoreline where substantial concrete debris is present. If successful, the GPR (or other) survey will be expanded to additional portions of the ISS area. Specific GPR application methods and transects will be determined in the field with the geophysical contractor and will be adapted as practical to obtain the most useable data.

3.2. Subsurface Utilities and Equipment

Geophysical and utility locating techniques also will be conducted to identify the locations of underground utilities, and remnant underground equipment or structures (e.g. foundations) associated with the former Haley wood treatment facility or facilities that predated the Haley operation. This work includes, but is not limited to, the ISS area. Based on work conducted during the RI, three active or remnant stormwater utilities are known to be present beneath the Haley Site. Other utilities that formerly served facilities on the Cornwall site may be present beneath the paved access road that crosses a portion of the anticipated ISS footprint. Remnant underground equipment associated with former wood treatment activities includes an abandoned underground storage tank, surge tank and associated piping in the southeast portion of the Haley Site.

Information presented in the RI will be augmented by more thorough surveying to support remedial design. Design-related survey work will include geophysical and utility locating services to identify all remnant or active underground equipment and utilities. This information is needed because the Haley remedy will include removal of abandoned or remnant wood treatment equipment, and removal or abandonment of remnant stormwater utilities. Components of the remedy that will disturb upland soil (e.g. ISS implementation) or increase the load on upland soil (e.g. upland capping) must account for the presence of active utilities.

3.3. Sheet Pile Integrity Evaluation

The ISS mix will be fluid during application and prior to curing of the mix. As a result, some form of containment is expected to be needed to contain ISS and LNAPL that might be liberated by the construction process. The existing sheet pile wall may serve as an effective containment barrier for a portion of the ISS target footprint. During ISS mixing, pressure against the inside of the sheet pile will increase locally and for a relatively short period of time until curing begins. The effectiveness of the existing sheet pile wall will depend on:

- The adequacy of the sheet pile thickness (originally 3/8-inch thick);
- Potential reductions in sheet pile wall thickness due to corrosion; and
- Integrity of sheet pile interlocks (some gaps are known to exist).

Field efforts to evaluate the integrity of the existing sheet pile wall will include:

- Additional measurements of sheet pile thickness at the ground surface;
- Additional visual inspection of the integrity of interlocks at the ground surface; and
- Ultrasonic thickness testing at low tide where corroded sheet pile is exposed along the shoreline.

It is currently anticipated that ISS will be performed prior to sediment removal seaward of the sheet pile so that the cured in-place ISS mix will provide structural support during the sediment removal, rather than the sheet piles. These assumptions are subject to further engineering analysis supporting ISS and sediment removal design. We do not currently anticipate reuse of the sheet piles at other locations during construction due to their short length and visible corrosion. Additional temporary shoring is expected to be needed south of the existing sheet pile wall to provide shoreline containment adjacent to the entire ISS footprint.

4.0 REFINING THE NORTHERN EXTENT OF UPLAND CONTAMINATION

Based on existing RI data, the northern extent of upland contamination has not been fully delineated relative to cleanup levels for certain polycyclic aromatic hydrocarbons (PAHs), pentachlorophenol (PCP), and dioxins/furans (D/F) in soil. A spatial data gap also exists for non-carcinogenic PAHs in groundwater near the shoreline. To address these data gaps, additional soil and groundwater sampling and analysis will be performed, and the results used in conjunction with existing data to refine the northern extent of upland capping. The proposed low-permeability upland cap footprint presented in the CAP is shown on Figure 1-2.

Existing soil data used to define the northern extent of capping in the FS is shown in Figure 4-1. Soil cleanup levels are established based on protection of groundwater, with the exception of dioxin/furans that have a cleanup level based on direct contact. Soil sample data shown in red on Figure 4-1 exceeds applicable cleanup levels; data shown in green is less than applicable cleanup levels. These data show that cleanup level exceedances of some PAHs, PCP and D/F constituents are not well delineated near the anticipated northern extent of upland capping. The existing and new analytical data will be used to refine the northern extent of the upland low-permeability cap. The cap will extend to portions of the Site where groundwater contamination exceeds groundwater cleanup levels and soil contamination exceeds direct contact cleanup levels.

4.1. Planned Soil Borings

Six additional soil borings will be completed along two east-west transects to further delineate the northern extent of cleanup level exceedances (Figure 4-1). The borings will be drilled to depths of approximately 15 feet bgs. Soil samples from the southern transect will be analyzed for PAHs and PCP, and samples from the northern transect will be analyzed on a contingency basis if one or more constituents from the southern transect exceed applicable cleanup levels.

A direct-push drill rig will be used to advance soil borings for collecting soil samples except for the boring (HSA2018-NER1) on the southern transect closest to the shoreline. This soil boring will be completed using standard hollow-stem auger drilling equipment for subsequent completion as a monitoring well (See Section 4.2). One soil sample for PAH and PCP laboratory analysis will be obtained from each boring within each of the following zones:

- The vadose zone above apparent high groundwater elevation. In the absence of field screening indications of contamination, this sample will be collected immediately below the ground surface, bottom of pavement, or bottom of a surficial gravel layer, if present. This approach is intended to characterize the shallowest soil horizon present at the time of historic wood treatment operations;
- The zone of groundwater table fluctuation, with adjustments based on field screening results; and
- Below the groundwater table, with adjustments based on field screening results.

In the absence of positive field screening results, the sampling depths described above also will be adjusted to approximately coincide with the depth of cleanup level exceedances further south.

4.2. Planned Monitoring Well Installation

Additional delineation also is needed for three indicator hazardous substances (IHSs) in groundwater beneath the northern portion of the Site: 1-methylnaphthalene, 2-methylnaphthalene and acenaphthene. Groundwater quality data from the most recent (2012) monitoring event is presented on Figure 4-2 for these compounds. These three constituents were detected at concentrations greater than their respective groundwater cleanup levels in HS-MW-5 and HS-MW-6. The monitoring wells identified in green indicate that these constituents were either not detected or detected at concentrations less than applicable cleanup levels.

New monitoring well HS-MW-20 is planned at the location shown on Figure 4-2 to further delineate the extent of cleanup level exceedances for these compounds between existing monitoring wells HS-MW-6 and HS-MW-15. The new monitoring well will be completed using standard hollow-stem auger drilling equipment followed by well development and sampling. The new well is planned to be screened between about 3 and 18 feet below ground surface (bgs), which spans the groundwater table. Groundwater samples will be submitted for chemical analysis as specified in Section 5.0.

4.3. Planned Near-Surface Soil Sampling

Eight near-surface soil samples will be collected at the locations shown on Figure 4-1 for laboratory analysis of D/F constituents. Samples will be collected immediately below the ground surface or bottom of a surficial gravel layer, if present. The samples will exclude gravel and debris if present. Soil samples from the three southern sampling locations will be analyzed for D/F constituents, and samples from next three locations to the north (central row of samples) will be analyzed on a contingency basis if D/F constituent concentrations from the southern three samples exceed the cleanup level. If D/F constituents in the central row of samples exceed cleanup levels, then the samples from the two northern locations will be analyzed.

5.0 SITE-WIDE GROUNDWATER MONITORING EVENT

The most recent characterization of groundwater quality beneath the Haley Site was completed in 2012, as reported in the 2016 RI/FS. The 2012 data includes groundwater chemical analytical results, gauged LNAPL thicknesses and groundwater elevations in wells located across the upland portion of the Haley Site and adjacent Cornwall Site to the south. LNAPL product monitoring in Site wells has continued through March 2018 and is on-going.

The purpose of this work element is to update groundwater quality data in selected monitoring wells throughout the Site. Monitoring wells for sampling were selected by first eliminating wells that contained LNAPL during product monitoring in January and March 2018. A subset of the wells sampled in 2012 was then selected based on well locations and screen depths. A total of 28 wells (including the new monitoring well discussed in Section 4.2) were identified for sampling, as shown on Figure 5-1. These wells provide representative coverage for characterizing current groundwater quality across the Site and include:

- Capping and ISS treatment areas including wells screened below the anticipated depth of ISS application near the shoreline;
- Locations along the shoreline bank at the western edge of the upland area;
- Cornwall site locations to the south; and
- Eastern (upgradient) portions of the Site.

Groundwater quality data from this sampling event will be used to support technical analyses needed for engineering design including an update of input parameters for remedy performance modeling.

Groundwater levels and product thicknesses will be measured in the monitoring wells Site-wide, and groundwater samples will be collected using standard low-flow sampling methods following purging. LNAPL is not expected to be present in the wells selected for sampling, but wells with measurable product will not be sampled. The groundwater samples will be submitted for laboratory analysis of TPH, PAHs, and PCP. In addition, groundwater samples collected from monitoring wells TL-MW-11, TL-MW-14 and TL-MW-16 will be submitted for laboratory analysis of dioxins/furans. These wells have discrete screens positioned below the groundwater table.

6.0 HEALTH AND SAFETY PLAN

A Health and Safety Plan (HASP) for project personnel implementing the upland field work is presented in Appendix C.

7.0 REPORTING

The results of the completed field study will be presented in one or more reports for inclusion as appendices to the Engineering Design Report.

8.0 SCHEDULE

Upland field work supporting Haley design is planned to be completed in July, August, and September 2018. Additional scheduling and coordination for each work element will be completed following submittal of the PRDI Project Plans to Ecology and pending Ecology's review.

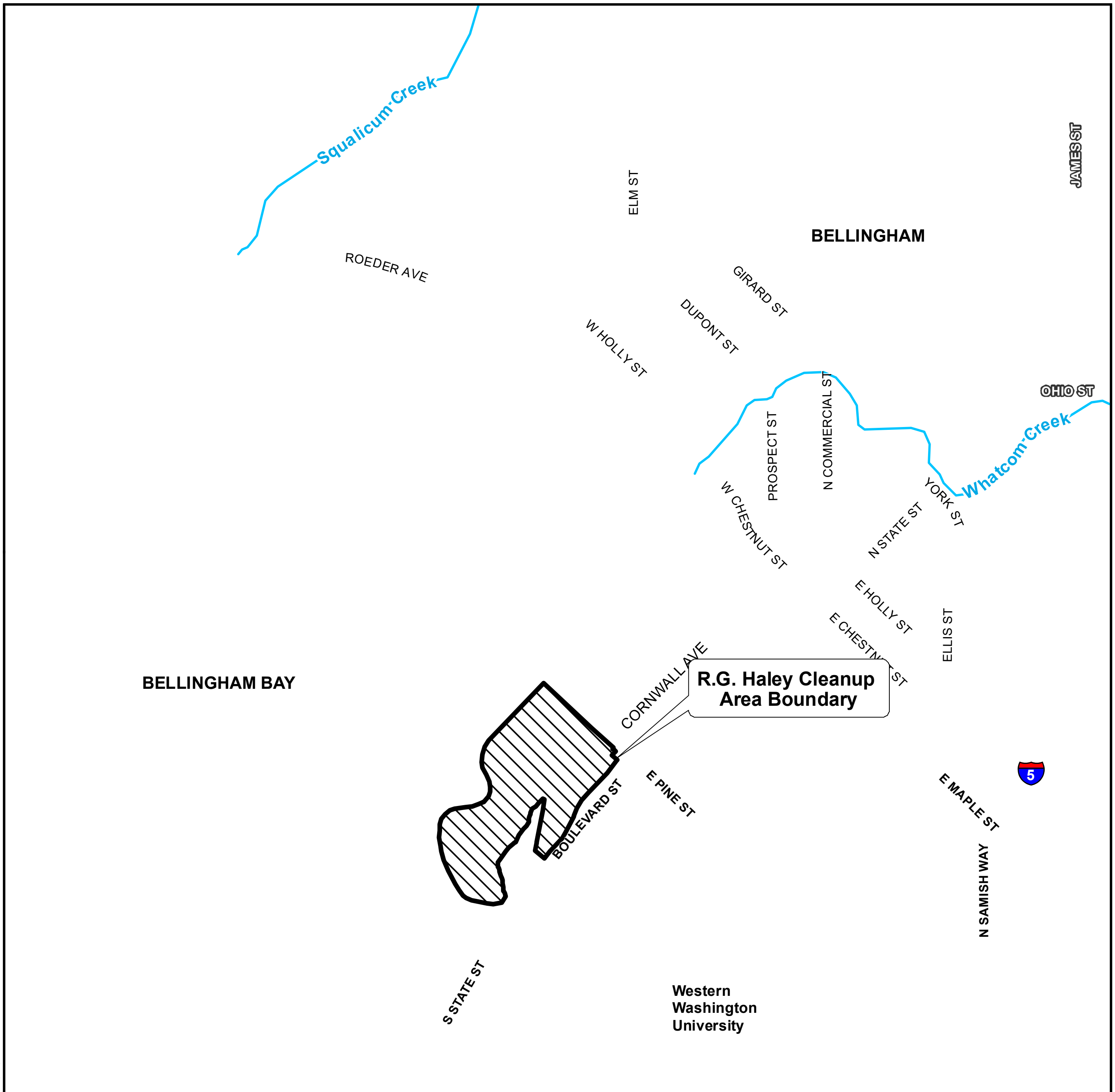
9.0 REFERENCES

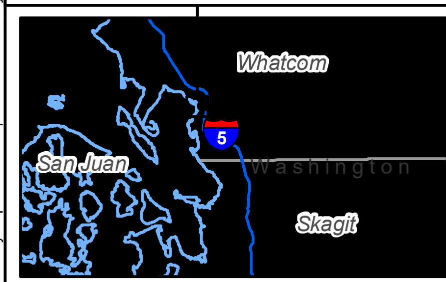
Ecology 2018a. Agreed Order No. DE 15776 between the Washington State Department of Ecology and the City of Bellingham, for the R.G. Haley Site, (June 1, 2018).

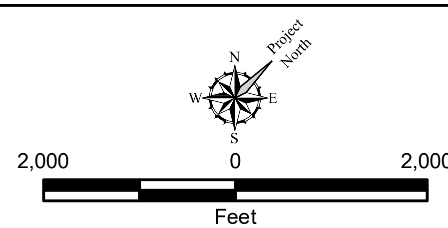
Ecology 2018b. "Final Cleanup Action Plan, R.G. Haley International Corporation Site, Bellingham, Washington." April 2018.

GeoEngineers 2016. "Final Remedial Investigation/Feasibility Study Report, R.G. Haley Site." Prepared for the City of Bellingham. February 1, 2016.

FIGURES







Reference: Whatcom County GIS, City of Bellingham GIS,
Aerial from Esri, 2017.

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. can not guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.
3. It is unlawful to copy or reproduce all or any part thereof, whether for personal use or resale, without permission.

Projection: NAD 1983 UTM Zone 10N

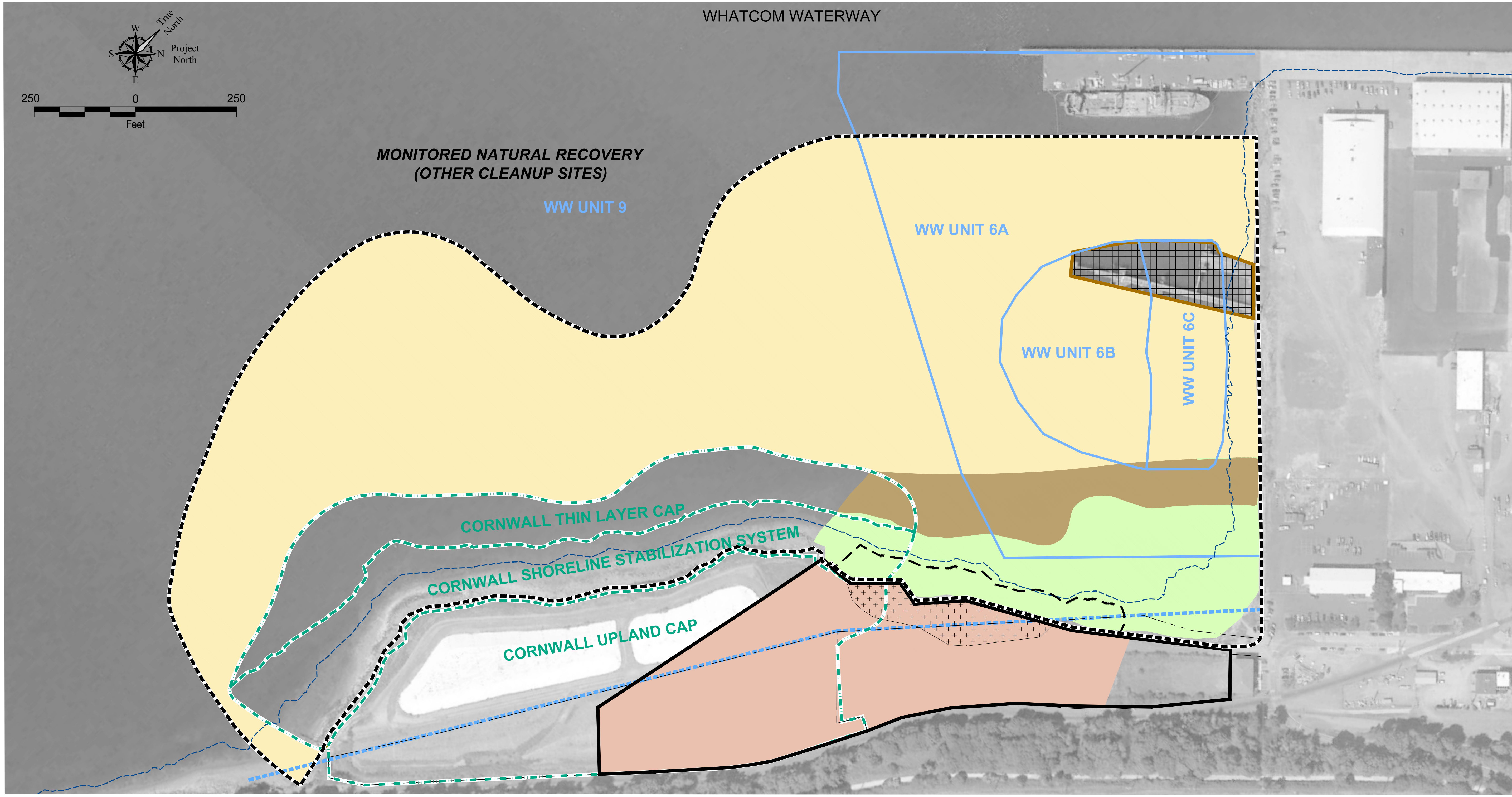
Vicinity Map

R.G. Haley Site
Bellingham, Washington

[redacted]

Figure 1-1

Path: P:\0\0356114\GIS\MXDs\Fig_1-1_VicinityMap.mxd Map Revised: 19 July 2018 cchelf



Notes

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.
3. Source: Modified from Figure 5, Final Cleanup Action Plan, R.G. Haley Site, Ecology, April 2018.

Reference: Base aerial photo from Google Earth Pro dated 7/24/2017.

Legend

- Cornwall Cleanup Action Components
- "WW Unit" Designation (Whatcom Waterway Units Slated for MNR)
- Inner Harbor Line
- Lower Limit of Intertidal Zone (-4ft NAVD88)

HALEY CLEANUP ACTION COMPONENTS

- Low-Permeability Upland Cap
- In-Situ Soil Solidification
- Sand Cap (2-Feet to 5-Feet Thick)
- Enhanced Natural Recovery
- Monitored Natural Recovery
- Extent of Sediment Removal
- Haley Upland Unit Boundary
- Haley Marine Unit Boundary
- Whatcom Waterway Capping and Armoring

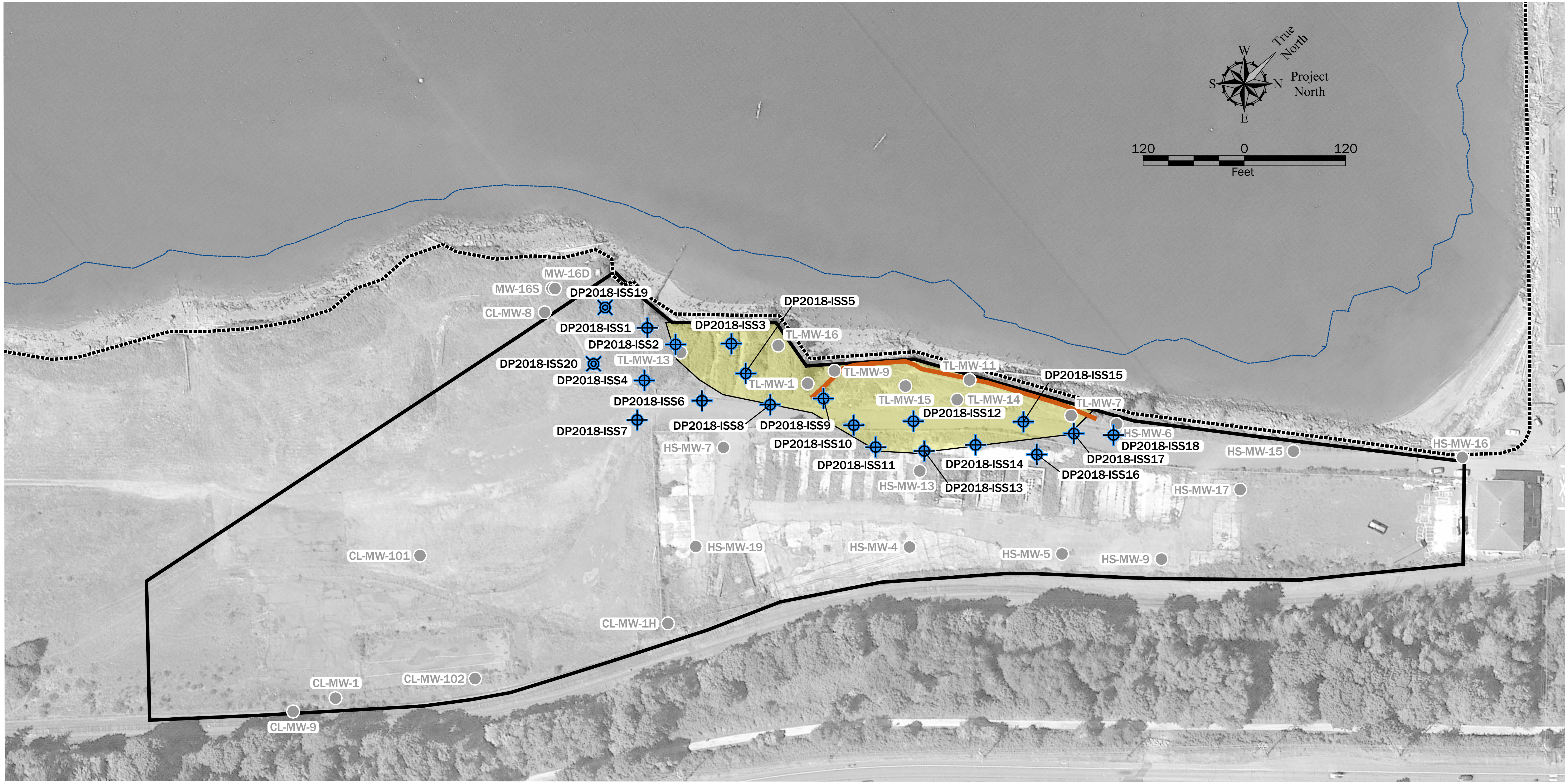
Cleanup Action Components

R.G. Haley Site
Bellingham, Washington

GEOENGINEERS

Figure 1-2

P:\0\0356114\CAD\08\Pre RI Work Plan\035611408_F1-2_Cleanup Action Components.dwg TAB:F05 Date Exported: 05/11/18 - 10:29 by tmichaud



Legend

HALEY CLEANUP ACTION COMPONENTS

- Lower Limit of Intertidal Zone (-4ft NAVD88)
- Sheet Pile Wall Installed in 2001 and 2002
- DP2018-ISS1 — Proposed Soil Boring (Adjustments may be made in the field)
- DP2018-ISS19 — Proposed Soil Boring (Contingency) (Adjustments may be made in the field)
- MW-16D — Existing Monitoring Well
- In-Situ Soil Solidification
- Haley Upland Unit Boundary
- Haley Marine Unit Boundary

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source: Base aerial photo from Google Earth Pro dated August 2011.

Projection: WA State Plane, N Zone, NAD83, US Foot

Proposed Soil Borings in In-Situ Soil Solidification Area

R.G. Haley Site
Bellingham, Washington

GeoEngineers

Figure 2-1

P:\0\0356114\CAD\08\Pre RI Work Plan\035611408_F2-1_ISSS Footprint Refinement.dwg TAB:11x17 Landscape Date Exported: 05/23/18 - 13:42 by tmichaud

Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.
3. Ground penetrating radar application methods and transects to be determined in the field with Contractor. Assessment areas may be further modified or expanded based on field conditions.
4. Geophysical and utility locating techniques also will be conducted to identify the locations of underground utilities, and remnant underground equipment or structures (e.g. foundations) associated with the former Haley wood treatment facility or facilities that predated the Haley operation. This work includes, but is not limited to, the ISS area.

Data Source: Base aerial photo from Google Earth Pro dated August 2011.

Projection: WA State Plane, N Zone, NAD83, US Foot

Legend

Preliminary Geophysical Survey Assessment Area

TP-TTWP-LF Treatability Study Test Pit / Sample Locations

Lower Limit of Intertidal Zone (-4ft NAVD88)

HALEY CLEANUP ACTION COMPONENTS

In-Situ Soil Solidification

Haley Upland Unit Boundary

Haley Marine Unit Boundary

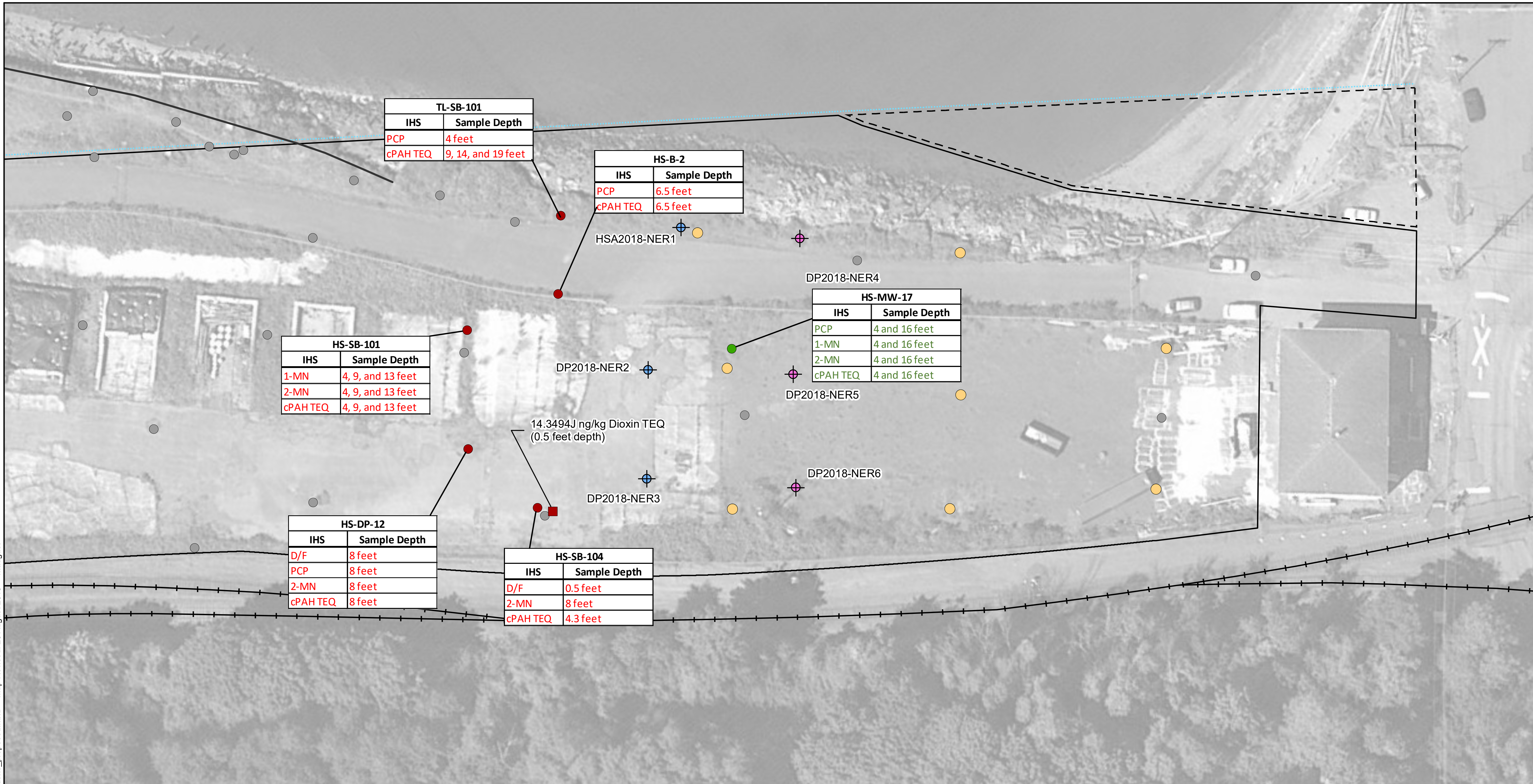
Geophysical Survey Preliminary Assessment Areas

R.G. Haley Site
Bellingham, Washington

GEOENGINEERS

Figure 3-1

P:\0\0356114\CAD\08\Pre RI Work Plan\035611408_F3-1_GPR.dwg TAB:11x17 Landscape Date Exported: 05/24/18 - 10:44 by tmichaud



Path: P:\00356114\GIS\MXDs\Fig_F04-1_SoilBoringLocations_proposed.mxd Map Revised: 20 August 2018 maugust

W True North S N E Project North

0 25 50
Feet

Data Source: Aerial from Google Earth, August 2011.

Projection: NAD 1983 StatePlane Washington North FIPS 4601 Feet

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Legend

- Soil Exploration Location
- Soil Exploration Not Used for Delineation of Northern Site Boundary
- Previous Soil Sample Testing Result > Cleanup Level
- Previous Soil Sample Testing Result ≤ Cleanup Level
- Previous D/F Near-Surface Sample

Soil cleanup levels are based on protection of groundwater except the dioxin/furan (D/F) cleanup level that is based on direct contact protection.

D/F = Dioxins/Furans
PCP = Pentachlorophenol
1-MN = 1-Methylnaphthalene
2-MN = 2-Methylnaphthalene
cPAH TEQ = Carcinogenic Polycyclic Aromatic Hydrocarbons Toxicity Equivalent Concentration

- Proposed Southern Transect Soil Boring Location
- Proposed Northern Transect Soil Boring Location

Soil sample to be submitted for chemical analysis of PCP and PAHs. Three soil samples per boring (See text for details).

- Proposed D/F Soil Sample Location (0.5 feet depth)

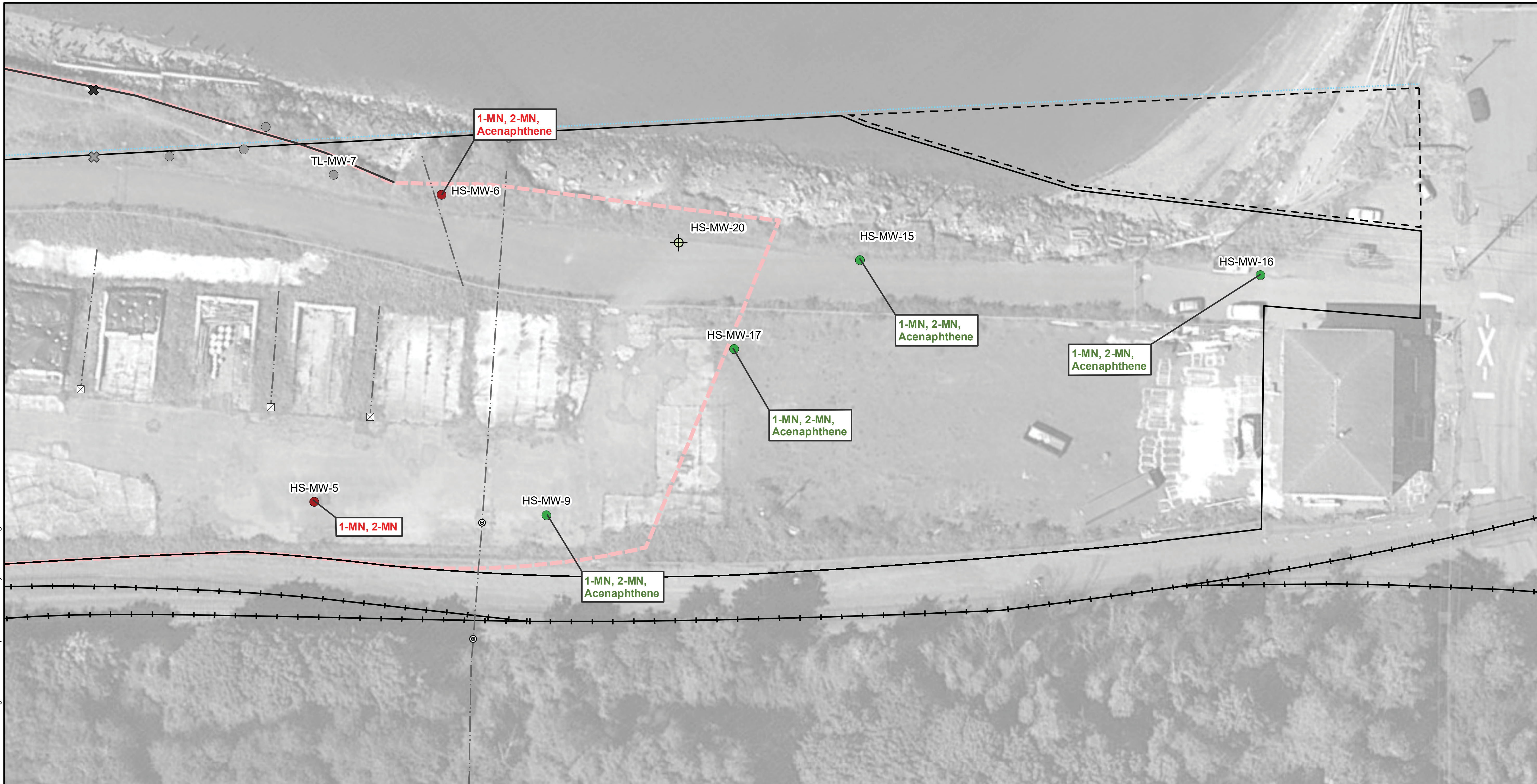
- City Owned Property, Former R.G. Haley International
- Port of Bellingham Property
- Inner Harbor Line
- Sheet Pile Wall

Proposed Soil Borings and Near-Surface Soil Samples To Delineate Northern Extent of Contamination

R.G. Haley Site
Bellingham, Washington

GEOENGINEERS

Figure 4-1



True North
Project North

0 25 50
Feet

Data Source: Aerial from Google Earth, August 2011.

Projection: NAD 1983 StatePlane Washington North FIPS 4601 Feet

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Legend

- Monitoring Well Location
- Previous Result > Cleanup Level
- Previous Result ≤ Cleanup Level
- Planned New Monitoring Well HS-MW-20
- City Owned Property, Former R.G. Haley International
- Cornwall Property
- Port of Bellingham Property
- Inner Harbor Line
- Cornwall Approximate Landward Boundary of Landfill Refuse
- Sheet Pile Wall
- Storm Drain
- Low-Permeability Upland Cap

1-MN = 1-Methylnaphthalene
2-MN = 2-Methylnaphthalene

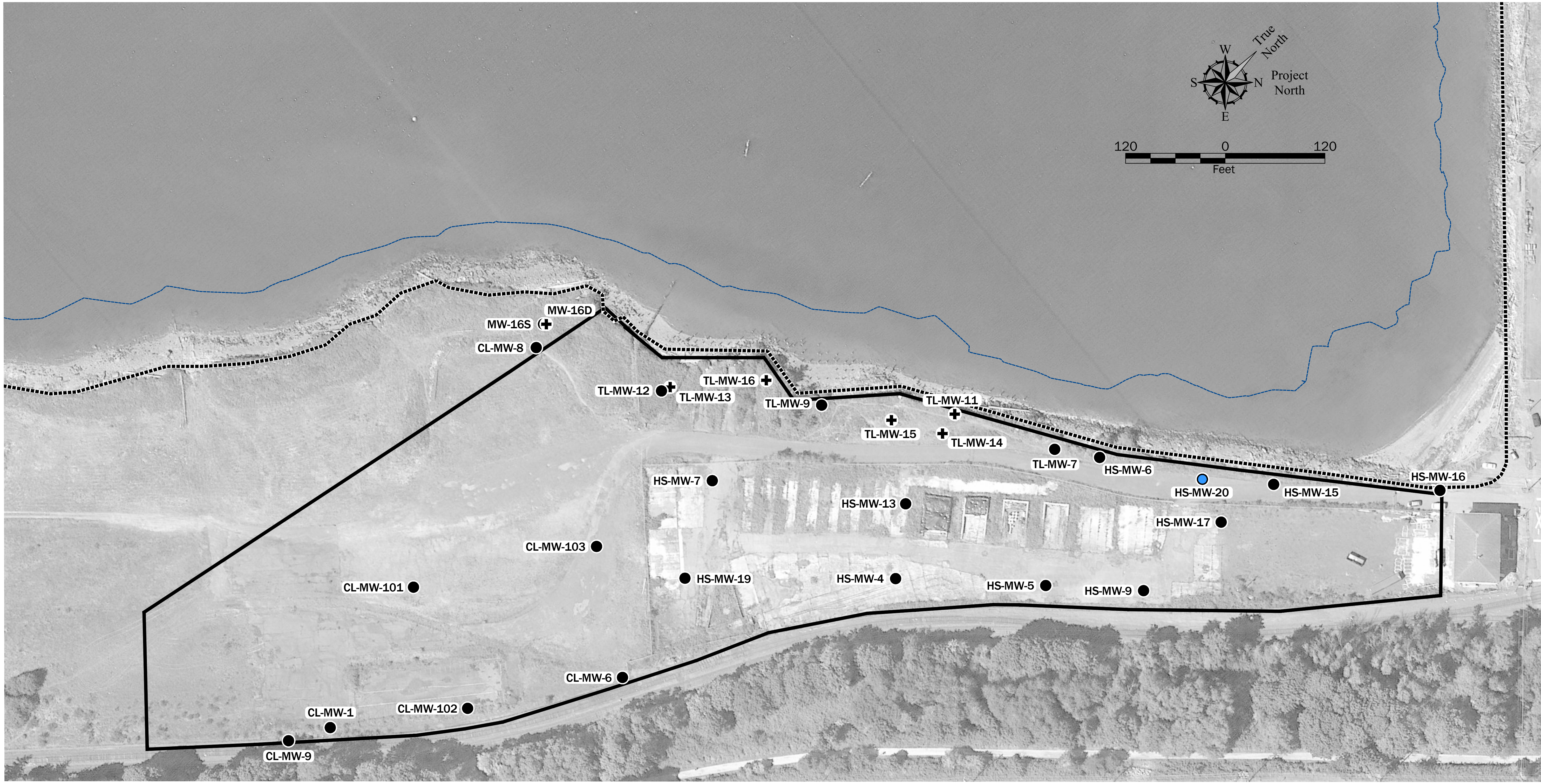
Proposed Groundwater Monitoring Well To Delineate Northern Extent of Contamination

R.G. Haley Site
Bellingham, Washington

GEOENGINEERS

Figure 4-2

Path: P:\0\0356114\GIS\MXDs\Fig_F04-2_GW_ProposedGroundwaterMonitoringWells.mxd Map Revised: 24 May 2018 maugust



Legend

Lower Limit of Intertidal Zone (-4ft NAVD88)

HS-MW-20 — Planned New Monitoring Well Proposed for Sampling

MW-16S — Existing Monitoring Well Proposed for Sampling (Shallow Well Screen)

MW-16D — Existing Monitoring Well Proposed for Sampling (Deep Well Screen)

HALEY CLEANUP ACTION COMPONENTS

Haley Upland Unit Boundary

Haley Marine Unit Boundary

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source: Base aerial photo from Google Earth Pro dated August 2011.

Projection: WA State Plane, N Zone, NAD83, US Foot

P:\0\0356114\CAD\08\Pre RI Work Plan\035611408_F5-1_Selected Site Monitoring Well Sampling.dwg TAB:11x17 Landscape Date Exported: 05/24/18 - 10:43 by tmichaud

Site Wide Groundwater Monitoring Event

R.G. Haley Site
Bellingham, Washington

GEOENGINEERS

Figure 5-1

APPENDICES

APPENDIX A
Sampling and Analysis Plan

Table of Contents

LIST OF TABLES

APPENDIX A
SAMPLING AND ANALYSIS PLAN

1.0 INTRODUCTION

This Pre-Remedial Design Investigation (PRDI) Sampling and Analysis Plan (SAP) describes procedures that will be used to complete the following investigations outlined in the PRDI Project Plans for the R.G. Haley (Haley) Site (Site):

- Investigate the extent of light non-aqueous phase liquid (LNAPL) to refine the footprint of in-situ soil solidification (ISS);
- Subsurface debris and utility survey to evaluate ISS constructability;
- Delineate the northern extent of upland contamination; and
- One site-wide sampling event to refresh the 2012 groundwater data set.

The objective of the PRDI investigation is to collect sufficient information to address data gaps and support development of design documents for the Haley Site. The SAP has been prepared in general accordance with requirements of the Washington State Model Toxics Control Act (MTCA; Chapter 173-340 Washington Administrative Code [WAC]). A Quality Assurance Project Plan (QAPP) is presented in Appendix B of the PRDI Project Plans.

1.1. Purpose

The SAP describes planned field methods, sample collection and handling, and analytical testing for soil and groundwater samples to be obtained during the PRDI field investigation activities listed above. The work will be conducted using appropriate protocols and procedures to obtain additional site data needed for remedial design.

1.2. Project Organization and Responsibilities

The key PRDI personnel and responsibilities are identified below. These key personnel are responsible for ensuring that the sampling and analysis activities are conducted in a manner sufficient to meet the PRDI objectives.

1.2.1. Associate-in-Charge

Rick Moore is the Associate-in-Charge and has overall responsibility for seeing that the project is implemented in accordance with the PRDI and related requirements.

1.2.2. Project Manager

Sydney Bronson is the Project Manager for the PRDI and will coordinate and schedule field and laboratory testing activities, assign project team members, coordinate subcontractors, and track budgets and schedules. Sydney will also verify that SAP and QAPP objectives are achieved or that potential modifications are documented, if such changes are needed based on conditions at the time of the work. Additionally, he will provide technical oversight and coordinate production and review of PRDI deliverables.

1.2.3. Field Coordinator

The Field Coordinator is responsible for the daily management of activities in the field. Specific responsibilities include:

- Provide technical direction to the field staff.
- Develop schedules and allocate resources for field tasks.
- Coordinate data collection activities to be consistent with information requirements.
- Supervise the compilation of field data and laboratory analytical results.
- Review data for correct and complete reporting.
- Implement and oversee field sampling in accordance with the PRDI Project Plans, SAP, and QAPP.
- Supervise field personnel.
- Coordinate work with on-site subcontractors.
- Schedule sample shipments with the analytical laboratory.
- Monitor that appropriate sampling, testing, and measurement procedures are followed.
- Coordinate the transfer of field data, sample tracking forms, and log books to the Project Manager for data reduction and review.
- Identify whether deviations from the SAP and QAPP procedures are appropriate to achieve the investigation goals and discuss these changes with the Project Manager.

The Field Coordinator will be confirmed before beginning the field work.

1.2.4. Quality Assurance Leader

The Quality Assurance (QA) Leader is responsible for coordinating quality assurance/quality control (QA/QC) for laboratory testing of field samples. Specific responsibilities include the following:

- Serve as the official contact for laboratory data QA questions and concerns.
- Confirm acceptability of the laboratory QA Plan.
- Respond to laboratory data QA needs, answer laboratory requests for guidance and assistance, and resolve issues.
- Monitor laboratory compliance with data quality requirements.
- Confirm that appropriate sampling, testing, and analysis procedures are followed and that proper QC checks are implemented.
- Review the implementation of the QAPP and the overall quality of the analytical data generated.
- Implement or direct corrective actions if necessary.
- Review project policies, procedures, and guidelines and review the project activities to verify that the QA program is being properly implemented.
- Provide oversight of the data development and review process and of subcontracting laboratories.

- Develop work scopes for the subcontracting laboratories that incorporate QAPP requirements.
- Conduct or delegate data review activities.
- Enter data into Washington State Department of Ecology's (Ecology's) Environmental Information Management (EIM) system.

Mark Lybeer, GeoEngineers' in-house chemist, will serve as the QA Leader.

1.2.5. Laboratory Management

The subcontracted laboratory(ies) conducting analytical testing for this project are required to confirm with the QA Leader that laboratory procedures are consistent with the project QA objectives. The Laboratory QA Coordinator administers the Laboratory QA Plan and is responsible for QC. Specific responsibilities of the Laboratory QA Coordinator include:

- Verify implementation of the Laboratory QA Plan.
- Serve as the laboratory point of contact.
- Activate corrective action as necessary when analytical control limits are exceeded.
- Issue the final laboratory QA/QC report.
- Comply with QAPP and contractual requirements for laboratory services.
- Participate in QA audits and compliance inspections if determined by GeoEngineers to be needed.

OnSite Environmental, Inc. (OnSite; Redmond, Washington) will be the Ecology-certified analytical laboratory for the PRDI for the analysis of all analytes except dioxins/furans (D/F constituents). David Baumeister or designate will be OnSite's Laboratory QA Coordinator.

Frontier Analytical Laboratory (Frontier; El Dorado Hills, California) will be the Ecology-certified analytical laboratory for the analysis of D/F constituents. Laboratory services provided by Frontier will be subcontracted to OnSite.

2.0 SAMPLE LOCATIONS, FREQUENCY AND DESIGNATION

Soil and groundwater will be sampled as part of the field activities for the PRDI. The objectives and rationale for the proposed sampling locations are presented in the main body of this report. Table A-1 presents a summary of the PRDI work elements, sample locations and frequency. A brief summary is presented below.

2.1. Soil Sample Locations

Soil samples will be collected from direct-push borings to refine the extent of ISS application and delineate the northern extent of upland soil and groundwater contamination. In addition, near-surface soil samples will be collected in the northern portion of the upland area for analysis of D/F constituents. The estimated number of soil samples to be collected is summarized in Table A-1, and includes the following:

- Sixty soil samples collected from 20 direct-push borings (Figure 2-1) to refine the footprint of ISS application. The two southern-most borings may not be completed, depending on field screening observations in the adjacent (northerly) borings. The soil samples will be submitted for laboratory analyses of:

- Diesel- and oil-range total petroleum hydrocarbons (TPH) using Ecology Method NW-TPH-Dx with silica gel cleanup.

- Eighteen soil samples collected from six borings completed along two transects (Figure 4-1) to delineate the norther extent of upland contamination. All borings except HSA2018-NER1 will be completed using direct-push drilling equipment. Soil boring HSA2018-NER1 will be completed using standard hollow-stem auger drilling equipment for subsequent completion as a monitoring well (See Section 3.4). Soil samples collected from borings on the southern transect (total of nine samples) will be submitted for laboratory analysis of the following:
  - Polycyclic aromatic hydrocarbons (PAHs) using United States Environmental Protection Agency (EPA) Method 8270 Selective Ion Monitoring (SIM) low-level analysis as-needed to attain QAPP laboratory practical quantitation limits (PQLs); and
  - Pentachlorophenol (PCP) using EPA Method 8151.

  Soil samples collected from borings on the northern transect will be submitted to the laboratory on hold and analyzed only if analytical results from the borings further south do not successfully delineate the northern extent of contamination.

- Eight near-surface soil samples will be collected at the locations shown on Figure 4-1 for laboratory analysis of D/F constituents. Samples will be collected immediately below the ground surface or bottom of a surficial gravel layer, if present. The samples will exclude gravel and debris if present. Soil samples from the three southern sampling locations will be analyzed for D/F constituents, and samples from next three locations to the north (central row of samples) will be analyzed on a contingency basis if D/F constituent concentrations from the southern three samples exceed the cleanup level. If D/F constituents in the central row of samples exceed cleanup levels, then the samples from the two northern locations will be analyzed.

The locations of all borings shown on Figures 2-1 and 4-1 are approximate and may be shifted during the investigation based on field screening observations in adjacent borings, or to avoid drilling obstructions. Locations of near-surface soil samples identified on Figure 4-1 will be shifted in the field as close to their target locations as practical if unexpected obstructions are encountered.

2.2. Soil Sample Designation

The soil samples will be assigned a unique sample identifier that will include the four components listed below.

- A qualifier identifying the soil boring or near-surface location from which the sample was collected (e.g. DP2018-ISS3 or HSA2018-NER1 for boring samples, and HS2018-SS1 for near-surface soil samples); and
- The sample depth in feet below ground surface (bgs).

For example, a soil sample collected from a depth of 4 to 8 feet bgs in direct-push boring DP2018-ISS3 would be designated as DP2018-ISS3-4-8. The sample identification will be placed on the sample label, field report form, and chain-of-custody form.

2.3. Groundwater Sample Locations

Groundwater samples will be collected for laboratory analysis from existing monitoring wells during the Site-wide groundwater monitoring event, and from one new monitoring well that will be installed in the northern portion of the Site. The estimated numbers of samples for each of these activities are identified in SAP Table A-1 including:

- One sample collected from each of the (27) existing monitoring wells identified for the Site-wide groundwater monitoring event submitted for laboratory analyses of TPH (Ecology Method NW-TPH-Dx with silica gel cleanup), PAHs (EPA Method 8270 SIM), and PCP (EPA Method 8151).
- One sample collected from each of the existing monitoring wells TL-MW-11, TL-MW-14 and TL-MW-16 submitted for laboratory analysis of D/F constituents (EPA Method 1613). These monitoring wells are located along the shoreline and have discrete well screens positioned below the groundwater table.
- Two samples collected from new monitoring HS-MW-20 submitted for laboratory analysis of TPH, PAHs, and PCP. One sample will be collected following well installation and one sample will be collected 3 to 6 months later.

The locations of existing monitoring wells and the new well are identified on Figures 4-2 and 5-1.

2.4. Groundwater Sample Designation

Groundwater samples collected from monitoring wells also will be assigned a unique sample identifier consisting of the well name and sample date. For example, a sample collected from monitoring well HS-MW-7 on September 10, 2018 would be identified as HS-MW-7-09102018. The sample names will be recorded in the field notes, on the sample label and on the chain-of-custody form.

2.5. ISS Debris and Constructability Survey

Field activities completed to evaluate ISS constructability will include subsurface Ground Penetrating Radar (GPR) or other geophysical method surveys and contingency test pit explorations. The ability of GPR or other geophysical methods to identify the presence of remnant piling, subsurface debris or other obstructions will be evaluated in the field prior to deciding whether to expand the survey area.

Contingency test pit explorations are included in this field task to observe the type and location of subsurface debris or obstructions in the general ISS application area, noting that this option will not be implemented unless deemed to provide additional value following GPR or other geophysical method surveys. No sampling or field or laboratory analytical testing will be conducted as part of this task.

Survey work including geophysical and utility locating services will be completed during this field task to support design and evaluate constructability. The survey will be conducted to identify the locations of underground utilities, and remnant underground equipment or structures (e.g. foundations) associated with the former Haley wood treatment facility or facilities that predated the Haley operation. This work includes, but is not limited to, the ISS area.

3.0 SAMPLING EQUIPMENT AND PROCEDURES

The following sections summarize sample collection procedures for soil and groundwater. Table A-1 provides additional rationale and details for the planned sampling and analytical program.

3.1. Underground Utilities Clearance

Prior to beginning subsurface investigations, the exploration locations will be marked in the field using stakes, white marking paint or similar techniques. The following general procedures will be followed for utility clearances.

- First, the locations of proposed explorations will be visually observed to determine whether debris or other objects may need to be removed prior to drilling.
- Next, the location coordinates of the proposed explorations will be determined using a portable global positioning system (GPS) unit.
- GeoEngineers will contact the Utilities Underground Location Center (1-800-424-5555) at least 48 hours prior to intrusive activities to arrange for location of underground utilities.
- GeoEngineers will also contact a commercial utility locating service to mark underground utilities in the vicinity of planned exploration locations.

The exploration locations may be modified if necessary to stay clear of utilities.

3.2. Drilling and Logging

Drilling activities will conform to State and local regulations including Chapter 173-160 WAC, *Minimum Standards for Construction and Maintenance of Wells*. Drilling activities for the PRDI will be completed by direct-push drilling and hollow-stem auger drilling methods by a licensed drilling contractor.

Subsurface debris or structures may be encountered, resulting in drilling refusal. If refusal is encountered, the exploration will be relocated as close to the originally planned location as practical and based on field conditions and other considerations at the time of the work.

3.2.1. Direct-Push Borings

Soil borings will be advanced using direct-push methods to hydraulically drive a probe from the ground surface to required depths. The direct-push borings will be advanced to a target depth of 20 feet bgs in the ISS area (Section 2.1) and 15 feet bgs in the northern delineation area. Soil samples will be collected continuously to the total depth of each boring by driving a 4-foot long probe rod through each sample interval. The probe rod will be lined with a disposable acetate sleeve that will be removed and opened to observe and retrieve the sample after each 4-foot sample interval is driven.

3.2.2. Hollow-stem Auger Borings

Soil boring HSA2018-NER1 (Figure 4-1) planned for the southern transect in the northern portion of the Site will be advanced to a target depth of 18 feet bgs using hollow-stem auger drilling equipment. Soil samples will be collected using an 18-inch split-spoon sampler. Soil cores will be collected continuously for field screening and lithologic description. A monitoring well will be constructed at this hollow-stem auger boring as described in Section 3.4.

3.2.3. Field Logging

The lithology encountered in drilled borings will be logged by the field geologist on field forms. Information on the boring logs will include the exploration location; general information about the drilling equipment;

sampling information such as sample intervals/depths, sample recoveries, lithologies and field screening results. Lithologies encountered will generally be described in accordance with ASTM International (ASTM) D 2488 Standard Practice for Description and Identification of Soils (Visual-Manual Procedure). In addition, identification of the Unified Soil Classification System (United State Geological Survey [USGS]) group symbol will be recorded on the field logs.

Besides the information noted above, additional information to be recorded on field logs includes depth to groundwater/saturated soil, heaving conditions, changes in drilling rate, and other noteworthy observations or conditions such as the presence or absence of stratification, depth of apparent lithologic contacts and the type and occurrence of anthropogenic materials.

Management of investigation-derived waste (IDW) generated during drilling (e.g., soil cuttings) is discussed in Section 3.10.

3.2.4. Field Screening

Soil samples will be field-screened for indications of possible non-aqueous phase liquid (NAPL) contamination. Field screening results will be recorded on the field logs. The following field screening methods will be used: 1) visual screening, 2) water sheen screening, and 3) headspace vapor screening.

3.2.4.1. Visual Screening

The soil will be observed for unusual color or staining that may be indicative of contamination. In addition, the following screening criteria will be used to identify the presence of NAPL in soil:

Classification	Identifier	Description
No Visible Evidence	None	No visible evidence of oil on sample
Sheen	(Sh)	Sheen as described by the sheen testing nomenclature described in Section 3.2.3.2
Staining	(St)	Visible black or brown staining on sediment. Can be visible as mottling or in bands. Typically associated with fine-grained soils
Oil-Coated	(OC)	Visible brown or black oil coating soil grains. Typically associated with coarse-grained soils
Oil-Wetted	(OW)	Visible brown or black oil wetting the sediment sample. Oil appears as a liquid and is not held by soil grains

NAPL is identified as oil-coated or oil-wetted conditions in soil. Oil-wetted conditions are interpreted as indicative of free-phase (potentially mobile) NAPL.

3.2.4.2. Water Sheen Screening

This is a qualitative field screening method that can help identify the presence or absence of petroleum hydrocarbons. A portion of the soil sample will be placed in a pan containing distilled water. The water surface will be observed for signs of sheen. The following sheen classifications will be used:

Classification	Identifier	Description
No Sheen	(NS)	No visible sheen on the water surface
Slight Sheen	(SS)	Light, colorless, dull sheen; spread is irregular, not rapid; sheen dissipates rapidly
Moderate Sheen	(MS)	Light to heavy sheen; may have some color/iridescence; spread is irregular to flowing, may be rapid; few remaining areas of no sheen on the water surface
Heavy Sheen	(HS)	Heavy sheen with color/iridescence; spread is rapid; entire water surface may be covered with sheen

3.2.4.3. Headspace Vapor Screening

This is a semi-quantitative field screening method that can help identify the presence or absence of volatile chemicals. As soon as possible after collecting a soil sample, a portion of the sample is placed in a resealable plastic bag. Ambient air is captured in the bag; the bag is sealed and then shaken gently to expose the soil to the air trapped in the bag. Vapors present within the sample bag headspace are measured by inserting the probe of a photoionization detector (PID) through a small opening in the bag. A PID measures the concentration of organic vapors ionizable by a 10.6 electron volt lamp (standard) in parts per million (ppm) and quantifies organic vapor concentrations in the range between 0.1 ppm and 2,000 ppm (isobutylene-equivalent) with an accuracy of 1 ppm between 0 ppm and 100 ppm. The maximum vapor concentration will be recorded on the field report for each sample. The PID will be calibrated to 100 ppm isobutylene.

3.3. Soil Sampling

Soil samples will be collected from borings for lithologic logging and chemical analysis by removing representative soil volumes from the acetate liners of the direct-push drill rods. The samples to be submitted for chemical analysis will be placed into laboratory-supplied containers, lightly packed and capped with a plastic lid. The sand-sized and finer fractions of the soil will be targeted for collection. Foreign material including debris and surface pavement that can be physically excluded from the in-situ soil matrix will not be sampled.

Soil boring samples will be selected for analysis based on sample depth and field screening results.

- Three soil samples will be selected for chemical analysis from each boring to evaluate the vertical and lateral footprint of ISS application. In general, it is anticipated that the mid-depth sample will characterize soil with the most prevalent field indicators of potentially mobile LNAPL to inform ‘worst case’ conditions for ISS design. A shallower and deeper sample will be collected from each boring with the goal of selecting the vertical extent of ISS application. It is anticipated the depth of the shallower soil sample will be near the groundwater table. This conceptual sampling framework will be modified, as needed, based on conditions encountered in the field (e.g. if two distinct horizons of LNAPL-impacted soil are observed).
- Three soil samples will be selected for chemical analysis from each boring completed to delineate the northern extent of contamination. One sample will be selected from the vadose zone. In the absence of field screening indications of contamination, this sample will be collected immediately below the ground surface, bottom of pavement, or bottom of a surficial gravel layer, if present. One sample will be collected at a mid-depth location within the zone of groundwater table fluctuation, with adjustments based on field screening for potentially mobile LNAPL. One sample will be collected below the groundwater table, with adjustments based on field screening results.

The soil boring samples will be selected based on subsurface conditions and field observations at the time of the work. The number of samples selected for chemical analysis and sample depth intervals may be further adjusted based field conditions and observations.

Near-surface samples for D/F analyses will be collected at each sampling location by homogenizing representative soil material in a stainless steel bowl using a stainless steel spoon.

Soil samples will be collected in labeled, pre-cleaned sample bottles provided by the analytical laboratory. The samples will be placed in containers with ice and delivered under chain-of-custody (COC) protocols to the analytical laboratory for analysis of constituents listed in Table A-1.

Reusable equipment used to obtain soil samples will be decontaminated prior to each use using an aqueous Alconox® or Liqui-Nox® solution and a distilled water rinse as described in Section 3.7.

3.4. New Monitoring Well Installation

New groundwater monitoring well HS-MW-20 will be installed in the northern portion of the Site using hollow-stem auger drilling methods. The planned location of the new well is shown on Figures 4-2 and 5-1. Monitoring well construction details will be recorded on field forms/logs. Well construction elements are discussed below.

3.4.1. Well Casing

The monitoring well will be constructed using 2-inch diameter, Schedule 40, threaded, polyvinyl chloride (PVC) casing that meets the following requirements: 1) casing will be new (unused); 2) glue will not be used to join casing sections; casing sections will be joined only by tightening the threaded sections; and 3) casing will be straight and plumb.

3.4.2. Well Screen

New monitoring well HS-MW-20 will be constructed with a screened interval of 15 feet in length set across the groundwater table and positioned from approximately 3 to 18 feet bgs. This screened interval is approximately the same as the screened interval for HS-MW-6, the next closest monitoring well located about 100 feet to the south of the planned location for HS-MW-20. The well screen will consist of 2-inch diameter, Schedule 40, 0.010-inch or 0.020-inch machine-slotted, PVC well screens. PVC end cap will be installed on the bottom of the well screen.

3.4.3. Filter Pack

The filter pack for the new well will consist of silica sand with the appropriate grain size distribution to reduce the entry of fine-grained particulates from the surrounding formation into the wells (e.g., 10-20 or 20-40 sand). The filter pack will extend from the bottom of the well screen to at least 1 foot above the top of the well screen. The top of the sand pack will be sounded to verify its depth during placement.

3.4.4. Annular Seal

The annular seal will consist of a minimum 1-foot thick layer of hydrated bentonite pellets or chips installed between the filter pack and the concrete surface seal.

3.4.5. Surface Completion

The new monitoring well will be completed with a flush-mount monument. The well casing will be cut approximately 3 inches bgs, and a locking j-plug (compression) or similar well cap will be installed to prevent surface water from entering the well. The well monument will be installed in a concrete surface seal. The well number will be marked on the well monument lid and/or the well cap. The new monitoring well will be secured with a corrosion-resistant lock as soon as possible after drilling.

3.5. New and Existing Monitoring Well Development

New monitoring well HS-MW-20 will be developed no sooner than 24 hours after installation to allow the surrounding water-bearing zone to recover after well installation and allow the bentonite annular seal to cure. Monitoring wells to be sampled during the Site-wide groundwater monitoring event will be redeveloped before sampling. Groundwater sampling will be conducted no sooner than 48 hours after well development.

Before each well is developed, the depth to water in the well and the total well depth will be measured, and the well will be checked for the presence of LNAPL. Monitoring wells with a measurable thickness of LNAPL will not be developed or sampled. The new and existing monitoring wells will be developed using a combination of surging and purging. The wells will be purged until at least five well casing volumes have been removed and turbidity has stabilized. The target turbidity is less than 10 nephelometric turbidity units (NTU) as a target but may not be achieved in all wells. Water quality parameters (e.g., temperature, pH, conductivity, turbidity) will be measured and recorded on field logs during well purging.

3.6. Groundwater Monitoring

A total of 28 wells are identified for the Site-wide groundwater monitoring event, as listed in Table A-1 and shown on Figure 5-1. Samples collected from the monitoring wells will be analyzed for TPH, PAHs, and PCP as noted in Table A-1. In addition, samples from monitoring wells TL-MW-11, TL-MW-14 and TL-MW-16 will be analyzed for D/F constituents.

Prior to sampling, each of the existing monitoring wells will be inspected for signs of tampering or other damage. If tampering is suspected (i.e., casing is damaged, lock or cap is missing), this will be recorded in the field report and on the well sampling form and reported to the Project Manager.

Groundwater monitoring activities will be recorded in field reports, and well purging/sampling data will be recorded on groundwater sampling forms.

The following sections describe the activities to be conducted during the groundwater monitoring event.

3.6.1. LNAPL Thickness/Groundwater Level Measurement

LNAPL thickness (if present) and groundwater levels will be measured in all monitoring wells, including wells not slated for sampling, before samples are collected. Standing water inside the outer protective casing or monument around each well casing will be removed prior to opening the well. Wells will be opened and allowed to vent for at least 10 minutes prior to water level measurement.

A decontaminated interface probe will be used to check for the presence of LNAPL in wells not slated for sampling and wells where LNAPL is expected to be present. The groundwater level and thickness of any LNAPL in the well will then be measured to the nearest 0.01 feet using the interface probe. An electronic water level indicator will be used for water level measurement in wells identified for sampling. Water levels will be measured from a permanent mark located at the top of the well casing.

If LNAPL is encountered in a well, the thickness of the LNAPL will be calculated by subtracting the depth to LNAPL from the depth to groundwater. The water level measurements (and LNAPL thickness, if applicable) will be recorded on the groundwater sampling form. Wells with LNAPL will not be sampled, in which an alternative monitoring well may be sampled if needed for spatial coverage.

Following water level measurement, the total depth of the well from the top of the casing will be measured using a weighted measuring tape or electronic sounding device and recorded on the groundwater sampling form. The depth to groundwater will then be subtracted from the total depth of the well to determine the height of the water column present in the well casing.

Water level measurements will be measured at all monitoring wells at least once within a four-hour period to determine the elevation of the groundwater table. Any known conditions (e.g., unusually low or high barometric pressure) that may affect groundwater levels will be recorded in the field report. Additionally, the tidal conditions at the time of water level measurement and groundwater sampling will be recorded in the field report.

LNAPL thickness and water level measuring equipment will be decontaminated between each well according to the procedures described in Section 3.7.

3.6.2. Well Purging Prior to Sampling

Monitoring wells will be purged prior to sampling using low-flow methods to evacuate standing water in the well that may not be representative of groundwater in the surrounding formation. Before the start of purging/sampling activities, plastic sheeting will be placed on the ground surrounding the well, if necessary, to provide a clean working area around the well and to reduce the possibility of soil contaminants contacting groundwater sampling equipment.

Well purging will be accomplished using new dedicated tubing and a portable peristaltic pump, submersible pump, or bladder pump. The pump intake will be placed near the middle of the well screen interval, and the well will be purged at a target rate of 250 to 500 milliliters (mL) per minute. A flow-through cell and portable water quality meter(s) will be used to monitor water quality parameters during purging. The wells will be purged until water quality parameters have stabilized. Stabilization goals are as follows:

- Temperature ± 1°C
- pH ± 0.1 pH units
- Salinity and/or conductivity/specific conductance ± 3 percent
- Dissolved oxygen ± 0.3 milligrams per liter
- Redox potential (Eh) ± 10 mV
- Turbidity <10 NTU (if 10 NTU cannot be achieved, then ± 10 percent)

The portable water quality meter will be calibrated in accordance with manufacturer specifications prior to use.

3.6.3. Groundwater Sample Collection

Groundwater samples will be collected after water quality parameters have stabilized as discussed above. The samples will be collected using a peristaltic pump, submersible pump, or bladder pump and analyzed for the constituents listed in Table A-1. Groundwater samples will be collected in labeled, pre-cleaned sample bottles provided by the analytical laboratory. The sample containers will be retained on ice and delivered under COC to the analytical laboratory.

Required sample containers, preservation methods, volumes, and holding times are summarized in Table B-1 of the QAPP.

Reusable sampling equipment will be decontaminated prior to commencing sampling activities, and between each well, as discussed in Section 3.7.

3.7. Decontamination Procedures

To prevent cross-contamination of collected samples, reusable sampling equipment will be decontaminated prior to collecting each sample using the following procedures. Deviations from these procedures, if any, will be documented in field notes/logs.

3.7.1. Drilling Equipment

For large pieces of drilling equipment (such as augers, drill rods, drill bits, and those portions of the drill rig that may be positioned directly over a boring location), the following procedure will be used to decontaminate the equipment between borings and upon completion of drilling activities. The equipment will be pressure-washed and, if necessary, scrubbed to remove visible dirt, grime, grease, oil, loose paint, rust flakes, etc. The equipment will then be rinsed with potable water.

Sampling devices will be cleaned using an aqueous Alconox® or Liqui-Nox® solution and a distilled water rinse before each sample is collected.

3.7.2. Reusable Sampling Equipment

Whenever possible, disposable sampling equipment will be used to minimize the need for decontaminating equipment. Prior to and between sample collection, reusable sampling equipment that comes in contact with soil or groundwater will be decontaminated. Reusable sampling equipment may include split-barrel soil samplers, groundwater sampling pumps, interface probes, sounding tapes, trowels, spoons, and other hand tools or sampling/measuring devices.

For soil sampling equipment, excess soil will first be removed from the equipment. The equipment will then be pressure-washed or washed using an aqueous Alconox® or Liqui-Nox® detergent solution and a brush. Detergent will be used to clean surfaces of sampling tools that directly contact samples (e.g., split-barrel core sampler); equipment that does not directly contact samples (e.g., augers) will be pressure-washed and rinsed. Decontaminated equipment will be temporarily staged on clean plastic sheeting, wrapped or covered with aluminum foil, and/or stored in a clean, dry place.

Oil-water interface probes and electronic water level indicators/well sounders used for well gauging will be decontaminated before and after use at each well. Decontamination will be performed as follows:

1. Wipe off any visible LNAPL with disposable towels.
2. Clean measurement probe and tape with an aqueous Alconox® or Liqui-Nox® solution.
3. Rinse with distilled water.

Submersible (centrifugal) or bladder-type groundwater pumps will be decontaminated before and after each use by washing the exterior with an aqueous Alconox® or Liqui-Nox® solution and a brush. The interior of the pump may be cleaned by first pumping an aqueous Alconox® or Liqui-Nox® solution through the system, followed by distilled water.

3.7.3. Sample Containers

Pre-cleaned sample bottles and jars will be supplied by the subcontracted analytical laboratory. The sample containers will be protected from contact with dust, dirt, and other potential sources of cross-contamination. Sample containers will not be reused.

3.7.4. Used Decontamination Water

Used decontamination water will be stored on-property in labeled 55-gallon drums for subsequent characterization and off-property disposal at a permitted facility. Investigation Derived Waste (IDW) management is discussed in Section 3.10.

3.8. Field Documentation

Three primary types of field documentation will used for this project: field reports and field forms, sample container labels, and COC forms. A description of each of these documentation methods is provided in the following sections.

3.8.1. Field Reports

Field reports are intended to provide a sufficient record of observations and data to enable participants to reconstruct events that occur during project field activities. They contain factual, detailed and objective information.

Field reports will be used to document the field and sampling activities performed at the project site for each day of field work. Field reports will include the date, time, description of field activities performed, names of personnel and site visitors, weather conditions, areas where photographs were taken (if applicable), and any other data pertinent to the project. Field reports will also contain sample collection and identification information and (if appropriate) a drawing of each area sampled, along with the locations (coordinates) where samples were collected. Sample data recorded in field reports will include the sample date, time, location, identification number, matrix, collection method, analyses to be performed, any comments and the sampler's name. Field reports will also document any safety issues; quality control samples collected (e.g., duplicate samples, equipment rinsate blanks); calibration checks of field monitoring/measuring instruments (e.g., PID, water quality meter); field measurements; and IDW disposition (e.g., number of drums generated and their contents and location).

Soil boring information will be recorded on boring logs attached to the field report. A groundwater/well sampling record will be used for each well to record the information collected during water sampling.

Following review by the Project Manager, the original field records will be kept in the project file.

3.8.2. Sample Labels

Sample containers will be clearly labeled with waterproof black ink at the time of sampling. Sample labels will include the following information:

- Project/site name;
- Sampling date;
- Sampling time;
- Sample identification number;
- Preservation used, if any; and
- Initials of sampler.

The same information entered on the sample label will be recorded on the COC form and in the field report.

3.8.3. Chain-of-Custody Forms

Samples will be retained in the field crew's custody until samples are delivered to the analytical laboratory. After samples have been collected and labeled, they will be maintained under COC procedures. These procedures document the transfer of custody of samples from the field to the laboratory. Each sample sent to the laboratory for analysis will be recorded on a COC form.

The COC form documents sample names, dates, times, and analyses to be performed for each sample, as well as all transfers of sample custody from the field to the analytical laboratory. The COC form will be completed using waterproof ink. Any corrections will be made by drawing a line through and initialing and dating the change, then entering the correct information.

When transferring custody of samples, the individuals relinquishing and receiving them will sign, date, and note the time on the COC form. Sample coolers shipped by common carrier will have the COC form enclosed in a resealable plastic bag and placed in the sample cooler prior to sealing the cooler for shipping. Custody seals will be used on sample coolers that are shipped by common carrier or delivered by courier to the laboratory. The sample shipping receipt will be retained in the project files as part of the COC documentation. The shipping company will not sign the COC forms as a receiver; instead the laboratory will sign as a receiver when the samples are received. Internal laboratory records will document custody of the samples from the time they are received through final disposition.

3.9. Exploration Location and Surveying

3.9.1. Exploration Location by Field Crews

The horizontal coordinates of exploration locations will be determined using a hand-held Trimble GeoXT® GPS unit or similar equipment. GeoEngineers field personnel will log the exploration location names and coordinates in the GPS unit for subsequent downloading to a computer. GPS data collected in the field will be processed in the office using measurements from the nearest reference station to each data collection point.

3.9.2. Surveying by Professional Land Surveyor

New monitoring well HS-MW-20 will be surveyed by a Washington-licensed professional land surveyor to determine and record the vertical and horizontal coordinates or each exploration location. Elevations will be measured to the nearest 0.01 feet relative the North American Vertical Datum of 1988 (NAVD88) which is the vertical datum established for the Site. Horizontal coordinates will be referenced to the Washington State Plane North coordinate system. The horizontal survey will have an accuracy of 0.10 feet.

3.10. Investigation Derived Waste

IDW will be placed in labeled storage containers and stored on the Haley property in the designated containment area, which is surrounded by Ecology blocks and enclosed by fencing. Each waste container will be labeled, secured, stored and disposed according to applicable local, State, and Federal regulations.

3.10.1. Soil

Soil cuttings from borings will be placed in 55-gallon drums marked with the contents, date, and contact information and placed in the containment area.

3.10.2. Groundwater and Decontamination Water

Well development and purge water removed from monitoring wells and decontamination water generated during sampling activities will be placed in 55-gallon drums marked with the contents, date and contact information. The drums will be placed in the containment area.

3.10.3. Incidental Waste

Incidental waste generated during field activities includes items such as disposable personal protective clothing, gloves, and sampling supplies such as aluminum foil, paper towels, plastic bags/sheeting, and similar discarded materials. These materials will be placed in plastic garbage bags or other appropriate containers. These containers will be removed from sampling areas daily and placed in a central staging area on the Haley property. At the completion of the field investigation, incidental waste will be removed from the staging area and disposed of as municipal waste at a local trash receptacle or county disposal facility.

4.0 SAMPLE HANDLING

4.1. Sample Containers and Preservation

Requirements for sample containers, sample preservation, and sample holding times for the planned laboratory analyses are discussed in the QAPP (Appendix B).

4.2. Sample Packaging and Shipping

Samples will be packed on ice in a cooler for delivery to the analytical laboratory. The samples will be either hand-delivered to the laboratory by field personnel or courier, or shipped via a commercial carrier. Custody seals will be used on sample coolers that are not hand-delivered by field personnel.

Upon receipt of the sample coolers at the laboratory, the custody seals (if present) will be broken, the condition and temperature of the samples will be recorded, and the COC forms will be signed to document transfer of sample custody. The COC forms will be used internally in the laboratory to track sample handling and final disposition.

5.0 LABORATORY ANALYTICAL METHODS

The analytical methods to be used for sample analysis are listed in Table A-1. Details regarding analytical methods, sample containers, sample preservatives, and sample holding times are discussed in the QAPP (Appendix B).

6.0 QUALITY ASSURANCE AND QUALITY CONTROL REQUIREMENTS

The QAPP (Appendix B) discusses quality assurance and quality control (QA/QC) requirements in detail.

Table A-1

Field Investigation Summary

R.G. Haley Site

Bellingham, Washington

PRDI Field Work Element	Planned Explorations and Locations	Purpose	Scope/Rationale	Field Screening and Sample Collection Intervals	Chemical Analysis Analytical Methods				
					TOC	TPH	PAHs	Dioxin/Furans	PCP
					EPA SW9060A	Ecology NWTPH-Dx with silica gel cleanup	EPA 8270-SIM (Low-Level)	EPA 1613	EPA 8151
Refine the extent of light non-aqueous phase liquid (LNAPL) to select the footprint of in-situ soil solidification (ISS)	**Approximately 20 Direct Push Borings** **DP2018-ISS1 through DP2018-ISS20** See PRDI Project Plans Figure 2-1 Approximate boring depth is 20 feet bgs, based on elevated TPH concentrations observed in previous soil boring.	Evaluate and refine the horizontal and vertical extent of TPH and LNAPL for ISS design. Collect TOC, PAH and PCP analytical data to estimate groundwater concentrations beneath the future ISS monolith and support technical analyses needed for design and remedy modeling.	Field screening for presence of NAPL. Collect soil samples from the groundwater water table to the total depth of each boring. Select three samples from each boring for chemical analysis based on field screening results including indications of potential NAPL: - One sample from shallow depth interval (ground water table) - One sample from a mid-depth interval to be determined based on most prevalent field indicators of potentially mobile LNAPL - One sample from a deeper depth interval to refine vertical profile of ISS application Additional soil samples may be collected and analyzed based on field screening or analytical testing results. **Contingency:** Collect soil samples from contingent borings DP2018-ISS19 and -ISS20 and analyze if needed based on results from the nearest borings to the north. Collect soil samples from mid to deeper depth intervals from approximately three to four soil borings below the ISS footprint for TOC, PAH and PCP analysis.	Continuous cores from ground surface to approximately 20 feet bgs. Select three samples from each boring for TPH analysis. Select two samples each from approximately three to four borings for TOC, PAH and PCP analysis.	6 to 8 soil samples	Estimated 60 soil samples	6 to 8 soil samples		6 to 8 soil samples
Site-wide Groundwater Sampling Event	**28 monitoring wells** See PRDI Project Plans Figure 5-1 **Haley Site Groundwater Monitoring Wells:** HS-MW-4, HS-MW-5, HS-MW-6, HS-MW-7, HS-MW-9, HS-MW-13, HS-MW-15, HS-MW-16, HS-MW-17, HS-MW-19, HS-MW-20, TL-MW-7, TL-MW-9, TL-MW-11, TL-MW-12, TL-MW-13, TL-MW-14, TL-MW-15, TL-MW-16 **Cornwall Site Groundwater Monitoring Wells:** CL-MW-1, CL-MW-6, CL-MW-8, CL-MW-9, CL-MW-16S, CL-MW-16D, CL-MW-101, CL-MW-102, CL-MW-103	Update baseline groundwater quality to inform design and further remedy performance modeling.	Samples to be collected from representative monitoring wells with no measurable thickness of LNAPL to evaluate current groundwater quality.	Low-flow sampling		28 groundwater samples	28 groundwater samples	3 groundwater samples TL-MW-11, TL-MW-14 and TL-MW-16	28 groundwater samples
Refine Northern Extent of Upland Contamination	**Direct Push Borings** **DP2018-NER2 through DP2018-NER6** **Hollow Stem Auger Borings** **HSA2018-NER1** See PRDI Project Plans Figure 4-1 Approximate boring depth is 15 feet bgs, based on PAH and PCP concentrations in previous soil borings versus cleanup levels.	Evaluate the extent of PAH and PCP concentrations in soil exceeding cleanup levels to refine northern extent of upland remedy.	Collect and analyze soil samples from the ground surface to the total depth in each boring. Select three samples from each boring for chemical analysis: - One vadose zone sample immediately below the ground surface or bottom of surface gravel layer, if present. - One sample within the zone of groundwater table fluctuation - One sample below the water table Samples will be selected based on field screening and/or the depth of cleanup level exceedances in the borings to the south. Samples collected from the northern transect will be submitted for chemical analysis only if needed, based on results from the southern transect.	Five-foot intervals from ground surface to approximately 15 feet bgs. Select three samples from each southern transect boring for chemical analysis. **Contingency:** If needed, select three samples from one or more northern transect borings for chemical analysis.			9 soil samples from southern transect borings Up to 9 contingency soil samples from northern transect borings		9 soil samples from southern transect borings Up to 9 contingency soil samples from northern transect borings
	Near-Surface Soil Samples **HS2018-SS1 through HS2018-SS8** See PRDI Project Plans Figure 4-1	Evaluate the extent of D/F constituents in near-surface soil exceeding cleanup levels to refine northern extent of upland remedy.	Collect one near-surface soil sample at each sampling location immediately below the ground surface or bottom of surface gravel layer, if present. Samples collected from the central and northern rows will be submitted for chemical analysis only if needed, based on results from the southern and central rows, respectively.	Near-surface samples				8 soil samples	
	New Groundwater Monitoring Well **HS-MW-20** See PRDI Project Plans Figures 4-2 and 5-1	Evaluate northern extent of PAH in groundwater and obtain baseline groundwater quality to inform design.	Collect and analyze one groundwater sample following new well installation and one sample three to six months later.	Screen between 3 and 18 feet bgs Low-flow sampling		1 groundwater sample	1 groundwater sample		1 groundwater sample

Notes

bgs = below ground surface

EPA = U.S. Environmental Protection Agency

TOC = total organic carbon

PAHs = polycyclic aromatic hydrocarbons

PCP = pentachlorophenol

D/F = dioxin/furan constituents

TPH = total petroleum hydrocarbons

APPENDIX B
Quality Assurance Project Plan

Table of Contents

LIST OF TABLES

APPENDIX B
QUALITY ASSURANCE PROJECT PLAN

1.0 INTRODUCTION

This Quality Assurance Project Plan (QAPP) has been prepared for the R.G. Haley Site (herein referred to as the Site) as an appendix to the Pre-Remedial Design Investigation Work Plan (PRDI). The pre-remedial design investigation is being conducted to collect sufficient information to fill in data gaps and support development of design documents for the Site. This QAPP presents the procedures, organization, and specific quality assurance/quality control (QA/QC) activities designed to achieve the data quality objectives (DQOs) established for the project.

The QAPP has been developed based on guidelines specified in the Washington State Model Toxics Control Act (MTCA) Cleanup Regulation (Chapter 173-340 of the Washington Administrative Code [WAC]) and Washington State Department of Ecology (Ecology) guidance contained in Ecology Publication #04-03-030, *Guidelines for Preparing Quality Assurance Project Plans for Environmental Studies* (Ecology, 2004).

Throughout the project, environmental measurements will be conducted to produce data that are scientifically valid, of known and acceptable quality, and meet established objectives. QA/QC procedures will be implemented so that the precision, accuracy, representativeness, completeness, and comparability (PARCC) of the data generated meet the specified DQOs to the maximum extent possible.

2.0 SAMPLE COLLECTION, HANDLING, AND CUSTODY

The sample collection, handling, and custody procedures are explained in the Sampling and Analysis Plan (SAP; Appendix A of the PRDI). The chemical analytical laboratory subcontracted for this sampling event is OnSite Environmental, Inc. (OnSite) located in Redmond, Washington (425.883.3881). The analytical laboratory subcontracted for the dioxin/furan analysis is Frontier Analytical Laboratory (Frontier) located in El Dorado Hills, California (916.934.0900).

3.0 CHEMICAL ANALYSES/METHODS

Samples of soil and groundwater will be collected during field activities. Samples, analytes and analytical methods are listed below and summarized in Table 1 of the SAP (Appendix A of the PRDI).

- Total Organic Carbon (TOC), by United States Environmental Protection Agency (EPA) Method SW9060A;
- Total petroleum hydrocarbons (TPH), analyzed by Ecology Method Northwest Total Petroleum Hydrocarbons – Diesel Extended (NWTPH-Dx) with and without silica gel cleanup;
- Polycyclic aromatic hydrocarbons (PAHs), analyzed by EPA Method SW8270-SIM;
- Chlorophenols (pentachlorophenol) by EPA Method SW8151; and
- Tetra through Octa Chlorinated Dibenzo Dioxins and Furans by EPA 1613 (special request PQLs).

3.1. Sample Preservation, Container, and Holding Times

Samples subject to laboratory analyses will be prepared, containerized, and preserved in the field according to the guidelines described above and those detailed in Table B-1. Samples will be kept on ice in coolers while at the Site. The samples will be preserved and hand-delivered by the GeoEngineers' field representative to the laboratory. In cases where hand-delivery is not possible (inclement weather, after-hours sampling, etc.), the samples will be kept at 4°C until the next day. The samples will remain in a safe, refrigerated state upon delivery to the laboratory, and at the laboratory, until analyzed.

Holding times are defined as the time between sample collection and extraction, sample collection and analysis, or sample extraction and analysis. Some analytical methods specify a recommended holding time for analysis only. For many methods, recommended holding times may be extended by sample preservation techniques in the field. If a sample exceeds a recommended holding time, then the results may be biased low. For example, if the extraction holding time for volatile analysis of soil samples is exceeded, then the possibility exists that some of the organic constituents may have volatilized from the sample or degraded. Results for that analysis would be qualified as estimated to indicate that the reported results may be lower than actual site conditions. Recommended holding times are presented in Table B-1.

4.0 DATA QUALITY OBJECTIVES

The quality assurance objectives for technical project data are to collect environmental sampling data of known, acceptable, and documentable quality. The specific objectives established for the project are:

- Implement the procedures outlined herein for field sampling, sample custody, equipment operation and calibration, laboratory analysis, and data reporting to ensure consistency and thoroughness of data generated.
- Achieve the level of QA/QC required to produce scientifically valid analytical data of known and documented quality. This will be accomplished by establishing criteria for data precision, accuracy, representativeness, completeness, and comparability, and by evaluating project data against these criteria.

The sampling design, field procedures, useable laboratory procedures, and QC procedures established for this project were developed to provide defensible data. Specific data quality factors that may affect data usability include quantitative factors (precision, bias, accuracy, completeness, and reporting limits) and qualitative factors such as representativeness and comparability. The specific DQOs associated with these data quality factors are discussed below. Method-specific DQOs for chemical laboratory analyses are presented in Table B-2 and Table B-3.

4.1. Analytical Sensitivity

Analytical methods have qualitative limitations regarding the level at which an analyte can be theoretically detected with a given statistical level of confidence that are often expressed as the method detection limit (MDL). These same methods also have quantitative thresholds at which an analyte can be quantified that are typically represented by the lowest point of a 5- to-7-point calibration curve (linear, response factors, (1/a) weighted, etc.) that is conducted prior to field sample analysis. In all cases, these latter real-world measurements are always greater (3 to 5 times) than the MDLs and are often expressed as the method reporting limits (MRLs).

When compounds are positively identified (i.e., detected) at concentrations greater than the MDLs, but less than the MRLs the detected concentration is identified as an estimate (i.e., "J" flagged). The contract laboratory will provide numerical results for all analytes that are positively identified and report them as detected above the MRL or detected below the MRL but above the MDL.

Achieving a stated detection limit for a given analyte is helpful in providing statistically useful data. Intended data uses, such as comparison to numerical criteria or risk assessments, typically dictate specific project target reporting limits (RLs) necessary to fulfill stated objectives. The target RLs are presented in Table B-2. These target RLs will serve as the laboratory MRLs for this project. It may be possible to achieve MRLs less than the targets under ideal conditions. However, the target RLs presented in Table B-2 and Table B-3 are considered targets because several factors may influence final MRLs. First, moisture and other physical conditions of samples can affect MRLs. Second, analytical procedures may require sample dilutions or other practices to accurately quantify a particular analyte at concentrations above the range of the instrument. The effect of this is that other analytes could be reported as not detected, but at a laboratory-adjusted MRL significantly higher than a specified target RL. Data users must be aware that elevated MRLs can bias statistical data summaries, and careful interpretation is required when using data sets with MRLs exceeding targets.

4.2. Precision

Precision is the measurement of reproducibility among duplicate measurements of an analyte from the same sample and applies to split samples (from lab or field), replicate analyses of the same sample, and duplicate spiked environmental samples (matrix spike duplicates). The closer the measured values are to each other, the more precise the measurement process. Precision error may affect data usefulness. Good precision is indicative of relative consistency and comparability between different samples. Precision is expressed as the relative percent difference (RPD) of spike sample and field split sample comparisons of various matrices. The RPD is calculated as:

$$RPD(\%) = \frac{|D_1 - D_2|}{(D_1 + D_2)/2} X\ 100,$$

Where

D_1 = Concentration of analyte in primary sample.

D_2 = Concentration of analyte in the split sample/aliquot.

The RPD will be calculated for samples and compared to the project RPD QC control limits. The RPD QC control limits (50% for soils; 35% for ground waters) are only applicable if the primary and duplicate sample concentrations are greater than 5 times the MRL. For results less than 5 times the MRL, the difference between the primary and duplicate samples should be less than 2 times the MRL for soil samples, and less than the MRL for ground water samples.

4.3. Accuracy and Bias

Accuracy is a measure of bias in the analytical process. The closer the measurement value is to the true value, the greater the accuracy. Accuracy is typically evaluated by adding a known concentration (a "spike") of a target or surrogate compound to a sample prior to analysis. The detected concentration or percent recovery (%R) of the spiked compound reported in the sample provides a quantitative measure of analytical accuracy. Since most environmental data collected represent single points spatially and temporally rather than an average, accuracy is generally more important than precision in assessing the data. In general, if %R values are low, non-detect results may be reported for compounds of interest when in fact these compounds are present (i.e., false negative results), and results for detected compounds may be biased low. The reverse is true when %R values are high. In this case, non-detect values are considered accurate, whereas detected values may be higher than true values.

For this project, accuracy will be expressed as the %R of a known surrogate spike, matrix spike, or laboratory control sample (blank spike) concentration:

$$Recovery\ (\%R) = \frac{Spiked\ Result - Unspiked\ Result}{Known\ Spike\ Concentration}\ X\ 100$$

Accuracy (%R) criteria and precision criteria for laboratory control samples (Laboratory Control Samples OR Ongoing Precision and Recovery Samples) are presented in Table B-2 and Table B-3.

4.4. Representativeness, Completeness, and Comparability

Representativeness expresses the degree to which data accurately and precisely represent the actual site conditions. Representativeness of the data will be evaluated by:

- Comparing actual sampling procedures to those specified in this QAPP.
- Reviewing analytical results for field duplicates (i.e., second sample collected from the same parent sample) to determine the precision in the analytical results.
- Invalidating non-representative data or identifying data to be classified as questionable or qualitative in nature. Only representative data will be used in subsequent data reduction, validation, and reporting activities.

Completeness establishes whether a sufficient number of valid measurements were obtained to meet project objectives. The number of samples and results expected establishes the comparative basis for completeness. The completeness goal is 90 percent useable data for the samples/analyses planned. If the completeness goal is not achieved, an evaluation will be performed to determine if the data are adequate to meet study objectives. The following equation is used to calculate completeness:

% Completeness =Number of valid results x 100/Number of possible results

Comparability expresses the confidence with which one set of data can be compared to another. Although numeric goals do not exist for comparability, the following items are evaluated when assessing data comparability:

- Whether two data sets or batches contain the same set of parameters.
- Whether the units used for each data set are convertible to a common metric scale.
- Whether similar analytical procedures and quality assurance were used to collect data for both data sets.
- Whether the analytical instruments used for both data sets have approximately similar detection levels.
- Whether samples within data sets were selected and collected in a similar manner.

A statement on comparability will be prepared to assess overall usefulness of data sets generated during the project, following the evaluation of precision and accuracy.

5.0 QUALITY CONTROL SAMPLES AND PROCEDURES

QC samples will be analyzed to ensure the precision, accuracy, representativeness, comparability, and completeness of the data. Table B-4 summarizes the types and frequency of QC samples to be analyzed during the investigation, including both field QC and laboratory QC samples.

5.1. Field Quality Control Samples

Field QC samples serve as a control and check mechanism to monitor the consistency of sampling methods and potential influence of off-site factors on environmental samples. Examples of potential off-site factors include airborne volatile organic compounds (VOCs) and potable water used in drilling activities. As shown in Table B-4, field QC samples will consist of field duplicates. Description of this type of QC sample are provided in the following subsections.

5.1.1. Field Duplicates

Field duplicates serve as measures for precision. They are created by placing aliquots of a homogenized sample in separate containers, and identifying one of the aliquots as the primary or parent sample and the other as the duplicate sample. Field duplicates measure the precision and consistency of laboratory analytical procedures and methods, as well as the consistency of the sample processing techniques used by field personnel and/or the relative homogeneity of sample matrices. The duplicate sample is submitted to gain precision information on sample homogeneity, handling, shipping, storage and preparation, and analysis. Field duplicates will be analyzed for the same parameters as the associated primary samples.

One field duplicate will be collected for every 20 primary soil, and water samples (i.e., a frequency of 5 percent for each matrix). The duplicate samples will be collected at the same locations and as close as possible to the same times as the associated primary samples.

5.1.2. Other QC Samples

According to the *National Functional Guidelines for Organic Data Review* (EPA, 2008), "The purpose of laboratory (or field) blank analysis is to assess the existence and magnitude of contamination resulting from laboratory (or field) activities. The criteria for evaluation of blanks apply to any blank associated with the samples….." Field blanks will be used at the discretion of the QA Leader if there is a reason to suspect contamination introduced by ambient conditions in the field. Field blanks are samples of distilled water poured directly into sample containers in the field. Field blanks are analyzed for the same parameters as the associated project samples.

Analytical results for QC blanks will be interpreted in general accordance with EPA's *National Functional Guidelines for Organic and Inorganic Data Review* and professional judgment.

5.2. Chemical Laboratory Quality Control

The analytical laboratories will follow standard analytical method procedures that include specified QC monitoring requirements. These requirements will vary by method, but generally include:

- Method blanks;
- Internal standards;
- Instrument calibrations;

- Matrix spikes/matrix spike duplicates (MS/MSDs);
- Laboratory control samples/laboratory control sample duplicates (LCS/LCSDs);
- Laboratory replicates or duplicates; and
- Surrogate spikes.

5.2.1. Laboratory Blanks

Laboratory procedures employ the use of several types of blanks but the most commonly used blanks for QA/QC assessments are method blanks. Method blanks are laboratory QC samples that consist of either a soil-like material that has undergone a contaminant destruction process, or a sample of reagent water. Method blanks are extracted and analyzed with each batch of environmental samples undergoing analysis. Method blanks are particularly useful during volatiles analysis since VOCs can be transported in the laboratory through the vapor phase. If a substance is found in the method blank, it indicates that one (or more) of the following occurred:

- Measurement apparatus or containers were not properly cleaned and contained contaminants.
- Reagents used in the analytical process were contaminated with a substance(s) of interest.
- Contaminated analytical equipment was not properly cleaned.
- Volatile substances in the air with high solubility or affinities toward the sample matrix contaminated the samples during preparation or analysis.

It is difficult to determine which of the above scenarios took place if method blank contamination occurs. However, it is assumed that the conditions that affected the blanks also likely affected the project samples. If method blank contamination occurs, validation guidelines assist in determining which substances detected in associated project samples are likely truly present in the samples and which ones are likely attributable to the analytical process.

5.2.2. Matrix Spike/Matrix Spike Duplicates

MS/MSDs are used to assess influences or interferences caused by the physical or chemical properties of the sample itself. For example, extreme pH can affect the results of SVOC analyses. Or, the presence of a particular analyte in a sample may interfere with accurate quantitation of another analyte. MS/MSD data are reviewed in combination with other QC monitoring data to evaluate matrix effects. In some cases, matrix effects cannot be determined due to dilution and/or high levels of related substances in the sample. An MS is created by spiking a known amount of one or more of the target analytes into a project sample, ideally at a concentration at least 5 to 10 times higher than the concentration in the unspiked sample. Percent recovery value is calculated by subtracting the unspiked sample result from the spiked sample result, dividing by the spike amount, and multiplying by 100.

The samples designated for MS/MSD analysis should be obtained from a sampling location that is suspected to not be highly contaminated. A sample from an area of low-level contamination is needed because the objective of MS/MSD analyses is to assess possible matrix interferences, which can best be achieved with low levels of contaminants. For the pre-remedial design investigation, additional sample volume will be collected for MS/MSD analysis for every 20 primary soil samples and every 20 primary water samples, or as determined as necessary by the analytical laboratory.

5.2.3. Laboratory Control Spikes/ Laboratory Control Spike Duplicates

Also known as blank spikes, laboratory control spikes (LCS) and laboratory control spike duplicates (LCSDs) are similar to MS/MSD samples in that a known amount of one or more of the target analytes is spiked into a prepared medium and the percent recovery is calculated for the spiked substance(s). The primary difference between an MS and LCS is that the LCS spike medium is considered "clean" or contaminant-free. For example, reagent water is typically used for LCS water analyses. The purpose of an LCS is to help assess the overall accuracy and precision of the analytical process including sample preparation, instrument performance, and analyst performance. LCS data must be reviewed in context with other laboratory QC data to determine if corrective action is necessary for laboratory control limit exceedances.

5.2.4. Laboratory Replicates/Duplicates

Laboratories often utilize MS/MSDs, LCS/LCSDs, and/or laboratory replicates to assess precision. Replicates are a second analysis of a field-collected environmental sample. Replicates can be split at varying stages of the sample preparation and analysis process, but most commonly consist of a second analysis on the extracted media.

5.2.5. Surrogate Spikes

Surrogate spikes are used to verify the accuracy of the analytical instrument and extraction procedures used. Surrogates are substances similar to the target analytes. A known concentration of surrogate is added to each project sample and passed through the instrument, noting the surrogate recovery. Each surrogate used has an acceptable range of percent recovery. If a surrogate recovery is low, sample results may be biased low, and, depending on the percent recovery, a possibility of false negatives may exist. Conversely, when surrogate recoveries are above the specified range of acceptance, a possibility of false positives exists, although non-detected results are considered accurate.

5.3. Calibration Procedures

5.3.1. Field Instrumentation

Field instrument calibration and calibration checks facilitate accurate and reliable field measurements. The calibration of the instruments will be checked and adjusted as necessary in general accordance with manufacturers' recommendations. Methods and frequency of calibration checks and instrument maintenance will be based on the type of instrument, stability characteristics, required accuracy, intended use, and environmental conditions. The basic calibration check frequencies are described below.

5.3.2. Laboratory Instrumentation

Several types of instrument calibrations are used, depending on the method, to determine whether the methodology is 'in control' by verifying the linearity of the calibration curve and to assure that the sample results reflect accurate and precise measurements. This is done by verifying that the percent relative standard deviations (%RSD) and/or the correlation coefficients are within the control limits specified in the validation documents. The main calibrations used are initial calibrations, daily calibrations, and continuing calibration verification.

For chemical analytical testing, calibration procedures and their appropriate chemical standards are to comply with the specific methods within EPA SW-846, Test Methods for Evaluating Solid Waste, Physical and Chemical Methods, 3rd Edition, December 1996 and the laboratory's Standard Operating Procedures (SOPs). Calibration documentation will be retained at the laboratory for a minimum period of 6 months.

6.0 LABORATORY DATA REPORTING AND DELIVERABLES

Laboratories will report data in formatted hardcopy and electronic form to the Project Manager and QA Leader. Upon completion of analyses, the laboratory will prepare electronic deliverables for data packages in accordance with the specifications in the agreed-upon *Special Conditions for Lab Analysis (rev 05162014)* document. The laboratory will provide electronic data deliverables (EDDs) within 2 business days after GeoEngineers' receipt of printed-copy analytical results, including the appropriate QC documentation. Analytical laboratory measurements will be recorded in standard formats that display, at a minimum, the client/field sample identification, the laboratory sample identification, reporting units, analytical methods, analytes tested, analytical results, extraction and analysis dates, quantitation limits, and data qualifiers. Each sample delivery group will be accompanied by sample receipt forms and a case narrative identifying data quality issues.

GeoEngineers will establish EDD requirements with the contract laboratories, as part of subcontracting.

7.0 DATA REDUCTION AND ASSESSMENT PROCEDURES

This section describes the process for generating and checking data, as well as the process for producing reports for field and analytical laboratory data.

7.1. Data Reduction

Data reduction involves the conversion or transcription of field and analytical data to a useable format. The laboratory personnel will reduce the analytical data for review by the QA Leader and Task Manager. This will involve both hard-copy forms and EDDs. Both forms of data will be compared with each other to verify that the data are reliable and error-free.

7.2. Review of Field Documentation and Laboratory Receipt Information

Documentation of field sampling data will be reviewed periodically for conformance with project QC requirements described in this QAPP. At a minimum, field documentation will be checked for proper documentation of the following:

- Sample collection information (date, time, location, matrices, etc.);
- Field instruments used and calibration data;
- Sample collection protocol;
- Sample containers, preservation, and volume;
- Field QC samples collected at the frequency specified;
- Chain-of-custody protocols; and
- Sample shipment information.

Sample receipt forms provided by the laboratories will be reviewed for QC exceptions. The final laboratory data package will describe (in the case narrative) the effects that any identified QC exceptions have on data quality. The laboratories will review transcribed sample collection and receipt information for correctness prior to delivering the final data package.

7.3. Chemical Data Verification/Validation

Project decisions, conclusions, and recommendations will be based upon verified (validated) data. The purpose of data verification is to ensure that data used for subsequent evaluations and calculations are scientifically valid, of known and documented quality, and legally defensible. Field data verification will be used to eliminate data not collected or documented in accordance with the protocols specified in the SAP. Laboratory data verification will be used to eliminate data not obtained using prescribed laboratory procedures.

The QA Leader will validate data collected during the PRDI to ensure that the data are valid and usable. Data will be validated in general conformance with EPA functional guidelines for data validation (EPA, 2004, 2005, and 2008). At a minimum, the following items will be reviewed to verify the data as applicable:

- Documentation that a final review of the data was completed by the Laboratory QA Coordinator;
- Documentation of analytical and QC methodology;
- Documentation of sample preservation and transport;
- Sample receipt forms and case narratives; and
- The following QC parameters:
  - Holding times and sample preservation
  - Method blanks
  - MS/MSDs
  - LCS/LCSDs or OPR Samples
  - Surrogate or Labeled Compound spikes
  - Duplicates/replicates
  - Initial Calibrations
  - Continuing Calibrations
  - Internal Standards

When sample analytical data are received from the analytical laboratory, they will undergo a QC review by the QA Leader. The accuracy and precision achieved will be compared to the laboratory's analytical control limits. Example control limits are presented in Table B-1. Calculations of RPDs will follow standard statistical conventions and formulas as presented in Section 2.0. Additional specifications and professional judgment by the QA Leader may be incorporated when appropriate data from specific matrices and field samples are available.

A data quality assessment will be prepared to document the overall quality of the data relative to the DQOs. The major components of the data quality assessment are as follows:

- **Data Validation Summary.** Summarizes the data validation results for all sample delivery groups by analytical method. The summary identifies any systematic problems, data generation trends, general conditions of the data, and reasons for any data qualification.
- **QC Sample Evaluation.** Evaluates the results of QC sample analyses, and presents conclusions based on these results regarding the validity of the project data.

- **Assessment of DQOs.** An assessment of the quality of data measured and generated in terms of accuracy, precision, and completeness relative to objectives established for the project.
- **Summary of Data Usability.** Summarizes the usability of data, based on the assessment performed in the three preceding steps.

The data quality assessment will help to achieve an acceptable level of confidence in the decisions that are to be made based upon the project data. The project analytical data will be submitted to Ecology's Environmental Information Management (EIM) system after the data quality assessment is completed.

8.0 REFERENCES

Environmental Protection Agency. National Functional Guidelines for Inorganic Superfund Methods Data Review, EPA-540-R-2017-001. January 2017.

Environmental Protection Agency. National Functional Guidelines for High Resolution Superfund Methods Data Review, EPA-542-B-16-001. April 2016.

Environmental Protection Agency. National Functional Guidelines for Organic Superfund Methods Data Review, EPA-540-R-2017-002. January 2017.

Washington State Department of Ecology (Ecology), "Guidelines for Preparing Quality Assurance Project Plans for Environmental Studies," July 2004.

Washington Administrative Code (WAC) 173, Chapter 173-340-820.

Table B-1

Soil and Water Test Methods, Sample Containers, Preservatives and Holding Times

R.G. Haley Site

Bellingham, Washington

Analysis	Method	Minimum Sample Size		Sample Containers		Sample Preservatives		Sample Holding Times[2]	
		Soil	Water	Soil	Water	Soil	Water	Soil	Water
Total Organic Carbon (TOC)	EPA 9060A	2 g	NA	8 oz glass widemouth with Teflon-lined lid	NA	Cool ≤6°C	NA	28 days	NA
Diesel-range Hydrocarbons	NWTPH-Dx	20 g	500 mL	8 oz glass widemouth with Teflon-lined lid	Two 500-mL amber glass with Teflon-lined lid	Cool ≤6°C	Cool ≤6 °C, HCl to pH < 2 optional	14 days	14 days preserved, 7 days unpreserved, 40 days from extract to analysis
Pentachlorophenol (only)	SW8151 (Special Request PQL for SOIL)	50 g	1 L	8 oz glass widemouth with Teflon-lined lid	Two 500-mL amber glass with Teflon-lined lid	Cool ≤6°C	Cool ≤6°C	14 days to extraction, 40 days from extract to analysis	7 days to extraction, 40 days from extract to analysis
PAHs	SW8270-SIM (Special Request PQL for SOIL)	50 g	1 L	8 oz glass widemouth with Teflon-lined lid	Two 500-mL amber glass with Teflon-lined lid	Cool ≤6°C	Cool ≤6°C	14 days to extraction, 40 days from extract to analysis	7 days to extraction, 40 days from extract to analysis
Dioxins/furans	EPA 1613B (Special Request PQLs for WATER)	50 g	1 L	8 oz glass widemouth with Teflon-lined lid	Two 500-mL amber glass with Teflon-lined lid	NA	Cool ≤6°C	1 year	

Notes:

[1]Sample extraction and analysis for benzene, ethylbenzene, toulene and xylenes (BETX) in soil will be in accordance with U.S. Environmental Protection Agency (EPA) Method 5035A for low-level volatiles analysis.

[2]Holding times are based on elapsed time from date of sample collection.

°C = degrees celcius

g = gram

L = liter

mL = milliliter

NA = not applicable

oz = ounce

PAHs = polycyclic aromatic hydrocarbons

PQLs = practical quantitation limits

SIM = selective ion monitoring

Table B-2

Target Practical Quantitation Limits and Quality Control Limits for Soil Samples

R.G. Haley Site

Bellingham, Washington

Analyte	CAS Number	Target Practical Quantitation Limits for Soil [1]	Quality Control Limits for Soil	
			RPD*	% R
Total Organic Carbon (TOC) by SW9060A (%)				
Total Organic Carbon	NA	0.042	0-30	80-120
Total Petroleum Hydrocarbons by NWTPH-Dx (mg/kg)				
Diesel-Range Petroleum Hydrocarbons	NA	25	0-30	50-150
Heavy Oil-Range Petroleum Hydrocarbons	NA	50	0-30	50-150
Polycyclic Aromatic Hydrocarbons by SW8270-SIM (µg/kg)				
2-Methylnaphthalene	91-57-6	5.0	0-30	27 - 107
Acenaphthene	83-32-9	5.0	0-15	58 - 117
Acenaphthylene	208-96-8	5.0	0-15	59 - 119
Anthracene	120-12-7	5.0	0-15	66 - 126
Benzo(a)anthracene	56-55-3	5.0	0-15	64 - 132
Benzo(a)pyrene	50-32-8	5.0	0-15	62 - 125
Benzo(b)fluoranthene	205-99-2	5.0	0-15	57 - 128
Benzo(g,h,I)perylene	191-24-2	5.0	0-15	57 - 129
Benzo(k)fluoranthene	207-08-9	5.0	0-15	62 - 130
Chrysene	218-01-9	5.0	0-15	64 - 127
Dibenzo(a,h)anthracene	53-70-3	5.0	0-15	58 - 129
Fluoranthene	206-44-0	5.0	0-15	62 - 126
Fluorene	86-73-7	5.0	0-15	61 - 122
Indeno(1,2,3-cd)pyrene	193-39-5	5.0	0-15	55 - 130
Naphthalene	91-20-3	5.0	0-15	54 - 114
Phenanthrene	85-01-8	5.0	0-15	58 - 121
Pyrene	129-00-0	5.0	0-15	61 - 126
Chlorophenols by SW8151 (µg/kg)				
Pentachlorophenol	87-86-5	6.3	0-35	13 - 117
Dioxins and Furans by EPA 1613 (pg/g)				
2,3,7,8-TCDD	9014-42-0	0.5	NA	78.5 - 185
1,2,3,7,8-PeCDD	40321-76-4	2.5	NA	75.3 - 152
1,2,3,4,7,8-HxCDD	39227-28-6	2.5	NA	73.4 - 172
1,2,3,6,7,8-HxCDD	57653-85-7	2.5	NA	80.7 - 142
1,2,3,7,8,9-HxCDD	19408-74-3	2.5	NA	69.1 - 175
1,2,3,4,6,7,8-HxCDD	39227-28-6	2.5	NA	75.3 - 151
OCDD	3268-87-9	5.0	NA	85.6 - 158
2,3,7,8-TCDF	51207-31-9	0.5	NA	89.1 - 188
1,2,3,7,8-PeCDF	57117-41-6	2.5	NA	88.5 - 148
2,3,4,7,8-PeCDF	57117-31-4	2.5	NA	78.2 - 184
1,2,3,4,7,8-HxCDF	70648-26-9	2.5	NA	74.2 - 138
1,2,3,6,7,8-HxCDF	57117-44-9	2.5	NA	86.6 - 134
1,2,3,7,8,9-HxCDF	72918-21-9	2.5	NA	71.7 - 160
2,3,4,6,7,8-HxCDF	60851-34-5	2.5	NA	80.6 - 134
1,2,3,4,6,7,8-HpCDF	67562-39-4	2.5	NA	88.0 - 131
1,2,3,4,7,8,9-HPCDF	55673-89-7	2.5	NA	81.1 - 144
OCDF	39001-02-0	5.0	NA	66.0 - 178

Notes:

[1] The control limits for these compounds have not been set by the laboratory because they are typically not spiked into the QC samples. This may be done on special

% R = Percent recovery

* Listed RPD is for laboratory replicates and duplicate spiked samples; RPD goal for field duplicates is 0-50.

CAS = Chemical Abstract Services

cPAH = carcinogenic polycyclic aromatic hydrocarbons

Dx = Diesel extended range

Gx = Gasoline extended range

kg = Kilograms

mg = Milligrams

µg = Micrograms

NA = Not applicable

ng = Nanograms

NWTPH = Northwest Total Petroleum Hydrocarbons

PQL = practical quantitation limit

RPD = Relative percent difference

TEC = Toxic equivalent concentration; PQL calculated as prescribed in WAC 173-340 using one-half the PQL for individual constituents.

WAC = Washington Administrative Code

Table B-3

Target Practical Quantitation Limits and Quality Control Limits for Groundwater Samples

R.G. Haley Site

Bellingham, Washington

Analyte	CAS Number	Target Practical Quantitation Limits for Water [1]	Quality Control Limits for Water	
			RPD*	% R
Total Petroleum Hydrocarbons by NWTPH-Dx (µg/L)				
Diesel-Range Petroleum Hydrocarbons	NA	250	0-30	50-150
Heavy Oil-Range Petroleum Hydrocarbons	NA	500	0-30	50-150
Polycyclic Aromatic Hydrocarbons by SW8270-SIM (µg/L)				
Acenaphthene	83-32-9	0.01	0-33	41 - 113
Acenaphthylene	208-96-8	0.01	0-26	37 - 111
Anthracene	120-12-7	0.01	0-18	50 - 117
Benzo(a)anthracene	56-55-3	0.01	0-15	57 - 127
Benzo(a)pyrene	50-32-8	0.01	0-16	50 - 120
Benzo(b)fluoranthene	205-99-2	0.01	0-17	54 - 124
Benzo(g,h,I)perylene	191-24-2	0.01	0-19	45 - 130
Benzo(k)fluoranthene	207-08-9	0.01	0-18	50 - 127
Chrysene	218-01-9	0.01	0-15	51 - 120
Dibenzo(a,h)anthracene	53-70-3	0.01	0-18	49 - 129
Fluoranthene	206-44-0	0.01	0-15	52 - 120
Fluorene	86-73-7	0.01	0-23	47 - 114
Indeno(1,2,3-cd)pyrene	193-39-5	0.01	0-20	46 - 132
Naphthalene	91-20-3	0.01	0-38	28 - 109
Phenanthrene	85-01-8	0.01	0-18	50 - 113
Pyrene	129-00-0	0.01	0-31	51- 128
Chlorophenols by SW8151 (µg/L)				
Pentachlorophenol	87-86-5	0.04	0-20	48 - 111
Dioxins and Furans by EPA 1613 (pg/L)				
2,3,7,8-TCDD	9014-42-0	10	NA	78.5 - 185
1,2,3,7,8-PeCDD	40321-76-4	10	NA	75.3 - 152
1,2,3,4,7,8-HxCDD	39227-28-6	10	NA	73.4 - 172
1,2,3,6,7,8-HxCDD	57653-85-7	10	NA	80.7 - 142
1,2,3,7,8,9-HxCDD	19408-74-3	10	NA	69.1 - 175
1,2,3,4,6,7,8-HxCDD	39227-28-6	10	NA	75.3 - 151
OCDD	3268-87-9	20	NA	85.6 - 158
2,3,7,8-TCDF	51207-31-9	10	NA	89.1 - 188
1,2,3,7,8-PeCDF	57117-41-6	10	NA	88.5 - 148
2,3,4,7,8-PeCDF	57117-31-4	10	NA	78.2 - 184
1,2,3,4,7,8-HxCDF	70648-26-9	10	NA	74.2 - 138
1,2,3,6,7,8-HxCDF	57117-44-9	10	NA	86.6 - 134
1,2,3,7,8,9-HxCDF	72918-21-9	10	NA	71.7 - 160
2,3,4,6,7,8-HxCDF	60851-34-5	10	NA	80.6 - 134
1,2,3,4,6,7,8-HpCDF	67562-39-4	10	NA	88.0 - 131
1,2,3,4,7,8,9-HPCDF	55673-89-7	10	NA	81.1 - 144
OCDF	39001-02-0	20	NA	66.0 - 178

Notes:

[1] The control limits for these compounds have not been set by the laboratory because they are typically not spiked into the QC samples. This may be done on special request.

% R = Percent recovery

* Listed RPD is for laboratory replicates and duplicate spiked samples; RPD goal for field duplicates is 0-35.

CAS = Chemical Abstract Services

Dx = Diesel extended range

EPA = United States Enviornmental Protection Agency

Gx = Gasoline extended range

kg = Kilograms

mg = Milligrams

µg = Micrograms

NA = Not applicable

ng = Nanograms

NWTPH = Northwest Total Petroleum Hydrocarbons

pg = Picograms

PQL = practical quantitation limit

RPD = Relative percent difference

TEC = Toxic equivalent concentration; PQL calculated as prescribed in WAC 173-340 using one-half the PQL for individual constituents.

Table B-4

Quality Control Samples Type and Minimum Frequency

R.G. Haley Site

Bellingham, Washington

Parameter	Field QC Samples		Laboratory QC Samples			
	Field Duplicates	Equipment Rinsate Blanks	Method Blanks	LCS or OPR samples	MS/MSD	Lab Duplicates
TOC	1 per 20 primary groundwater/soil/samples	1 per 20 primary groundwater/soil samples (1 per day minimum)	1 per batch*	1 per batch*	1 per batch*	1 per batch*
Diesel- and Heavy Oil-Range Total Petroleum Hydrocarbons (with acid/silica gel cleanup)			1 per batch*	1 per batch*	1 per batch*	1 per batch*
PAHs			1 per batch*	1 per batch*	1 per batch*	NA
Chlorophenols			1 per batch*	1 per batch*	1 per batch*	NA
Dioxins/Furans	1 per sampling day	NA	1 per batch*	1 per batch*	NA	NA

Notes:

*An analytical batch is defined as a group of samples taken through a preparation procedure and sharing a method blank, LCS, and MS/MSD (or MS and lab duplicate). No more than 20 internal laboratory samples are contained in one batch.

LCS = Laboratory control sample

OPR = Ongoing precision and recovery

MS = Matrix spike

MSD = Matrix spike duplicate

PAHs = polycyclic aromatic hydrocarbons

NA = Not applicable

APPENDIX C
Health and Safety Plan

Site Health and Safety Plan

R.G. Haley Site
Bellingham, Washington

for
City of Bellingham

August 22, 2018

GeoEngineers

2101 4th Avenue, Suite 950
Seattle, Washington 98121
206.728.2674

Table of Contents

GEOENGINEERS, INC.
SITE HEALTH AND SAFETY PLAN
PRE-REMEDIAL DESIGN INVESTIGATON
R.G. HALEY SITE
FILE NO. 0356-114-08

1.0 INTRODUCTION

This Health and Safety Plan (HASP) has been prepared to address anticipated hazards and emergency response procedures for GeoEngineers personnel during the pre-remedial design investigation that will be performed at the R.G. Haley Cleanup Site (Site) located in Bellingham, Washington. This HASP is to be used in conjunction with the GeoEngineers, Inc. (GeoEngineers) safety programs by GeoEngineers personnel conducting soil and groundwater sampling and sample processing during the investigation; a copy of the HASP must be available on-site. If the work entails potential exposures to other substances or unusual situations, additional safety and health information will be included, and the plan will need to be approved by the GeoEngineers' Health and Safety Manager (HSM). Plans are to be used in conjunction with current standards and policies outlined in the GeoEngineers' Health and Safety Programs.

Liability Clause: If requested by subcontractors, this site HASP may be provided for informational purposes only. In this case, Form 1 shall be signed by the subcontractor. Please be advised that this site-specific HASP was written for use only by GeoEngineers' employees. Nothing herein shall be construed as granting rights to GeoEngineers' subcontractors or any other contractors working on this Site to use or legally rely on this HASP. GeoEngineers specifically disclaims any responsibility for the health and safety of any person not employed by the company.

1.1. General Project Information

Project Name	R.G. Haley Site Pre-Remedial Design Investigation
GeoEngineers Project Number	00356-114-08
Type of Project	Subsurface soil and groundwater exploration, soil and groundwater sampling, subsurface debris survey
Project Address	Cornwall Avenue & Pine Street, Bellingham, Washington
Start/Completion	Summer 2018/Fall 2018
Subcontractors	Utility Locate Subcontractor – Applied Professional Services Drilling Subcontractor – Cascade Drilling LLC Debris Survey Subcontractor - TBD Sheetpile Corrosion Testing Subcontractor – TBD

2.0 SITE BACKGROUND

The Site is located at the foot of Cornwall Avenue, near the intersection with Pine Street, in Bellingham, Washington (see Figure 1 in main work plan text) and composed of both an upland and marine unit.

2.1. Site Description

The upland Site surface is relatively flat and composed primarily of fill (e.g., dredged material, debris, garbage, etc.) and abuts the adjacent Cornwall Avenue Landfill, which is also undergoing cleanup. The Site shoreline is composed of a low to moderate bank with a coarse-grained beach sloping to the west. The bank and beach contain broken pile, riprap, construction and wood debris (refer to the Remedial Investigation/Feasibility Study report for a detailed description of the Site (GeoEngineers 2016). The upland Site is vacant and mostly surrounded by a chain link fence; only authorized vehicles can access the upland via a locked gate. Beach access is limited to trespassers, although use of the Pine Street beach at the foot of Cornwall Avenue is relatively common by local residents.

2.2. Site History

More than a century of industrial waterfront activities have affected environmental conditions at the Haley Site. The most prevalent impacts at the Haley Site were caused by past wood treatment including treated wood storage activities. Historical lumber mill activities also occurred at the Site, much of which occurred on overwater structures supported by wooden pilings. Former tidelands that comprise the present-day Haley upland were filled with lumber mill-derived wood debris, apparent construction debris, dredged marine sediment, and landfill waste.

Wood treatment activities were conducted at the Site from about 1948 to 1985. The wood was treated using pentachlorophenol (PCP) in a P-9 carrier oil (diesel-range petroleum) and this liquid was released to soil and groundwater at the Site. Wood treatment products leaked or were discharged to the shoreline area in the vicinity of the upland. Marine hydrological processes caused contaminated sediment to be redistributed in the nearshore area. Contaminated groundwater discharging in the nearshore area may have also contributed to the release of site chemicals-of-concern (COCs). Currently, soil, groundwater and sediment are contaminated with site-related chemicals at levels that may pose a risk to people and environmental receptors.

Chemicals released to environmental media (soil, groundwater and sediment) include pentachlorophenol (PCP) in a diesel oil carrier (measured as part of total petroleum hydrocarbons [TPH]), dioxins/furans (associated with the PCP), and polycyclic aromatic hydrocarbons (PAHs).

3.0 WORK PLAN

Details regarding the investigation purpose, objectives and scope are provided in the Pre-Remedial Design Investigation Project Plans (GeoEngineers 2018). The investigation scope is expected to include:

1. In-situ soil solidification (ISS) Footprint Refinement Soil Exploration
    a. Subsurface investigation including drilling (direct-push methods) and soil sampling. Soil samples will be obtained, field screened, and submitted to a laboratory.
2. Debris Survey
    a. Subsurface debris survey and documentation using Ground Penetrating Radar equipment.
3. Sheetpile Integrity Evaluation
    a. Measurement of sheetpile thickness and visual inspection of the integrity of interlocks at ground surface.

b. Ultrasonic thickness testing at low tide where corroded sheet pile is exposed along the shoreline.

4. Northern Site Boundary Refinement Soil and Groundwater Explorations

   a. Subsurface investigation including drilling (direct-push methods) and soil sampling. Soil samples will be obtained, field screened, and submitted to a laboratory.

   b. Installation (hollow stem auger drilling method) and development of groundwater monitoring well. Sample groundwater for chemical analyses and submit to a laboratory.

5. Selected Site Monitoring Well Sampling

   a. Sample groundwater from selected groundwater monitoring wells for chemical analyses.

6. Survey

   a. Surveying of exploration locations by hand-held global positioning system (GPS) unit. Monitoring well installed expected to be surveyed by professional land surveyor.

3.1. Schedule

Work is anticipated to occur in the fall of 2018.

3.2. List of Field Activities

Check the activities to be completed during the project:

☒ Job Hazard analyses (JHA) Form 3

☒ Site Reconnaissance

☒ Exploratory Borings

☐ Construction Monitoring

☒ Surveying

☐ Test Pit Exploration

☒ Soil Sample Collection

☒ Groundwater Sampling

☒ Groundwater Depth and Free Product Measurement

☐ Sediment Sampling (grabs and cores)

☒ Vapor Measurements (continuous PID monitoring)

☐ Product Sample collection

☐ Soil Stockpile Testing

☐ Remedial Excavation

☐ Recovery of Free Product

☒ Monitoring Well Installation

☒ Monitoring Well Development

☐ Underground Storage Tank (UST) Removal Monitoring

☒ Other: Core logging

☒ Field Screening of Samples (visual observation, PID readings, water sheen testing)

3.1. List of Field Personnel and Training

Anticipated field personnel include:

- Brian Anderson, Paul Robinette

Field personnel will have appropriate training (Hazardous Waste Operations and Emergency Response [HAZWOPER], first aid, respirator fit test, HAZWOPER supervisor training) and up to date certifications.

3.2. Chain of Command and Responsibilities

Key project personnel and GeoEngineers chain of command for the pre-remedial design investigation is presented in the following table. Functional responsibilities for GeoEngineers personnel during implementation of this work are described in the following sections.

Chain of Command	Title	Name	Telephone Numbers
1	Health and Safety Manager (HSM)	Mary Lou Sullivan	(o) 253.722.2425 (c) 360.633.9821
2	Project Manager	Sydney Bronson	(o) 206.518.5140 (c) 206.295.9571
3	Site Safety Officer (SSO)	Paul Robinette	(c) 253-278-0273 (o) 253-722-2794
4	Field Personnel	Brian Anderson, Paul Robinette	(c) 425-750-1326
5	Client	City of Bellingham, Craig Mueller	--
N/A	Subcontractor(s)	Applied Professional Services, Cascade Drilling, OnSite Environmental, Frontier Analytical Laboratory	Not applicable

3.2.1. Health and Safety Manager (HSM)

GeoEngineers' HSM is responsible for implementing and promoting employee participation in the program. The HSM issues directives, advisories and information regarding health and safety to the technical staff. Additionally, the HSM has the authority to audit on-site compliance with HASPs, suspend work or modify work practices for safety reasons, and dismiss from the Site any GeoEngineers or subcontractor employees whose conduct on the Site endangers the health and safety of themselves or others.

3.2.2. Project Manager (PM)

A project manager (PM) is assigned to manage the activities of various projects and is responsible to the principal-in-charge of the project. The PM is responsible for assessing the hazards present at a job site and incorporating the appropriate safety measures for field staff protection into the field briefing and/or Site Safety Plan. He or she is also responsible for assuring that appropriate HASPs complying with this manual are developed. The PM will provide a summary of chemical analysis to personnel completing the HASP. PMs shall also see that their project budgets consider health and safety costs. The PM shall keep the HSM informed of the project's health- and safety-related matters as necessary. The PM shall designate the project site safety officer (SSO) and help the SSO implement the specifications of the HASP. The PM is responsible for communicating information in site safety plans and checklists to appropriate field personnel. Additionally, the PM and SSO shall hold a site safety briefing before any field activities begin. The PM is responsible for transmitting health and safety information to the SSO when appropriate.

3.2.3. Site Safety Officer/HAZWOPER (SSO)

The SSO will have the on-site responsibility and authority to modify and stop work, or remove personnel from the site if working conditions change that may affect on-site and off-site health and safety. The SSO will be the main contact for any on-site emergency situation. The SSO is First Aid and cardiopulmonary resuscitation (CPR)-qualified, and has current Hazardous Waste Operations and Emergency Response (HAZWOPER) training. The SSO is responsible for implementing and enforcing the project safety program and safe work practices during Site activities. The SSO shall conduct daily safety meetings, perform air monitoring as required, conduct Site safety inspections as required, coordinate emergency medical care, and ensure personnel are wearing the appropriate personal protective equipment (PPE). The SSO shall have advanced field work experience and shall be familiar with health and safety requirements specific to the project. The SSO has the authority to suspend Site activities if unsafe conditions are reported or observed.

Duties of the SSO include the following:

- Implementing the HASP in the field and monitoring compliance with its guidelines by staff.
- Being sure that GeoEngineers field personnel have met the training and medical examination requirements. Advising other contractor employees of these requirements.
- Maintaining adequate and functioning safety supplies and equipment at the Site.
- Setting up work zones, markers, signs and security systems, if necessary.
- Performing or supervising air quality measurements. Communicating information on these measurements to GeoEngineers field staff and subcontractor personnel.
- Communicating health and safety requirements and site hazards to field personnel, subcontractors and contractor employees, and site visitors.
- Directing personnel to wear PPE and guiding compliance with health and safety practices in the field.
- Consulting with the PM regarding new or unanticipated site conditions, including emergency response activities. If monitoring detects concentrations of potentially hazardous substances at or above the established exposure limits, notify/consult with the PM. Consult with the PM and the HSM regarding new or unanticipated site conditions, including emergency response activities. If field monitoring indicates concentrations of potentially hazardous substances at or above the established exposure limits, the HSM must be notified and corrective action taken.
- Documenting accidents, illnesses and unsafe activities or conditions, and reporting them to the PM and the HSM.
- Directing decontamination operations of equipment and personnel.

3.2.4. Field Personnel

Field staff working on-site that have the potential of coming in contact with hazardous substances or physical hazards are responsible for participating in the health and safety program and complying with the site specific health and safety plans. These staff are required to:

- Participate and be familiar with the health and safety program as described in this plan.

- Notify the SSO that when there is need to stop work to address an unsafe situation.
- Comply with the HASP and acknowledge understanding of the plan.
- Report to the SSO, PM or HSM any unsafe conditions and all facts pertaining to incidents or accidents that could result in physical injury or exposure to hazardous materials.
- Participate in health and safety training, including initial 40-hour Occupational Safety and Health Administration (OSHA) course, annual 8-hour HAZWOPER refresher, and First Aid/CPR training.
- Participate in the medical surveillance program if applicable.
- Schedule and take a respirator fit test annually.
- Any field employee working onsite may stop work if the employee believes the work is unsafe.

3.2.5. Contractors Under GeoEngineers Supervision

Contractors working on the Site under GeoEngineers supervision or direct control that have the potential of coming in contact with hazardous substances or physical hazards shall have their own health and safety program that is in line with the site specific health and safety plan.

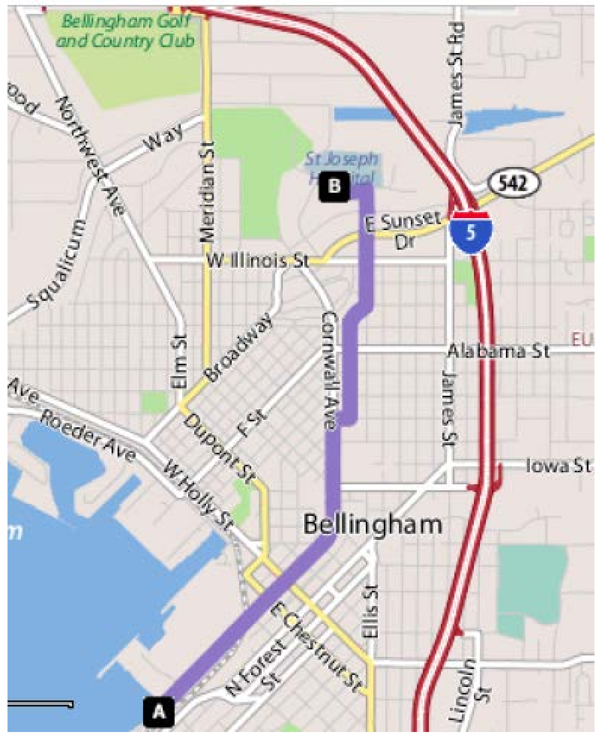
4.0 EMERGENCY INFORMATION

Hospital Name and Address:	St. Joseph Hospital and Medical Center 2901 Squalicum Parkway Bellingham, WA 98225-1898
Phone Numbers (Hospital ER):	**Hospital Phone**: 360.734.5400 **ER Phone:** 206.731.3000
Distance:	2.64 miles

Route to Hospital:

1. Start at 500 Cornwall Ave., Bellingham going toward E Pine St – go 2.32 mi
2. Turn Right on Sunset Drive – go 0.73 mi
3. Turn Left on Ellis St – go 0.72 mi
4. Turn Left on Squalicum Pkwy – go 0.10 mi
5. Arrive at 2901 Squalicum Pkwy on the Right

Map to Hospital:



Ambulance:	9-1-1
Poison Control:	Seattle 206.526.2121; Other 1.800.222.1222
Police:	9-1-1
Fire:	9-1-1
Location of Nearest Telephone:	Cell phones are carried by field personnel.
Nearest Fire Extinguisher:	Located in the GeoEngineers vehicle on-site.
Nearest First-Aid Kit:	Located in the GeoEngineers vehicle on-site.

4.1. Emergency Response

- Personnel on-site may be working alone. Field personnel should carry a cell phone programmed with the Puget Sound GeoEngineers office numbers should it be necessary to communicate to others regarding emergencies.

- If any member of the field crew experiences any adverse exposure symptoms while on-site, the entire field crew should immediately halt work and act according to the instructions provided by the Site Safety Officer.
- The discovery of any condition that would suggest the existence of a situation more hazardous than anticipated should result in the evacuation of the field team, contact of the SSO and PM, and reevaluation of the hazard and the level of protection required.
- If an accident occurs, the Site Safety and Health Supervisor and the injured person are to complete an Accident Report within 24 hours for submittal to the PM, the Health and Safety Manager and Human Resources. The PM should ensure that follow-up action is taken to correct the situation that caused the accident or exposure.

4.2. Standard Emergency Procedures

Get help

- Send another worker to phone 9-1-1 (if necessary)
- As soon as feasible, notify GeoEngineers' Project Manager

Reduce risk to injured person

- Turn off equipment
- Move person from injury location (if in life-threatening situation only)
- Keep person warm
- Perform CPR (if necessary)

Transport injured person to medical treatment facility (if necessary)

- By ambulance (if necessary) or GeoEngineers vehicle
- Stay with person at medical facility
- Keep GeoEngineers PM apprised of situation and notify Human Resources Manager of situation

5.0 HAZARD ANALYSIS

A hazard analysis has been completed as part of preparation of this HASP. The hazard analysis was performed taking into account the known and potential hazards at the Site and surrounding areas, as well as the planned work activities. The results of the hazard analysis are presented in this section. The hazard assessment will be evaluated each day before beginning work. Updates will be made as necessary and documented in the Job Hazard Analyses (JHA) Form 3 or daily field log.

The following are known or potential hazards.

5.1. Physical Hazards

☒ Drill rigs and Concrete Coring, including working inside a warehouse

☐ Backhoe

☐ Trackhoe

☐ Crane

☐ Front End Loader

☐ Excavations/trenching (1:1 slopes for Type B soil)

☐ Shored/braced excavation if greater than 4 feet of depth

☐ Hydraulically deployed sampling equipment; cable and winch operations.

☒ Tripping/puncture hazards: working close to eroded 4 to 6-foot tall bluff along shoreline. In places the edge of the bluff is obscured by vegetation, so care should be taken to ensure sure footing.

☐ Unusual traffic hazard – Street traffic

☒ Heat/Cold, Humidity

☒ Utilities/ utility locate

☐ Noise

☒ Transients frequent the Site and GeoEngineers personnel should leave the Site and call police at any indication of a threat.

☐ Over-water work

☐ Marine boat traffic

☒ Tide fluctuations in portion of Site affected by tides

5.1.1. Safe Work Practices

- A utility-locate shall be completed, as required, for the location to prevent drilling or digging into utilities.
- Upland work areas will be marked with reflective cones, barricades and/or caution tape. High-visibility vests will be worn by on-site personnel to ensure they can be seen by vehicle and equipment operators.
- Wear steel toes boots with puncture resistant soles.
- Personnel will avoid tripping hazards, steep slopes, pits and other hazardous encumbrances. If it becomes necessary to work within 6 feet of the edge of a pit, slope or other potentially hazardous area, appropriate fall protection measures will be implemented by the Site Safety Officer in accordance with OSHA/DOSH regulations and the GeoEngineers Health and Safety Program.
- Cold stress control measures will be implemented according to the GeoEngineers Health and Safety Program to prevent frost nip (superficial freezing of the skin), frost bite (deep tissue freezing), or hypothermia (lowering of the core body temperature). Heated break areas and warm beverages shall be available during periods of cold weather.
- Heat stress control measures required for this Site will be implemented according to GeoEngineers Health and Safety Program with water provided on-site.
- Wrap-around safety glasses will be worn during sampling to protect against splashing or other potential eye injuries.
- Personnel shall understand the times and magnitude of tides when working in the intertidal areas.

5.2. Biological Hazards and Procedures

Limited biological hazards are anticipated for this field investigation, as work will primarily be performed over water. Some inadvertent contact with insects or wildlife may occur.

☐ Poison Ivy or other vegetation	Hard hat, gloves and long sleeve shirt
☒ Insects or snakes	Work gloves and long sleeve shirt
☒ Hypodermic needles or other infectious hazards	Do not pick up or contact
☒ Wildlife	Click here to enter text.
☒ Other: Blackberry bushes, bird and mammal droppings	Hard hat, gloves and long sleeve shirt

5.2.1. Safe Practices and Protective Measures

- Avoid contact with wild or stray animals. If bitten or scratched, get medical attention immediately.
- Avoid contact with rats or rat-infested buildings. If you can't avoid contact, wear protective gloves and wash your hands regularly.
- Avoid contact with animal and bird droppings. Particles can become airborne and, if inhaled, cause sickness.
- Report dead animals to the proper authorities so they can be disposed of properly.
- Wear long pants, long sleeves, and socks. Tuck pants into boots or socks to provide an insect barrier.
- Be alert when working around abandoned buildings or debris.
- Wear work gloves, and stay on the lookout for spiders.
- Seek medical attention if bitten by a poisonous spider or deer tick or if you experience severe symptoms.
- Avoid scented soaps and perfumes.
- Don't leave food, drinks, and garbage out uncovered.

5.3. Ergonomic Hazard Mitigation Measures and Procedures

Back injuries often result from lifting objects that are too heavy or from using the wrong lifting technique. Employees shall keep their back healthy and pain-free by following common sense safety precautions.

- Minimize reaching by keeping frequently used items within arm's reach, moving your whole body as close as possible to the object.
- Avoid overextending by standing up when retrieving objects on shelves.
- Perform regular stretching exercises.
- Get help from a coworker or use a hand truck if the load is too heavy or bulky to lift alone.

5.3.1. Proper Lifting Techniques

- Face the load; don't twist. Stand in a wide stance with feet close to the object.
- Bend at the knees, keeping your back straight. Wrap arms around the object.
- Let legs do the lifting.
- Hold the object close to body and stand up straight. To set the load down, bend at the knees, not from the waist.

5.4. Chemical Hazards

CHEMICAL HAZARDS (POTENTIALLY PRESENT AT SITE)

Substance	Pathways
Pentachlorophenol (PCP)	Direct contact
Dioxins/furans (PCDDs, TCDDs, related congeners and other organics)	Direct contact
Petroleum hydrocarbons (as diesel)	Direct contact
Polycyclic aromatic hydrocarbons (PAHs)	Direct contact

SPECIFIC CHEMICAL HAZARDS AND EXPOSURES (POTENTIALLY PRESENT AT SITE)

Chemical or Compound/ Description	Exposure Limits	Exposure Routes	Immediate Symptoms of Exposure/Health Effects
Pentachlorophenol	PEL 0.5 mg/m^3 TLV 0.5 mg/m^3 REL 0.5 mg/m^3 IDLH 2.5 mg/m^3	Inhalation, ingestion, skin and/or eye contact	Irritating to the eyes, nose, throat; sneezing, cough; lassitude (weakness, exhaustion), anorexia, weight loss; sweating; headache, dizziness; nausea, vomiting; dyspnea (breathing difficulty), chest pain; high fever; dermatitis.
Dioxins/furans (PCDDs, TCDDs, related congeners and other organics)	See below	Ingestion, skin and/or eye contact	Increased risk of severe skin lesions such as chloracne and hyperpigmentation, altered liver function and lipid metabolism, general weakness associated with drastic weight loss, changes in activities of various liver enzymes, depression of the immune system, and endocrine- and nervous-system abnormalities
Diesel Fuel — liquid with a characteristic odor	None established by OSHA, but ACGIH has adopted 100 mg/m^3 for a TWA (as total hydrocarbons)	Ingestion, inhalation, skin absorption, skin and eye contact	Irritated eyes, skin, and mucous membrane; fatigue; blurred vision; dizziness; slurred speech; confusion; convulsions; headache; dermatitis
Polycyclic aromatic hydrocarbons (PAHs) as coal tar pitch volatiles	PEL 0.2 mg/m^3 TLV 0.2 mg/m^3 REL 0.1 mg/m^3 IDLH 80 mg/m^3	Inhalation, ingestion, skin and/or eye contact	Dermatitis, bronchitis, potential carcinogen

Notes:

IDLH = immediately dangerous to life or health

OSHA = Occupational Safety and Health Administration

ACGIH = American Conference of Governmental Industrial Hygienists

mg/m^3 = milligrams per cubic meter

TWA = time-weighted average (over 8 hrs.)

PEL = permissible exposure limit

TLV = threshold limit value (over 10 hrs)

STEL = short-term exposure limit (15 min)

ppm = parts per million

CHAPTER 296-841 WAC AIRBORNE CONTAMINANTS SAFETY AND HEALTH CORE RULE (UNLESS OTHERWISE NOTED)

Airborne contaminant		TWA 8	STEL	Ceiling	Skin
Diesel Fuel, as total hydrocarbons ACGIH TWA 8		100 mg/m³			X
Dioxins/furans	See discussion below				
Pentachlorophenol		0.5 mg/m³	1.5 mg/m³		X
Polycyclic Aromatic Hydrocarbons (PAHs)					
Polychlorobiphenyls (Chlorodiphenyls)	42% Chlorine (PCB)	1 mg/m³	3 mg/m³		X
	54% Chlorine (PCB)	0.5 mg/m³	1.5 mg/m³		X

Notes:

mg/m³ = milligrams per cubic meter

PCB = polychlorinated biphenyl

TWA = time-weighted average (over 8 hrs.)

STEL = short-term exposure limit (15 min)

5.5. Summary of Selected Chemical Hazards

5.5.1. Pentachlorophenol (PCP)

PCP, like other chlorinated phenolics, n-nitrosodiphenylamine, and dibenzofuran are absorbed through the skin. They are irritating to eyes, nose, and mucous membranes. They are potential carcinogens or listed as animal carcinogens. When inhaled they may cause cough, dizziness, headache, drowsiness, difficulty breathing, and sore throat. They are also hazardous by ingestion (soil particles, etc.) causing abdominal cramps, diarrhea, nausea, vomiting, and weakness. PCP has low volatility (VP @ 77 degrees F is 0.0001 mmHg) like the others, but often the combination of chemical odors in oils or heavily contaminated soils can cause transient nausea and headache. PCP (liquid) has an IDLH limit of 2.5 mg/m³ based on acute toxicity data in humans. This may be a conservative value due to the lack of relevant acute toxicity data for workers exposed to concentrations above 2.4 mg/m³.

5.5.2. Dioxins/Furans

Dioxins refers to a group of toxic chemical compounds that share certain chemical structures and biological characteristics. Several hundred of these chemicals exist and are members of three closely related families:

- Chlorinated dibenzo-p-dioxins (CDDs),
- Chlorinated dibenzofurans (CDFs) and
- Certain PCBs.

CDDs may cause a number of health effects in humans, via exposure to high levels of these chemicals. 2,3,7,8-TCDD, in particular, is considered a Group 1 carcinogen by the International Agency for Research on Cancer (IARC), a probable human carcinogen by the US Environmental Protection Agency (EPA) and "reasonably anticipated to be a carcinogen" by the National Toxicology Program (NTP). Health-effects data for people obtained from occupational settings are based on exposure to mixtures of CDDs at high concentrations or chemicals contaminated with CDDs. It produces a variety of toxic effects in animals and is considered one of the most toxic chemicals known. Most of the toxicity data available are from high-dose oral exposures to animals (including tumor production, immunological dysfunction, and teratogenesis). Some human dermal and inhalation exposure data are available in the literature.

It is important for field personnel to remember that while dioxins/furans are toxic and carcinogenic, much of the past exposure information is based on high doses to liquid product or ingestion of highly contaminated food products. There is a wide range of difference in sensitivity to regarding lethality in animals. The signs and symptoms of overexposure to chemicals contaminated with dioxins in humans, however, are similar to those observed in animals – i.e. damage to the skin; developmental delay of proper organ development; immune system problems and reproductive effects.

These products are not very volatile, so the major concern is on **preventing dermal absorption and incidental ingestion of soil particles**. In addition, **dust creation should be minimized, to prevent inhalation of contaminated particles**. Care should be taken to minimize potential dermal exposure, especially when sampling from drums and wells known to contain detectable levels of dioxins. Emphasis will be on working outside in well-ventilated areas using proper personal protective equipment (PPE; as discussed later in this plan).

Dioxin-contaminated soil may result in dioxins occurring in a food chain. This is especially important for the general population. It has been estimated that about 98 percent of exposure to dioxins is through the oral route. Exposure as a vapor is normally negligible because of the low vapor pressure typical of these compounds. In the 1980s, a concentration level of 1 ppb 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) in soil was specified as "a level of concern," based on cancer effects. However, recent studies indicate that end points other than cancer (such as those listed above) are also of concern based on a projected intake from 1 ppb TCDD in soil. **To prevent dermal absorption and incidental ingestion wear nitrile gloves when handling soil or groundwater samples, wash hands and forearms with warm soapy water before breaks and maintain good personal hygiene in the field to prevent tracking contaminated material into field vehicles.**

5.5.3. Diesel Oil

Diesel fuels are similar to fuel oils used for heating (fuel oils no. 1, no. 2 and no. 4). All fuel oils consist of complex mixtures of aliphatic and aromatic hydrocarbons. Diesel fuels predominantly contain a mixture of C10 through C19 hydrocarbons, which include approximately 64 percent aliphatic hydrocarbons, 1 to 2 percent olefinic hydrocarbons and 35 percent aromatic hydrocarbons. Workers may be exposed to fuel oils through their skin without adequate protection, such as gloves, boots, coveralls or other protective clothing. Breathing diesel fuel vapors for a long time may damage your kidneys, increase your blood pressure, or lower your blood's ability to clot. Constant skin contact (for example, washing) with diesel fuel may also damage your kidneys. IARC has determined that residual (heavy) fuel oils and marine diesel fuel are possibly carcinogenic to humans (Group 2B classification).

5.5.4. Polycyclic Aromatic Hydrocarbons (PAHs), Carcinogenic PAHs (cPAHs)

Exposure to carcinogenic PAHs (cPAHs) can occur via inhalation of vapors, ingestion, and skin and eye contact. Skin contact can result in reddening or corrosion. Ingestion can cause nausea, vomiting, blood pressure fall, abdominal pain, convulsions and coma. Damage to the central nervous system can also occur. The U.S. Department of Health and Human Services (1989) has classified 15 PAHs compounds as having sufficient evidence for carcinogenicity, while EPA (1990) has classified at least five of the identified PAHs as human carcinogens. There is no currently assigned permissible exposure limit/time-weighted average (PEL-TWA) for cPAHs, but the closely related material coal tar is listed as coal tar pitch volatiles with a PEL-TWA of 0.2 mg/m^3. PAHs and cPAHs as soil contaminants can be irritating to eyes and mucous membranes. PAHs are also formed during combustion and are linked to lung cancers with exposure to combustion byproducts. Lymphatic cancers are reported in the literature with PAHs in the presence of carbon black.

5.6. Additional Hazards

Additional hazards that are specific to your site should be identified here or on the Job Hazard Analyses (JHA) Form 3.

Daily field logs should include evaluation of:

- *Physical Hazards* (excavations and shoring, equipment, traffic, tripping, heat stress, cold stress and others)
- *Biological Hazards* (snakes, spiders, bees/wasps, animals, discarded needles, poison ivy, pollen, and others present)
- *Ergonomic Hazards* (lifting heavy loads, tight work spaces, etc.)
- *Chemical Hazards* (odors, spills, free product, airborne particulates and others present)

6.0 AIR MONITORING PLAN

Work will be conducted upwind of explorations if at all possible.

Air monitoring will be performed using a photoionization detector (PID) before performing work at each area to measure background conditions. Air monitoring will be performed as necessary in the breathing zone during groundwater- nonaqueous phase liquid (NAPL) sampling activities. The PID will be used to measure parts per million (ppm) of organic vapors. If the PID registers a measurable concentration in the breathing zone, air monitoring frequencies and personal protection shall be modified per the “Air Monitoring Action Levels” table below.

Check instrumentation to be used

☒ Photoionization Detector (PID)

☐ X-Ray Fluorescence Analyzer (XRF)

☐ Other (i.e., detector tubes or badges) Please specify: Click here to enter text.

Check monitoring frequency/locations and type (specify: work space, borehole, breathing zone):

☒ Continuous during sample collection

☐ 15 minutes during soil disturbance (such as drilling, soil trenching)

☐ 30 minutes

☐ Every 1 hour (at perimeter of exclusion zone during drilling or active earthwork)

6.1. Additional Personal Air Monitoring for Specific Chemical Exposure

- The workspace will be monitored using a PID. These instruments are to be maintained, calibrated and charged (refer to the instrument manuals for details). Zero this meter in the same relative humidity as the area in which it will be used and allow at least a 10-minute warm-up before zeroing. Do not zero in a contaminated area.
- An initial vapor measurement survey of the site should be conducted to detect “hot spots” if contaminated soil is exposed at the surface. Vapor measurement surveys of the workspace should be conducted at least hourly or more often if persistent petroleum-related odors are detected. Additionally, if sustained vapor concentrations exceed 2.0 ppm above background continuously for 60 seconds as measured in the breathing zone, upgrade to Level C PPE or move to a non-contaminated area.
- Standard industrial hygiene/safety procedure is to require that action be taken to reduce worker exposure to organic vapors when vapor concentrations exceed one-half the threshold limit value (TLV). Because of the variety of chemicals, the PID will not indicate exposure to a specific PEL and is therefore not a preferred tool for determining worker exposure to specific chemicals. If odors are detected, then employees shall upgrade to respirators with Organic Vapor cartridges and will contact the Health and Safety Program Manager for other sampling options.

PERSONNEL AIR MONITORING ACTION LEVELS

Chemical Type	Activity	Monitoring Device	Frequency of Monitoring Breathing Zone	Action Level	Action
Organic Vapors	Environmental Remedial Actions	PID	Start of shift; before ground disturbing activities; every 15 minutes during ground disturbing activities	Background to 2.0 parts per million (ppm) in breathing zone	Use Level D or Modified Level D PPE
Organic Vapors	Environmental Remedial Actions	PID	Start of shift; before ground disturbing activities; every 15 minutes during ground disturbing activities	2.0 to 10 ppm in breathing zone	Upgrade to Level C respiratory protection OR Temporarily step away from the area and allow the vapors to dissipate.
Organic Vapors	Environmental Remedial Actions	PID	Start of shift; before ground disturbing activities; every 15 minutes during ground disturbing activities	> 10 ppm in breathing zone	Stop work and evacuate the area. Contact Health and Safety Manager (HSM) for guidance.

Chemical Type	Activity	Monitoring Device	Frequency of Monitoring Breathing Zone	Action Level	Action
Combustible Atmosphere	Environmental Remedial Actions	4 or 5 gas meter	Start of shift; before ground disturbing activities; every 15 minutes	>10% LEL	Stop work and evacuate the site. Contact HSM for guidance.
Oxygen Deficient/ Enriched Atmosphere	Environmental Remedial Actions Confined Spaces	Oxygen meter, 4 or 5 gas meter	Start of shift; before ground disturbing activities; every 15 minutes	>19.5<23.5%	Continue work if inside range. If outside range, exit area and contact HSM.

7.0 SITE CONTROL PLAN

7.1. Work Zones

Work zones will be considered within 25 feet of the drill rig and other support equipment. Employees should work upwind of the machinery if possible. To the extent practicable, use the buddy system. Do not approach heavy equipment unless you are sure the operator sees you and has indicated it is safe to approach. All personnel from GeoEngineers and subcontractor(s) should be made aware of equipment safety features during each morning's safety tailgate meeting (location of fire extinguishers, first aid kit, etc.).

An exclusion zone, contamination reduction zone, and support zone will be established, to the extent practicable, around working areas. Personnel leaving the facility or on break should exit the exclusion zone through the contamination reduction zone. The contamination reduction zone, at a minimum, should consist of garbage bags into which used PPE should be disposed.

For monitoring well gauging and sampling, the exclusion zone will be an approximate 8-foot distance outward from the perimeter of the working area. The exclusion zone around monitoring wells will be clearly marked by GeoEngineers staff with traffic cones/candles, rope, barriers, tape, or other apparent marking methods. Inside the exclusion zone, workers will be required to have current hazardous materials training and meet all other health and safety requirements, as stated in this HASP. Exclusion zone controls including working upwind and personnel air monitoring will be implemented to limit the potential for chemical exposure associated with site activities. Access to the exclusion zone will be controlled by GeoEngineers. Only authorized personnel shall be permitted access to the exclusion zone, and staff will stop work if members of the public insist on entering.

For medical assistance, see Section 4.0 above.

Method of delineation/excluding non-site personnel

☒ Temporary chain-link fence (only areas left overnight with equipment). Fence cannot penetrate ground surface.

☒ Caution tape

☒ Traffic cones, barricades or candles

☐ Other: Click here to enter text.

7.2. Traffic or Vehicle Access Control Plans

Within the upland portion of the Site, traffic is restricted to authorized vehicles on the one road that goes through the Site; access is only through a locked gate. No work activities are planned within this road.

7.3. Buddy System

Personnel on-site should use the buddy system (pairs), particularly whenever communication is restricted. If only one GeoEngineers employee is on site, a buddy system can be arranged with subcontractor/ contractor personnel or by establishing call in/out times during the project to the Project Manager.

7.4. Site Communication Plan

Positive communications (within sight and hearing distance or via radio) should be maintained between pairs on-site, with the pair remaining in proximity to assist each other in case of emergencies. The team should prearrange hand signals or other emergency signals for communication when voice communication becomes impaired (including cases of lack of radios or radio breakdown) and an agreed upon location for an emergency assembly area.

In instances where communication cannot be maintained, you should consider suspending work until it can be restored. If this is not an option, the following are some examples for communication:

- Hand gripping throat: Out of air, can't breathe.
- Gripping partner's wrist or placing both hands around waist: Leave area immediately, no debate.
- Hands on top of head: Need assistance.
- Thumbs up: Okay, I'm all right; or, I understand.
- Thumbs down: No, negative.

7.5. Emergency Action

In the event of an emergency, employees with convene in a designated area Identified on the JHA Form 3. Employees should communicate with others working on site and the PM to determine the Emergency Action Plan for each site. GeoEngineers employees and subcontractor(s) should be made aware of the Emergency Action for the Site at each morning's safety tailgate meeting (drill rig shutoff switch, location of fire extinguishers, cell phone numbers, etc.). For medical assistance, see Section 3.0 above.

7.6. Decontamination Procedures

Decontamination, at a minimum, should include removing and disposing of PPE when exiting the exclusion zone; and washing hands. Decontamination may also consist of removing outer protective gloves and washing soiled boots and gloves using bucket and brush provided on-site in the contamination reduction zone. If needed, inner gloves will then be removed, and respirator, hands and face will be washed in either a portable wash station or a bathroom facility at the Site. Soiled boots (if boot covers not worn) should be cleaned using bucket and brush provided on-site in the decontamination area. Drilling contractor will clean equipment as needed while sampling personnel will perform decontamination of sampling equipment between each monitoring well/soil boring location. Employees will perform decontamination procedures and wash before eating, drinking or leaving the Site.

7.7. Waste Disposal or Storage

Used PPE is to be placed in plastic bags within labelled spent PPE waste containers located in the investigative waste storage area.

Investigation-derived waste (IDW) will be generated during field activities. The IDW that is generated during the sampling, including drill cuttings and development/decontamination water, will be contained in 55-gallon drums and temporarily stored on site. The drums with decontamination water and well development water will be disposed at a permitted disposal facility after waste characterization is completed.

7.8. Spill Containment Plans (Drum and Container Handling)

Drums will be fitted with secure lids to limit the potential for spills. A spill containment plan will be prepared if required by the client.

7.9. Sampling, Managing and Handling Drums and Containers

Drums and containers used during the cleanup shall meet the appropriate Department of Transportation (DOT), Occupational Safety and Health Administration (OSHA) and EPA regulations for the waste that they contain. Site operations shall be organized to minimize the amount of drum or container movement. When practicable, drums and containers shall be inspected and their integrity shall be ensured before they are moved. Unlabeled drums and containers shall be considered to contain hazardous substances and handled accordingly until the contents are positively identified and labeled. Before drums or containers are moved, all employees involved in the transfer operation shall be warned of the potential hazards associated with the contents.

Drums or containers and suitable quantities of proper absorbent shall be kept available and used where spills, leaks or rupture may occur. Where major spills may occur, a spill containment program shall be implemented to contain and isolate the entire volume of the hazardous substance being transferred. Fire extinguishing equipment shall be on hand and ready for use to control incipient fires.

Drill cutting/well development/decontamination water disposal or storage:

☐ On site, pending analysis and further action

☒ Secured (list method): On-site in 55-gallon drums

☐ Other (describe destination, responsible parties): Click here to enter text.

8.0 PERSONAL PROTECTIVE EQUIPMENT

Minimum level of PPE for this Site is Level D. After the initial and/or daily hazard assessment has been completed, select the appropriate protective gear (PPE) to preserve worker safety. Task-specific levels of PPE shall be reviewed with field personnel during the pre-work briefing conducted before drilling/sampling activities begin.

Personnel air monitoring will be conducted to determine the level of respiratory protection.

- Half-face combination organic vapor/particulate air cartridge respirators will be available on site to be used as necessary. Combination organic vapor/P100 cartridges are protective against both dust and vapor. Check that the PID will detect the chemicals of concern on site.

- Level D PPE, unless a higher level of protection is required, will be worn on the site. Potentially exposed personnel will remove gloves and wash hands, face and other pertinent items before hand-to-mouth activities including eating, smoking, etc.
- Adequate personnel and equipment decontamination will be used to decrease potential ingestion and inhalation.

Check applicable personal protection gear to be used:

☒ Hardhat

☒ Steel-toed boots (if crushing hazards are a potential or if client requests)

☒ Safety glasses (as necessary for dust, particles, or other hazards are present, and during handling/mixing of reagents and injection of reagent)

☒ Reflective vest (if working near traffic or equipment)

☒ Hearing protection (if it is difficult to carry on a conversation 6 feet away)

☒ Rubber boots (if wet conditions)

Gloves (specify):

☒ Nitrile, as necessary to provide dermal protection against chemical hazards

☐ Latex

☒ Leather, as necessary to provide hand protection against physical hazards

Protective clothing:

☒ Cotton (Level D)

☐ Rain gear (as needed) (Level D)

☐ Layered warm clothing (as needed) (Level D)

Inhalation hazard protection:

☐ Level D (no respirator)

If additional dermal or respiratory protection is required, the following will be added to Level D PPE as appropriate:

Protective clothing:

☒ Tyvek, as necessary for dermal protection (if dry conditions are encountered, Tyvek is sufficient) (modified Level D or Level C)

Inhalation hazard protection:

☐ Level C respirators with organic vapor/P100 filters will be onsite with workers if conditions warrant upgrading respiratory protection.

☐ Level B (Self Contained Breathing Apparatus) STOP, Consult the HSM

8.1. Personal Protective Clothing Checks

PPE clothing ensembles designated for use during site activities shall be selected to provide protection against known or anticipated hazards. However, no protective garment, glove or boot is entirely chemical-resistant, nor does PPE provide protection against all types of hazards. To obtain optimum performance from PPE, site personnel shall be trained in the proper use and checking of PPE. This training shall include the following:

- Check PPE before and during use for imperfect seams, non-uniform coatings, tears, poorly functioning closures or other defects. If the integrity of the PPE is compromised, proceed to the contamination reduction zone and replace the PPE.
- Check PPE during use for visible signs of chemical permeation such as swelling, discoloration, stiffness, brittleness, cracks, tears or other signs of punctures. If the integrity of the PPE is compromised, proceed to the contamination reduction zone and replace the PPE.
- Disposable PPE should not be reused after breaks unless it has been decontaminated.

8.2. Respirator Selection, Use and Maintenance

GeoEngineers has developed a written respiratory protection program in compliance with OSHA requirements contained in 29 Code of Federal Regulations (CFR) 1910.134. Site personnel shall be trained on the proper use, maintenance, and limitations of respirators. Site personnel that are required to wear respiratory protection shall be medically qualified to wear respiratory protection in accordance with 29 CFR 1910.134. Site personnel that use a tight-fitting respirator are to have passed a qualitative or quantitative fit test conducted in accordance with an OSHA-accepted fit test protocol. Fit testing should be performed annually or whenever a new type of respirator is used.

8.3. Respirator Cartridges

If the action levels identified in the Personnel Air Monitoring Action Levels Table in Section 5.0, are exceeded, site personnel should don respiratory protection appropriate for the known or suspected chemicals of concern. For most sites, a half-face or full-face air purifying respirator with a National Institute for Occupational Safety and Health (NIOSH)-approved organic vapor/P100 combination cartridge (Level C), will be appropriate for the known or suspected chemicals of concern. Monitoring frequency should be continuous while using Level C respiratory protection. The SSO will closely monitor personnel using respiratory protection, including observing for signs of fatigue or respiratory distress, the potential for cartridge breakthrough or increased resistance to inhalation, and the need for changes in the level of respiratory protection based on personnel air monitoring. The frequency and duration of breaks should be increased for personnel working in respiratory protection. If personnel air monitoring indicates Level B respiratory protection is warranted, personnel should leave the exclusion zone and consult with the HSM.

If site personnel are required to wear air-purifying respirators, the appropriate cartridges shall be selected to protect personnel from known or anticipated site chemicals of concern. The respirator/cartridge combination shall be NIOSH-approved. A cartridge change-out schedule shall be developed based on known site chemicals of concern, anticipated chemical concentrations and data supplied by the cartridge manufacturer related to the absorption capacity of the cartridge for specific chemicals. Site personnel shall be made aware of the cartridge change-out schedule before the initiation of site activities. Site personnel shall also be instructed to change respirator cartridges if they detect increased resistance during inhalation or detect vapor breakthrough by smell, taste or feel, although breakthrough is not an acceptable method of determining the change-out schedule. Cartridges should be changed a minimum of once daily.

8.4. Respirator Checks and Cleaning

The SSO shall periodically (weekly) check respirators at the project site. Site personnel shall check respirators before each use in accordance with the manufacturer's instructions. In addition, site personnel wearing a tight-fitting respirator shall perform a positive and negative pressure user seal check each time the respirator is donned, to check for proper fit and function. User seal checks shall be performed in accordance with the GeoEngineers' respiratory protection program or the respirator manufacturer's instructions.

Respirators shall be hygienically cleaned as often as necessary to maintain the equipment in a sanitary condition. At a minimum, respirators shall be cleaned at the end of each work shift. Respirator cleaning procedures shall include an initial soap/water cleaning, a water rinse, a sanitizing soaking, and a final water rinse. One capful of bleach per one gallon of water can be used to create the sanitizing soak solution. When not in use, respirators shall be stored to protect against damage, hazardous chemicals, sunlight, dust, excessive temperatures, and excessive moisture. In addition, respirators shall be stored to avoid deformation of the face piece and exhalation valve.

8.5. Facial Hair and Corrective Lenses

Site personnel with facial hair that interferes with the sealing surface of a respirator shall not be permitted to wear respiratory protection or work in areas where respiratory protection is required. Normal eyeglasses cannot be worn under full-face respirators because the temple bars interfere with the sealing surface of the respirator. Site personnel requiring corrective lenses will be provided with a half face respirator or spectacle inserts designed for use with full-face respirators. Contact lenses should not be worn with full-face respiratory protection.

9.0 ADDITIONAL ELEMENTS

9.1. Cold Stress Prevention

Working in cold environments presents many hazards to site personnel and can result in frost nip (superficial freezing of the skin), frost bite (deep tissue freezing), or hypothermia (lowering of the core body temperature).

The combination of wind and cold temperatures increases the degree of cold stress experienced by site personnel. Site personnel shall be trained on the signs and symptoms of cold-related illnesses, how the human body adapts to cold environments, and how to prevent the onset of cold-related illnesses. Heated break areas and warm beverages shall be provided during periods of cold weather.

9.2. Heat Stress Prevention

Keep workers hydrated in a hot outdoor environment requires more water be provided than at other times of the year. When employee exposure is at or above an applicable temperature listed in the Heat Stress table below, Project Managers will check that:

- A sufficient quantity of drinking water is continuously accessible to employees; and
- All employees have the opportunity to drink at least one quart of drinking water per hour.

HEAT STRESS

Type of Clothing	Outdoor Temperature Action Levels
Non-breathing clothes including vapor barrier clothing or PPE such as chemical resistant suits	52°
Double-layer woven clothes including coveralls, jackets and sweatshirts	77°
All other clothing	89°

9.3. Emergency Response

- Personnel on site should use the "buddy system" (pairs).
- Visual contact should be maintained between "pairs" on site, with the team remaining nearby to assist each other in case of emergencies.
- During certain phases of the project, personnel on-site may be working alone. Field personnel should carry a cell phone programmed with the GeoEngineers office number should it be necessary to communicate to others regarding emergencies.
- If a member of the field crew experiences adverse exposure symptoms while on site, the entire field crew should immediately halt work and act according to the instructions provided by the SSO.
- Wind indicators visible to onsite personnel should be provided by the SSO to indicate routes for upwind escape. Alternatively, the SSO may ask onsite personnel to observe the wind direction periodically during site activities.
- The discovery of a condition that would suggest the existence of a situation more hazardous than anticipated should result in the evacuation of the field team, contact of the PM, and reevaluation of the hazard and the level of protection required.
- If an accident occurs, the SSO and the injured person are to complete, within 24 hours, an Accident Report (Form 4) for submittal to the PM, the HSM, and GeoEngineers' Human Resources Director. The PM should check that follow-up action is taken to correct the situation that caused the accident or exposure.

10.0 MISCELLANEOUS

10.1. Personnel Medical Surveillance

GeoEngineers employees are not in a medical surveillance program because they do not fall into the category of "Employees Covered" in OSHA 1910.120(f)(2), which states that a medical surveillance program is required for the following employees:

(1) Employees who are or may be exposed to hazardous substances or health hazards at or above the permissible exposure limits or, if there is no permissible exposure limit, above the published exposure levels for these substances, without regard to the use of respirators, for 30 days or more a year;

(2) Employees who wear a respirator for 30 days or more a year or as required by state and federal regulations;

(3) Employees who are injured, become ill or develop signs or symptoms due to possible overexposure involving hazardous substances or health hazards from an emergency response or hazardous waste operation; and

(4) Members of HAZMAT teams.

10.2. Sanitation

Water should be available in the decontamination area for washing.

10.3. Lighting

Work is anticipated to be performed during daylight hours. Work may extend slightly into the evening provided adequate lighting is used (e.g. portable flood lights).

11.0 DOCUMENTATION TO BE COMPLETED FOR HAZWOPER PROJECTS

- Health and Safety Summary in the Daily Field Log
- FORM 1 – Health and Safety Pre-Entry Briefing and Acknowledgment of Site Health and Safety Plan for use by employees, subcontractors and visitors
- FORM 2 – Safety Meeting Record
- FORM 3 – Job Hazard Analyses (JHA) Form
- FORM 4 – Accident/Exposure Report Form

NOTE: The Field Log is to contain the following information:

- Updates on hazard assessments, field decisions, conversations with subcontractors, client or other parties, etc.;
- Air monitoring/calibration results, including: personnel, locations monitored, activity at the time of monitoring, etc.;
- Actions taken;
- Action level for upgrading PPE and rationale; and
- Meteorological conditions (temperature, wind direction, wind speed, humidity, rain, snow, etc.).

12.0 APPROVALS

1. Plan Prepared by Sydney Bronson	Signature	August 22, 2018 Date
2. Plan Approval Rick Moore	Associate-in-Charge Signature	August 22, 2018 Date
3. Health and Safety Program Manager Mary Lou Sullivan	HSPM Signature	August 22, 2018 Date

FORM 1
HEALTH AND SAFETY PRE-ENTRY BRIEFING AND ACKNOWLEDGEMENT OF THE SITE HEALTH AND SAFETY PLAN FOR GEOENGINEERS' EMPLOYEES, SUBCONTRACTORS AND VISITORS
R.G. HALEY SITE
FILE NO. 0356-114-08

Inform employees, contractors and subcontractors or their representatives about:

- The nature, level and degree of exposure to hazardous substances they're likely to encounter;
- Site-related emergency response procedures; and
- Any identified potential fire, explosion, health, safety or other hazards.

Conduct briefings for employees, contractors and subcontractors, or their representatives as follows:

- A pre-entry briefing before any site activity is started.
- Additional briefings, as needed, to make sure that the Site-specific HASP is followed.
- Make sure employees working on the Site are informed of any risks identified and trained on how to protect themselves and other workers against the Site hazards and risks.
- Update information to reflect current sight activities and hazards.
- Personnel participating in this project must receive initial health and safety orientation. Thereafter, brief tailgate safety meetings will be held as deemed necessary by the Site Safety Officer.
- The orientation and the tailgate safety meetings shall include a discussion of emergency response, site communications and site hazards.

(GeoEngineers' Site workers shall complete this form, which should remain attached to the HASP and be filed with other project documentation). Please be advised that this site-specific HASP is intended for use by GeoEngineers employees only. Nothing herein shall be construed as granting rights to GeoEngineers' subcontractors or any other contractors working on this site to use or legally rely on this HASP. GeoEngineers specifically disclaims any responsibility for the health and safety of any person not employed by the company.

I hereby verify that a copy of the current HASP has been provided by GeoEngineers, Inc., for my review and personal use. I have read the document completely and acknowledge an understanding of the safety procedures and protocol for my responsibilities on Site. I agree to comply with the required, specified safety regulations and procedures.

Print Name **Signature** **Date**

____

____

____

____

FORM 2
SAFETY MEETING RECORD
R.G. HALEY SITE
FILE NO. 0356-114-08

Safety meetings should include a discussion of emergency response, site communications and site hazards.

- Use in conjunction with the HASP and Job Hazard Analyses (JHA) Form 3 to help identify hazards.

Date: ____________________________ **Site Safety Officer (SSO)**:__________________________________

Topics: ____

Attendees:
Print Name **Signature:**

____

____

____

____

____

____

____

____

____

____

____

____

____

____

____

____

FORM 3
JOB HAZARD ANALYSES (JHA) FORM
R. G. HALEY PRE-REMEDIAL DESIGN INVESTIGATION
FILE NO. 0356-114-08

This form can be used for analyses of daily hazards where there are multiple tasks and ongoing projects and for record keeping purposes. Make copies as needed.

Project: Site Reconnaissance **File No:** 0356-114-08	**Date:** 5/8/2018	**Site Location:** Cornwall Avenue & Pine Street, Bellingham, Washington

Exploration Team:	**Position/Title:**	**Reviewed by:**	**Position/Title:**
Name		Name	Position
Name		Name	Position

Minimum Required Protective Equipment: (see critical actions for task-specific requirements)

PPE	**Equipment**	**Tools**	**Actions**
☒ Hard Hat	☐ Safety Beacons	☒ Cell Phone/Satellite	☒ Stay Visible
☒ High Visibility Vest	☐ Safety Cones	☐ Digital Camera	☒ Equipment Checks
☒ Safety Shoes/Waders	☒ First Aid Kit	☐	☒ Work in Pairs
☒ Gloves	☒ Fire Extinguisher	☐	☒ Safety Control/Traffic Plan
☒ Safety Glasses	☐ Eye Wash/ Drinking Water	☐	☐

Job Steps	**Potential Hazards**	**Critical Actions to Mitigate Hazards**
Pre-Job Activities	Traffic congestion, Mechanical Failure, Flat Tires, Vehicle Fire, Exhaust Leaks, Vehicle Collision, Internal Projectiles	■ Check the vehicle before departure: ▪ Check for tire cuts, fluid leaks, flat tires, body damage, windshield cracks, and other damage. ▪ Check lights, wipers, fluid levels, and seat belts. ■ Study the area maps, photos and use GPS and compass skills. ■ Identify the safest spot to park field vehicles.
Familiarize crew with the task and location of site	Unidentified job site hazards, physical, chemical, ergonomic, and biological hazards. Other Hazards	■ Example: Conduct a tailgate safety meeting discussing the jobs, the hazards and actions that will be taken to avoid injury. ■ Discuss “Stop Work Authority” as it applies to each site member. ■ Discuss appropriate PPE including high visibility clothing such as reflective vest. ■ Notify owner/crew chief of work activities and location. ■ Discuss appropriate PPE including high visibility clothing such as reflective vest. ■ Set up exclusion zone surrounding work area.

Driving to work site location (Highway driving)	Unfamiliar road, Mechanical Failure, Flat Tires, Vehicle Fire, Vehicle Collision. Other Hazards	■ Check the vehicle before departure: ▪ Check for tire cuts, fluid leaks, flat tires, body damage, windshield cracks, and other damage. ▪ Check lights, wipers, fluid levels, and seat belts. ■ Study the area maps, photos and use GPS and compass skills. ■ Use only vehicles appropriate for the work needs and the driving conditions expected. ■ Check that the vehicle has a complete and current first aid kit and fire extinguisher. ■ Place heavy objects behind a secure safety cage if they are be carried in a passenger compartment. ■ Use parking brake, and don't leave vehicle unattended while it is running. ■ Check that the vehicle has fuel to get to and from your destinations. ■ Inform your Project Manager of your destination and estimated time of return. ■ Carry extra food, water, and clothing. ■ Drive defensively.
Driving on Unimproved Roads (Off-Highway Driving)	Encountering Other Vehicles on Narrow Unfamiliar Road, Narrow, Rough Roads, Animal /Object Collision, Running / Skidding Off Road, Icy / Muddy Roads, Flying Debris (Rocks, etc.), Poor Visibility, Backing, Run-Away Vehicle, Roadway Obstacles, Project Manager unaware of location.	■ Stay on the main roadway. Pull over on firm ground and avoid soft shoulders, if a stop is necessary. ■ Drive on maintained trails when practicable. ■ Drive with care in tall brush and grass. Watch for wildlife, fallen trees, rocks, and other obstacles. ■ Slow down, especially on corners. Maintain a safe speed. ■ Follow from a safe distance. ■ Know when and how to use 4WD. ■ Use only vehicles appropriate to the road conditions. Learn these conditions before you go. ■ Pull over to allow larger vehicles (i.e.: trucks and trailers) to pass from either direction. ■ Don't travel the road at all if there is high potential for vehicle damage. ■ Park so that backing up will not be necessary. ■ Use a spotter or get out to check behind vehicle. ■ Use ground guide to walk the path on questionable roadways. ■ When removing debris from the roadway, use care, use recommended lifting procedures, and use proper equipment and PPE. ■ When descending a long grade, use lower gears rather than brakes to reduce or maintain speed. ■ Keep vehicle well ventilated by opening a window at least 6 inches, when idling or heating for a period. ■ Keep all windows clear of snow, ice, mud, and anything else obstructing the driver's view. ■ Keep vehicle windows clean, inside and out, and washer fluid full. Replace damaged or worn wipers.

Traveling on Foot	Biological Hazards	■ Identify and use safe travel routes. Do not exceed physical abilities or equipment design. ■ Use pack equipment as recommended. Carry weight on hips, not back. ■ Warm up and stretch the appropriate muscle groups before and after hitting the trail. ■ Test and use secure footing. Move cautiously and deliberately. Do not run. ■ In heavy undergrowth, particularly off-trail, slow down and watch carefully. ■ Carry tools on the downhill side. ■ Wear safety-toed boots with good, non-skid soles that are tall enough to support ankles. ■ Know basic first aid. Completion of a basic first aid course is required. ■ Use footwear appropriate to the terrain and load being carried. ■ Know how to fall. Roll, protect the head and neck, and do not extend arms to break the fall. ■ Wear fire retardant clothing ■ Refer to GeoEngineers Personal Safety Program – Do not endanger your personal safety. Leave the area and contact your Project Manager. ■ Travel on maintained trails when practicable. ■ Discuss applicable hazard mitigation measures - Insects, Snakes, Wildlife, Vegetation
Mobilize and set drill rig and drill to required depth.	Caught between moving equipment. Lifting, pinch points and rotating equipment.	■ Stay clear of moving equipment and parts. ■ Use correct lifting techniques, and mechanical or physical assistance when needed. Be aware of all pinch points. ■ Do not trap yourself between equipment and stationary objects. Keep hand, feet and clothing clear of all rotating parts or equipment.
Cleaning soil cuttings from top of borehole.	Rotating Equipment, abrasions.	■ Use a shovel at all times. Do not use feet or hands to clear cuttings away from drill string.
Using sampling and tools, hoisting, core barrels.	Moving equipment, Pinch Points, Worn Tools and Equipment, Wire ropes.	■ Stay clear of moving equipment and parts. ■ Make sure all rod connections are flush and tight prior to using hammer. ■ When hoisting rods from borehole stand clear of upper load until tension in soil has released.
Setup and collection of groundwater/soil/samples	Lifting, physical hazards, handling glass containers, chemical hazards	■ Use correct lifting techniques ■ Set up exclusion boundary around each location ■ Check for broken glass jars. Use caution while handling sample glass jars ■ Use proper PPE as specified in the MSDS during sample collection to avoid splashing and skin contact.
Communication	Emergency	■ Verify cell phone is working. ■ Maintain communication with Project Manager throughout job task. ■ Verify location and contact numbers for emergency medical assistance or 911.

		■ Designated meeting point if an emergency occurs.
	Additional Hazards, i.e., Emergency	■ **Dial 911** ■ Hospital Route
Required Control Measures: (check the box when complete)		
☐ Perform a pre-work vehicle check (First Aid kit, fire extinguisher).		
☐ Drive defensively looking out for the other guy.		
☐ Conduct a pre-work safety meeting.		
☐ Use a Safety Watch to monitor equipment Minimum Approach Distance (MAD) and to keep personnel clear if needed.		
☐ Wear Personal Protective Equipment (PPE).		
☐ Check that training is current (First Aid, defensive driving, etc.).		
☐ Conduct Task Safety Assessments throughout the job.		
Additional Comments:		

DAILY HAZARD ASSESSMENT RECORD OF SAFETY MEETINGS

Signature **Date** **Signature** **Date**

____

____

____

FORM 4
ACCIDENT/EXPOSURE REPORT FORM
R.G. HALEY SITE
FILE NO. 0356-114-08

To (Supervisor): ______________________ From (Employee): ______________________

Telephone (with area code): ______________________

Name of injured or ill employee: ______________________

Date of accident: Time of accident: Exact location of accident:

Narrative description of accident/exposure (circle one):

Medical attention given on site:

Nature of illness or injury and part of body involved: Lost Time? Yes ☐ No ☐

Probably Disability (check one):

Fatal	Lost work day with days away from work	Lost work day with days of restricted activity	No lost work day	First Aid only
☐	☐	☐	☐	☐

Corrective action taken by reporting unit and corrective action that remains to be taken (by whom and when):

Employee Signature: Date:

Name of Supervisor:

GeoEngineers