Engineering Design Report
Blaine Marina, Inc. Site
Blaine, Washington

June 25, 2018

Prepared for

Port of Bellingham
Bellingham, Washington

LANDAU ASSOCIATES

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LIST OF ABBREVIATIONS AND ACRONYMS

ACM ..... asbestos-containing material
AHERA ..... Asbestos Hazard Emergency Response Act
AST ..... aboveground storage tank
bgs ..... below ground surface
BMP ..... best management practice
BTEX ..... benzene, toluene, ethylbenzene, and xylenes
CAP ..... cleanup action plan
CFR ..... Code of Federal Regulations
CL ..... cleanup level
CMP ..... compliance monitoring plan
CQA ..... construction quality assurance
CQC ..... construction quality control
Ecology ..... Washington State Department of Ecology
EDR ..... engineering design report
IHS ..... indicator hazardous substance
ft ..... foot/feet
FS ..... feasibility study
HASP ..... health and safety plan
HBMS ..... hazardous building materials survey
LAI ..... Landau Associates, Inc.
lb ..... pound
LNAPL ..... light non-aqueous phase liquid
MCL ..... maximum contaminant level
mg/kg ..... milligrams per kilogram
mg/L ..... milligrams per liter
mg N/L ..... milligrams nitrate-as-nitrogen per liter
MLLW ..... mean lower low water
MNA ..... monitored natural attenuation
MTCA ..... Model Toxics Control Act
NOAA ..... National Oceanic and Atmospheric Administration
PCB ..... polychlorinated biphenyl
PEL ..... permissible exposure limit
Port ..... Port of Bellingham
PVC ..... polyvinyl chloride
RAO ..... remedial action objective
RCW ..... Revised Code of Washington
RI ..... remedial investigation
Site ..... Blaine Marina, Inc. Site

LIST OF ABBREVIATIONS AND ACRONYMS (CONTINUED)

SMA ..... Shoreline Management Act
SWPPP ..... stormwater pollution prevention plan
TPH ..... total petroleum hydrocarbons
TPH-D ..... diesel-range total petroleum hydrocarbons
TPH-G ..... gasoline-range total petroleum hydrocarbons
VOC ..... volatile organic compound
WAC ..... Washington Administrative Code

1.0 INTRODUCTION AND PROJECT BACKGROUND

Landau Associates, Inc. (LAI) prepared this engineering design report (EDR), which provides preliminary design plans for the final cleanup action at the Blaine Marina, Inc. cleanup site (Site), along with the engineering basis for design. The cleanup action described in this EDR is based on implementing the approved cleanup action plan (CAP) (Ecology 2016) as required by the Amended Agreed Order between the Washington State Department of Ecology (Ecology) and the parties to the Order (Ecology 2012, 2017). The table below summarizes Site identification information and parties to the Order:

Site Name:	Blaine Marina, Inc.
Site Location:	214 Sigurdson Avenue, Blaine, Washington
Facility Site Identification No.:	2888
Agreed Order No.:	DE 9000
Effective Date of Order:	May 25, 2012; and as amended May 5, 2017
Parties to the Order:	Port of Bellingham
Current Property Owner:	Port of Bellingham, Washington State Department of Natural Resources

Contamination is being cleaned up to bring the Site into compliance with Washington State cleanup standards, under the authority of the Model Toxics Control Act (MTCA), Chapter 70.105D of the Revised Code of Washington (RCW), and the MTCA Cleanup Regulation, Chapter 173-340 of the Washington Administrative Code (WAC). Preparing this EDR is a required element of the MTCA Cleanup Regulation, in order for Ecology to evaluate whether the preliminary plans and engineering basis for the cleanup action are reasonable and consistent with the Agreed Order and applicable regulations.

1.1 Site Background

The Site is located in Blaine, Washington within Blaine Harbor (Figure 1), at the north end of Drayton Harbor in the northwest quarter of Section 1, Township 40 North, Range 1 West, Willamette Meridian. Blaine Marina, Inc. leased approximately 39,000 square feet of property at 214 Sigurdson Avenue from the Port of Bellingham (Port) from the 1950s, until it vacated the leasehold in 2015. In addition to other retail activities, Blaine Marina, Inc. operated a bulk fuel storage and transfer facility that resulted in the release of petroleum hydrocarbons to soil and groundwater at the Site.

The Site boundary based on the remedial investigation is shown on Figure 2. Ultimately, the Site includes all areas where hazardous substances have been deposited, stored, disposed of, placed, or otherwise have come to be located. With the exception of the vicinity map provided as Figure 1, the plan-view figures in this report are oriented to the northwest. Descriptions of direction in this report are in reference to *map north*, which is toward Marine Drive.

1.1.1 Site History and Operations

The history of Site development and operations are presented in the remedial investigation/feasibility study (RI/FS) report (LAI 2015) and in the CAP (Ecology 2016), based on a review of existing environmental reports related to previous Site investigations and a review of historical aerial photographs taken between 1949 and 2011. A brief summary of relevant Site history is provided below:

Year	Relevant Activity/Operations
1930s	Blaine Harbor was originally constructed by dredging 2 acres of tideflats to create a small boat harbor and the uplands on which the Site is located.
1940s	Harbor expansion: 4 additional acres were dredged, additional tidelands were filled; added a breakwater, bulkheads, floats, and boat ramps.
1950s	Harbor expansion: 15 additional acres were dredged; breakwater was extended. Improvements to upland facilities including additional building and aboveground storage tanks (ASTs) to support the storage of fuel dispensed at the fuel dock and a horizontally oriented AST for heating oil; Blaine Marina, Inc. operating, selling furniture, appliances, and fuel products.
Operations through 2011	Reported releases of fuel during AST filling; Blaine Marina, Inc. replaces metallic fuel pipes with non-metallic hose. Indications of contamination prompt the initiation of an RI/FS to determine the nature and extent of contamination, and develop a cleanup strategy.
May 2015	Blaine Marina, Inc. ceases operations.
2011-2017	Interim action conducted in 2012 included demolition of the former fuel office building and repair of a failing section of bulkhead. RI/FS conducted from 2011 to 2016; fueling operations cease in 2015; CAP developed by Ecology in 2016; pre-remedial design investigation data collected in 2016 and 2017.

1.1.2 Site Investigations

A number of environmental investigations were conducted at the Site prior to developing the CAP. The RI/FS report (LAI 2015) summarized historical investigations and detailed those conducted for the RI as part of the Agreed Order.

In 2016 and 2017, the Port collected additional data after completing the RI/FS, to support design of the remedial action in what is referred to herein as the pre-remedial design investigation. This included additional soil and groundwater characterization in areas previously unavailable for sampling (e.g., beneath the furniture retail building), professional surveying to support preparation of construction plan drawings, and a survey of potential hazardous building materials for buildings planned for demolition as part of the cleanup action. These additional data were used to support development of this EDR, and are described further in Section 3 and Appendices A and B.

1.2 Cleanup Action Goals

The CAP describes the final cleanup action for the Site that was selected by Ecology based on the results of the RI/FS conducted from 2011 to 2016. The CAP specifies the cleanup approach that will be taken and the applicable standards by which cleanup will be assessed. The goal of the cleanup action presented in the CAP and explained further in this EDR is to meet remedial action objectives (RAOs) identified below, and bring the Site into compliance with Washington State cleanup standards.

The RAOs identified for the Site consist of:

RAO-1: Remove the fuel storage and dispensing system and recoverable light non-aqueous phase liquid (LNAPL) to eliminate any ongoing sources of contamination

RAO-2: Prevent human or terrestrial ecological receptors from being exposed to hazardous substances through direct contact with contaminated media (soil and groundwater)

RAO-3: Prevent hazardous substances in soil from leaching to groundwater at concentrations that exceed the groundwater cleanup levels (CLs)

RAO-4: Prevent hazardous substances in soil from migrating (by erosion) to marine sediment at concentrations that exceed marine sediment CLs

RAO-5: Prevent hazardous substances in groundwater from migrating to surface water and marine sediment at concentrations that exceed the groundwater CLs

RAO-6: Prevent use of shallow Site groundwater for drinking.

2.0 ENVIRONMENTAL CONDITIONS

Site conditions related to geology, hydrogeology, and contaminant concentrations were evaluated extensively during a series of investigations, as detailed in the RI/FS report (LAI 2015). This section contains a brief summary of these findings as they relate to design of the cleanup action.

2.1 Geology and Hydrogeology

The RI/FS report provides a detailed description of the geology and hydrogeology of the Site. In summary:

- Much of the Site is covered with asphalt pavement or buildings, which is underlain by 0.5 to 2 feet (ft) of a granular fill trafficking layer (sand and gravel), though in some locations, such as along the bulkhead in the western portion of the Site, the maximum thickness of the trafficking layer was observed to be as much as 4 ft.
- Near the ASTs, the surface is composed of pervious gravel (Figure 2); outside of this area, the surface is covered with asphalt pavement or buildings.
- Beneath the surface and trafficking layer, up to 15 ft of dredge fill was encountered, which consists of two general types of fill:
  - A sandy to silty clay unit that is generally present in large lenses, including a massive deposit underlying the fuel storage area
  - Interbedded fine sand, slightly silty to silty fine sand, and sandy silt.
- Below the interpreted limits of the dredge fill, fine sand to silty fine sand was encountered, which appear to be native marine deposits. This contact is inferred based on changes in the abundance of shells, observations of sulfur-like odors, or a darkening from light to dark gray color. Lithologic changes typically observed at the fill/native interface included the reduced presence of clay deposits, reduced silt content, and an increase in poorly graded, fine sand.
- Glaciomarine drift was encountered below the fine sand at approximately 25 ft below ground surface (bgs) and consists of very soft to medium stiff, silty clay and pockets of sandy clay to the maximum depth of the exploration (46.5 ft bgs). It is likely that the clay deposits encountered in the dredge fill originated from dredging of glaciomarine drift.

Groundwater flow at the Site appears to be heavily influenced by recharge in the unpaved, gravelly area near the ASTs. A slight groundwater mound is noticeable in this area (near the ASTs), indicating some component of flow in all directions, though primarily to the west-southwest, which is the closest point of discharge for Site groundwater to surface water. The depth to groundwater ranged from approximately 7 to 10 ft bgs across the Site, considerably shallower during the wet season than the dry season. In early 2017, after a season of heavy rain, groundwater elevations were noted to be 1 to 3 ft shallower than typical during dry season monitoring events.

The Site is adjacent to marine surface water. The RI evaluated surface water and sediment quality and confirmed that Site contamination is limited to the uplands. This is likely attributable to the fine-grained nature of the soil used to construct the uplands in the 1930s and 1940s. The material

dredged from the mudflats contains a significant amount of silt and clay, which has limited contaminant migration, resulting in the highest concentrations of contamination (including LNAPL) near the source area (near the ASTs). Although the marine environment appears to have been protected, the cleanup will include aggressive source removal actions in the uplands and further shoreline protection (installation of a sheetpile bulkhead with sealed joints) based on the close proximity to surface water, and the sensitive nature of receptors in the marine environment.

2.2 Site Contamination

This section briefly summarizes the findings of the RI related to the nature and extent of contamination by describing the indicator hazardous substances (IHSs) identified in the RI/FS report and established in the CAP. The RI was conducted in multiple phases, refining the understanding of environmental conditions with additional explorations and data collection until the nature and extent of contamination was adequately delineated. The investigations indicate that contamination related to releases of petroleum products is present in groundwater, soil, and soil vapor at the Site. The contamination is greatest in the source area, near the ASTs. In this area, contamination is generally observed from fairly shallow depths (due potentially to surface releases) to about 12 ft bgs, with a significant decrease in concentrations below 10 to 11 ft bgs. Contamination in soil and groundwater generally decreases in concentration moving outward in all directions from the source area, to below CLs at the distance approximated by the Site boundary shown on Figure 3. Most of the contamination at the Site is limited to a zone several feet thick, near the groundwater table elevation.

An extensive list of contaminants associated with petroleum hydrocarbons were analyzed for in all Site media. The IHSs listed below were developed from the initially larger suite of contaminants of potential concern in accordance with MTCA procedures, based on evaluation of the RI data, and in coordination with Ecology. The Site IHSs were selected to represent the nature and extent, and risk-drivers, that were important in determining where cleanup activities will occur, and to what degree they must be taken. Although there may be some contaminants present in addition to the IHSs, it has been determined that they are typically co-located with the IHS, present lower risks of impacts to human health or the environment, and will be addressed by the cleanup actions that target the following IHSs:

- Soil:
  - Diesel-range total petroleum hydrocarbons (TPH-D)
  - Gasoline-range total petroleum hydrocarbons (TPH-G)
  - Volatile organic compounds (VOCs): benzene, ethylbenzene, xylenes, naphthalenes
- Groundwater:
  - TPH-D
  - TPH-G
  - VOCs: benzene, naphthalenes

- Soil Vapor:
  - VOCs: benzene, 1,3 butadiene

Figure 3 shows the RI sample locations and the Site boundary that approximate the lateral extent of the IHSs as determined during the RI and adjusted by the results of the pre-remedial design investigation discussed further in Section 3 of this report. As indicated on Figure 3, the highest levels of contamination are present in the area near the ASTs, identified during the RI/FS as the source area, likely due to releases of fuel to the ground surface within the pervious secondary containment system around the ASTs.

2.3 Cleanup Standards

Site cleanup standards consist of: 1) numerical CLs defined by regulatory criteria to provide protection to both human health and the environment, and 2) the points of compliance at which the CLs must be met.

The following sections provide additional details regarding the CLs for Site IHSs, which are summarized in Table 1. For this cleanup, the points of compliance (where attainment of numerical CLs must be achieved) includes the entire Site for soil (WAC 173-340-740[6]), groundwater (WAC 173-340-720[8]), and soil vapor (WAC 173-340-750[6]).

2.3.1 Groundwater

Numerical CLs for groundwater were evaluated in the RI/FS for protection of various receptors or migration pathways. The evaluation resulted in development of CLs that protect for groundwater discharge to surface water (i.e., Blaine Harbor). The CLs provide protection for aquatic organisms, benthic organisms, or human consumption of aquatic organisms.

Since TPH-G and TPH-D do not have surface water criteria and because available literature indicates that MTCA Method A groundwater CLs are adequately protective of aquatic organisms, MTCA Method A groundwater CLs were evaluated for these IHSs. Groundwater CLs for VOCs are MTCA Method B values protective of vapor intrusion.

2.3.2 Soil

Based on the potential exposure pathways and receptors evaluated in the RI/FS for unrestricted Site use, numerical criteria were developed to protect for potential impacts to surface water (through the groundwater pathway), the lowest and most-protective of the CLs. Because the CLs for soil are based on calculated impacts to groundwater (assuming three-phase partitioning), it may be possible to demonstrate compliance through empirical demonstration of attaining groundwater cleanup standards throughout the Site. This will be further evaluated in the compliance monitoring plan.

2.3.3 Soil Vapor

The VOC concentrations in soil vapor observed during the RI were acceptable for potential work exposures at Site buildings. As a conservatively protective measure, CLs were developed to be protective of unrestrictive Site use (to include residential occupancy) and adapted in the CAP based on MTCA Method B indoor air CLs.

3.0 PRE-REMEDIAL DESIGN INVESTIGATION SUMMARY

The pre-remedial design investigation was conducted to collect additional data that were needed to complete the design of the cleanup action. The Site data obtained during the RI sufficiently addressed MTCA requirements for completing an RI/FS; however, additional data were needed to support preparation of detailed construction plans. The pre-remedial design investigation was conducted in 2017, and included the following activities:

- Land Surveying:
  - Significant Site features (buildings, permanent equipment, etc.)
  - Surface elevations
  - Overhead and underground utilities
- Evaluate Building Conditions:
  - Visually inspect general building conditions
  - Conduct a hazardous building materials survey (HBMS)
- Additional Soil Investigation
  - Conduct field screening for contamination by advancing borings and test pits to evaluate core and sidewall soil samples
  - Collect and analyze additional subsurface soil samples to supplement the Site characterization data
- Additional Groundwater Investigation
  - Collect and analyze groundwater samples from existing monitoring wells and groundwater grab samples from direct-push borings.

The results of the pre remedial design investigation are provided in Appendix A and B and summarized in the following sections.

3.1 Land Surveying and Site Topography

Upland and aquatic areas of the Site were surveyed to support cleanup design activities. The upland and bathymetric surveys (conducted by Wilson Surveying/Engineering in 2011 and 2017) were combined to develop an accurate 0.5-ft contour plan of the Site appropriate for design. The Site plan (presenting a 1-ft contour interval) is shown on Figure 2 and is used as the base plan for the remainder of the plan figures. The horizontal datum for the survey is NAD83[1]/07 WA North Zone, and the vertical datum is National Oceanic and Atmospheric Administration (NOAA)/Tidal mean lower low water (MLLW) = 0.00". To convert the MLLW datum to the NAVD88[2] reference data, 1.02 ft would be

[1] North American Datum of 1983.
[2] North American Vertical Datum of 1988.

added to the NAVD value. For example, a benchmark monument having an NAVD88 elevation of 15 ft would have a MLLW elevation of 16.02 ft.

3.2 Hazardous Building Materials Survey

An inspector with certification under the Asbestos Hazard Emergency Response Act (AHERA) conducted the HBMS to support planning for demolition of the structures that must be removed to implement the remedial excavation. The survey included the furniture retail building, two smaller storage buildings adjacent to the northeast, and three ASTs just north of the furniture retail building. Each structure was surveyed for asbestos-containing material (ACM), lead-containing paint, polychlorinated biphenyls (PCBs)-containing materials, and miscellaneous hazardous materials-containing equipment. Additionally, one composite sample of the painted materials in the structures was collected for waste designation analysis using the Toxicity Characteristic Leaching Procedure for lead to evaluate whether waste streams containing the painted materials would be considered dangerous wastes under Chapter 173-303 WAC.

The survey procedures, regulatory framework, results, and findings are detailed in the HBMS report provided in Appendix B and summarized below. The results of the survey indicate some abatement of hazardous building materials will be required during demolition of Site structures to ensure worker safety and provide for proper disposal. The construction plans and specifications will include the associated procedures and requirements for the abatement contractor based on the findings summarized below.

3.2.1 Building Materials – Asbestos

Samples of building materials were collected for asbestos analysis from various paints, vinyl floor tiles, gypsum wallboard systems, cove base, built-up roofing materials, carpets and associated adhesives, acoustic ceiling tiles, faux-wood paneling and associated adhesive, leveling compound, popcorn ceiling texture, gaskets on the tank piping and access hatches, and caulks. A minimum of one sample was collected of each potential or suspect ACM type from each homogeneous area.

Five of the materials sampled in the structures were identified as ACM (defined under AHERA as a material containing greater than 1 percent asbestos), during the HBMS:

- Popcorn ceiling texture on the first floor ceiling;
- Beige vinyl floor tiles at the west end of the first floor;
- Silver-coat roofing paint on the west side of the roof; and
- Gaskets on the lower access hatches of the northern and middle ASTs.
- One fire door, assumed to contain ACM insulation, was also observed during the survey, but was not opened and inspected as that would void the door's warranty.

These materials identified as ACM will be abated in accordance with all appropriate state and federal regulations prior to demolition of the structures. The popcorn ceiling texture and silver-coat paint are considered to be friable under AHERA.

3.2.2 Building Materials – Lead

Paints sampled during the HBMS included silver-coat roofing paint, gray-blue exterior wall paint, white exterior trim paint, multiple colors of interior wall paints, white paint under faux-wood paneling, red and gray exterior foundation wall paint, and gray-blue paint on the ASTs. Lead was detected in 16 of the 23 samples collected at concentrations ranging from 82 milligrams per kilogram (mg/kg) to 18,000 mg/kg.

The waste designation sample consisting of a composite of each of the paints sampled along with the underlying substrate was found to contain less than 0.5 milligrams per liter (mg/L) of lead. This is below the dangerous waste toxicity characteristic threshold for lead of 5 mg/L.

3.2.3 Building Materials – PCBs

Two composite samples of potential PCB-containing materials were collected during the survey for laboratory analysis. Each composite sample consisted of similar material types (i.e., paints observed in and on the buildings, and various caulks and sealants). PCBs were not detected in the either of the two composite bulk material samples analyzed.

Fluorescent light fixtures in the buildings were screened for PCB-containing light fixture ballasts using a hand-held ballast checker, which can distinguish magnetic ballasts that typically contain PCBs from electronic ballasts that do not. Fixtures indicated to be magnetic using the ballast checker were opened and the ballasts were inspected for “No PCBs” stickers. Those without “No PCBs” stickers are assumed to contain PCBs.

A total of 87 fluorescent light fixtures containing 204 fluorescent light tubes and 87 ballasts were observed in the buildings. Based on the results of the ballast-checker screening and inspection of a limited number of fixtures, no PCB-containing ballasts are expected to be present in the buildings.

3.2.4 Miscellaneous Building Materials

During the HBMS field work, a thermostat located inside the Verizon telecommunications room on the second floor of the Blaine Marina, Inc. building was opened and observed to contain mercury switches. The other thermostats in the building were subsequently opened and inspected. No other mercury switches were observed. The thermostat with mercury switches will be removed by the abatement contractor and disposed of in accordance with the appropriate state and federal regulations.

3.3 Additional Soil and Groundwater Characterization

Additional soil and groundwater samples were collected to better delineate the extent of the highly contaminated soil (source material) to be removed during the cleanup action. A total of 24 soil samples collected from the smear zone near the groundwater table, and 13 groundwater samples were analyzed in the laboratory to support the remedial design. Results are provided in Appendix A.

During this investigation, a direct-push drilling rig was used to collect core soil samples from the ground surface to approximately 15 ft bgs. The soil cores were field-screened for contamination and soil samples were collected for laboratory analysis from the vertical interval approximately 2 ft above to 2 ft below the groundwater table. Field-screening observations were used to improve the understanding of the lateral extent of heavily contaminated soil. A readily observable sheen was present in the source area, and was observed during this investigation to the east and west of the ASTs, though notably, the sheen was not present as far west as the borings near the existing bulkhead. These observations and laboratory results were used to refine and expand the excavation boundary, which is somewhat larger as presented in this report than was estimated in the RI/FS and CAP reports.

Groundwater samples were collected from seven existing monitoring wells and groundwater grab samples were collected from five of the direct-push borings. Six of the locations exhibited concentrations of TPH-D that exceeded the CL (500 mg/L). Total petroleum hydrocarbons (TPH) in the oil range were not detected at concentrations greater than the laboratory reporting limits, except in the grab sample from boring BMI-GP-27, which is located in the northwest corner of the furniture store footprint. Concentrations of TPH-G were detected in six of the groundwater samples, but exceeded the 800 mg/L CL only at monitoring well MW-7.

Prior to sampling, field personnel measured the depth to groundwater and LNAPL thickness on top of groundwater, if it was present. LNAPL was encountered in areas where it was previously detected (MW-1, MW-2, and MW-3), as expected, but also at MW-9 and MW-10, where it had not been observed in the past. At MW-10, LNAPL was observed with a thickness of approximately 0.25 ft, and at MW-9, it was present with a thickness of 2.4 ft. The thickness of accumulated LNAPL in MW-9 warranted further investigation, so two additional investigations were conducted: an LNAPL recoverability test and further soil observations by advancing test pits near monitoring well MW-9.

3.3.1 LNAPL Recoverability Test

The recoverability test included removing the LNAPL from MW-9 and monitoring its recovery, then using a spreadsheet tool to determine LNAPL transmissivity. The recovery data can be used in this manner to evaluate if hydraulic recovery of the LNAPL is feasible.

The test was conducted on May 18, 2017. LNAPL thickness at the start of the test was 2.81 ft. The LNAPL was removed (by pump) and recovery was observed over the course of 6 hours. During this

time, the LNAPL did not fully recover to its original thickness. The final thickness was 1.03 ft. The poor recovery was insufficient to calculate an LNAPL transmissivity. It is likely that the observed LNAPL recovery was recharge from the well sandpack, and that LNAPL transmissivity from the surrounding aquifer is very low. A follow-up measurement was collected after 1 month (June 19, 2017) at which time the thickness was 1.13 ft, supporting the conclusion that no recoverable LNAPL is present.

3.3.2 Test Pits

To provide additional information regarding the LNAPL observation at MW-9, five test pits were dug hydraulically upgradient and downgradient of MW-9, as shown on Figure 3. The goal was to evaluate whether a significant accumulation of LNAPL was present near MW-9. The test pits were each approximately 8 ft long, 3.5 ft wide, and 8.5 to 12 ft deep, depending on the depth to groundwater. Field personnel visually observed the test pit sidewalls and groundwater seepage for the presence of LNAPL. No LNAPL or heavy sheen was observed in any of the test pits. A slight sheen was observed in groundwater seepage from test pit TP-2 on the western wall at approximately 12 ft bgs, but was not observed on the eastern wall. Based on the test pit findings, it appears that there is not a significant amount of LNAPL in the soil formation surrounding MW-9, which is consistent with the results of the LNAPL recoverability test discussed in Section 3.3.1.

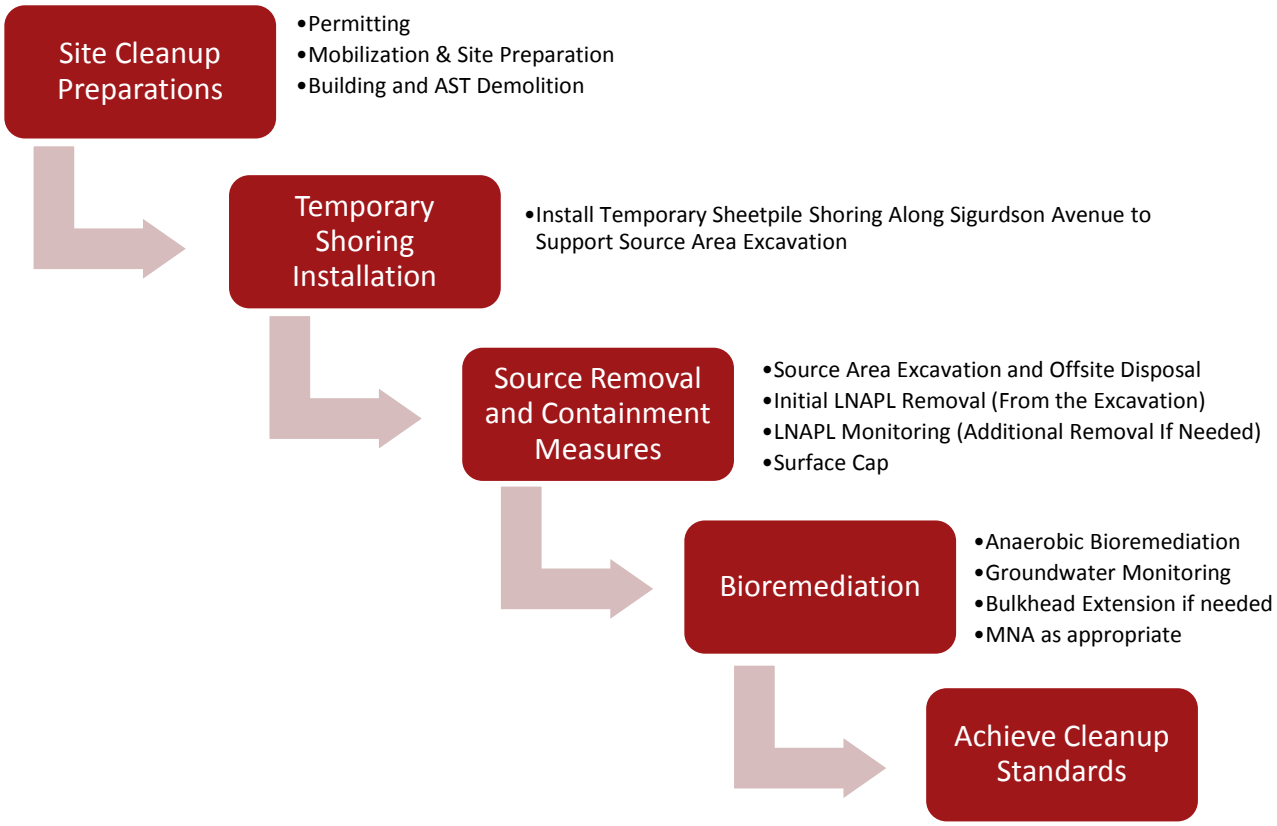
Although no significant LNAPL was found outside of the MW-9 well casing, the cleanup action has been modified to include LNAPL monitoring and recovery, to be conducted after the source area excavation, and prior to implementing bioremediation. However, it is not anticipated that a significant quantity of LNAPL will be observed that would require ongoing recovery efforts.

4.0 CLEANUP ACTION – CONCEPTUAL DESIGN OVERVIEW

This section provides a conceptual-level summary for each element in the cleanup action. Section 4.1 provides the general sequencing of the cleanup process and Section 4.2 provides a conceptual overview for each of the primary elements of the cleanup action. Further detail and the engineering basis of design are discussed in Section 5 of this report.

4.1 General Summary and Sequencing of the Cleanup Action

The flow chart below provides a general overview of the cleanup process. Prior to implementing the cleanup activities summarized below, this EDR will go through an agency and public review and comment period before being finalized. Detailed construction plans will be prepared based on the approved conceptual design in the EDR.



It is anticipated that construction activities will commence in 2018 and, based on an 8-year restoration timeframe, cleanup standards should be achieved in 2026.

4.2 Elements of the Cleanup Action

The following subsections provide a conceptual-level overview of the activities that will be included in the cleanup action, separated into the major components and sequenced in the general order of planned implementation.

4.2.1 Site Cleanup Preparations

The following activities are described as cleanup preparation. These actions do not directly affect soil or groundwater quality, but must be conducted as part of the cleanup action.

- Project permitting
- Contractor mobilization
- Decommissioning of groundwater monitoring wells currently located within the excavation boundary
- Demolition and removal of the buildings that currently prevent access for excavation
- Decommissioning and removal of the ASTs and ancillary equipment.

4.2.1.1 Project Permitting

The cleanup will include earthwork and other construction activities that typically require regulatory permitting. In accordance with MTCA, because this is a cleanup action, the project may not need to obtain all of the permits that would be required for a normal construction project. The project team will prepare permit applications and meet with the appropriate agencies to determine which permits are required, and when it is appropriate to meet the substantive requirements instead. Meeting the substantive requirements ensures conformance to the jurisdictional agency's input.

It is assumed that permits (or meeting the substantive requirements) will be necessary for building demolition, grading, the bulkhead improvement, and construction stormwater management. Additionally, MTCA requires compliance with applicable state and federal laws (WAC 173-340-710[1]). MTCA defines applicable state and federal laws to include legally applicable requirements and those requirements that are relevant and appropriate, although obtaining the actual permit may not be required. The relevant and appropriate regulations include:

- Clean Water Act Section 402 (b) and 40 CFR Part 123: The cleanup will be designed to allow stormwater to infiltrate to the interior of the Site and, therefore, have no surface water discharge off of the Site. However, the Port will apply for a National Pollutant Discharge Elimination System construction stormwater general permit that will be used during the upland cleanup action, including developing a construction Stormwater Pollution Prevention Plan (SWPPP) that provides specific procedures for stormwater management during cleanup of contaminated soil.
- Washington Water Pollution Control Act and its implementing regulation, Water Quality Standards for Surface Waters (Chapter 173-201A WAC). These regulations establish water quality standards for surface waters of the State of Washington consistent with public health

and the propagation and protection of fish, shellfish, and wildlife. These standards will be used to develop the appropriate stormwater best management practices (BMPs) for the Site.

- Washington Solid Waste Management Act (Chapter 70.95 RCW) and its implementing regulation, Criteria for Municipal Solid Waste Landfills (Chapter 173-351 WAC). These regulations establish a comprehensive statewide program for solid waste management, including proper handling and disposal. The management of excavated contaminated soil from the Site will be conducted in accordance with these regulations to the extent that the soil can be managed as solid waste.
- Shoreline Management Act (SMA; Chapter 90.58 RCW and WAC 173-26-201). This regulation establishes permitting and other requirements for substantial development occurring within waters of the US or within 200 ft of a shoreline, and requires that the activities in coastal zones be consistent with local regulations. MTCA exempts cleanup projects being conducted under an enforceable order or consent decree from the requirement of obtaining the shoreline permit; however, the cleanup must be conducted in accordance with the substantive requirements of the regulation.
- Hazardous Waste Operations (Chapter 296-843 WAC). This regulation establishes safety requirements for workers investigating and cleaning up sites containing hazardous materials. These requirements will be applicable to onsite cleanup activities and will be addressed in a Site health and safety plan (HASP) prepared specifically for these activities.

All work related to the cleanup action is planned to occur within the upland portion of the Site (i.e., above the mean higher high water) and the need for a Section 10 permit is not anticipated.

4.2.1.2 Mobilization and Site Preparation

The Site will be prepared for cleanup action construction. Site preparations include:

1. Installing 6-ft-high temporary chain-link fencing around the perimeter of the Site working areas. Working areas will change during the course of the cleanup. Initially, the work area will be established around the sheetpile installation areas, then around the building demolition areas, then around the source area excavation.
2. Lockable gates and informational signage will be used to provide Site security.
3. A wheel wash system and decontamination area will be installed before the exit from the fenced area during periods of work that could cause soil to be tracked off site (during excavation).
4. Traffic controls will be implemented as necessary to maintain roadway access to prevent disruption to nearby operations.
5. A temporary restroom will be provided for Site workers.

4.2.1.3 Hazardous Building Materials Abatement

Prior to building demolition, the hazardous building materials identified by the HBMS will be abated and removed from the Site for proper disposal in accordance with AHERA requirements, WAC 296-62-07712, and Section 570 of Northwest Clean Air Agency regulations. The friable ACM identified

by the HBMS (popcorn ceiling texture and silver-coat paint) will require abatement in accordance with AHERA. Abatement of these materials will therefore be Class I asbestos work. Abatement of the non-friable floor tiles, gaskets, and fire door will be Class II asbestos work.

Lead hazards during demolition will be controlled through:

- Isolation of the area to prevent exposure to the public
- Misting of the area with water to control lead dust
- Use of best management practices to mitigate migration of lead dust into Site stormwater
- Preparation of a bid-specification providing methods to prevent worker exposure to lead.

The hazardous materials-containing equipment identified during the HBMS (fluorescent light tubes and mercury switches in one thermostat) will be removed prior to building demolition by the abatement contractor. The light tubes and thermostat will be managed and disposed of at an appropriate facility as Universal Wastes under WAC 173-303-573 and 40 CFR 273.

The following guidance specifications will be included in the bid package to provide the contractor with specific requirements that must be met for abatement or mitigation of the hazardous materials prior to and during demolition:

- Asbestos Abatement
- Mitigation of Lead Hazards
- Handling and Disposal of Universal Wastes.

The specifications will be prepared by a professional engineer licensed in the State of Washington and an AHERA-certified project designer.

4.2.1.4 Demolition of Aboveground Storage Tanks, Building, and Pavement

The ASTs and other ancillary equipment and the three buildings identified on Figure 4 (the furniture retail building and two smaller storage buildings) will be demolished and disposed of off site. This includes removing concrete pavement slabs and foundations within the footprint of the planned excavation. The equipment and buildings must be removed to prevent the ASTs and ancillary equipment from being a potential ongoing source of contamination, and to provide access for excavating the soil in the area with the highest levels of contamination.

Pavement and foundations will be reduced to manageable rubble using construction equipment and personnel equipped with pneumatic hammers or other equipment designed to break up concrete and asphalt. The connector plates will be removed from the beams, the beams removed from the foundation concrete and cut to a manageable length (as required by the waste acceptance criteria), and will be placed into dump trucks for disposal at a permitted municipal solid waste disposal facility or recycling, if practicable. Demolition debris will be intermittently sprayed with water (from a fire

hydrant, see Figure 6 for location) to minimize dust. Runoff from the dust control activities will be diverted to infiltration areas within the Site cleanup area.

Rubble from the demolition will be stockpiled in a designated area northwest of the Site. The demolition rubble will then be segregated, stockpiling concrete and asphalt separately from other debris that will be disposed of off site in conjunction with contaminated soil. Debris designated for disposal will be loaded onto dump trucks for transport and disposal at an inert waste landfill or municipal solid waste landfill, as applicable. Reinforcing steel will be separated from the onsite rubble, loaded onto dump trucks, and transported to a metals recycling facility. Concrete and asphalt rubble from the cleanup action demolition will be evaluated for potential beneficial reuse as roadway base course or roadway fill.

Additionally, two features will require demolition, which are currently located in the planned bulkhead extension alignment as shown on Figure 4. These features appear to be related to fish processing though it is not determined at the time of this EDR whether they are currently used, or simply historical remnants. Each of these features appears to have subsurface concrete vaults that will be removed in preparation of the bulkhead installation.

4.2.1.5 Decommissioning Monitoring Wells

Three existing monitoring wells will need to be decommissioned before excavation occurs because they are located within the excavation boundary. Wells MW-1, MW-2, and MW-3 will be decommissioned by a drilling contractor licensed in the State of Washington in accordance with Chapter 18.104 RCW.

4.2.2 Sheetpile Bulkhead and Temporary Shoring Installation

Prior to completing the RI, it was noted that a section of bulkhead along the western side of Sigurdson Avenue was failing, and could result in migration of contaminated soil (through erosion) to the marine environment. As an interim cleanup action, a sheetpile bulkhead was installed along the landward side of the failing timber bulkhead, which effectively stopped the shoreline failure.

Based on a recent assessment of the shoreline and bulkhead conditions in the vicinity (Reid Middleton 2017), the condition of the shoreline north of the section improved during the interim action is in fair condition and not in need of significant improvements. As a result, the final cleanup action may be successfully implemented without further bulkhead improvements. However, in recognition that additional shoreline protection or hydraulic isolation may assist in implementing the bioremediation program, this EDR includes planning for an extension of the sheetpile bulkhead to provide additional shoreline protection to the north, as shown on Figure 4. If this section is needed, the seams between the steel sheetpiles in the extension will be sealed to limit water passage through the bulkhead. As discussed further in Section 4.2.5.4, the necessity of installing this bulkhead improvement will be assessed when implementing the bioremediation program, in coordination with Ecology.

Temporary sheetpile shoring will be installed along the eastern side of Sigurdson Avenue to protect the roadway and utilities. This temporary shoring will allow the source area excavation to advance as close to Sigurdson Avenue as possible without undermining the significant number of subsurface utilities beneath the road that service many nearby buildings.

Prior to excavation of the source area, temporary sheetpile shoring will be installed along the west side of the excavation (the east side of Sigurdson Avenue) to protect the roadway and underlying utilities. The temporary shoring will be constructed with steel PZC-18 section sheetpiling, or equivalent as determined during remedial design, and will be driven to a minimum depth of 35 ft bgs. The alignment of the sheetpile is shown on Figure 4 and the conceptual details are shown in section-view on Figure 5. As detailed in Appendix C, the shoring has been designed to support the full lateral loads from earth pressures, hydrostatic loads from groundwater, and vehicle loading from construction equipment.

Prior to installation of the temporary sheetpile shoring, the alignment (and area nearby where utilities are known to be present) will be screened for the presence of utilities and subsurface obstructions by air-knife or hand-excavating a minimum width of the sheetpile to a depth of 4 ft. The excavated materials will be stockpiled and assessed for reuse as backfill at the Site. After clearance for utilities, the sheetpiles will be vibrated into place along the alignment.

4.2.3 Source Removal

The soil and groundwater in the vicinity of the ASTs are heavily contaminated from releases of petroleum products. LNAPL may be present in the source area, as shown on Figure 3. The cleanup action described in the FS and in the CAP included excavation of approximately 3,000 tons of soil from this area. Based on the results of the pre-remedial design investigation, the excavation has been expanded somewhat and is anticipated to remove between 3,000 and 4,000 tons of heavily contaminated soil from the source area. The goal of this action is to remove the most highly contaminated soil and all free-phase LNAPL from the Site, except for what is inaccessible to excavation, beneath Sigurdson Avenue.

Source removal will be conducted by excavating the heavily contaminated soil from within the approximate lateral extent of free-phase LNAPL in the source area, as shown on Figure 6 and in cross section on Figure 8. The excavation will extend from the ground surface to approximately 10 to 12 ft bgs (depending upon observations and safety conditions). The excavation will occur in the dry season (late summer to early fall) when groundwater levels are lowest for safety and to avoid the need for dewatering. Based on the RI data, an excavation depth of 9 to 11 ft bgs in the source area is anticipated to fully remove the highly contaminated soil. Concentrations of contaminants in soil decrease by orders of magnitude below this depth, as represented in the four closest soil borings to the ASTs (BMI-GP-14, BMI-GP-15, BMI-GP-17, and BMI-GP-20; LAI 2015).

When the groundwater table is encountered, the excavator bucket will be used to agitate soils below the groundwater table to release any remaining LNAPL that may be held by capillary forces, confirming removal. It is not anticipated that free-phase LNAPL will be present at this depth. Some contamination exists outside of the targeted vertical and horizontal extents, but at much lower concentrations than the source material. This residual contamination will be addressed after the excavation through bioremediation. Minor dewatering efforts within the excavation may be conducted as a contingency during construction. However, significant efforts to lower the groundwater table are not planned.

While the excavation is open and the groundwater table exposed, LNAPL may enter the excavation through the sidewalls. LNAPL that enters the excavation will be recovered using a vactor truck and/or sorbent pads to skim LNAPL from the exposed groundwater table. Field screening will be used to identify overburden soil that can be stockpiled and assessed for re-use as backfill at the Site. It is assumed that the upper 5 ft of soil at the northern, eastern, and southern extents of the excavation are not impacted, and might be suitable for use as backfill material after the source area removal.

For the purposes of this EDR, we assume that the excavated soil will be hauled to a municipal solid waste landfill (Resource Conservation Recovery Act Subtitle D facility) for disposal. However, based on the RI data, *ex situ* treatment by thermal desorption may be practicable, which would allow the soil (after treatment) to be used for other purposes, such as reclamation material, in accordance with Ecology guidance documents. This approach would be evaluated prior to implementation, but would not affect the removal process or Site conditions—only the final disposition of the removed materials.

The excavation will be conducted with standard construction equipment (e.g., trackhoes and front-end loaders), and it is anticipated that impacted soil will be loaded directly into dump trucks or intermodal containers. In the event that direct loading cannot be conducted, excavated soil will be temporarily stockpiled on Site and, if stockpiles are placed on clean soil surfaces, the surface will be adequately protected to prevent surface contamination (e.g., placed on plastic sheeting and covered with plastic sheeting held down with rope-connected sandbags or tires, if necessary).

Based on test pit observations, the soil to be excavated would be classified as Type B soil (per 29 CFR 1926 Subpart P; Appendix C) due to the variable nature of fill materials. Excavation will depend on the contractor's means and methods; however, no personnel will be allowed within the excavation or during backfill operations unless the cut slopes are laid back to 1 horizontal to 1 vertical (1H:1V) or flatter. Similarly, construction plans and specifications will indicate allowable equipment operations near the excavation edge based on maintaining slope stability during the construction effort.

The excavation will be backfilled with imported fill material, and possibly shallow Site soil excavated from the cleanup area if it does not exceed CLs and if it is considered geotechnically suitable for use as backfill. The source area will be backfilled with relatively permeable soil, so the entirety of the backfilled area can later be used as an infiltration gallery during bioremediation. While backfilling the

source area excavation, perforated polyvinyl chloride (PVC) piping will be installed near the base of the excavation, and vertical PVC risers will terminate in traffic-rated vaults at the ground surface. The installed equipment will allow for later introduction of bioremediation solutions in a manner intended to fill the backfilled excavation with the liquid that would then seep out of the source area along pathways formerly taken by TPH.

Backfilling will return the Site to the existing grade, and will return the Site to existing surface pervious conditions (e.g., compacted gravel surfaces in areas currently surfaced in gravel, and asphalt pavement where pavement or buildings currently exist). Upon completion of backfilling, the temporary sheetpile shoring will be removed and any resulting voids will be backfilled with compacted imported fill.

After source removal is complete, the newly installed surfacing will function as a clean soil cap to provide containment for the residual contaminated soil that will remain until bioremediation (discussed in Section 4.24 below) is complete. Although the surfacing will function as a temporary containment system, it is not anticipated to be necessary in the long term, so institutional controls are not anticipated to be required to maintain its integrity.

4.2.4 Non-Aqueous Phase Liquid Observation and Recovery

After completing the source removal and installation efforts described above, a period of no less than 2 weeks will be allowed for potential LNAPL accumulation. Monitoring for the presence of LNAPL will take place at the infiltration gallery (created when backfilling the source area excavation), at bioremediation infiltration trenches, and at existing and newly installed groundwater monitoring wells.

As noted in Section 4.2.3, after removing the source materials, the source area excavation will be backfilled in a manner so it functions as a large infiltration gallery. The equipment installed during backfilling will include perforated risers to facilitate monitoring for, and removing LNAPL if it is found present at recoverable levels. In addition to monitoring for LNAPL at the infiltration gallery, bioremediation trenches will also be installed, as shown on Figure 7. These trenches will also include perforated riser pipes to facilitate LNAPL monitoring and removal, if needed. And finally, four additional groundwater monitoring wells will be installed to supplement the existing monitoring network, and will provide for additional LNAPL monitoring.

At the end of the 2-week accumulation period, non-aqueous phase liquid (NAPL) observation wells and groundwater monitoring wells will be assessed for the presence of NAPL using an oil/water interface probe. If NAPL is observed accumulating at recoverable levels, the NAPL will be hydraulically captured and taken off site for disposal. It is not anticipated that appreciable quantities of NAPL would be present after conducting the source area removal efforts. However, the locations of infiltration trenches (and their NAPL monitoring components) have been selected to provide for NAPL

monitoring and removal efforts, if needed, prior to implementing the bioremediation program, as described below.

4.2.5 Bioremediation and Monitored Natural Attenuation

A bioremediation program will be implemented after the source removal to reduce concentrations of IHSs until the Site is remediated and groundwater cleanup standards are achieved. To optimize the efficacy of bioremediation in a naturally reducing environment, nitrate will be used as an electron acceptor to stimulate anaerobic degradation, and will be introduced to the subsurface using the large infiltration gallery created when backfilling the source area excavation, and the treatment trenches shown in the conceptual layout on Figure 7.

The effectiveness of bioremediation is limited in areas containing significant free-phase LNAPL; therefore, bioremediation typically follows LNAPL removal to achieve cleanup in a reasonable restoration timeframe. This is due to the mass of electron acceptor required to treat a given mass of TPH (i.e., stoichiometry) and the low ratio of NAPL surface area to mass that makes TPH as LNAPL less available to micro-organisms for biodegradation.

Implemented after the source removal is complete and the highest levels of contamination are removed from the Site, bioremediation is anticipated to achieve cleanup standards within 4 years of beginning injections. As described further below, groundwater monitoring will be conducted throughout the bioremediation period to assess progress and inform potential modifications to the nitrate solution injection plans for subsequent injection events. As the bioremediation process nears completion, monitoring may indicate no additional nitrate is needed, but monitoring to confirm continued progress may be needed. This period of monitoring would be considered monitored natural attenuation (MNA). As previously mentioned, active measures (instead of MNA) will be used to the greatest extent practicable, and the MNA period is included for consideration only near the end of the cleanup process if no further active measures are warranted.

The following sections provide further details related to the design of the bioremediation program. Bioremediation design input parameters are provided in Appendix D.

4.2.5.1 *In Situ* Anaerobic Bioremediation Summary

In situ bioremediation of TPH typically consists of enhancing or stimulating naturally occurring aerobic or anaerobic biological processes in saturated subsurface soil and groundwater through the introduction of oxygen, nitrate, or sulfate. Macro/micro nutrients are also commonly added. The introduction of these reagents increases the rate of degradation of petroleum constituents in soil and groundwater by microbial activity when the natural degradation is limited by the availability of electron acceptors and nutrients. Data collected during the RI indicate limited availability of electron acceptors at the Site, which suggests that nitrate injection will likely stimulate the biological processes to degrade TPH.

Reagent introduction to the subsurface can be accomplished by various means. These include direct injection into wells or borings, or infiltration to trenches or infiltration galleries.

It is anticipated that multiple injections of nitrate will be required to complete treatment of residual TPH mass present in the aqueous and sorbed phases remaining following source removal. TPH concentrations in groundwater are expected to fluctuate during treatment until non-aqueous TPH mass is depleted. This fluctuation occurs because concentrations of TPH in groundwater may initially increase, as injection disturbance and biological treatment of aqueous-phase contamination can enhance desorption from the aquifer soil. Aqueous-phase TPH will be degraded by micro-organisms using nitrate as the electron acceptor. Upon the depletion of injected nitrate, contaminant concentrations are expected to rebound until additional nitrate is injected. It is understood that rebound will continue to occur as long as contaminant mass remains in the sorbed-phase or as residual NAPL within the aquifer or in upper portions of the smear zone are periodically contacted by a high water table.

4.2.5.2 Injection Approach – Infiltration Gallery and Trenches

As noted in Section 4.2.4, the source area excavation will be backfilled with non-contaminated sand and gravel, and will include two sections of horizontal perforated pipe installed near the groundwater table to create a large infiltration gallery for injection of bioremediation reagents. These infiltration galleries, shown on Figures 7 and 8, will allow injection events to introduce large quantities of bioremediation agents into the newly installed gravel backfill. The design approach includes mounding the groundwater in this area to cause flow outward in the manner and pathway currently taken by contaminated groundwater.

Two additional treatment trenches will be constructed to the east and south of the source area excavation using perforated pipe and sand and gravel backfill. Backfill for the infiltration gallery and trenches will be imported backfill material meeting the following requirements for Gravel Borrow:

- Aggregate for Gravel Borrow will consist of granular material, either naturally occurring or processed, and will meet the following requirements for grading and quality:

Sieve Size	**Percent Passing**
4"	99-100
2"	75-100
No. 4	50-80
No. 40	30 max.
No. 200	8 max.
Sand Equivalent	50 min.

- If wet weather construction is anticipated, then the amount of fines in the Gravel Borrow may be limited to 5 percent or less based on the fraction of the material passing a US Standard ¾-inch sieve.

- Imported fill soil will be certified by the commercial quarry supplier that it has been tested and the fill soil does not contain arsenic at concentrations greater than MTCA Method A cleanup levels or diesel- and oil-range hydrocarbons at concentrations greater than 200 mg/kg. Imported fill from other sites will be tested at a rate of one sample per 1,000 cubic yards to verify that the fill soil is not contaminated with arsenic or diesel- and oil-range hydrocarbons and meets the specified gradation requirements that will be provided in the construction plans, and will include provisions to ensure the imported fill is native source material and does not include concrete, asphalt, or other waste materials. Once the imported fill has passed this verification, the fill soil will be transported to the Site and used to backfill the excavations. The backfill will be placed in loose, horizontal lifts greater than 10 inches in thickness and compacted to at least 92 percent of the maximum dry density, except the upper 12 inches of subgrade will be compacted to a minimum of 95 percent of the maximum dry density, as determined by the ASTM International D1557 test procedure (modified Proctor).

The locations and conceptual details of the excavation area infiltration gallery and two additional treatment trenches are shown on Figure 7 and described below. The infiltration gallery in the source area will be created by installing two horizontal lengths of perforated pipe within the backfilled excavation. The Piping will be 3- or 4-inch-diameter, rigid high-density polyethylene or PVC, approximately 50 to 60 ft long and installed at the approximate locations shown on Figure 7. Pipe perforations will be oriented downward to minimize filling with sand.

Filter fabric will not be used for material separation between the piping and adjacent soil due to potential fouling by LNAPL and/or biological activity. The horizontal perforated pipe will be placed on top of 2 ft of fill placed in the bottom of the excavation to prevent the pipe from silting up with disturbed soil at the bottom of the excavation. Vertical risers for injection and cleanout will be installed at both ends of the horizontal perforated pipe using cleanout sweep tees. Risers will be contained within traffic-rated vaults at the surface to allow future access for monitoring and injection, while minimizing aboveground features. The top 3 ft of backfill around each riser will consist of cement-bentonite grout as a surface seal. Risers will be completed with female pipe thread adaptors and threaded plugs to facilitate connection to injection hoses. All connections and fittings will be solvent-welded.

The treatment trenches installed outside the source area will extend 1 to 2 ft below the water table to intersect the TPH smear zone. The two trenches will be located east and south of the infiltration gallery for focused treatment in those area. Each trench will be approximately 30 ft long and 3 ft wide. Backfill and perforated pipe installation will be as described above for the infiltration gallery. Risers will be installed at each end for injection and monitoring. Additional risers are included for LNAPL observation and recovery, which as discussed earlier, will be conducted prior to initiating bioremediation.

4.2.5.3 Bioremediation – Implementation Details

This section describes the reagent delivery approach and electron acceptor selection tailored to Site-specific conditions. Site-specific considerations are:

- Generally low hydraulic conductivity (i.e., slow injection or infiltration rates)
- Alternating lenses of sand and silt/clay resulting in variable hydraulic conductivity and distribution of petroleum contamination
- A naturally reduced aquifer condition due to the depositional environment of soils in the shallow water-bearing zone at the Site.

Due to the low hydraulic conductivity anticipated in the finer silt or clay soils, infiltration is preferred at the Site instead of injection. Use of infiltration galleries and trenches allows for relatively quick injection of substrates to granular backfill, followed by slower infiltration to native soils. Through the use of galleries/trenches, the reagents can be introduced to the subsurface in large batches, resulting in water-level mounding within the gallery/trench that will drive outward distribution of reagents to the surrounding aquifer. Infiltration galleries/trenches also result in improved distribution of reagents to the layers intercepted by the gallery/trench.

The use of nitrate as an electron acceptor is preferred due to naturally anaerobic conditions at the Site. Shallow Site soils are typical of a marine depositional environment, as they are predominantly dredged marine sediments used in the 1930s and 1940s to create the uplands. The high concentrations of natural organic matter and reduced metals present in these anaerobic soils make oxygen an ineffective electron acceptor for TPH treatment, due to the substantial oxygen demand exerted by the natural soil condition. If oxygen was introduced at the Site, most of it would go to satisfy this natural demand instead of stimulating biodegradation of TPH.

Biodegradation of TPH occurs through microbially mediated reactions, whereby micro-organisms obtain energy by redox reactions. TPH is used as the electron donor together with various electron acceptors (oxygen, nitrate, manganese [IV], ferric iron, sulfate, and carbon dioxide) that occur naturally or can be added to stimulate treatment. These redox reactions can be compared to the process whereby humans obtain energy through consumption of food (electron donor) and oxygen (electron acceptor). Bacteria obtain the greatest energy yield by using oxygen as an acceptor, as it is highly oxidized and can be reduced easily and to a large extent. When oxygen is depleted, bacteria use the less oxidized electron acceptors in the following order: nitrate, manganese (IV), ferric iron, sulfate, and carbon dioxide. After oxygen, nitrate is the most readily used electron acceptor. The micro-organisms responsible for TPH biodegradation occur naturally in the aquifer.

Anaerobic biodegradation of TPH is the preferred approach (over aerobic biodegradation) for this Site, consistent with its usage at other cleanup sites with reduced aquifers (Wiedemeier et al. 1999). Although nitrate and sulfate can both be used as electron acceptors for anaerobic bioremediation of TPH (Cunningham et al. 2001), nitrate is typically a more effective acceptor and is preferred by aquifer bacteria, as it provides more energy than sulfate and is typically depleted in areas of TPH contamination. Nitrate also has various advantages over oxygen as an electron acceptor. Nitrate is a weaker oxidizing agent than oxygen, which means that demand for nitrate represented by natural aquifer organics and reduced metals is less than the demand for oxygen. As a result, nitrate has a

greater longevity than oxygen and a larger portion of the injected electron acceptor will be used for TPH degradation. Additionally, the solubility of nitrate is much greater than oxygen, which allows for a higher initial concentration of electron acceptor at the infiltration point, greater longevity, and a greater downgradient extent of treatment.

Although a drinking water maximum contaminant level (MCL) exists for nitrate (10 milligrams nitrate-as-nitrogen per liter [mg N/L]), drinking water is not a beneficial use of shallow groundwater at the Site and, therefore, the MCL does not apply. As described in the RI/FS report, the highest beneficial use for Site groundwater is the discharge to the marine surface water of Blaine Harbor. There are no marine surface water criteria for nitrate based on the MTCA Cleanup Levels and Risk Calculation database (Ecology 2015; accessed August 7, 2017). It is anticipated that the sheetpile walls installed prior to bioremediation will increase the retention, allowing for utilization of the nitrate and limiting migration to surface water.

The following sections describe the conceptual plan for injection volumes, substrate types, substrate concentrations, and anticipated modifications for subsequent injections. Volume calculations and a table of substrate masses required for different nitrate concentrations are provided in Appendix D. Further details related to the injection and performance tracking/modifications will be provided in a bioremediation work plan, as part of the detailed construction plans after approval of this EDR.

Volume

The estimated initial injection volume (per injection event) is approximately 40,000 gallons, based on the desired distribution and estimated pore volumes for the large infiltration gallery and the two treatment trenches. The infiltration gallery injection volume (35,000 gallons) is based on an approximate area of 5,200 square ft and a desired 3-ft increase in the water level within the infiltration gallery backfill.[3] A rise in water level within the infiltration gallery is desired to contact the high portion of the TPH smear zone and to provide a driving head to distribute injection fluid into the surrounding native soil. The treatment trench injection volume (1,600 gallons each) is based on trench dimensions of 3 ft wide by 30 ft long and a desired rise of 8 ft from the water table to just below ground surface; this rise in the water level is desired to maximize the injection volume distributed to the trench, to contact the high portion of the TPH smear zone, and to provide a driving head to distribute injection fluid into the surrounding native soil. The total calculated injection volume of 38,238 gallons is rounded up the 40,000 gallons. Volume calculations are provided in Appendix D, Table D-1.

[3] For comparison, if the same 5,200-square-ft area was injected using a grid of injection wells on 15-ft centers (25 wells), the 35,000-gallon injection volume planned for the injection gallery would correspond to approximately 1,500 gallons per well. This is within the range of typical injection well volumes.

Reagent Concentrations

Ammonium nitrate, ammonium phosphate, and yeast extract will be mixed with clean tap water at the Site to create the injection solution. Ammonium nitrate provides the nitrate electron acceptor. Ammonium phosphate and yeast extract provide macro- and micro-nutrients for bacteria cell growth.

It is anticipated that the concentration of injected nitrate may range from 225 mg N/L to 10 times that concentration (2,250 mg N/L). This is an empirical design concentration based on engineering and implementation experience at other cleanup sites, where nitrate concentrations of 225 mg N/L to 1,800 mg N/L have been effectively used with a nitrate longevity of 4 to 12+ months. The amount of phosphate added to the injection solution is based on a nitrogen to phosphorus ratio of 10:1, an optimal nutrient ratio (Tchobanoglous et al. 2003). Yeast extract is provided at 1 pound (lb)/1,000 gallons of injection fluid to provide micro-nutrients. The required mass of these reagents for the range of anticipated nitrate concentrations is provided in Appendix D, Table D-2. Based on stoichiometry, it takes about 5 lbs of nitrate to degrade 1 lb of TPH/benzene, toluene, ethylbenzene, and xylenes (BTEX) if nitrate is fully used for TPH degradation; this stoichiometry is discussed further in Appendix D, Table D-3.

Multiple injections of nitrate are anticipated to complete treatment of TPH, as it is present in various forms, including NAPL, dissolved-aqueous phase, and adsorbed to soil particles. Reagent concentrations, injection frequency, and/or injection volume will likely be modified for subsequent injections to optimize treatment. Modifications would be based on observations during and after injection and on monitoring data indicating the distribution and longevity of injected nitrate. More concentrated reagent concentrations may be used in the injection trenches than the infiltration gallery due to freeboard volume limitations.

4.2.5.4 Extension of Sheetpile Bulkhead

The sheetpile bulkhead that was installed as an interim action may be extended to the north to reduce near-shore tidal exchange in the affected upland area and extend the residence time for the bioremediation solutions on an as-needed basis to be determined in coordination with Ecology, based on conditions observed while implementing the bioremediation program. The joints where the individual sheetpile sections connect will be sealed with a non-toxic interlock sealant that provides watertight connections between the individual sheets. The sealant will be applied to the joints prior to driving the sheets. The location of the bulkhead extension is shown on Figure 4, and the conceptual details in section-view are shown on Figure 5.

A geotechnical report was prepared in 2012 (LAI 2012a) to support the bulkhead design for the section of bulkhead constructed during the interim action. The report will provide basis for design considerations for the construction plans, and is provided in Appendix C for reference.

If needed, the new bulkhead wall will be constructed with steel PZC-13 section sheetpiling, driven to a minimum depth of 30 ft bgs. The design of the sheetpile bulkhead is based on a 10-ft exposed height on the waterward face of the bulkhead. While the height of the exposed face is currently less than 10 ft, the wall has been designed to be stable in the event that the riprap and fill shifts or is removed from the waterward face of the bulkhead at some point in the future. The bulkhead will be a cantilevered design and will not include a tieback system. The cantilevered bulkhead has been designed to support the full lateral loads from earth pressures, hydrostatic loads from retained groundwater, and vehicle loading from Sigurdson Avenue.

For sheetpile bulkhead installation, the bulkhead alignment landward of the existing timber bulkhead will be screening for the presence of utilities and subsurface obstructions by excavating a trench along the alignment a minimum of 5 ft wide by 3 ft deep prior to sheetpile installation. The excavation may be deeper and/or wider in some areas to verify conditions such as utilities or the existence (and removal) of tiebacks. The excavation would be in relatively shallow soil that is not anticipated to be contaminated. The excavated soil will be stockpiled for assessment and potentially used at the Site for backfill. The sheetpiles will then be vibrated into place along the shoreline just landward of the existing timber bulkhead. The top area around the sheetpile will be backfilled with controlled lifts of specified maximum thickness and minimum compacted density.

Prior to installation, two structures located in the planned alignment will require demolition, as discussed in Section 4.2.1. Procedures for the demolition of these structures will be included in the construction plans and specifications after approval of this EDR.

4.2.6 Compliance Monitoring

Compliance monitoring is a required element of any MTCA cleanup action. Compliance monitoring will be conducted in accordance with WAC 173-340-410 to confirm that cleanup standards have been achieved and to confirm the long-term effectiveness of cleanup actions at the Site. Detailed monitoring requirements will be developed with the detailed construction plans, after approval of this EDR, in a compliance monitoring plan (CMP). The CMP will specify the location, duration, and frequency of monitoring and the rationale for the termination of monitoring.

The three types of compliance monitoring to be conducted are:

- **Protection Monitoring** to confirm that human health and the environment are adequately protected during the construction period of the cleanup action
- **Performance Monitoring** to confirm that the cleanup action has attained cleanup standards or other performance standards
- **Confirmation Groundwater Monitoring** to confirm the long-term effectiveness of the cleanup action once cleanup standards and performance standards have been attained.

4.2.6.1 Protection Monitoring

The purpose of protection monitoring is to safeguard human health and worker safety during activities related to construction, operation, and maintenance of the cleanup action as addressed through the project health and safety plan (HASPs). The project HASPs address potential physical and chemical hazards associated with Site activities, consistent with the requirements of WAC 173-340-810. Anticipated potential physical hazards include exposure to hazardous building materials, working in proximity to heavy equipment, open excavations or trenches, and contaminated soil and/or water. Exposure to Site contaminants in the soil or groundwater could occur through various exposure pathways including direct contact, ingestion, and inhalation. The existing project HASP will be updated (if needed) for use by the engineering team during construction oversight and the selected construction contractor will be required to prepare and submit a HASP for use by their workers and subcontractors.

Environmental protection monitoring will be conducted as described in the CMP. This is anticipated to include dust monitoring, monitoring to ensure proper implementation of the stormwater pollution prevention plan (SWPPP), and monitoring best management practices (BMPs) that will be implemented to minimize and control stormwater runoff from contaminated soil during construction. During construction, a certified construction erosion and sediment control lead will monitor performance of the BMPs and recommend changes in approach or application, if required.

4.2.6.2 Construction Performance Monitoring

Performance monitoring will include verifying that the physical limits of the planned excavation are sufficient to remove source materials from the Site. No soil confirmation samples will be collected from the excavation bottom or sidewalls because the excavation is not intended to reduce IHS concentrations in soil to meet CLs. Rather, the excavation will remove most of the source material before bioremediation and MNA are used to clean up the remaining contamination in Site soil and groundwater.

Survey control points will be provided in the construction plans and specifications, which will be used by the contractor to guide excavation efforts and check that excavation is conducted as planned. A field engineer will observe construction and will work with the contractor to confirm adherence to the excavation plans.

Baseline and subsequent performance monitoring events will consist of collecting groundwater samples from wells located upgradient, within, and downgradient of the infiltration gallery and trenches. It is anticipated that after removal of the three monitoring wells that must be decommissioned because they are within the boundary of the excavation (MW-1, MW-2, and MW-3), the other seven groundwater monitoring wells will remain at the Site for monitoring conditions. Additional monitoring wells will also be installed. The actual locations of groundwater monitoring wells will be determined during remedial design and shown in the CMP.

Monitoring will begin with observations for LNAPL accumulation in groundwater monitoring wells and the LNAPL monitoring risers installed in the larger infiltration gallery and two treatment trenches. Recovery will be conducted if practicable as described in Section 4.2.4. Afterward, a baseline groundwater monitoring event will be conducted to establish IHS and nitrate concentrations for later comparison to the post-injection monitoring events. Post-injection monitoring is anticipated to occur on a quarterly basis during the first 2 years of active injections, transitioning to a semiannual frequency in the third year. The first post-injection event is anticipated to occur 1 to 2 months after injection. Monitoring frequency may be adjusted based on the monitoring results. Groundwater monitoring results will be evaluated for trends in contaminant and nitrate concentrations and to assess changes in aquifer redox conditions as contaminant mass is consumed. It is anticipated that samples collected during baseline and post-injection monitoring will be analyzed for TPH-G, TPH-D, benzene, total naphthalenes, nitrate, sulfate, and ferrous iron (by a field test kit), although adjustments to the suite of analytical parameters may be made over time in consultation with Ecology based on the analytical results.

4.2.6.3 Monitored Natural Attenuation

The cleanup action may include a period of MNA after completing the bioremediation program, if needed, as a final polishing step to allow for IHS concentrations to be reduced to below cleanup standards. It is the intent of the cleanup action to use active cleanup measures to minimize the restoration timeframe to the greatest degree practicable. MNA would be implemented after bioremediation efforts have successfully reduced the concentrations of contaminants to the degree that the restoration timeframe through MNA would be considered reasonable in accordance with the CAP and MTCA guidelines. If the evaluation of MNA data indicates additional active remedial action is required to achieve cleanup standards within a reasonable restoration timeframe, further bioremediation or hotspot removal through excavation could be implemented.

The goal of MNA is to allow for natural processes to reduce contaminants in groundwater while monitoring the Site boundary and exposure pathways to ensure that the remaining contamination does not pose a risk to human health or the environment. This goal will be accomplished in two ways:

- Monitoring of the natural attenuation of IHS concentrations in groundwater at the Site until they are below the CLs established for groundwater
- Ongoing evaluation of whether MNA will achieve the cleanup goal in a reasonable restoration timeframe (or if contingent actions are necessary).

Trends in groundwater chemical concentrations and geochemical parameters will be used to evaluate MNA effectiveness.

5.0 ENGINEERING BASIS FOR DESIGN

The following sections present the engineering basis and design rationale for the cleanup action described herein. The discussion below provides typical design criteria, assumptions used in developing the preliminary design details, MTCA-required design considerations, and the rationale for how and why the cleanup action will achieve the remedial action objectives (RAOs) and meet cleanup standards in accordance with MTCA requirements.

5.1 General Design Criteria

The general design criteria for this cleanup action will include the following, some of which cannot be further developed until detailed construction plans are prepared:

- Cleanup standards established in the CAP (Section 2.3)
- Erosion and sediment control regulations and requirements
- Soil sloping and stability for the temporary excavations (Appendix C)
- Fill material physical and chemical characteristics appropriate for future Site use
- Subtitle D municipal solid waste landfill waste acceptance criteria
- Finish grade, surfacing, and/or landscape specifications
- Applicable permitting requirements (Section 4.2.1.1).

5.2 MTCA-Required Design Considerations

This section describes Site-specific design considerations required in WAC 173-340-400(4) pertinent to the design, construction, and operation of the cleanup action. Specifically, this section addresses the relationship between the proposed cleanup action and the Site geographic features, subsurface conditions, existing structures, and current and future Site operations.

5.2.1 Facility Characteristics Affecting the Cleanup Action

As shown on Figure 2, aside from the gravel surfacing near the ASTs, most of the surface is asphalt-paved or covered with slab-on-grade industrial buildings. Utilities in the vicinity of the Site cleanup will require decommissioning prior to other Site work. These include fuel pipelines on the west side of the Site, which transferred fuel from the ASTs to the fueling dock, and both underground and aboveground power lines on the east side of the Site, which service the existing buildings. The utility lines will be deactivated and sealed within the proposed excavation and temporary shoring areas (extents shown on Figure 6). The portion of utilities within the excavation area will be removed as a part of this cleanup action.

The presence of Sigurdson Avenue and the high density of subsurface utilities beneath the road will affect the source area excavation. Some contamination below the road would have been removed as part of the source area excavation, but will remain in place due to the impracticality of excavation.

The utilities are active and service many nearby buildings and activities. After source area removal, the contamination beneath the roadway will be the highest levels remaining on Site, but it is anticipated that bioremediation will be effective to achieve CLs in this area.

The paving, flooring, and foundations will be demolished and removed as part of the cleanup action. The demolition material will be recycled or disposed of at permitted waste handling facilities, as appropriate. The demolition excavations will be backfilled with non-contaminated engineered fill soil that is imported to the Site or excavated from non-contaminated areas as part of the cleanup excavation. The general public associated with these nearby access points will be protected from the Site cleanup activities by perimeter fencing, secured access gates, and traffic controls.

5.2.2 Controls to Prevent Hazardous Material Releases

The following controls will be implemented to prevent releases of hazardous materials during excavation and handling of contaminated soils:

- Installation and maintenance of temporary erosion and sediment control structures and implementation of BMPs. These controls and BMPs include wetting of soil, as necessary, during excavation to control dust; silt fencing; tire washing of haul trucks; applying crushed rock over exposed soil; and stormwater drainage to infiltration areas.
- Properly covering and securing loads during hauling operations.

In addition, the shoreline will be protected from erosion by the installation of a sealed sheetpile bulkhead.

5.2.3 Flooding

The Site is located between Semiahmoo Bay and Drayton Harbor and is subject to ocean tide fluctuations that are below the finished grades of the Site. Flooding is, therefore, unlikely to impact the Site unless an extreme storm event impacts the Site. Based on the proposed depth of excavation, it is anticipated that stormwater runoff from even high-intensity events during the cleanup action will be completely contained.

5.2.4 Seismic Activity

The Site is located in a seismically active zone. However, the proposed excavation will be generally less than 12 ft in depth and is not anticipated to be a hazard in the event of an earthquake. The potential for hazard is lowered by removing structures prior to the cleanup action, excavation shoring, and sloping the excavation sidewalls to a safe conditions.

5.2.5 Temperature Extremes

The cleanup action consists of excavation and backfill in the generally mild climate of the Pacific Northwest. Higher temperatures (i.e., above 80^{o}F) may affect the health and safety of the construction workers; therefore, a Site-specific health and safety plan (HASP; discussed in Section 6.4)

will be prepared by the contractor that will include provisions to address hydration and workers keeping cool within the confines of the Site. Cold temperatures will also impact the safety of the workers and will also be addressed in the contractor's HASP. Cold weather will affect backfilling of the excavations; the placement of backfill will not be conducted while the temperature is below 35°F to avoid placing frozen soil.

5.2.6 Existing and Future Site Uses

As described in Section 1, the Site and surrounding areas support the fishing and boating industries. Additionally, a retail furniture and appliance store was located on the Site. In preparation for this cleanup, the Site has been vacated and the existing buildings will be demolished and removed. After the cleanup action, future Site uses may include construction of commercial buildings, parking areas; roadways; public access; marina access; and associated utilities.

5.2.7 Local Planning and Development Issues

The Site is zoned for commercial use and there are no known local development issues that would prevent or impact the proposed cleanup action.

5.2.8 Public Access

The working areas of the Site will generally be closed to public access during the cleanup construction period. Traffic may be routed to avoid Sigurdson Avenue during portions of the cleanup, if an acceptable alternative route can be made east of the furniture retail building. Construction plans and specifications will ensure that the cleanup activities can be staged and implemented in a manner that maintains ingress and egress for local businesses and maintains safe distances from the excavation.

5.2.9 Future Sea Level Rise Considerations

Site cleanup activities will not change the existing grade or elevation of the Site. Based on the small size of the upland area, which is almost entirely surrounded by marine surface water, addressing sea level rise at the shoreline of the Site would be ineffective at preventing overtopping elsewhere, if it were to occur. Future sea level rise mitigation would require consideration during property redevelopment in a comprehensive manner, which is outside the scope of this EDR. Further, it is not anticipated that contamination will be left in place after the cleanup action is complete, so sea level rise is not a consideration for achieving cleanup standards.

5.2.10 Contingency Beach and Shellfish Bed Closure

No in-water work will be conducted as part of the cleanup action and no beaches or shellfish beds are in the Site vicinity. No closures are in consideration.

5.3 Efficacy of the Cleanup Action

Excavation of the highly contaminated soil in the source area is a rapid and efficient method to immediately reduce Site contamination and risks of exposure or migration. Soil excavation will reduce the risks posed to human health and the environment by removing potential exposure pathways to human and environmental receptors. The source area excavation facilitates LNAPL removal while the excavation is open, and NAPL monitoring/recovery wells will be used to observe for and remove additional NAPL if it is present.

Surface containment will be constructed to prevent exposure to residual contamination left in place after the source area removal until bioremediation has achieved cleanup standards. Anaerobic bioremediation is a proven effective approach to reducing concentrations of TPH contamination.

Wasserman et al. (2005) injected a nitrate solution for treatment of No. 2 fuel oil contamination, and within approximately 1 year after the initial treatment, soil and groundwater contaminant concentrations were reduced by 50 to 60 percent. Nitrate injection has been used extensively at Co-Op fueling sites in Canada (Campbell et al. 2009). Additionally, LAI has successfully used nitrate injection for TPH remediation at five other sites in Washington State, including two marine shoreline sites.

6.0 CONSTRUCTION REQUIREMENTS

The following section provides a description of the construction documents that will be prepared for the upland cleanup action, the quality assurance and control procedures that will be implemented to monitor and document the implementation of the cleanup action, the procedures that will be implemented to prevent releases of hazardous substances during construction, and the health and safety requirements that will be applied during implementation of the cleanup action.

6.1 Construction Drawings and Specifications

Construction plans and specifications will be prepared to develop details of the cleanup actions to be performed after approval of this EDR. The construction plans and specifications will be prepared in conformance with currently accepted engineering practices and WAC 173-340-400 (4)(b), and provide:

- A general description of the project that details the cleanup action, including work to be done, a summary of Site environmental conditions, a summary of design criteria, an existing facility map, adequate Site surveying, and a copy of permits and approvals
- Detailed plans and specifications necessary for construction, construction materials storage, construction waste storage and management, utility locations within cleanup areas, surface drainage, materials, backfill, and change in grades
- A description of construction impact controls (including dust, stormwater, traffic, and noise)
- Construction documentation including specific quality control tests such as soil density/ in-place compaction, moisture content, material gradation, subgrade strength, depth measurements, frequency of tests, and acceptable results.

6.2 Construction Quality Control/Quality Assurance

Day-to-day construction quality control (CQC) will be performed by the contractor, consistent with the requirements of the construction contract specifications for the cleanup action. The Port will have a construction quality assurance (CQA) representative on Site during construction to confirm that the work is being performed in accordance with the intent of the plans and specifications. CQC will include the necessary elements to ensure that the provisions of the contaminated materials handling plan are being followed. In accordance with WAC 173 340 400(7)(b), all aspects of construction will be performed under the supervision of a professional engineer registered in the State of Washington or a qualified technician under the direct supervision of the engineer.

A CQA plan is being prepared in conjunction with the construction plans and specifications. The plan includes the following monitoring parameters:

- Adequacy of construction submittals
- General construction methods and equipment
- Field engineering and survey methods
- Fill gradation, quality, and consistency

- Fill placement and compaction
- Suitability, quality, and installation of structural elements
- Stormwater runoff and erosion control measures
- Decontamination procedures
- Traffic control plan
- Contractor quality control methods and documentation
- As-built dimensions of completed work.

Specific quantitative measures and performance requirements have been established for each of the above-noted CQC/CQA parameters and will be incorporated into the construction specifications and the CQA plan for the cleanup action.

6.3 Control of Hazardous Materials, Accidental Discharges, and Stormwater

Prior to building demolition at the Site, the asbestos-containing material (ACM), mercury switch-containing thermostats, and fluorescent light tubes identified during the hazardous building materials Survey (HBMS; Appendix C) will be removed and properly disposed of at an offsite disposal facility prior to demolition in accordance with all appropriate federal, state, and local regulations. Lead exposure hazards will be controlled by misting the structures during demolition to mitigate dust impacts, and implementing BMPs to prevent migration of lead dust. Additional lead worker exposure and decontamination controls will be described in the construction plans and specifications package to be implemented if monitoring during implementation indicates that workers will be exposed to lead at concentrations above the permissible exposure limit (PEL).

Procedures to control and, as appropriate, respond to spills from construction equipment and fueling operations will be incorporated into the construction plans and specifications. During Site cleanup, the materials most likely to be spilled include equipment fuel and oil, or contaminated soil. Additionally, stormwater runoff has the potential to convey water and soil off the Site. The contractor will prepare construction, equipment decontamination, and stormwater management plans in accordance with project- and Site-specific requirements set forth in the plans and specifications that adequately address environmental protection measures. The contractor will be required to perform work involving the handling of the above-noted materials in accordance with these plans. These plans will be subject to review and comment by the Port's CQA representative prior to initiating the work.

The contractor's project construction plan will describe the overall sequence and construction methods that will be used to complete the cleanup action. The plan will include detailed procedures for controlling, collecting, handling, and disposing of residual contaminated soil and debris, and any liquids generated during disposal operations. The equipment decontamination plan will provide design details for the contractor's equipment decontamination pad, including the pad dimensions;

construction materials; and water collection, conveyance, and treatment systems. The contractor's stormwater management plan will provide construction details and operation procedures for collection, conveyance, and treatment and disposal of stormwater runoff, and for erosion and sediment control measures, as required to ensure that materials are properly managed and maintained within the Site boundary. This plan will also address procedures for handling and storage of hazardous materials used for construction purposes (e.g., fuel, oil, etc.), and for prevention and, as appropriate, response to hazardous material spills or accidental discharges.

6.4 Health and Safety

Health and safety procedures that will be followed during the cleanup action are provided in this section.

6.4.1 Health and Safety for Demolition

Prior to demolition, the contractor must have an adequate HASP for properly trained and equipped personnel to remove ACM, lead paint and other hazardous building materials from the Site including but not limited to:

- Abatement of popcorn ceiling tiles, which will be Class I asbestos work.
- Abatement of the non-friable floor tiles, gaskets, and fire door, which will be Class II asbestos work.
- Exposure to lead. It is the employer's responsibility to ensure that work practices are in accordance with the Washington State Department of Labor and Industries' lead in construction rule (WAC 296-155-176). A Lead Handling specification will be included in the construction plans and specifications that will describe requirements for worker protection should monitoring during implementation indicate that workers will be exposed at concentrations above the PEL for lead. The contractor will also need to restrict access to the Site and control dust during demolition to prevent exposure to the public and/or migration of paint-chip waste into Site stormwater.
- Management of Universal Waste including light tubes, which must be packaged and disposed of in accordance with WAC 173-303-573(5).

6.4.2 Health and Safety During Cleanup Action

The following design features will be implemented as part of the cleanup action to ensure the safety of Site workers and the public:

- Safety Fences – Temporary security fencing will be installed around the Site to allow unrestricted access to Site cleanup personnel while maintaining a secure perimeter around the Site. A detailed temporary fencing diagram will be provided on the construction plans. Additionally, safety fencing will be installed, as necessary, around open excavations to prevent unauthorized entry.
- Load Covering – All loads of excavated soil will be properly secured and covered to prevent release and exposure of contaminated materials during hauling operations.

- Personal and Perimeter Air Monitoring – Personal and perimeter air/dust monitoring will be conducted until there are sufficient data to indicate that there are no significant risks to Site workers or the public.
- Excavation Safety– Any areas of the excavation that exceed 4 ft in depth will be sloped or benched to reduce the potential for sidewall collapse. The LAI project-specific HASP will be prepared and provided under separate cover.
- A HASP will also be prepared by the contractor for use by their workers before beginning work on the Site. The contractor's HASP will be required to be at least as protective as LAI's HASP. Each HASP will be required to be at least as protective as the existing Site-specific HASP (LAI 2012b) used for previous Site investigation activities, and will satisfy the requirements of the Port; Ecology (per WAC 173-340 810); the Occupational Safety and Health Act of 1970 (29 USC. Sec. 651 et seq.); and the Washington Industrial Safety and Health Act (Chapters 296-24, 296-62, and 296-155 WAC). All workers at the Site will be required to read and sign the applicable HASP. A health and safety meeting will be conducted with the contractor, subcontractors, construction testing personnel, and appropriate Port employees before starting work at the Site.

6.4.3 Long-Term Health and Safety

Contaminated material will be excavated and removed from the Site and the excavations backfilled with imported clean soil. Residual contaminated soil contained on Site following completion of the excavation will be addressed by bioremediation. Therefore, the Site will not pose a threat to future long-term workers, the public, or other people accessing the Site.

6.5 Construction Completion Report

Upon completion of finish grading activities, the Port will prepare and submit a construction completion report for the upland cleanup in accordance with WAC 173-400 (6)(b). The construction completion report will include:

- A statement that the construction has been performed under the oversight of a professional engineer in the State of Washington or by qualified technicians under their direct supervision.
- A narrative describing the aspects of the work performed including construction techniques and materials used, items installed, and tests and measurements performed. The narrative will be supplemented with daily reports and photographs in the appendices.
- Results of the compliance monitoring (per Section 6.0) documenting that the contaminated soil has been removed, with testing results and locations shown in the appendices.
- As-built drawings documenting the extent of excavation and grading performed at the Site, including the following details:
  - Existing Site grades and locations and elevations of utility vaults, surface monuments, catch basins and manholes, and other structures in the vicinity of the work
  - Excavation elevations
  - Backfill material types and grades

  - Locations of existing utilities and locations and elevations of all utility repairs and replacements
  - Field changes of dimensions and details.

- A statement from the engineer, based on testing results and inspections, as to whether the cleanup action has been constructed in substantial compliance with the plans and specifications and related documents.

7.0 OPERATION AND MAINTENANCE OF THE CLEANUP ACTION

It is anticipated that the cleanup action will achieve the cleanup standards and that institutional controls will not be required following completion of the cleanup action.

If the restoration timeframe is longer than estimated, institutional controls will be implemented to provide the following protections until the Site is restored:

- Require maintenance of the Site's pavement and gravel cap
- Prevent the use of Site groundwater for drinking water
- Ensure the proper management of excavated soil or groundwater and appropriate worker safety associated with any future intrusive activities through implementation of a soil and groundwater management plan until cleanup standards are achieved in accordance with WAC 173-340-440.

If the cleanup action requires more time than currently estimated, institutional controls, potentially including a restrictive covenant, will be implemented to ensure that the integrity of the capping system and other cleanup equipment is maintained to prevent contact with contaminated media, protect the integrity of the cleanup action, and prevent the use of Site groundwater as a drinking water source until the Site cleanup standards are achieved.

8.0 USE OF THIS REPORT

This EDR has been prepared for the exclusive use of the Port of Bellingham and the Washington State Department of Ecology for specific application to the planned remedial action at the Blaine Marina, Inc. Site in Blaine Washington. Any reuse of information, conclusions, and recommendations provided herein for extensions of the project or for any other project, without review and authorization by LAI, shall be at the user's sole risk. LAI warrants that within the limitations of scope, schedule, and budget, our services have been provided in a manner consistent with that level of care and skill ordinarily exercised by members of the profession currently practicing in the same locality under similar conditions as this project. We make no other warranty, either express or implied.

9.0 REFERENCES

Campbell, P., T. Carlson, and K. Bradshaw. 2009. "Enhanced Natural Attenuation Using Supplied Electron Acceptors and Trace Nutrients." Proceedings of the Tenth International In Situ and On-Site Bioremediation Symposium. Baltimore, MD. May.

Cunningham, Jeffrey A., Halla Rahme, Gary D. Hopkins, Carmen Lebron, and Martin Reinhard. 2001. "Enhanced In Situ Bioremediation of BTEX-Contaminated Groundwater by Combined Injection of Nitrate and Sulfate." Environmental Science & Technology 35 (8):1663-1670. doi: 10.1021/es001722t.

Ecology. 2012. Agreed Order for Interim Action, Remedial Investigation, Feasibility Study, and Draft Cleanup Action Plan – Blaine Marina, Inc. Site, No. DE 9000, in the Matter of Remedial Action by Port of Bellingham. Washington State Department of Ecology. Effective Date: May 25.

Ecology. 2015. "Cleanup Levels and Risk Calculations (CLARC)." Washington State Department of Ecology. https://fortress.wa.gov/ecy/clarc/CLARCHome.aspx.

Ecology. 2016. Cleanup Action Plan, Blaine Marina, Inc. Site, Blaine, Washington. Washington State Department of Ecology. August 11.

Ecology. 2017. First Amendment to Agreed Order No. DE 9000 in the Matter of Remedial Action by Port of Bellingham. Washington State Department of Ecology. Effective Date: May 5.

LAI. 2012a. Report: Geotechnical Engineering Services, Blaine Marina Fuel Pier Bulkhead Replacement, Bellingham, Washington. Landau Associates, Inc. April 6.

LAI. 2012b. Remedial Investigation Work Plan, Blaine Marina, Inc. Site, Blaine, Washington. Landau Associates, Inc. October 4.

LAI. 2015. Report: Remedial Investigation / Feasibility Study, Blaine Marina, Inc. Site, Blaine, Washington. Landau Associates, Inc. August 20.

Reid Middleton. 2017. Condition Assessment of Shoreline and Bulkheads, Blaine Marine Industrial Area. April 3.

Tchobanoglous, George, Franklin L. Burton, and H.D. Stensel. 2003. Wastewater Engineering: Treatment and Reuse. 4th ed. McGraw-Hill Education.

Wasserman, R.S., A.C. Easterday, E.C. Hice, A. Leite, and C.J. Varner. 2005. "Innovative Anaerobic In Situ Remediation to Treat Fuel-Oil Contamination - Case Study." Eighth International In Situ and On-Site Bioremediation Symposium, Baltimore, MD, June 6-9.

Wiedemeier, Todd H., John T. Wilson, Donald H. Kampbell, Ross N. Miller, and Jerry E. Hansen. 1999. Technical Protocol for Implementing Intrinsic Remediation with Long-Term Monitoring for Natural Attenuation of Fuel Contamination Dissolved in Groundwater. Technology Transfer Division, US Air Force Center for Environmental Excellence. March 8.

Data Source: Esri 2012

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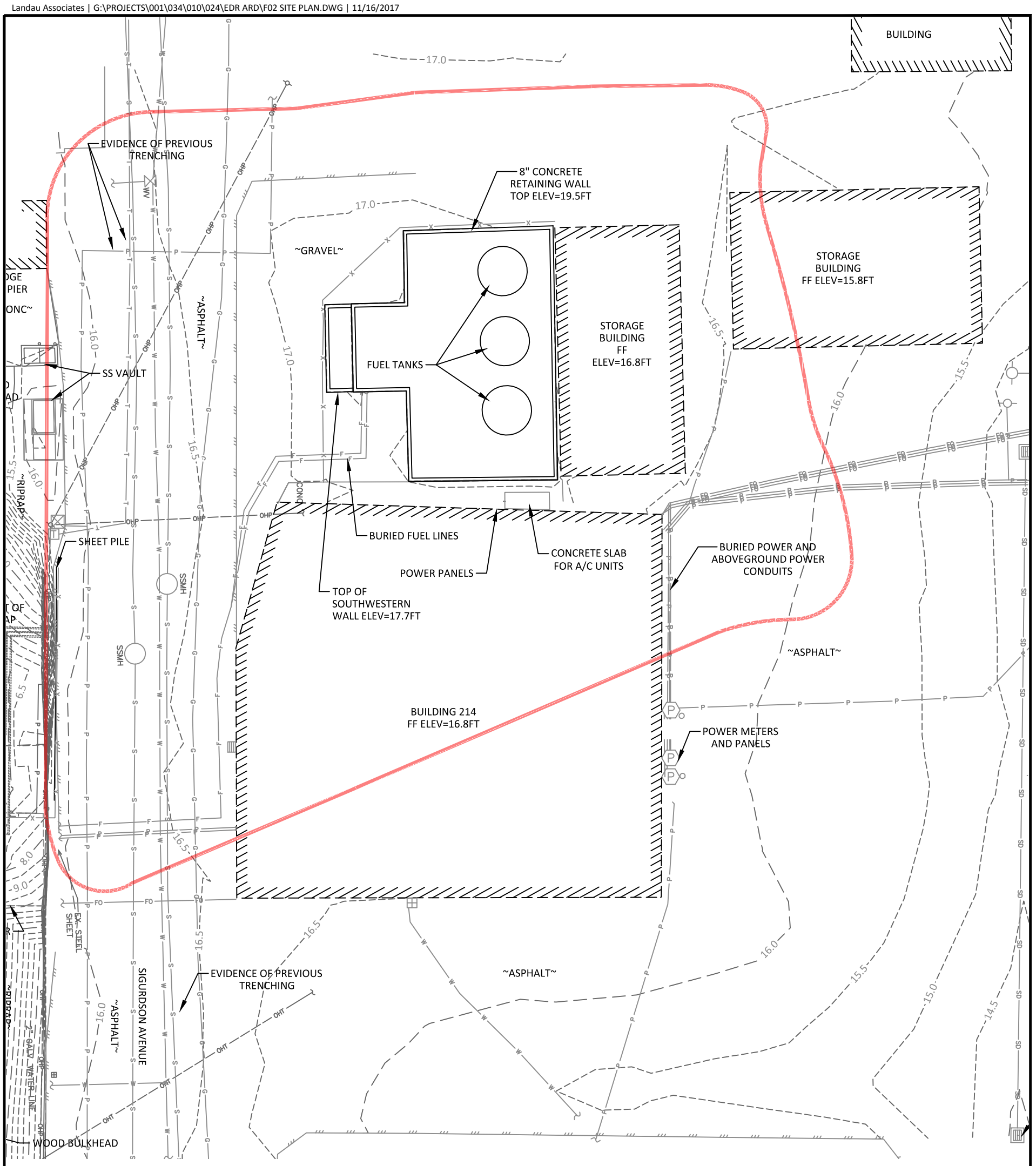
LANDAU ASSOCIATES

Engineering Design Report Blaine Marina, Inc. Site Blaine, Washington	**Vicinity Map**	Figure 1



LEGEND

- = SITE BOUNDARY
- = EXISTING MAJOR CONTOUR
- = EXISTING MINOR CONTOUR
- = EXISTING OVERHEAD POWER
- = EXISTING POWER CONDUIT
- = EXISTING OVERHEAD TELECOMMUNICATIONS
- = EXISTING WATER LINE
- = EXISTING GAS LINE
- = EXISTING SANITARY SEWER LINE
- = EXISTING EDGE OF PAVEMENT
- = EXISTING EDGE OF PIER
- = EXISTING FENCE
- = EXISTING EDGE OF RIPRAP
- = EXISTING FUEL LINE
- = EXISTING FUEL LINE (BENEATH PIER)
- = EXISTING BUILDING
- = EXISTING BULKHEAD

- = EXISTING LUMINAIRE
- = EXISTING POWER METER
- = EXISTING SANITARY SEWER MANHOLE
- = EXISTING PILING
- FP = EXISTING FUEL PUMP
- HR = EXISTING HOSE RACK
- LDR = EXISTING LADDER
- = EXISTING SURVEY TBM
- = EXISTING WATER METER
- = EXISTING WATER VALVE
- = EXISTING FIRE HYDRANT
- = EXISTING UTILITY POLE

ABBREVIATIONS:

APPROX	=APPROXIMATE
CONC	=CONCRETE
ELEV	=ELEVATION
EXIST, EX.	=EXISTING
FF	=FINISH FLOOR
HYD	=HYDRANT
INV	=INVERT
IE	=INVERT ELEVATION
MH	=MANHOLE
MISC	=MISCELLANEOUS
OHP	=OVERHEAD POWER
SD	=STORM DRAIN
SS	=SANITARY SEWER
SSMH	=SANITARY SEWER MANHOLE
TP	=TEST PIT
TYP	=TYPICAL
WV	=WATER VALVE

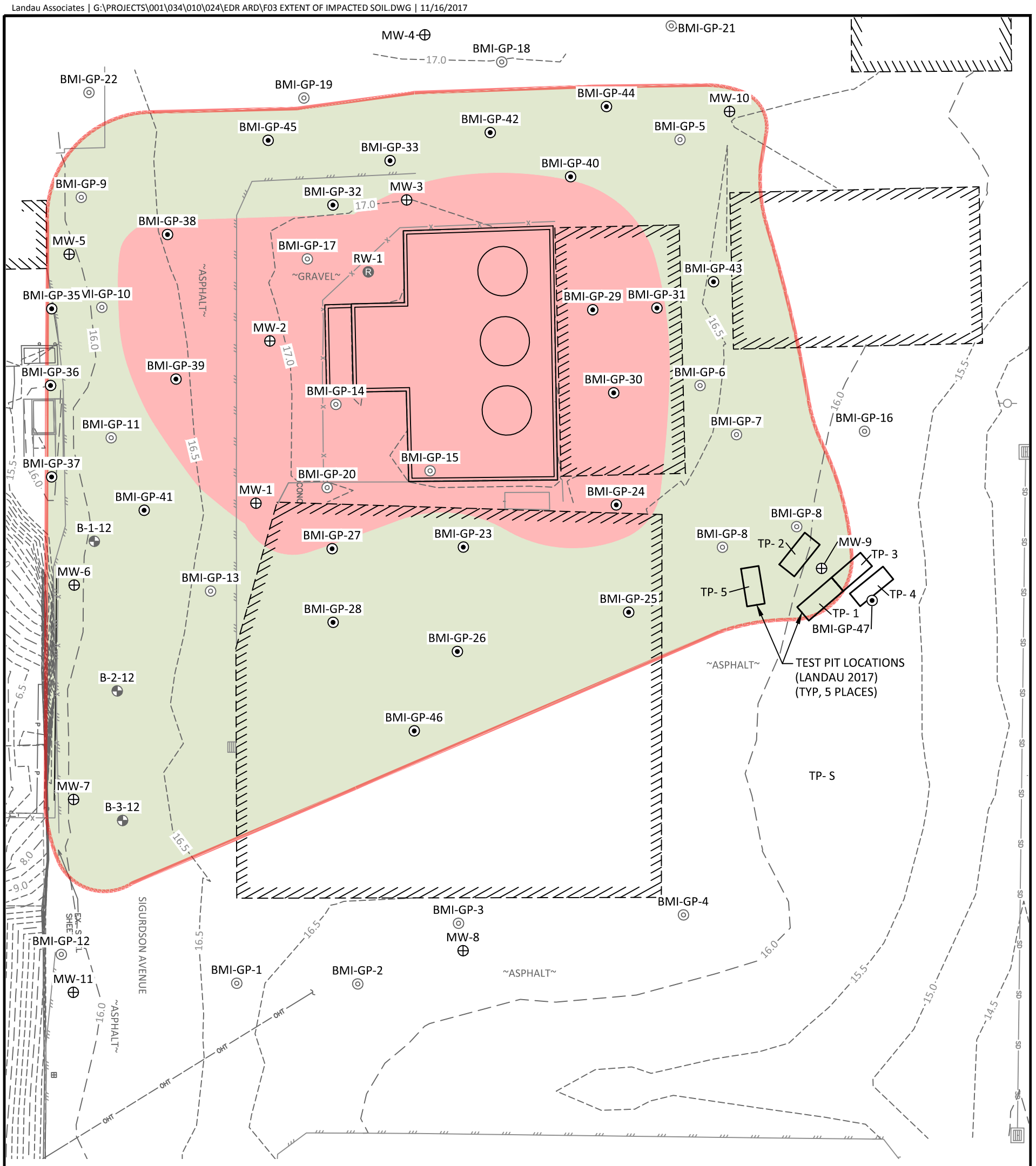
PROJECT NORTH
TRUE NORTH

0 20 40
Scale in Feet

Sources: Wilson Engineering topographic survey, 4/26/17; Wilson Engineering topographic survey, 11/02/11

LANDAU ASSOCIATES

Engineering Design Report Blaine Marina, Inc. Site Blaine, Washington	**Site Plan**	Figure 2



Legend

- PRDI Boring Location
- RI Boring Location
- Groundwater Monitoring Well Location
- Geotechnical Soil Boring (Landau Associates 2012)
- Pilot LNAPL Recovery Well
- Site Boundary
- Contamination is Present in Soil and Groundwater above Cleanup Levels
- Highest Potential for NAPL to be Present

Notes

RI = Remedial Investigation, conducted in 2012 to delineate the nature and extent of contamination to evaluate Site cleanup alternatives.

PRDI = Pre-Remedial Design Investigation, conducted in 2017 to address data gaps to support detailed design of the cleanup action.

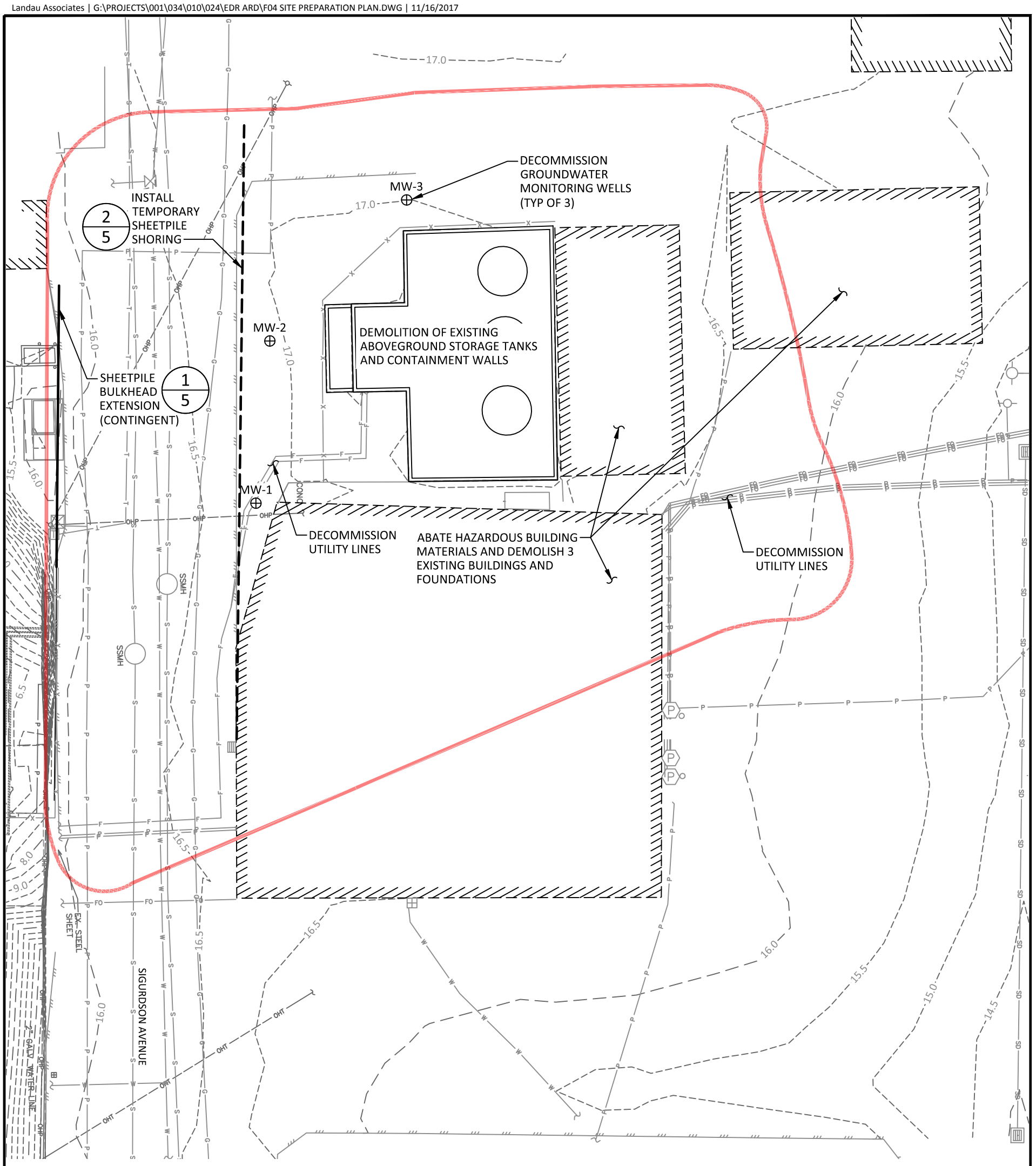
Sources: Wilson Engineering topographic survey, 4/26/17; Wilson Engineering topographic survey, 11/02/11

LANDAU ASSOCIATES

Engineering Design Report
Blaine Marina, Inc. Site
Blaine, Washington

Summary of Site Contamination

Figure 3

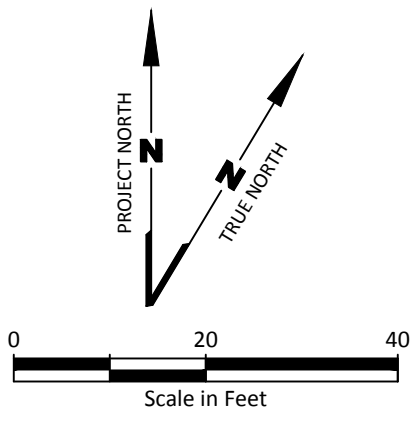


Legend

Site Boundary

SITE CLEANUP PREPARATIONS INCLUDE:

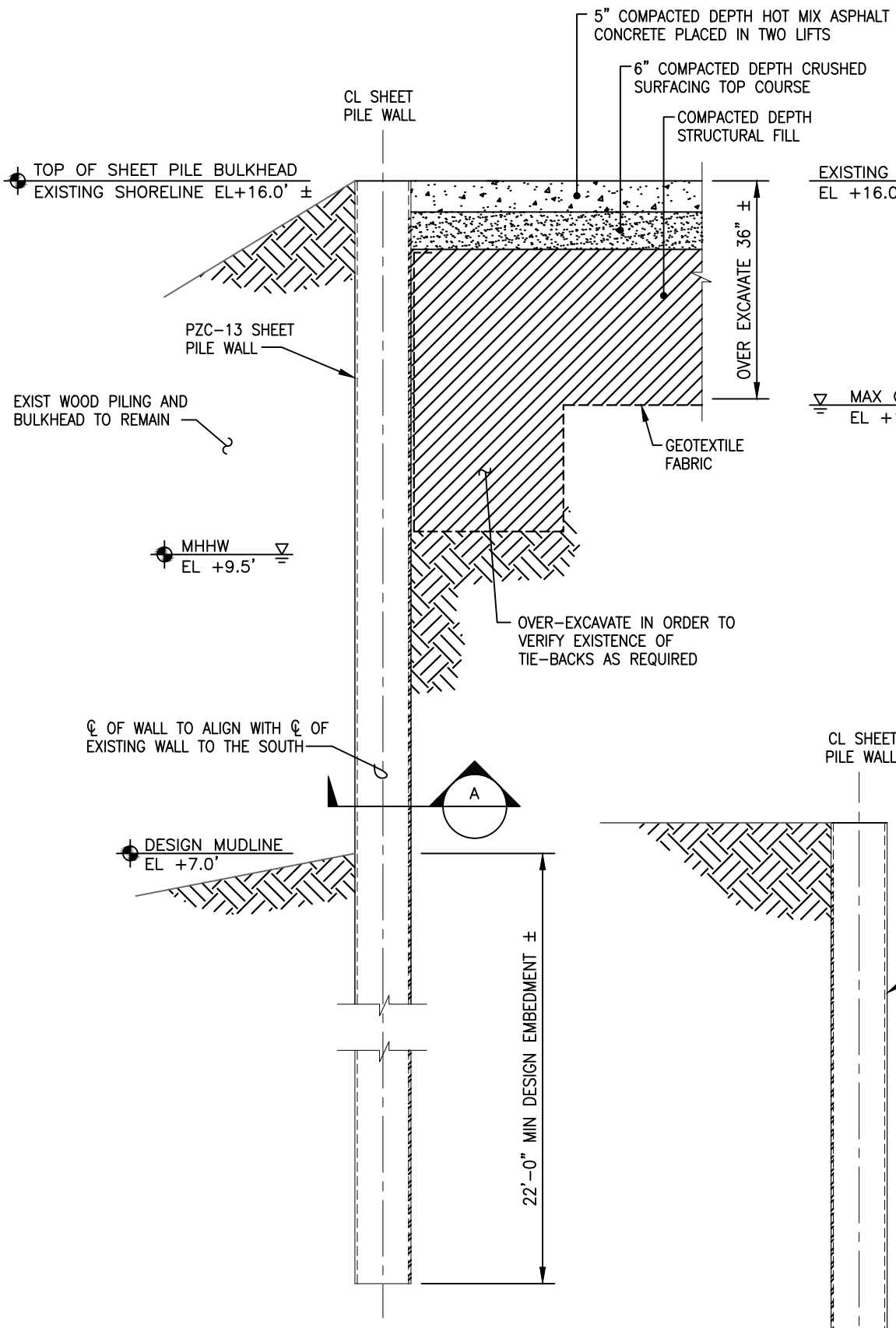
- Demolish 3 Existing Buildings Including Slabs, Foundations, and Associated Utilities.
- Decommission Above-ground Storage Tanks and Ancillary Equipment.
- Install Temporary Sheetpile Shoring for Future Excavation Work.

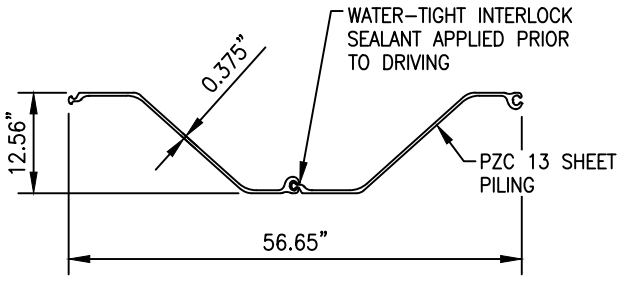


Sources: Wilson Engineering topographic survey, 4/26/17; Wilson Engineering topographic survey, 11/02/11

LANDAU ASSOCIATES

Engineering Design Report Blaine Marina, Inc. Site Blaine, Washington	**Site Preparation Plan**	Figure 4





A SECTION – PZC 13
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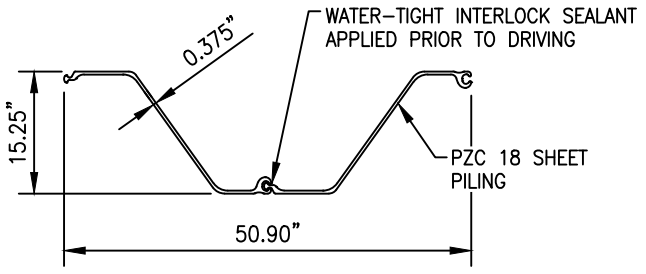

B SECTION – PZC 18
SCALE: NTS

1/4 SECTION – SHEET PILE PERMANENT BULKHEAD
SCALE: 3/4"=1'-0"

0 2 4
Scale in Feet

NOTE: CONTINGENT ACTION; NECESSITY TO BE DETERMINED IN COORDINATION WITH ECOLOGY

NOTES

1. VERTICAL DATUM: ELEVATIONS SHOWN ARE REFERENCED TO THE NOAA/TIDAL MLLW = 0.00' DATUM, BASED UPON SURVEY DATA PROVIDED BY WILSON ENGINEERING.

2/4 SECTION – SHEET PILE TEMPORARY SHORING
SCALE: 3/4"=1'-0"

0 2 4
Scale in Feet

Source: Reid Middleton, Inc., 2017

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Engineering Design Report Blaine Marina, Inc. Site Blaine, Washington	**Sheetpile Details**	Figure 5

1:H : 1V CUT SLOPE

VERTICAL EXCAVATION ALONG INSTALLED SHEETPILE SHORING

TOE OF EXCAVATION SLOPE

EXCAVATE 10 TO 12 FEET BELOW EXISTING GRADE NO DEEPER THAN ELEVATION 5' OR UNTIL GROUNDWATER TABLE IS ENCOUNTERED

TOP OF EXCAVATION SLOPE

FIRE HYDRANT TO USE AS CONTRACTOR WATER SUPPLY

IMPACTED SOIL STOCKPILE AREA

CLEAN OVERBURDEN SOIL STOCKPILE AREA

RUBBLE STOCKPILE AREA

WHEEL WASH SYSTEM

SIGURDSON AVENUE

EX. STEEL SHEET

EX. 8" GALV. WATER LINE

SSMH

A

A'

B

1+40

1+20

1+00

0+80

0+60

0+40

0+20

0+00

0+10

0+20

0+40

0+60

0+80

1+00

1+20

1+40

1+60

Legend

- Site Boundary
- Limits of Excavation (Approximate Actual Limits May be Greater to Remove Free-phase NAPL if Encountered)
- Monitoring Wells to be Decommisioned
- Temporary Tencing 6ft-High
- Lockable Gates
- Fire Hydrant to Use as Contractor Water Supply
- Temporary Sheetpile Shoring
- Section Alignment

PROJECT NORTH

N

TRUE NORTH

0 20 40

Scale in Feet

Sources: Wilson Engineering topographic survey, 4/26/17; Wilson Engineering topographic survey, 11/02/11

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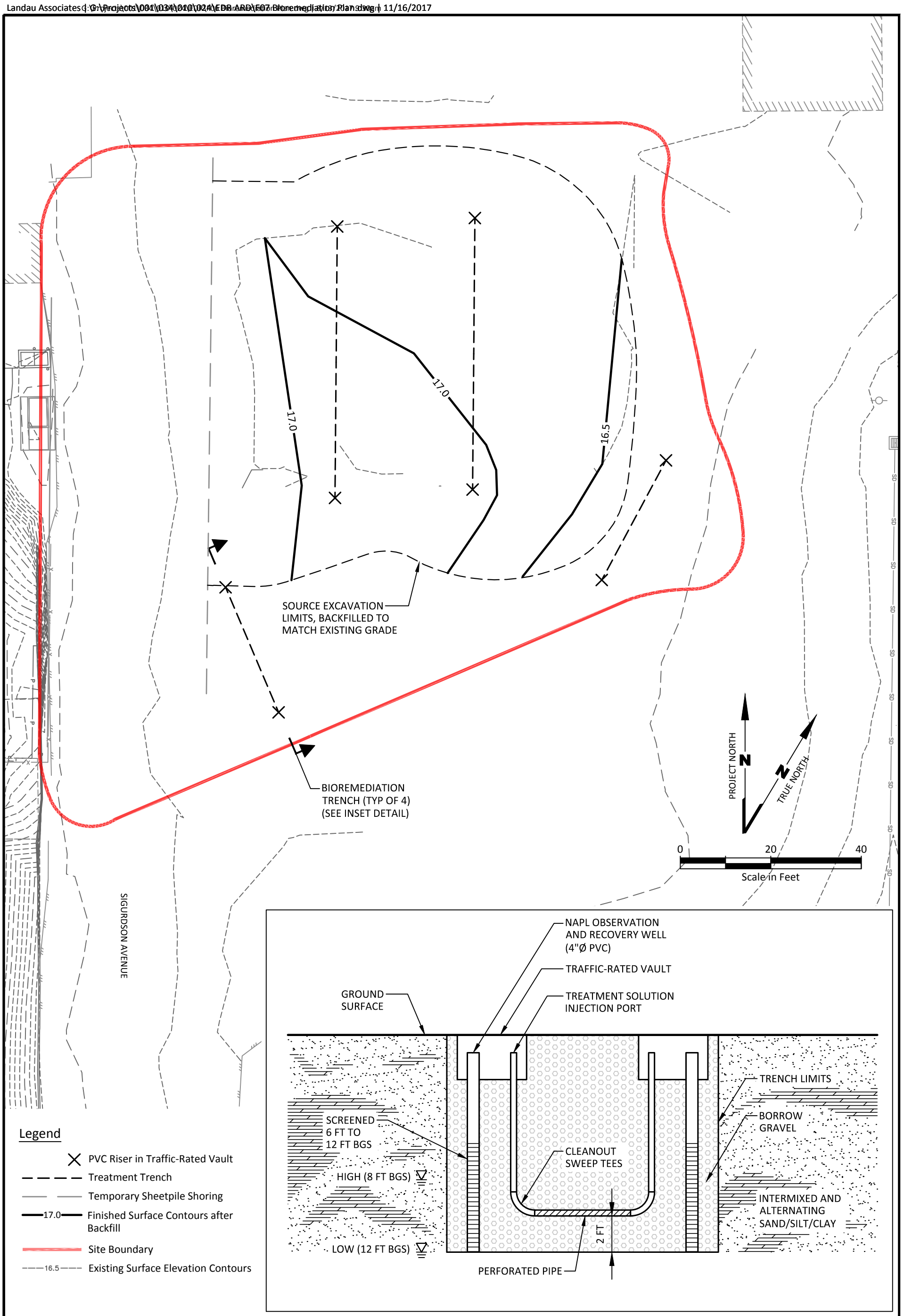
Engineering Design Report
Blaine Marina, Inc. Site
Blaine, Washington

Site Excavation Plan

Figure 6

Landau Associates | G:\Projects\001\034\010\024\EDR ARD\F07 Bioremediation Plan.dwg | 11/16/2017



Legend

- PVC Riser in Traffic-Rated Vault
- Treatment Trench
- Temporary Sheetpile Shoring
- 17.0 Finished Surface Contours after Backfill
- Site Boundary
- 16.5 Existing Surface Elevation Contours

Treatment Trench - Conceptual Cross Section
Not to Scale

Sources: Wilson Engineering topographic survey, 4/26/17; Wilson Engineering topographic survey, 11/02/11

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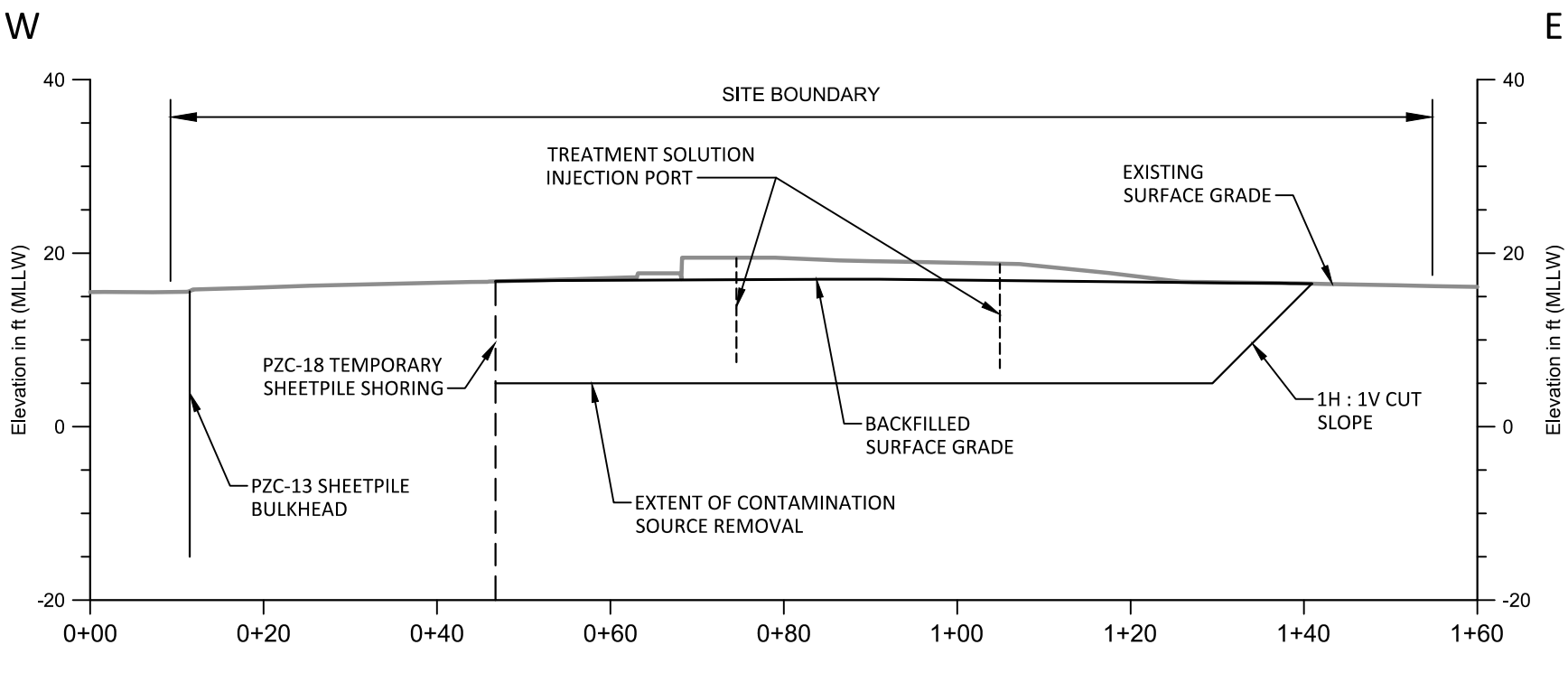
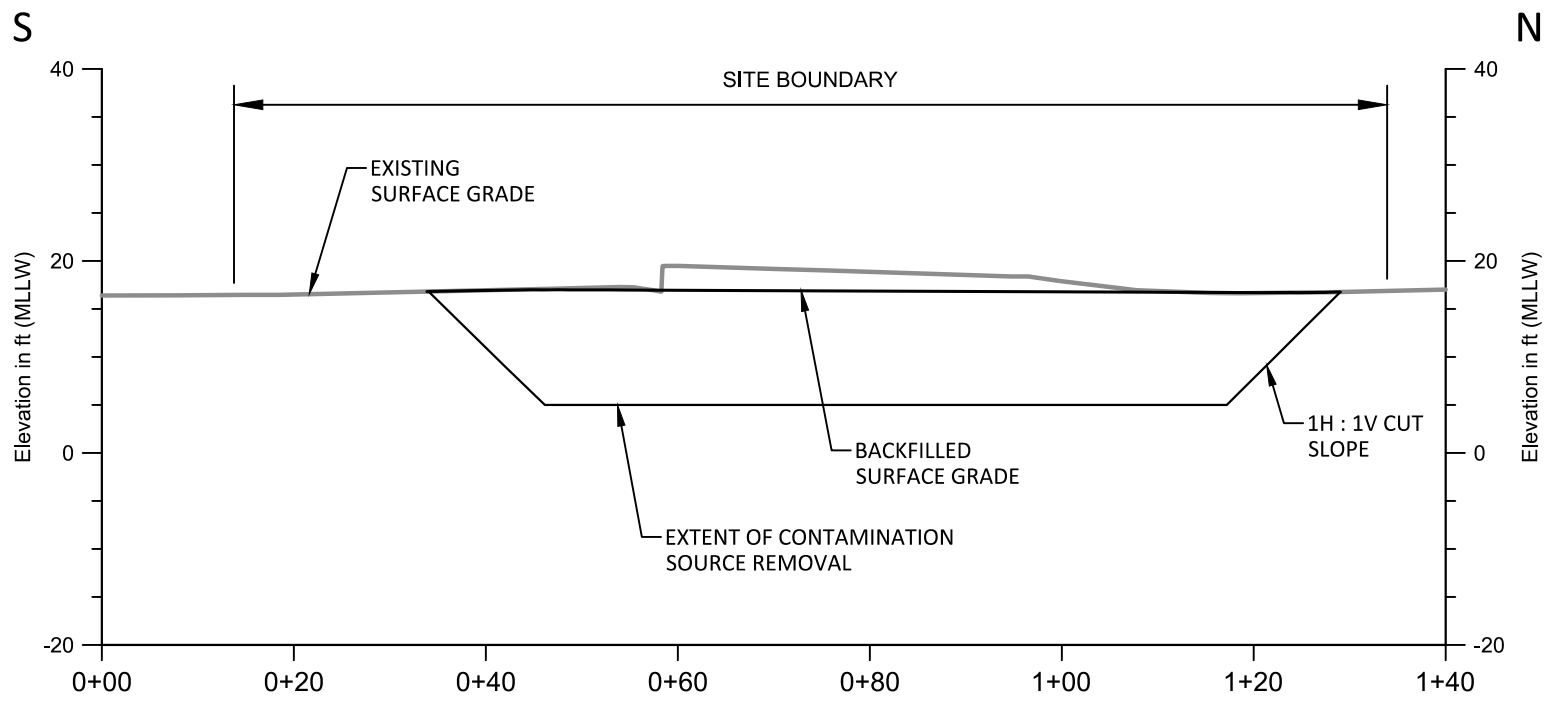
Engineering Design Report Blaine Marina, Inc. Site Blaine, Washington	**Final Grading Plan and Treatment Trench Locations**	Figure 7



SECTION A

0 20 40

Scale in Feet
1x Vertical Exaggeration



SECTION B

0 20 40

Scale in Feet
1x Vertical Exaggeration

Sources: Wilson Engineering topographic survey, 4/26/17; Wilson Engineering topographic survey, 11/02/11

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Engineering Design Report Blaine Marina, Inc. Site Blaine, Washington	**Excavation Conceptual Cross Sections**	Figure 8

Table 1
Site Cleanup Levels
Engineering Design Report
Blaine Marina, Inc. Site – Blaine, Washington

IHS	Unsaturated Soil Cleanup Level [a] (mg/kg)	Saturated Soil Cleanup Level [a] (mg/kg)	Groundwater Cleanup Level [b] (mg/L)	Soil Vapor (µg/m^3)
1,3-Butadiene	-- [c]	-- [c]	--	2.8
Benzene	0.014	0.005	0.0024	11
Ethylbenzene	18	1	--	--
Total Xylenes	9.100	0.052	--	--
TPH-D	2,000	2,000	0.500	--
TPH-G	30 [d]	30 [d]	0.800	--
Total Naphthalenes	2.30	0.12	0.083	--

Notes:

[a] Cleanup level based on lowest soil criteria corrected for practical quantitation limit (PQL) and background.

[b] Cleanup level based on lowest Water Quality Standard or PQL, unless noted otherwise.

[c] -- = Not applicable because constituent is not an indicator hazardous substance for the medium.

[d] MTCA Method A cleanup level is 100 mg/kg if benzene is not present and the total of ethylbenzene, toluene, and xylenes is less than 1% of the gasoline mixture; otherwise the cleanup level is 30 mg/kg.

Abbreviations and Acronyms:

IHS = indicator hazardous substance
TPH-D = diesel-range total petroleum hydrocarbons
TPH-G = gasoline-range total petroleum hydrocarbons
µg/m^3 = micrograms per cubic meter
mg/kg = milligrams per kilogram
mg/L = milligrams per liter

APPENDIX A

Pre-Remedial Design Investigation Data Report

Pre-Remedial Design Investigation Data Report
Blaine Marina, Inc. Site
Blaine, Washington

November 6, 2017

Prepared for

Port of Bellingham
Bellingham, Washington

LANDAU ASSOCIATES

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Pre-Remedial Design Investigation Data Report
Blaine Marina, Inc. Site
Blaine, Washington

This document was prepared by, or under the direct supervision of, the technical professionals noted below.

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Date: November 6, 2017
Project No.: 0001034.010
File path: P:\001\034\010\FileRm\R\EDR\Appendix A
Project Coordinator: Christopher C. Young

LANDAU ASSOCIATES

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TABLE OF CONTENTS

FIGURES

TABLES

ATTACHMENT

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LIST OF ABBREVIATIONS AND ACRONYMS

µg/L ..... micrograms per liter
AST ..... aboveground storage tank
bgs ..... below ground surface
EPA ..... US Environmental Protection Agency
ft ..... feet
LNAPL ..... light non-aqueous phase liquid
mg/kg ..... milligrams per kilogram
mg/L ..... milligrams per liter
PID ..... photoionization detector
Site ..... Blaine Marina Inc. Site
TPH ..... total petroleum hydrocarbons
TPH-D ..... diesel-range total petroleum hydrocarbons
TPH-G ..... gasoline-range total petroleum hydrocarbons
VOC ..... volatile organic compound

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INTRODUCTION

This data report presents the results from soil and groundwater pre-remedial design investigations conducted at the Blaine Marina Inc. Site (Site) in Blaine, Washington (Figure 1). The investigation was completed in accordance with the Pre-Remedial Design Investigation Work Plan (Work Plan; LAI 2017) to collect the additional information needed to complete the design of the final cleanup action selected for the Site, as outlined in the Cleanup Action Plan (Ecology 2016).

The pre-remedial design investigation included the following activities:

- Land Surveying:
  - Significant Site features (buildings, permanent equipment, etc.)
  - Surface elevations
  - Overhead and underground utilities
- Evaluate Building Conditions:
  - Visually inspect general building conditions
  - Conduct a hazardous building materials survey
- Additional Soil Investigation
  - Conduct field screening for contamination by advancing borings and test pits to evaluate core and sidewall soil samples
  - Collect and analyze additional subsurface soil samples to supplement the Site characterization data
- Additional Groundwater Investigation
  - Collect and analyze groundwater samples from existing monitoring wells and groundwater grab-samples from direct-push borings.

During initial investigation activities, unexpected light non-aqueous phase liquid (LNAPL) was encountered in two groundwater monitoring wells and, as a result, additional activities were added to the scope of the Work Plan. These activities were:

- Evaluate LNAPL observed in monitoring well MW-9 by conducting a recoverability test
- Evaluate soil conditions near MW-9 by excavating a test pit for observation.

SOIL INVESTIGATION RESULTS

Additional subsurface explorations were conducted to better characterize soil conditions sufficiently to determine the extent of the highly contaminated soil (source material) to be removed during the cleanup action. Data from these explorations will be used to delineate the lateral boundary for excavation beneath the Furniture and Appliance Retail store and to the east of the aboveground storage tanks (ASTs) beneath the storage buildings. Soil samples were also collected as near as possible to the existing bulkhead, to determine if LNAPL is present in this area.

Field-screening techniques were used to assess the degree of LNAPL presence and 24 soil samples were submitted for laboratory analysis of total petroleum hydrocarbons (TPH) by Methods NWTPH-Dx and NWTPH-G. Soil results were compared to the applicable cleanup levels and are provided in Table 1.

A total of 24 borings were advanced (BMI-GP-23 through BMI-GP-33 and BMI-GP-35 through BMI-GP-47) to a depth of 12 to 16 feet (ft) below ground surface (bgs) in order to observe conditions at least 3 ft below the groundwater table at each location. Logs of explorations containing soil classifications and notes of observable signs of contamination are provided in Attachment 1. Petroleum hydrocarbon oil sheen, possibly indicative of nearby LNAPL, was observed at nine of the boring locations. The greatest indications of contamination were located near the ASTs. Soil samples collected from near the bulkhead contained no signs of contamination. Samples for laboratory analysis were collected from depth intervals within 2 ft above or below the groundwater table.

Analytical results for locations that had one or more cleanup level exceedances are shown on Figure 3. Soil samples from nine locations contained concentrations of diesel-range TPH (TPH-D) above the cleanup level of 2,000 milligrams per kilogram (mg/kg). And soil samples from 16 locations contained concentrations of TPH-G above the cleanup level of 30 mg/kg. Many of the gasoline-range TPH (TPH-G) data point exceedances were also J-flagged, indicating that the laboratory had positively identified the analyte, but the associated numerical value is an approximate concentration. The highest TPH-D and TPH-G concentrations in soil were detected in the sample from BMI-GP-24, located near the northeast corner of the Furniture and Appliance Retail store footprint. The cleanup excavation boundary will be expanded to include this area as discussed in the Engineering Design Report.

GROUNDWATER INVESTIGATION RESULTS

Groundwater samples were collected from five of the direct-push borings (BMI-GP-27, BMI-GP-30, and BMI-GP-38 through BMI-GP-40) and samples were collected from seven of the existing groundwater monitoring wells. Groundwater elevations and the amount of LNAPL, if present, were measured at the time of sampling.

Prior to groundwater sampling from the existing monitoring wells, each well was inspected for integrity and the need for well development. All of the existing wells appeared to be in good condition. During measurement of groundwater elevations, LNAPL was observed in five of the existing wells. Groundwater samples were not collected from wells where LNAPL was present, except from MW-9. Because LNAPL had not been observed at MW-9 before, a sample of the LNAPL was collected and analyzed for TPH by Method NWTPH-HCID.

All other groundwater samples were submitted for laboratory analysis for TPH by Methods NWTPH-G and NWTPH-Dx; for benzene, toluene, ethylbenzene, and xylenes by US Environmental Protection Agency (EPA) Method 8021, and for naphthalenes by EPA Method 8270D. Groundwater samples were also analyzed for conventional geochemical indicator parameters to support the bioremediation design evaluation; including manganese by EPA Method 620, and nitrate and sulfate by EPA Method 300.

Groundwater results are provided and compared to applicable cleanup levels in Table 2. Data from locations where concentrations exceeded cleanup levels are shown on Figure 3. Six of the locations contained TPH-D concentrations that exceeded the cleanup level of 500 micrograms per liter (µg/L). Oil-range TPH was not detected at concentrations greater than the laboratory reporting limit, except in the grab sample from boring BMI-GP-27, which is located near the northwest corner of the Furniture and Appliance Retail store footprint. TPH-G was detected in six of the groundwater samples, but exceeded the 800 µg/L cleanup level only at monitoring well MW-7.

Benzene was not detected at concentrations greater than the laboratory reporting limit in 8 of the groundwater samples. Detections of benzene did occur in samples from MW-6, BMI-GP-38, and BMI-GP-39, but all concentrations were below the cleanup level. Total naphthalene was detected in six of the samples and concentrations exceeded cleanup levels at MW-7, BMI-GP-38, and BMI-GP-40.

Geochemical indicator parameters were consistent with previous remedial investigation measurements, continuing to support that anaerobic biological activity is occurring but could possibly be enhanced due to rate-limiting low concentrations of nitrate. Dissolved oxygen concentrations were typically below 3 milligrams per liter (mg/L), except at locations near the bulkhead, which appear to be tidally influenced. Nitrate concentrations ranged from concentrations not detected above 0.15 to 14 mg/L as nitrogen. These concentrations are relatively low and could indicate that nitrate is used very quickly in the aquifer. Sulfate concentrations ranged from non-detect (below 0.26 mg/L) to

1,700 mg/L, which indicates sulfate-reducing bacteria are not readily using it as an electron acceptor. Therefore, sulfate will not be added to the initial bioremediation injection fluid.

Results from the LNAPL sample collected at MW-9 indicate that the product contains petroleum hydrocarbons in all three ranges (gasoline, diesel, and oil). LNAPL had never previously been encountered at this location, and its presence warranted further investigation, which is detailed in the next section.

ADDITIONAL LNAPL INVESTIGATION RESULTS

As part of the groundwater investigation, field personnel measured depth to groundwater and LNAPL thickness on top of groundwater, if it was present. LNAPL was noted as present in the areas it was previously detected, but also at MW-10 and MW-9, where it has not been observed in the past. At MW-10, it was present with a thickness of about 0.25 ft, and at MW-9, it was present with a thickness of 2.4 ft.

To address these unexpected conditions, additional investigations were conducted near MW-9. LNAPL was further investigated by conducting a recoverability test at MW-9 using the procedures outlined in the Remedial Investigation Work Plan Addendum (LAI 2013). In addition, test pits were dug upgradient and downgradient of MW-9 to evaluate whether the source of LNAPL is located in soil near MW-9.

Recoverability Test

The recoverability test included removing the LNAPL from MW-9 and monitoring its recovery, then using a spreadsheet tool to determine LNAPL transmissivity. The recovery data can be used in this manner to evaluate if hydraulic recovery of the LNAPL is feasible.

The test was conducted on May 18, 2017. The LNAPL thickness at the start of the test was 2.81 ft. The LNAPL was removed (by pump) and recovery was observed over the course of 6 hours. During this time, the LNAPL did not fully recover to its original thickness. The final thickness was 1.03 ft. The poor recovery was insufficient to calculate an LNAPL transmissivity. It is likely that the observed LNAPL recovery was recharged from the well sandpack, and that LNAPL transmissivity from the surrounding aquifer is very low. A follow-up measurement was collected after 1 month (June 19, 2017) at which time the thickness was 1.13 ft, supporting the conclusion that no recoverable free product is present.

Test Pits

Five test pits were dug on June 19, 2017 at the locations shown on Figure 4 near MW-9. The test pits were each approximately 8 ft long, 3.5 ft wide, and 8.5 to 12 ft deep, depending on the depth to groundwater. Sloughing of side walls at depths below the groundwater table prevented the test pits from extending to 12 ft bgs at all locations. Field personnel visually observed the test pit sidewalls and groundwater seepage for the presence of LNAPL. The excavated soil was stockpiled on plastic sheeting on Site and returned to the test pit upon completion of the observation. Soil was returned to the test pit on the same day it was excavated, in the order it was removed so it would reside in approximately the same location after the test pit exploration was complete. Logs of each test pit, containing soil classifications and notes of observable signs of contamination, are provided in Attachment 1.

Soil from sidewalls were collected and tested using a photoionization detector (PID) to screen for volatile organic compounds (VOCs). The highest PID readings were measured in test pits TP-2, TP-3,

and TP-5, while readings in test pits to the east, in TP-1 and TP-4, had little to no VOC hits. PID results and observations of contamination are shown on Figure 4. A heavy sheen and LNAPL were not observed in any of the test pits. A slight sheen was observed in groundwater seepage from test pit TP-2 on the west wall (at 12 ft bgs), but not on the east wall. Based on these findings, it appears that there is not a significant amount of LNAPL in the soil formation surrounding MW-9.

The rate of groundwater seepage in all test pits was observed as “slow.”

In addition to evaluating environmental conditions, field personnel observed the test-pit sidewalls for stability to note conditions that will be encountered during remedial excavation. The stability of sidewalls was compromised at depths greater than approximately 8 ft bgs, because of saturated soil. These conditions were considered during design of the LNAPL excavation for Site remediation.

USE OF THIS REPORT

This Pre-Remedial Design Investigation Data Report has been prepared for the exclusive use of the Port of Bellingham and its representatives for specific application to the Blaine Marina, Inc. project. No other party is entitled to rely on the information, conclusions, and recommendations included in this document without the express written consent of LAI. Further, the reuse of information, conclusions, and recommendations provided herein for extensions of the project or for any other project, without review and authorization by LAI, shall be at the user's sole risk. LAI warrants that within the limitations of scope, schedule, and budget, our services have been provided in a manner consistent with that level of care and skill ordinarily exercised by members of the profession currently practicing in the same locality under similar conditions as this project. We make no other warranty, either express or implied.

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REFERENCES

Ecology. 2016. Cleanup Action Plan, Blaine Marina Inc. Site, Blaine, Washington. Washington State Department of Ecology. August 11.

LAI. 2013. Technical Memorandum: Remedial Investigation Work Plan Addendum, Blaine Marina Inc. Site, Blaine, Washington. Landau Associates, Inc. March 18.

LAI. 2017. Pre-Remedial Design Investigation Work Plan, Blaine Marina Inc. Site, Blaine, Washington. Landau Associates, Inc. March 14.

Data Source: Esri 2012

G:\Projects\001\034\010\018\FSIF01VicMap.mxd 4/7/2015 NAD 1983 StatePlane Washington North FIPS 4601 Feet

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Blaine Marina, Inc. Site Blaine Harbor Blaine, Washington	**Vicinity Map**	Figure 1

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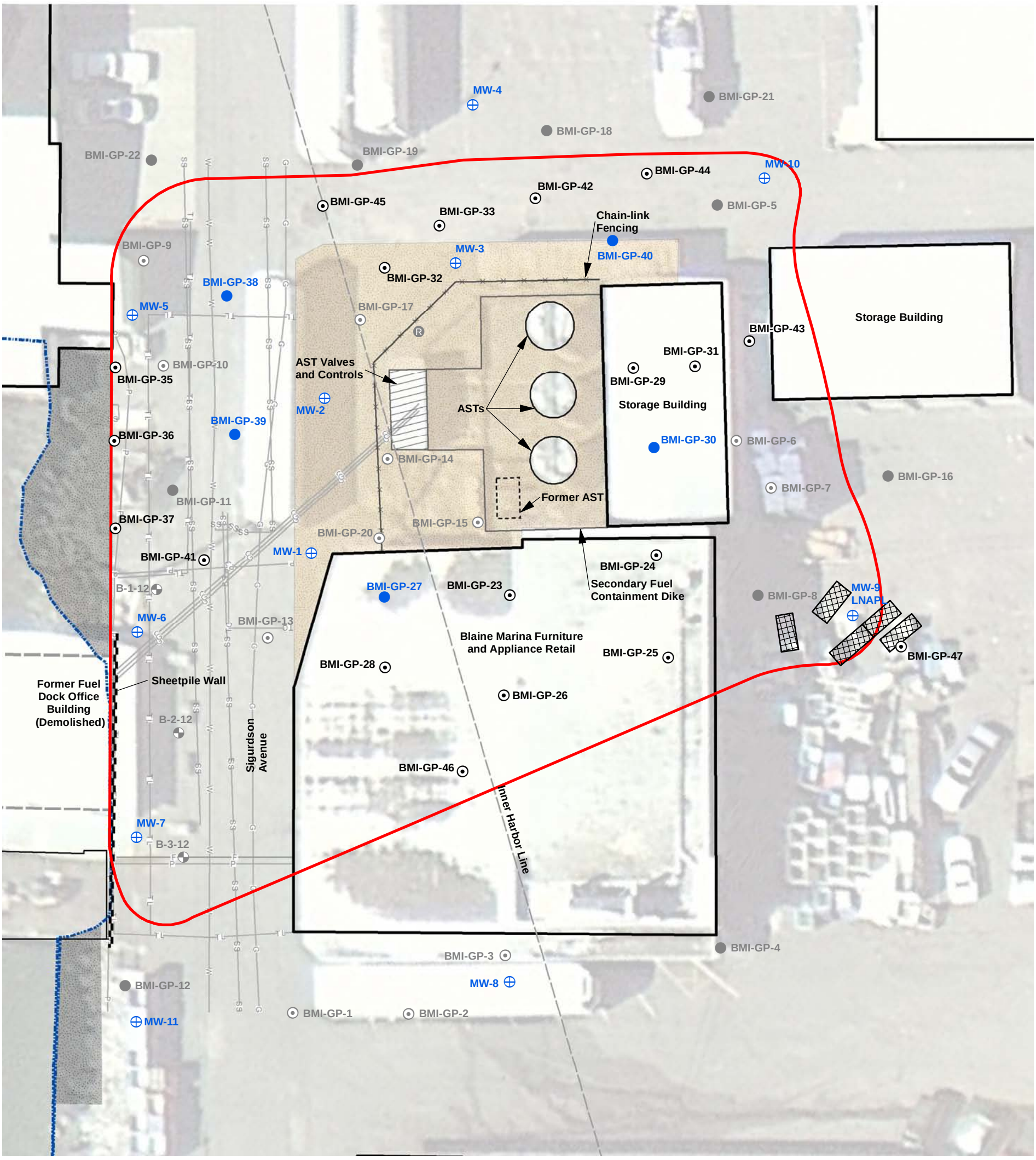
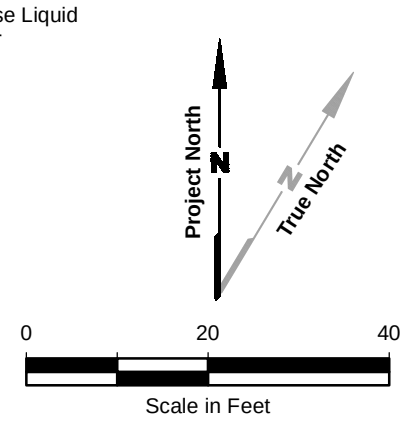


Legend

- Pre-Remedial Design Soil Sample Location
- Pre-Remedial Design Soil Sample and Groundwater Grab Sample Location
- Groundwater Monitoring Well Location
- Previous Soil Sample and Groundwater Grab Sample Location
- Previous Soil Sample Location
- Previous Geotechnical Boring Location
- Pilot LNAPL Recovery Well
- MHHW - 9.5 ft Above MLLW
- Gravel Area
- Riprap Slope
- Test Pit Location
- Site Boundary
- SS Sanitary Sewer Line
- W Water
- F Fire Booster Line
- IR Irrigation Line
- F Fuel Line
- G Old Fuel Line
- V Vault Line
- P Power Line
- TC HTCI
- TL Telephone Line

Abbreviations

LNAPL = Light Non-Aqueous Phase Liquid
MHHW = Mean Higher High Water
MLLW = Mean Lower Low Water



Source: Wilson Engineering 2011, Port of Bellingham 2011, Walker and Associates, Inc.

Notes

1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

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Blaine Marina, Inc. Site
Blaine Harbor
Blaine, Washington

Site Plan with Pre-Remedial Design Investigation Sampling Locations

Figure 2

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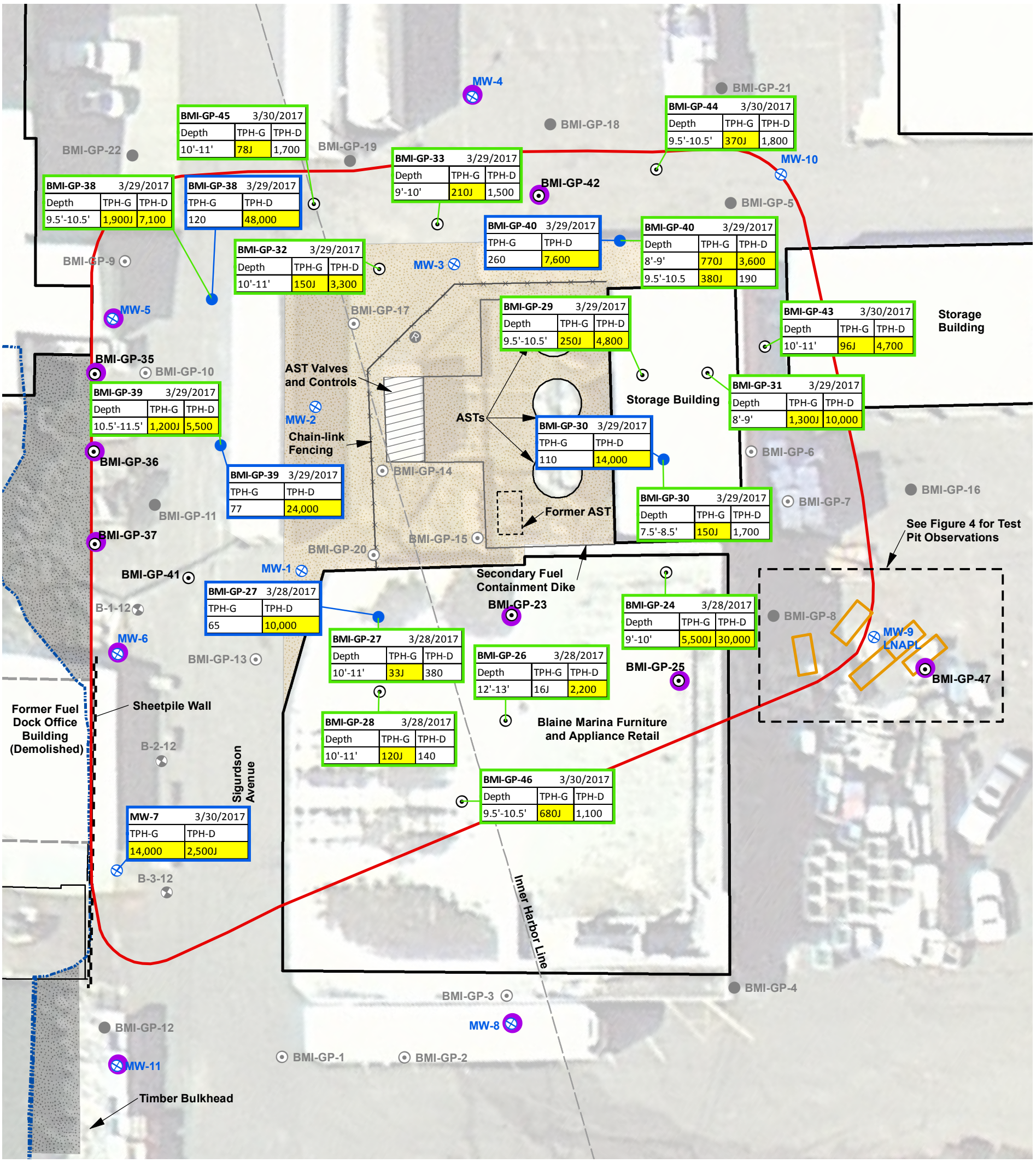

Legend

- Pre-Remedial Design Soil Sample Location
- Pre-Remedial Design Soil Sample and Groundwater Grab Sample Location
- Groundwater Monitoring Well Location
- Previous Soil Sample and Groundwater Grab Sample Location
- Previous Soil Sample Location
- Previous Geotechnical Boring Location
- Pilot LNAPL Recovery Well
- MHHW - 9.5 ft Above MLLW
- Gravel Area
- Riprap Slope
- Test Pit Location
- Site Boundary
- Soil/Groundwater sample results are below cleanup levels

Project North / True North

Notes

1. Groundwater results are shown in µg/L. Soil results are shown in mg/kg.
2. Data shown are those locations with one or more exceedance of screening levels for TPH-D and/or TPH-G. All Pre-Remediation Design Investigation results are shown in Tables 1 and 2.
3. Data highlighted in yellow indicate a screening level exceedance.
4. "J" flagged data indicate the analyte was positively identified, but the associated numerical value is an approximate concentration
5. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Abbreviations

LNAPL = Light Non-Aqueous Phase Liquid
MHHW = Mean Higher High Water
MLLW = Mean Lower Low Water
TPH-D = Total Petroleum Hydrocarbons; Diesel Range
TPH-G = Total Petroleum Hydrocarbons; Gasoline Range

Soil Analytical Results

Groundwater Analytical Results

0 20 40
Scale in Feet

Source: Wilson Engineering 2011, Port of Bellingham 2011, Walker and Associates, Inc.

LANDAU ASSOCIATES

Blaine Marina Inc. Site
Blaine Harbor
Blaine, Washington

Pre-Remediation Design Investigation Results - Exceedances

Figure 3

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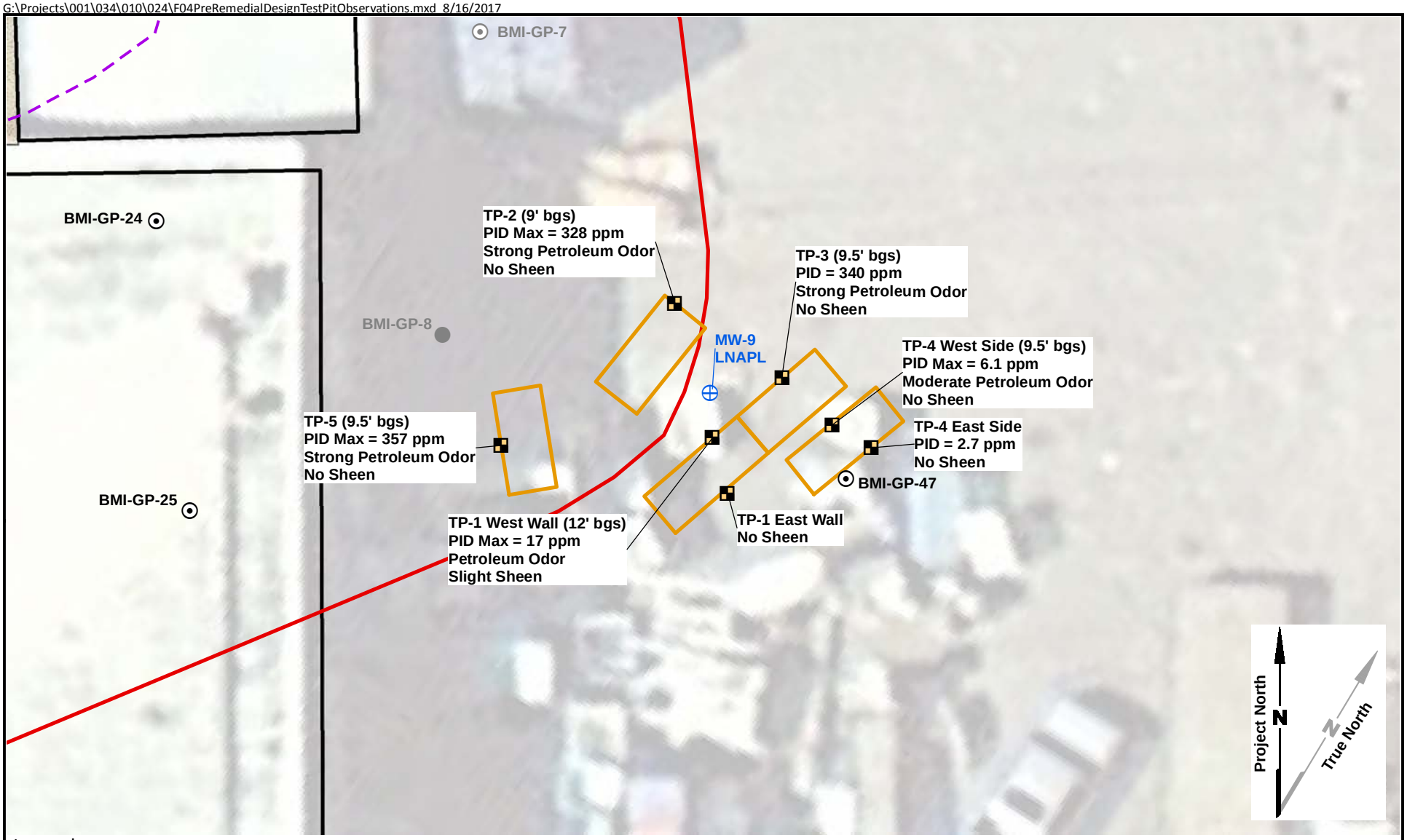

Legend

- Test Pit Sidewall Sample Location
- Remedial Design Soil Sample Location
- Groundwater Monitoring Well Location
- Previous Soil Sample and Groundwater Grab Sample Location
- Previous Soil Sample Location
- Test Pit Location
- Approximate Site Boundary

bgs = Below Ground Surface
ppm = Parts Per Million
PID = Photoionization Detector

0 10 20
Scale in Feet

Source: Wilson Engineering 2011, Port of Bellingham 2011, Walker and Associates, Inc.

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Blaine Marina, Inc. Site
Blaine Harbor
Blaine, Washington

Pre-Remedial Design Test Pit Observations

Figure 4

Table 1
Soil Analytical Results
Pre-Remedial Design Investigation
Blaine Marina, Inc. Site – Blaine, Washington

Analyte	Cleanup Level	Location ID, Sample Depth, Laboratory ID, and Sample Date					
		BMI-GP-23-S 8'-9' EV17030261-05 3/28/2017 N	BMI-GP-24-S 9'-10' EV17030261-01 3/28/2017 N	BMI-GP-25-S 10.5'-11.5' EV17030261-07 3/28/2017 N	BMI-GP-26-S 12'-13' EV17030261-06 3/28/2017 N	BMI-GP-27-S 10'-11' EV17030261-02 3/28/2017 N	BMI-GP-28-S 10'-11' EV17030261-04 3/28/2017 N
Petroleum Hydrocarbons (mg/kg; NWTPH-Gx/Dx)							
TPH-Gasoline Range (C7-C12)	30	**25 J**	**5,500 J**	**9.0 J**	**16 J**	**33 J**	**120 J**
TPH-Diesel Range (C12-C24)	2,000	**54**	**30,000**	**870**	**2,200**	**380**	**140**
TPH-Oil Range (C24-C40)	2,000	50 U	2,500 U	**50**	250 U	100 U	50 U

Table 1
Soil Analytical Results
Pre-Remedial Design Investigation
Blaine Marina, Inc. Site – Blaine, Washington

Analyte	Cleanup Level	Location ID, Sample Depth, Laboratory ID, and Sample Date					
		BMI-GP-29-S 9.5'-10.5' EV17030261-10 3/29/2017 N	BMI-GP-30-S 7.5'-8.5' EV17030261-09 3/29/2017 N	BMI-GP-31-S 8'-9' EV17030261-11 3/29/2017 N	BMI-GP-32-S 10'-11' EV17030289-01 3/29/2017 N	BMI-GP-33-S 9'-10' EV17030289-03 3/29/2017 N	BMI-GP-35-S 9'-10' EV17030289-04 3/30/2017 N
Petroleum Hydrocarbons (mg/kg; NWTPH-Gx/Dx)							
TPH-Gasoline Range (C7-C12)	30	**250 J**	**150 J**	**1,300 J**	**150 J**	**210 J**	**9.2 J**
TPH-Diesel Range (C12-C24)	2,000	**4,800**	**1,700**	**10,000**	**3,300**	**1,500**	25 U
TPH-Oil Range (C24-C40)	2,000	250 U	**91**	**1,100**	250 U	**130**	50 U

Table 1
Soil Analytical Results
Pre-Remedial Design Investigation
Blaine Marina, Inc. Site – Blaine, Washington

Analyte	Cleanup Level	Location ID, Sample Depth, Laboratory ID, and Sample Date					
		BMI-GP-36-S 10.5'-11.5' EV17030289-05 3/30/2017 N	BMI-GP-37-S 11'-12' EV17030289-06 3/30/2017 N	BMI-GP-38-S 9.5'-10.5' EV17030261-13 3/29/2017 N	BMI-GP-39-S 10.5'-11.5' EV17030261-14 3/29/2017 N	BMI-GP-40-S 8'-9' EV17030261-12 3/29/2017 N	BMI-GP-40-S 9.5'-10.5' EV17030289-07 3/30/2017 N
Petroleum Hydrocarbons (mg/kg; NWTPH-Gx/Dx)							
TPH-Gasoline Range (C7-C12)	30	**15 J**	**8.0 J**	**1,900 J**	**1,200 J**	**770 J**	**380 J**
TPH-Diesel Range (C12-C24)	2,000	**220**	25 U	**7,100**	**5,500**	**3,600**	**190**
TPH-Oil Range (C24-C40)	2,000	50 U	50 U	500 U	250 U	**270**	50 U

Table 1
Soil Analytical Results
Pre-Remedial Design Investigation
Blaine Marina, Inc. Site – Blaine, Washington

Analyte	Cleanup Level	Location ID, Sample Depth, Laboratory ID, and Sample Date					
		BMI-GP-42-S 11.5'-12.5' EV17030289-02 3/29/2017 N	BMI-GP-43-S 10'-11' EV17030289-08 3/30/2017 N	BMI-GP-44-S 9.5'-10.5' EV17030289-09 3/30/2017 N	BMI-GP-45-S 10'-11' EV17030289-10 3/30/2017 N	BMI-GP-46-S 9.5'-10.5' EV17030289-11 3/30/2017 N	BMI-GP-47-S 9'-10' EV17030289-12 3/30/2017 N
Petroleum Hydrocarbons (mg/kg; NWTPH-Gx/Dx)							
TPH-Gasoline Range (C7-C12)	30	**17 J**	**96 J**	**370 J**	**78 J**	**680 J**	**27 J**
TPH-Diesel Range (C12-C24)	2,000	25 U	**4,700**	**1,800**	**1,700**	**1,100**	**710**
TPH-Oil Range (C24-C40)	2,000	50 U	500 U	100 U	**60**	**74**	50 U

Notes:

U = The compound was not detected at the reported concentration.

J = The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.

N = Primary sample

Bold text indicates detected analyte.

= reported result is greater than the screening level.

Abbreviations:

mg/kg = milligrams per kilogram

ID = identification

FD = field duplicate

N = primary sample

NWTPH = Northwest Total Petroleum Hydrocarbon

SDG = Sample delivery group

TPH = total petroleum hydrocarbons

Table 2
Groundwater Analytical Results
Pre-Remedial Design Investigation
Blaine Marina, Inc. Site – Blaine, Washington

Analyte	Cleanup Level	Field Sample ID, Lab Sample ID, Sample Date, & Sample Type				
		BMI-GP-27-GW EV17030261-03 3/28/2017 N	BMI-GP-30-GW EV17030261-08 3/29/2017 N	BMI-GP-38-GW EV17030261-17 3/29/2017 N	BMI-GP-39-GW EV17030261-16 3/29/2017 N	BMI-GP-40-GW EV17030261-18 3/29/2017 N
Dissolved Metals (µg/L; EPA 200.8)						
Manganese	--	**79**	**91**	**24**	**39**	**430**
Conventionals (mg/L; EPA 300.0)						
Nitrogen, Nitrate (As NO_3)	--	0.15 U	0.15 U	**0.22**	0.15 U	0.15 U
Sulfate	--	**15**	0.26 U	**240**	**68**	**2.8**
Petroleum Hydrocarbons (µg/L; NWTPH-Gx/Dx)						
TPH-Gasoline Range (C7-C12)	800	**65**	**110**	**120**	**77**	**260 J**
TPH-Diesel Range (C12-C24)	500	**10,000**	**14,000**	**48,000**	**24,000**	**7,600**
TPH-Oil Range (C24-C40)	500	**860**	500 U	2,500 U	1,200 U	**420**
Petroleum Hydrocarbons (mg/kg; NWTPH-HCID)						
HCID-Gasoline Range (C7-C12)	--	--	--	--	--	--
HCID-Diesel Range (C12-C24)	--	--	--	--	--	--
HCID-Oil Range (C24-C40)	--	--	--	--	--	--
BTEX (µg/L; SW-846 8021B)						
Benzene	51	1.0 U	1.0 U	**8.2**	**2.5**	1.0 U
Toluene	--	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U
Ethylbenzene	--	1.0 U	1.0 U	**1.4**	1.0 U	1.0 U
Xylenes, Total	--	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U
SVOCs (µg/L; SW-846 8270D SIM)						
Naphthalene	--	0.020 U	0.020 U	**53**	**15**	**740**
2-Methylnaphthalene	--	**29**	**20**	**79**	**5.9**	**150**
1-Methylnaphthalene	--	**34**	**15**	**91**	**50**	**110**
Total Naphthalenes	83	**63**	**35**	**223**	**71**	**1,000**

Table 2
Groundwater Analytical Results
Pre-Remedial Design Investigation
Blaine Marina, Inc. Site – Blaine, Washington

Analyte	Cleanup Level	Field Sample ID, Lab Sample ID, Sample Date, & Sample Type				
		MW-4 EV17030287-05 3/30/2017 N	MW-5 EV17030287-04 3/30/2017 N	MW-6 EV17030287-01 3/30/2017 N	DUP of MW-6 EV17030287-06 3/30/2017 FD	MW-7 EV17030287-02 3/30/2017 N
Dissolved Metals (µg/L; EPA 200.8)						
Manganese	--	**740**	2.0 U	**7.6**	**7.7**	**350**
Conventionals (mg/L; EPA 300.0)						
Nitrogen, Nitrate (As NO_3)	--	0.15 UJ	**3.1**	**14**	**15**	**13 J**
Sulfate	--	**58**	**780**	**59**	**62**	**1,000**
Petroleum Hydrocarbons (µg/L; NWTPH-Gx/Dx)						
TPH-Gasoline Range (C7-C12)	800	50 U	50 U	50 U	50 U	**14,000**
TPH-Diesel Range (C12-C24)	500	**360**	130 U	**140**	130 U	**2,500 J**
TPH-Oil Range (C24-C40)	500	250 U	250 U	250 U	250 U	**490**
Petroleum Hydrocarbons (mg/kg; NWTPH-HCID)						
HCID-Gasoline Range (C7-C12)	--	--	--	--	--	--
HCID-Diesel Range (C12-C24)	--	--	--	--	--	--
HCID-Oil Range (C24-C40)	--	--	--	--	--	--
BTEX (µg/L; SW-846 8021B)						
Benzene	51	1.0 U	1.0 U	**3.2**	**3.3**	20 U
Toluene	--	1.0 U	1.0 U	1.0 U	1.0 U	20 U
Ethylbenzene	--	1.0 U	1.0 U	1.0 U	1.0 U	**52**
Xylenes, Total	--	3.0 U	3.0 U	**6.0**	**5.9**	**210**
SVOCs (µg/L; SW-846 8270D SIM)						
Naphthalene	--	0.020 U	0.020 U	0.020 U	0.020 U	**170**
2-Methylnaphthalene	--	0.020 U	0.020 U	0.020 U	0.020 U	**120**
1-Methylnaphthalene	--	0.020 U	0.020 U	0.020 U	0.020 U	**210**
Total Naphthalenes	83	0.020 U	0.020 U	0.020 U	0.020 U	**500**

Table 2
Groundwater Analytical Results
Pre-Remedial Design Investigation
Blaine Marina, Inc. Site – Blaine, Washington

Analyte	Cleanup Level	Field Sample ID, Lab Sample ID, Sample Date, & Sample Type		
		MW-8 EV17030287-07 3/30/2017 N	MW-9 (PRODUCT) EV17030287-08 3/30/2017 N	MW-11 EV17030287-03 3/30/2017 N
Dissolved Metals (µg/L; EPA 200.8)				
Manganese	--	**83**	--	2.0 U
Conventionals (mg/L; EPA 300.0)				
Nitrogen, Nitrate (As NO_3)	--	0.15 UJ	--	**14 J**
Sulfate	--	**98**	--	**1,700**
Petroleum Hydrocarbons (µg/L; NWTPH-Gx/Dx)				
TPH-Gasoline Range (C7-C12)	800	50 U	--	50 U
TPH-Diesel Range (C12-C24)	500	130 U	--	130 U
TPH-Oil Range (C24-C40)	500	250 U	--	250 U
Petroleum Hydrocarbons (mg/kg; NWTPH-HCID)				
HCID-Gasoline Range (C7-C12)	--	--	**3,900**	--
HCID-Diesel Range (C12-C24)	--	--	**15,000**	--
HCID-Oil Range (C24-C40)	--	--	**20,000**	--
BTEX (µg/L; SW-846 8021B)				
Benzene	51	1.0 U	--	1.0 U
Toluene	--	1.0 U	--	1.0 U
Ethylbenzene	--	1.0 U	--	1.0 U
Xylenes, Total	--	3.0 U	--	3.0 U
SVOCs (µg/L; SW-846 8270D SIM)				
Naphthalene	--	0.020 U	--	0.020 U
2-Methylnaphthalene	--	0.020 U	--	0.020 U
1-Methylnaphthalene	--	0.020 U	--	0.020 U
Total Naphthalenes	83	0.020 U	--	0.020 U

Table 2
Groundwater Analytical Results
Pre-Remedial Design Investigation
Blaine Marina, Inc. Site – Blaine, Washington

Notes:

U = The compound was not detected at the reported concentration.

J = The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.

UJ = The analyte was not detected in the sample; the reported sample reporting limit is an estimate.

Bold text indicates detected analyte.

-- = Not analyzed

= reported result is greater than the screening level.

Abbreviations:

mg/kg = milligrams per kilogram

mg/L = milligrams per liter

µg/L = micrograms per liter

EPA = US Environmental Protection Agency

FD = field duplicate

HCID = hydrocarbon identification

N = primary sample

NA = screening level not available

NWTPH = Northwest Total Petroleum Hydrocarbon

SIM = selected ion monitoring

SVOC = semivolatile organic compound

TPH = total petroleum hydrocarbons

ATTACHMENT 1

Logs of Exploration

Soil Classification System

MAJOR DIVISIONS			GRAPHIC SYMBOL	USCS LETTER SYMBOL[1]	TYPICAL DESCRIPTIONS [2][3]
COARSE-GRAINED SOIL (More than 50% of material is larger than No. 200 sieve size)	GRAVEL AND GRAVELLY SOIL (More than 50% of coarse fraction retained on No. 4 sieve)	CLEAN GRAVEL (Little or no fines)		GW	Well-graded gravel; gravel/sand mixture(s); little or no fines
				GP	Poorly graded gravel; gravel/sand mixture(s); little or no fines
		GRAVEL WITH FINES (Appreciable amount of fines)		GM	Silty gravel; gravel/sand/silt mixture(s)
				GC	Clayey gravel; gravel/sand/clay mixture(s)
	SAND AND SANDY SOIL (More than 50% of coarse fraction passed through No. 4 sieve)	CLEAN SAND (Little or no fines)		SW	Well-graded sand; gravelly sand; little or no fines
				SP	Poorly graded sand; gravelly sand; little or no fines
		SAND WITH FINES (Appreciable amount of fines)		SM	Silty sand; sand/silt mixture(s)
				SC	Clayey sand; sand/clay mixture(s)
FINE-GRAINED SOIL (More than 50% of material is smaller than No. 200 sieve size)	SILT AND CLAY (Liquid limit less than 50)			ML	Inorganic silt and very fine sand; rock flour; silty or clayey fine sand or clayey silt with slight plasticity
				CL	Inorganic clay of low to medium plasticity; gravelly clay; sandy clay; silty clay; lean clay
				OL	Organic silt; organic, silty clay of low plasticity
	SILT AND CLAY (Liquid limit greater than 50)			MH	Inorganic silt; micaceous or diatomaceous fine sand
				CH	Inorganic clay of high plasticity; fat clay
				OH	Organic clay of medium to high plasticity; organic silt
	HIGHLY ORGANIC SOIL			PT	Peat; humus; swamp soil with high organic content

OTHER MATERIALS	GRAPHIC SYMBOL	LETTER SYMBOL	TYPICAL DESCRIPTIONS
PAVEMENT		AC or PC	Asphalt concrete pavement or Portland cement pavement
ROCK		RK	Rock (See Rock Classification)
WOOD		WD	Wood, lumber, wood chips
DEBRIS		DB	Construction debris, garbage

Notes:
1. USCS letter symbols correspond to symbols used by the Unified Soil Classification System and ASTM classification methods. Dual letter symbols (e.g., SP-SM for sand or gravel) indicate soil with an estimated 5-15% fines. Multiple letter symbols (e.g., ML/CL) indicate borderline or multiple soil classifications.
2. Soil descriptions are based on the general approach presented in the Standard Practice for Description and Identification of Soils (Visual-Manual Procedure), outlined in ASTM D 2488. Where laboratory index testing has been conducted, soil classifications are based on the Standard Test Method for Classification of Soils for Engineering Purposes, as outlined in ASTM D 2487.
3. Soil description terminology is based on visual estimates (in the absence of laboratory test data) of the percentages of each soil type and is defined as follows:

Primary Constituent:	> 50% - "GRAVEL," "SAND," "SILT," "CLAY," etc.
Secondary Constituents:	> 30% and ≤ 50% - "very gravelly," "very sandy," "very silty," etc.
	> 15% and ≤ 30% - "gravelly," "sandy," "silty," etc.
Additional Constituents:	> 5% and ≤ 15% - "with gravel," "with sand," "with silt," etc.
	≤ 5% - "with trace gravel," "with trace sand," "with trace silt," etc., or not noted.

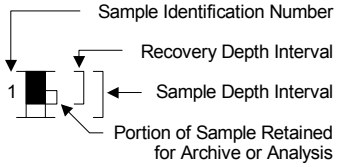
4. Soil density or consistency descriptions are based on judgement using a combination of sampler penetration blow counts, drilling or excavating conditions, field tests, and laboratory tests, as appropriate.

Drilling and Sampling Key

SAMPLER TYPE

Code	Description
a	3.25-inch O.D., 2.42-inch I.D. Split Spoon
b	2.00-inch O.D., 1.50-inch I.D. Split Spoon
c	Shelby Tube
d	Grab Sample
e	Single-Tube Core Barrel
f	Double-Tube Core Barrel
g	2.50-inch O.D., 2.00-inch I.D. WSDOT
h	3.00-inch O.D., 2.375-inch I.D. Mod. California
i	Other - See text if applicable
1	300-lb Hammer, 30-inch Drop
2	140-lb Hammer, 30-inch Drop
3	Pushed
4	Vibrocore (Rotosonic/Geoprobe)
5	Other - See text if applicable

SAMPLE NUMBER & INTERVAL



Field and Lab Test Data

Code	Description
PP = 1.0	Pocket Penetrometer, tsf
TV = 0.5	Torvane, tsf
PID = 100	Photoionization Detector VOC screening, ppm
W = 10	Moisture Content, %
D = 120	Dry Density, pcf
-200 = 60	Material smaller than No. 200 sieve, %
GS	Grain Size - See separate figure for data
AL	Atterberg Limits - See separate figure for data
GT	Other Geotechnical Testing
CA	Chemical Analysis

Groundwater

▽ Approximate water level at time of drilling (ATD)

▼ Approximate water level at time other than ATD

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Blaine Marina Tank Farm
Blaine, Washington

Soil Classification System and Key

Figure 1-1

Calibration Point

SAMPLE DATA				SOIL PROFILE			GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)	Graphic Symbol	USCS Symbol	Drilling Method: Geoprobe™ Ground Elevation (ft): Not Determined	
0						SP-SM	Brown, fine SAND with silt and gravel; No odor, no sheen. (loose, moist)	Groundwater not encountered.
						SP	Brownish, gray SAND with gravel; Slight petroleum-like odor, no sheen. (loose, moist)	
2		i3		0.0		SM	Gray, silty, medium to coarse SAND; Strong petroleum like odor, slight sheen, no staining (loose, moist)	
4								
6		i3		206				
8								

Boring Completed 03/28/17
Total Depth of Boring = 8.0 ft.

10
12
14
16
18
20

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

0001034.010.024 11/6/17 N:\PROJECTS\0001034.010.024.GPJ SOIL BORING LOG

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Blaine Marina Tank Farm Blaine, Washington	Log of Boring Calibration Point	Figure 1-2

BMI-GP-23

SAMPLE DATA				SOIL PROFILE			GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)	Graphic Symbol	USCS Symbol	Water Level
0						PC	Drilling Method: Geoprobe™ Ground Elevation (ft): Not Determined Concrete No Recovery
2		i3				SP	Brown, fine to medium SAND with trace silt; Petroleum-like odor, no sheen. (loose, moist)
4				10			
6		i3		44 7			
8				8			
				15		ML	Gray SILT; Petroleum-like odor, no sheen. (soft, moist) Soil Sample: BMI-GP-23-S(8'-9')
10		i3					
				1.5			▽ ATD
12						SM	Gray, very silty SAND with trace shells; Petroleum-like odor, no sheen. (loose, wet)
14		i3		10 0.0			
16				0.0			
18							
20							

Boring Completed 03/28/17
Total Depth of Boring = 16.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

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Blaine Marina Tank Farm
Blaine, Washington

Log of Boring BMI-GP-23

Figure
1-3

BMI-GP-24

Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)	Graphic Symbol	USCS Symbol	SOIL PROFILE	Water Level
							Drilling Method: Geoprobe™	
							Ground Elevation (ft): Not Determined	
0				0.0		PC	Concrete	
		i3				SP-SM	Brown, fine SAND with fine gravel and silt; Slight odor, no sheen; (loose, dry)	
2				3		WD	Wood debris; Slight odor, no sheen. (loose, damp)	
						ML	Gray SILT with shells; petroleum-like odor, no sheen. (medium stiff, damp)	
4		i3		18				
				5.6				
6								
				23.9				
		i3						
8				235			-becomes moist; Strong petroleum-like odor, dull, colorless sheen	
							Soil Sample: BMI-GP-24-S(9'-10')	
10				30		ML	Brownish, gray, sandy SILT; Petroleum-like odor, no sheen. (medium stiff, wet)	
		i3		9				▽ ATD
12								

Boring Completed 03/28/17
Total Depth of Boring = 12.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

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Blaine Marina Tank Farm
Blaine, Washington

Log of Boring BMI-GP-24

Figure
1-4

BMI-GP-25

SAMPLE DATA				SOIL PROFILE			GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)	Graphic Symbol	USCS Symbol	Drilling Method: Geoprobe™ Ground Elevation (ft): Not Determined	Water Level
0						PC	Concrete	
		i3		0.0		SP	Brown fine to medium SAND with gravel and shells; No odor, no sheen. (loose, damp)	
2								
				0.0		CL	Gray, silty CLAY with shells; No odor, no sheen (medium stiff, damp)	
4		i3		0.0				
6				0.0		SM	Gray, silty medium to coarse SAND with shells; No odor, no sheen. (loose, moist)	
		i3		0.0				
8				0.0				ATD
				1.0				
10				2.6		ML	Gray SILT with sand; No odor, no sheen. (stiff, wet)	
		i3		26			Soil Sample: BMI-GP-25-S(10.5'-11.5')	
12						SP	Gray, fine SAND; Slight petroleum-like odor, no sheen. (medium dense, wet)	
14								
16								
18								
20								

Boring Completed 03/28/17
Total Depth of Boring = 12.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

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Blaine Marina Tank Farm
Blaine, Washington

Log of Boring BMI-GP-25

Figure
1-5

BMI-GP-26

SAMPLE DATA				SOIL PROFILE			GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)	Graphic Symbol	USCS Symbol	Drilling Method: Geoprobe™ Ground Elevation (ft): Not Determined	Water Level
0						PC	Concrete	
						SP	Brownish gray, fine to medium SAND with gravel; No odor, no sheen. (loose, dry)	
				0.0		CL	Gray CLAY with shells and silt; No odor, no sheen. (medium stiff, damp)	
2		i3		0.0				
				0.0				
4						SP	Gray SAND with shells; No odor, no sheen. (loose, damp)	
				0.0				
				0.0				
6		i3				CL-ML	Gray, very silty CLAY; No odor, no sheen. (medium stiff, damp)	
				0.0				
				0.0				
8						SM	Gray, shiny, very silty SAND; Petroleum-like odor, slight sheen. (medium dense, moist)	
				1.6				
10		i3		0.5				
				11				
12								▽ ATD
				11		SP-SM	Dark gray SAND with silt and trace shells; Petroleum-like odor, no sheen. (medium dense, wet)	
				28			Soil Sample: BMI-GP-26-S(12'-13')	
14		i3		2				
				1.8				
16								
18								
20								

Boring Completed 03/28/17
Total Depth of Boring = 16.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

0001034.010.024 11/6/17 N:\PROJECTS\0001034.010.024.GPJ SOIL BORING LOG

LANDAU ASSOCIATES

Blaine Marina Tank Farm
Blaine, Washington

Log of Boring BMI-GP-26

Figure
1-6

BMI-GP-27

SAMPLE DATA				SOIL PROFILE			GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)	Graphic Symbol	USCS Symbol	Water Level
0						PC	Concrete
						SM	Brown, silty SAND with shells; No odor, no sheen. (loose, damp)
				0.0			
2		i3		0.0			
				0.0			
4				.5			
6		i3				ML	Gray SILT with shells; No odor, no sheen. (medium stiff, damp)
				18			
8				24			
				26			
							Petroleum odor, slight colorless sheen, no staining at 9.5 feet BGS.
10		i3		10			
							Soil Sample: BMI-GP-27-S(10'-11')
				3			▽ ATD
12						SP-SM	Dark gray, fine SAND with silt; Petroleum-like odor, no sheen. (medium dense, wet)
		i3		9			Groundwater Sample: BMI-GP-27-GW
14				1.2			
16							
18							
20							

Drilling Method: Geoprobe™

Ground Elevation (ft): Not Determined

Boring Completed 03/28/17
Total Depth of Boring = 16.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

0001034.010.024 11/6/17 N:\PROJECTS\0001034.010.024.GPJ SOIL BORING LOG

LANDAU ASSOCIATES

Blaine Marina Tank Farm
Blaine, Washington

Log of Boring BMI-GP-27

Figure
1-7

BMI-GP-28

SAMPLE DATA				SOIL PROFILE			GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)	Graphic Symbol	USCS Symbol	Drilling Method: Geoprobe™ Ground Elevation (ft): Not Determined	Water Level
0						PC	Concrete	
				4		SP-SM	Brown SAND with gravel and silt; No odor, no sheen. (loose, dry)	
2		i3						
4						ML	Brown to gray SILT with fine sand and trace shells; No odor, no sheen. (loose, dry)	
6		i3		4 1				
				0.0		SP/ML	Highly stratified, SAND, SILT and CLAY layers with shells to 11.5 feet BGS; No odor, no sheen. (medium dense/stiff, damp to moist)	
8				4.4				
10		i3						
				10			Soil Sample: BMI-GP-28-S(10'-11')	
							-Slight odor, slight sheen at 11 feet BGS	
12						SP-SM	Dark gray, fine SAND with silt; Slight odor, no sheen. (medium dense, wet)	▽ ATD
				1				
14		i3						
				0.0				
				0.0			-With shells at 15.5 feet BGS.	
16								
18								
20								

Boring Completed 03/28/17
Total Depth of Boring = 16.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

0001034.010.024 11/6/17 N:\PROJECTS\0001034.010.024.GPJ SOIL BORING LOG

LANDAU ASSOCIATES

Blaine Marina Tank Farm
Blaine, Washington

Log of Boring BMI-GP-28

Figure
1-8

BMI-GP-29

SAMPLE DATA				SOIL PROFILE			GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)	Graphic Symbol	USCS Symbol	Drilling Method: Geoprobe™ Ground Elevation (ft): Not Determined	Water Level
0				0.0		AC	Asphalt	
				0.0		ML	Gray SILT with sand and gravel; No odor, no sheen. (stiff, dry)	
2		i3		0.0				
4				18		ML	Gray SILT with trace shells; No odor, no sheen. (medium stiff, damp)	
6		i3		4			-Colorless sheen, strong petroleum-like odor at 5.5 feet BGS.	
8				14				
				20		SP	Gray, shiny SAND with shells; Strong petroleum-like odor, colorless sheen. (medium dense, wet)	▽ ATD
10		i3		20			Soil Sample: BMI-GP-29-S(9.5'-10.5')	
				2				
12							-Slight petroleum like odor, no sheen at 12 feet BGS.	
				2				
14		i3		4				
				1				
				1				
16								
18								
20								

Boring Completed 03/29/17
Total Depth of Boring = 16.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

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Blaine, Washington

Log of Boring BMI-GP-29

Figure
1-9

BMI-GP-30

SAMPLE DATA				SOIL PROFILE			GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)	Graphic Symbol	USCS Symbol	Drilling Method: Geoprobe™ Ground Elevation (ft): Not Determined	Water Level
0						AC	Asphalt	
						SP	Brown to black, medium to coarse SAND; No odor, no sheen. (loose, dry)	
				0.0				
2		i3						
				0.0				
						ML	Gray SILT with shells; No odor, no sheen. (soft, damp)	
4				1.3				
				12.5		SP	Gray SAND with shells; No odor, no sheen. (loose, moist)	
						CL		
6		ii		37.2			Gray, metalitc stained CLAY with trace shells; Petroleum-like odor, heavy sheen. (stiff, moist)	
				44				ATD
8							Soil Sample: BMI-GP-30-S(7.5'-8.5')	
				12				
10		ii		12				
				6.4			-Strong petroleum-like odor, moderate sheen at 10.5 feet BGS.	
						SP	Dark gray, fine SAND; Slight petroleum-like odor, no sheen. (medium dense, wet)	
12				0.0				
							Groundwater Sample: BMI-GP-30-GW	
				0.0				
14		ii				ML	Gray SILT; Slight petroleum-like odor, no sheen. (stiff, wet)	
				0.0		SP		
							Dark gray, fine SAND; No odor, no sheen. (medium dense, wet)	
				0.0				
16								
18								
20								

Boring Completed 03/29/17
Total Depth of Boring = 16.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

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Blaine, Washington

Log of Boring BMI-GP-30

Figure
1-10

BMI-GP-31

SAMPLE DATA				SOIL PROFILE			GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)	Graphic Symbol	USCS Symbol	Drilling Method: Geoprobe™ Ground Elevation (ft): Not Determined	Water Level
0				0.0		AC	Asphalt	
				0.0		SP	Brown to gray, fine to medium SAND with gravel; No odor, no sheen. (loose, dry)	
2		i3		2		SP/ ML	Highly stratified SAND, SILT and CLAY with shells to 3.2 feet BGS; No odor, no sheen. (medium dense/stiff, dry to damp)	
4				5		ML	Gray SILT with shells; Slight petroleum-like odor, no sheen. (medium stiff, moist)	
6		i3		1 30 12				
8				32		SP/ SM	Gray SAND with shells and silt; Strong petroleum like odor, slight sheen. (loose, wet)	▽ ATD
				16			Soil Sample: BMI-GP-31-S(8'-9') -Heavy sheen, metallic staining at 9 feet BGS.	
10		i3		24			-Moderate sheen at 10.5 feet BGS.	
				2.5				
12				0.0				
				0.0				
14		i3				ML	Gray SILT; Stong petroleum like odor, no sheen. (stiff, wet)	
						SP	Black, fine SAND with trace shells; Slight petroleum-like odor, no sheen. (medium dense, wet)	
16								
18								
20								

Boring Completed 03/29/17
Total Depth of Boring = 16.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

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Log of Boring BMI-GP-31

Figure
1-11

BMI-GP-32

SAMPLE DATA				SOIL PROFILE			GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)	Graphic Symbol	USCS Symbol	Drilling Method: Geoprobe™ Ground Elevation (ft): Not Determined	Water Level
0						GP	Gray and brown, angular cobbles; No odor, no sheen. (loose, dry)	
2								
4		i3		0.0 0.0		SP-SM	Brown, medium to coarse SAND with silt and trace gravel; No odor, no sheen. (loose, dry)	
6				8.5		ML	Gray SILT with fine sand and trace shells; Petroleum-like odor, slight sheen. (medium stiff, damp)	
8		i3		40 23.5		SM	-Strong odor, heavy sheen at 7.5 feet BGS. Silty, fine SAND; Strong odor, heavy sheen. (medium dense, moist)	
10				3.7			-Becomes wet. Soil Sample: BMI-GP-32-S(10'-11')	▽ ATD
12		i3		2.3 4.6			-Slight sheen, slight odor.	
14				2.4 4.7		ML	Gray SILT; Slight odor, slight sheen. (stiff, wet)	
16								
18								
20								

Boring Completed 03/29/17
Total Depth of Boring = 15.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

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Log of Boring BMI-GP-32

Figure
1-12

BMI-GP-33

SAMPLE DATA				SOIL PROFILE			GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)	Graphic Symbol	USCS Symbol	Water Level
0						GP	Drilling Method: Geoprobe™ Ground Elevation (ft): Not Determined Gray, coarse, angular cobbles; No odor, no sheen. (loose, dry)
2		i3					
4				0.0		SP	Brown to gray SAND with gravel; Slight petroleum-like odor, no sheen. (loose, dry)
6				0.0		ML	Gray SILT with fine sand; Strong petroleum-like odor, no sheen. (medium stiff, damp)
				5.2			
8		i3		10.2			
				15.2			
10							Soil Sample: BMI-GP-33-S(9'-10')
12		i3		10			-Becomes wet. ▽ ATD
				3.6		SP	Dark gray, fine SAND with shells (Petroleum-like odor, no sheen) (medium dense, wet)
14				4.2			
16							
18							
20							

Boring Completed 03/29/17
Total Depth of Boring = 15.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

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Log of Boring BMI-GP-33

Figure
1-13

BMI-GP-35

SAMPLE DATA | **SOIL PROFILE** | **GROUNDWATER**

Drilling Method: Geoprobe™

Ground Elevation (ft): Not Determined

Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)	Graphic Symbol	USCS Symbol	Soil Profile	Water Level
0						AC	Asphalt	
						SP	Brown, fine to medium SAND with gravel; No odor, no sheen. (loose, dry)	
2		i3						
4						ML	Gray SILT with fine sand; No odor, no sheen. (soft, dry to damp)	
6				0.0				
8		i3		0.0			-With shells at 8 feet BGS	
						SP-SM	Gray SAND with shells and silt; No odor, no sheen. (medium dense, damp)	
10				0.0			Soil Sample: BMI-GP-35-S(9'-10')	▽ ATD
							-Becomes wet.	
12		i3		0.0				
14						ML	Gray with black stained SILT with wood chips; Strong sulphur-like odor, no sheen. (soft, wet)	
				0.0		SP-SM	Gray fine to medium SAND; Slight sulphur-like odor, no sheen. (medium dense, wet)	
16							Boring Completed 03/28/17 Total Depth of Boring = 15.0 ft.	
18								
20								

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

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Log of Boring BMI-GP-35

Figure
1-14

BMI-GP-36

SAMPLE DATA				SOIL PROFILE			GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)	Graphic Symbol	USCS Symbol	Drilling Method: Geoprobe™ Ground Elevation (ft): Not Determined	Water Level
0						SP	Brown, fine to medium SAND with gravel and trace cobbles; No odor, no sheen. (loose, damp)	
2		i3						
4								
6				0.0		SP-SM	Gray, gravelly SAND with silt; No odor, no sheen. (loose, moist)	
						ML	Gray with black staining, SILT; Petroleum like odor, moderate sheen. (medium stiff, moist)	
8		i3					-Becomes wet.	▽ ATD
10				35			Soil Sample: BMI-GP-36-S(10.5'-11.5')	
12		i3		0.0				
14				0.0			-With wood chips.	
16								
18								
20								

Boring Completed 03/28/17
Total Depth of Boring = 15.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

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Log of Boring BMI-GP-36

Figure
1-15

BMI-GP-37

SAMPLE DATA				SOIL PROFILE			GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)	Graphic Symbol	USCS Symbol	Drilling Method: Geoprobe™ Ground Elevation (ft): Not Determined	Water Level
0						AC	Asphalt	
2						SP	Gray, fine to coarse SAND with gravel and cobbles; No odor, no sheen. (loose, dry)	
4		i3				ML	Brown SILT with trace sand; No odor, no sheen. (soft, damp to wet)	
6								
8		i3		0.0			-With shells and fine sand; Slight sulphur-like odor, no sheen. -Becomes wet.	▽ ATD
10				0.0				
12		i3		0.0			Soil Sample: BMI-GP-37-S(11'-12') -Slight petroleum-like odor, no sheen at 12 feet BGS.	
14				0.0				
16							Boring Completed 03/28/17 Total Depth of Boring = 15.0 ft.	
18								
20								

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

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Log of Boring BMI-GP-37

Figure
1-16

BMI-GP-38

SAMPLE DATA				SOIL PROFILE			GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)	Graphic Symbol	USCS Symbol	Drilling Method: Geoprobe™ Ground Elevation (ft): Not Determined	Water Level
0						AC	Asphalt	
						SP	Brown, fine SAND with gravel; No odor, no sheen. (loose, damp)	
2		i3						
						GP	Gray cobbles; No odor, no sheen. (loose, damp)	
4						SP	Gray, fine SAND, No odor, no sheen. (medium dense, moist)	
				5				
6				20				ATD
8		i3		23			-Black staining and slight petroleum like odor at 8 feet BGS.	
				64		SP-SM	Gray, medium to coarse SAND with shells and silt; Very strong petroleum like odor, globular sheen. (medium dense, wet)	
10							Soil Sample: BMI-GP-38-S(9.5'-10.5')	
				10			-Slight sheen at 11.5 feet.	
12				50			Groundwater Sample; BMI-GP-38-GW	
		i3		72			-Heavy sheen, strong petroleum like odor at 12.5 feet BGS.	
				16				
14				3				
						ML	Gray SILT; Slight sheen, Petroleum-like odor. (stiff, wet)	
16								
18								
20								

Boring Completed 03/28/17
Total Depth of Boring = 15.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

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Log of Boring BMI-GP-38

Figure
1-17

BMI-GP-39

SAMPLE DATA				SOIL PROFILE			GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)	Graphic Symbol	USCS Symbol	Drilling Method: Geoprobe™ Ground Elevation (ft): Not Determined	Water Level
0						AC	Asphalt	
						SP	Brown, fine to coarse SAND with gravel and cobbles; No odor, no sheen. (loose, damp)	
2		i3						
						ML	Gray SILT; No odor, no sheen. (medium stiff, damp to moist)	
4							-Slight petroleum like odor, no sheen, no staining at 5 feet BGS.	
6				3.5				
				3				
		i3						
8				4.5				
				13				
10								▽ ATD
				19		SP	Gray SAND with shells (strong petroleum like odor, heavy sheen). (loose, wet)	
				36			Soil Sample: BMI-GP-39-S(10.5'-11.5')	
12				18			Groundwater Sample: BMI-GP-39-GW	
		i3						
				10				
14				11				
16								
18								
20								

Boring Completed 03/28/17
Total Depth of Boring = 15.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

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Log of Boring BMI-GP-39

Figure
1-18

BMI-GP-40

SAMPLE DATA				SOIL PROFILE			GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)	Graphic Symbol	USCS Symbol	Drilling Method: Geoprobe™ Ground Elevation (ft): Not Determined	Water Level
0				0.0		AC	Asphalt	
				0.0		SP-SM	Brownish gray SAND with gravel and silt; No odor, no sheen. (loose, damp)	
2		i3		0.0		CL	Gray CLAY with trace shells; Slight petroleum-like odor, no sheen. (stiff, moist)	
				1				
4								
				5		ML	Gray SILT; Petroleum-like odor, no sheen. (medium stiff, moist)	
6								
		i3						ATD
8				4			-Strong petroleum like odor, heavy colorful sheen at 8 feet BGS.	
				1.0			Soil Sample: BMI-GP-40-S(8'-9')	
10								
				5				
12							-Slight odor, slight sheen at 12 feet BGS.	
		i3					Groundwater Sample: BMI-GP-40-GW	
						SP	Gray, medium to coarse SAND with shells; Slight petroleum-like odor, no sheen. (medium dense, wet)	
14				30				
16								
18								
20								

Boring Completed 03/29/17
Total Depth of Boring = 15.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

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Log of Boring BMI-GP-40

Figure
1-19

BMI-GP-41

SAMPLE DATA				SOIL PROFILE			GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)	Graphic Symbol	USCS Symbol	Drilling Method: Geoprobe™ Ground Elevation (ft): Not Determined	Water Level
0						AC	Asphalt	
						SP	Brownish gray SAND and gravel with silt; No odor, no sheen. (loose, damp)	
2								
		i3						
4						ML	Gray to brown SILT; No odor, no sheen. (medium stiff, moist to wet)	
6								
8		i3		0.0			-Slight petroleum like odor, no sheen at 8 feet BGS.	
				70			-Strong petroleum like odor, very slight sheen, no staining at 9.5 feet BGS.	▽ ATD
10							Soil Sample: BMI-GP-41-S(9.5'-10.5')	
				6			-Strong petroleum like odor, no sheen, no staining at 11 feet BGS.	
12				6				
		i3		124			-Slight petroleum like odor, no sheen, no staining at 12.5 feet BGS.	
				0.0				
14				0.0				
16								
18								
20								

Boring Completed 03/28/17
Total Depth of Boring = 15.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

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Log of Boring BMI-GP-41

Figure
1-20

BMI-GP-42

SAMPLE DATA				SOIL PROFILE			GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)	Graphic Symbol	USCS Symbol	Water Level
0				0.0		AC	
							Asphalt
				0.0		SP	Brown to gray SAND with gravel; No odor, no sheen. (loose, damp)
2		i3				ML	Gray to brown SILT; No odor, no sheen. (medium stiff, damp to moist)
4							
6				0.0			
		i3					
8							
						SP	Gray fine SAND; No odor, no sheen. (medium dense, moist)
				0.0		ML	
10						SP	Gray SILT; No odor, no sheen. (medium stiff, moist)
							Gray, fine SAND; No odor, no sheen. (medium dense, moist to wet)
							ATD
							Soil Sample: BMI-GP-42-S(11.5'-12.5)
12		i3					-Slight petroleum like odor, no sheen at 12 feet BGS.
14							
16							
18							
20							

Drilling Method: Geoprobe™

Ground Elevation (ft): Not Determined

Boring Completed 03/29/17
Total Depth of Boring = 15.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

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Log of Boring BMI-GP-42

Figure
1-21

BMI-GP-43

SAMPLE DATA				SOIL PROFILE			GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)	Graphic Symbol	USCS Symbol	Drilling Method: Geoprobe™ Ground Elevation (ft): Not Determined	Water Level
0						AC	Asphalt	
						SP	Brown to gray, SAND with gravel; No odor, no sheen. (medium dense, damp to moist)	
2		i3						
4								
6								
		i3				ML	Gray to brown, SILT with sand and shells; Heavy petroleum-like odor, globular sheen. (medium stiff, moist to wet)	
8								
10						SP	Gray, fine to medium SAND; Petroleum-like odor, no sheen. (dense, wet) Soil Sample: BMI-GP-43-S(10'-11') -Slight petroleum-like odor at 11.5 feet BGS	▽ ATD
12		i3					-No odor, no sheen at 12.5 feet BGS.	
14								
16								
18								
20								

Boring Completed 03/30/17
Total Depth of Boring = 15.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

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Log of Boring BMI-GP-43

Figure
1-22

BMI-GP-44

SAMPLE DATA				SOIL PROFILE			GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)	Graphic Symbol	USCS Symbol	Drilling Method: Geoprobe™ Ground Elevation (ft): Not Determined	Water Level
0						AC	Asphalt	
						SP-SM	Brown, fine SAND with silt and trace gravel; No odor, no sheen. (medium dense, damp)	
2		i3		0.0		ML	Brown SILT; No odor, no sheen. (medium stiff, damp to moist)	
4								
6						WD	Brown WOOD debris; Organic odor, no sheen. (dense, moist)	
		i3		0.0		SP-SM	Gray SAND with shells and silt; Slight petroleum-like odor, globular sheen. (dense, moist to wet)	
8				0.0				
				22				▽ ATD
10							Soil Sample: BMI-GP-44-S(9.5'-10.5')	
				0.0				
12		i3		8				
				0.0				
				0.0		ML	Brown to gray SILT; No odor, no sheen. (stiff, wet)	
14						SP		
				0.0			Blackish gray SAND; No odor, no sheen. (dense, wet)	
16								
18								
20								

Boring Completed 03/30/17
Total Depth of Boring = 15.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

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Log of Boring BMI-GP-44

Figure
1-23

BMI-GP-45

SAMPLE DATA				SOIL PROFILE			GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)	Graphic Symbol	USCS Symbol	Drilling Method: Geoprobe™ Ground Elevation (ft): Not Determined	Water Level
0						AC	Asphalt	
						DB	Brown to gray GRAVEL and WOOD debris; No odor, no sheen. (loose, damp to moist)	
2								
4								
6		i3						
						SP-SM	Gray, fine to medium SAND with gravel and silt; No odor, no sheen. (medium dense, moist)	
8		i3		0.0				
						ML	Gray SILT; No odor, no sheen. (medium stiff, moist)	
				27				▽ ATD
10						SP-SM	Gray, medium SAND with silt; Slight petroleum-like odor, no sheen. (medium dense, wet) Soil Sample: BMI-GP-45-S(10'-11')	
12		i3						
14								
16								
18								
20								

Boring Completed 03/30/17
Total Depth of Boring = 15.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

0001034.010.024 11/6/17 N:\PROJECTS\0001034.010.024.GPJ SOIL BORING LOG

LANDAU ASSOCIATES

Blaine Marina Tank Farm
Blaine, Washington

Log of Boring BMI-GP-45

Figure
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BMI-GP-46

SAMPLE DATA				SOIL PROFILE			GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)	Graphic Symbol	USCS Symbol	Water Level
0				0.0		AC	Drilling Method: Geoprobe™ Ground Elevation (ft): Not Determined Asphalt
						ML	Brown SILT with shells and sand; No odor, no sheen. (medium stiff to stiff, damp to wet)
2		i3					
4				0.0			
6		i3		0.0			
8				0.0			
				15.5			
10		i3		30			Soil Sample: BMI-GP-46-S(9.5'-10.5') ▽ ATD
				1.1			
12						SP-SM	Gray, medium to coarse SAND with silt and shells; Slight petroleum-like odor, no sheen. (medium dense, wet)
				20			
14		i3					
				0.0			
16							
18							
20							

Boring Completed 03/30/17
Total Depth of Boring = 16.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

0001034.010.024 11/6/17 N:\PROJECTS\0001034.010.024.GPJ SOIL BORING LOG

LANDAU ASSOCIATES

Blaine Marina Tank Farm
Blaine, Washington

Log of Boring BMI-GP-46

Figure
1-25

BMI-GP-47

SAMPLE DATA				SOIL PROFILE			GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)	Graphic Symbol	USCS Symbol	Drilling Method: Geoprobe™ Ground Elevation (ft): Not Determined	Water Level
0				0.0		AC	Asphalt	
				0.0		SP-SM	Brown, fine to medium SAND with gravel and silt; No odor, no sheen. (loose, damp)	
2		i3		0.0		SP/ML	Brown, sandy SILT; No odor, no sheen. (medium stiff, damp to moist)	
				0.0				
4				0.0				
				0.0				
6				0.0				
		i3		0.0				
8				0.0				
				15		SP-SM	Gray, fine to coarse SAND with silt; Strong petroleum-like odor, no sheen. (medium dense, moist to wet)	▽ ATD
10							Soil Sample: BMI-GP-47-S(9'-10')	
				0.7				
12							-SILT lense from 12-13 feet BGS.	
		i3		1				
				0.0				
				0.0				
14								
16								
18								
20								

Boring Completed 03/30/17
Total Depth of Boring = 15.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

0001034.010.024 11/6/17 N:\PROJECTS\0001034.010.024.GPJ SOIL BORING LOG

LANDAU ASSOCIATES

Blaine Marina Tank Farm
Blaine, Washington

Log of Boring BMI-GP-47

Figure
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TP-17-1

SAMPLE DATA				SOIL PROFILE			GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	PID (ppm)	Graphic Symbol	USCS Symbol	Excavation Method: Tracked Excavator Ground Elevation (ft): Not Surveyed Logged By: SAR	
0					AC	Asphalt	
2		d5	0.0		SP/ SM	Brown, fine SAND with silt and gravel; No odor, no sheen. (loose, dry)	
4		d5	0.0		SP	Gray to brown, fine to coarse SAND with trace silt, shells and fine gravel; No odor, no sheen. (loose, dry)	
6		d5	0.0		CL	Gray CLAY with fine sand and shells; No odor, no sheen. (medium stiff, dry to damp)	
8		d5	17		SP	Gray, medium to coarse SAND; Petroleum-like odor, no sheen. (loose, damp) -Becomes silty with shells.	
10						-Becomes stratified with clay; Strong petroleum-like odor and small sheen at 12 feet BGS.	Slow Seepage groundwater seepage encountered at 12.0 ft.
12							
14							

Test Pit Completed 06/19/17
Total Depth of Test Pit = 12.0 ft.

TP-17-2

SAMPLE DATA				SOIL PROFILE			GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	PID (ppm)	Graphic Symbol	USCS Symbol	Excavation Method: Tracked Excavator Ground Elevation (ft): Not Surveyed Logged By: SAR	
0					AC	Asphalt	
2		d5	0.0		SP-SM	Brown, fine SAND with silt and gravel; No odor, no sheen. (loose, dry)	
4		d5	0.0		CL	Gray CLAY; Slight petroleum-like odor, no sheen. (medium stiff, damp)	
6		d5	215		SP/ CL	Gray, 3 to 6 inch, stratified CLAY and fine to coarse SAND layers; Strong petroleum-like odor, no sheen. (loose, damp) -With shells at 8 feet BGS.	
8		d5	328			-Becomes wet at 10 feet BGS.	Slow Seepage groundwater seepage encountered at 10.0 ft.
10							
12							
14							

Test Pit Completed 06/19/17
Total Depth of Test Pit = 10.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

0001034.010.024 11/6/17 N:\PROJECTS\0001034.010.024.GPJ TEST PIT LOG

LANDAU ASSOCIATES

Blaine Marina Tank Farm
Blaine, Washington

Log of Test Pits

Figure
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TP-17-3

SAMPLE DATA				SOIL PROFILE			GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	PID (ppm)	Graphic Symbol	USCS Symbol	Excavation Method: Tracked Excavator Ground Elevation (ft): Not Surveyed Logged By: SAR	
0					AC	Asphalt	
2		d5	0.0		SP/SM	Brown, fine to medium SAND with silt and gravel; No odor, no sheen. (loose, dry)	
4		d5	34		SP/SM	Brown to gray, 2 to 5 inch silty SAND and clay layers; Petroleum-like odor, no sheen. (medium dense, damp)	
6		d5	170		SP/SM	Gray, medium to coarse SAND with silt and shells; Strong petroleum-like odor, slight sheen. (loose, moist)	
8		d5	250				
10		d5	340				Slow Seepage groundwater seepage encountered at 9.5 ft.
12							
14							

Test Pit Completed 06/19/17
Total Depth of Test Pit = 9.5 ft.

TP-17-4

SAMPLE DATA				SOIL PROFILE			GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	PID (ppm)	Graphic Symbol	USCS Symbol	Excavation Method: Tracked Excavator Ground Elevation (ft): Not Surveyed Logged By: SAR	
0					AC	Asphalt	
2		d5	0.0		SP/SM	Brown, fine to medium SAND with silt and gravel; No odor, no sheen. (loose, dry)	
4		d5	0.0			-Becomes damp at 3.5 feet BGS.	
6		d5	0.0				
8		d5	3.0				
10		d5	6.1		SP	Gray, fine to medium SAND with shells and trace silt; Slight petroleum-like odor, no sheen. (loose, wet)	Slow Seepage groundwater seepage encountered at 9.5 ft.
12							
14							

Test Pit Completed 06/19/17
Total Depth of Test Pit = 9.5 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

TP-17-5

SAMPLE DATA				SOIL PROFILE			GROUNDWATER
Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	PID (ppm)	Graphic Symbol	USCS Symbol	Excavation Method: Tracked Excavator Ground Elevation (ft): Not Surveyed Logged By: SAR	
0						AC	Asphalt	
						SP/ SM	Brown, fine SAND with silt and gravel; No odor, no sheen. (loose, dry)	
2						SP/ CL	Stratified fine to coarse SAND and CLAY; Petroleum-like odor, no sheen. (loose, damp)	
4			d5	0.0			-Becomes moist at 5 feet BGS.	
6			d5	0.0				
8			d5	357		SP/ SM	Gray, medium to coarse SAND with silt and shells; Petroleum-like odor, no sheen. (loose, moist)	
10			d5	327				Slow Seepage groundwater seepage encountered at 10.5 ft.
12								
14								

Test Pit Completed 06/19/17
Total Depth of Test Pit = 10.5 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

0001034.010.024 11/6/17 N:\PROJECTS\0001034.010.024.GPJ TEST PIT LOG

LANDAU ASSOCIATES

Blaine Marina Tank Farm
Blaine, Washington

Log of Test Pits

Figure
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APPENDIX B

Hazardous Building Materials Survey

Report
Hazardous Building Materials Survey
Blaine Marina, Inc. Site
Blaine, Washington

November 6, 2017

Prepared for

Port of Bellingham
Bellingham, Washington

LANDAU ASSOCIATES

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Hazardous Building Materials Survey
Blaine Marina, Inc. Site
Blaine, Washington

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LIST OF ABBREVIATIONS AND ACRONYMS

ACM	asbestos-containing material
AHERA	Asbestos Hazard Emergency Response Act
AST	aboveground storage tank
CFR	Code of Federal Regulations
EPA	US Environmental Protection Agency
HBMS	hazardous building materials survey
LAI	Landau Associates, Inc.
LCP	lead-containing paint
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
NVL	NVL Labs
NWCAA	Northwest Clean Air Agency
PCBs	polychlorinated biphenyl
Port	Port of Bellingham
Site	214 Sigurdson Avenue, Blaine, Washington
sf	square foot/feet
TCLP	Toxicity Characteristic Leaching Procedure
TSCA	Toxic Substances Control Act
WAC	Washington Administrative Code
WISHA	Washington State Industrial Safety and Health Administration

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1.0 INTRODUCTION

Landau Associates, Inc. (LAI) completed a hazardous building materials survey (HBMS) for asbestos-containing material (ACM), lead-containing paint (LCP), and polychlorinated biphenyl (PCB)-containing materials at the Blaine Marina, Inc. site (Site) located at 214 Sigurdson Avenue in Blaine, Washington (Figure 1). The scope of the HBMS included the furniture retail building, two smaller storage buildings adjacent to the northeast of the main building, and three aboveground storage tanks (ASTs) and associated piping located adjacent to the north of the main building. The survey was conducted for the Port of Bellingham (Port) prior to demolition of the buildings and tanks, which is needed to provide access for planned remedial excavation to remove petroleum hydrocarbon-contaminated soil beneath the tanks and buildings. This report describes the HBMS procedures and presents the findings of the survey.

2.0 REGULATORY COMPLIANCE

The following section provides a discussion of relevant regulatory compliance related to the potential presence of ACM and LCP at the Site.

2.1 Asbestos

The Asbestos Hazard Emergency Response Act (AHERA) regulation (40 Code of Federal Regulations [CFR] 763) is the primary governing regulation for performing asbestos surveys. AHERA defines suspect ACM and specifies the minimum number of samples to be collected and analyzed from a suspect material. AHERA was originally enacted for school buildings; however, since 1994 it has been applied to public and commercial buildings by the Asbestos School Hazard Abatement Reauthorization Act. The US Occupational Safety and Health Administration and Washington Industrial Safety and Health Act worker protection regulations, specifically 29 CFR 1926.1101(k) and Washington Administrative Code (WAC) 296-62-077, have also incorporated AHERA for demolition and renovation projects.

The Northwest Clean Air Agency Asbestos Control Standards (Section 570), should be consulted prior to renovation or demolition of structures containing ACM. This regulation is available at the following web address: http://nwcleanairwa.gov/regulation/section-550-590/. Typically, certified abatement contractors will prepare the required notifications prior to a planned asbestos abatement project.

2.2 Lead

Worker and environmental protection requirements apply to all construction activities that may disturb materials containing lead. Precautions must be taken during demolition and remodeling activities in accordance with Washington State regulations to address worker safety and the protection of human health and the environment. Worker exposure, public health, and waste characterization are issues of concern when working with LCP during building demolition or remodeling. When workers may be exposed to lead, it is the employer's responsibility to ensure that work practices are in accordance with the US Environmental Protection Agency's (EPA) Lead Renovation, Repair, and Painting rule, 40 CFR 745. The property owner(s) should ensure that the public does not have access to the property during demolition or remodeling activities.

2.3 Polychlorinated Biphenyls

PCBs are a federally regulated hazardous material. The disposal of PCBs is regulated by the EPA under the Toxic Substances Control Act (TSCA). Materials with PCB concentrations greater than 50 milligrams per kilogram (mg/kg) are considered PCB bulk product waste and must be disposed of under TSCA guidelines (40 CFR 761). The EPA requires all PCB bulk product waste be removed by a certified abatement company once it has been identified. Based on the age of the structures, building materials such as caulking, insulation, putty, and paint may contain PCBs. PCBs were added to these materials as a plasticizing agent until the use of PCBs was banned in the United States in 1979.

Additionally, fluorescent light ballasts (FLBs) produced prior to 1979 may contain PCBs and must be identified and segregated prior to disposal of the fluorescent light fixture.

3.0 HAZARDOUS BUILDING MATERIALS SURVEY

LAI conducted the HBMS at the Site on March 7, 2017. The HBMS was conducted to screen for the presence of hazardous building materials that will require special handling and disposal prior to, or during, demolition. The structures included in the scope of the HBMS were:

- The Blaine Marina, Inc. building: An approximately 6,000-square-foot (sf), slab-on-grade building with an approximately 2,550-sf second story over the eastern end of the building. The building is wood-framed with exterior wood siding and a flat torch-down roof. Apart from a Verizon telecommunications room on the second floor containing equipment to power and control cellular phone transmitters on the building's roof, the building was unoccupied and empty at the time of the HBMS.
- Two approximately 1,200-sf, single-story, slab-on-grade storage buildings located adjacent to the northeast of the Blaine Marina, Inc. building. These buildings were both wood-framed with a mix of wood and corrugated metal siding, and corrugated metal roofs. The building immediately adjacent to the northeast corner of the Blaine Marina, Inc. building was unoccupied and empty at the time of the HBMS. The other storage building contained tanks and equipment reportedly associated with the Drayton Harbor Seafood company. The presence of the equipment did not restrict access for the HBMS.
- Three metal ASTs and their associated piping located adjacent to the north of the Blaine Marina, Inc. building. Each AST was approximately 15 feet tall and 9 feet in diameter. The tanks appeared to be empty and the piping inoperable at the time of the HBMS.

3.1 Asbestos

The purpose of the ACM survey described in this report was to evaluate materials in or on the buildings at the Site for the presence of asbestos that would require abatement prior to demolition. The survey was conducted in compliance with the asbestos good faith inspection requirements of WAC 296-62-077, which requires the building owner to identify and properly dispose of ACM that may be encountered during demolition or renovation activities.

The scope of services included the following:

- An asbestos survey conducted by AHERA-certified building inspectors (certificates provided in Attachment 1) with a focus on identifying accessible suspect ACM. The survey included inspection and sampling of accessible suspect interior building materials likely to be affected by the renovations. Destructive sampling was conducted to access materials hidden within or behind walls or ceilings.
- Collecting bulk samples of suspect ACM in accordance with Washington State Department of Ecology guidelines for surveys of buildings related to demolition or renovation projects.
- Submitting bulk samples to a laboratory for asbestos analysis by polarized light microscopy with dispersion staining by US EPA Method 600/R-93/116.
- Recording the quantity and locations of suspect ACM.
- Preparing a report that summarizes the findings and conclusions of the survey.

AHERA specifies that only one positive asbestos result necessitates designating a suspect material as ACM. It also specifies the minimum number of samples to be collected and analyzed to establish that a suspect ACM is non-ACM, based on the material type. The three material types recognized by AHERA are: surfacing materials, thermal system insulation, and miscellaneous materials.

LAI collected 39 samples of suspect materials for analysis in accordance with AHERA sampling protocols and the procedures described in the Pre-Remedial Design Investigation Work Plan (LAI 2017)[1]. The samples were collected using a clean knife or chisel to penetrate all layers of each material. At least one teaspoon of each material was collected for analysis and placed in a laboratory-provided bag labeled with the location and sample identification. Prior to sampling potentially friable materials, a respirator was donned by the sampler and the sampling area was wetted with distilled water. All sampling equipment was wiped clean with a paper towel between sample locations. Following sample collection, a sample description and an estimated quantity of the suspect ACM were recorded on a field sample inventory form. This information, along with a summary of the laboratory analytical results, is provided in Table 1. The sample locations are shown on Figures 2 and 3

The samples were submitted to NVL Labs (NVL) of Seattle, Washington under standard chain-of-custody protocols for asbestos analysis by the method described above.

3.2 Lead-Containing Materials

A survey was conducted to assess the lead content in the various types of paint in or on the buildings. The survey included the collection of representative samples from the discrete paint types observed.

LAI collected 23 paint samples using a clean utility knife or chisel to scrape off at least 0.5 grams of paint into a laboratory-supplied sample bag. The knife or chisel was cleaned between samples using disposable baby wipes. A separate sample containing the paint and the underlying substrate was collected concurrently with the paint-chip sample. The paint-and-substrate sample was used to generate a composite sample representative of the waste stream that likely to contain painted material from the building for waste designation analysis.

Table 2 describes the paints identified for sampling, the locations that were sampled, and a summary of the laboratory analytical results. The paint-chip sample locations are shown on Figures 2 and 3.

The paint-chip and waste designation samples were submitted to NVL under standard chain-of-custody protocols. The paint-chip samples were analyzed using atomic absorption by EPA Method 7000B. The waste designation samples were analyzed for leachable lead using the Toxicity Characteristic Leaching Procedure (TCLP) to produce a leachate sample and EPA Method 7000B to determine the lead concentration of the leachate.

[1] LAI. 2017. Pre-Remedial Design Investigation Work Plan, Blaine Marina Inc. Site, Blaine, Washington. Landau Associates, Inc. March 14.

3.3 PCB-Containing Materials

Two composite samples of potential PCB-containing materials were collected during the HBMS for laboratory analysis, as described in Table 4. The composite samples consisted of similar material types: sample BMI-PCB-1 was made up of the paints observed in and on the buildings and sample BMI-PCB-2 consisted of the various caulks.

The samples were submitted to NVL under standard chain-of-custody procedures for PCB analysis by EPA Method 8082.

Fluorescent light fixtures in the buildings were screened for PCB-containing fluorescent light ballasts using a hand-held ballast checker, which can distinguish magnetic ballasts that typically contain PCBs from electronic ballasts that do not. Fixtures indicated to be magnetic using the ballast checker were opened and the ballasts were inspected for “No PCBs” stickers. Those without “No PCBs” stickers are assumed to contain PCBs.

4.0 HAZARDOUS BUILDING MATERIALS SURVEY RESULTS

The analytical results for the samples of suspect ACM, LCP, PCB-containing materials, and the waste disposal characterization sample collected for the survey are presented in the following sections. The results are summarized in Tables 1 through 3 and the laboratory analytical reports are provided in Attachment 2.

4.1 Asbestos

Materials sampled during the HBMS included various paints, vinyl floor tiles, gypsum wallboard systems, cove base, built-up roofing materials, carpets and associated adhesives, acoustic ceiling tiles, faux-wood paneling and associated adhesive, leveling compound, popcorn ceiling texture, gaskets on the tank piping and access hatches, and caulks. A minimum of one sample was collected of each potential or suspect ACM type from each homogeneous area.

Asbestos was detected at concentrations exceeding 1 percent in four of the materials sampled:

- Popcorn ceiling texture on the first-floor ceiling
- Beige vinyl floor tiles at the west end of the first floor
- Silver-coat roofing paint on the west side of the roof
- Gaskets on the lower access hatches of the northern and middle ASTs.

These materials would therefore be considered ACM under AHERA. Table 1 provides a summary of the analytical results along with an estimate of the quantity of each ACM and an evaluation of their friability.

The gypsum wallboard system within the main building (excluding the Verizon telecommunications room) was found to contain asbestos at less than 1 percent when taken as a composite, as allowed under Washington State Industrial Safety and Health Administration (WISHA) Regional Directive 23.30 (Department of Labor and Industries 2000). Because it was found to contain less than 1 percent asbestos, it is not considered to be an ACM. However, WISHA requires additional work practices and training when disturbing this material.

One fire door was observed at the second-floor entrance to the Verizon telecommunications room. Fire doors typically contain asbestos; however, because opening the door to inspect the interior would void the door's warranty, it was not opened for sampling. The door should be considered an ACM unless opened and sampled to prove otherwise.

Due to fall protection issues, the access hatches on the tops of the ASTs were not opened to inspect for gaskets. Gaskets on these hatches should be assumed to be ACM unless sampling and analysis proves otherwise.

4.2 Lead

Paints sampled during the HBMS included silver-coat roofing paint, gray-blue exterior wall paint, white exterior trim paint, multiple colors of interior wall paints, white paint under faux-wood paneling, red and gray exterior foundation wall paint, and gray-blue paint on the ASTs. Lead was detected in 16 of the 23 samples collected at concentrations ranging from 82 mg/kg (0.0082 percent) on the gray-blue AST paint to 18,000 mg/kg (1.8 percent) in the white wall paint beneath the faux-wood paneling in the main Blaine Marina, Inc. building. The complete list of results of lead in paint chips are provided in Table 2.

The waste designation sample consisting of a composite of each of the paints sampled along with the underlying substrate was found to contain less than 0.5 milligrams per liter (mg/L) of lead, as shown in Table 3. This is below the hazardous waste toxicity characteristic threshold for lead of 5 mg/L.

4.3 Polychlorinated Biphenyls

A total of 87 fluorescent light fixtures containing 204 fluorescent light tubes and 87 ballasts were observed in the buildings. Based on the results of the ballast-checker screening and inspection of a limited number of fixtures, no PCB-containing ballasts are expected to be present in the buildings. However, the fluorescent light tubes are considered a Universal Waste and must be packaged and disposed of in accordance with WAC 173-303-573(5).

PCBs were not detected in the two composite bulk material samples analyzed, as shown in Table 4.

4.4 Miscellaneous Materials

During the HBMS field work, a thermostat located inside the Verizon telecommunications room on the second floor of the Blaine Marina, Inc. building was opened and observed to contain mercury switches. The location of this thermostat is shown on Figure 2. The other thermostats in the building were subsequently opened and inspected. No other mercury switches were observed.

5.0 CONCLUSIONS AND RECOMMENDATIONS

The sampling and analysis of potential/suspect ACM in the survey area identified four materials as ACM: popcorn ceiling texture, silver-coat roofing paint, vinyl floor tiles, and access hatch gaskets on two of the ASTs. Two other materials, the fire door at the entrance to the Verizon telecommunications room and gaskets on the access hatches on the tops of the ASTs, were not sampled, but are assumed to be ACM. Additionally, the gypsum wallboard system throughout most of the main building contained asbestos at less than 1 percent when taken as a composite.

We recommend that the materials positively identified as ACM be abated in accordance with all appropriate state and federal regulations prior to building demolition. The popcorn ceiling texture and silver-coat paint should be considered to be friable under AHERA. Abatement of these materials will therefore be Class I asbestos work. Abatement of the non-friable floor tiles, gaskets, and fire door will be Class II asbestos work.

While the wallboard system containing less than 1 percent asbestos is not considered an ACM, certain requirements still apply to removal of this material, including:

- Wet, non-aggressive methods must be used and cleanup of material must be prompt
- Vacuums used must be HEPA-filtered.
- Worker training must include asbestos awareness and hands-on training as promulgated in WAC 296-62-07722(5).
- Respiratory protection must be based on overall dust levels.
- A competent person must be assigned and trained under the requirements of WAC 296-62-07728.

Lead was detected in 16 of the 23 paints sampled in the buildings. Therefore, precautions must be taken during demolition to address worker safety, protection of human health and the environment, and disposal of demolition debris in accordance with state regulations. When workers may be exposed to lead, it is the employer's responsibility to ensure that work practices are in accordance with the Washington State Department of Labor and Industries' lead in construction rule (WAC 296-155-176) and, for non-demolition projects, the EPA's Lead Renovation, Repair, and Painting rule, 40 CFR 745. The property owner should ensure that the public does not have access to the property during demolition activities.

TCLP analysis found that the composite waste designation sample leached less than 5 mg/L lead, which is the hazardous waste toxicity characteristic threshold for lead under 40 CFR Part 261 and WAC 173-303-090. The painted material in the building would therefore not be considered a characteristic hazardous waste due to the LCP and may be disposed of at any landfill permitted to accept it.

Eighty-seven fluorescent light fixtures containing a total of 204 bulbs and 87 ballasts were present in the buildings. Fixtures with ballasts indicated to be magnetic (using the ballast checker), and therefore

potentially PCB-containing, were opened and inspected for “No PCBs” stickers. All of the ballasts inspected had “No PCBs” stickers so no PCB-containing ballasts are expected to be present at the Site. The fluorescent light tubes should be removed prior to demolition and recycled or disposed of as Universal Wastes.

PCBs were not detected in the two bulk composite samples collected for analysis. The presence of PCBs is therefore not expected to affect the demolition work or debris disposal.

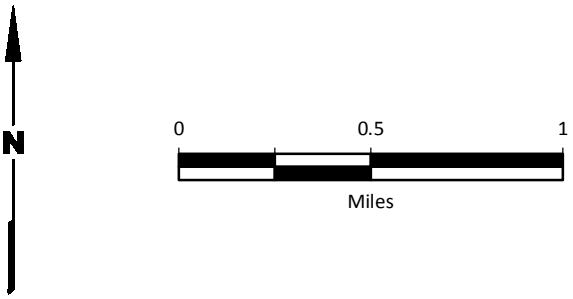
A thermostat located inside the Verizon telecommunications room on the second floor of the furniture store building was identified as containing mercury switches. We recommend that the thermostat be removed by the abatement contractor and disposed of in accordance with the appropriate state and federal regulations.

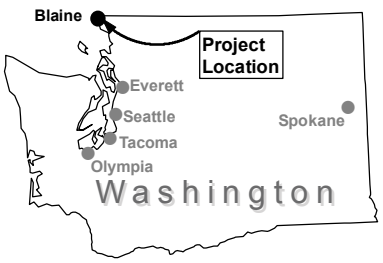
6.0 LIMITATIONS

A good-faith HBMS was conducted to identify ACM and LCP in the Site buildings. Construction methods and materials use vary with contractor and construction trades, and suspect ACM may exist in non-typical locations that were not investigated. During the demolition process, care should be taken that additional suspect materials, if present, are not disturbed without following the appropriate regulatory requirements for sampling and analysis. Where suspect materials are encountered, they should be assumed to be ACM until shown to be negative for asbestos through laboratory analysis. If laboratory analysis is not performed, all suspect materials should be assumed to be ACM.

LAI performed this sampling consistent with the level of care and skill ordinarily exercised by professionals currently practicing under similar conditions in the industry. No other warranty, express or implied, is made. Reuse of the information in this report for any other purpose without LAI's written authorization shall be at the client's risk. The client agrees to indemnify and hold harmless LAI from all actions, claims, damages, and expense, including attorney fees, arising out of any unauthorized reuse.

This report has been prepared for the exclusive use of the Port of Bellingham and its representatives. The analyses, conclusions, and recommendations presented in this report are based on conditions encountered at the time of our study and on our experience and judgment. LAI cannot be held responsible for the interpretation by others of the data in this report.



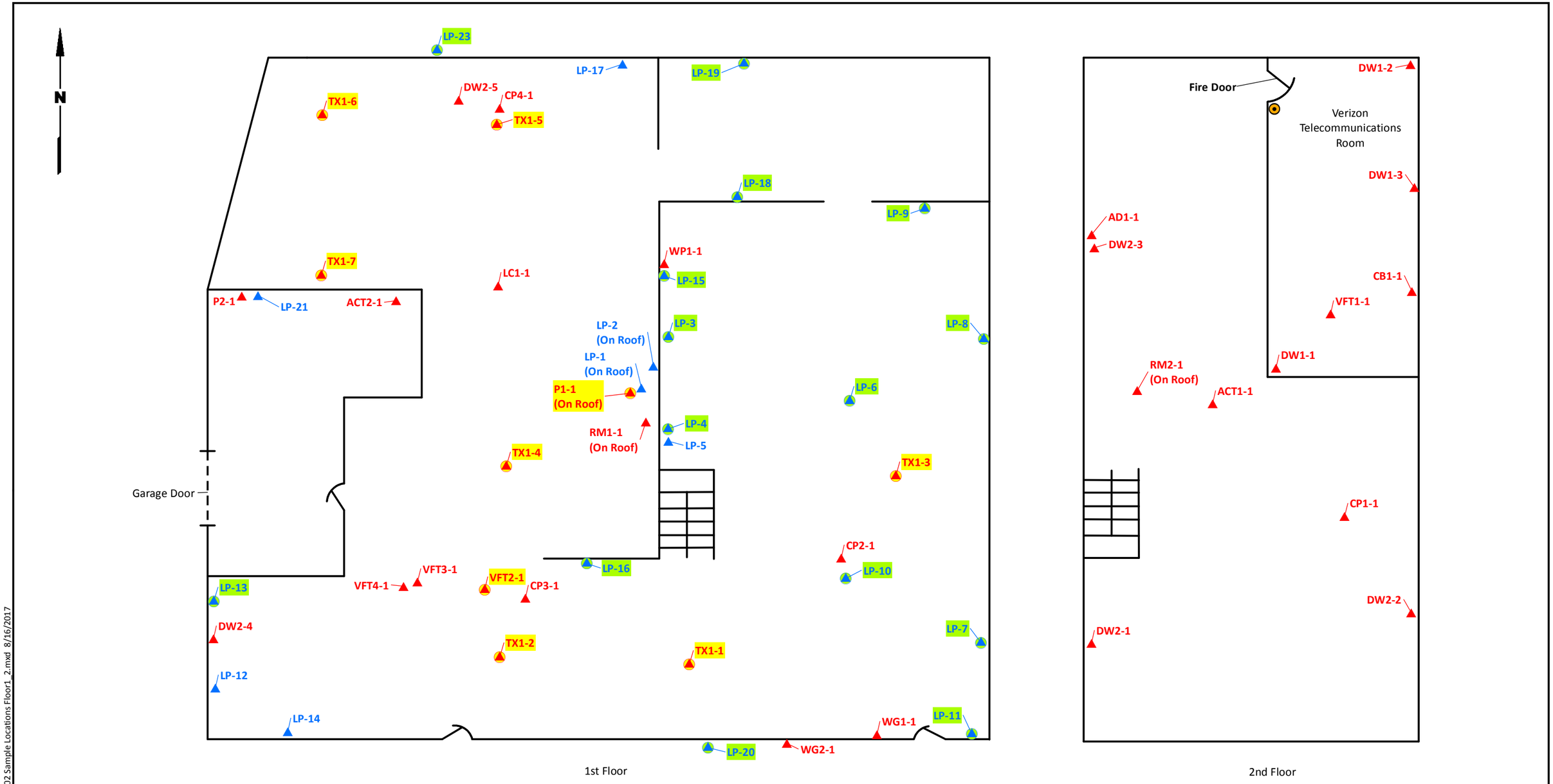


Data Source: Esri 2012

G:\Projects\001\034\010\023\HBMS\F01VicMap.mxd 4/4/2017

LANDAU ASSOCIATES

Blaine Marina Inc. Site Hazardous Building Material Survey Blaine, Washington	**Vicinity Map**	Figure 1



Legend

- Asbestos Sample Location
- Asbestos Sample Location > 1% Concentration
- Lead Sample Location
- Lead Sample Location > Reporting Limit
- Mercury-Containing Thermostat
- Building Layout

Note

1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

0 10 20

Scale in Feet

Data Source: Landau Associates, Inc.

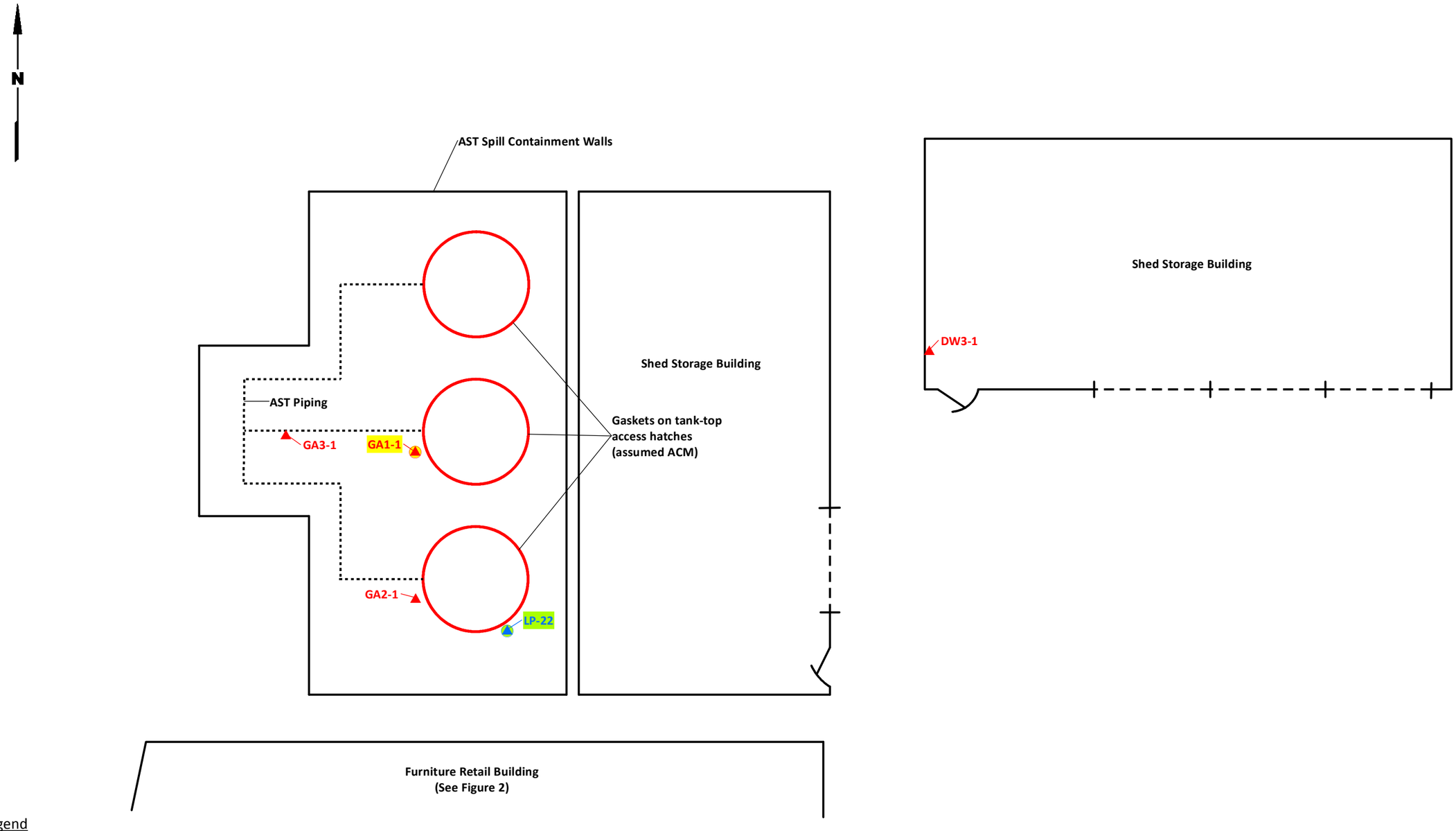
Blaine Marina, Inc. Site
Hazardous Building
Materials Survey
Blaine, Washington

Sample Locations
Furniture Retail Building

Figure
2

LANDAU ASSOCIATES

G:\Projects\001\034\010\023\HBMS\F02 Sample Locations Floor1_2.mxd 8/16/2017



Legend

- Asbestos Sample Location
- Asbestos Sample Location > 1% Concentration
- Lead Sample Location > Reporting Limit
- Building Layout
- 10' Diameter ASTs

ACM = Asbestos-Containing Material
AST = Aboveground Storage Tank

Note

1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

0 10 20
Scale in Feet

Data Source: Landau Associates, Inc.

Blaine Marina, Inc. Site
Hazardous Building
Materials Survey
Blaine, Washington

Sample Locations
Shed Buildings and ASTs

Figure 3

LANDAU ASSOCIATES

G:\Projects\001\034\010\023\HBMS\F03 Sample Locations Shed_AST.mxd 8/16/2017

Table 1
Analytical Results – Asbestos Samples
Hazardous Building Materials Survey
Blaine Marina, Inc. Site – Blaine, Washington

Sample Name	Material Description	Asbestos Content	Friable?	Estimated Quantity of Confirmed ACM
BMI- DW1-1	Gypsum wallboard system in Verizon room	Joint Compound: ND Drywall: ND Tape: ND	---	---
BMI- DW1-2			---	---
BMI- DW1-3			---	---
BMI- CB1-1	3" Brown cove base	Cove Base: ND Mastic: ND	---	---
BMI- VFT1-1	12" x 12" Beige marble vinyl floor tile	Tile: ND Mastic: ND Substrate: ND	---	---
BMI- VFT2-1	**12" x 12" Beige/brown marble vinyl floor tile on first floor**	**Tile: CH 4% Mastic: ND**	**No**	**1,200 sf**
BMI- VFT3-1	12" x 12" Dark gray vinyl floor tile	Tile: ND Mastic: ND	---	---
BMI- VFT4-1	12" x 12" Green with black specks vinyl floor tile	Tile: ND Mastic: ND	---	---
BMI- WG1-1	Caulk on interior side of windows	ND	---	---
BMI- WG2-1	Caulk on exterior side of windows	ND	---	---
BMI- RM1-1	Built-up roofing material on first-floor roof	Shingle Layer 1: ND Shingle Layer 2: ND Asphaltic Mastic: ND Membrane: ND	---	---
BMI- RM2-1	Built-up roofing material on second-floor roof	Shingle Layer: ND Asphaltic Mastic: ND Membrane: ND	---	---
BMI- P1-1	**Silver coat roofing paint**	**CH 4%**	**Yes**	**3,500 sf**
BMI- P2-1	White and silver paint w/fibrous mesh	Silver Paint: ND Yellow Paint: ND Tape: ND	---	---
BMI- CP1-1	Red and brown carpet on second floor	Carpet: ND Mastic: ND	---	---
BMI- CP2-1	Gray carpet	Carpet: ND Mastic: ND	---	---
BMI- CP3-1	Blue/gray mottled carpet	Carpet: ND Mastic: ND	---	---
BMI- CP4-1	Brown carpet	Carpet: ND Mastic: ND Leveling Compound: ND	---	---
BMI- ACT1-1	2' x 4' Acoustic ceiling tile	ND	---	---
BMI- ACT2-1	12" x 12" nail-up acoustic ceiling tiles	ND	---	---
BMI- AD1-1	Adhesive on wood paneling	ND	---	---
BMI- DW2-1	Gypsum wallboard system on walls and ceiling	Joint Compound: CH2% Drywall: ND Composite: <1%	---	---
BMI- DW2-2		Joint Compound: CH <1% Drywall: ND	---	---
BMI- DW2-3		Joint Compound: CH2% Drywall: ND Composite: <1%	---	---
BMI- DW2-4		Joint Compound: ND Drywall: ND	---	---
BMI- DW2-5		ND	---	---

Table 1
Analytical Results – Asbestos Samples
Hazardous Building Materials Survey
Blaine Marina, Inc. Site – Blaine, Washington

Sample Name	Material Description	Asbestos Content	Friable?	Estimated Quantity of Confirmed ACM
BMI- LC1-1	Leveling compound over sump covers	Leveling Compound: ND Carpet Mastic: ND	---	---
BMI- WP1-1	Faux wood paneling	ND	---	---
BMI- TX1-1	**Popcorn ceiling texture**	**CH 5%**	**Yes**	**5,500 sf**
BMI- TX1-2		**Na[a]**		
BMI- TX1-3		**NA[a]**		
BMI- TX1-4		**NA[a]**		
BMI- TX1-5		**NA[a]**		
BMI- TX1-6		**NA[a]**		
BMI- TX1-7		**NA[a]**		
BMI- DW3-1	Bare drywall in Drayton Harbor shed	ND	---	---
BMI- GA1-1	**Gaskets on north and middle ASTs access hatches**	**CH 23%**	**No**	**2 Gaskets**
BMI- GA2-1	Gaskets on southernmost AST access hatches	ND	---	---
BMI- GA3-1	Gaskets on ground-level piping	ND	---	---
	Gaskets on AST top access hatches	**Assumed**	**No**	**3 Gaskets**
	Fire Door	**Assumed**	**No**	**1 Door**

Note:

[a] Positive sample result for BMI-TX1-1 indicates material is ACM. Remaining samples of this material not analyzed.

Abbreviations and Acronyms:

ND = not detected
NA = not analyzed
ACM = asbestos-containing material
AST = aboveground storage tank
CH = chrysotile
sf = square feet

Table 2
Analytical Results – Lead Paint-Chip Samples
Haardous Building Materials Survey
Blaine Marina, Inc. Site – Blaine, Washington

Sample Name	Material Description	Lead Concentration (mg/kg)	Lead Concentration (percent)
BMI- LP-1	Silver-coat roofing paint	< 56	< 0.0056
BMI- LP-2	Gray-blue exterior paint	< 54	< 0.0054
BMI- LP-3	**Red-brown paint on second-floor faux-wood paneling**	**1,400**	**0.14**
BMI- LP-4	**Cream-colored paint n first-floor faux-wood paneling and columns**	**1,400**	**0.14**
BMI- LP-5	Red-brown paint on first-floor faux-wood paneling and columns	< 200	< 0.02
BMI- LP-6	**Dark brown paint on metal poles**	**4,900**	**0.49**
BMI- LP-7	**Dark cream-colored paint on CMU block walls**	**1,400**	**0.14**
BMI- LP-8	**Light cream-colored paint on CMU block walls**	**1,400**	**0.14**
BMI- LP-9	**Orange-brown paint on CMU block walls**	**4,400**	**0.44**
BMI- LP-10	**Dark-brown paint on wooden ceiling beams**	**160**	**0.016**
BMI- LP-11	**Very dark brown paint on window casings**	**690**	**0.069**
BMI- LP-12	Pink paint on wood wall	< 110	< 0.011
BMI- LP-13	**Layered paint (orange/brown/cream) on wood**	**2,600**	**0.26**
BMI- LP-14	Beige paint on lower half of walls	< 130	<0.013
BMI- LP-15	**White paint on wood under paneling**	**18,000**	**1.8**
BMI- LP-16	**White paint on support posts**	**2,300**	**0.23**
BMI- LP-17	Beige paint on CMU block walls	< 49	< 0.0049
BMI- LP-18	**Brown paint on CMU block walls**	**720**	**0.072**
BMI- LP-19	**Red paint on CMU block walls**	**1,300**	**0.13**
BMI- LP-20	**Exterior white trim paint**	**12,000**	**1.2**
BMI- LP-21	White and silver paint in garage area	< 80	< 0.008
BMI- LP-22	**Gray-blue paint on tanks**	**82**	**0.0082**
BMI- LP-23	**Red and gray exterior paint at base of north walls**	**14,000**	**1.4**

< = Not detected above detection limit shown
mg/kg = milligrams per kilogram
CMU = concrete masonry unit

Table 3
Analytical Result – Waste Designation Sample
Hazardous Building Materials Survey
Blaine Marina, Inc. Site – Blaine, Washington

Sample Name	Material Description	Leachable Lead Concentration (mg/L)	Hazardous Waste Toxicity Characterisitc Concentration for Lead (mg/L)
BMI- TCLP-1	Composite sample of painted materials	0.5	5

mg/L = milligrams per liter

Table 4
Analytical Results – PCB Samples
Hazardous Building Materials Survey
Blaine Marina, Inc. Site – Blaine, Washington

Sample Name	Material Description	PCB Concentration (mg/kg)
BMI- PCB-1	Composite paint sample	< 1.2
BMI- PCB-2	Composite caulk sample	< 5.2

< = Not detected above detection limit shown
mg/kg = milligrams per kilogram

ATTACHMENT 1

AHERA Building Inspector Certificate

Certificate of Completion

This is to certify that

Cody M. Johnson

has satisfactorily completed
4 hours of refresher training as an

Asbestos Building Inspector

to comply with the training requirements of
TSCA Title II / 40 CFR 763 (AHERA)

Certificate #
157413

Susan N Maas
Instructor
EPA Provider Certificate #1085

ARGUS PACIFIC
TRAINING • CONSULTING
A Terracon COMPANY

May 25, 2016
Date(s) of Training
Exam Score: NA
Expiration Date: May 25, 2017

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ATTACHMENT 2

Laboratory Analytical Reports

March 16, 2017

Cody Johnson
Landau Associates
130 2nd Avenue South
Edmonds, WA 98020

NVL LABS
INDUSTRIAL HYGIENE SERVICES
Laboratory | Management | Training

RE: Bulk Asbestos Fiber Analysis; NVL Batch # 1704290.00

Client Project: 001034.010.016
Location: Blaine Marina Inc.

Dear Mr. Johnson,

Enclosed please find test results for the 39 sample(s) submitted to our laboratory for analysis on 3/8/2017.

Examination of these samples was conducted for the presence of identifiable asbestos fibers using polarized light microscopy (PLM) with dispersion staining in accordance with both **EPA 600/M4-82-020**, Interim Method for the Determination of Asbestos in Bulk Insulation Samples and **EPA 600/R-93/116** Method for the Determination of Asbestos in Bulk Building Materials.

For samples containing more than one separable layer of materials, the report will include findings for each layer (labeled Layer 1 and Layer 2, etc. for each individual layer). The asbestos concentration in the sample is determined by calibrated visual estimation.

For those samples with asbestos concentrations between 1 and 10 percent based on visual estimation, the EPA recommends a procedure known as point counting (NESHAPS, 40 CFR Part 61). Point counting is a statistically more accurate means of quantification for samples with low concentrations of asbestos.

The detection limit for the calibrated visual estimation is <1%, 400 point counts is 0.25% and 1000 point counts is 0.1%

Samples are archived for two weeks following analysis. Samples that are not retrieved by the client are discarded after two weeks.

Thank you for using our laboratory services. Please do not hesitate to call if there is anything further we can assist you with.

Sincerely,

Nick Ly, Technical Director

Enc.: Sample Results

NVLAP Lab Code: 102063-0

1.888.NVL.LABS
1.888.(685.5227)
www.nvllabs.com

NVL Laboratories, Inc.
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Bulk Asbestos Fibers Analysis

By Polarized Light Microscopy

Client: Landau Associates
Address: 130 2nd Avenue South
Edmonds, WA 98020

Attention: Mr. Cody Johnson
Project Location: Blaine Marina Inc.

Batch #: 1704290.00
Client Project #: 001034.010.016
Date Received: 3/8/2017
Samples Received: 39
Samples Analyzed: 33
Method: EPA/600/R-93/116
& EPA/600/M4-82-020

Lab ID: 17021968 **Client Sample #: BMI-ACT1-1**
Location: Blaine Marina Inc.

Layer 1 of 1 **Description:** Brown compressed fibrous material with paint

Non-Fibrous Materials:	Other Fibrous Materials:%	**Asbestos Type: %**
Binder/Filler, Wood flakes, Paint	Cellulose 54%	**None Detected ND**
	Wood fibers 34%	

Lab ID: 17021969 **Client Sample #: BMI-ACT2-1**
Location: Blaine Marina Inc.

Layer 1 of 1 **Description:** Brown compressed fibrous material with paint

Non-Fibrous Materials:	Other Fibrous Materials:%	**Asbestos Type: %**
Binder/Filler, Wood flakes, Paint	Cellulose 56%	**None Detected ND**
Perlite	Wood fibers 27%	

Lab ID: 17021970 **Client Sample #: BMI-AD1-1**
Location: Blaine Marina Inc.

Layer 1 of 1 **Description:** White compacted powdery material with paint and paper

Non-Fibrous Materials:	Other Fibrous Materials:%	**Asbestos Type: %**
Calcareous particles, Calcareous binder, Paint/Vinyl	Cellulose 34%	**None Detected ND**

Lab ID: 17021971 **Client Sample #: BMI-CB1-1**
Location: Blaine Marina Inc.

Layer 1 of 2 **Description:** Brown rubbery material

Non-Fibrous Materials:	Other Fibrous Materials:%	**Asbestos Type: %**
Rubber/Binder, Binder/Filler	None Detected ND	**None Detected ND**

Sampled by: Client
Analyzed by: Jacob Laugeson **Date:** 03/15/2017
Reviewed by: Nick Ly **Date:** 03/16/2017

Nick Ly, Technical Director

Note: If samples are not homogeneous, then subsamples of the components were analyzed separately. All bulk samples are analyzed using both EPA 600/R-93/116 and 600/M4-82-020 Methods with the following measurement uncertainties for the reported % Asbestos (1%=0-3%, 5%=1-9%, 10%=5-15%, 20%=10-30%, 50%=40-60%). This report relates only to the items tested. If sample was not collected by NVL personnel, then the accuracy of the results is limited by the methodology and acuity of the sample collector. This report shall not be reproduced except in full, without written approval of NVL Laboratories, Inc. It shall not be used to claim product endorsement by NVLAP or any other agency of the US Government

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4708 Aurora Ave N, Seattle, WA 98103
p 206.547.0100 | f 206.634.1936 | www.nvllabs.com

Bulk Asbestos Fibers Analysis

By Polarized Light Microscopy

Client: Landau Associates
Address: 130 2nd Avenue South
Edmonds, WA 98020

Attention: Mr. Cody Johnson
Project Location: Blaine Marina Inc.

Batch #: 1704290.00
Client Project #: 001034.010.016
Date Received: 3/8/2017
Samples Received: 39
Samples Analyzed: 33
Method: EPA/600/R-93/116
& EPA/600/M4-82-020

Layer 2 of 2 **Description:** Off-white soft mastic with paint and paper

Non-Fibrous Materials:	Other Fibrous Materials:%	**Asbestos Type: %**
Mastic/Binder, Calcareous particles, Binder/Filler	Cellulose 27%	**None Detected ND**
Paint		

Lab ID: 17021972 **Client Sample #: BMI-WP1-1**
Location: Blaine Marina Inc.

Layer 1 of 1 **Description:** Dark brown compressed fibrous material with paint

Non-Fibrous Materials:	Other Fibrous Materials:%	**Asbestos Type: %**
Binder/Filler, Wood flakes, Paint	Cellulose 54%	**None Detected ND**
	Wood fibers 31%	

Lab ID: 17021973 **Client Sample #: BMI-WG1-1**
Location: Blaine Marina Inc.

Layer 1 of 1 **Description:** Black foamy material with paint

Non-Fibrous Materials:	Other Fibrous Materials:%	**Asbestos Type: %**
Synthetic foam, Paint	Synthetic fibers 2%	**None Detected ND**

Lab ID: 17021974 **Client Sample #: BMI-WG2-1**
Location: Blaine Marina Inc.

Layer 1 of 1 **Description:** White soft material with paint

Non-Fibrous Materials:	Other Fibrous Materials:%	**Asbestos Type: %**
Caulking compound, Binder/Filler, Paint	Cellulose 3%	**None Detected ND**

Lab ID: 17021975 **Client Sample #: BMI-LC1-1**
Location: Blaine Marina Inc.

Sampled by: Client
Analyzed by: Jacob Laugeson **Date:** 03/15/2017
Reviewed by: Nick Ly **Date:** 03/16/2017

Nick Ly, Technical Director

Note: If samples are not homogeneous, then subsamples of the components were analyzed separately. All bulk samples are analyzed using both EPA 600/R-93/116 and 600/M4-82-020 Methods with the following measurement uncertainties for the reported % Asbestos (1%=0-3%, 5%=1-9%, 10%=5-15%, 20%=10-30%, 50%=40-60%). This report relates only to the items tested. If sample was not collected by NVL personnel, then the accuracy of the results is limited by the methodology and acuity of the sample collector. This report shall not be reproduced except in full, without written approval of NVL Laboratories, Inc. It shall not be used to claim product endorsement by NVLAP or any other agency of the US Government

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Bulk Asbestos Fibers Analysis

By Polarized Light Microscopy

Client: Landau Associates
Address: 130 2nd Avenue South
Edmonds, WA 98020

Attention: Mr. Cody Johnson
Project Location: Blaine Marina Inc.

Batch #: 1704290.00
Client Project #: 001034.010.016
Date Received: 3/8/2017
Samples Received: 39
Samples Analyzed: 33
Method: EPA/600/R-93/116
& EPA/600/M4-82-020

Layer 1 of 2	**Description:** Tan soft mastic			
	Non-Fibrous Materials:	Other Fibrous Materials:	%	**Asbestos Type: %**
	Mastic/Binder, Calcareous particles	Polyethylene fibers	4%	**None Detected ND**
Layer 2 of 2	**Description:** White crumbly compacted powdery material			
	Non-Fibrous Materials:	Other Fibrous Materials:	%	**Asbestos Type: %**
	Calcareous particles, Calcareous binder	Cellulose	7%	**None Detected ND**

Lab ID: 17021976 **Client Sample #: BMI-P1-1**
Location: Blaine Marina Inc.

Layer 1 of 1	**Description:** Silver paint			
	Non-Fibrous Materials:	Other Fibrous Materials:	%	**Asbestos Type: %**
	Metallic paint, Calcareous particles	Cellulose	2%	**Chrysotile 4%**

Lab ID: 17021977 **Client Sample #: BMI-P2-1**
Location: Blaine Marina Inc.

Layer 1 of 3	**Description:** Silver thin flaky paint			
	Non-Fibrous Materials:	Other Fibrous Materials:	%	**Asbestos Type: %**
	Metallic paint	None Detected	ND	**None Detected ND**
Layer 2 of 3	**Description:** Yellow brittle material with fibrous elements and paint			
	Non-Fibrous Materials:	Other Fibrous Materials:	%	**Asbestos Type: %**
	Resin/Binder, Binder/Filler, Paint	Glass fibers	44%	**None Detected ND**
Layer 3 of 3	**Description:** Gray crumbly/brittle material			
	Non-Fibrous Materials:	Other Fibrous Materials:	%	**Asbestos Type: %**
	Binder/Filler, Calcareous particles	Cellulose	8%	**None Detected ND**
		Glass fibers	5%	

Lab ID: 17021978 **Client Sample #: BMI-GA1-1**
Location: Blaine Marina Inc.

Sampled by: Client
Analyzed by: Jacob Laugeson **Date:** 03/15/2017
Reviewed by: Nick Ly **Date:** 03/16/2017

Nick Ly, Technical Director

Note: If samples are not homogeneous, then subsamples of the components were analyzed separately. All bulk samples are analyzed using both EPA 600/R-93/116 and 600/M4-82-020 Methods with the following measurement uncertainties for the reported % Asbestos (1%=0-3%, 5%=1-9%, 10%=5-15%, 20%=10-30%, 50%=40-60%). This report relates only to the items tested. If sample was not collected by NVL personnel, then the accuracy of the results is limited by the methodology and acuity of the sample collector. This report shall not be reproduced except in full, without written approval of NVL Laboratories, Inc. It shall not be used to claim product endorsement by NVLAP or any other agency of the US Government

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Bulk Asbestos Fibers Analysis

By Polarized Light Microscopy

Client: Landau Associates
Address: 130 2nd Avenue South
Edmonds, WA 98020

Attention: Mr. Cody Johnson
Project Location: Blaine Marina Inc.

Batch #: 1704290.00
Client Project #: 001034.010.016
Date Received: 3/8/2017
Samples Received: 39
Samples Analyzed: 33
Method: EPA/600/R-93/116 & EPA/600/M4-82-020

Layer 1 of 1 **Description:** Black brittle material with fibrous elements and paint

Non-Fibrous Materials:	Other Fibrous Materials:%	**Asbestos Type: %**
Binder/Filler, Calcareous binder, Paint	Cellulose 3%	**Chrysotile 23%**

Lab ID: 17021979 **Client Sample #: BMI-GA2-1**
Location: Blaine Marina Inc.

Layer 1 of 1 **Description:** Black rubbery material with trace paint

Non-Fibrous Materials:	Other Fibrous Materials:%	**Asbestos Type: %**
Rubber/Binder, Paint	None Detected ND	**None Detected ND**

Lab ID: 17021980 **Client Sample #: BMI-GA3-1**
Location: Blaine Marina Inc.

Layer 1 of 1 **Description:** Gray compressed fibrous material

Non-Fibrous Materials:	Other Fibrous Materials:%	**Asbestos Type: %**
Binder/Filler, Calcareous particles	Cellulose 82%	**None Detected ND**

Lab ID: 17021981 **Client Sample #: BMI-RM1-1**
Location: Blaine Marina Inc.

Layer 1 of 4 **Description:** Black asphaltic built-up material

Non-Fibrous Materials:	Other Fibrous Materials:%	**Asbestos Type: %**
Asphalt/Binder, Binder/Filler, Calcareous binder	Synthetic fibers 27%	**None Detected ND**

Layer 2 of 4 **Description:** Black asphaltic built-up material

Non-Fibrous Materials:	Other Fibrous Materials:%	**Asbestos Type: %**
Asphalt/Binder, Binder/Filler, Calcareous binder	Glass fibers 34%	**None Detected ND**

Layer 3 of 4 **Description:** Black asphaltic mastic

Non-Fibrous Materials:	Other Fibrous Materials:%	**Asbestos Type: %**
Mastic/Binder, Calcareous binder	Cellulose 5%	**None Detected ND**

Sampled by: Client
Analyzed by: Jacob Laugeson **Date:** 03/15/2017
Reviewed by: Nick Ly **Date:** 03/16/2017

Nick Ly, Technical Director

Note: If samples are not homogeneous, then subsamples of the components were analyzed separately. All bulk samples are analyzed using both EPA 600/R-93/116 and 600/M4-82-020 Methods with the following measurement uncertainties for the reported % Asbestos (1%=0-3%, 5%=1-9%, 10%=5-15%, 20%=10-30%, 50%=40-60%). This report relates only to the items tested. If sample was not collected by NVL personnel, then the accuracy of the results is limited by the methodology and acuity of the sample collector. This report shall not be reproduced except in full, without written approval of NVL Laboratories, Inc. It shall not be used to claim product endorsement by NVLAP or any other agency of the US Government

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Bulk Asbestos Fibers Analysis

By Polarized Light Microscopy

Client: Landau Associates
Address: 130 2nd Avenue South
Edmonds, WA 98020

Attention: Mr. Cody Johnson
Project Location: Blaine Marina Inc.

Batch #: 1704290.00
Client Project #: 001034.010.016
Date Received: 3/8/2017
Samples Received: 39
Samples Analyzed: 33
Method: EPA/600/R-93/116
& EPA/600/M4-82-020

Layer 4 of 4 **Description:** Black asphaltic fibrous layered material

Non-Fibrous Materials:	Other Fibrous Materials:%	**Asbestos Type: %**
Asphalt/Binder, Binder/Filler	Glass fibers 84%	**None Detected ND**

Lab ID: 17021982 **Client Sample #: BMI-RM2-1**
Location: Blaine Marina Inc.

Layer 1 of 3 **Description:** Black asphaltic fibrous material with granules

Non-Fibrous Materials:	Other Fibrous Materials:%	**Asbestos Type: %**
Asphalt/Binder, Binder/Filler, Granules	Glass fibers 31%	**None Detected ND**
	Cellulose 12%	

Layer 2 of 3 **Description:** Black asphaltic material

Non-Fibrous Materials:	Other Fibrous Materials:%	**Asbestos Type: %**
Asphalt/Binder, Binder/Filler	Glass fibers 43%	**None Detected ND**

Layer 3 of 3 **Description:** Black asphaltic fibrous layered material

Non-Fibrous Materials:	Other Fibrous Materials:%	**Asbestos Type: %**
Asphalt/Binder, Binder/Filler	Glass fibers 74%	**None Detected ND**

Lab ID: 17021983 **Client Sample #: BMI-CP1-1**
Location: Blaine Marina Inc.

Layer 1 of 2 **Description:** Red fibrous carpet material with gray mastic and mesh

Non-Fibrous Materials:	Other Fibrous Materials:%	**Asbestos Type: %**
Synthetic/Binder, Mastic/Binder	Synthetic fibers 89%	**None Detected ND**

Layer 2 of 2 **Description:** Tan soft mastic

Non-Fibrous Materials:	Other Fibrous Materials:%	**Asbestos Type: %**
Mastic/Binder, Calcareous particles	Synthetic fibers 4%	**None Detected ND**

Lab ID: 17021984 **Client Sample #: BMI-CP2-1**
Location: Blaine Marina Inc.

Sampled by: Client
Analyzed by: Jacob Laugeson **Date:** 03/15/2017
Reviewed by: Nick Ly **Date:** 03/16/2017

Nick Ly, Technical Director

Note: If samples are not homogeneous, then subsamples of the components were analyzed separately. All bulk samples are analyzed using both EPA 600/R-93/116 and 600/M4-82-020 Methods with the following measurement uncertainties for the reported % Asbestos (1%=0-3%, 5%=1-9%, 10%=5-15%, 20%=10-30%, 50%=40-60%). This report relates only to the items tested. If sample was not collected by NVL personnel, then the accuracy of the results is limited by the methodology and acuity of the sample collector. This report shall not be reproduced except in full, without written approval of NVL Laboratories, Inc. It shall not be used to claim product endorsement by NVLAP or any other agency of the US Government

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p 206.547.0100 | f 206.634.1936 | www.nvllabs.com

Bulk Asbestos Fibers Analysis

By Polarized Light Microscopy

Client: Landau Associates
Address: 130 2nd Avenue South
Edmonds, WA 98020

Attention: Mr. Cody Johnson
Project Location: Blaine Marina Inc.

Batch #: 1704290.00
Client Project #: 001034.010.016
Date Received: 3/8/2017
Samples Received: 39
Samples Analyzed: 33
Method: EPA/600/R-93/116 & EPA/600/M4-82-020

Layer 1 of 2	**Description:** Gray fibrous carpet material with gray mastic and mesh			
	Non-Fibrous Materials:	Other Fibrous Materials:%		**Asbestos Type: %**
	Synthetic/Binder, Mastic/Binder	Synthetic fibers	86%	**None Detected ND**
Layer 2 of 2	**Description:** Trace tan soft mastic			
	Non-Fibrous Materials:	Other Fibrous Materials:%		**Asbestos Type: %**
	Mastic/Binder, Calcareous particles	Synthetic fibers	7%	**None Detected ND**

Lab ID: 17021985 **Client Sample #: BMI-CP3-1**
Location: Blaine Marina Inc.

Layer 1 of 2	**Description:** Gray/multi-colored fibrous carpet material with gray mastic and mesh			
	Non-Fibrous Materials:	Other Fibrous Materials:%		**Asbestos Type: %**
	Synthetic/Binder, Mastic/Binder	Synthetic fibers	90%	**None Detected ND**
Layer 2 of 2	**Description:** Tan soft mastic			
	Non-Fibrous Materials:	Other Fibrous Materials:%		**Asbestos Type: %**
	Mastic/Binder, Calcareous particles	Synthetic fibers	5%	**None Detected ND**

Lab ID: 17021986 **Client Sample #: BMI-CP4-1**
Location: Blaine Marina Inc.

Layer 1 of 3	**Description:** Brown fibrous carpet material with gray mastic and mesh			
	Non-Fibrous Materials:	Other Fibrous Materials:%		**Asbestos Type: %**
	Synthetic/Binder, Mastic/Binder	Synthetic fibers	87%	**None Detected ND**
Layer 2 of 3	**Description:** Tan soft mastic			
	Non-Fibrous Materials:	Other Fibrous Materials:%		**Asbestos Type: %**
	Mastic/Binder, Calcareous particles	Synthetic fibers	4%	**None Detected ND**
Layer 3 of 3	**Description:** White crumbly material			
	Non-Fibrous Materials:	Other Fibrous Materials:%		**Asbestos Type: %**
	Calcareous binder, Binder/Filler, Calcareous particles	Cellulose	8%	**None Detected ND**

Sampled by: Client
Analyzed by: Jacob Laugeson **Date:** 03/15/2017
Reviewed by: Nick Ly **Date:** 03/16/2017

Nick Ly, Technical Director

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Bulk Asbestos Fibers Analysis

By Polarized Light Microscopy

Client: Landau Associates
Address: 130 2nd Avenue South
Edmonds, WA 98020

Attention: Mr. Cody Johnson
Project Location: Blaine Marina Inc.

Batch #: 1704290.00
Client Project #: 001034.010.016
Date Received: 3/8/2017
Samples Received: 39
Samples Analyzed: 33
Method: EPA/600/R-93/116
& EPA/600/M4-82-020

Lab ID: 17021987 **Client Sample #: BMI-VFT1-1**
Location: Blaine Marina Inc.

Layer 1 of 3	**Description:** White vinyl tile		
	Non-Fibrous Materials:	Other Fibrous Materials:%	**Asbestos Type: %**
	Vinyl/Binder, Binder/Filler	None Detected ND	**None Detected ND**
Layer 2 of 3	**Description:** Black asphaltic mastic		
	Non-Fibrous Materials:	Other Fibrous Materials:%	**Asbestos Type: %**
	Mastic/Binder, Asphalt/Binder, Calcareous particles	Cellulose 5%	**None Detected ND**
Layer 3 of 3	**Description:** Brown woody material		
	Non-Fibrous Materials:	Other Fibrous Materials:%	**Asbestos Type: %**
	Wood flakes, Binder/Filler, Calcareous binder	Wood fibers 74%	**None Detected ND**

Lab ID: 17021988 **Client Sample #: BMI-VFT2-1**
Location: Blaine Marina Inc.

Layer 1 of 2	**Description:** Tan vinyl tile		
	Non-Fibrous Materials:	Other Fibrous Materials:%	**Asbestos Type: %**
	Vinyl/Binder, Binder/Filler	Cellulose 2%	**Chrysotile 4%**
Layer 2 of 2	**Description:** Tan soft mastic		
	Non-Fibrous Materials:	Other Fibrous Materials:%	**Asbestos Type: %**
	Mastic/Binder, Calcareous particles, Calcareous binder	Cellulose 6%	**None Detected ND**

Lab ID: 17021989 **Client Sample #: BMI-VFT3-1**
Location: Blaine Marina Inc.

Layer 1 of 2	**Description:** Gray vinyl tile		
	Non-Fibrous Materials:	Other Fibrous Materials:%	**Asbestos Type: %**
	Vinyl/Binder, Binder/Filler, Fine grains	Cellulose 4%	**None Detected ND**

Sampled by: Client
Analyzed by: Jacob Laugeson **Date:** 03/15/2017
Reviewed by: Nick Ly **Date:** 03/16/2017

Nick Ly, Technical Director

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Bulk Asbestos Fibers Analysis

By Polarized Light Microscopy

Client: Landau Associates
Address: 130 2nd Avenue South
Edmonds, WA 98020

Attention: Mr. Cody Johnson
Project Location: Blaine Marina Inc.

Batch #: 1704290.00
Client Project #: 001034.010.016
Date Received: 3/8/2017
Samples Received: 39
Samples Analyzed: 33
Method: EPA/600/R-93/116
& EPA/600/M4-82-020

Layer 2 of 2 **Description:** Tan soft mastic

Non-Fibrous Materials:	Other Fibrous Materials:%	**Asbestos Type: %**
Mastic/Binder, Calcareous particles, Calcareous binder	Cellulose 5%	**None Detected ND**

Lab ID: 17021990 **Client Sample #: BMI-VFT4-1**
Location: Blaine Marina Inc.

Layer 1 of 2 **Description:** Gray vinyl tile

Non-Fibrous Materials:	Other Fibrous Materials:%	**Asbestos Type: %**
Vinyl/Binder, Binder/Filler, Fine grains	Cellulose 3%	**None Detected ND**

Layer 2 of 2 **Description:** Tan soft mastic

Non-Fibrous Materials:	Other Fibrous Materials:%	**Asbestos Type: %**
Mastic/Binder, Calcareous particles, Calcareous binder	Cellulose 3%	**None Detected ND**

Lab ID: 17021991 **Client Sample #: BMI-TX1-1**
Location: Blaine Marina Inc.
Comments: Sample was dried prior to analysis.

Layer 1 of 1 **Description:** White lumpy foamy material with paint

Non-Fibrous Materials:	Other Fibrous Materials:%	**Asbestos Type: %**
Calcareous binder, Synthetic foam, Paint	Cellulose 5%	**Chrysotile 5%**

Lab ID: 17021992 **Client Sample #: BMI-TX1-2** **Sample Status: Not Analyzed**

Lab ID: 17021993 **Client Sample #: BMI-TX1-3** **Sample Status: Not Analyzed**

Lab ID: 17021994 **Client Sample #: BMI-TX1-4** **Sample Status: Not Analyzed**

Sampled by: Client
Analyzed by: Jacob Laugeson **Date:** 03/15/2017
Reviewed by: Nick Ly **Date:** 03/16/2017

Nick Ly, Technical Director

Note: If samples are not homogeneous, then subsamples of the components were analyzed separately. All bulk samples are analyzed using both EPA 600/R-93/116 and 600/M4-82-020 Methods with the following measurement uncertainties for the reported % Asbestos (1%=0-3%, 5%=1-9%, 10%=5-15%, 20%=10-30%, 50%=40-60%). This report relates only to the items tested. If sample was not collected by NVL personnel, then the accuracy of the results is limited by the methodology and acuity of the sample collector. This report shall not be reproduced except in full, without written approval of NVL Laboratories, Inc. It shall not be used to claim product endorsement by NVLAP or any other agency of the US Government

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Bulk Asbestos Fibers Analysis

By Polarized Light Microscopy

Client: Landau Associates
Address: 130 2nd Avenue South
Edmonds, WA 98020

Attention: Mr. Cody Johnson
Project Location: Blaine Marina Inc.

Batch #: 1704290.00
Client Project #: 001034.010.016
Date Received: 3/8/2017
Samples Received: 39
Samples Analyzed: 33
Method: EPA/600/R-93/116
& EPA/600/M4-82-020

Lab ID: 17021995 **Client Sample #: BMI-TX1-5** **Sample Status: Not Analyzed**

Lab ID: 17021996 **Client Sample #: BMI-TX1-6** **Sample Status: Not Analyzed**

Lab ID: 17021997 **Client Sample #: BMI-TX1-7** **Sample Status: Not Analyzed**

Lab ID: 17021998 **Client Sample #: BMI-DW1-1**
Location: Blaine Marina Inc.

Layer 1 of 3	**Description:** White compacted powdery material with paint			
	Non-Fibrous Materials:	Other Fibrous Materials:%		**Asbestos Type: %**
	Calcareous particles, Perlite, Paint	None Detected	ND	**None Detected ND**
Layer 2 of 3	**Description:** White compacted powdery material with paper			
	Non-Fibrous Materials:	Other Fibrous Materials:%		**Asbestos Type: %**
	Calcareous particles, Perlite, Binder/Filler	Cellulose	31%	**None Detected ND**
Layer 3 of 3	**Description:** White chalky material with paper			
	Non-Fibrous Materials:	Other Fibrous Materials:%		**Asbestos Type: %**
	Gypsum/Binder, Binder/Filler	Cellulose	27%	**None Detected ND**

Lab ID: 17021999 **Client Sample #: BMI-DW1-2**
Location: Blaine Marina Inc.

Layer 1 of 3	**Description:** White compacted powdery material with paint			
	Non-Fibrous Materials:	Other Fibrous Materials:%		**Asbestos Type: %**
	Calcareous particles, Perlite, Paint	None Detected	ND	**None Detected ND**

Sampled by: Client
Analyzed by: Jacob Laugeson **Date:** 03/15/2017
Reviewed by: Nick Ly **Date:** 03/16/2017

Nick Ly, Technical Director

Note: If samples are not homogeneous, then subsamples of the components were analyzed separately. All bulk samples are analyzed using both EPA 600/R-93/116 and 600/M4-82-020 Methods with the following measurement uncertainties for the reported % Asbestos (1%=0-3%, 5%=1-9%, 10%=5-15%, 20%=10-30%, 50%=40-60%). This report relates only to the items tested. If sample was not collected by NVL personnel, then the accuracy of the results is limited by the methodology and acuity of the sample collector. This report shall not be reproduced except in full, without written approval of NVL Laboratories, Inc. It shall not be used to claim product endorsement by NVLAP or any other agency of the US Government

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Attention: Mr. Cody Johnson
Project Location: Blaine Marina Inc.

Batch #: 1704290.00
Client Project #: 001034.010.016
Date Received: 3/8/2017
Samples Received: 39
Samples Analyzed: 33
Method: EPA/600/R-93/116
& EPA/600/M4-82-020

Layer 2 of 3	**Description:** White compacted powdery material with paper			
	Non-Fibrous Materials:	Other Fibrous Materials:%		**Asbestos Type: %**
	Calcareous particles, Perlite, Binder/Filler	Cellulose 33%		**None Detected ND**
Layer 3 of 3	**Description:** White chalky material with paper			
	Non-Fibrous Materials:	Other Fibrous Materials:%		**Asbestos Type: %**
	Gypsum/Binder, Binder/Filler	Cellulose 26%		**None Detected ND**

Lab ID: 17022000 **Client Sample #: BMI-DW1-3**

Location: Blaine Marina Inc.

Layer 1 of 3	**Description:** White compacted powdery material with paint			
	Non-Fibrous Materials:	Other Fibrous Materials:%		**Asbestos Type: %**
	Calcareous particles, Perlite, Paint	None Detected ND		**None Detected ND**
Layer 2 of 3	**Description:** White compacted powdery material with paper			
	Non-Fibrous Materials:	Other Fibrous Materials:%		**Asbestos Type: %**
	Calcareous particles, Perlite, Binder/Filler	Cellulose 32%		**None Detected ND**
Layer 3 of 3	**Description:** White chalky material with paper			
	Non-Fibrous Materials:	Other Fibrous Materials:%		**Asbestos Type: %**
	Gypsum/Binder, Binder/Filler	Cellulose 25%		**None Detected ND**

Lab ID: 17022001 **Client Sample #: BMI-DW2-1**

Location: Blaine Marina Inc.

Comments: Composite result (per client request) for whole sample is less than 1% asbestos.

Layer 1 of 2	**Description:** White compacted powdery material with paint			
	Non-Fibrous Materials:	Other Fibrous Materials:%		**Asbestos Type: %**
	Calcareous particles, Calcareous binder, Paint	Cellulose 4%		**Chrysotile 2%**

Sampled by: Client
Analyzed by: Jacob Laugeson **Date:** 03/15/2017
Reviewed by: Nick Ly **Date:** 03/16/2017

Nick Ly, Technical Director

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Bulk Asbestos Fibers Analysis

By Polarized Light Microscopy

Client: Landau Associates
Address: 130 2nd Avenue South
Edmonds, WA 98020

Attention: Mr. Cody Johnson
Project Location: Blaine Marina Inc.

Batch #: 1704290.00
Client Project #: 001034.010.016
Date Received: 3/8/2017
Samples Received: 39
Samples Analyzed: 33
Method: EPA/600/R-93/116
& EPA/600/M4-82-020

Layer 2 of 2 **Description:** White chalky material with paper

Non-Fibrous Materials:	Other Fibrous Materials:%	**Asbestos Type: %**
Gypsum/Binder, Binder/Filler	Cellulose 27%	**None Detected ND**

Lab ID: 17022002 **Client Sample #: BMI-DW2-2**

Location: Blaine Marina Inc.

Layer 1 of 2 **Description:** White compacted powdery material with paint

Non-Fibrous Materials:	Other Fibrous Materials:%	**Asbestos Type: %**
Calcareous particles, Calcareous binder, Paint	Cellulose 3%	**Chrysotile <1%**

Layer 2 of 2 **Description:** White chalky material with paper

Non-Fibrous Materials:	Other Fibrous Materials:%	**Asbestos Type: %**
Gypsum/Binder, Binder/Filler	Cellulose 29%	**None Detected ND**

Lab ID: 17022003 **Client Sample #: BMI-DW2-3**

Location: Blaine Marina Inc.

Comments: Composite result (per client request) for whole sample is less than 1% asbestos.

Layer 1 of 2 **Description:** White compacted powdery material

Non-Fibrous Materials:	Other Fibrous Materials:%	**Asbestos Type: %**
Calcareous particles, Calcareous binder, Paint	Cellulose 5%	**Chrysotile 2%**

Layer 2 of 2 **Description:** White chalky material with paper

Non-Fibrous Materials:	Other Fibrous Materials:%	**Asbestos Type: %**
Gypsum/Binder, Binder/Filler	Cellulose 26%	**None Detected ND**

Lab ID: 17022004 **Client Sample #: BMI-DW2-4**

Location: Blaine Marina Inc.

Layer 1 of 2 **Description:** White compacted powdery material

Non-Fibrous Materials:	Other Fibrous Materials:%	**Asbestos Type: %**
Calcareous particles, Perlite, Paint	None Detected ND	**None Detected ND**

Sampled by: Client
Analyzed by: Jacob Laugeson **Date:** 03/15/2017
Reviewed by: Nick Ly **Date:** 03/16/2017

Nick Ly, Technical Director

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Bulk Asbestos Fibers Analysis

By Polarized Light Microscopy

Client: Landau Associates
Address: 130 2nd Avenue South
Edmonds, WA 98020

Attention: Mr. Cody Johnson
Project Location: Blaine Marina Inc.

Batch #: 1704290.00
Client Project #: 001034.010.016
Date Received: 3/8/2017
Samples Received: 39
Samples Analyzed: 33
Method: EPA/600/R-93/116
& EPA/600/M4-82-020

Layer 2 of 2 **Description:** White chalky material with paper

Non-Fibrous Materials:	Other Fibrous Materials:%	**Asbestos Type: %**
Gypsum/Binder, Binder/Filler	Cellulose 31%	**None Detected ND**

Lab ID: 17022005 **Client Sample #: BMI-DW2-5**
Location: Blaine Marina Inc.

Layer 1 of 1 **Description:** White chalky material with paper and paint

Non-Fibrous Materials:	Other Fibrous Materials:%	**Asbestos Type: %**
Gypsum/Binder, Binder/Filler, Paint	Cellulose 34%	**None Detected ND**

Lab ID: 17022006 **Client Sample #: BMI-DW3-1**
Location: Blaine Marina Inc.

Layer 1 of 1 **Description:** White chalky material with paper

Non-Fibrous Materials:	Other Fibrous Materials:%	**Asbestos Type: %**
Gypsum/Binder, Binder/Filler	Cellulose 27%	**None Detected ND**

Sampled by: Client
Analyzed by: Jacob Laugeson **Date:** 03/15/2017
Reviewed by: Nick Ly **Date:** 03/16/2017

Nick Ly, Technical Director

Note: If samples are not homogeneous, then subsamples of the components were analyzed separately. All bulk samples are analyzed using both EPA 600/R-93/116 and 600/M4-82-020 Methods with the following measurement uncertainties for the reported % Asbestos (1%=0-3%, 5%=1-9%, 10%=5-15%, 20%=10-30%, 50%=40-60%). This report relates only to the items tested. If sample was not collected by NVL personnel, then the accuracy of the results is limited by the methodology and acuity of the sample collector. This report shall not be reproduced except in full, without written approval of NVL Laboratories, Inc. It shall not be used to claim product endorsement by NVLAP or any other agency of the US Government

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ASBESTOS LABORATORY SERVICES

Company Landau Associates
Address 130 2nd Avenue South
Edmonds, WA 98020
Project Manager Mr. Cody Johnson
Phone (425) 778-0907
Cell (206) 877-2173

NVL Batch Number **1704290.00**
TAT 5 Days **AH** No
Rush TAT
Due Date 3/15/2017 **Time** 4:50 PM
Email cjohnson@landauinc.com
Fax (425) 778-6409

Project Name/Number: 001034.010.016 **Project Location:** Blaine Marina Inc.

Subcategory PLM Bulk
Item Code ASB-02 EPA 600/R-93-116 Asbestos by PLM <bulk>

Total Number of Samples 39 Rush Samples

	Lab ID	Sample ID	Description	A/R
1	17021968	BMI-ACT1-1		A
2	17021969	BMI-ACT2-1		A
3	17021970	BMI-AD1-1		A
4	17021971	BMI-CB1-1		A
5	17021972	BMI-WP1-1		A
6	17021973	BMI-WG1-1		A
7	17021974	BMI-WG2-1		A
8	17021975	BMI-LC1-1		A
9	17021976	BMI-P1-1		A
10	17021977	BMI-P2-1		A
11	17021978	BMI-GA1-1		A
12	17021979	BMI-GA2-1		A
13	17021980	BMI-GA3-1		A
14	17021981	BMI-RM1-1		A
15	17021982	BMI-RM2-1		A
16	17021983	BMI-CP1-1		A
17	17021984	BMI-CP2-1		A
18	17021985	BMI-CP3-1		A

	Print Name	Signature	Company	Date	Time
Sampled by	Client				
Relinquished by	Client				

Office Use Only	Print Name	Signature	Company	Date	Time
Received by	Jacob Laugeson		NVL	3/8/17	1650
Analyzed by	Jacob Laugeson		NVL	3/15/17	
Results Called by					
☐ **Faxed** ☐ **Emailed**					

Special Instructions:

Date: 3/9/2017
Time: 11:22 AM
Entered By: Sarah Khan

NVL Laboratories, Inc.
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p 206.547.0100 | f 206.634.1936 | www.nvllabs.com

ASBESTOS LABORATORY SERVICES

Company Landau Associates
Address 130 2nd Avenue South
Edmonds, WA 98020
Project Manager Mr. Cody Johnson
Phone (425) 778-0907
Cell (206) 877-2173

NVL Batch Number **1704290.00**
TAT 5 Days **AH** No
Rush TAT
Due Date 3/15/2017 **Time** 4:50 PM
Email cjohnson@landauinc.com
Fax (425) 778-6409

Project Name/Number: 001034.010.016 **Project Location:** Blaine Marina Inc.

Subcategory PLM Bulk
Item Code ASB-02 EPA 600/R-93-116 Asbestos by PLM <bulk>

Total Number of Samples 39 Rush Samples

	Lab ID	Sample ID	Description	A/R
19	17021986	BMI-CP4-1		A
20	17021987	BMI-VFT1-1		A
21	17021988	BMI-VFT2-1		A
22	17021989	BMI-VFT3-1		A
23	17021990	BMI-VFT4-1		A
24	17021991	BMI-TX1-1	**Stop At First Positive	A
25	17021992	BMI-TX1-2	**	A
26	17021993	BMI-TX1-3	**	A
27	17021994	BMI-TX1-4	**	A
28	17021995	BMI-TX1-5	**	A
29	17021996	BMI-TX1-6	**	A
30	17021997	BMI-TX1-7	**	A
31	17021998	BMI-DW1-1		A
32	17021999	BMI-DW1-2		A
33	17022000	BMI-DW1-3		A
34	17022001	BMI-DW2-1	Composite per client JL	A
35	17022002	BMI-DW2-2		A
36	17022003	BMI-DW2-3	Composite per client JL	A

	Print Name	Signature	Company	Date	Time
Sampled by	Client				
Relinquished by	Client				

Office Use Only	Print Name	Signature	Company	Date	Time
Received by	Jacob Laugeson		NVL	3/8/17	1650
Analyzed by	Jacob Laugeson		NVL	3/15/17	
Results Called by					
☐ **Faxed** ☐ **Emailed**					

Special Instructions:

Date: 3/9/2017
Time: 11:22 AM
Entered By: Sarah Khan

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ASBESTOS LABORATORY SERVICES

Company Landau Associates
Address 130 2nd Avenue South
Edmonds, WA 98020
Project Manager Mr. Cody Johnson
Phone (425) 778-0907
Cell (206) 877-2173

NVL Batch Number **1704290.00**
TAT 5 Days **AH** No
Rush TAT
Due Date 3/15/2017 **Time** 4:50 PM
Email cjohnson@landauinc.com
Fax (425) 778-6409

Project Name/Number: 001034.010.016 **Project Location:** Blaine Marina Inc.

Subcategory PLM Bulk
Item Code ASB-02 EPA 600/R-93-116 Asbestos by PLM <bulk>

Total Number of Samples 39 Rush Samples

	Lab ID	Sample ID	Description	A/R
37	17022004	BMI-DW2-4		A
38	17022005	BMI-DW2-5		A
39	17022006	BMI-DW3-1		A

	Print Name	Signature	Company	Date	Time
Sampled by	Client				
Relinquished by	Client				

Office Use Only	Print Name	Signature	Company	Date	Time
Received by	Jacob Laugeson		NVL	3/8/17	1650
Analyzed by	Jacob Laugeson		NVL	3/15/17	
Results Called by					
☐ **Faxed** ☐ **Emailed**					

Special Instructions:

Date: 3/9/2017
Time: 11:22 AM
Entered By: Sarah Khan

1704290

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INDUSTRIAL HYGIENE SERVICES
Laboratory | Management | Training

ASBESTOS CHAIN OF CUSTODY

Turn Around Time
- ☐ 1 Hour
- ☐ 2 Hours
- ☐ 4 Hours
- ☐ 24 Hours
- ☑ 2 Days
- ☐ 3 Days
- ☐ 4 Days
- ☑ 5 Days
- ☐ 10 Days

Please call for TAT less than 24 Hours

Company: Landau Associates
Address: 130 2nd Ave. S
Edmonds, WA
Phone: ( ) -

Project Manager: Cody Johnson
Cell: (206) 877 - 2173
Email: cjohnson@landauin.com
Fax: ( ) -

Project Name/Number: 001034.010.016
Project Location: Blaine Marina Inc.

- ☐ PCM Air (NIOSH 7400)
- ☑ PLM (EPA 600/R-93-116)
- ☐ PLM Gravimetry (600/R-93-116)
- ☐ Asbestos Friable/Non-Friable (EPA 600/R-93/116)
- ☐ TEM (NIOSH 7402)
- ☐ EPA 400 Points (600/R-93-116)
- ☐ Asbestos in Vermiculite (EPA 600/R-04/004)
- ☐ TEM (AHERA)
- ☐ Other
- ☐ TEM (EPA Level II Modified)
- ☐ EPA 1000Points (600/R-93-116)
- ☐ Asbestos in Sediment (EPA 1900 Points)

Reporting Instructions
☐ Call ( ) - ☐ Fax ( ) - ☑ Email cjohnson@landauin.com

Total Number of Samples 39

	Sample ID	Description	A/R
1	BMI-ACT1-1		
2	BMI-ACT2-1		
3	BMI-AD1-1		
4	BMI-CB1-1		
5	BMI-WP1-1		
6	BMI-WG1-1		
7	BMI-WG2-1		
8	BMI-LC1-1		
9	BMI-P1-1		
10	BMI-P2-1		
11	BMI-GA1-1		
12	BMI-GA2-1		
13	BMI-GA3-1		
14	BMI-RM1-1		
15	BMI-RM2-1		

	Print Name	Signature	Company	Date	Time
Sampled by					
Relinquish by	Cody Johnson	[signature]	LAZ	3/8/17	1650

Office Use Only

	Print Name	Signature	Company	Date	Time
Received by	Jacob L	[signature]	NVL	3.8.17	1650
Analyzed by					
Called by					
Faxed/Email by					

1704290

NVL LABS
INDUSTRIAL HYGIENE SERVICES
Laboratory | Management | Training

ASBESTOS CHAIN OF CUSTODY

Turn Around Time
- ☐ 1 Hour
- ☐ 2 Hours
- ☐ 4 Hours
- ☐ 24 Hours
- ☑ 2 Days
- ☐ 3 Days
- ☐ 4 Days
- ☑ 5 Days
- ☐ 10 Days

Please call for TAT less than 24 Hours

Company: Landau Associates
Address: 130 2nd Ave. S
Edmonds, WA
Phone: ( ) -

Project Manager: Cody Johnson
Cell: (206) 877 - 2173
Email: cjohnson@landauin.com
Fax: ( ) -

Project Name/Number: 001034.010.016
Project Location: Blaine Marina Inc.

- ☐ PCM Air (NIOSH 7400)
- ☑ PLM (EPA 600/R-93-116)
- ☐ PLM Gravimetry (600/R-93-116)
- ☐ Asbestos Friable/Non-Friable (EPA 600/R-93/116)
- ☐ TEM (NIOSH 7402)
- ☐ EPA 400 Points (600/R-93-116)
- ☐ Asbestos in Vermiculite (EPA 600/R-04/004)
- ☐ TEM (AHERA)
- ☐ Other
- ☐ TEM (EPA Level II Modified)
- ☐ EPA 1000Points (600/R-93-116)
- ☐ Asbestos in Sediment (EPA 1900 Points)

Reporting Instructions
☐ Call ( ) - ☐ Fax ( ) - ☑ Email cjohnson@landauin.com

Total Number of Samples 39

	Sample ID	Description	A/R
1	BMI-CP1-1		
2	BMI-CP2-1		
3	BMI-CP3-1		
4	BMI-CP4-1		
5	BMI-VFT1-1		
6	BMI-VFT2-1		
7	BMI-VFT3-1		
8	BMI-VFT4-1		
9	BMI-TX1-1	Stop at first positive in this series	
10	BMI-TX1-2		
11	BMI-TX1-3		
12	BMI-TX1-4		
13	BMI-TX1-5		
14	BMI-TX1-6		
15	BMI-TX1-7		

	Print Name	Signature	Company	Date	Time
Sampled by					
Relinquish by	Cody Johnson		LAZ	3/8/17	1650

Office Use Only

	Print Name	Signature	Company	Date	Time
Received by	Jamb L		NM	3.8.17	1650
Analyzed by					
Called by					
Faxed/Email by					

1704290

NVL LABS
INDUSTRIAL HYGIENE SERVICES
Laboratory | Management | Training

ASBESTOS CHAIN OF CUSTODY

Turn Around Time
- ☐ 1 Hour
- ☐ 2 Hours
- ☐ 4 Hours
- ☐ 24 Hours
- ☑ 2 Days
- ☐ 3 Days
- ☐ 4 Days
- ☑ 5 Days
- ☐ 10 Days

Please call for TAT less than 24 Hours

Company: Landau Associates
Address: 130 2nd Ave. S
Edmonds, WA
Phone: ( ) -

Project Manager: Cody Johnson
Cell: (206) 877 - 2173
Email: cjohnson@landauin.com
Fax: ( ) -

Project Name/Number: 001034.010.016
Project Location: Blaine Marina Inc.

- ☐ PCM Air (NIOSH 7400)
- ☑ PLM (EPA 600/R-93-116)
- ☐ PLM Gravimetry (600/R-93-116)
- ☐ Asbestos Friable/Non-Friable (EPA 600/R-93/116)
- ☐ TEM (NIOSH 7402)
- ☐ EPA 400 Points (600/R-93-116)
- ☐ Asbestos in Vermiculite (EPA 600/R-04/004)
- ☐ TEM (AHERA)
- ☐ Other
- ☐ TEM (EPA Level II Modified)
- ☐ EPA 1000Points (600/R-93-116)
- ☐ Asbestos in Sediment (EPA 1900 Points)

Reporting Instructions
☐ Call ( ) -
☐ Fax ( ) -
☑ Email cjohnson@landauin.com

Total Number of Samples 39

	Sample ID	Description	A/R
1	BMI-DW1-1		
2	BMI-DW1-2		
3	BMI-DW1-3		
4	BMI-DW2-1		
5	BMI-DW2-2		
6	BMI-DW2-3		
7	BMI-DW2-4		
8	BMI-DW2-5		
9	BMI-DW3-1		
10			
11			
12			
13			
14			
15			

	Print Name	Signature	Company	Date	Time
Sampled by					
Relinquish by	Cody Johnson		LAZ	3/8/17	1650

Office Use Only

	Print Name	Signature	Company	Date	Time
Received by	Jacob L		NL	3.8.17	1650
Analyzed by					
Called by					
Faxed/Email by					

NVL LABS
INDUSTRIAL HYGIENE SERVICES
Laboratory | Management | Training

ASBESTOS CHAIN OF CUSTODY

Turn Around Time
- ❑ 1 Hour
- ❑ 2 Hours
- ❑ 4 Hours
- ❑ 24 Hours
- ☑ 2 Days
- ❑ 3 Days
- ❑ 4 Days
- ☑ 5 Days
- ❑ 10 Days

Please call for TAT less than 24 Hours

Company: Landau Associates
Address: 130 2nd Ave. S
Edmonds, WA
Phone:

Project Manager: Cody Johnson
Cell: (206) 877 - 2173
Email: cjohnson@landauin.com
Fax: ( ) -

Project Name/Number: 001034.010.016
Project Location: Blaine Marina Inc.

- ❑ PCM Air (NIOSH 7400)
- ☑ PLM (EPA 600/R-93-116)
- ❑ PLM Gravimetry (600/R-93-116)
- ❑ Asbestos Friable/Non-Friable (EPA 600/R-93/116)
- ❑ TEM (NIOSH 7402)
- ❑ EPA 400 Points (600/R-93-116)
- ❑ Asbestos in Vermiculite (EPA 600/R-04/004)
- ❑ TEM (AHERA)
- ❑ Other
- ❑ TEM (EPA Level II Modified)
- ❑ EPA 1000Points (600/R-93-116)
- ❑ Asbestos in Sediment (EPA 1900 Points)

Reporting Instructions
❑ Call ( ) -
❑ Fax ( ) -
☑ Email cjohnson@landauin.com

Total Number of Samples 39

	Sample ID	Description	A/R
1	BMI-ACT1-1		
2	BMI-ACT2-1		
3	BMI-AD1-1		
4	BMI-CB1-1		
5	BMI-WP1-1		
6	BMI-WG1-1		
7	BMI-WG2-1		
8	BMI-LC1-1		
9	BMI-P1-1		
10	BMI-P2-1		
11	BMI-GA1-1		
12	BMI-GA2-1		
13	BMI-GA3-1		
14	BMI-RM1-1		
15	BMI-RM2-1		

	Print Name	Signature	Company	Date	Time
Sampled by					
Relinquish by					

Office Use Only

	Print Name	Signature	Company	Date	Time
Received by					
Analyzed by					
Called by					
Faxed/Email by					

March 9, 2017

Cody Johnson
Landau Associates
130 2nd Avenue South
Edmonds, WA 98020

NVL LABS
INDUSTRIAL HYGIENE SERVICES
Laboratory | Management | Training

RE: Metals Analysis; NVL Batch # 1704254.00

Dear Mr. Johnson,

Enclosed please find the test results for samples submitted to our laboratory for analysis. Preparation of these samples was conducted following protocol outlined in EPA Method SW 846 -3051 unless stated otherwise. Analysis of these samples was performed using analytical instruments in accordance with U.S. EPA, NIOSH, OSHA and other ASTM methods.

For matrix materials submitted as paint, dust wipe, soil or TCLP samples, analysis for the presence of total metals is conducted using published U.S. EPA Methods. Paint and soil results are usually expressed in mg/Kg which is equivalent to parts per million (ppm). Lead (Pb) in paint is usually expressed in mg/Kg (ppm) , Percent (%) or mg/cm^2 by area. Dust wipe sample results are usually expressed in ug/wipe and ug/ft^2. TCLP samples are reported in mg/L (ppm). For air filter samples, analyses are conducted using NIOSH and OSHA Methods. Results are expressed in ug/filter and ug/m^3. Other matrix materials are analyzed accordingly using published methods or specified by client. The reported test results pertain only to items tested and are not blank corrected.

For recent regulation updates pertaining to current regulatory levels or permissible exposure levels, please call your local regulatory agencies for more details.

This report is considered highly confidential and will not be released without your approval. Samples are archived for two weeks following analysis. Samples that are not retrieved by the client are discarded after two weeks.

Thank you for using our laboratory services. if you need further assistance please feel free to call us at 206-547-0100 or 1-888-NVLLABS.

Sincerely,

Shalini Patel, Laboratory Analyst

ilac-MRA

AIHA LAP, LLC
ACCREDITED LABORATORY
INDUSTRIAL HYGIENE & ENVIRONMENTAL LEAD
ISO/IEC 17025:2005
WWW.AIHAACCREDITEDLABS.ORG
LAB # 101861

NVL Laboratories, Inc.
4708 Aurora Ave N, Seattle, WA 98103
p 206.547.0100 | f 206.634.1936 | www.nvllabs.com

Analysis Report

Total Lead (Pb)

Client: Landau Associates
Address: 130 2nd Avenue South
Edmonds, WA 98020

Attention: Mr. Cody Johnson
Project Location: Blaine Marina

Batch #: 1704254.00
Matrix: Paint
Method: EPA 3051/7000B
Client Project #: 001034.010.016
Date Received: 3/8/2017
Samples Received: 15
Samples Analyzed: 15

Lab ID	Client Sample #	Sample Weight (g)	RL in mg/Kg	Results in mg/Kg	Results in percent
17021825	BMI-LP-1	0.1801	56.0	< 56.0	<0.0056
17021826	BMI-LP-2	0.1870	54.0	< 54.0	<0.0054
17021827	BMI-LP-3	0.0971	100.0	1400.0	0.1400
17021828	BMI-LP-4	0.1364	74.0	1400.0	0.1400
17021829	BMI-LP-5	0.0500	200.0	< 200.0	<0.0200
17021830	BMI-LP-6	0.0206	240.0	4900.0	0.4900
17021831	BMI-LP-7	0.2029	50.0	1400.0	0.1400
17021832	BMI-LP-8	0.1702	59.0	1400.0	0.1400
17021833	BMI-LP-9	0.0766	130.0	4400.0	0.4400
17021834	BMI-LP-10	0.1295	78.0	160.0	0.0160
17021835	BMI-LP-11	0.0640	160.0	690.0	0.0690
17021836	BMI-LP-12	0.0902	110.0	< 110.0	<0.0110
17021837	BMI-LP-13	0.1821	55.0	2600.0	0.2600
17021838	BMI-LP-14	0.0788	130.0	< 130.0	<0.0130
17021839	BMI-LP-15	0.0444	110.0	18000.0	1.8000

Comments: Small sample size (<0.05g) for BMI-LP-6 and -15.

Sampled by: Client
Analyzed by: Yasuyuki Hida
Reviewed by: Shalini Patel
Date Analyzed: 03/09/2017
Date Issued: 03/09/2017

Shalini Patel, Laboratory Analyst

mg/ Kg =Milligrams per kilogram
Percent = Milligrams per kilogram / 10000
RL = Reporting Limit
'<' = Below the reporting Limit
Note : Method QC results are acceptable unless stated otherwise.
Unless otherwise indicated, the condition of all samples was acceptable at time of receipt.

Bench Run No: 2017-0309-3

NVL Laboratories, Inc.
4708 Aurora Ave N, Seattle, WA 98103
p 206.547.0100 | f 206.634.1936 | www.nvllabs.com

LEAD LABORATORY SERVICES

Company Landau Associates
Address 130 2nd Avenue South
Edmonds, WA 98020
Project Manager Mr. Cody Johnson
Phone (425) 778-0907
Cell (206) 877-2173

NVL Batch Number **1704254.00**
TAT 5 Days **AH** No
Rush TAT
Due Date 3/15/2017 **Time** 4:50 PM
Email cjohnson@landauinc.com
Fax (425) 778-6409

Project Name/Number: 001034.010.016 **Project Location:** Blaine Marina

Subcategory Flame AA (FAA)
Item Code FAA-02 EPA 7000B Lead by FAA <paint>

Total Number of Samples 15 Rush Samples

	Lab ID	Sample ID	Description	A/R
1	17021825	BMI-LP-1		A
2	17021826	BMI-LP-2		A
3	17021827	BMI-LP-3		A
4	17021828	BMI-LP-4		A
5	17021829	BMI-LP-5		A
6	17021830	BMI-LP-6		A
7	17021831	BMI-LP-7		A
8	17021832	BMI-LP-8		A
9	17021833	BMI-LP-9		A
10	17021834	BMI-LP-10		A
11	17021835	BMI-LP-11		A
12	17021836	BMI-LP-12		A
13	17021837	BMI-LP-13		A
14	17021838	BMI-LP-14		A
15	17021839	BMI-LP-15		A

	Print Name	Signature	Company	Date	Time
Sampled by	Client				
Relinquished by	Client				

Office Use Only	Print Name	Signature	Company	Date	Time
Received by	Jacob Laugeson		NVL	3/8/17	1650
Analyzed by	Yasuyuki Hida		NVL	3/9/17	
Results Called by					
☐ **Faxed** ☐ **Emailed**					

Special Instructions:

Date: 3/9/2017
Time: 8:09 AM
Entered By: Mohammed Jamal

1704254

NVL LABS
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METALS CHAIN OF CUSTODY

Turn Around Time
- ❑ 2 Hour ❑ 4 Hours ❑ 24 Hours
- ❑ 2 Days ❑ 3 Days ❑ 4 Days
- ☑ 5 Days ❑ 6-10 Days
- Please call for TAT less than 24 Hours

Company: Landau Associates, Inc.
Address: 130 2nd Ave. S.
Edmonds, WA 98020
Phone:

Project Manager: Cody Johnson
Cell: (206) 877 - 2173
Email: cjohnson@landauinc.com
Fax: ( ) -

Project Name/Number: 001034.010.016
Project Location: Blaine Marina

- ☑ Total Metals ❑ TCLP
- ☑ FAA (ppm ❑ ICP (PPM ❑ GFAA (ppb) ❑ CVAA (ppb)
- ❑ Air Filter ❑ Paint Chips (cm) ❑ Drinking Water ❑ Other
- ☑ Paint Chips (%) ❑ Dust Wipes ❑ Waste Water ❑ Soil
- RCRA 8: ❑ Barium ❑ Chromium ❑ Silver ❑ Arsenic ❑ Mercury ☑ Lead ❑ Selenium ❑ Cadmium
- RCRA 11: ❑ Copper ❑ Zinc ❑ Other

Reporting Instructions
❑ Call ( ) - ❑ Fax ( ) - ❑ Email cjohnson@landauinc.com

Total Number of Samples 23

	Sample ID	Description	A/R
1	BMI-LP-1		
2	BMI-LP-2		
3	BMI-LP-3		
4	BMI-LP-4		
5	BMI-LP-5		
6	BMI-LP-6		
7	BMI-LP-7		
8	BMI-LP-8		
9	BMI-LP-9		
10	BMI-LP-10		
11	BMI-LP-11		
12	BMI-LP-12		
13	BMI-LP-13		
14	BMI-LP-14		
15	BMI-LP-15		

	Print Name	Signature	Company	Date	Time
Sampled by					
Relinquish by	Cody Johnson		LAI	3/8/2017	1652

Office Use Only

	Print Name	Signature	Company	Date	Time
Received by	Jawb L		NM	3.8.17	1650
Analyzed by					
Called by					
Faxed/Email by					

March 10, 2017

Cody Johnson
Landau Associates
130 2nd Avenue South
Edmonds, WA 98020

NVL LABS
INDUSTRIAL HYGIENE SERVICES
Laboratory | Management | Training

RE: Metals Analysis; NVL Batch # 1704257.00

Dear Mr. Johnson,

Enclosed please find the test results for samples submitted to our laboratory for analysis. Preparation of these samples was conducted following protocol outlined in EPA Method SW 846 -3051 unless stated otherwise. Analysis of these samples was performed using analytical instruments in accordance with U.S. EPA, NIOSH, OSHA and other ASTM methods.

For matrix materials submitted as paint, dust wipe, soil or TCLP samples, analysis for the presence of total metals is conducted using published U.S. EPA Methods. Paint and soil results are usually expressed in mg/Kg which is equivalent to parts per million (ppm). Lead (Pb) in paint is usually expressed in mg/Kg (ppm) , Percent (%) or mg/cm^2 by area. Dust wipe sample results are usually expressed in ug/wipe and ug/ft^2. TCLP samples are reported in mg/L (ppm). For air filter samples, analyses are conducted using NIOSH and OSHA Methods. Results are expressed in ug/filter and ug/m^3. Other matrix materials are analyzed accordingly using published methods or specified by client. The reported test results pertain only to items tested and are not blank corrected.

For recent regulation updates pertaining to current regulatory levels or permissible exposure levels, please call your local regulatory agencies for more details.

This report is considered highly confidential and will not be released without your approval. Samples are archived for two weeks following analysis. Samples that are not retrieved by the client are discarded after two weeks.

Thank you for using our laboratory services. if you need further assistance please feel free to call us at 206-547-0100 or 1-888-NVLLABS.

Sincerely,

Nick Ly, Technical Director

ilac-MRA
AIHA LAP, LLC
ACCREDITED LABORATORY
INDUSTRIAL HYGIENE & ENVIRONMENTAL LEAD
ISO/IEC 17025:2005
WWW.AIHAACCREDITEDLABS.ORG
LAB # 101861

1.888.NVL.LABS
1.888.(685.5227)
www.nvllabs.com

NVL Laboratories, Inc.
4708 Aurora Ave N, Seattle, WA 98103
p 206.547.0100 | f 206.634.1936

NVL Laboratories, Inc.
4708 Aurora Ave N, Seattle, WA 98103
p 206.547.0100 | f 206.634.1936 | www.nvllabs.com

Analysis Report

Total Lead (Pb)

Client: Landau Associates
Address: 130 2nd Avenue South
Edmonds, WA 98020

Attention: Mr. Cody Johnson
Project Location: Blaine Marina

Batch #: 1704257.00
Matrix: Paint
Method: EPA 3051/7000B
Client Project #: 001034.010.016
Date Received: 3/8/2017
Samples Received: 8
Samples Analyzed: 8

Lab ID	Client Sample #	Sample Weight (g)	RL in mg/Kg	Results in mg/Kg	Results in percent
17021843	BMI-LP-16	0.1801	55.0	2300.0	0.2300
17021844	BMI-LP-17	0.2038	49.0	< 49.0	< 0.0049
17021845	BMI-LP-18	0.1898	52.0	720.0	0.0720
17021846	BMI-LP-19	0.1447	68.0	1300.0	0.1300
17021847	BMI-LP-20	0.1924	52.0	12000.0	1.2000
17021848	BMI-LP-21	0.1245	80.0	< 80.0	< 0.0080
17021849	BMI-LP-22	0.1933	51.0	82.0	0.0082
17021850	BMI-LP-23	0.1967	50.0	14000.0	1.4000

Sampled by: Client
Analyzed by: Yasuyuki Hida
Reviewed by: Nick Ly

Date Analyzed: 03/10/2017
Date Issued: 03/10/2017

Nick Ly, Technical Director

mg/ Kg =Milligrams per kilogram
Percent = Milligrams per kilogram / 10000
RL = Reporting Limit
'<' = Below the reporting Limit
Note : Method QC results are acceptable unless stated otherwise.
Unless otherwise indicated, the condition of all samples was acceptable at time of receipt.

Bench Run No: 2017-0310-2

NVL Laboratories, Inc.
4708 Aurora Ave N, Seattle, WA 98103
p 206.547.0100 | f 206.634.1936 | www.nvllabs.com

LEAD LABORATORY SERVICES

Company Landau Associates
Address 130 2nd Avenue South
Edmonds, WA 98020
Project Manager Mr. Cody Johnson
Phone (425) 778-0907
Cell (206) 877-2173

NVL Batch Number **1704257.00**
TAT 5 Days **AH** No
Rush TAT
Due Date 3/15/2017 **Time** 4:50 PM
Email cjohnson@landauinc.com
Fax (425) 778-6409

Project Name/Number: 001034.010.016 **Project Location:** Blaine Marina

Subcategory Flame AA (FAA)
Item Code FAA-02 EPA 7000B Lead by FAA <paint>

Total Number of Samples 8 Rush Samples

	Lab ID	Sample ID	Description	A/R
1	17021843	BMI-LP-16		A
2	17021844	BMI-LP-17		A
3	17021845	BMI-LP-18		A
4	17021846	BMI-LP-19		A
5	17021847	BMI-LP-20		A
6	17021848	BMI-LP-21		A
7	17021849	BMI-LP-22		A
8	17021850	BMI-LP-23		A

	Print Name	Signature	Company	Date	Time
Sampled by	Client				
Relinquished by	Client				

Office Use Only	Print Name	Signature	Company	Date	Time
Received by	Jacob Laugeson		NVL	3/8/17	1650
Analyzed by	Yasuyuki Hida		NVL	3/10/17	
Results Called by					
☐ **Faxed** ☐ **Emailed**					

Special Instructions:

Date: 3/9/2017
Time: 8:23 AM
Entered By: Mohammed Jamal

1704257

NVL LABS
INDUSTRIAL HYGIENE SERVICES
Laboratory | Management | Training

METALS CHAIN OF CUSTODY

Turn Around Time
- ❑ 2 Hour ❑ 4 Hours ❑ 24 Hours
- ❑ 2 Days ❑ 3 Days ❑ 4 Days
- ☑ 5 Days ❑ 6-10 Days
- Please call for TAT less than 24 Hours

Company: Landau Associates, Inc.
Address: 130 2nd Ave. S.
Edmonds, WA 98020
Phone:

Project Manager: Cody Johnson
Cell: (206) 877 - 2173
Email: cjohnson@landauinc.com
Fax: ( ) -

Project Name/Number: 001034.010.016
Project Location: Blaine Marina

- ☑ Total Metals ❑ TCLP
- ☑ FAA (ppm ❑ ICP (PPM ❑ GFAA (ppb) ❑ CVAA (ppb)
- ❑ Air Filter ❑ Paint Chips (cm) ❑ Drinking Water ❑ Other
- ☑ Paint Chips (%) ❑ Dust Wipes ❑ Waste Water ❑ Soil
- RCRA 8: ❑ Barium ❑ Chromium ❑ Silver ❑ Arsenic ❑ Mercury ☑ Lead ❑ Selenium ❑ Cadmium
- RCRA 11: ❑ Copper ❑ Zinc ❑ Other

Reporting Instructions
❑ Call ( ) - ❑ Fax ( ) - ❑ Email cjohnson@landauinc.com

Total Number of Samples 23

	Sample ID	Description	A/R
1	BMI-LP-16		
2	BMI-LP-17		
3	BMI-LP-18		
4	BMI-LP-19		
5	BMI-LP-20		
6	BMI-LP-21		
7	BMI-LP-22		
8	BMI-LP-23		
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14			
15			

	Print Name	Signature	Company	Date	Time
Sampled by					
Relinquish by	Cody Johnson		LAI	3/8/2017	1650

Office Use Only

	Print Name	Signature	Company	Date	Time
Received by	Jacob L		M	3.8.17	1650
Analyzed by					
Called by					
Faxed/Email by					

NVL LABS
INDUSTRIAL HYGIENE SERVICES
Laboratory | Management | Training

METALS CHAIN OF CUSTODY

Turn Around Time
- ❑ 2 Hour ❑ 4 Hours ❑ 24 Hours
- ❑ 2 Days ☑ 3 Days ☑ 4 Days
- ❑ 5 Days ❑ 6-10 Days
- Please call for TAT less than 24 Hours

Company: Landau Associates
Address: 130 2nd Ave. S
Edmonds, WA
Phone:

Project Manager: Cody Johnson
Cell: (206) 877 - 2173
Email: cjohnson@landauin.com
Fax: ( ) -

Project Name/Number: 001034.010.016
Project Location: Blaine Marina Inc.

- ❑ Total Metals
- ☑ TCLP
- ❑ FAA (ppm
- ❑ ICP (PPM
- ❑ GFAA (ppb)
- ❑ CVAA (ppb)
- ❑ Air Filter
- ❑ Paint Chips (cm)
- ❑ Drinking Water
- ☑ Paint Chips (%)
- ❑ Dust Wipes
- ❑ Waste Water
- ❑ Soil
- ❑ Other

RCRA 8
- ❑ Barium
- ❑ Arsenic
- ❑ Selenium
- ❑ Chromium
- ❑ Mercury
- ❑ Cadmium
- ❑ Silver
- ☑ Lead

RCRA 11
- ❑ Copper
- ❑ Zinc
- ❑ Other

Reporting Instructions
❑ Call ( ) - ❑ Fax ( ) - ☑ Email cjohnson@landauin.com

Total Number of Samples 39

	Sample ID	Description	A/R
1	BMI-ACT1-1		
2	BMI-ACT2-1		
3	BMI-AD1-1		
4	BMI-CB1-1		
5	BMI-WP1-1		
6	BMI-WG1-1		
7	BMI-WG2-1		
8	BMI-LC1-1		
9	BMI-P1-1		
10	BMI-P2-1		
11	BMI-GA1-1		
12	BMI-GA2-1		
13	BMI-GA3-1		
14	BMI-RM1-1		
15	BMI-RM2-1		

	Print Name	Signature	Company	Date	Time
Sampled by					
Relinquish by					

Office Use Only

	Print Name	Signature	Company	Date	Time
Received by					
Analyzed by					
Called by					
Faxed/Email by					

NVL LABS
INDUSTRIAL HYGIENE SERVICES
Laboratory | Management | Training

METALS CHAIN OF CUSTODY

Turn Around Time
- ❑ 2 Hour ❑ 4 Hours ❑ 24 Hours
- ❑ 2 Days ☑ 3 Days ☑ 4 Days
- ❑ 5 Days ❑ 6-10 Days
- Please call for TAT less than 24 Hours

Company: Landau Associates
Address: 130 2nd Ave. S
Edmonds, WA
Phone:

Project Manager: Cody Johnson
Cell: (206) 877 - 2173
Email: cjohnson@landauin.com
Fax: ( ) -

Project Name/Number: 001034.010.016
Project Location: Blaine Marina Inc.

- ❑ Total Metals
- ☑ TCLP
- ❑ FAA (ppm
- ❑ ICP (PPM
- ❑ GFAA (ppb)
- ❑ CVAA (ppb)
- ❑ Air Filter
- ❑ Paint Chips (cm)
- ❑ Drinking Water
- ☑ Paint Chips (%)
- ❑ Dust Wipes
- ❑ Waste Water
- ❑ Soil
- ❑ Other

RCRA 8
- ❑ Barium
- ❑ Arsenic
- ❑ Selenium
- ❑ Chromium
- ❑ Mercury
- ❑ Cadmium
- ❑ Silver
- ☑ Lead

RCRA 11
- ❑ Copper
- ❑ Zinc
- ❑ Other

Reporting Instructions
❑ Call ( ) - ❑ Fax ( ) - ☑ Email cjohnson@landauin.com

Total Number of Samples 39

	Sample ID	Description	A/R
1	BMI-ACT1-1		
2	BMI-ACT2-1		
3	BMI-AD1-1		
4	BMI-CB1-1		
5	BMI-WP1-1		
6	BMI-WG1-1		
7	BMI-WG2-1		
8	BMI-LC1-1		
9	BMI-P1-1		
10	BMI-P2-1		
11	BMI-GA1-1		
12	BMI-GA2-1		
13	BMI-GA3-1		
14	BMI-RM1-1		
15	BMI-RM2-1		

	Print Name	Signature	Company	Date	Time
Sampled by					
Relinquish by					

Office Use Only

	Print Name	Signature	Company	Date	Time
Received by					
Analyzed by					
Called by					
Faxed/Email by					

March 15, 2017

Mr. Cody Johnson

Landau Associates
130 2nd Avenue South
Edmonds, WA 98020

Re: **NVL Batch 1704262.00**

Project Name/Number: 001034.010.016

Project location: Blaine Marina, Inc.

Dear Mr. Johnson,

Enclosed please find test results for samples submitted to our laboratory for analysis. Preparation and analysis of these samples were conducted in accordance with published industry standards and methods specified on the attached analytical report.

The content of this package consists of the following:

-Case Narrative & Definition of Data Qualifiers
-Analytical Test Results
-Applicable QC Summary
-Client Chain-of-Custody (CoC)
-NVL Receiving Record

The report is considered highly confidential and will not be released without your approval. Samples are archived for two weeks following analysis. Samples that are not retrieved by the client will be discarded after two weeks.

Thank you for using our laboratory services. If you need further assistance, please contact us at 206-547-0100 or 1-888-NVLLABS.

Sincerely,

Nick Ly, Technical Director

Enclosure: Sample Results

Case Narrative:

The following summarizes samples received on date as shown on the accompanied Chain of custody by NVL Laboratories, Inc. from Landau Associates for Project number: 001034.010.016. Samples were logged in for PCB analysis per client request using both customer sample ID's and laboratory assigned ID's as listed on the Chain-of-Custody (CoC). All samples as received were processed and analyzed within specified turnaround time without any abnormalities and deviations that may affect the analytical results. All quality control requirements were acceptable unless stated otherwise. The conditions of all samples were acceptable at time of receipt and all samples submitted with this batch were analyzed unless stated otherwise on the CoC.

Test Results are reported based on dry weight in milligram per kilograms (mg/kg) for PCB samples as shown on the analytical reports.

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Definition Appendix

Terms

% Rec	Percent recovery.
<	Below Reporting Limit(RL) or Limit of Quantitation(LoQ) of the instrument.
B	Blank contamination. The recorded results is associated with a contaminated blank.
DF	Dilution Factor
J	The reported concentration is an estimated value because something may be present in the sample that interfered with the analysis.
J1	The reported concentration is an estimated value because the laboratory control sample (LCS) is out of control limits.
J2	The reported concentration is an estimated value because the percent recovery for matrix spike is out of control limits.
J3	The reported concentration is an estimated value because the relative percent difference(RPD) for duplicate analysis is out of control limits.
J4	Percent recovery is outside of established control limits.
LCS	Laboratory Control Sample.
LFS	Laboratory Fortified Spike
Limits	The upper and lower control limits for spike recoveries.
LN	Quality control sample is outside of control limits. This analyte was not detected in the sample.
LOQ	Limit of quantitation(same as RL)
mg/kg	Milligrams per kilogram.
ND	Analyte not detected or below the reporting limit of the instrument or methodology

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Definition Appendix

Terms

PPM	Parts per Million.
QC Batch Group	Quality Control Batch Group. The entity that links analytical results and supporting quality control results.
R	The data are not reliable due to possible contamination or loss of material during preparation or analysis. Re-sampling and reanalysis are necessary for verification.
RL	Reporting Limit. The minimum concentration that can be quantified under routine operating conditions.
RPD	Relative Percent Difference. The relative difference between duplicate results(matrix spike, blank spike, or samples duplicate) expressed as a percentage.
RPD Limit	The maximum RPD allowed for a set of duplicate measurements(see RPD).
SMI	Surrogate has matrix interference.
Spike Conc.	The measured concentration, in sample basis units, of a spiked sample.
SURR-ND	Surrogate was not detected due to matrix interference or dilution.
ug/m3	Micrograms per cubic meter.
ug/mL	Micrograms per milliliter
mg/Kg	milligram per kilogram

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ANALYSIS REPORT

Polychlorinated Biphenyls by Gas Chromatography

Client	**Landau Associates**	Samples Received*	**2**
SDG Number	**1704262.00**	Analyzed By	**Evelyn Ahulu**
Date Reported	**03/15/2017**	Samples Analyzed*	**2**
Project Number	**001034.010.016**	Analysis Method	**8082A**
Location	**Blaine Marina, Inc.**	Preparation Method	**3546PR (PCB)**

* for this test only

Sample Number	**BMI-PCB-1**	Received	03/08/2017
Lab Sample ID	17021856	Matrix	Material
Initial Sample Size	1.693 gm	Units of Result	mg/Kg, as received

Analyte	RL	Final Result	Analysis Date
Aroclor-1016	1.2	< 1.2	03/09/2017
Aroclor-1221	1.2	< 1.2	03/09/2017
Aroclor-1232	1.2	< 1.2	03/09/2017
Aroclor-1242	1.2	< 1.2	03/09/2017
Aroclor-1248	1.2	< 1.2	03/09/2017
Aroclor-1254	1.2	< 1.2	03/09/2017
Aroclor-1260	1.2	< 1.2	03/09/2017
PCBs, Total	**1.2**	**<1.2**	

Comments: Paint composite

Sample Number	**BMI-PCB-2**	Received	03/08/2017
Lab Sample ID	17021857	Matrix	Material
Initial Sample Size	0.3823 gm	Units of Result	mg/Kg, as received

Analyte	RL	Final Result	Analysis Date
Aroclor-1016	5.2	< 5.2	03/09/2017
Aroclor-1221	5.2	< 5.2	03/09/2017
Aroclor-1232	5.2	< 5.2	03/09/2017
Aroclor-1242	5.2	< 5.2	03/09/2017
Aroclor-1248	5.2	< 5.2	03/09/2017
Aroclor-1254	5.2	< 5.2	03/09/2017
Aroclor-1260	5.2	< 5.2	03/09/2017
PCBs, Total	**5.2**	**<5.2**	

Comments: Caulk composite; Reporting limit raised due to small sample size.

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Quality Control Results

Project Number:	**001034.010.016**	**SDG Number:**	**1704262**
		Project Manager:	**Cody Johnson**
QC Batch(es):	**Q562**	Analysis Method:	**8082A**
QC Batch Method:	3546PR (PCB)	Analysis Description:	Polychlorinated Biphenyls by Gas Chromatography
Preparation Date:	03/09/2017		

Blank: MBLK-1704262

Analyte	Blank Result	Units	DF	RL	Control Limit	Qualifiers
Aroclor-1016	ND	mg/Kg	1	1.0	1	
Aroclor-1221	ND	mg/Kg	1	1.0	1	
Aroclor-1232	ND	mg/Kg	1	1.0	1	
Aroclor-1242	ND	mg/Kg	1	1.0	1	
Aroclor-1248	ND	mg/Kg	1	1.0	1	
Aroclor-1254	ND	mg/Kg	1	1.0	1	
Aroclor-1260	ND	mg/Kg	1	1.0	1	
PCBs, Total	ND	mg/Kg	1	1.0	1	
Surrogates:				% Rec		
Tetrachloro-m-xylene			1	66	40-140	
Decachlorobiphenyl			1	85	40-140	

Lab Control Sample: LCS-1254-1704262

Analyte	Blank Spike Result	Units	DF	Spike Conc.	% Rec	% Rec Limits	Qualifiers
Aroclor-1254	18.6	mg/Kg	1	20.0	93	40-140	
Surrogates:							
Tetrachloro-m-xylene			1		64	40-140	
Decachlorobiphenyl			1		84	40-140	

Lab Control Sample: LCS-1016+1260-1704262
Lab Control Sample Duplicate: LCS Dup-1704262

Analyte	Blank Spike Result	Units	DF	Spike Conc.	% Rec	Limits	RPD	RPD Limit	Qualifiers
Aroclor-1016	15.6	mg/Kg	1	20.0	78	40-140			
	13.7			20.0	69	40-140	13	50	
Aroclor-1260	20.1	mg/Kg	1	20.0	100	40-140			
	17.1			20.0	85	40-140	16	50	
Surrogates:									
Tetrachloro-m-xylene			1		68	40-140			
					71	40-140			
Decachlorobiphenyl			1		92	40-140			
					86	40-140			

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Surrogate Recovery Summary Report

Client Landau Associates **SDG Number** 1704262

Project 001034.010.016

Customer Sample ID	Lab Sample ID	Analyte	Recovery	Limits
BMI-PCB-1	17021856	Decachlorobiphenyl	96%	40-140
BMI-PCB-1	17021856	Tetrachloro-m-xylene	90%	40-140
BMI-PCB-2	17021857	Decachlorobiphenyl	100%	40-140
BMI-PCB-2	17021857	Tetrachloro-m-xylene	89%	40-140
LCS Dup-1704262	LCS Dup-1704262	Decachlorobiphenyl	86%	40-140
LCS Dup-1704262	LCS Dup-1704262	Tetrachloro-m-xylene	71%	40-140
LCS-1016+1260-1704262	LCS-1016+1260-1704262	Decachlorobiphenyl	92%	40-140
LCS-1016+1260-1704262	LCS-1016+1260-1704262	Tetrachloro-m-xylene	68%	40-140
LCS-1254-1704262	LCS-1254-1704262	Decachlorobiphenyl	84%	40-140
LCS-1254-1704262	LCS-1254-1704262	Tetrachloro-m-xylene	64%	40-140
MBLK-1704262	MBLK-1704262	Decachlorobiphenyl	85%	40-140
MBLK-1704262	MBLK-1704262	Tetrachloro-m-xylene	66%	40-140

* Recovery outside limits

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INITIAL AND CONTINUING CALIBRATION VERIFICATION

SDG No: **1704262** Contract:

Determination: **8082 PCB Aroclors <Material>**

Run	Sample	Source	Analyzed	Analyte	True	Found	Unit	% Rec	Limits
R000555	CCV1 1016-1260	PCB_2016-1-2	03/09/2017	Aroclor-1016	5	5	ug/mL	100	80-120
		PCB_2016-1-2	03/09/2017	Aroclor-1260	5	5	ug/mL	100	80-120
	CCV1 1254	PCB_2016-1-3	03/09/2017	Aroclor-1254	5	5	ug/mL	100	80-120
	ICV 1016-1254-1260	PCB_2016-1-4	03/09/2017	Aroclor-1016	5	4.442	ug/mL	89	85-115
		PCB_2016-1-4	03/09/2017	Aroclor-1254	5	5.564	ug/mL	111	85-115
		PCB_2016-1-4	03/09/2017	Aroclor-1260	5	5.223	ug/mL	104	85-115
	CCV2 1016-1260	PCB_2016-1-2	03/09/2017	Aroclor-1016	5	5.215	ug/mL	104	80-120
		PCB_2016-1-2	03/09/2017	Aroclor-1260	5	5.392	ug/mL	108	80-120
	CCV2 1254	PCB_2016-1-3	03/09/2017	Aroclor-1254	5	5.127	ug/mL	103	80-120

% Rec = Percent recovery

* = Percent recovery not within control limits

ORGANICS LABORATORY SERVICES

NVL LABS

Company	Landau Associates	**NVL Batch Number**	**1704262.00**
Address	130 2nd Avenue South Edmonds, WA 98020	**TAT**	5 Days **AH** No
		Rush TAT	
Project Manager	Mr. Cody Johnson	**Due Date**	3/15/2017 **Time** 4:50 PM
Phone	(425) 778-0907	**Email**	cjohnson@landauinc.com
Cell	(206) 877-2173	**Fax**	(425) 778-6409

Project Name/Number: 001034.010.016 **Project Location:** Blaine Marina Inc.

Subcategory Quantitative analysis

Item Code ORG-05 **Method** 8082 PCB Aroclors <Bulk>

Total Number of Samples 2 Rush Samples

	Lab ID	Sample ID	Description	A/R
1	17021856	BMI-PCB-1		A
2	17021857	BMI-PCB-2		A

	Print Name	Signature	Company	Date	Time
Sampled by	Client				
Relinquished by	Client				

Office Use Only	Print Name	Signature	Company	Date	Time
Received by	Jacob Laugeson		NVL	3/8/17	1650
Analyzed by	Evelyn Ahnlu		NVL	3/9/17	16:00
Results Called by					
☐ **Faxed** ☐ **Emailed**					

Special Instructions:

Entered By: Mohammed Jamal Date: 3/9/2017 Time: 9:17 AM 1 of 1

1704262

NVL LABS
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PCB'S
CHAIN OF CUSTODY

Turn Arou...
- ☐ 24 Hours
- ☐ 2 Days
- ☐ 3 Days
- ☐ 4 Days
- ☑ 5 Days
- ☐ 10 Days

Please call for TAT less than 24 Hours

Company: Landau Associates, Inc.
Address: 130 2nd Ave. S.
Edmonds, WA
Phone: ( ) -

Project Manager: Cody Johnson
Cell: (206) 877 - 2173
Email: cjohnson@landauinc.com
Fax: ( ) -

Project Name/Number: 001034.010.016
Project Location: Blaine Marina, Inc.

- ☐ PCB's in Air
- ☐ PCB's in Wipe
- ☑ PCB in Bulk
- ☐ PCB in Liquid

Reporting Instructions
- ☐ Call ( ) -
- ☐ Fax ( ) -
- ☑ Email cjohnson@landauinc.com

Total Number of Samples 2

	Sample ID	Description	A/R
1	BMI-PCB-1	Paint composite	
2	BMI-PCB-2	Caulk composite	
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			

	Print Name	Signature	Company	Date	Time
Sampled by					
Relinquish by	Cody Johnson		LAI	3/8/2017	1650

Office Use Only

	Print Name	Signature	Company	Date	Time
Received by	Jacob L		NVL	3.8.17	1650
Analyzed by	Evelyn Ahnln		NVL	3/9/17	16:00
Called by					
Faxed/Email by					

NVL LABS
INDUSTRIAL HYGIENE SERVICES
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PCB'S
CHAIN OF CUSTODY

Turn Around Time
- ☐ 24 Hours
- ☑ 2 Days
- ☐ 3 Days
- ☐ 4 Days
- ☑ 5 Days
- ☐ 10 Days

Please call for TAT less than 24 Hours

Company: Landau Associates
Address: 130 2nd Ave. S
Edmonds, WA
Phone:

Project Manager: Cody Johnson
Cell: (206) 877 - 2173
Email: cjohnson@landauin.com
Fax: ( ) -

Project Name/Number: 001034.010.016
Project Location: Blaine Marina Inc.

- ☐ PCB's in Air
- ☐ PCB's in Wipe
- ☐ PCB in Bulk
- ☑ PCB in Liquid

Reporting Instructions
☐ Call ( ) - ☐ Fax ( ) - ☑ Email cjohnson@landauin.com

Total Number of Samples 39

	Sample ID	Description	A/R
1	BMI-ACT1-1		
2	BMI-ACT2-1		
3	BMI-AD1-1		
4	BMI-CB1-1		
5	BMI-WP1-1		
6	BMI-WG1-1		
7	BMI-WG2-1		
8	BMI-LC1-1		
9	BMI-P1-1		
10	BMI-P2-1		
11	BMI-GA1-1		
12	BMI-GA2-1		
13	BMI-GA3-1		
14	BMI-RM1-1		
15	BMI-RM2-1		

	Print Name	Signature	Company	Date	Time
Sampled by					
Relinquish by					

Office Use Only

	Print Name	Signature	Company	Date	Time
Received by					
Analyzed by					
Called by					
Faxed/Email by					

March 15, 2017

Cody Johnson
Landau Associates
130 2nd Avenue South
Edmonds, WA 98020

NVL LABS
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RE: Metals Analysis; NVL Batch # 1704252.00

Dear Mr. Johnson,

Enclosed please find the test results for samples submitted to our laboratory for analysis. Preparation of these samples was conducted following protocol outlined in EPA Method SW 846 -3051 unless stated otherwise. Analysis of these samples was performed using analytical instruments in accordance with U.S. EPA, NIOSH, OSHA and other ASTM methods.

For matrix materials submitted as paint, dust wipe, soil or TCLP samples, analysis for the presence of total metals is conducted using published U.S. EPA Methods. Paint and soil results are usually expressed in mg/Kg which is equivalent to parts per million (ppm). Lead (Pb) in paint is usually expressed in mg/Kg (ppm) , Percent (%) or mg/cm^2 by area. Dust wipe sample results are usually expressed in ug/wipe and ug/ft^2. TCLP samples are reported in mg/L (ppm). For air filter samples, analyses are conducted using NIOSH and OSHA Methods. Results are expressed in ug/filter and ug/m^3. Other matrix materials are analyzed accordingly using published methods or specified by client. The reported test results pertain only to items tested and are not blank corrected.

For recent regulation updates pertaining to current regulatory levels or permissible exposure levels, please call your local regulatory agencies for more details.

This report is considered highly confidential and will not be released without your approval. Samples are archived for two weeks following analysis. Samples that are not retrieved by the client are discarded after two weeks.

Thank you for using our laboratory services. if you need further assistance please feel free to call us at 206-547-0100 or 1-888-NVLLABS.

Sincerely,

Nick Ly, Technical Director

ilac-MRA

AIHA LAP, LLC
ACCREDITED LABORATORY
INDUSTRIAL HYGIENE & ENVIRONMENTAL LEAD
ISO/IEC 17025:2005
WWW.AIHAACCREDITEDLABS.ORG
LAB # 101861

NVL Laboratories, Inc.
4708 Aurora Ave N, Seattle, WA 98103
p 206.547.0100 | f 206.634.1936 | www.nvllabs.com

Analysis Report

Toxicity Characteristic Leaching Procedure - Lead (Pb)

Client: Landau Associates
Address: 130 2nd Avenue South
Edmonds, WA 98020

Attention: Mr. Cody Johnson
Project Location: Blaine Marina

Batch #: 1704252.00
Matrix: Bulk
Method: EPA 1311/7000B
Client Project #: 001034.010.016
Date Received: 3/8/2017
Samples Received: 1
Samples Analyzed: 1

Lab ID	Client Sample #	RL mg/ L	Results in mg/L	Results in ppm
17021823	BMI-TCLP-1	0.5	< 0.5	< 0.5

Sampled by: Client
Analyzed by: Yasuyuki Hida
Reviewed by: Nick Ly
Date Analyzed: 03/15/2017
Date Issued: 03/15/2017

Nick Ly, Technical Director

mg/ L =Milligrams per liter
ppm = parts per million
RL = Reporting Limit
'<' = Below the reporting Limit

Note : Method QC results are acceptable unless stated otherwise.
Unless otherwise indicated, the condition of all samples was acceptable at time of receipt.

NVL Laboratories, Inc.
4708 Aurora Ave N, Seattle, WA 98103
p 206.547.0100 | f 206.634.1936 | www.nvllabs.com

LEAD LABORATORY SERVICES

Company Landau Associates
Address 130 2nd Avenue South
Edmonds, WA 98020
Project Manager Mr. Cody Johnson
Phone (425) 778-0907
Cell (206) 877-2173

NVL Batch Number **1704252.00**
TAT 5 Days **AH** No
Rush TAT
Due Date 3/15/2017 **Time** 4:50 PM
Email cjohnson@landauinc.com
Fax (425) 778-6409

Project Name/Number: 001034.010.016 **Project Location:** Blaine Marina

Subcategory Flame AA (FAA)
Item Code TCLP-1 EPA 1311/7000B Lead by FAA <TCLP>

Total Number of Samples 1 Rush Samples

	Lab ID	Sample ID	Description	A/R
1	17021823	BMI-TCLP-1		A

	Print Name	Signature	Company	Date	Time
Sampled by	Client				
Relinquished by	Client				

Office Use Only	Print Name	Signature	Company	Date	Time
Received by	Jacob Laugeson		NVL	3/8/17	1650
Analyzed by	Yasuyuki Hida		NVL	3/15/17	
Results Called by					
☐ **Faxed** ☐ **Emailed**					

Special Instructions:

Date: 3/9/2017
Time: 8:06 AM
Entered By: Mohammed Jamal

1704252

NVL LABS
INDUSTRIAL HYGIENE SERVICES
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METALS CHAIN OF CUSTODY

Turn Around Time
- ☐ 2 Hour ☐ 4 Hours ☐ 24 Hours
- ☐ 2 Days ☐ 3 Days ☐ 4 Days
- ☑ 5 Days ☐ 6-10 Days
- Please call for TAT less than 24 Hours

Company: Landau Associates, Inc.
Address: 130 2nd Ave. S.
Edmonds, WA 98020
Phone:

Project Manager: Cody Johnson
Cell: (206) 877 - 2173
Email: cjohnson@landauinc.com
Fax: ( ) -

Project Name/Number: 001034.010.016
Project Location: Blaine Marina

- ☐ Total Metals
- ☑ TCLP
- ☑ FAA (ppm
- ☐ ICP (PPM
- ☐ GFAA (ppb)
- ☐ CVAA (ppb)
- ☐ Air Filter
- ☐ Paint Chips (%)
- ☐ Soil
- ☐ Paint Chips (cm)
- ☐ Dust Wipes
- ☐ Drinking Water
- ☐ Waste Water
- ☑ Other
- RCRA 8: ☐ Barium ☐ Chromium ☐ Silver ☐ Arsenic ☐ Mercury ☑ Lead ☐ Selenium ☐ Cadmium
- RCRA 11: ☐ Copper ☐ Zinc ☐ Other

Reporting Instructions
☐ Call ( ) - ☐ Fax ( ) - ☐ Email cjohnson@landauinc.com

Total Number of Samples _____

	Sample ID	Description	A/R
1	BMI-TCLP-1		
2			
3			
4			
5			
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8			
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11			
12			
13			
14			
15			

	Print Name	Signature	Company	Date	Time
Sampled by					
Relinquish by	Cody Johnson		LAI	3/8/2017	1602

Office Use Only

	Print Name	Signature	Company	Date	Time
Received by	Jacob L		NVL	3.8.17	1650
Analyzed by					
Called by					
Faxed/Email by					

NVL LABS
INDUSTRIAL HYGIENE SERVICES
Laboratory | Management | Training

METALS CHAIN OF CUSTODY

Turn Around Time
- ❑ 2 Hour ❑ 4 Hours ❑ 24 Hours
- ❑ 2 Days ☑ 3 Days ☑ 4 Days
- ❑ 5 Days ❑ 6-10 Days
- Please call for TAT less than 24 Hours

Company: Landau Associates
Address: 130 2nd Ave. S
Edmonds, WA
Phone:

Project Manager: Cody Johnson
Cell: (206) 877 - 2173
Email: cjohnson@landauin.com
Fax: ( ) -

Project Name/Number: 001034.010.016
Project Location: Blaine Marina Inc.

- ❑ Total Metals
- ☑ TCLP
- ❑ FAA (ppm
- ❑ ICP (PPM
- ❑ GFAA (ppb)
- ❑ CVAA (ppb)
- ❑ Air Filter
- ❑ Paint Chips (cm)
- ❑ Drinking Water
- ☑ Paint Chips (%)
- ❑ Dust Wipes
- ❑ Waste Water
- ❑ Soil
- ❑ Other

RCRA 8
- ❑ Barium
- ❑ Arsenic
- ❑ Selenium
- ❑ Chromium
- ❑ Mercury
- ❑ Cadmium
- ❑ Silver
- ☑ Lead

RCRA 11
- ❑ Copper
- ❑ Zinc
- ❑ Other

Reporting Instructions
❑ Call ( ) - ❑ Fax ( ) - ☑ Email cjohnson@landauin.com

Total Number of Samples 39

	Sample ID	Description	A/R
1	BMI-ACT1-1		
2	BMI-ACT2-1		
3	BMI-AD1-1		
4	BMI-CB1-1		
5	BMI-WP1-1		
6	BMI-WG1-1		
7	BMI-WG2-1		
8	BMI-LC1-1		
9	BMI-P1-1		
10	BMI-P2-1		
11	BMI-GA1-1		
12	BMI-GA2-1		
13	BMI-GA3-1		
14	BMI-RM1-1		
15	BMI-RM2-1		

	Print Name	Signature	Company	Date	Time
Sampled by					
Relinquish by					

Office Use Only

	Print Name	Signature	Company	Date	Time
Received by					
Analyzed by					
Called by					
Faxed/Email by					

APPENDIX C

Geotechnical Conditions and Sheetpile Design Reports

Geotechnical Engineering Services
Blaine Marina Fuel Pier
Bulkhead Replacement
Bellingham, Washington

April 6, 2012

Prepared for

Port of Bellingham
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FIGURES

APPENDICES

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INTRODUCTION

This report summarizes the results of geotechnical engineering services conducted for the Port of Bellingham's (Port) proposed Blaine Marina Fuel Pier Bulkhead Replacement project in Blaine, Washington. The general project location is shown on the Vicinity Map (Figure 1). The general configuration of the project site and some of the existing site features are shown on the Site and Exploration Plan (Figure 2).

This report has been prepared based on our discussions with representatives of the Port, Reid Middleton, Inc. (Reid Middleton), and Wilson Engineering, LLC (Wilson Engineering); a recent base map of the project area prepared by Wilson Engineering; data collected during our geotechnical field exploration and laboratory testing programs; our review of subsurface information previously collected for other environmental and geotechnical projects in the area; and our experience on similar projects.

PROJECT BACKGROUND

The Blaine Marina fuel pier bulkhead is located along the western side of Sigurdson Avenue, as shown on Figure 2. The existing bulkhead retains approximately 7 to 9 feet (ft) of soil adjacent to a pile-supported fuel office building and fuel pier, located immediately to the west. Segments of the existing timber pile and lagging bulkhead display obvious signs of deflection, shearing, and other indications of advanced structural distress. Several sinkholes and areas of collapsing pavement are present behind much of the failing bulkhead segment that abuts the fuel pier. To the south and north of the fuel pier, riprap slope armor is present in front of the bulkhead, and the bulkhead does not appear to be distressed in these areas. The Port intends to construct an approximately 66-ft-long replacement bulkhead behind the failing bulkhead using cantilevered steel sheetpiles.

The fuel pier is used for vessel refueling operations and includes diesel and gasoline supply lines originating from three aboveground storage tanks (ASTs) located about 120 ft east of the failing bulkhead. Petroleum hydrocarbon contamination is known to have impacted shallow soils and groundwater around the ASTs, as discussed in the draft Interim Action Plan (Landau Associates 2012).

SCOPE OF SERVICES

The purpose of our geotechnical engineering services was to provide Reid Middleton and the Port with information related to subsurface conditions along the replacement bulkhead alignment and to provide geotechnical engineering parameters and recommendations to support design of the proposed replacement bulkhead.

Our geotechnical engineering scope of services was provided in general accordance with the terms of a Professional Services Agreement between the Port and Landau Associates, dated October 13, 2011. Our geotechnical engineering scope of services included the following specific tasks:

- Collecting and reviewing readily available geotechnical and geologic data for the project area
- Coordinating the location of underground utilities prior to performing field activities
- Advancing three exploratory borings near the existing failing timber bulkhead
- Logging each soil unit observed in the exploratory borings and recording pertinent information, including soil sample depths, stratigraphy, soil characteristics, and depth to groundwater
- Conducting a limited laboratory testing program
- Performing certain engineering analyses and developing geotechnical engineering conclusions and recommendations to support design of the replacement bulkhead
- Preparing and submitting this written geotechnical engineering report summarizing our findings and geotechnical engineering conclusions and recommendations. This report includes:
  - A site plan showing the locations of subsurface explorations completed for this and certain previous studies in the project area
  - Descriptive logs of our borings and the results of geotechnical and analytical laboratory testing that was conducted on selected samples obtained from our explorations
  - A summary of subsurface soil and groundwater conditions anticipated along the planned alignment of the replacement bulkhead
  - Recommendations for active earth pressures (including surcharge and seismic earth pressures) acting behind the wall and passive earth pressures acting in front of the wall
  - Recommendations for bulkhead embedment depth that may be needed to satisfy global stability of the new wall constructed in the unconsolidated fill and marine deposits that are present in the project area
  - A discussion of constructability issues, including sheetpile driving and penetration
  - Recommended geotechnical monitoring and testing during construction.

SITE CONDITIONS

This section discusses the general geologic setting of the project area and describes the surface and subsurface conditions observed in the vicinity of the project site at the time of our field investigation. Interpretations of the site conditions are based on the results of our review of available information, and the results of our site reconnaissance, subsurface exploration, and laboratory testing programs.

GENERAL GEOLOGIC CONDITIONS

General geologic information for the project area was obtained from the *Geologic Map of the Bellingham 1:100,00 Quadrangle, Washington* (Lapen 2000), published by the Washington Division of

Geology and Earth Resources. According to Lapen, fill that overlies glaciomarine drift is present in the project area. Glaciomarine drift can have various distributions of gravel, sand, silt, and clay; however, finer sediments (silt and clay with fine sand) are most typical, with coarse sand and gravel occurring as "dropstones."

Glaciomarine drift in the project area is typically soft or loose, although where exposed to drying or other consolidation after deposition, it can form a hardened crust several feet in thickness. We did not observe this crust in our explorations. The soils encountered in our subsurface explorations generally conform to the mapped geology, although an interval of silty sand encountered during drilling (described below) may be of glaciomarine origin, or it may be unmapped marine deposits that overlie the glaciomarine drift. For the purposes of this report, this interval of silty sand is referred to as marine deposits.

SURFACE CONDITIONS

The general configuration of the existing timber bulkhead, fuel office building, and fuel pier is shown on Figure 2. The ground surface behind the existing fuel pier bulkhead contains sinkholes and collapsed pavement that extends horizontally about 3 to 4 ft behind (east of) the bulkhead. This condition reduces the usable width of Sigurdson Avenue and could compromise the integrity of numerous buried utilities located near the project area. We observed sinkholes about 2 ft deep with suspended electrical and communication conduits spanning these areas. We understand that "hard-piped" fuel lines have been recently replaced by flexible fuel hoses using the existing pipes as sleeves to facilitate installation. A concrete block and wire-rope barricade directs vehicular and pedestrian traffic around the area of collapsing pavement. Based upon a comparison of the extent of collapsed pavement between late last year and the time of our subsurface exploration program on January 5, 2012, it appears that the extent of the collapsed pavement behind the bulkhead has expanded to the south.

The impacted bulkhead consists of distorted timber lagging restrained by timber piles that support the eastward edge of the fuel pier and fuel office. Many of these piles show relatively large distortions and tilting, or are sheared. Beyond both ends of the failed portions of the timber bulkhead, which extend beyond the project area, fill consisting of riprap and boulders is in place on the water side of (i.e., west of) the bulkhead. Where protected by this fill, the bulkhead appears to be intact and does not show obvious signs of distress.

SUBSURFACE SOIL CONDITIONS

Subsurface conditions along the proposed replacement bulkhead alignment were explored by advancing and sampling three exploratory borings (identified as borings B-1-12, B-2-12, and B-3-12)

with a truck-mounted drill rig on January 5, 2012. The exploratory borings were advanced to depths ranging from about 16½ to 46½ ft below the existing ground surface (BGS). The approximate locations of our exploratory borings are shown on Figure 2. A discussion of our field exploration and laboratory testing program, along with edited logs of the exploratory borings and laboratory test results are provided in Appendix A.

Additional information regarding subsurface conditions near the project site was obtained from a review of summary logs of borings that were previously advanced near the project area. These borings, advanced in 1998, indicate that glaciomarine drift is present to a considerable depth beneath the project site (Otten 1998).

Based on the subsurface conditions observed in our exploratory borings, the alignment of the proposed replacement bulkhead appears to be underlain by about 12 to 15 ft of fill that generally consists of soft to loose, sandy, silty clay and lenses of silty sand. These materials are consistent with dredge fill, which was placed in the project area during marina dredging operations that took place in the late 1950s. While not observed in our borings, fill could also include coarser material, such as construction debris, gravel, or boulders, and the top of the native mudline could include logs or other debris not observed during our subsurface exploration program. Below the fill, loose silty fine sand and soft sandy silt (interpreted to be marine deposits) were present in each of our three borings; these soils were observed to a depth of about 25 ft BGS in B-2-12 (our other two borings were terminated in this soil unit). Below a depth of about 25 ft BGS, very soft to medium stiff silty clay and pockets of sandy clay (interpreted to be glaciomarine drift) were present to the maximum depth explored at the location of boring B-2-12 (about 46½ ft BGS). Dropstones consisting of coarse sand and gravel, and occasionally boulders, are often present in glaciomarine drift, although we did not observe dropstones in our subsurface explorations.

ENVIRONMENTAL CONDITIONS

Blaine Marina, Inc. has operated a small fuel tank farm at the project site since 1955. At least two releases of petroleum hydrocarbons have occurred at the site during that time. Several environmental investigations have been conducted at the site since 1990 to assess soil and groundwater quality for evidence of petroleum hydrocarbon releases from facility operations. These investigations discovered petroleum hydrocarbon contamination in soil and groundwater at the site, generally decreasing in concentration with increasing distance from the ASTs. Sheen has been observed in soil and groundwater over a large area in the vicinity of the ASTs. However, the extent of contamination is not well bounded by investigations conducted to date, and most of the data are 15 to 20 years old and may not be representative of current conditions. Additional investigations will be conducted as part of the Remedial

Investigation/Feasibility Study (RI/FS) process to better understand the nature and extent of contamination at the site.

During advancement of the three borings for our geotechnical investigation, soil samples were collected and field-screened for indications of obvious contamination. Field screening included visual inspection for evidence of staining or sheen on the surface of the soil, photoionization detector (PID) screening for the presence of volatile organic compounds (VOCs), and observations of unusual odors. The observed soil conditions and field-screening results are summarized on our summary boring logs, which are provided in Appendix A.

Landau Associates personnel detected petroleum hydrocarbon odors at each of the three boring locations, beginning at a depth of approximately 7½ ft BGS and persisting to depths ranging from about 14 to 17 ft BGS. Other observations, including the presence of an oil sheen and PID screening results, are presented on the boring logs in Appendix A. PID screening results greater than 400 parts per million (ppm) were observed at each boring location. Soil samples were collected for discretionary chemical analysis from the depths with the greatest indication of contamination based on the results of the field screening. Samples were collected from the sampler and placed directly into 4-oz glass, non-preserved sampling jars supplied by the analytical laboratory. Samples were labeled, placed on ice, and delivered directly to ALS Laboratories in Everett, Washington following standard chain-of-custody procedures. Because this was a geotechnical investigation and significant volatile contamination was not anticipated, sample collection procedures did not conform to U.S. Environmental Protection Agency (EPA) Method 5035 standards.

ALS Laboratories analyzed the discrete soil samples for gasoline-range total petroleum hydrocarbons (TPH-G) by Method NWTPH-Gx, for diesel- and oil-range total petroleum hydrocarbons (TPH-D and TPH-O, respectively) by Method NWTPH-Dx, and for the VOCs most commonly associated with petroleum hydrocarbon contamination—benzene, toluene, ethylbenzene, and xylenes (BTEX)—by EPA Method 8021. Investigation-derived waste (IDW) included soil cuttings from each of the borings and washwater used to decontaminate drilling equipment. IDW was stored at the project site in labeled 55-gallon drums pending disposal. Soil samples were collected from the drums containing soil, and a water sample was collected from a drum containing decontamination fluids for waste characterization to support disposal. A copy of the analytical laboratory report prepared by ALS Laboratories is provided in Appendix B. The report presents the analytical results for discrete soil samples B-1 S-3 7.5', B-2 S-3 7.5', and B-3 S-3, 7.5', and waste characterization samples Drum #2-a and Drill Wash Water.

The field-screening and analytical results for the discrete soil samples indicate that TPH-G is present in the soil adjacent to the bulkhead at concentrations significantly above the Model Toxics Control Act (MTCA) Method A cleanup levels, which are the preliminary screening levels for the site.

The preliminary screening levels for TPH-G are 100 milligrams per kilogram (mg/kg) if benzene is not present or 30 mg/kg if benzene is present. The contamination encountered in our subsurface explorations appeared to be confined to a zone between approximately 7½ ft BGS and 14 to 17 ft BGS. TPH-G was detected in soil samples from borings B-1-12, B-2-12, and B-3-12 at concentrations of 680 mg/kg, 6,100 mg/kg, and 1,800 mg/kg, respectively. Concentrations of TPH-D, TPH-O, and BTEX were below the preliminary screening levels. Benzene was not detected at concentrations above the laboratory reporting limits, although these limits were somewhat elevated and slightly above the preliminary screening levels. The results are considered adequate to suggest that TPH-G contamination is present near the bulkhead. BTEX constituents that are typically associated with TPH-G are present only at very low concentrations, supporting the conclusion that the contamination observed is not in the immediate vicinity of the source.

GROUNDWATER

At the time of our subsurface investigation in early January 2012, groundwater was observed in our borings beginning at depths of about 7 to 9½ ft BGS. These depths correspond to the sandier material observed near the bottom of the fill unit. Due to the low permeability of the clayey upper fill, the piezometric groundwater surface may be somewhat higher, although this could not be confirmed due to the relatively short duration between boring completion and decommissioning. The groundwater conditions reported on the exploratory boring logs are for the specific locations and dates indicated, and therefore may not necessarily be indicative of other locations and/or times. Furthermore, it is expected that groundwater conditions vary depending on local subsurface conditions, tidal fluctuations, the weather, and other factors.

CONCLUSIONS AND RECOMMENDATIONS

Based on the results of our field exploration, laboratory testing, and engineering analyses conducted for this project, it is our opinion that construction of the proposed cantilevered sheetpile replacement bulkhead is feasible from a geotechnical perspective, provided the recommendations contained herein are incorporated into project design and construction. Additional conclusions and specific recommendations regarding environmental considerations, seismic design considerations, bulkhead design, sheetpile installation, pile driving considerations, and wall backfill placement and compaction are presented in the following sections.

ENVIRONMENTAL CONSIDERATIONS

Based on the environmental conditions for the site as discussed above, construction activities are likely to be conducted above the zone of petroleum hydrocarbon contamination. Because installation of

the sheetpile wall is generally conducted from above the ground surface, and includes only limited excavation activities, construction activities will not likely encounter significant contamination. Planned excavation for the sheetpile bulkhead repair will likely be limited to about the upper 2 to 3 ft of soil, and the contamination in the vicinity of the planned bulkhead repair appears limited to below approximately 7½ ft BGS.

Based on the proximity to contamination, excavated material should be screened for contamination by typical field-screening techniques including visual, olfactory, and PID observation. Soil exhibiting indications of potential contamination should be segregated from soil that appears to be clean. Potentially contaminated soil should be sampled and analyzed as described in the draft Interim Action Plan (Landau Associates 2012). Excavated soil should remain on site pending the results of chemical analyses and waste profiling. Soil management procedures, including handling, storage, and best management practices to prevent migration of the soil away from the managed area, should be addressed in the design documents and implemented by the contractor during construction activities. All soil that exceeds MTCA cleanup levels should be disposed of off site at an appropriate disposal facility based on the disposal profile, and in accordance with Washington State regulations. Soil that does not exhibit any visual, olfactory, or field-screening indications of potential contamination, or does not exceed MTCA cleanup levels, may be reused on site as either backfill for the interim action or as general fill.

Anticipated potential chemical hazards include exposure to site contaminants through various exposure pathways (i.e., direct contact, inhalation, and ingestion). Because the interim action includes only limited excavation to depths not anticipated to contain hazardous substances at concentrations of concern, chemical exposure is unlikely to be an issue. Therefore, screening of work zone vapor conditions and soil quality should initially be conducted using visual and olfactory screening by an environmental professional. If indications of TPH contamination are observed, workspace air and excavated soil should be screened using a PID to determine if VOC concentrations are high enough to warrant the preparation and implementation of a contractor health and safety plan (HASP). If so determined, intrusive activities should be halted until the HASP is implemented.

SEISMIC DESIGN CONSIDERATIONS

The Pacific Northwest is seismically active and the project site could be subject to ground shaking from a moderate to major earthquake. Consequently, moderate levels of earthquake shaking should be anticipated during the design life of the project, and the proposed replacement bulkhead should be designed to resist earthquake loading using an appropriate design methodology. The recommended lateral earth pressures for design of the sheetpile wall that are presented in the next section of this report include an increment due to seismic earth pressures.

Liquefaction is a phenomenon where soil below the groundwater table temporarily experiences a reduction in strength during and following an earthquake. Soils most susceptible to liquefaction include primarily loose sands with low fines content. Although loose sand was encountered in the lower portion of the fill and in the uppermost native soils, it typically contains considerable silt. Due to the silt content, we expect that liquefaction behind the replacement bulkhead would be relatively moderate. Based upon the site history of the Blaine Marina, we expect that similar liquefiable soils are present wherever hydraulic fill has been placed and that widespread liquefaction would occur following a major earthquake. Following liquefaction, additional post-earthquake settlement would occur. Our scope of services did not include a quantitative analysis of the factor-of-safety for liquefaction or the magnitude of post-liquefaction settlement. Differential settlement caused by liquefaction could adversely impact underground utilities. Accordingly, we recommend that underground utilities that will penetrate the bulkhead be designed and constructed with an appropriate degree of flexibility to limit the potential for joint dislocation or failure.

BULKHEAD DESIGN

The replacement sheetpile bulkhead should be designed and constructed to resist active lateral earth pressures. The use of active lateral earth pressures assumes that sufficient deformation of the soil behind the wall could occur to develop an active condition. Theoretical and observed lateral deflections at the top of bulkheads designed for active pressures are typically on the order of 0.001 to 0.002 times the height of the wall. This lateral deformation is likely to be accompanied by minor vertical settlement.

In the case of a bulkhead acting as a cantilevered wall, the applied active lateral earth pressure can be represented by a triangular pressure distribution. Figure 3 presents design parameters for active lateral earth pressures for the proposed replacement bulkhead. The active lateral pressures would act over the full height of the wall. The assumed mudline elevation in front of the bulkhead [Elevation +6 ft mean lower low water (MLLW), as shown on Figure 3] assumes that the existing timber bulkhead completely deteriorates over time and the backfill between the existing and replacement bulkheads erodes over time so as to provide no soil support in front of the replacement bulkhead.

Our recommended design lateral earth pressures assume a groundwater level at Elevation +8 ft MLLW on the upland side of the replacement bulkhead and a level consistent with the assumed mudline on the water side of the bulkhead, or Elevation +6 ft MLLW. The design lateral pressures presented on Figure 3 include this unbalanced hydrostatic force on the proposed sheetpile wall.

Design earthquake loads on the bulkhead were based on an interpretation of the Mononobe-Okabe pseudo-static method of analysis, as summarized in the Washington State Department of Transportation (WSDOT) *Bridge Design Manual* (WSDOT 1998). The seismic coefficient used in the

analysis was 0.15, which is about one-half of the peak ground acceleration associated with an earthquake with a probability of exceedance of 7 percent in 75 years (1-in-975-year event) (USGS website 2012). It is assumed that the new sheetpile bulkhead will be able to yield sufficiently to approximate an active condition. The resulting seismic lateral pressure was approximated by an inverse trapezoidal pressure distribution acting over the wall, as shown on Figure 3.

It is common practice to accommodate traffic and typical construction equipment loading with a vertical surcharge pressure of 200 to 300 pounds per square foot. Larger surcharge loads, such as from heavy cranes or other concentrated loading, should be addressed by use of a higher surcharge pressure. For walls free to rotate during loading, a uniformly distributed lateral pressure of 0.36 times the surcharge pressure should be included as shown on Figure 3.

Passive earth pressure criteria for resistance of lateral loads are also presented on Figure 3. The passive pressures were reduced due to the presence of a downward-sloping mudline in front of the sheetpile wall. The passive earth pressures shown on Figure 3 are ultimate values and do not include a factor of safety; therefore, the calculated wall embedment depth should be multiplied by 1.4.

To maintain global stability of the sheetpile bulkhead (stability along a critical surface that extends through the soil below the tip of the sheetpile wall), we recommend a minimum sheetpile embedment depth of 10 ft below the assumed mudline at Elevation +6 ft MLLW, which corresponds to a minimum pile embedment at Elevation –4 ft MLLW. It is expected that internal stability to resist design lateral loads would control the required minimum embedment depth.

SHEETPILE INSTALLATION

We understand that the existing fuel office building will be removed prior to construction of the replacement bulkhead. Sheetpile bulkhead installation is planned within a few feet behind the existing timber bulkhead, which is supported by timber piles that are embedded an unknown depth. Because of the presence of generally soft and loose soils at the project site, it is expected that a vibratory hammer could be used to install the sheetpiles. This expectation is based upon the reported successful installation of 16-inch-diameter steel pipe piles using a vibratory hammer in similar soils around the wave barrier at the harbor entrance (PN&D 1999). However, it should be noted that some obstructions may exist at the project site that could complicate or prevent sheetpile installation, as discussed in the General Geologic Conditions section. It is also possible that some of the existing timber bulkhead piles were not installed plumb or have rotated following construction of the existing bulkhead. Where this has occurred, these piles could be encountered at depth during sheetpile installation.

In addition to utilities that cross the bulkhead, we observed what appear to be bearing plates on the outside face of some of the timber piles that support the timber bulkhead lagging. These plates may be the

termini of bulkhead anchor ties. We were not able to conclusively determine whether deadman or other anchors were used for bulkhead support; however, if present, they would conflict with sheetpile installation. If present, we expect that the anchor ties could be removed as sheetpile installation progresses. Only the tie closest to the active sheetpile installation area should be cut, and the ties should be left in place for as long as available space permits.

PILE DRIVING VIBRATION AND SETTLEMENT CONSIDERATIONS

Installation of sheetpiles using a vibratory hammer will produce ground vibration in the vicinity of the sheetpile installation. While unlikely, ground vibrations associated with installation of the sheetpiles could potentially cause some damage to nearby structures. Ground vibrations occurring in loose sand, such as is present in the lower fill and upper native soil at the project site, could also result in the densification of the loose soil and some settlement of the ground surface. Ground vibrations producing densification and settlement are dependent on a complex combination of factors, including energy and amplitude of the vibratory hammer, number of repetitions, soil properties, pile length, location of the water table, type of pile installation, and distance from the pile.

Settlement of the ground surface resulting from vibrations densifying loose sand has been documented in previous published (Dowding 1995) and unpublished case histories. The magnitude of settlement is typically greatest in the immediate vicinity of the pile and decreases with increasing distance from the pile.

Vibration resulting from pile installation has been found to be perceptible to occupants of nearby structures at levels much lower than those that result in building damage. Claims of damage due to vibration often arise when the vibration is quite noticeable, even if it is at levels that are unlikely to produce damage. For that reason, we recommend that a detailed visual reconnaissance of the existing structures and photographic documentation of any existing cracks or building distress be accomplished prior to installation of the replacement bulkhead. We also recommend that the condition of existing buried utilities, especially storm and sanitary sewers, be documented before and during construction. This can be accomplished with conventional vertical and horizontal surveying, television surveys, and other methods.

GEOTECHNICAL CONSULTATION AND CONSTRUCTION MONITORING

We recommend that Landau Associates review the earthwork and bulkhead design portions of the project drawings and specifications. The purpose of this review would be to verify that the recommendations presented in this report have been properly interpreted and incorporated.

The integrity of the replacement bulkhead can be dependent on confirmation of site and subsurface conditions at the time of construction and the use of appropriate installation procedures. Accordingly, we recommend construction monitoring services be provided during demolition, sheetpile installation, and site restoration activities. Landau Associates would be pleased to provide these services.

USE OF THIS REPORT

Landau Associates prepared this report for the exclusive use of the Port of Bellingham and Reid Middleton for specific application to the design of the proposed Blaine Marina Fuel Pier Bulkhead Replacement project. Use of this report by others or for another project is at the user's sole risk. Within the limitations of scope, schedule, and budget, Landau Associates' services have been conducted in accordance with generally accepted practices of the geotechnical engineering profession; no other warranty, express or implied, is made as to the professional advice included in this report.

The conclusions and recommendations contained in this report are based in part upon the subsurface data obtained from the explorations completed for this study. There may be some variation in subsurface soil and groundwater conditions at the site, and the nature and extent of the variations may not become evident until construction. Accordingly, a contingency for unanticipated conditions should be included in the construction budget and schedule.

If variations in subsurface conditions are encountered during construction, Landau Associates should be notified for review of the recommendations of this report, and revision of such if necessary. If there is a substantial lapse of time between submission of this report and the start of construction, or if conditions change due to construction operations at or adjacent to the project site, we recommend that we review this report to determine the applicability of the conclusions and recommendations contained herein.

We appreciate the opportunity to provide geotechnical services on this project and look forward to assisting you as needed during the construction phases of the project. If you have any questions or comments regarding the information contained in this report, or if we may be of further service, please contact us.

LANDAU ASSOCIATES, INC.

APRIL 6, 2012

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REFERENCES

Dowding, C.H. 1995. "Vibration-Induced Settlement from Blast Densification and Pile Driving." *Vertical and Horizontal Deformations of Foundations and Embankments*. Vol. 2, pp. 1672-1688.

Farallon. 2008. *Subsurface Investigation Report, Blaine Marina – Sigurdson Site, 214 Sigurdson Avenue & 205 Sigurdson Avenue, Blaine, Washington*. Farallon Consulting, L.L.C. Prepared for Port of Bellingham. February 25.

Landau Associates. 2012. Draft: *Interim Action Plan, Blaine Marina Inc. Site, Blaine, Washington*. Prepared for Port of Bellingham. February 14.

Lapen, T.J. 2000. *Geologic Map of the Bellingham 1:100,000 Quadrangle, Washington*. Open File Report 2000-5. Washington Division of Geology and Earth Resources, Washington State Department of Natural Resources.

Otten. 1998. *Geotechnical Report, Blaine Bulkhead Replacement, Blaine, Washington*. Otten Engineering. Prepared for Anvil Corporation. June 17.

PN&D. 1999. *Geotechnical Report, Blaine Wave Barrier, Blaine, Washington*. Peratrovich, Nottingham & Drage, Inc. Prepared for Port of Bellingham. September.

USGS website. 2012. *Geologic Hazards Science Center: 2002 Interactive Deaggregations*. https://geohazards.usgs.gov/deaggint/2002/. Accessed February 12.

WSDOT. 1998. *Bridge Design Manual*. Washington State Department of Transportation, Program Development Division, Bridge and Structures. September.

N

0 0.5 1

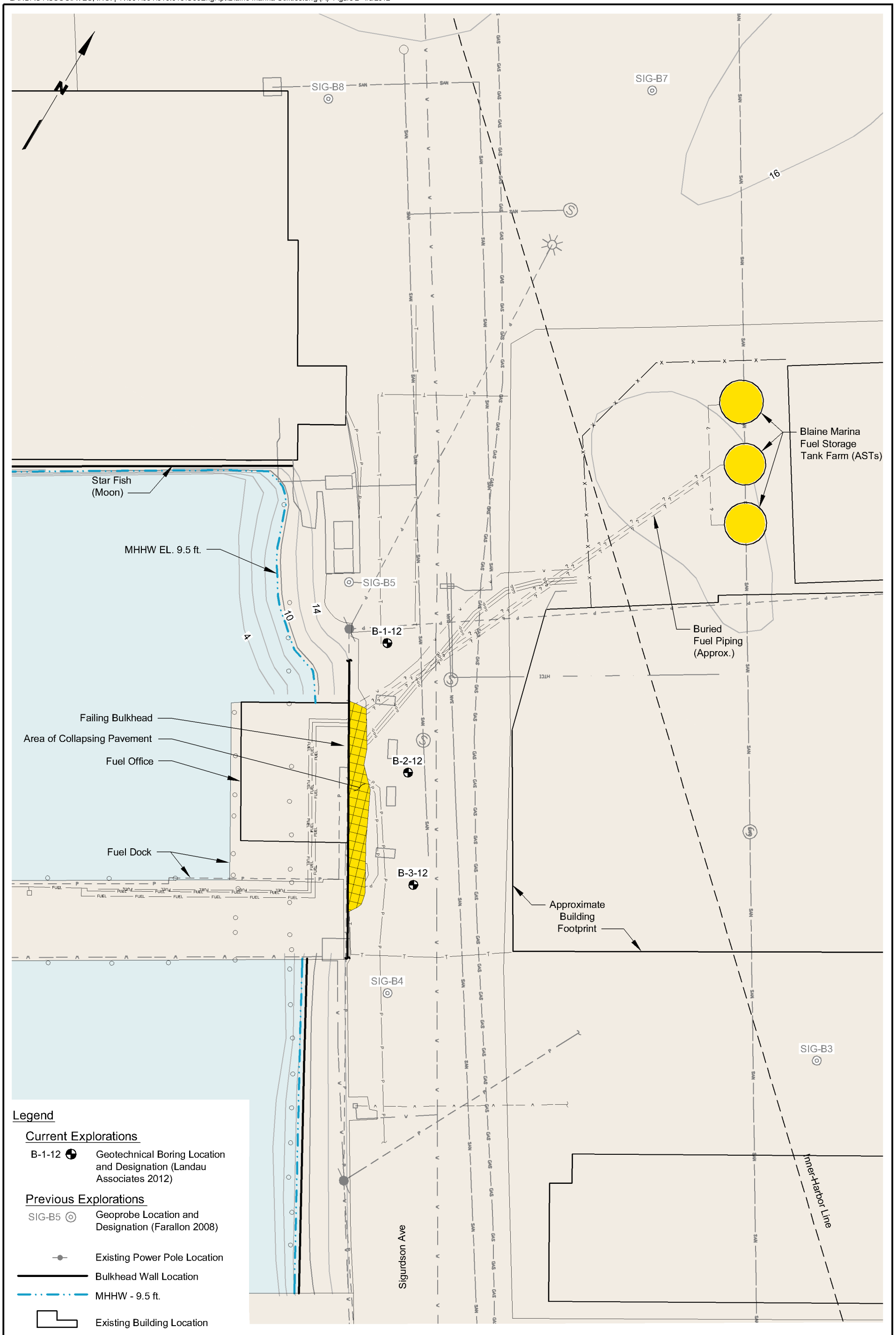
Miles

Data Source: ESRI 2008

Y:\Projects\0010034\010.015\GeoEngRpt\Mapdocs\Figure 1.mxd

LANDAU ASSOCIATES

Blaine Marina Fuel Pier Bulkhead Replacement Blaine, Washington	**Vicinity Map**	Figure 1



Source: Wilson Engineering 2011, Port of Bellingham 2011, Walker and Associates, Inc.

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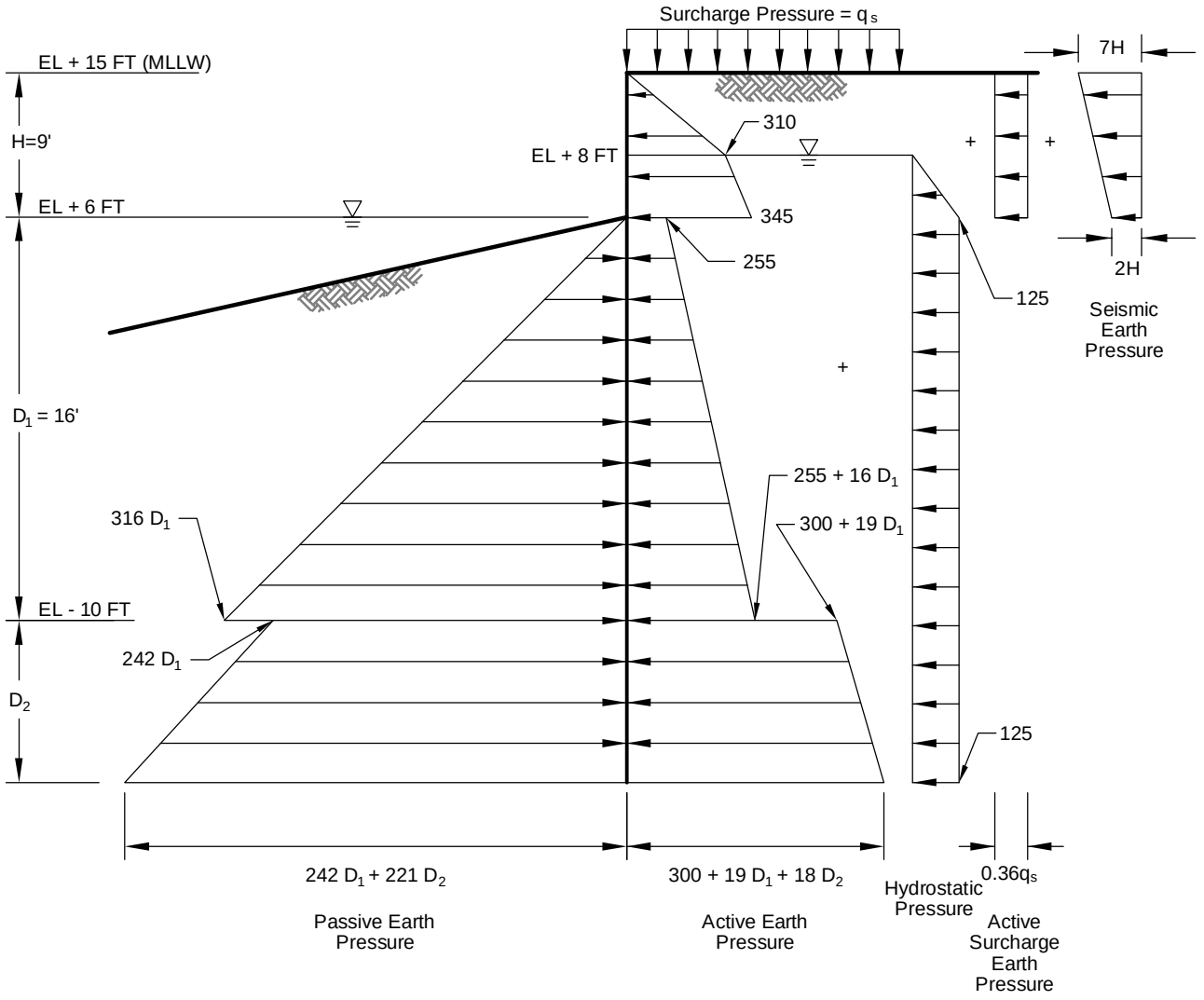
0 20 40
Scale in Feet

Blaine Marina Fuel Pier
Bulkhead Replacement
Blaine, Washington

Site and Exploration Plan

Figure
2



Not To Scale

Notes:

1. Active pressure diagram assumes cantilevered sheeting.
2. Cantilevered wall height, H, assumes deterioration and loss of existing timber bulkhead in front of replacement sheetpile bulkhead.
3. Solve for embedment depth, $D_1 + D_2$, by summation of moments about bottom of wall.
4. Passive pressure presented as an ultimate value; therefore embedment depth, $D_1 + D_2$, should be multiplied by 1.4.
5. Active and passive pressures are in terms of pounds per square foot with all dimensions in feet.
6. It is typical practice to accommodate traffic and construction equipment loading with a vertical surcharge pressure (q_s) of 200 to 300 PSF. Other larger surcharges should be addressed where appropriate by use of a larger surcharge pressure.
7. For sheetpile walls, the active and passive pressures can be assumed to act over the full width of the wall.

LANDAU ASSOCIATES

Blaine Marina Fuel Pier
Bulkhead Replacement
Blaine, Washington

Design Lateral Earth Pressures
Cantilevered Sheetpile Wall

Figure
3

APPENDIX A

Field Exploration and Laboratory Testing

APPENDIX A
FIELD EXPLORATIONS AND LABORATORY TESTING

Subsurface conditions at the project site were explored on January 5, 2012. The exploration program consisted of advancing and sampling three soil borings (B-1-12 through B-3-12) at the approximate locations shown on the Site and Exploration Plan (Figure 2 of this report). The exploratory borings were advanced to depths ranging from about 16½ to 46½ ft below the ground surface (BGS) using a truck-mounted drill rig and the hollow-stem auger drilling technique. Holocene Drilling, Inc. of Puyallup, Washington advanced the borings under subcontract to Landau Associates. The explorations were located approximately in the field by hand-taping distances from existing physical features and referenced to a site map prepared by Wilson Engineering, Inc. The ground surface elevations at the exploratory boring locations were interpreted from topographic information indicated on the above referenced site map.

The field exploration program was coordinated and monitored by a Landau Associates geotechnical engineer, who also obtained representative soil samples, maintained a detailed record of observed subsurface soil and groundwater conditions, and described the soil encountered by visual and textural examination. Each representative soil type observed in our exploratory borings was described using the soil classification system shown on Figure A-1, in general accordance with ASTM International (ASTM) standard D 2488, *Standard Recommended Practice for Description of Soils (Visual-Manual Procedure)*. Summary logs of the exploratory borings are presented on Figures A-2 through A-4. These logs represent Landau Associates' interpretation of subsurface conditions identified during the field exploration program. The stratigraphic contacts shown on the summary logs represent the approximate boundaries between soil types; actual transitions may be more gradual. The soil and groundwater conditions depicted on the summary logs are only for the specific date and locations reported, and therefore are not necessarily representative of other locations and times. A further discussion of the soil and groundwater conditions observed is in the text portion of this report.

Representative disturbed samples of the soils encountered in the exploratory borings were obtained at selected intervals using either a 1.5-inch inside-diameter (ID) Standard Penetration Test split-spoon sampler or a 2.42-inch ID split-barrel sampler. The sampler was driven up to 18 inches into the undisturbed soil ahead of the drill bit with a 140-lb automatic hammer falling a distance of approximately 30 inches. The number of blows required to drive the sampler for the final 12 inches of soil penetration, or part thereof, is noted on the boring logs, adjacent to the appropriate sample notation. Upon completion of drilling and sampling, the boreholes were decommissioned in general accordance with the requirements of Washington Administrative Code (WAC) 173-160.

Samples obtained from the exploratory borings were taken to our laboratory for further examination and testing. The laboratory testing program, which was performed in general accordance with the ASTM standard test procedures described below, was limited to visual inspection to confirm our field soil descriptions and determination of natural moisture content and grain size distribution. The natural moisture contents of selected soil samples obtained from our exploratory borings were determined in general accordance with ASTM D 2216 test procedures. The results from the moisture content determinations are indicated adjacent to the corresponding samples on the summary logs. The grain size distribution of selected soil samples obtained from our exploratory borings was determined in general accordance with ASTM D 422 test procedures. The test results are presented in the form of a grain size distribution curve on Figure A-5.

Soil Classification System

MAJOR DIVISIONS			GRAPHIC SYMBOL	USCS LETTER SYMBOL[1]	TYPICAL DESCRIPTIONS [2][3]
COARSE-GRAINED SOIL (More than 50% of material is larger than No. 200 sieve size)	GRAVEL AND GRAVELLY SOIL (More than 50% of coarse fraction retained on No. 4 sieve)	CLEAN GRAVEL (Little or no fines)		GW	Well-graded gravel; gravel/sand mixture(s); little or no fines
				GP	Poorly graded gravel; gravel/sand mixture(s); little or no fines
		GRAVEL WITH FINES (Appreciable amount of fines)		GM	Silty gravel; gravel/sand/silt mixture(s)
				GC	Clayey gravel; gravel/sand/clay mixture(s)
	SAND AND SANDY SOIL (More than 50% of coarse fraction passed through No. 4 sieve)	CLEAN SAND (Little or no fines)		SW	Well-graded sand; gravelly sand; little or no fines
				SP	Poorly graded sand; gravelly sand; little or no fines
		SAND WITH FINES (Appreciable amount of fines)		SM	Silty sand; sand/silt mixture(s)
				SC	Clayey sand; sand/clay mixture(s)
FINE-GRAINED SOIL (More than 50% of material is smaller than No. 200 sieve size)	SILT AND CLAY (Liquid limit less than 50)			ML	Inorganic silt and very fine sand; rock flour; silty or clayey fine sand or clayey silt with slight plasticity
				CL	Inorganic clay of low to medium plasticity; gravelly clay; sandy clay; silty clay; lean clay
				OL	Organic silt; organic, silty clay of low plasticity
	SILT AND CLAY (Liquid limit greater than 50)			MH	Inorganic silt; micaceous or diatomaceous fine sand
				CH	Inorganic clay of high plasticity; fat clay
				OH	Organic clay of medium to high plasticity; organic silt
	HIGHLY ORGANIC SOIL			PT	Peat; humus; swamp soil with high organic content

OTHER MATERIALS	GRAPHIC SYMBOL	LETTER SYMBOL	TYPICAL DESCRIPTIONS
PAVEMENT		AC or PC	Asphalt concrete pavement or Portland cement pavement
ROCK		RK	Rock (See Rock Classification)
WOOD		WD	Wood, lumber, wood chips
DEBRIS		DB	Construction debris, garbage

Notes:
1. USCS letter symbols correspond to symbols used by the Unified Soil Classification System and ASTM classification methods. Dual letter symbols (e.g., SP-SM for sand or gravel) indicate soil with an estimated 5-15% fines. Multiple letter symbols (e.g., ML/CL) indicate borderline or multiple soil classifications.
2. Soil descriptions are based on the general approach presented in the Standard Practice for Description and Identification of Soils (Visual-Manual Procedure), outlined in ASTM D 2488. Where laboratory index testing has been conducted, soil classifications are based on the Standard Test Method for Classification of Soils for Engineering Purposes, as outlined in ASTM D 2487.
3. Soil description terminology is based on visual estimates (in the absence of laboratory test data) of the percentages of each soil type and is defined as follows:

Primary Constituent:	> 50%	"GRAVEL," "SAND," "SILT," "CLAY," etc.
Secondary Constituents:	> 30% and ≤ 50%	"very gravelly," "very sandy," "very silty," etc.
	> 15% and ≤ 30%	"gravelly," "sandy," "silty," etc.
Additional Constituents:	> 5% and ≤ 15%	"with gravel," "with sand," "with silt," etc.
	≤ 5%	"with trace gravel," "with trace sand," "with trace silt," etc., or not noted.

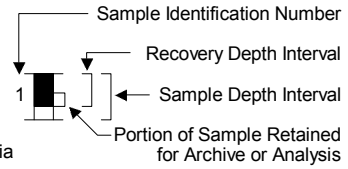
4. Soil density or consistency descriptions are based on judgement using a combination of sampler penetration blow counts, drilling or excavating conditions, field tests, and laboratory tests, as appropriate.

Drilling and Sampling Key

SAMPLER TYPE

Code	Description
a	3.25-inch O.D., 2.42-inch I.D. Split Spoon
b	2.00-inch O.D., 1.50-inch I.D. Split Spoon
c	Shelby Tube
d	Grab Sample
e	Single-Tube Core Barrel
f	Double-Tube Core Barrel
g	2.50-inch O.D., 2.00-inch I.D. WSDOT
h	3.00-inch O.D., 2.375-inch I.D. Mod. California
i	Other - See text if applicable
1	300-lb Hammer, 30-inch Drop
2	140-lb Hammer, 30-inch Drop
3	Pushed
4	Vibrocore (Rotosonic/Geoprobe)
5	Other - See text if applicable

SAMPLE NUMBER & INTERVAL



Field and Lab Test Data

Code	Description
PP = 1.0	Pocket Penetrometer, tsf
TV = 0.5	Torvane, tsf
PID = 100	Photoionization Detector VOC screening, ppm
W = 10	Moisture Content, %
D = 120	Dry Density, pcf
-200 = 60	Material smaller than No. 200 sieve, %
GS	Grain Size - See separate figure for data
AL	Atterberg Limits - See separate figure for data
GT	Other Geotechnical Testing
CA	Chemical Analysis

Groundwater

▽ Approximate water level at time of drilling (ATD)

▼ Approximate water level at time other than ATD

LANDAU ASSOCIATES

Blaine Marina Fuel Pier
Bulkhead Replacement
Blaine, Washington

Soil Classification System and Key

Figure A-1

B-1-12

LAI Project No: 001034.010

SAMPLE DATA | **SOIL PROFILE**

Drilling Method: Hollow-Stem Auger
Ground Elevation (ft): 15
Drilled By: Holocene Drilling Inc.
Logged By: CTM Date: 01/05/12

Moisture Content (%) — Plastic Limit — Liquid Limit — 10 20 30 40
▲ SPT N-Value ▲ △ Non-Standard N-Value △ — 10 20 30 40
× Fines Content (%) × — 10 20 30 40

Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)	Graphic Symbol	USCS Symbol	Soil Description	Groundwater
0	15						AC	Approximately 5-inches of asphalt concrete pavement	
							GW-GM	Brown, sandy GRAVEL with silt (medium dense, damp)	
		S-1	a2	5	0.4 W = 33		CL	**(FILL)**	
5	10	S-2	b2	0	0.0 W = 38			Gray, sandy CLAY with numerous jumbled pockets of clayey SAND (soft/loose to very soft/very loose, moist to damp) no odor	ATD
		S-3	b2	4	455		SP-SM	Gray, fine to medium SAND with silt and shell fragments, plus zones of sandy silt (loose, wet) strong gasoline and diesel odor	
10	5	S-4	b2	0	371		SM/ML	Gray, sandy SILT with zones of silty fine to medium SAND (very soft/very loose, wet) strong gasoline and diesel odor	
		S-5	b2	2	4.1			-- moderate to weak diesel and gas odor, sulfur odor also present	
15	0	S-6	b2	4	0 W = 36		SM	Gray, silty fine SAND with shells, occasional coarse wood fragments (very loose to loose, wet) weak sulfur odor **(MARINE DEPOSITS)**	
20	-5	S-7	b2	4	0				
25									
30									
35									

Boring Completed 01/05/12
Total Depth of Boring = 21.5 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

1034.01 4/5/12 N:\PROJECTS\001034.010.015.GPJ SOIL BORING LOG WITH GRAPH

LANDAU ASSOCIATES

Blaine Marina Fuel Pier
Bulkhead Replacement
Blaine, Washington

Log of Boring B-1-12

Figure
A-2

B-2-12

LAI Project No: 001034.010

SAMPLE DATA | **SOIL PROFILE**

Drilling Method: Hollow-Stem Auger
Ground Elevation (ft): 15
Drilled By: Holocene Drilling Inc.
Logged By: CTM Date: 01/05/12

Moisture Content (%) — Plastic Limit / Liquid Limit — 10 20 30 40
▲ SPT N-Value ▲ △ Non-Standard N-Value △ — 10 20 30 40
× Fines Content (%) × — 10 20 30 40

Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)	Graphic Symbol	USCS Symbol	Soil Description	Groundwater
0	15						AC	Approximately 5-inches of asphalt concrete pavement	
							GW-GM		
							CL	Brown, sandy GRAVEL with silt (medium dense, damp) **(FILL)**	
		S-1	b2	3	W = 34				
5	10	S-2	b2	0	2.5 W = 38			Gray, silty CLAY with pockets of silty sand, trace of gravel, occasional coarse wood fragments (very soft to soft, moist) no odor -- no gravel, no odor	
		S-3	b2	2	452			-- color change to dark gray, strong diesel and gasoline odor, oil sheen in sampler	▽ ATD
10	5	S-4	b2	1	220		SM	Dark gray, silty fine SAND (very loose, wet) very strong diesel and gasoline odor, sheen in sampler	
							SM	Dark gray, silty fine SAND to SAND with silt, with scattered shells (very loose to loose, wet) **(MARINE DEPOSITS)**	
15	0	S-5	b2	4	47			-- very strong diesel and gasoline odor, sheen in sampler	
		S-6	b2	5	4.5 W = 27 GS			-- color change to gray, moderate petroleum odor and sheen -- below 18 ft, weighted mud added to auger to help prevent heave	
20	-5	S-7	b2	4				-- occasional shells, no sheen, slight sulfur odor	
25	-10	S-8a S-8b	b2 b2	3			CL/ CH	-- gray, silty fine SAND with shells, occasional wood fragments, no odor, no sheen Gray, silty CLAY, occasional clayey sand pockets (very soft to medium stiff, moist) **(GLACIOMARINE DRIFT)**	
30	-15	S-9	b2	5	W = 45			-- trace of fine sand and shell fragments, no odor, no sheen	
35	-20								

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

1034.01 4/5/12 N:\PROJECTS\001034.010.015.GPJ SOIL BORING LOG WITH GRAPH

LANDAU ASSOCIATES

Blaine Marina Fuel Pier
Bulkhead Replacement
Blaine, Washington

Log of Boring B-2-12

Figure
A-3
(1 of 2)

B-2-12

LAI Project No: 001034.010

SAMPLE DATA | **SOIL PROFILE**

Drilling Method: Hollow-Stem Auger
Ground Elevation (ft): 15
Drilled By: Holocene Drilling Inc.
Logged By: CTM Date: 01/05/12

Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)	Graphic Symbol	USCS Symbol	Groundwater
35	-20	S-10	b2	1			CL/ CH	
40	-25	S-11	b2	5	W = 26			
45	-30	S-12	b2	0				

Gray, silty CLAY, occasional clayey sand pockets (very soft to medium stiff, moist)
(GLACIOMARINE DRIFT)

-- occasional partings of fine sandy silt

Moisture Content (%)
Plastic Limit — Liquid Limit
10 20 30 40

▲ SPT N-Value ▲
△ Non-Standard N-Value △
10 20 30 40

× Fines Content (%) ×
10 20 30 40

Boring Completed 01/05/12
Total Depth of Boring = 46.5 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

1034.01 4/5/12 N:\PROJECTS\001034.010.015.GPJ SOIL BORING LOG WITH GRAPH

LANDAU ASSOCIATES

Blaine Marina Fuel Pier
Bulkhead Replacement
Blaine, Washington

Log of Boring B-2-12

Figure
A-3
(2 of 2)

B-3-12

LAI Project No: 001034.010

SAMPLE DATA | **SOIL PROFILE**

Drilling Method: Hollow-Stem Auger
Ground Elevation (ft): 15
Drilled By: Holocene Drilling Inc.
Logged By: CTM Date: 01/05/12

Moisture Content (%) — Plastic Limit — Liquid Limit — 10 20 30 40
▲ SPT N-Value ▲ △ Non-Standard N-Value △ — 10 20 30 40
× Fines Content (%) × — 10 20 30 40

Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)	Graphic Symbol	USCS Symbol	Soil Description	Groundwater
0	15						AC	Approximately 4-inches of asphalt concrete pavement	
							GW-GM	Brown, sandy GRAVEL with silt (medium dense, damp) **(FILL)**	
		S-1	b2	2	W = 27		CL/CH	Gray, sandy CLAY with sand pockets (very soft, moist)	
5	10	S-2	b2	2	10.8 W = 24			-- no odor	▽ ATD
		S-3	b2	5	406		SM	Gray, silty, fine SAND to SAND with silt, numerous shell fragments (very loose to loose, wet) -- strong diesel and gasoline odor	
10	5	S-4	b2	3	14.5 W = 27 GS			-- moderate diesel and gasoline odor	
		S-5	b2	3	11.8		SM	Gray, silty fine SAND, no shells, faint bedding (very loose to loose, wet) faint petroleum odor **(MARINE DEPOSITS)**	
15	0	S-6	b2	5	3.1 W = 25			-- no odor	

Boring Completed 01/05/12
Total Depth of Boring = 16.5 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

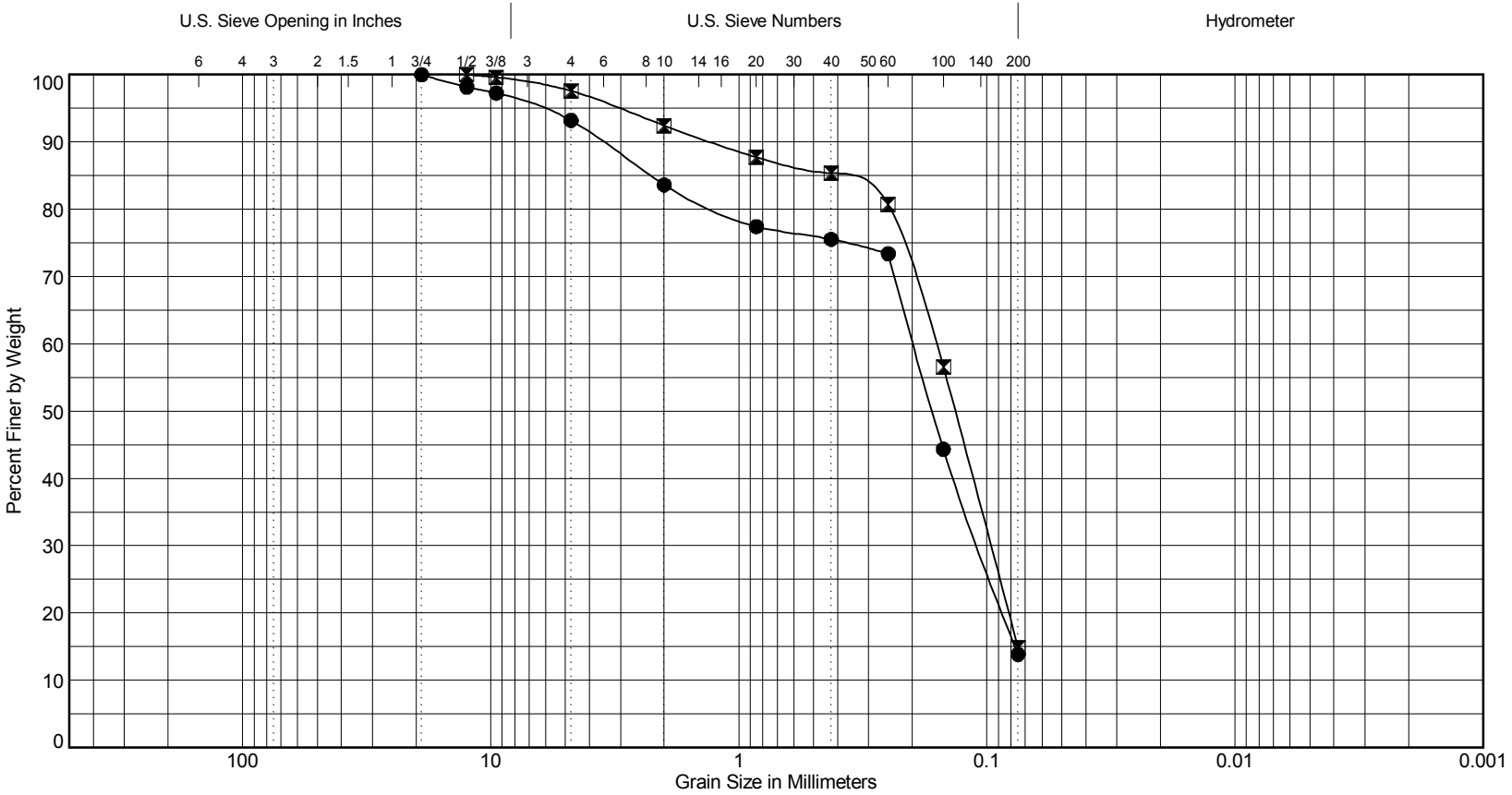
1034.01 4/5/12 N:\PROJECTS\001034.010.015.GPJ SOIL BORING LOG WITH GRAPH

LANDAU ASSOCIATES

Blaine Marina Fuel Pier
Bulkhead Replacement
Blaine, Washington

Log of Boring B-3-12

Figure
A-4



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Exploration Number	Sample Number	Depth (ft)	Natural Moisture (%)	Soil Description	Unified Soil Classification
●	B-2-12	S-6	17.5	27	Fine SAND with silt and fine gravel, numerous shells	SP-SM
⧓	B-3-12	S-4	10.0	27	Fine SAND with silt, trace fine gravel, numerous shells	SP-SM

LANDAU ASSOCIATES

Blaine Marina Fuel Pier
Bulkhead Replacement
Blaine, Washington

Grain Size Distribution

Figure
A-5

APPENDIX B

Environmental Laboratory Analytical Report

January 23, 2012

Mr. Jeremy Davis
Landau Associates, Inc.
130 - 2nd Ave. S.
Edmonds, WA 98020

Dear Mr. Davis,

On January 6th, 10 samples were received by our laboratory and assigned our laboratory project number 1201032. The project was identified as your Blaine Marina Bulkhead. The sample identification and requested analyses are outlined on the attached chain of custody record.

No abnormalities or nonconformances were observed during the analyses of the project samples.

Please do not hesitate to call me if you have any questions or if I can be of further assistance.

Sincerely,

ALS Laboratory Group

Rick Bagan
Laboratory Director

ADDRESS 8620 Holly Drive, Suite 100, Everett, WA 98208 | PHONE 425-356-2600 | FAX 425-356-2626
ALS Laboratory Group A Campbell Brothers Limited Company

CERTIFICATE OF ANALYSIS

CLIENT:	Landau Associates, Inc. 130 - 2nd Ave. S. Edmonds, WA 98020	DATE: ALS JOB#: ALS SAMPLE#:	1/23/2012 1201032 -01
CLIENT CONTACT:	Jeremy Davis	DATE RECEIVED:	1/6/2012
CLIENT PROJECT:	Blaine Marina Bulkhead	COLLECTION DATE:	1/5/2012 12:27
CLIENT SAMPLE ID	B-1 S-3 7.5'	WDOE ACCREDITATION:	C601

DATA RESULTS

ANALYTE	METHOD	RESULTS	REPORTING LIMITS	DILUTION FACTOR	UNITS	ANALYSIS DATE	ANALYSIS BY
TPH-Volatile Range	NWTPH-GX	**680**	30	10	MG/KG	01/09/2012	DLC
Benzene	EPA-8021	U	0.30	10	MG/KG	01/09/2012	DLC
Toluene	EPA-8021	**0.89**	0.50	10	MG/KG	01/09/2012	DLC
Ethylbenzene	EPA-8021	**1.6**	0.50	10	MG/KG	01/09/2012	DLC
Xylenes	EPA-8021	U	2.0	10	MG/KG	01/09/2012	DLC
TPH-Diesel Range	NWTPH-DX w/ SGA	**140**	25	1	MG/KG	01/06/2012	DLC
TPH-Oil Range	NWTPH-DX w/ SGA	U	50	1	MG/KG	01/06/2012	DLC

SURROGATE	METHOD	%REC	ANALYSIS DATE	ANALYSIS BY
TFT 10X Dilution	NWTPH-GX	**33.6 DS2**	01/09/2012	DLC
TFT 10X Dilution	EPA-8021	**26.1 DS2**	01/09/2012	DLC
C25	NWTPH-DX w/ SGA	**118**	01/06/2012	DLC

U - Analyte analyzed for but not detected at level above reporting limit.
DS2 - Due to high dilution factor surrogate results should be considered uncontrolled.
Chromatogram indicates that it is likely that sample contains weathered gasoline and weathered diesel.

ADDRESS 8620 Holly Drive, Suite 100, Everett, WA 98208 | PHONE 425-356-2600 | FAX 425-356-2626
ALS Laboratory Group A Campbell Brothers Limited Company

ALS Environmental

CERTIFICATE OF ANALYSIS

CLIENT:	Landau Associates, Inc. 130 - 2nd Ave. S. Edmonds, WA 98020	DATE: ALS JOB#: ALS SAMPLE#:	1/23/2012 1201032 -02
CLIENT CONTACT:	Jeremy Davis	DATE RECEIVED:	1/6/2012
CLIENT PROJECT:	Blaine Marina Bulkhead	COLLECTION DATE:	1/5/2012 14:59
CLIENT SAMPLE ID	B-2 S-3 7.5'	WDOE ACCREDITATION:	C601

DATA RESULTS

ANALYTE	METHOD	RESULTS	REPORTING LIMITS	DILUTION FACTOR	UNITS	ANALYSIS DATE	ANALYSIS BY
TPH-Volatile Range	NWTPH-GX	**6100**	300	100	MG/KG	01/06/2012	DLC
Benzene	EPA-8021	U	3.4	100	MG/KG	01/06/2012	DLC
Toluene	EPA-8021	U	5.7	100	MG/KG	01/06/2012	DLC
Ethylbenzene	EPA-8021	**120**	5.0	100	MG/KG	01/06/2012	DLC
Xylenes	EPA-8021	**120**	20	100	MG/KG	01/06/2012	DLC
TPH-Diesel Range	NWTPH-DX w/ SGA	**510**	25	1	MG/KG	01/06/2012	DLC
TPH-Oil Range	NWTPH-DX w/ SGA	U	50	1	MG/KG	01/06/2012	DLC

SURROGATE	METHOD	%REC	ANALYSIS DATE	ANALYSIS BY
TFT 100X Dilution	NWTPH-GX	**35.5 DS2**	01/06/2012	DLC
TFT 100X Dilution	EPA-8021	**33.5 DS2**	01/06/2012	DLC
C25	NWTPH-DX w/ SGA	**103**	01/06/2012	DLC

U - Analyte analyzed for but not detected at level above reporting limit.
DS2 - Due to high dilution factor surrogate results should be considered uncontrolled.
Chromatogram indicates that it is likely that sample contains weathered gasoline and weathered diesel.
Diesel range product reporting limits raised due to volatile range product overlap.

ADDRESS 8620 Holly Drive, Suite 100, Everett, WA 98208 | PHONE 425-356-2600 | FAX 425-356-2626
ALS Laboratory Group A Campbell Brothers Limited Company

ALS Environmental

CERTIFICATE OF ANALYSIS

CLIENT:	Landau Associates, Inc. 130 - 2nd Ave. S. Edmonds, WA 98020	DATE: ALS JOB#: ALS SAMPLE#:	1/23/2012 1201032 -03
CLIENT CONTACT:	Jeremy Davis	DATE RECEIVED:	1/6/2012
CLIENT PROJECT:	Blaine Marina Bulkhead	COLLECTION DATE:	1/5/2012 16:45
CLIENT SAMPLE ID	B-3 S-3 7.5'	WDOE ACCREDITATION:	C601

DATA RESULTS

ANALYTE	METHOD	RESULTS	REPORTING LIMITS	DILUTION FACTOR	UNITS	ANALYSIS DATE	ANALYSIS BY
TPH-Volatile Range	NWTPH-GX	**1800**	300	100	MG/KG	01/06/2012	DLC
Benzene	EPA-8021	U	3.0	100	MG/KG	01/06/2012	DLC
Toluene	EPA-8021	U	5.0	100	MG/KG	01/06/2012	DLC
Ethylbenzene	EPA-8021	**31**	5.0	100	MG/KG	01/06/2012	DLC
Xylenes	EPA-8021	**42**	20	100	MG/KG	01/06/2012	DLC
TPH-Diesel Range	NWTPH-DX w/ SGA	**330**	25	1	MG/KG	01/06/2012	DLC
TPH-Oil Range	NWTPH-DX w/ SGA	**150**	50	1	MG/KG	01/06/2012	DLC

SURROGATE	METHOD	%REC	ANALYSIS DATE	ANALYSIS BY
TFT 100X Dilution	NWTPH-GX	**6.55 DS2**	01/06/2012	DLC
TFT 100X Dilution	EPA-8021	**19.4 DS2**	01/06/2012	DLC
C25	NWTPH-DX w/ SGA	**125**	01/06/2012	DLC

U - Analyte analyzed for but not detected at level above reporting limit.
DS2 - Due to high dilution factor surrogate results should be considered uncontrolled.
Chromatogram indicates that it is likely that sample contains highly weathered gasoline and weathered diesel.
Diesel range product reporting limits raised due to volatile range product overlap.

ADDRESS 8620 Holly Drive, Suite 100, Everett, WA 98208 | PHONE 425-356-2600 | FAX 425-356-2626
ALS Laboratory Group A Campbell Brothers Limited Company

CERTIFICATE OF ANALYSIS

CLIENT:	Landau Associates, Inc. 130 - 2nd Ave. S. Edmonds, WA 98020	DATE: ALS JOB#: ALS SAMPLE#:	1/23/2012 1201032 -05
CLIENT CONTACT:	Jeremy Davis	DATE RECEIVED:	1/6/2012
CLIENT PROJECT:	Blaine Marina Bulkhead	COLLECTION DATE:	1/5/2012 12:20
CLIENT SAMPLE ID	Drum #2-A	WDOE ACCREDITATION:	C601

DATA RESULTS

ANALYTE	METHOD	RESULTS	REPORTING LIMITS	DILUTION FACTOR	UNITS	ANALYSIS DATE	ANALYSIS BY
Mercury	EPA-7471	U	0.020	1	MG/KG	01/11/2012	RAL
Arsenic	EPA-6020	**3.5**	0.82	5	MG/KG	01/10/2012	RAL
Barium	EPA-6020	**38**	0.70	5	MG/KG	01/10/2012	RAL
Cadmium	EPA-6020	U	1.4	5	MG/KG	01/10/2012	RAL
Chromium	EPA-6020	**18**	0.81	5	MG/KG	01/10/2012	RAL
Lead	EPA-6020	**3.6**	0.79	5	MG/KG	01/10/2012	RAL
Selenium	EPA-6020	U	1.2	5	MG/KG	01/10/2012	RAL
Silver	EPA-6020	U	0.26	5	MG/KG	01/10/2012	RAL

U - Analyte analyzed for but not detected at level above reporting limit.

ADDRESS 8620 Holly Drive, Suite 100, Everett, WA 98208 | PHONE 425-356-2600 | FAX 425-356-2626
ALS Laboratory Group A Campbell Brothers Limited Company

CERTIFICATE OF ANALYSIS

CLIENT:	Landau Associates, Inc. 130 - 2nd Ave. S. Edmonds, WA 98020	DATE: ALS JOB#: ALS SAMPLE#:	1/23/2012 1201032 -10
CLIENT CONTACT:	Jeremy Davis	DATE RECEIVED:	1/6/2012
CLIENT PROJECT:	Blaine Marina Bulkhead	COLLECTION DATE:	1/5/2012 17:05
CLIENT SAMPLE ID	Drill Wash Water	WDOE ACCREDITATION:	C601

DATA RESULTS

ANALYTE	METHOD	RESULTS	REPORTING LIMITS	DILUTION FACTOR	UNITS	ANALYSIS DATE	ANALYSIS BY
TPH-Volatile Range	NWTPH-GX	**830**	50	1	UG/L	01/06/2012	DLC
Benzene	EPA-8021	**2.1**	1.0	1	UG/L	01/06/2012	DLC
Toluene	EPA-8021	**1.7**	1.0	1	UG/L	01/06/2012	DLC
Ethylbenzene	EPA-8021	**6.5**	1.0	1	UG/L	01/06/2012	DLC
Xylenes	EPA-8021	**9.6**	3.0	1	UG/L	01/06/2012	DLC
TPH-Diesel Range	NWTPH-DX w/ SGA	**1300**	540	1	UG/L	01/09/2012	EBS
TPH-Oil Range	NWTPH-DX w/ SGA	**1700**	490	1	UG/L	01/09/2012	EBS

SURROGATE	METHOD	%REC	ANALYSIS DATE	ANALYSIS BY
TFT	NWTPH-GX	**106**	01/06/2012	DLC
TFT	EPA-8021	**106**	01/06/2012	DLC
C25	NWTPH-DX w/ SGA	**69.7**	01/09/2012	EBS

Chromatogram indicates that it is likely that sample contains weathered gasoline.
Chromatogram indicates that it is likely that sample contians diesel and lube oil. Diesel and motor oil range product reporting limits raised due to low sample volume.

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ALS Laboratory Group A Campbell Brothers Limited Company

ALS Environmental

CERTIFICATE OF ANALYSIS

CLIENT:	Landau Associates, Inc. 130 - 2nd Ave. S. Edmonds, WA 98020	DATE:	1/23/2012
		ALS SDG#:	1201032
		WDOE ACCREDITATION:	C601
CLIENT CONTACT:	Jeremy Davis		
CLIENT PROJECT:	Blaine Marina Bulkhead		

LABORATORY BLANK RESULTS

MBG-010612S - Batch 2422 - Soil by NWTPH-GX

ANALYTE	METHOD	RESULTS	REPORTING LIMITS	DILUTION FACTOR	UNITS	ANALYSIS DATE	ANALYSIS BY
TPH-Volatile Range	NWTPH-GX	U	3.0	1	MG/KG	01/06/2012	DLC

MBG-010512W - Batch 2417 - Water by NWTPH-GX

ANALYTE	METHOD	RESULTS	REPORTING LIMITS	DILUTION FACTOR	UNITS	ANALYSIS DATE	ANALYSIS BY
TPH-Volatile Range	NWTPH-GX	U	50	1	UG/L	01/05/2012	DLC

MB-010612S - Batch 2422 - Soil by EPA-8021

ANALYTE	METHOD	RESULTS	REPORTING LIMITS	DILUTION FACTOR	UNITS	ANALYSIS DATE	ANALYSIS BY
Benzene	EPA-8021	U	0.030	1	MG/KG	01/06/2012	DLC
Toluene	EPA-8021	U	0.050	1	MG/KG	01/06/2012	DLC
Ethylbenzene	EPA-8021	U	0.050	1	MG/KG	01/06/2012	DLC
Xylenes	EPA-8021	U	0.20	1	MG/KG	01/06/2012	DLC

MB-010512W - Batch 2417 - Water by EPA-8021

ANALYTE	METHOD	RESULTS	REPORTING LIMITS	DILUTION FACTOR	UNITS	ANALYSIS DATE	ANALYSIS BY
Benzene	EPA-8021	U	1.0	1	UG/L	01/05/2012	DLC
Toluene	EPA-8021	U	1.0	1	UG/L	01/05/2012	DLC
Ethylbenzene	EPA-8021	U	1.0	1	UG/L	01/05/2012	DLC
Xylenes	EPA-8021	U	3.0	1	UG/L	01/05/2012	DLC

MB-010612S - Batch 2421 - Soil by NWTPH-DX

ANALYTE	METHOD	RESULTS	REPORTING LIMITS	DILUTION FACTOR	UNITS	ANALYSIS DATE	ANALYSIS BY
TPH-Diesel Range	NWTPH-DX	U	25	1	MG/KG	01/06/2012	DLC
TPH-Oil Range	NWTPH-DX	U	50	1	MG/KG	01/06/2012	DLC

MB-010912W - Batch 2425 - Water by NWTPH-DX

ANALYTE	METHOD	RESULTS	REPORTING LIMITS	DILUTION FACTOR	UNITS	ANALYSIS DATE	ANALYSIS BY
TPH-Diesel Range	NWTPH-DX	U	130	1	UG/L	01/09/2012	EBS
TPH-Oil Range	NWTPH-DX	U	250	1	UG/L	01/09/2012	EBS

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CERTIFICATE OF ANALYSIS

CLIENT:	Landau Associates, Inc. 130 - 2nd Ave. S. Edmonds, WA 98020	DATE: ALS SDG#: WDOE ACCREDITATION:	1/23/2012 1201032 C601
CLIENT CONTACT:	Jeremy Davis		
CLIENT PROJECT:	Blaine Marina Bulkhead		

LABORATORY BLANK RESULTS

MB-010912S - Batch 2423 - Soil by EPA-6020

ANALYTE	METHOD	RESULTS	REPORTING LIMITS	DILUTION FACTOR	UNITS	ANALYSIS DATE	ANALYSIS BY
Arsenic	EPA-6020	U	0.12	1	MG/KG	01/10/2012	RAL
Barium	EPA-6020	U	0.16	1	MG/KG	01/10/2012	RAL
Cadmium	EPA-6020	U	0.20	1	MG/KG	01/10/2012	RAL
Chromium	EPA-6020	U	0.12	1	MG/KG	01/10/2012	RAL
Lead	EPA-6020	U	0.12	1	MG/KG	01/10/2012	RAL
Selenium	EPA-6020	U	0.69	1	MG/KG	01/10/2012	RAL
Silver	EPA-6020	U	0.063	1	MG/KG	01/10/2012	RAL

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ALS Environmental

CERTIFICATE OF ANALYSIS

CLIENT:	Landau Associates, Inc. 130 - 2nd Ave. S. Edmonds, WA 98020	DATE:	1/23/2012
		ALS SDG#:	1201032
		WDOE ACCREDITATION:	C601
CLIENT CONTACT:	Jeremy Davis		
CLIENT PROJECT:	Blaine Marina Bulkhead		

LABORATORY CONTROL SAMPLE RESULTS

ALS Test Batch ID: 2422 - Soil by NWTPH-GX

SPIKED COMPOUND	METHOD	%REC	RPD	QUAL	ANALYSIS DATE	ANALYSIS BY
TPH-Volatile Range - BS	NWTPH-GX	**84.9**			01/06/2012	DLC
TPH-Volatile Range - BSD	NWTPH-GX	**96.9**	**13**		01/06/2012	DLC

ALS Test Batch ID: 2417 - Water by NWTPH-GX

SPIKED COMPOUND	METHOD	%REC	RPD	QUAL	ANALYSIS DATE	ANALYSIS BY
TPH-Volatile Range - BS	NWTPH-GX	**103**			01/05/2012	DLC
TPH-Volatile Range - BSD	NWTPH-GX	**105**	**2**		01/05/2012	DLC

ALS Test Batch ID: 2422 - Soil by EPA-8021

SPIKED COMPOUND	METHOD	%REC	RPD	QUAL	ANALYSIS DATE	ANALYSIS BY
Benzene - BS	EPA-8021	**99.9**			01/06/2012	DLC
Benzene - BSD	EPA-8021	**100**	**0**		01/06/2012	DLC
Toluene - BS	EPA-8021	**95.8**			01/06/2012	DLC
Toluene - BSD	EPA-8021	**96.0**	**0**		01/06/2012	DLC
Ethylbenzene - BS	EPA-8021	**93.0**			01/06/2012	DLC
Ethylbenzene - BSD	EPA-8021	**93.6**	**1**		01/06/2012	DLC
Xylenes - BS	EPA-8021	**93.2**			01/06/2012	DLC
Xylenes - BSD	EPA-8021	**93.7**	**1**		01/06/2012	DLC

ALS Test Batch ID: 2417 - Water by EPA-8021

SPIKED COMPOUND	METHOD	%REC	RPD	QUAL	ANALYSIS DATE	ANALYSIS BY
Benzene - BS	EPA-8021	**108**			01/05/2012	DLC
Benzene - BSD	EPA-8021	**111**	**3**		01/05/2012	DLC
Toluene - BS	EPA-8021	**102**			01/05/2012	DLC
Toluene - BSD	EPA-8021	**105**	**3**		01/05/2012	DLC
Ethylbenzene - BS	EPA-8021	**100**			01/05/2012	DLC
Ethylbenzene - BSD	EPA-8021	**103**	**2**		01/05/2012	DLC
Xylenes - BS	EPA-8021	**99.9**			01/05/2012	DLC
Xylenes - BSD	EPA-8021	**103**	**3**		01/05/2012	DLC

ALS Test Batch ID: 2421 - Soil by NWTPH-DX

SPIKED COMPOUND	METHOD	%REC	RPD	QUAL	ANALYSIS DATE	ANALYSIS BY
TPH-Diesel Range - BS	NWTPH-DX	**95.9**			01/06/2012	DLC
TPH-Diesel Range - BSD	NWTPH-DX	**99.1**	**3**		01/06/2012	DLC

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CERTIFICATE OF ANALYSIS

CLIENT:	Landau Associates, Inc. 130 - 2nd Ave. S. Edmonds, WA 98020	DATE:	1/23/2012
		ALS SDG#:	1201032
		WDOE ACCREDITATION:	C601
CLIENT CONTACT:	Jeremy Davis		
CLIENT PROJECT:	Blaine Marina Bulkhead		

LABORATORY CONTROL SAMPLE RESULTS

ALS Test Batch ID: 2425 - Water by NWTPH-DX

SPIKED COMPOUND	METHOD	%REC	RPD	QUAL	ANALYSIS DATE	ANALYSIS BY
TPH-Diesel Range - BS	NWTPH-DX	**73.5**			01/09/2012	EBS
TPH-Diesel Range - BSD	NWTPH-DX	**78.7**	**7**		01/09/2012	EBS

ALS Test Batch ID: 2423 - Soil by EPA-6020

SPIKED COMPOUND	METHOD	%REC	RPD	QUAL	ANALYSIS DATE	ANALYSIS BY
Arsenic - BS	EPA-6020	**98.9**			01/10/2012	RAL
Arsenic - BSD	EPA-6020	**97.6**	**1**		01/10/2012	RAL
Barium - BS	EPA-6020	**104**			01/10/2012	RAL
Barium - BSD	EPA-6020	**105**	**1**		01/10/2012	RAL
Cadmium - BS	EPA-6020	**101**			01/10/2012	RAL
Cadmium - BSD	EPA-6020	**101**	**0**		01/10/2012	RAL
Chromium - BS	EPA-6020	**102**			01/10/2012	RAL
Chromium - BSD	EPA-6020	**102**	**0**		01/10/2012	RAL
Lead - BS	EPA-6020	**103**			01/10/2012	RAL
Lead - BSD	EPA-6020	**103**	**0**		01/10/2012	RAL
Selenium - BS	EPA-6020	**96.3**			01/10/2012	RAL
Selenium - BSD	EPA-6020	**95.4**	**1**		01/10/2012	RAL
Silver - BS	EPA-6020	**108**			01/10/2012	RAL
Silver - BSD	EPA-6020	**108**	**1**		01/10/2012	RAL

APPROVED BY

Laboratory Director

ADDRESS 8620 Holly Drive, Suite 100, Everett, WA 98208 | PHONE 425-356-2600 | FAX 425-356-2626
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ALS ENVIRONMENTAL

Sample Receiving Checklist

Client: Landau Associates ALS Job #: 1201032

Project: Blaine Marina Bulkhead

Received Date: 1/6/12 Received Time: 12:45 By: SR

Type of shipping container: Cooler X Box ___ Other ___

Shipped via: UPS/FedEx ___ US Postal Service ___ Courier ___ Hand Delivered X

	Yes	No	N/A
Were custody seals on outside of sample?	___	X	___
If yes, how many? ___ Where? ___			
Custody seal date: ___ Seal name: ___			
Was Chain of Custody properly filled out (ink, signed, dated, etc.)?	X	___	___
Did all bottles have labels?	X	___	___
Did all bottle labels and tags agree with Chain of Custody?	X	___	___
Were samples received within hold time?	X	___	___
Did all bottles arrive in good condition (unbroken, etc.)?	X	___	___
Was sufficient amount of sample sent for the tests indicated?	___	X	see note below
Was correct preservation added to samples?	___	X	see note below

If no, Sample Control added preservative to the following:

Sample Number	Reagent	Analyte

Were VOA vials checked for absence of air bubbles?	___	___	X
Bubbles present in sample #: ___			

Temperature of cooler upon receipt: 7.5 °C (Cold) Cool Ambient N/A

Explain any discrepancies: Sample #10 had insufficient sample volume for Gx, Dx, + metals on ice. Jeremy said to run Gx + Dx first hold remaining if any to run metals - Nothing left. RB

Was client contacted? Yes Who was called? Jeremy By whom? Rick Bogen Date: 1-6-12

Outcome of call: Jeremy says run Gx + Dx first hold metals.

ALS Environmental
8620 Holly Drive, Suite 100
Everett, WA 98208
Phone (425) 356-2600
(425) 356-2626 Fax
http://www.alsglobal.com

Chain Of Custody/ Laboratory Analysis Request

ALS Job# (Laboratory Use Only): 1201032

Date 1/6/2012 Page 1 Of 1

PROJECT ID: BLAINE MARINA BULKHEAD
REPORT TO COMPANY: LANDAU ASSOCIATES
PROJECT MANAGER: JEREMY DAVIS
ADDRESS: 130 2ND AVE S
EDMONDS, WA 98020
PHONE: 425-778-0907 FAX:
P.O. NUMBER: 001034.010.015 E-MAIL: JDAVIS@LANDAUINC.COM
INVOICE TO COMPANY: SAME AS ABOVE
ATTENTION: JEREMY DAVIS
ADDRESS: SAME

ANALYSIS REQUESTED

OTHER (Specify)

SAMPLE I.D.	DATE	TIME	TYPE	LAB#	NWTPH-HCID	NWTPH-DX	NWTPH-GX	BTEX by EPA-8021	MTBE by EPA-8021 ☐ EPA-8260 ☐	Halogenated Volatiles by EPA 8260	Volatile Organic Compounds by EPA 8260	EDB / EDC by EPA 8260 SIM (water)	EDB / EDC by EPA 8260 (soil)	Semivolatile Organic Compounds by EPA 8270	Polycyclic Aromatic Hydrocarbons (PAH) by EPA-8270 SIM ☐	PCB ☐ Pesticides ☐ by EPA 8081/8082	Metals-MTCA-5 ☐ RCRA-8 ☒ Pri Pol ☐ TAL ☐	Metals Other (Specify)	TCLP-Metals ☐ VOA ☐ Semi-Vol ☐ Pest ☐ Herbs ☐	HOLD	MAY CONTAIN SOAP	HEAVILY IMPACTED → DILUTE?					NUMBER OF CONTAINERS	RECEIVED IN GOOD CONDITION?
1. B-1 S-3 7.5'	1/5/2012	1227	SOIL	1		/	/	⊗													/					1	
2. B-2 S-3 7.5'	"	1459	SOIL	2		/	/	⊗													/					1	
3. B-3 S-3 7.5'	"	1645	SOIL	3		/	/	⊗													/					1	
4. DRUM #1-A	"	1214	SOIL	4															/							1	
5. ~~DRUM #1-B~~																										1	
6. DRUM #2-A	"	1220	SOIL	5													/									1	
7. DRUM #2-B	"	1356	SOIL	6															/							1	
8. DRUM #3	"	1438	SOIL	7															/							1	
9. DRUM #4	"	1440	SOIL	8															/							1	
10. DRUM #5	"	1602	SOIL	9															/							1	
DRILL WASH WATER	1/5/2012	1705	LIQUID	10		/	/	⊗									/			/							

SPECIAL INSTRUCTIONS

⊗ Add BTEX per Jeremy 1/23/12. SM

No Insufficient Sample Volume RB

SIGNATURES (Name, Company, Date, Time):

1. Relinquished By: CHAD MCMULLEN, LANDAU ASSOC 1245 1/6/2012
Received By: Shawn Robinson ALS 1/6/12 12:45
2. Relinquished By:
Received By:

TURNAROUND REQUESTED in Business Days*

Organic, Metals & Inorganic Analysis: ~~10~~ Standard | 5 | 3 | 2 | 1 | SAME DAY

Fuels & Hydrocarbon Analysis: ~~5~~ Standard | 3 | 1 | SAME DAY

OTHER:
Specify: SILICA-GEL CLEAN-UP

* Turnaround request less than standard may incur Rush Charges

LABORATORY COPY

ReidMiddleton

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Everett, WA 98204
Ph: 425-741-3800
www.reidmiddleton.com

M E M O R A N D U M

To: Kent Wiken, Landau Associates

From: Jon Padvorac, PE

Date: August 11, 2017

File No.: 24-17-002

Port of Bellingham Blaine Bulkhead – Preliminary Engineering Design
Subject: Memorandum For Department of Ecology Review Process

Background

Landau Associates (Landau) is currently working with the Port of Bellingham in the Blaine Harbor Industrial Area on the cleanup of a former fuel facility. The project includes excavation and removal of contaminated materials and installation of a water tight bulkhead on the shoreline alongside Sigurdson Avenue. The existing shoreline consists of older timber bulkheads. Riprap is placed waterward along the face of the existing bulkheads in some locations.

The new shoreline bulkhead will consist of a steel sheet pile, similar to an adjacent bulkhead installed in 2012. Interlock sealant or other means will be required to provide watertightness for the sheet pile joints and prevent groundwater migration through the wall. The wall will be designed for an undrained condition. This technical memorandum describes the preliminary design for the bulkhead and includes preliminary calculations. Final design and calculations will be provided with the final construction documents at a later date.

Preliminary Design

The new bulkhead will connect to and begin at the northern end of the previously placed sheet pile wall. The new bulkhead will installed along the shoreline just landward of the existing timber bulkhead. A site plan of the bulkhead alignment is provided in the main Landau report.

The new bulkhead will consist of sheet piling vibrated into place. A preliminary design of the bulkhead has been completed based on geotechnical information from Landau, a site observation of general site conditions, and information from the recent design and installation of the adjacent sheet pile wall.

The design for the new sheet pile wall is based on a ten-foot exposed height on the waterward face of the bulkhead. While the height of the exposed face is currently less than ten feet, the wall

will be designed to be stable in the event the rip rap and fill shifts or is removed from the waterward face of the bulkhead at some point in the future. The bulkhead will be a cantilevered design and will not include a tie-back system. The cantilevered bulkhead has been preliminary designed to support the full lateral loads from earth pressures, hydrostatic loads from retained groundwater, and vehicle loading from Sigurdson Avenue.

To the North of the bulkhead is an aging fish processing bulding. The new bulkhead will be as close as feasible to this building, which is anticipated to result in approximately a 47-foot long bulkhead that terminates approximately 10 feet away. In the event that this building or the supporting bulkhead and piling show signs of distress due to the vibrations caused by pile driving, bulkhead installation would cease. Were this to occur, the finished length of the bulkhead may be less than the targeted 47 feet.

The sheet piling section will be a steel PZC 13 section or approved equal. The top portion of the sheets will be coated to protect from corrosion. This is similar to the adjacent steel sheet piling section that was installed in 2012. The new sheet piling will be connected to the north end of the existing sheet piling via an existing connection joint that was installed on the north end of the existing sheet pile bulkhead. The new sheets will be driven from the south to the north to install the new bulkhead. There is a risk that unknown buried conditions could impact installation. If unknown conditions are encountered during installation such as boulders or hard driving, minor adjustments in the alignment or configuration of the bulkhead may be performed in the field during construction.

The joints where the individual sheet pile sections connect will be treated to provide a watertight bulkhead. The treatment will be a non-toxic, environmentally-friendly interlock sealant that provides watertight connections between the individual sheets. The sealant will be applied to the joints prior to driving the sheets.

Based on the calculations attached, geotechnical information, and the performance and installation process of the adjacent similar sheet pile bulkhead, it is expected that the new sheet pile bulkhead as designed will meet code and performance requirements to support the load conditions on the site. The use of watertight sealant in the sheet pile joints will prevent migration of potentially contaminated groundwater through the new bulkhead.

Calculations

Preliminary calculations and typical details are attached.

Jon A. Padvorac, P.E., C.W.I.
Project Engineer

ReidMiddleton

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Everett, WA 98204
Ph: 425-741-3800
www.reidmiddleton.com

M E M O R A N D U M

To: Kent Wiken, Landau Associates

From: Jon Padvorac, PE

Date: August 11, 2017

File No.: 24-17-002
Port of Bellingham Blaine Contaminated Soil Removal Shoring – Preliminary Engineering Design
Subject: Memorandum For Department of Ecology Review Process

Background

Landau Associates (Landau) is currently working with the Port of Bellingham in the Blaine Harbor Industrial Area on the cleanup of a former fuel facility. The project includes excavation and removal of contaminated materials and installation of a watertight bulkhead on the shoreline alongside Sigurdson Avenue.

The removal of contaminated soil materials will include excavation of material up to twelve feet below the ground surface. In order to provide safety and remove the contaminated soils in a controlled manner and protect adjacent utilities and infrastructure, shoring will be provided in the excavations. This technical memorandum describes the preliminary design for the shoring and includes preliminary calculations. Final design and calculations for a shoring system will be provided with the final construction documents at a later date.

Preliminary Design

The shoring will consist of temporary steel sheet piling installed around the area to be excavated and removed. The shoring will be vibrated into place prior to the excavation and removal of contaminated soils. The shoring will not have a tie-back system but may include temporary bracing from within the excavation area. The design for the temporary shoring is based on 12-foot exposed height which includes the expected maximum excavation depth of twelve feet with a factor of safety.

The shoring is designed to support the full lateral loads from earth pressures, hydrostatic loads from groundwater, and vehicle loading from equipment. The sheet piling section will be a steel PZC-18 section or approved equal.

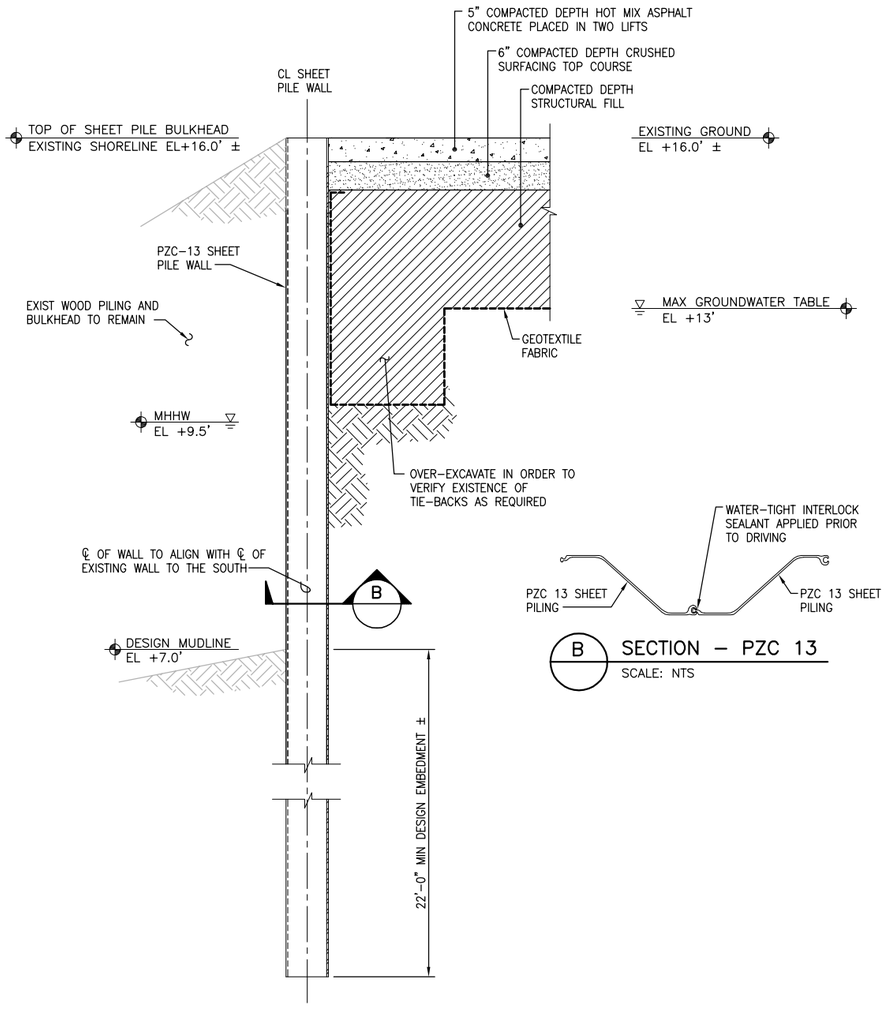
Based on the calculations attached, and geotechnical information, it is expected that the temporary shoring as designed will meet code and performance requirements to support the temporary load conditions on the site. There is a risk that unknown buried conditions could impact installation. If unknown conditions are encountered during installation such as boulders or hard driving, minor adjustments in the alignment or configuration of the shoring may be performed in the field during construction.

Calculations

Preliminary calculations and typical details are attached.

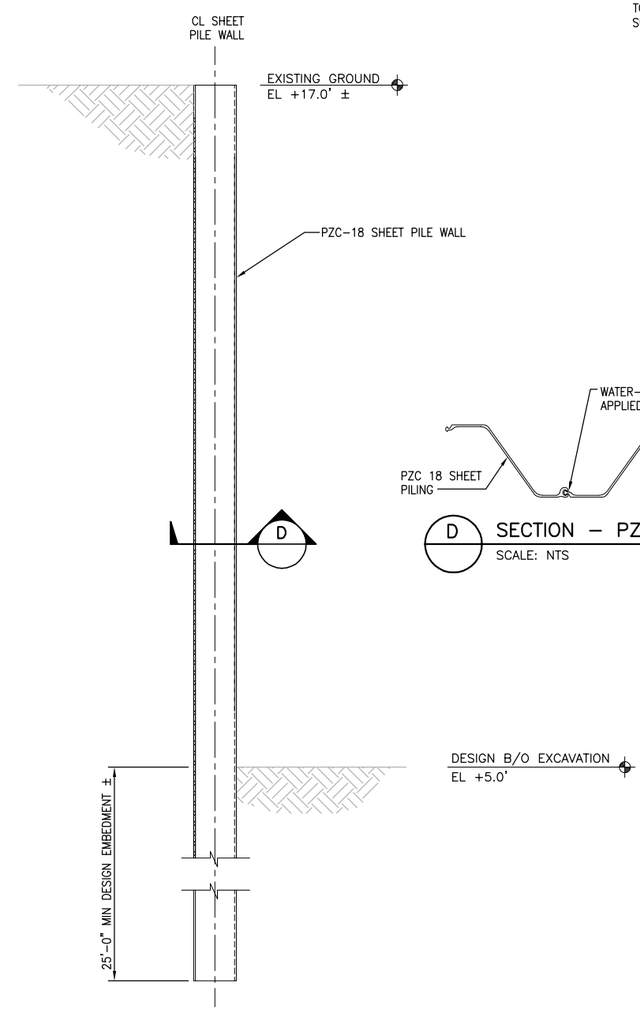
NOTES

1. VERTICAL DATUM: ELEVATIONS SHOWN ARE REFERENCED TO THE NOAA/TIDAL MLLW = 0.00' DATUM, BASED UPON SURVEY DATA PROVIDED BY WILSON ENGINEERING.



B SECTION – PZC 13
SCALE: NTS

A SECTION – SHEET PILE PERMANENT BULKHEAD
SCALE: 3/4"=1'-0"



D SECTION – PZC 18
SCALE: NTS

C SECTION – SHEET PILE TEMPORARY SHORING
SCALE: 3/4"=1'-0"

Reid Middleton
728 134th Street SW · Suite 200
Everett, Washington 98204
Ph: 425 741-3800

TYPICAL BULKHEAD DETAILS - BULKHEAD AND SHORING

PORT OF BELLINGHAM - BLAINE HARBOR BULKHEAD

FIGURE 1

BLAINE FUEL BULKHEAD

Owner: Port of Bellingham

Date: August 10, 2017

Prepared for:
Port of Bellingham

STRUCTURAL CALCULATIONS

PRELIMINARY

Jon A. Padvorac, P.E., C.W.I.
Project Engineer

Prepared By:

Jon Padvorac, P.E.

ReidMiddleton

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File No. 242017.002

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Section

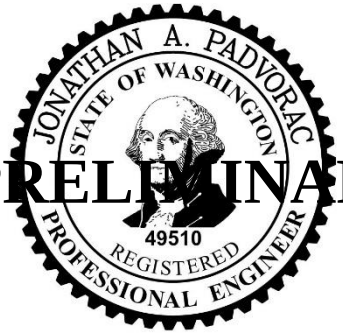
BLAINE FUEL BULKHEAD

Owner: Port of Bellingham

Date: August 10, 2017

Prepared for:
Port of Bellingham

DESIGN CRITERIA



PRELIMINARY

Jon A. Padvorac, P.E., C.W.I.
Project Engineer

Prepared By:

Jon Padvorac, P.E.

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File No. 242017.002

CODES AND REFERENCES

- 2015 International Building Code
- ASCE 7-10 Minimum Design Loads for Buildings and Other Structures

Steel

- AISC Steel Construction Manual, 14th Edition (2010)

COMPUTER PROGRAMS

- Shoring Suite by CivilTech Software

MATERIAL PROPERTIES

Concrete

Type	Normal Weight
Bulkhead Wall	f'_c = 4,000 psi

Reinforcing Steel

Typical	ASTM A615, Grade 60

Structural Steel

Sheet Piling	ASTM A572, Grade 50

FOUNDATIONS AND SOILS

Reference Geotechnical Report:	Blaine Marine Fuel Pier Bulkhead Replacement Blaine, Washington Landau Associates, Inc.

Bulkhead Wall

Passive Lateral Pressure	Varies, See Lateral Pressures Diagram
Active Lateral Pressure:	Varies, See Lateral Pressures Diagram
Hydrostatic Pressure:	125 PCF, See Lateral Pressures Diagram
Active Surcharge Pressure:	0.36*q_s, See Lateral Pressures Diagram
Seismic Earth Pressure:	7H to 2H, Se Lateral Pressures Diagram

BLAINE FUEL BULKHEAD

Owner: Port of Bellingham

Date: August 10, 2017

Prepared for:
Port of Bellingham

GEOTECHNICAL LOADS

PRELIMINARY

Jon A. Padvorac, P.E., C.W.I.
Project Engineer

Prepared By:

Jon Padvorac, P.E.

ReidMiddleton

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www.reidmiddleton.com

File No. 242017.002

ReidMiddleton

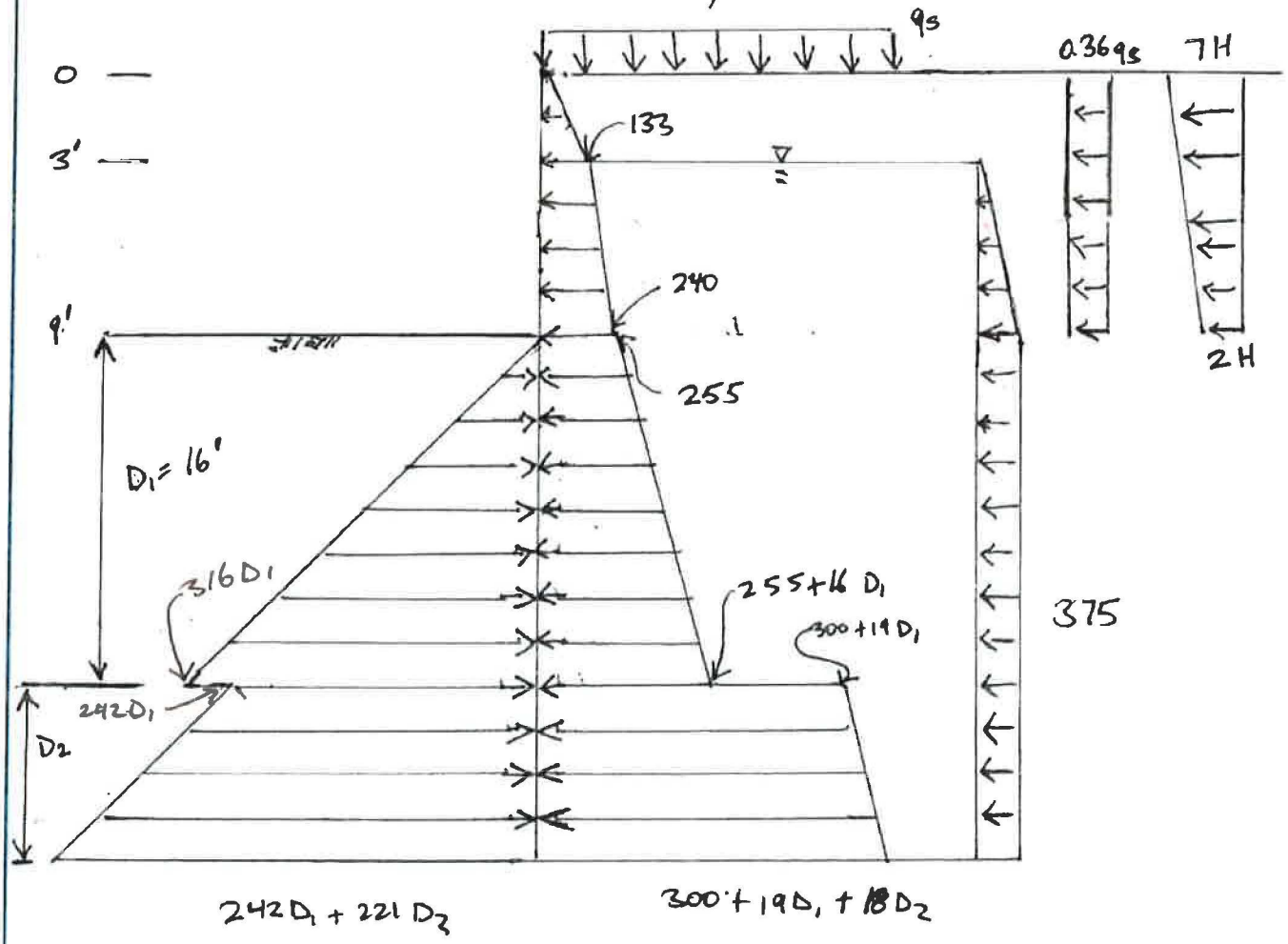
Client PORT OF BELLINGHAM
Project BLAINE BULHEAD
Permanent Bulkhead

Project No. 24 2017.002

Sheet of
Design by KMG
Date 8/17
Checked by JAP
Date 8/11/17

DESIGN LATERAL PRESSURES - 9 FOOT HIGH w/ WATER TABLE AT 3' BGS

DESIGN PRESSURES WERE PROVIDED FOR A 9' HIGH RETAINING HEIGHT ON A REPORT BY LANDAU ASSOCIATES DATED APRIL 6, 2012. FOR THE SCENARIO WHERE THE WATER TABLE IS LOCATED 3' BELOW GROUND SURFACE THE DESIGN PRESSURES WHICH INCLUDE THE HYDROSTATIC PRESSURE WAS EXTRAPOLATED FROM DESIGN PRESSURES PROVIDED BY LANDAU AS SHOWN BELOW.



★NOT TO SCALE
ALL UNITS ARE IN ENGLISH (Ft, lb, PSF)

ReidMiddleton

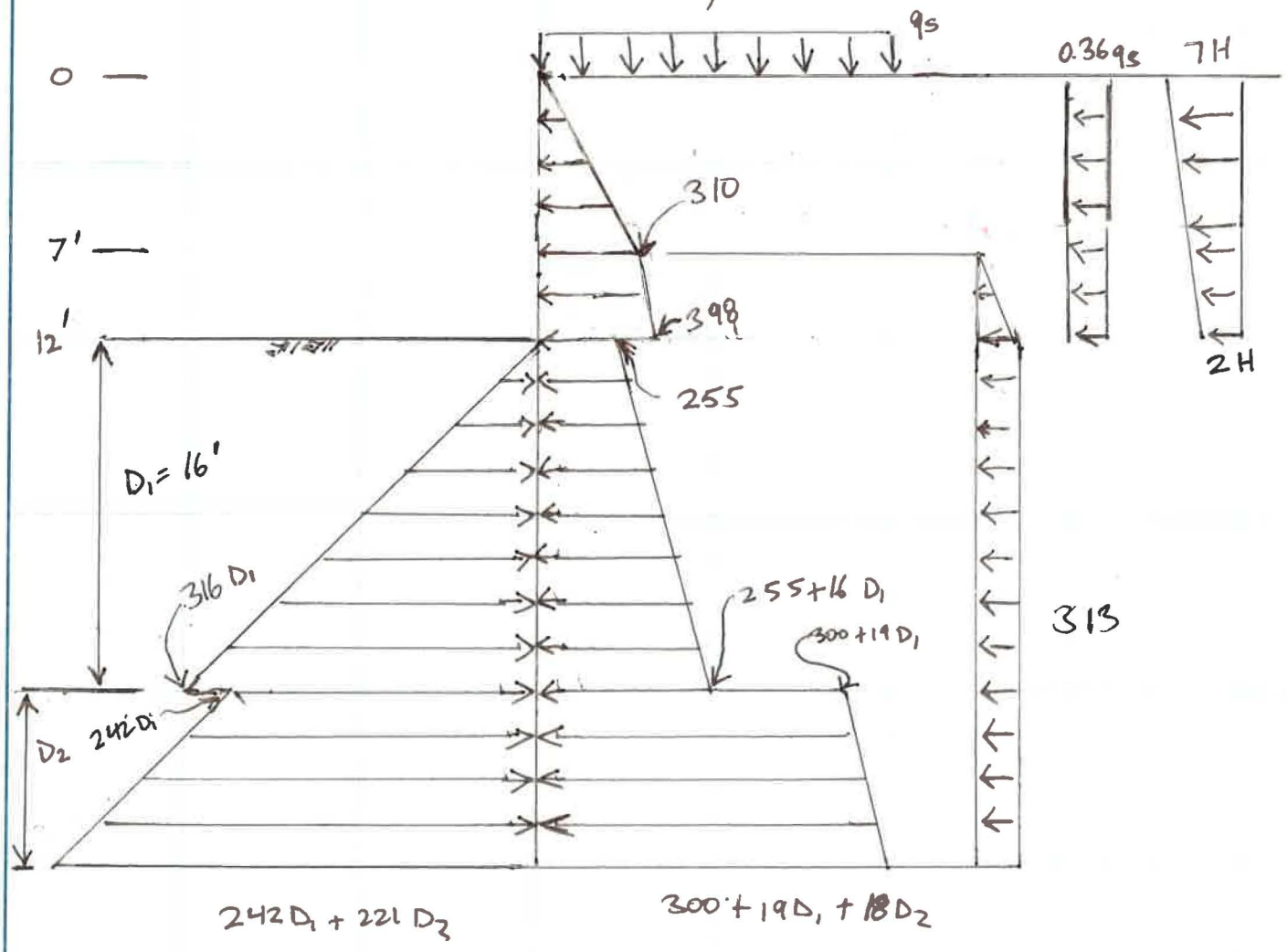
Client PORT OF BELLINGHAM
Project BLAINE BULHEAD
Temporary Bulkhead

Project No. 24 2017.002

Sheet of
Design by KMG
Date 8/17
Checked by JAP
Date 8/11/17

DESIGN LATERAL PRESSURES - 12 FOOT HIGH w/ WATER TABLE AT 7' BGS

DESIGN PRESSURES WERE PROVIDED FOR A 12' HIGH RETAINING HEIGHT ON A REPORT BY LANDAU ASSOCIATES DATED APRIL 6, 2012. FOR THE SCENARIO WHERE THE WATER TABLE IS LOCATED 7' BELOW GROUND SURFACE THE DESIGN PRESSURES WHICH INCLUDE THE HYDROSTATIC PRESSURE WAS EXTRAPOLATED FROM DESIGN PRESSURES PROVIDED BY LANDAU AS SHOWN BELOW.



* NOT TO SCALE
ALL UNITS ARE IN ENGLISH (Ft, lb, PSF)

BLAINE FUEL BULKHEAD

Owner: Port of Bellingham

Date: August 10, 2017

Prepared for:
Port of Bellingham

BULKHEAD DESIGN

PRELIMINARY

Jon A. Padvorac, P.E., C.W.I.
Project Engineer

Prepared By:

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File No. 242017.002

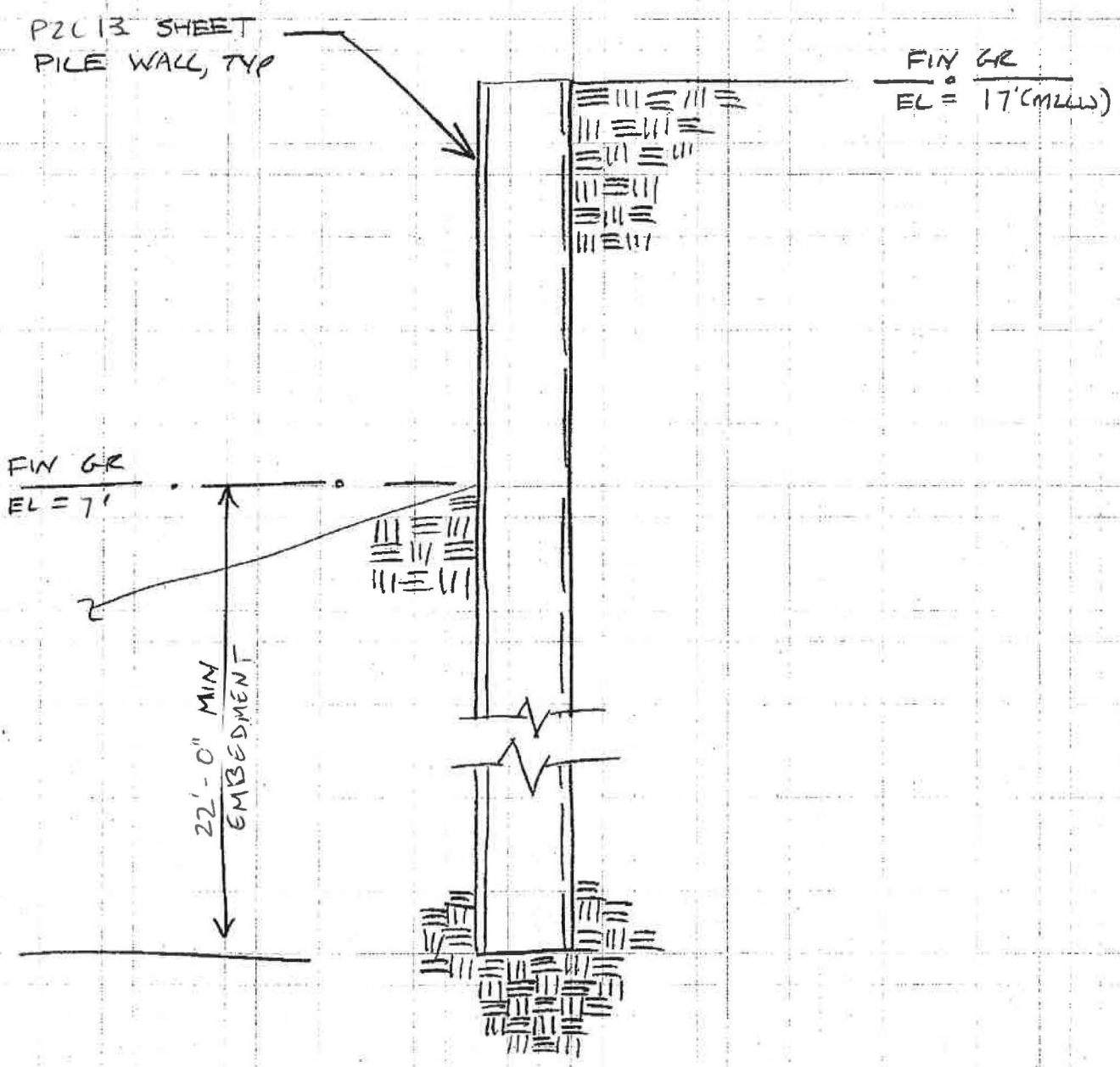
Reid Middleton

Client LANDAU
Project BLAINE HARBOR BULKHEAD
Project No. 242017.002

Sheet ____ of ____
Design by KMG
Date 8/2017
Checked by JAP
Date 8/11/17

9' HIGH STICK UP SHEET PILE WALL

Permanent Bulkhead

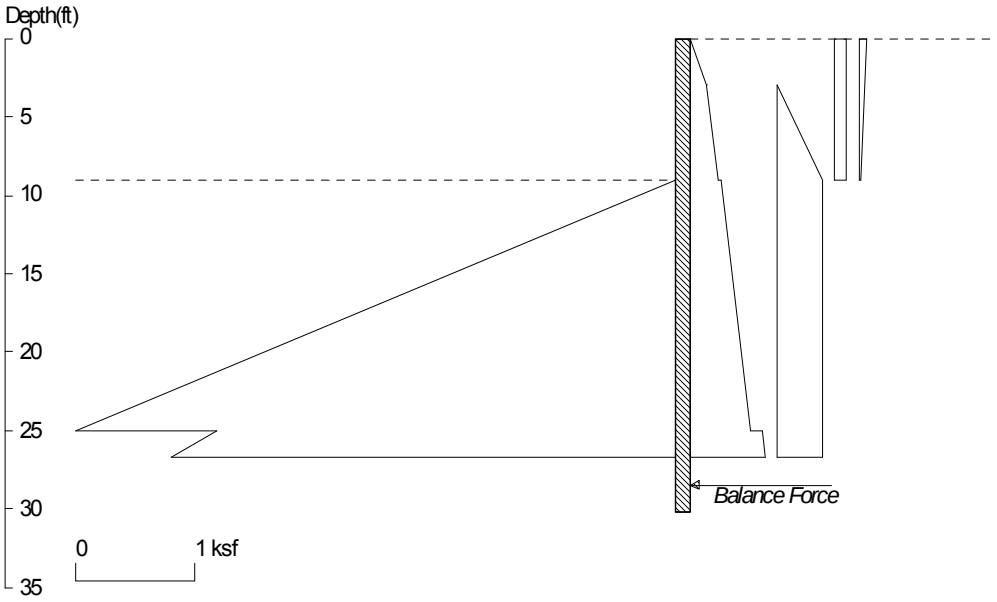


BULKHEAD SHEET PILE WALL SECTION

SK-1

BLAINE HARBOR

Sheet Pile Bulkhead



<ShoringSuite> CIVILTECH SOFTWARE USA www.civiltechsoftware.com

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Date: 8/10/2017 File Name:

Wall Height=9.0 Pile Diameter=1.0 Pile Spacing=1.0 Wall Type: 1. Sheet Pile

PILE LENGTH: Min. Embedment=21.23, Min. Pile Length=30.23
MOMENT IN PILE: Max. Moment=49.83 per Pile Spacing=1.0 at Depth=19.24

PILE SELECTION:
Request Min. Section Modulus = 18.1 in3/feet, Fy= 50 ksi = 345 MPa, Fb/Fy=0.66
-> Piles meet Min. Section Requirements: Top Deflection is shown in (in)
SPZ22 (3.77) CZ113 (3.99) SZ22 (3.16) SPZ23.5 (3.57) 2NRD3 (3.13)
SZ313 (2.60) 2N (2.93) BZ12 (2.73) H116 (2.64) SZ340 (2.39)
BZ12.1L (2.51) SZ350 (2.33) AZ13 (2.01) PZC13 (1.91)

ACTIVE SPACING:	Z depth	Spacing
1	0.00	1.00
2	9.00	1.00

PASSIVE SPACING:	Z depth	Spacing
1	9.00	1.00

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

No.	Z1	P1	Z2	P2	Slope
1	0.0	0.00	3.0	0.13	0.044
2	3.0	0.13	9.0	0.24	0.018
3	9.0	0.25	25.0	0.51	0.016
4	25.0	0.60	26.7	14.53	0.018
5	3.0	0.00	9.0	0.38	0.063
6	9.0	0.38	26.7	0.38	0.000
7	0.0	0.11	9.0	0.11	0.000
8	0.0	0.06	9.0	0.02	-0.005

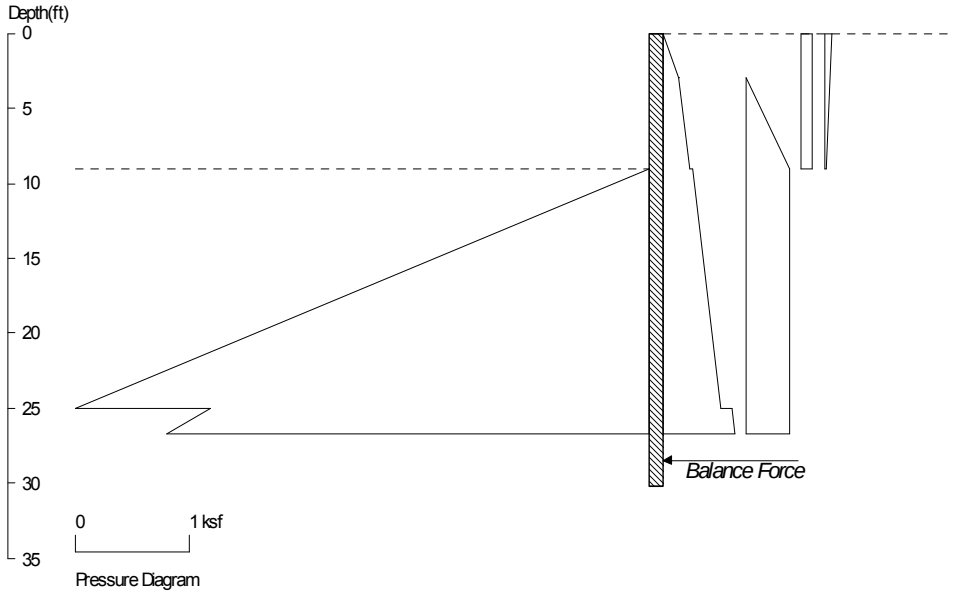
PASSIVE PRESSURES:

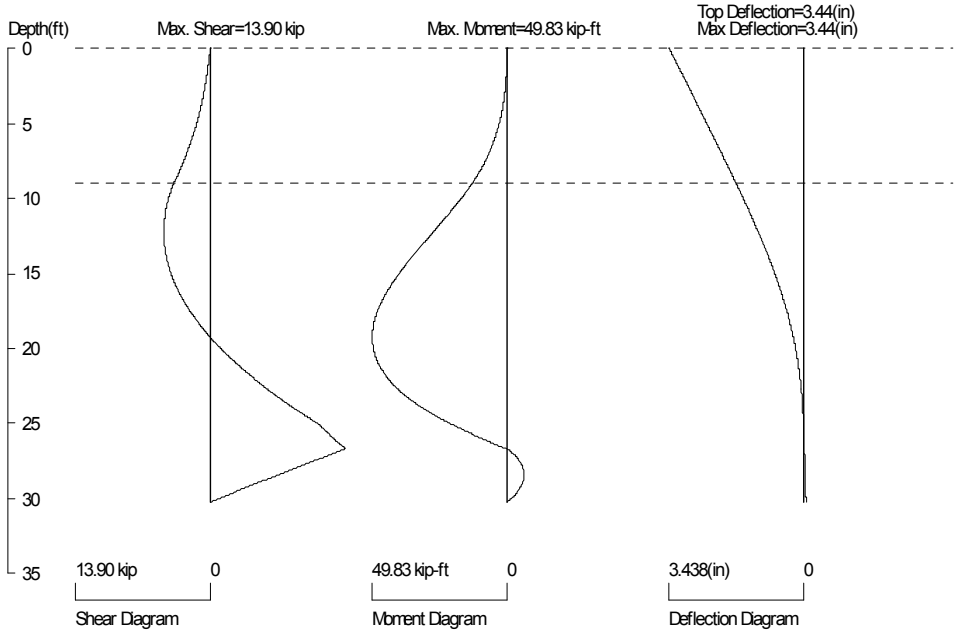
No.	Z1	P1	Z2	P2	Slope
1	9.00	0.00	25.00	5.06	0.3160
2	25.00	3.87	26.69	174.90	0.2207

UNITS: Width/Spacing/Diameter/Length/Depth - ft, Force - kip, Moment - kip-ft,
UNITS: Friction/Bearing/Pressure - ksf, Pres. Slope - kip/ft3, Deflection - in

BLAINE HARBOR

Sheet Pile Bulkhead





PRESSURE, SHEAR, MOMENT, AND DEFLECTION DIAGRAMS

Based on pile spacing: 1.0 feet or meter

User input properties: E (ksi)=29000, I (in4)=84.4

Date: 8/10/2017 File Name: C:\Users\kgalvez\Documents\Blaine Bulkhead\10' Wall - Varying Heights\170720 Blaine Sheetpile - 10' Wall - 3 BGS.sh8

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SHORING WALL CALCULATION SUMMARY
The leading shoring design and calculation software

www.civiltechsoftware.com

****

ShoringSuite Software is developed by CivilTech Software, Bellevue, WA, USA.
The calculation method is based on the following references:

1. FHWA 98-011, FHWA-RD-97-130, FHWA SA 96-069, FHWA-IF-99-015
2. STEEL SHEET PILING DESIGN MANUAL by Pile Buck Inc., 1987
3. DESIGN MANUAL DM-7 (NAVFAC), Department of the Navy, May 1982
4. TRENCHING AND SHORING MANUAL Revision 12, California Department of Transportation, January 2000
6. EARTH SUPPORT SYSTEM & RETAINING STRUCTURES, Pile Buck Inc. 2002
5. DESIGN OF SHEET PILE WALLS, EM 1110-2-2504, U.S. Army Corps of Engineers, 31 March 1994
7. EARTH RETENTION SYSTEMS HANDBOOK, Alan Macnab, McGraw-Hill. 2002
8. AASHTO HB-17, American Association of State and Highway Transportation Officials, 2 September 2002

UNITS: Width/Spacing/Diameter/Length/Depth - ft, Force - kip, Moment - kip-ft, Friction/Bearing/Pressure - ksf, Pres. Slope - kip/ft3, Deflection - in

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Date: 8/10/2017 File: C:\Users\kgalvez\Documents\Blaine Bulkhead\10' Wall - Varying Heights\170720 Blaine Sheetpile - 10' Wall - 3 BGS.sh8

Title: BLAINE HARBOR
Subtitle: Sheet Pile Bulkhead

**********INPUT DATA**********

Wall Type: 1. Sheet Pile
Wall Height: 9.00
Pile Diameter: 1.00
Pile Spacing: 1.00
Factor of Safety (F.S.): 1.50
Max. Moment reduce 20%
Lateral Support Type (Braces): 1. No
Top Brace Increase (Multi-Bracing): Add 15%*
Embedment Option: 1. Yes
Friction at Pile Tip: No*
Pile Properties:
Allowable Fb/Fy: 0.66
Steel Strength, Fy: 50 ksi = 345 MPa
Elastic Module, E: 29000.00
Moment of Inertia, I: 84.40
User Input Pile: PZ22

* DRIVING PRESSURE (ACTIVE, WATER, & SURCHARGE) *

No.	Z2 top	Top Pres.	Z2 bottom	Bottom Pres.	Slope
1	0.00	0.00	3.00	0.13	0.0443
2	3.00	0.13	9.00	0.24	0.0175
3	9.00	0.25	25.00	0.51	0.0160
4	25.00	0.60	800.00	14.53	0.0180
5	3.00	0.00	9.00	0.38	0.0625
6	9.00	0.38	800.00	0.38	0.0000
7	0.00	0.11	9.00	0.11	0.0000
8	0.00	0.06	9.00	0.02	-0.0050

* PASSIVE PRESSURE *

No.	Z1 top	Top Pres.	Z2 bottom	Bottom Pres.	Slope
1	9.00	0.00	25.00	5.06	0.3160
2	25.00	3.87	800.00	174.90	0.2207

The pressure above will be divided by a Factor of Safety =1.5

* ACTIVE SPACE *

No.	Z depth	Spacing
1	0.00	1.00
2	9.00	1.00

* PASSIVE SPACE *

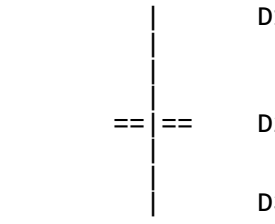
No.	Z depth	Spacing
1	9.00	1.00

*For Tieback: Input1 = Diameter; Input2 = Bond Stength
*For Plate: Input1 = Diameter; Input2 = Allowable Pressure
*For Deaman: Input1 = Horz. Width; Input2 = Allowable Pressure; Angle = 0

**********CALCULATION**********

The calculated moment and shear are per pile spacing. Sheet piles are per one feet or meter; Soldier piles are per pile.

Top Pressures start at depth = 0.00



D1 - TOP DEPTH
D2 - EXCAVATION BASE
D3 - PILE TIP (20% increased, see EMBEDMENT Notes below)

MOMENT BALANCE: M=0.00 AT DEPTH=26.69 WITH EMBEDMENT OF 17.69
FORCE BALANCE: F=0.00 AT DEPTH=30.23 WITH EMBEDMENT OF 21.23
The program calculates embedment for moment equilibrium, then increased by 20% to reach force equilibrium.

Total Passive Pressure = Total Active Pressure, OK!

**********RESULTS**********

* EMBEDMENT Notes *
Based on USS Design Manual, fist calculate embedment for moment equilibrium, then increased by 20 to 40 % to reach force equilibrium.
The embedment for moment equilibrium is 17.69
The 20% increased embedment for force equilibrium is 21.23 (Used by Program)
The 30% increased embedment for force equilibrium is 23.00
The 40% increased embedment for force equilibrium is 24.77

Based on AASHTO Standard Specifications, fist calculate embedment for moment equilibrium, then add safety factor of 30% for temporary shoring; add safety factor of 50% for permanent shoring.
The embedment for moment equilibrium is 17.69
Add 30% embedment for temporary shoring (FS=1.3) is 23.00
Add 50% embedment for permanent shoring (FS=1.5) is 26.54

PROGRAM RECOMMENDED MINIMUM EMBEDMENT = 21.23
TOTAL MINIMUM PILE LENGTH = 30.23

* MOMENT IN PILE (per pile spacing)*
Overall Maximum Moment = 49.83 at 19.24
Maximum Shear = 13.90
Moment and Shear are per pile spacing: 1.0 feet or meter

* VERTICAL LOADING *
Vertical Loading from Braces = 0.00
Vertical Loading from External Load = 0.00
Total Vertical Loading = 0.00

**********SHEET PILE SELECTION**********

Request Min. Section Modulus = 18.1 in3/feet, Fy= 50 ksi = 345 MPa, Fb/Fy=0.66
The pile selection is based on the magnitude of the moment only. Axial force is neglected.
Sx(in3) and Ix(in4) are per one foot of horizontal width of the pile

* Note: The sheet pile properties are in English Units and based on one foot width (even in Metric unit).

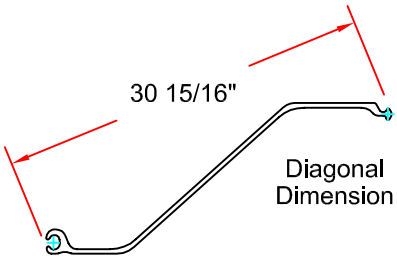
SPZ22 Sx= 18.3 Ix= 77 Weight= 43.28 Top Deflection= 3.77
CZ113 Sx= 18.4 Ix= 72.7 Weight= 41.7 Top Deflection= 3.99
SZ22 Sx= 19.3 Ix= 91.9 Weight= 48.6 Top Deflection= 3.16
SPZ23.5 Sx= 19.3 Ix= 81.2 Weight= 46.76 Top Deflection= 3.57
2NRD3 Sx= 20.1 Ix= 92.7 Weight= 34.43 Top Deflection= 3.13
SZ313 Sx= 20.62 Ix= 111.53 Weight= 40.4 Top Deflection= 2.60
2N Sx= 21.4 Ix= 99 Weight= 36.42 Top Deflection= 2.93
BZ12 Sx= 22.3 Ix= 106.4 Weight= 37.7 Top Deflection= 2.73
H116 Sx= 22.3 Ix= 109.9 Weight= 40.92 Top Deflection= 2.64
SZ340 Sx= 22.4 Ix= 121.45 Weight= 44.1 Top Deflection= 2.39
BZ12.1L Sx= 22.5 Ix= 115.5 Weight= 43.27 Top Deflection= 2.51
SZ350 Sx= 22.96 Ix= 124.62 Weight= 45.3 Top Deflection= 2.33
AZ13 Sx= 24.2 Ix= 144.3 Weight= 21.92 Top Deflection= 2.01
PZC13 Sx= 24.2 Ix= 152 Weight= 50.4 Top Deflection= 1.91

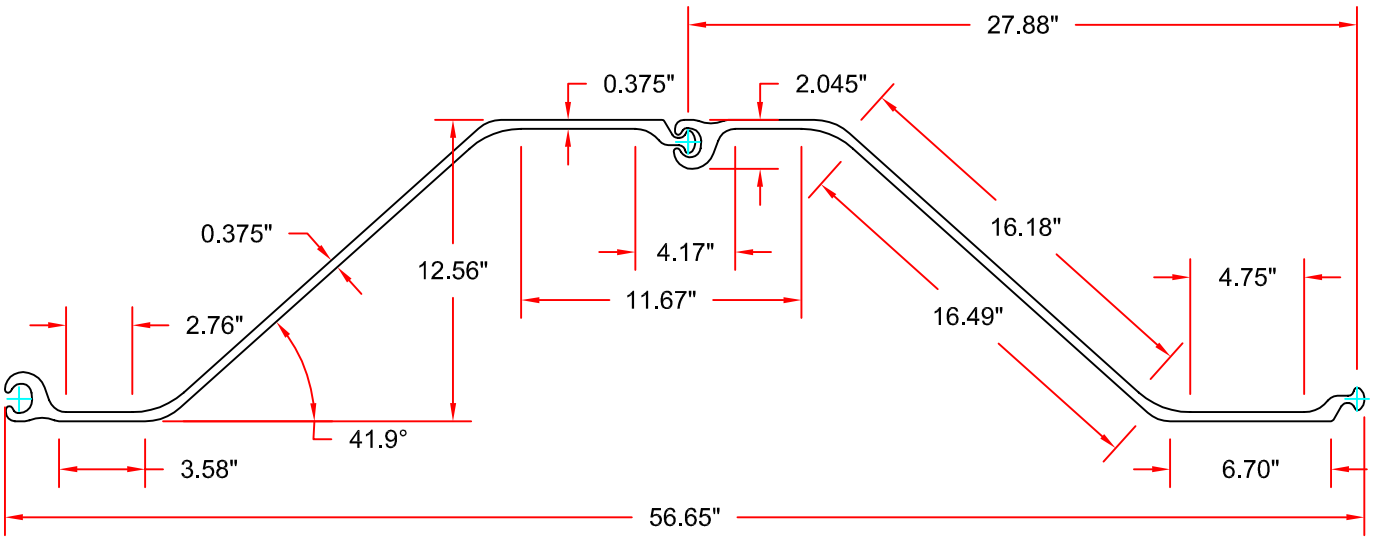
********SHEAR, MOMENT, AND DEFLECTION v.s. DEPTH************

The shear and moment are per single soldier pile (secant/tangent pile) or one foot of sheet pile (concrete wall). The deflection is based on users input pile below:
User Input Pile: PZ22
Elastic Module, E: 29000.00
Moment of Inertia, I: 84.40

No	DEPTH ft	SHEAR kip	MOMENT kip-ft	DEFLECTION in
1	0.00	0.00	0.00	3.438
2	0.04	0.01	0.00	3.431
3	0.08	0.01	0.00	3.424
4	0.11	0.02	0.00	3.416
5	0.15	0.03	0.00	3.409
6	0.19	0.03	0.00	3.402

PZC 13

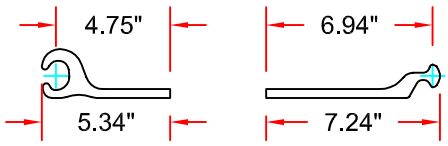




Sheet Pile Section Properties										
Nominal Width (in)	Area (in^2)		Weight (lbs)		Moment of Inertia (in^4)		Section Modulus (in^3)		Surface Area (ft^2 / ft)	
	Single Section	Per Linear Foot of Wall	Per Foot of Sheet	Per Square Foot	Single Section	Per Linear Foot of Wall	Single Section	Per Linear Foot of Wall	Total Area	Nominal Coating Area *
27.88	14.82	6.38	50.4	21.7	353.0	152.0	56.2	24.2	6.10	5.60

* Excludes socket interior & ball of interlock.

Available Material Grades: ASTM A572 Grade 50 and 60, Also A588 and A690.



Flange Dimensions

LBFoster

PILING DIVISION
L.B. FOSTER COMPANY
SUWANEE, GA 30024

TITLE: SHEET PILING DIMENSIONS & PROPERTIES

PROJECT: PZC13 STEEL SHEET PILE

CUSTOMER	N/A			FILE	X:\Pil_Engr\2011\Engr Design Manual\Sheet Pile\#
PROJ #	11-052	SO#	N/A	SP-DC13	0
DRAWN	TWT	DATE	07/29/11		
CHK'D		SCALE	1-1/2"=1'0"	DWG #	SHT 1 of 1 REVISION

REV.	DATE	DESCRIPTION
R0	08/01/11	Issued for Review and Comment.

				report
7	0.23	0.04	0.00	3.395
8	0.27	0.05	0.01	3.387
9	0.30	0.05	0.01	3.380
10	0.34	0.06	0.01	3.373
11	0.38	0.07	0.01	3.366
12	0.42	0.07	0.02	3.358
13	0.45	0.08	0.02	3.351
14	0.49	0.09	0.02	3.344
15	0.53	0.10	0.03	3.337
16	0.57	0.10	0.03	3.329
17	0.61	0.11	0.03	3.322
18	0.64	0.12	0.04	3.315
19	0.68	0.13	0.04	3.308
20	0.72	0.13	0.05	3.300
21	0.76	0.14	0.05	3.293
22	0.80	0.15	0.06	3.286
23	0.83	0.16	0.06	3.279
24	0.87	0.16	0.07	3.271
25	0.91	0.17	0.08	3.264
26	0.95	0.18	0.08	3.257
27	0.98	0.19	0.09	3.250
28	1.02	0.20	0.10	3.242
29	1.06	0.20	0.10	3.235
30	1.10	0.21	0.11	3.228
31	1.14	0.22	0.12	3.221
32	1.17	0.23	0.13	3.213
33	1.21	0.24	0.14	3.206
34	1.25	0.24	0.15	3.199
35	1.29	0.25	0.16	3.192
36	1.33	0.26	0.17	3.185
37	1.36	0.27	0.18	3.177
38	1.40	0.28	0.19	3.170
39	1.44	0.29	0.20	3.163
40	1.48	0.30	0.21	3.156
41	1.51	0.30	0.22	3.148
42	1.55	0.31	0.23	3.141
43	1.59	0.32	0.24	3.134
44	1.63	0.33	0.26	3.127
45	1.67	0.34	0.27	3.119
46	1.70	0.35	0.28	3.112
47	1.74	0.36	0.29	3.105
48	1.78	0.37	0.31	3.098
49	1.82	0.38	0.32	3.090
50	1.86	0.39	0.34	3.083
51	1.89	0.39	0.35	3.076
52	1.93	0.40	0.37	3.069
53	1.97	0.41	0.38	3.061
54	2.01	0.42	0.40	3.054
55	2.04	0.43	0.41	3.047
56	2.08	0.44	0.43	3.040
57	2.12	0.45	0.45	3.032
58	2.16	0.46	0.46	3.025
59	2.20	0.47	0.48	3.018
60	2.23	0.48	0.50	3.011
61	2.27	0.49	0.52	3.003
62	2.31	0.50	0.54	2.996
63	2.35	0.51	0.56	2.989
64	2.39	0.52	0.58	2.982
65	2.42	0.53	0.60	2.974
66	2.46	0.54	0.62	2.967
67	2.50	0.55	0.64	2.960
68	2.54	0.56	0.66	2.953
69	2.58	0.57	0.68	2.945

				report
70	2.61	0.58	0.70	2.938
71	2.65	0.59	0.72	2.931
72	2.69	0.60	0.75	2.924
73	2.73	0.61	0.77	2.916
74	2.76	0.62	0.79	2.909
75	2.80	0.63	0.82	2.902
76	2.84	0.64	0.84	2.895
77	2.88	0.66	0.86	2.888
78	2.92	0.67	0.89	2.880
79	2.95	0.68	0.91	2.873
80	2.99	0.69	0.94	2.866
81	3.03	0.70	0.97	2.859
82	3.07	0.71	0.99	2.851
83	3.11	0.72	1.02	2.844
84	3.14	0.73	1.05	2.837
85	3.18	0.74	1.08	2.830
86	3.22	0.76	1.10	2.822
87	3.26	0.77	1.13	2.815
88	3.29	0.78	1.16	2.808
89	3.33	0.79	1.19	2.801
90	3.37	0.80	1.22	2.793
91	3.41	0.81	1.25	2.786
92	3.45	0.83	1.28	2.779
93	3.48	0.84	1.32	2.772
94	3.52	0.85	1.35	2.765
95	3.56	0.86	1.38	2.757
96	3.60	0.88	1.41	2.750
97	3.64	0.89	1.45	2.743
98	3.67	0.90	1.48	2.736
99	3.71	0.91	1.51	2.728
100	3.75	0.93	1.55	2.721
101	3.79	0.94	1.58	2.714
102	3.82	0.95	1.62	2.707
103	3.86	0.97	1.66	2.699
104	3.90	0.98	1.69	2.692
105	3.94	0.99	1.73	2.685
106	3.98	1.01	1.77	2.678
107	4.01	1.02	1.81	2.671
108	4.05	1.04	1.85	2.663
109	4.09	1.05	1.89	2.656
110	4.13	1.06	1.93	2.649
111	4.17	1.08	1.97	2.642
112	4.20	1.09	2.01	2.634
113	4.24	1.11	2.05	2.627
114	4.28	1.12	2.09	2.620
115	4.32	1.14	2.13	2.613
116	4.35	1.15	2.18	2.606
117	4.39	1.17	2.22	2.598
118	4.43	1.18	2.27	2.591
119	4.47	1.20	2.31	2.584
120	4.51	1.21	2.36	2.577
121	4.54	1.23	2.40	2.570
122	4.58	1.24	2.45	2.562
123	4.62	1.26	2.50	2.555
124	4.66	1.27	2.54	2.548
125	4.70	1.29	2.59	2.541
126	4.73	1.30	2.64	2.533
127	4.77	1.32	2.69	2.526
128	4.81	1.34	2.74	2.519
129	4.85	1.35	2.79	2.512
130	4.89	1.37	2.84	2.505
131	4.92	1.38	2.90	2.497
132	4.96	1.40	2.95	2.490

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133	5.00	1.42	3.00	2.483
134	5.04	1.43	3.06	2.476
135	5.07	1.45	3.11	2.469
136	5.11	1.47	3.17	2.461
137	5.15	1.48	3.22	2.454
138	5.19	1.50	3.28	2.447
139	5.23	1.52	3.34	2.440
140	5.26	1.54	3.39	2.433
141	5.30	1.55	3.45	2.425
142	5.34	1.57	3.51	2.418
143	5.38	1.59	3.57	2.411
144	5.42	1.61	3.63	2.404
145	5.45	1.62	3.69	2.397
146	5.49	1.64	3.75	2.390
147	5.53	1.66	3.82	2.382
148	5.57	1.68	3.88	2.375
149	5.60	1.70	3.94	2.368
150	5.64	1.72	4.01	2.361
151	5.68	1.73	4.07	2.354
152	5.72	1.75	4.14	2.347
153	5.76	1.77	4.21	2.339
154	5.79	1.79	4.27	2.332
155	5.83	1.81	4.34	2.325
156	5.87	1.83	4.41	2.318
157	5.91	1.85	4.48	2.311
158	5.95	1.87	4.55	2.304
159	5.98	1.89	4.62	2.296
160	6.02	1.91	4.69	2.289
161	6.06	1.92	4.77	2.282
162	6.10	1.94	4.84	2.275
163	6.13	1.96	4.91	2.268
164	6.17	1.98	4.99	2.261
165	6.21	2.00	5.06	2.253
166	6.25	2.02	5.14	2.246
167	6.29	2.04	5.22	2.239
168	6.32	2.06	5.30	2.232
169	6.36	2.09	5.37	2.225
170	6.40	2.11	5.45	2.218
171	6.44	2.13	5.53	2.211
172	6.48	2.15	5.61	2.203
173	6.51	2.17	5.70	2.196
174	6.55	2.19	5.78	2.189
175	6.59	2.21	5.86	2.182
176	6.63	2.23	5.95	2.175
177	6.66	2.25	6.03	2.168
178	6.70	2.27	6.12	2.161
179	6.74	2.30	6.20	2.154
180	6.78	2.32	6.29	2.146
181	6.82	2.34	6.38	2.139
182	6.85	2.36	6.47	2.132
183	6.89	2.38	6.56	2.125
184	6.93	2.40	6.65	2.118
185	6.97	2.43	6.74	2.111
186	7.01	2.45	6.83	2.104
187	7.04	2.47	6.93	2.097
188	7.08	2.49	7.02	2.090
189	7.12	2.52	7.11	2.083
190	7.16	2.54	7.21	2.075
191	7.19	2.56	7.31	2.068
192	7.23	2.59	7.40	2.061
193	7.27	2.61	7.50	2.054
194	7.31	2.63	7.60	2.047
195	7.35	2.65	7.70	2.040

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196	7.38	2.68	7.80	2.033
197	7.42	2.70	7.90	2.026
198	7.46	2.72	8.01	2.019
199	7.50	2.75	8.11	2.012
200	7.54	2.77	8.22	2.005
201	7.57	2.80	8.32	1.998
202	7.61	2.82	8.43	1.991
203	7.65	2.84	8.53	1.984
204	7.69	2.87	8.64	1.977
205	7.73	2.89	8.75	1.969
206	7.76	2.92	8.86	1.962
207	7.80	2.94	8.97	1.955
208	7.84	2.97	9.08	1.948
209	7.88	2.99	9.20	1.941
210	7.91	3.02	9.31	1.934
211	7.95	3.04	9.43	1.927
212	7.99	3.07	9.54	1.920
213	8.03	3.09	9.66	1.913
214	8.07	3.12	9.78	1.906
215	8.10	3.14	9.89	1.899
216	8.14	3.17	10.01	1.892
217	8.18	3.19	10.13	1.885
218	8.22	3.22	10.26	1.878
219	8.26	3.24	10.38	1.871
220	8.29	3.27	10.50	1.864
221	8.33	3.30	10.63	1.857
222	8.37	3.32	10.75	1.850
223	8.41	3.35	10.88	1.843
224	8.44	3.38	11.00	1.836
225	8.48	3.40	11.13	1.829
226	8.52	3.43	11.26	1.822
227	8.56	3.45	11.39	1.816
228	8.60	3.48	11.52	1.809
229	8.63	3.51	11.66	1.802
230	8.67	3.54	11.79	1.795
231	8.71	3.56	11.92	1.788
232	8.75	3.59	12.06	1.781
233	8.79	3.62	12.20	1.774
234	8.82	3.64	12.33	1.767
235	8.86	3.67	12.47	1.760
236	8.90	3.70	12.61	1.753
237	8.94	3.73	12.75	1.746
238	8.97	3.76	12.89	1.739
239	9.01	3.78	13.04	1.732
240	9.05	3.81	13.18	1.726
241	9.09	3.83	13.32	1.719
242	9.13	3.85	13.47	1.712
243	9.16	3.87	13.62	1.705
244	9.20	3.90	13.76	1.698
245	9.24	3.92	13.91	1.691
246	9.28	3.94	14.06	1.684
247	9.32	3.96	14.21	1.677
248	9.35	3.98	14.36	1.671
249	9.39	4.01	14.51	1.664
250	9.43	4.03	14.66	1.657
251	9.47	4.05	14.82	1.650
252	9.50	4.07	14.97	1.643
253	9.54	4.09	15.12	1.636
254	9.58	4.11	15.28	1.630
255	9.62	4.13	15.44	1.623
256	9.66	4.15	15.59	1.616
257	9.69	4.16	15.75	1.609
258	9.73	4.18	15.91	1.603

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259	9.77	4.20	16.07	1.596
260	9.81	4.22	16.23	1.589
261	9.85	4.24	16.39	1.582
262	9.88	4.25	16.55	1.575
263	9.92	4.27	16.71	1.569
264	9.96	4.29	16.87	1.562
265	10.00	4.31	17.03	1.555
266	10.04	4.32	17.20	1.548
267	10.07	4.34	17.36	1.542
268	10.11	4.35	17.53	1.535
269	10.15	4.37	17.69	1.528
270	10.19	4.38	17.86	1.522
271	10.22	4.40	18.02	1.515
272	10.26	4.41	18.19	1.508
273	10.30	4.43	18.36	1.502
274	10.34	4.44	18.52	1.495
275	10.38	4.46	18.69	1.488
276	10.41	4.47	18.86	1.482
277	10.45	4.48	19.03	1.475
278	10.49	4.50	19.20	1.468
279	10.53	4.51	19.37	1.462
280	10.57	4.52	19.54	1.455
281	10.60	4.53	19.71	1.448
282	10.64	4.55	19.89	1.442
283	10.68	4.56	20.06	1.435
284	10.72	4.57	20.23	1.429
285	10.75	4.58	20.41	1.422
286	10.79	4.59	20.58	1.415
287	10.83	4.60	20.75	1.409
288	10.87	4.61	20.93	1.402
289	10.91	4.62	21.10	1.396
290	10.94	4.63	21.28	1.389
291	10.98	4.64	21.45	1.383
292	11.02	4.65	21.63	1.376
293	11.06	4.66	21.80	1.369
294	11.10	4.67	21.98	1.363
295	11.13	4.68	22.16	1.356
296	11.17	4.68	22.34	1.350
297	11.21	4.69	22.51	1.343
298	11.25	4.70	22.69	1.337
299	11.28	4.71	22.87	1.331
300	11.32	4.71	23.05	1.324
301	11.36	4.72	23.23	1.318
302	11.40	4.73	23.40	1.311
303	11.44	4.73	23.58	1.305
304	11.47	4.74	23.76	1.298
305	11.51	4.74	23.94	1.292
306	11.55	4.75	24.12	1.286
307	11.59	4.75	24.30	1.279
308	11.63	4.76	24.48	1.273
309	11.66	4.76	24.66	1.266
310	11.70	4.77	24.84	1.260
311	11.74	4.77	25.02	1.254
312	11.78	4.77	25.20	1.247
313	11.81	4.78	25.38	1.241
314	11.85	4.78	25.57	1.235
315	11.89	4.78	25.75	1.228
316	11.93	4.78	25.93	1.222
317	11.97	4.79	26.11	1.216
318	12.00	4.79	26.29	1.209
319	12.04	4.79	26.47	1.203
320	12.08	4.79	26.65	1.197
321	12.12	4.79	26.83	1.191

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322	12.16	4.79	27.02	1.184
323	12.19	4.79	27.20	1.178
324	12.23	4.79	27.38	1.172
325	12.27	4.79	27.56	1.166
326	12.31	4.79	27.74	1.160
327	12.35	4.79	27.92	1.153
328	12.38	4.79	28.10	1.147
329	12.42	4.79	28.29	1.141
330	12.46	4.79	28.47	1.135
331	12.50	4.79	28.65	1.129
332	12.53	4.78	28.83	1.123
333	12.57	4.78	29.01	1.117
334	12.61	4.78	29.19	1.110
335	12.65	4.78	29.37	1.104
336	12.69	4.77	29.55	1.098
337	12.72	4.77	29.73	1.092
338	12.76	4.77	29.92	1.086
339	12.80	4.76	30.10	1.080
340	12.84	4.76	30.28	1.074
341	12.88	4.75	30.46	1.068
342	12.91	4.75	30.64	1.062
343	12.95	4.74	30.82	1.056
344	12.99	4.74	31.00	1.050
345	13.03	4.73	31.17	1.044
346	13.06	4.73	31.35	1.038
347	13.10	4.72	31.53	1.032
348	13.14	4.71	31.71	1.026
349	13.18	4.71	31.89	1.020
350	13.22	4.70	32.07	1.014
351	13.25	4.69	32.25	1.009
352	13.29	4.68	32.42	1.003
353	13.33	4.68	32.60	0.997
354	13.37	4.67	32.78	0.991
355	13.41	4.66	32.95	0.985
356	13.44	4.65	33.13	0.979
357	13.48	4.64	33.31	0.973
358	13.52	4.63	33.48	0.968
359	13.56	4.62	33.66	0.962
360	13.59	4.61	33.83	0.956
361	13.63	4.60	34.01	0.950
362	13.67	4.59	34.18	0.945
363	13.71	4.58	34.35	0.939
364	13.75	4.57	34.53	0.933
365	13.78	4.56	34.70	0.927
366	13.82	4.55	34.87	0.922
367	13.86	4.54	35.05	0.916
368	13.90	4.52	35.22	0.910
369	13.94	4.51	35.39	0.905
370	13.97	4.50	35.56	0.899
371	14.01	4.49	35.73	0.893
372	14.05	4.47	35.90	0.888
373	14.09	4.46	36.07	0.882
374	14.12	4.45	36.24	0.877
375	14.16	4.43	36.40	0.871
376	14.20	4.42	36.57	0.866
377	14.24	4.40	36.74	0.860
378	14.28	4.39	36.91	0.855
379	14.31	4.37	37.07	0.849
380	14.35	4.36	37.24	0.844
381	14.39	4.34	37.40	0.838
382	14.43	4.33	37.57	0.833
383	14.47	4.31	37.73	0.827
384	14.50	4.29	37.89	0.822

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385	14.54	4.28	38.05	0.816
386	14.58	4.26	38.22	0.811
387	14.62	4.24	38.38	0.806
388	14.66	4.22	38.54	0.800
389	14.69	4.21	38.70	0.795
390	14.73	4.19	38.86	0.789
391	14.77	4.17	39.01	0.784
392	14.81	4.15	39.17	0.779
393	14.84	4.13	39.33	0.774
394	14.88	4.11	39.48	0.768
395	14.92	4.09	39.64	0.763
396	14.96	4.07	39.79	0.758
397	15.00	4.05	39.95	0.753
398	15.03	4.03	40.10	0.747
399	15.07	4.01	40.25	0.742
400	15.11	3.99	40.40	0.737
401	15.15	3.97	40.56	0.732
402	15.19	3.95	40.71	0.727
403	15.22	3.93	40.85	0.722
404	15.26	3.90	41.00	0.716
405	15.30	3.88	41.15	0.711
406	15.34	3.86	41.30	0.706
407	15.37	3.83	41.44	0.701
408	15.41	3.81	41.59	0.696
409	15.45	3.79	41.73	0.691
410	15.49	3.76	41.87	0.686
411	15.53	3.74	42.02	0.681
412	15.56	3.72	42.16	0.676
413	15.60	3.69	42.30	0.671
414	15.64	3.67	42.44	0.666
415	15.68	3.64	42.57	0.661
416	15.72	3.62	42.71	0.656
417	15.75	3.59	42.85	0.652
418	15.79	3.56	42.98	0.647
419	15.83	3.54	43.12	0.642
420	15.87	3.51	43.25	0.637
421	15.90	3.48	43.38	0.632
422	15.94	3.46	43.52	0.627
423	15.98	3.43	43.65	0.623
424	16.02	3.40	43.78	0.618
425	16.06	3.37	43.90	0.613
426	16.09	3.34	44.03	0.608
427	16.13	3.32	44.16	0.604
428	16.17	3.29	44.28	0.599
429	16.21	3.26	44.41	0.594
430	16.25	3.23	44.53	0.590
431	16.28	3.20	44.65	0.585
432	16.32	3.17	44.77	0.580
433	16.36	3.14	44.89	0.576
434	16.40	3.11	45.01	0.571
435	16.43	3.08	45.13	0.566
436	16.47	3.05	45.24	0.562
437	16.51	3.02	45.36	0.557
438	16.55	2.98	45.47	0.553
439	16.59	2.95	45.58	0.548
440	16.62	2.92	45.69	0.544
441	16.66	2.89	45.80	0.539
442	16.70	2.85	45.91	0.535
443	16.74	2.82	46.02	0.531
444	16.78	2.79	46.13	0.526
445	16.81	2.75	46.23	0.522
446	16.85	2.72	46.33	0.517
447	16.89	2.69	46.44	0.513

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448	16.93	2.65	46.54	0.509
449	16.97	2.62	46.64	0.504
450	17.00	2.58	46.74	0.500
451	17.04	2.55	46.83	0.496
452	17.08	2.51	46.93	0.492
453	17.12	2.48	47.02	0.487
454	17.15	2.44	47.12	0.483
455	17.19	2.40	47.21	0.479
456	17.23	2.37	47.30	0.475
457	17.27	2.33	47.39	0.471
458	17.31	2.29	47.48	0.466
459	17.34	2.25	47.56	0.462
460	17.38	2.22	47.65	0.458
461	17.42	2.18	47.73	0.454
462	17.46	2.14	47.81	0.450
463	17.50	2.10	47.89	0.446
464	17.53	2.06	47.97	0.442
465	17.57	2.02	48.05	0.438
466	17.61	1.98	48.12	0.434
467	17.65	1.94	48.20	0.430
468	17.68	1.90	48.27	0.426
469	17.72	1.86	48.34	0.422
470	17.76	1.82	48.41	0.418
471	17.80	1.78	48.48	0.414
472	17.84	1.74	48.55	0.410
473	17.87	1.70	48.61	0.407
474	17.91	1.66	48.68	0.403
475	17.95	1.62	48.74	0.399
476	17.99	1.57	48.80	0.395
477	18.03	1.53	48.86	0.391
478	18.06	1.49	48.91	0.388
479	18.10	1.45	48.97	0.384
480	18.14	1.40	49.02	0.380
481	18.18	1.36	49.08	0.377
482	18.21	1.31	49.13	0.373
483	18.25	1.27	49.18	0.369
484	18.29	1.23	49.22	0.366
485	18.33	1.18	49.27	0.362
486	18.37	1.14	49.31	0.358
487	18.40	1.09	49.35	0.355
488	18.44	1.05	49.39	0.351
489	18.48	1.00	49.43	0.348
490	18.52	0.95	49.47	0.344
491	18.56	0.91	49.51	0.341
492	18.59	0.86	49.54	0.337
493	18.63	0.81	49.57	0.334
494	18.67	0.77	49.60	0.330
495	18.71	0.72	49.63	0.327
496	18.74	0.67	49.65	0.324
497	18.78	0.62	49.68	0.320
498	18.82	0.57	49.70	0.317
499	18.86	0.53	49.72	0.313
500	18.90	0.48	49.74	0.310
501	18.93	0.43	49.76	0.307
502	18.97	0.38	49.77	0.304
503	19.01	0.33	49.79	0.300
504	19.05	0.28	49.80	0.297
505	19.09	0.23	49.81	0.294
506	19.12	0.18	49.82	0.291
507	19.16	0.13	49.82	0.288
508	19.20	0.07	49.83	0.284
509	19.24	0.02	49.83	0.281
510	19.28	-0.03	49.83	0.278

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511	19.31	-0.08	49.83	0.275
512	19.35	-0.13	49.82	0.272
513	19.39	-0.19	49.82	0.269
514	19.43	-0.24	49.81	0.266
515	19.46	-0.29	49.80	0.263
516	19.50	-0.35	49.78	0.260
517	19.54	-0.40	49.77	0.257
518	19.58	-0.45	49.75	0.254
519	19.62	-0.51	49.74	0.251
520	19.65	-0.56	49.72	0.248
521	19.69	-0.62	49.69	0.245
522	19.73	-0.67	49.67	0.242
523	19.77	-0.73	49.64	0.240
524	19.81	-0.78	49.61	0.237
525	19.84	-0.84	49.58	0.234
526	19.88	-0.89	49.55	0.231
527	19.92	-0.95	49.52	0.228
528	19.96	-1.01	49.48	0.226
529	19.99	-1.07	49.44	0.223
530	20.03	-1.12	49.40	0.220
531	20.07	-1.18	49.35	0.218
532	20.11	-1.24	49.31	0.215
533	20.15	-1.30	49.26	0.212
534	20.18	-1.35	49.21	0.210
535	20.22	-1.41	49.16	0.207
536	20.26	-1.47	49.10	0.204
537	20.30	-1.53	49.05	0.202
538	20.34	-1.59	48.99	0.199
539	20.37	-1.65	48.93	0.197
540	20.41	-1.71	48.86	0.194
541	20.45	-1.77	48.80	0.192
542	20.49	-1.83	48.73	0.189
543	20.52	-1.89	48.66	0.187
544	20.56	-1.95	48.59	0.184
545	20.60	-2.02	48.51	0.182
546	20.64	-2.08	48.43	0.180
547	20.68	-2.14	48.35	0.177
548	20.71	-2.20	48.27	0.175
549	20.75	-2.26	48.19	0.173
550	20.79	-2.33	48.10	0.170
551	20.83	-2.39	48.01	0.168
552	20.87	-2.45	47.92	0.166
553	20.90	-2.52	47.82	0.163
554	20.94	-2.58	47.73	0.161
555	20.98	-2.65	47.63	0.159
556	21.02	-2.71	47.53	0.157
557	21.05	-2.78	47.42	0.155
558	21.09	-2.84	47.32	0.152
559	21.13	-2.91	47.21	0.150
560	21.17	-2.97	47.10	0.148
561	21.21	-3.04	46.98	0.146
562	21.24	-3.10	46.87	0.144
563	21.28	-3.17	46.75	0.142
564	21.32	-3.24	46.63	0.140
565	21.36	-3.30	46.50	0.138
566	21.40	-3.37	46.38	0.136
567	21.43	-3.44	46.25	0.134
568	21.47	-3.51	46.12	0.132
569	21.51	-3.58	45.98	0.130
570	21.55	-3.64	45.84	0.128
571	21.59	-3.71	45.70	0.126
572	21.62	-3.78	45.56	0.124
573	21.66	-3.85	45.42	0.122

				report
574	21.70	-3.92	45.27	0.120
575	21.74	-3.99	45.12	0.119
576	21.77	-4.06	44.97	0.117
577	21.81	-4.13	44.81	0.115
578	21.85	-4.20	44.66	0.113
579	21.89	-4.27	44.50	0.111
580	21.93	-4.34	44.33	0.110
581	21.96	-4.42	44.17	0.108
582	22.00	-4.49	44.00	0.106
583	22.04	-4.56	43.83	0.105
584	22.08	-4.63	43.65	0.103
585	22.12	-4.71	43.48	0.101
586	22.15	-4.78	43.30	0.100
587	22.19	-4.85	43.11	0.098
588	22.23	-4.93	42.93	0.096
589	22.27	-5.00	42.74	0.095
590	22.30	-5.07	42.55	0.093
591	22.34	-5.15	42.36	0.092
592	22.38	-5.22	42.16	0.090
593	22.42	-5.30	41.96	0.089
594	22.46	-5.37	41.76	0.087
595	22.49	-5.45	41.55	0.086
596	22.53	-5.52	41.35	0.084
597	22.57	-5.60	41.14	0.083
598	22.61	-5.68	40.92	0.081
599	22.65	-5.75	40.71	0.080
600	22.68	-5.83	40.49	0.079
601	22.72	-5.91	40.26	0.077
602	22.76	-5.98	40.04	0.076
603	22.80	-6.06	39.81	0.074
604	22.83	-6.14	39.58	0.073
605	22.87	-6.22	39.35	0.072
606	22.91	-6.30	39.11	0.070
607	22.95	-6.38	38.87	0.069
608	22.99	-6.45	38.63	0.068
609	23.02	-6.53	38.38	0.067
610	23.06	-6.61	38.13	0.065
611	23.10	-6.69	37.88	0.064
612	23.14	-6.77	37.62	0.063
613	23.18	-6.85	37.37	0.062
614	23.21	-6.93	37.11	0.061
615	23.25	-7.02	36.84	0.059
616	23.29	-7.10	36.57	0.058
617	23.33	-7.18	36.30	0.057
618	23.36	-7.26	36.03	0.056
619	23.40	-7.34	35.75	0.055
620	23.44	-7.43	35.47	0.054
621	23.48	-7.51	35.19	0.053
622	23.52	-7.59	34.91	0.052
623	23.55	-7.67	34.62	0.051
624	23.59	-7.76	34.32	0.050
625	23.63	-7.84	34.03	0.049
626	23.67	-7.93	33.73	0.048
627	23.71	-8.01	33.43	0.047
628	23.74	-8.10	33.12	0.046
629	23.78	-8.18	32.82	0.045
630	23.82	-8.27	32.50	0.044
631	23.86	-8.35	32.19	0.043
632	23.90	-8.44	31.87	0.042
633	23.93	-8.52	31.55	0.041
634	23.97	-8.61	31.23	0.040
635	24.01	-8.70	30.90	0.039
636	24.05	-8.78	30.57	0.038

				report
637	24.08	-8.87	30.23	0.038
638	24.12	-8.96	29.90	0.037
639	24.16	-9.05	29.56	0.036
640	24.20	-9.13	29.21	0.035
641	24.24	-9.22	28.86	0.034
642	24.27	-9.31	28.51	0.033
643	24.31	-9.40	28.16	0.033
644	24.35	-9.49	27.80	0.032
645	24.39	-9.58	27.44	0.031
646	24.43	-9.67	27.08	0.030
647	24.46	-9.76	26.71	0.030
648	24.50	-9.85	26.34	0.029
649	24.54	-9.94	25.96	0.028
650	24.58	-10.03	25.58	0.027
651	24.61	-10.12	25.20	0.027
652	24.65	-10.21	24.82	0.026
653	24.69	-10.30	24.43	0.025
654	24.73	-10.39	24.04	0.025
655	24.77	-10.49	23.64	0.024
656	24.80	-10.58	23.24	0.023
657	24.84	-10.67	22.84	0.023
658	24.88	-10.77	22.43	0.022
659	24.92	-10.86	22.02	0.022
660	24.96	-10.95	21.61	0.021
661	24.99	-11.05	21.20	0.020
662	25.03	-11.11	20.78	0.020
663	25.07	-11.17	20.35	0.019
664	25.11	-11.24	19.93	0.019
665	25.14	-11.30	19.50	0.018
666	25.18	-11.36	19.07	0.017
667	25.22	-11.42	18.64	0.017
668	25.26	-11.48	18.21	0.016
669	25.30	-11.54	17.77	0.016
670	25.33	-11.61	17.33	0.015
671	25.37	-11.67	16.89	0.015
672	25.41	-11.73	16.45	0.014
673	25.45	-11.79	16.01	0.014
674	25.49	-11.86	15.56	0.013
675	25.52	-11.92	15.11	0.013
676	25.56	-11.98	14.65	0.012
677	25.60	-12.05	14.20	0.012
678	25.64	-12.11	13.74	0.011
679	25.67	-12.17	13.28	0.011
680	25.71	-12.24	12.82	0.010
681	25.75	-12.30	12.36	0.010
682	25.79	-12.37	11.89	0.009
683	25.83	-12.43	11.42	0.009
684	25.86	-12.50	10.95	0.009
685	25.90	-12.56	10.47	0.008
686	25.94	-12.63	10.00	0.008
687	25.98	-12.69	9.52	0.007
688	26.02	-12.76	9.03	0.007
689	26.05	-12.82	8.55	0.006
690	26.09	-12.89	8.06	0.006
691	26.13	-12.96	7.57	0.006
692	26.17	-13.02	7.08	0.005
693	26.20	-13.09	6.59	0.005
694	26.24	-13.15	6.09	0.004
695	26.28	-13.22	5.59	0.004
696	26.32	-13.29	5.09	0.004
697	26.36	-13.36	4.59	0.003
698	26.39	-13.42	4.08	0.003
699	26.43	-13.49	3.57	0.002

				report
700	26.47	-13.56	3.06	0.002
701	26.51	-13.63	2.54	0.002
702	26.55	-13.69	2.02	0.001
703	26.58	-13.76	1.50	0.001
704	26.62	-13.83	0.98	0.000
705	26.66	-13.90	0.46	0.000
706	26.70	-13.75	-0.26	0.000
707	26.74	-13.60	-0.52	-0.001
708	26.77	-13.45	-0.77	-0.001
709	26.81	-13.31	-1.01	-0.002
710	26.85	-13.16	-1.25	-0.002
711	26.89	-13.01	-1.49	-0.002
712	26.92	-12.86	-1.71	-0.003
713	26.96	-12.71	-1.93	-0.003
714	27.00	-12.56	-2.15	-0.004
715	27.04	-12.41	-2.36	-0.004
716	27.08	-12.27	-2.57	-0.004
717	27.11	-12.12	-2.77	-0.005
718	27.15	-11.97	-2.96	-0.005
719	27.19	-11.82	-3.15	-0.005
720	27.23	-11.67	-3.33	-0.006
721	27.27	-11.52	-3.51	-0.006
722	27.30	-11.37	-3.68	-0.007
723	27.34	-11.23	-3.84	-0.007
724	27.38	-11.08	-4.00	-0.007
725	27.42	-10.93	-4.16	-0.008
726	27.45	-10.78	-4.31	-0.008
727	27.49	-10.63	-4.45	-0.009
728	27.53	-10.48	-4.59	-0.009
729	27.57	-10.33	-4.72	-0.010
730	27.61	-10.18	-4.84	-0.010
731	27.64	-10.04	-4.96	-0.010
732	27.68	-9.89	-5.08	-0.011
733	27.72	-9.74	-5.19	-0.011
734	27.76	-9.59	-5.29	-0.012
735	27.80	-9.44	-5.39	-0.012
736	27.83	-9.29	-5.48	-0.013
737	27.87	-9.14	-5.57	-0.013
738	27.91	-9.00	-5.65	-0.013
739	27.95	-8.85	-5.72	-0.014
740	27.98	-8.70	-5.79	-0.014
741	28.02	-8.55	-5.85	-0.015
742	28.06	-8.40	-5.91	-0.015
743	28.10	-8.25	-5.96	-0.016
744	28.14	-8.10	-6.01	-0.016
745	28.17	-7.96	-6.05	-0.016
746	28.21	-7.81	-6.09	-0.017
747	28.25	-7.66	-6.12	-0.017
748	28.29	-7.51	-6.14	-0.018
749	28.33	-7.36	-6.16	-0.018
750	28.36	-7.21	-6.17	-0.019
751	28.40	-7.06	-6.18	-0.019
752	28.44	-6.92	-6.18	-0.020
753	28.48	-6.77	-6.17	-0.020
754	28.51	-6.62	-6.16	-0.021
755	28.55	-6.47	-6.15	-0.021
756	28.59	-6.32	-6.13	-0.022
757	28.63	-6.17	-6.10	-0.022
758	28.67	-6.02	-6.07	-0.023
759	28.70	-5.88	-6.03	-0.023
760	28.74	-5.73	-5.98	-0.024
761	28.78	-5.58	-5.93	-0.024
762	28.82	-5.43	-5.88	-0.025

				report
763	28.86	-5.28	-5.82	-0.025
764	28.89	-5.13	-5.75	-0.026
765	28.93	-4.98	-5.68	-0.026
766	28.97	-4.84	-5.60	-0.027
767	29.01	-4.69	-5.52	-0.027
768	29.05	-4.54	-5.43	-0.028
769	29.08	-4.39	-5.33	-0.028
770	29.12	-4.24	-5.23	-0.029
771	29.16	-4.09	-5.13	-0.029
772	29.20	-3.94	-5.01	-0.030
773	29.23	-3.79	-4.90	-0.030
774	29.27	-3.65	-4.77	-0.031
775	29.31	-3.50	-4.64	-0.031
776	29.35	-3.35	-4.51	-0.032
777	29.39	-3.20	-4.37	-0.032
778	29.42	-3.05	-4.22	-0.033
779	29.46	-2.90	-4.07	-0.033
780	29.50	-2.75	-3.91	-0.034
781	29.54	-2.61	-3.75	-0.034
782	29.58	-2.46	-3.58	-0.035
783	29.61	-2.31	-3.41	-0.035
784	29.65	-2.16	-3.23	-0.036
785	29.69	-2.01	-3.04	-0.036
786	29.73	-1.86	-2.85	-0.037
787	29.76	-1.71	-2.66	-0.037
788	29.80	-1.57	-2.45	-0.038
789	29.84	-1.42	-2.24	-0.039
790	29.88	-1.27	-2.03	-0.039
791	29.92	-1.12	-1.81	-0.040
792	29.95	-0.97	-1.59	-0.040
793	29.99	-0.82	-1.36	-0.041
794	30.03	-0.67	-1.12	-0.041
795	30.07	-0.53	-0.88	-0.042
796	30.11	-0.38	-0.63	-0.042
797	30.14	-0.23	-0.38	-0.043
798	30.18	-0.08	-0.12	-0.043
799	30.22	0.07	0.15	-0.044

The above data can be selected using mouse, then copy and paste into Excel to create graphics

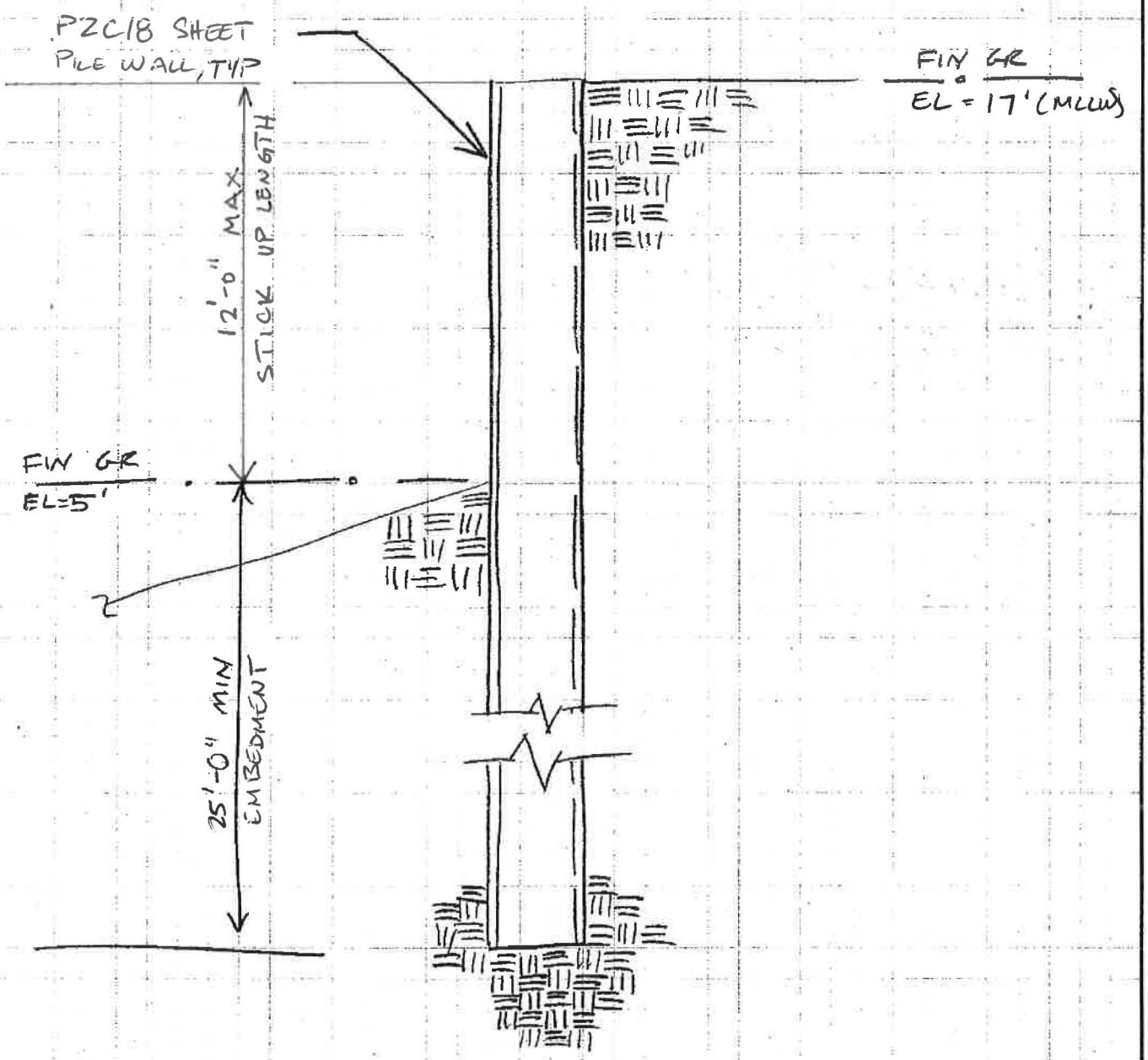
Reid Middleton

Client LANDAU
Project BLAINE HARBOR BULKHEAD
Project No. 242017.002

Sheet ____ of ____
Design by KMG
Date 8/2017
Checked by JAP
Date 8/11/17

12' HIGH STICK UP SHEET PILE WALL

Temporary Bulkhead

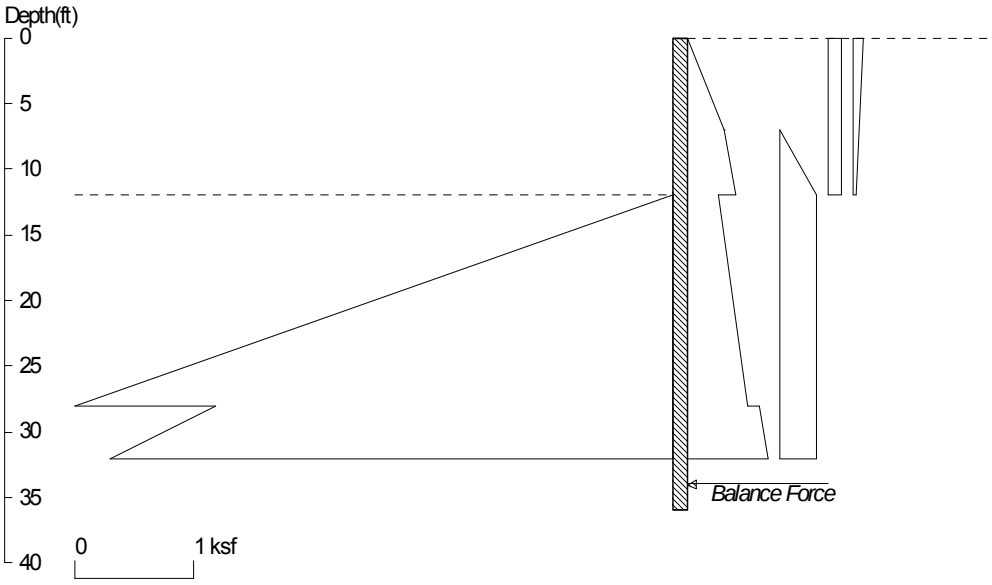


BULKHEAD SHEET PILE WALL SECTION

SK-2

BLAINE HARBOR

Sheet Pile Bulkhead



Licensed to 4324324234 3424343
Date: 8/10/2017 File Name:

Wall Height=12.0 Pile Diameter=1.0 Pile Spacing=1.0 Wall Type: 1. Sheet Pile

PILE LENGTH: Min. Embedment=24.02, Min. Pile Length=36.02
MOMENT IN PILE: Max. Moment=79.00 per Pile Spacing=1.0 at Depth=23.04

PILE SELECTION:
Request Min. Section Modulus = 28.7 in3/feet, Fy= 50 ksi = 345 MPa, Fb/Fy=0.66
-> Piles meet Min. Section Requirements: Top Deflection is shown in (in)
SZ24 (3.48) SZ24A (3.32) SZ25 (3.41) CZ114RD (3.11) 3N(M) (3.69)
PZ27 (3.37) PLZ23 (3.04) BZ16.4 (3.44) RZ10 (3.60) 134N (3.42)
PZ27 (3.31) BZ17 (3.37) SPZ23 (2.97) 3NA (3.30)

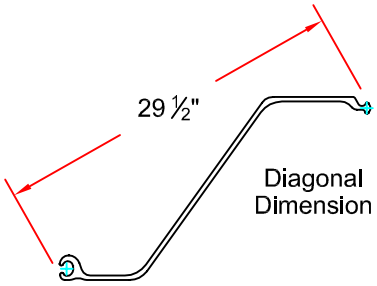
ACTIVE SPACING:	Z depth	Spacing
1	0.00	1.00
2	12.00	1.00

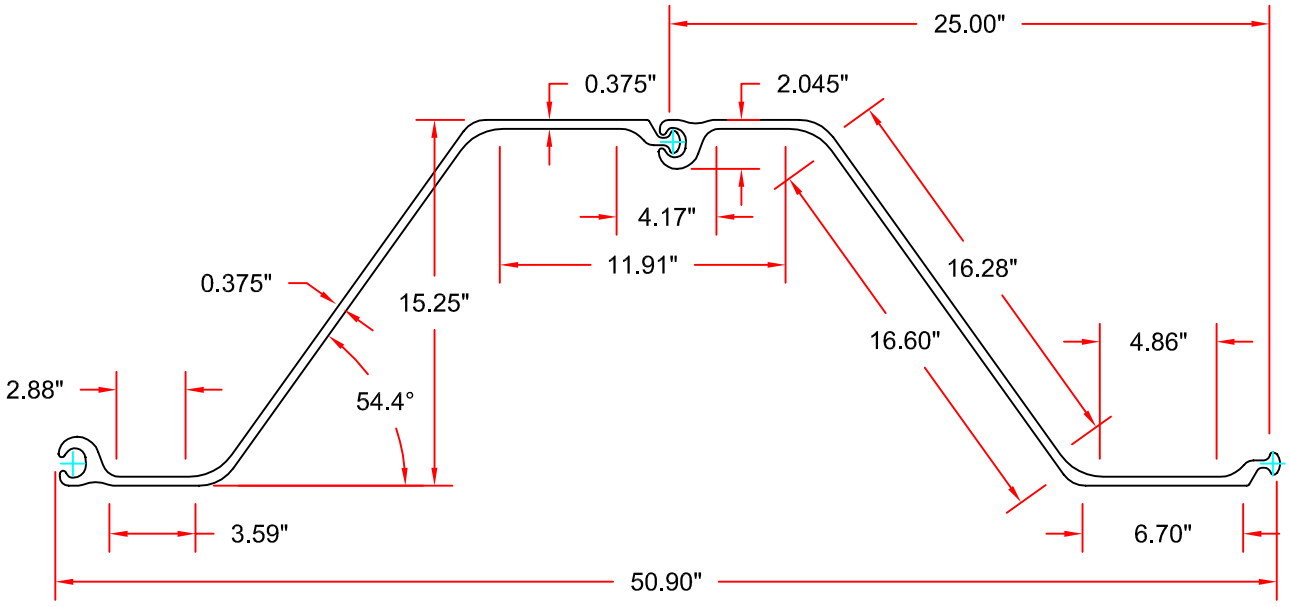
PASSIVE SPACING:	Z depth	Spacing
1	12.00	1.00

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

No.	Z1	P1	Z2	P2	Slope
1	0.0	0.00	7.0	0.31	0.044
2	7.0	0.31	12.0	0.41	0.021
3	12.0	0.25	28.0	0.51	0.016
4	28.0	0.60	32.0	14.53	0.018
5	7.0	0.00	12.0	0.31	0.063
6	12.0	0.31	32.0	0.31	0.000
7	0.0	0.11	12.0	0.11	0.000
8	0.0	0.08	12.0	0.02	-0.005

PZC 18

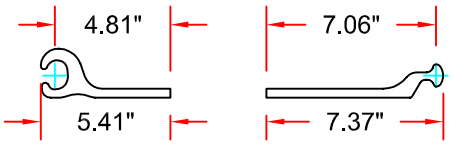




Sheet Pile Section Properties										
Nominal Width (in)	Area (in^2)		Weight (lbs)		Moment of Inertia (in^4)		Section Modulus (in^3)		Surface Area (ft^2 / ft)	
	Single Section	Per Linear Foot of Wall	Per Foot of Sheet	Per Square Foot	Single Section	Per Linear Foot of Wall	Single Section	Per Linear Foot of Wall	Total Area	Nominal Coating Area *
25.00	14.82	7.12	50.4	24.2	532.2	255.5	69.8	33.5	6.10	5.60

* Excludes socket interior & ball of interlock.

Available Material Grades: ASTM A572 Grade 50 and 60, Also A588 and A690.



Flange Dimensions

LBFoster

PILING DIVISION
L.B. FOSTER COMPANY
SUWANEE, GA 30024

TITLE: SHEET PILING DIMENSIONS & PROPERTIES

PROJECT: PZC18 STEEL SHEET PILE

CUSTOMER	N/A			FILE	X:\PIL_Engr\Engr Design Manual\Sheet Pile\
PROJ #	11-052	SO#	N/A	SP-DC18	0
DRAWN	TWT	DATE	07/29/11		
CHK'D		SCALE	1-1/2"=1'0"	DWG #	SHT 1 of 1 REVISION

REV.	DATE	DESCRIPTION
R0	08/01/11	Issued for Review and Comment.

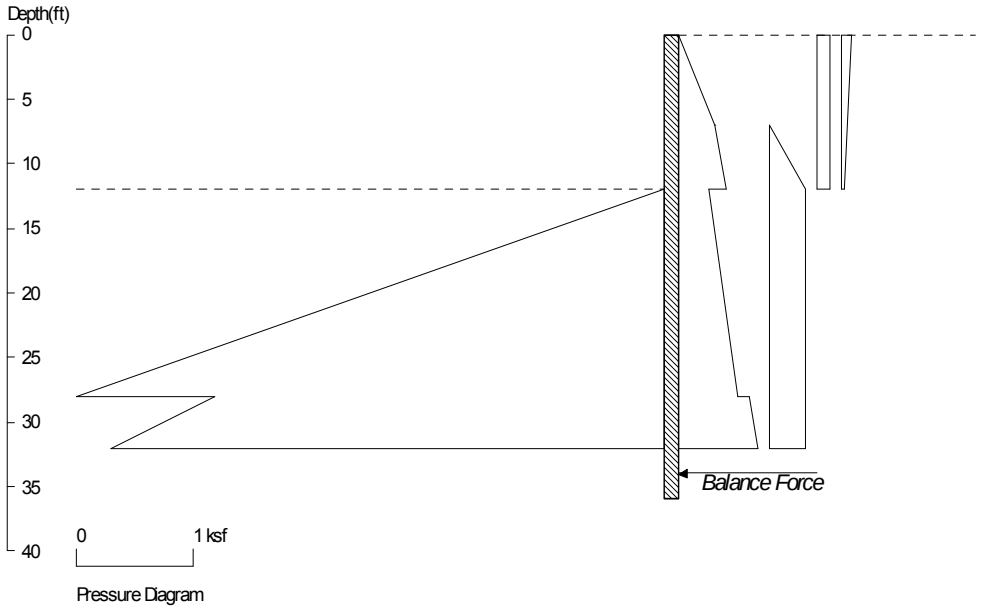
PASSIVE PRESSURES:

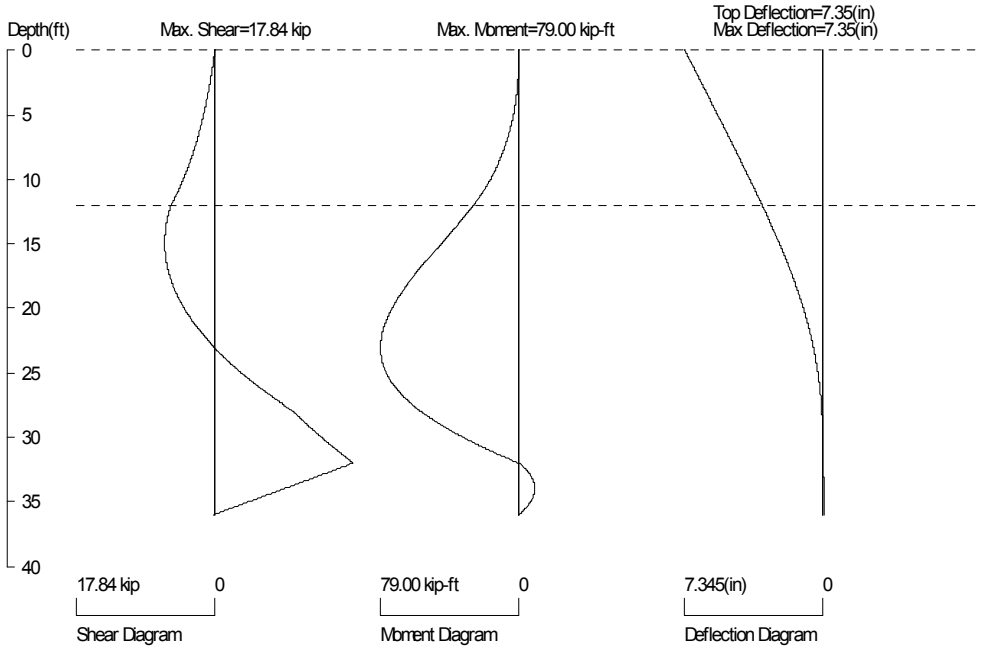
No.	Z1	P1	Z2	P2	Slope
1	12.00	0.00	28.00	5.06	0.3160
2	28.00	3.87	32.01	174.90	0.2215

UNITS: Width/Spacing/Diameter/Length/Depth - ft, Force - kip, Moment - kip-ft,
UNITS: Friction/Bearing/Pressure - ksf, Pres. Slope - kip/ft3, Deflection - in

BLAINE HARBOR

Sheet Pile Bulkhead





PRESSURE, SHEAR, MOMENT, AND DEFLECTION DIAGRAMS

Based on pile spacing: 1.0 feet or meter

User input properties: E (ksi)=29000, I (in4)=84.4

Date: 8/10/2017 File Name: C:\Users\kgalvez\Documents\Blaine Bulkhead\170720 Blaine Sheetpile - 12' Wall.sh8

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SHORING WALL CALCULATION SUMMARY
The leading shoring design and calculation software

www.civiltechsoftware.com

****

ShoringSuite Software is developed by CivilTech Software, Bellevue, WA, USA.
The calculation method is based on the following references:

1. FHWA 98-011, FHWA-RD-97-130, FHWA SA 96-069, FHWA-IF-99-015
2. STEEL SHEET PILING DESIGN MANUAL by Pile Buck Inc., 1987
3. DESIGN MANUAL DM-7 (NAVFAC), Department of the Navy, May 1982
4. TRENCHING AND SHORING MANUAL Revision 12, California Department of Transportation, January 2000
6. EARTH SUPPORT SYSTEM & RETAINING STRUCTURES, Pile Buck Inc. 2002
5. DESIGN OF SHEET PILE WALLS, EM 1110-2-2504, U.S. Army Corps of Engineers, 31 March 1994
7. EARTH RETENTION SYSTEMS HANDBOOK, Alan Macnab, McGraw-Hill. 2002
8. AASHTO HB-17, American Association of State and Highway Transportation Officials, 2 September 2002

UNITS: Width/Spacing/Diameter/Length/Depth - ft, Force - kip, Moment - kip-ft, Friction/Bearing/Pressure - ksf, Pres. Slope - kip/ft3, Deflection - in

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Date: 8/10/2017 File: C:\Users\kgalvez\Documents\Blaine Bulkhead\170720 Blaine Sheetpile - 12' Wall.sh8

Title: BLAINE HARBOR
Subtitle: Sheet Pile Bulkhead

**********INPUT DATA**********

Wall Type: 1. Sheet Pile
Wall Height: 12.00
Pile Diameter: 1.00
Pile Spacing: 1.00
Factor of Safety (F.S.): 1.50
Max. Moment reduce 20%
Lateral Support Type (Braces): 1. No
Top Brace Increase (Multi-Bracing): Add 15%*
Embedment Option: 1. Yes
Friction at Pile Tip: No*
Pile Properties:
Allowable Fb/Fy: 0.66
Steel Strength, Fy: 50 ksi = 345 MPa
Elastic Module, E: 29000.00
Moment of Inertia, I: 84.40
User Input Pile: PZ22

* DRIVING PRESSURE (ACTIVE, WATER, & SURCHARGE) *

No.	Z2 top	Top Pres.	Z2 bottom	Bottom Pres.	Slope
1	0.00	0.00	7.00	0.31	0.0443
2	7.00	0.31	12.00	0.41	0.0210
3	12.00	0.25	28.00	0.51	0.0160
4	28.00	0.60	800.00	14.53	0.0180
5	7.00	0.00	12.00	0.31	0.0626
6	12.00	0.31	800.00	0.31	0.0000
7	0.00	0.11	12.00	0.11	0.0000
8	0.00	0.08	12.00	0.02	-0.0050

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* PASSIVE PRESSURE *

No.	Z1 top	Top Pres.	Z2 bottom	Bottom Pres.	Slope
1	12.00	0.00	28.00	5.06	0.3160
2	28.00	3.87	800.00	174.90	0.2215

The pressure above will be divided by a Factor of Safety =1.5

* ACTIVE SPACE *

No.	Z depth	Spacing
1	0.00	1.00
2	12.00	1.00

* PASSIVE SPACE *

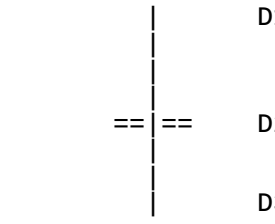
No.	Z depth	Spacing
1	12.00	1.00

*For Tieback: Input1 = Diameter; Input2 = Bond Stength
*For Plate: Input1 = Diameter; Input2 = Allowable Pressure
*For Deaman: Input1 = Horz. Width; Input2 = Allowable Pressure; Angle = 0

**********CALCULATION**********

The calculated moment and shear are per pile spacing. Sheet piles are per one feet or meter; Soldier piles are per pile.

Top Pressures start at depth = 0.00



D1 - TOP DEPTH
D2 - EXCAVATION BASE
D3 - PILE TIP (20% increased, see EMBEDMENT Notes below)

MOMENT BALANCE: M=0.00 AT DEPTH=32.01 WITH EMBEDMENT OF 20.01
FORCE BALANCE: F=0.00 AT DEPTH=36.02 WITH EMBEDMENT OF 24.02
The program calculates embedment for moment equilibrium, then increased by 20% to reach force equilibrium.

Total Passive Pressure = Total Active Pressure, OK!

**********RESULTS**********

* EMBEDMENT Notes *
Based on USS Design Manual, fist calculate embedment for moment equilibrium, then increased by 20 to 40 % to reach force equilibrium.
The embedment for moment equilibrium is 20.01
The 20% increased embedment for force equilibrium is 24.02 (Used by Program)
The 30% increased embedment for force equilibrium is 26.02
The 40% increased embedment for force equilibrium is 28.02

Based on AASHTO Standard Specifications, fist calculate embedment for moment equilibrium, then add safety factor of 30% for temporary shoring; add safety factor of 50% for permanent shoring.
The embedment for moment equilibrium is 20.01
Add 30% embedment for temporary shoring (FS=1.3) is 26.02
Add 50% embedment for permanent shoring (FS=1.5) is 30.02

PROGRAM RECOMMENDED MINIMUM EMBEDMENT = 24.02
TOTAL MINIMUM PILE LENGTH = 36.02

* MOMENT IN PILE (per pile spacing)*
Overall Maximum Moment = 79.00 at 23.04
Maximum Shear = 17.84
Moment and Shear are per pile spacing: 1.0 feet or meter

* VERTICAL LOADING *
Vertical Loading from Braces = 0.00
Vertical Loading from External Load = 0.00
Total Vertical Loading = 0.00

**********SHEET PILE SELECTION**********

Request Min. Section Modulus = 28.7 in3/feet, Fy= 50 ksi = 345 MPa, Fb/Fy=0.66
The pile selection is based on the magnitude of the moment only. Axial force is neglected.
Sx(in3) and Ix(in4) are per one foot of horizontal width of the pile

* Note: The sheet pile properties are in English Units and based on one foot width (even in Metric unit).

SZ24 Sx= 29 Ix= 177.9 Weight= 44.1 Top Deflection= 3.48
SZ24A Sx= 29.5 Ix= 186.5 Weight= 42.6 Top Deflection= 3.32
SZ25 Sx= 29.7 Ix= 182 Weight= 45.3 Top Deflection= 3.41
CZ114RD Sx= 29.76 Ix= 199.24 Weight= 43.8 Top Deflection= 3.11
3N(M) Sx= 30.2 Ix= 168.1 Weight= 44.55 Top Deflection= 3.69
PZ27 Sx= 30.2 Ix= 184.2 Weight= 40.5 Top Deflection= 3.37
PLZ23 Sx= 30.2 Ix= 203.8 Weight= 45.2 Top Deflection= 3.04
BZ16.4 Sx= 30.5 Ix= 180 Weight= 43.27 Top Deflection= 3.44
RZ10 Sx= 30.5 Ix= 172.1 Weight= 47.71 Top Deflection= 3.60
134N Sx= 30.7 Ix= 181.3 Weight= 45.16 Top Deflection= 3.42
PZ27 Sx= 31 Ix= 187.5 Weight= 40.5 Top Deflection= 3.31
BZ17 Sx= 31.1 Ix= 183.7 Weight= 43.96 Top Deflection= 3.37
SPZ23 Sx= 31.3 Ix= 208.7 Weight= 46.22 Top Deflection= 2.97
3NA Sx= 31.4 Ix= 188.1 Weight= 42.07 Top Deflection= 3.30

********SHEAR, MOMENT, AND DEFLECTION v.s. DEPTH**********

The shear and moment are per single soldier pile (secant/tangent pile) or one foot of sheet pile (concrete wall). The deflection is based on users input pile below:
User Input Pile: PZ22
Elastic Module, E: 29000.00
Moment of Inertia, I: 84.40

No	DEPTH ft	SHEAR kip	MOMENT kip-ft	DEFLECTION in
1	0.00	0.00	0.00	7.345
2	0.05	0.01	0.00	7.330
3	0.09	0.02	0.00	7.314
4	0.14	0.03	0.00	7.298
5	0.18	0.04	0.00	7.283
6	0.23	0.04	0.00	7.267

				report
7	0.27	0.05	0.01	7.252
8	0.32	0.06	0.01	7.236
9	0.36	0.07	0.01	7.220
10	0.41	0.08	0.02	7.205
11	0.45	0.09	0.02	7.189
12	0.50	0.10	0.02	7.173
13	0.54	0.11	0.03	7.158
14	0.59	0.12	0.03	7.142
15	0.63	0.13	0.04	7.126
16	0.68	0.14	0.05	7.111
17	0.72	0.15	0.05	7.095
18	0.77	0.16	0.06	7.079
19	0.81	0.17	0.07	7.064
20	0.86	0.18	0.07	7.048
21	0.90	0.19	0.08	7.033
22	0.95	0.20	0.09	7.017
23	0.99	0.21	0.10	7.001
24	1.04	0.22	0.11	6.986
25	1.08	0.23	0.12	6.970
26	1.13	0.24	0.13	6.954
27	1.17	0.25	0.14	6.939
28	1.22	0.26	0.15	6.923
29	1.26	0.27	0.17	6.907
30	1.31	0.28	0.18	6.892
31	1.35	0.30	0.19	6.876
32	1.40	0.31	0.21	6.861
33	1.44	0.32	0.22	6.845
34	1.49	0.33	0.23	6.829
35	1.53	0.34	0.25	6.814
36	1.58	0.35	0.26	6.798
37	1.62	0.36	0.28	6.782
38	1.67	0.38	0.30	6.767
39	1.71	0.39	0.31	6.751
40	1.76	0.40	0.33	6.735
41	1.80	0.41	0.35	6.720
42	1.85	0.42	0.37	6.704
43	1.89	0.43	0.39	6.688
44	1.94	0.45	0.41	6.673
45	1.98	0.46	0.43	6.657
46	2.03	0.47	0.45	6.642
47	2.07	0.48	0.47	6.626
48	2.12	0.50	0.49	6.610
49	2.16	0.51	0.52	6.595
50	2.21	0.52	0.54	6.579
51	2.25	0.53	0.56	6.563
52	2.30	0.55	0.59	6.548
53	2.34	0.56	0.61	6.532
54	2.39	0.57	0.64	6.516
55	2.44	0.58	0.66	6.501
56	2.48	0.60	0.69	6.485
57	2.53	0.61	0.72	6.470
58	2.57	0.62	0.75	6.454
59	2.62	0.64	0.77	6.438
60	2.66	0.65	0.80	6.423
61	2.71	0.66	0.83	6.407
62	2.75	0.68	0.86	6.391
63	2.80	0.69	0.89	6.376
64	2.84	0.70	0.93	6.360
65	2.89	0.72	0.96	6.344
66	2.93	0.73	0.99	6.329
67	2.98	0.75	1.02	6.313
68	3.02	0.76	1.06	6.298
69	3.07	0.77	1.09	6.282

				report
70	3.11	0.79	1.13	6.266
71	3.16	0.80	1.16	6.251
72	3.20	0.82	1.20	6.235
73	3.25	0.83	1.24	6.219
74	3.29	0.84	1.27	6.204
75	3.34	0.86	1.31	6.188
76	3.38	0.87	1.35	6.173
77	3.43	0.89	1.39	6.157
78	3.47	0.90	1.43	6.141
79	3.52	0.92	1.47	6.126
80	3.56	0.93	1.51	6.110
81	3.61	0.95	1.56	6.094
82	3.65	0.96	1.60	6.079
83	3.70	0.98	1.64	6.063
84	3.74	0.99	1.69	6.048
85	3.79	1.01	1.73	6.032
86	3.83	1.02	1.78	6.016
87	3.88	1.04	1.83	6.001
88	3.92	1.06	1.87	5.985
89	3.97	1.07	1.92	5.969
90	4.01	1.09	1.97	5.954
91	4.06	1.10	2.02	5.938
92	4.10	1.12	2.07	5.923
93	4.15	1.13	2.12	5.907
94	4.19	1.15	2.17	5.891
95	4.24	1.17	2.22	5.876
96	4.28	1.18	2.28	5.860
97	4.33	1.20	2.33	5.845
98	4.37	1.22	2.38	5.829
99	4.42	1.23	2.44	5.813
100	4.46	1.25	2.50	5.798
101	4.51	1.27	2.55	5.782
102	4.55	1.28	2.61	5.767
103	4.60	1.30	2.67	5.751
104	4.64	1.32	2.73	5.735
105	4.69	1.33	2.79	5.720
106	4.74	1.35	2.85	5.704
107	4.78	1.37	2.91	5.689
108	4.83	1.38	2.97	5.673
109	4.87	1.40	3.03	5.657
110	4.92	1.42	3.10	5.642
111	4.96	1.44	3.16	5.626
112	5.01	1.45	3.23	5.611
113	5.05	1.47	3.29	5.595
114	5.10	1.49	3.36	5.580
115	5.14	1.51	3.43	5.564
116	5.19	1.52	3.50	5.548
117	5.23	1.54	3.56	5.533
118	5.28	1.56	3.63	5.517
119	5.32	1.58	3.70	5.502
120	5.37	1.60	3.78	5.486
121	5.41	1.61	3.85	5.471
122	5.46	1.63	3.92	5.455
123	5.50	1.65	4.00	5.439
124	5.55	1.67	4.07	5.424
125	5.59	1.69	4.15	5.408
126	5.64	1.71	4.22	5.393
127	5.68	1.73	4.30	5.377
128	5.73	1.74	4.38	5.362
129	5.77	1.76	4.46	5.346
130	5.82	1.78	4.54	5.331
131	5.86	1.80	4.62	5.315
132	5.91	1.82	4.70	5.300

				report
133	5.95	1.84	4.78	5.284
134	6.00	1.86	4.87	5.268
135	6.04	1.88	4.95	5.253
136	6.09	1.90	5.04	5.237
137	6.13	1.92	5.12	5.222
138	6.18	1.94	5.21	5.206
139	6.22	1.96	5.30	5.191
140	6.27	1.98	5.38	5.175
141	6.31	2.00	5.47	5.160
142	6.36	2.02	5.56	5.144
143	6.40	2.03	5.66	5.129
144	6.45	2.06	5.75	5.113
145	6.49	2.08	5.84	5.098
146	6.54	2.10	5.94	5.082
147	6.58	2.12	6.03	5.067
148	6.63	2.14	6.13	5.051
149	6.67	2.16	6.22	5.036
150	6.72	2.18	6.32	5.020
151	6.76	2.20	6.42	5.005
152	6.81	2.22	6.52	4.989
153	6.85	2.24	6.62	4.974
154	6.90	2.26	6.72	4.958
155	6.94	2.28	6.82	4.943
156	6.99	2.30	6.93	4.928
157	7.03	2.32	7.03	4.912
158	7.08	2.34	7.14	4.897
159	7.13	2.37	7.24	4.881
160	7.17	2.39	7.35	4.866
161	7.22	2.41	7.46	4.850
162	7.26	2.43	7.57	4.835
163	7.31	2.45	7.68	4.819
164	7.35	2.48	7.79	4.804
165	7.40	2.50	7.90	4.789
166	7.44	2.52	8.01	4.773
167	7.49	2.54	8.13	4.758
168	7.53	2.57	8.24	4.742
169	7.58	2.59	8.36	4.727
170	7.62	2.61	8.48	4.712
171	7.67	2.64	8.59	4.696
172	7.71	2.66	8.71	4.681
173	7.76	2.68	8.83	4.665
174	7.80	2.71	8.96	4.650
175	7.85	2.73	9.08	4.635
176	7.89	2.75	9.20	4.619
177	7.94	2.78	9.33	4.604
178	7.98	2.80	9.45	4.589
179	8.03	2.83	9.58	4.573
180	8.07	2.85	9.71	4.558
181	8.12	2.88	9.84	4.542
182	8.16	2.90	9.97	4.527
183	8.21	2.93	10.10	4.512
184	8.25	2.95	10.23	4.496
185	8.30	2.98	10.36	4.481
186	8.34	3.00	10.50	4.466
187	8.39	3.03	10.64	4.451
188	8.43	3.06	10.77	4.435
189	8.48	3.08	10.91	4.420
190	8.52	3.11	11.05	4.405
191	8.57	3.14	11.19	4.389
192	8.61	3.16	11.33	4.374
193	8.66	3.19	11.48	4.359
194	8.70	3.22	11.62	4.344
195	8.75	3.24	11.77	4.328

				report
196	8.79	3.27	11.91	4.313
197	8.84	3.30	12.06	4.298
198	8.88	3.33	12.21	4.283
199	8.93	3.35	12.36	4.267
200	8.97	3.38	12.51	4.252
201	9.02	3.41	12.67	4.237
202	9.06	3.44	12.82	4.222
203	9.11	3.47	12.98	4.206
204	9.15	3.50	13.13	4.191
205	9.20	3.52	13.29	4.176
206	9.24	3.55	13.45	4.161
207	9.29	3.58	13.61	4.146
208	9.33	3.61	13.77	4.131
209	9.38	3.64	13.94	4.115
210	9.43	3.67	14.10	4.100
211	9.47	3.70	14.27	4.085
212	9.52	3.73	14.44	4.070
213	9.56	3.76	14.61	4.055
214	9.61	3.79	14.78	4.040
215	9.65	3.82	14.95	4.025
216	9.70	3.85	15.12	4.010
217	9.74	3.88	15.29	3.994
218	9.79	3.91	15.47	3.979
219	9.83	3.94	15.65	3.964
220	9.88	3.97	15.83	3.949
221	9.92	4.01	16.01	3.934
222	9.97	4.04	16.19	3.919
223	10.01	4.07	16.37	3.904
224	10.06	4.10	16.55	3.889
225	10.10	4.13	16.74	3.874
226	10.15	4.17	16.93	3.859
227	10.19	4.20	17.12	3.844
228	10.24	4.23	17.31	3.829
229	10.28	4.26	17.50	3.814
230	10.33	4.30	17.69	3.799
231	10.37	4.33	17.88	3.784
232	10.42	4.36	18.08	3.769
233	10.46	4.39	18.28	3.754
234	10.51	4.43	18.48	3.739
235	10.55	4.46	18.68	3.724
236	10.60	4.50	18.88	3.710
237	10.64	4.53	19.08	3.695
238	10.69	4.56	19.29	3.680
239	10.73	4.60	19.49	3.665
240	10.78	4.63	19.70	3.650
241	10.82	4.67	19.91	3.635
242	10.87	4.70	20.12	3.620
243	10.91	4.74	20.34	3.605
244	10.96	4.77	20.55	3.591
245	11.00	4.81	20.77	3.576
246	11.05	4.84	20.98	3.561
247	11.09	4.88	21.20	3.546
248	11.14	4.91	21.42	3.532
249	11.18	4.95	21.65	3.517
250	11.23	4.98	21.87	3.502
251	11.27	5.02	22.10	3.487
252	11.32	5.06	22.32	3.473
253	11.36	5.09	22.55	3.458
254	11.41	5.13	22.78	3.443
255	11.45	5.17	23.01	3.428
256	11.50	5.20	23.25	3.414
257	11.54	5.24	23.48	3.399
258	11.59	5.28	23.72	3.384

				report
259	11.63	5.32	23.96	3.370
260	11.68	5.35	24.20	3.355
261	11.72	5.39	24.44	3.341
262	11.77	5.43	24.69	3.326
263	11.82	5.47	24.93	3.311
264	11.86	5.50	25.18	3.297
265	11.91	5.54	25.43	3.282
266	11.95	5.58	25.68	3.268
267	12.00	5.62	25.93	3.253
268	12.04	5.65	26.19	3.239
269	12.09	5.67	26.44	3.224
270	12.13	5.70	26.70	3.210
271	12.18	5.72	26.95	3.195
272	12.22	5.74	27.21	3.181
273	12.27	5.77	27.47	3.167
274	12.31	5.79	27.73	3.152
275	12.36	5.81	28.00	3.138
276	12.40	5.84	28.26	3.123
277	12.45	5.86	28.52	3.109
278	12.49	5.88	28.79	3.095
279	12.54	5.90	29.05	3.080
280	12.58	5.92	29.32	3.066
281	12.63	5.94	29.59	3.052
282	12.67	5.96	29.85	3.037
283	12.72	5.98	30.12	3.023
284	12.76	6.00	30.39	3.009
285	12.81	6.02	30.66	2.995
286	12.85	6.04	30.94	2.980
287	12.90	6.06	31.21	2.966
288	12.94	6.07	31.48	2.952
289	12.99	6.09	31.76	2.938
290	13.03	6.11	32.03	2.924
291	13.08	6.12	32.31	2.910
292	13.12	6.14	32.58	2.896
293	13.17	6.15	32.86	2.881
294	13.21	6.17	33.14	2.867
295	13.26	6.18	33.42	2.853
296	13.30	6.20	33.70	2.839
297	13.35	6.21	33.98	2.825
298	13.39	6.23	34.26	2.811
299	13.44	6.24	34.54	2.797
300	13.48	6.25	34.82	2.783
301	13.53	6.26	35.10	2.770
302	13.57	6.28	35.39	2.756
303	13.62	6.29	35.67	2.742
304	13.66	6.30	35.95	2.728
305	13.71	6.31	36.24	2.714
306	13.75	6.32	36.52	2.700
307	13.80	6.33	36.81	2.686
308	13.84	6.34	37.09	2.673
309	13.89	6.35	37.38	2.659
310	13.93	6.36	37.67	2.645
311	13.98	6.37	37.95	2.631
312	14.02	6.38	38.24	2.618
313	14.07	6.38	38.53	2.604
314	14.11	6.39	38.82	2.590
315	14.16	6.40	39.10	2.577
316	14.21	6.40	39.39	2.563
317	14.25	6.41	39.68	2.549
318	14.30	6.41	39.97	2.536
319	14.34	6.42	40.26	2.522
320	14.39	6.43	40.55	2.509
321	14.43	6.43	40.84	2.495

				report
322	14.48	6.43	41.13	2.482
323	14.52	6.44	41.42	2.468
324	14.57	6.44	41.71	2.455
325	14.61	6.44	42.00	2.442
326	14.66	6.45	42.29	2.428
327	14.70	6.45	42.58	2.415
328	14.75	6.45	42.87	2.401
329	14.79	6.45	43.16	2.388
330	14.84	6.45	43.45	2.375
331	14.88	6.45	43.75	2.362
332	14.93	6.45	44.04	2.348
333	14.97	6.45	44.33	2.335
334	15.02	6.45	44.62	2.322
335	15.06	6.45	44.91	2.309
336	15.11	6.45	45.20	2.296
337	15.15	6.45	45.49	2.283
338	15.20	6.45	45.78	2.270
339	15.24	6.44	46.07	2.256
340	15.29	6.44	46.36	2.243
341	15.33	6.44	46.65	2.230
342	15.38	6.43	46.94	2.217
343	15.42	6.43	47.23	2.205
344	15.47	6.42	47.52	2.192
345	15.51	6.42	47.81	2.179
346	15.56	6.41	48.10	2.166
347	15.60	6.41	48.39	2.153
348	15.65	6.40	48.68	2.140
349	15.69	6.39	48.97	2.127
350	15.74	6.39	49.26	2.115
351	15.78	6.38	49.54	2.102
352	15.83	6.37	49.83	2.089
353	15.87	6.36	50.12	2.077
354	15.92	6.36	50.41	2.064
355	15.96	6.35	50.69	2.051
356	16.01	6.34	50.98	2.039
357	16.05	6.33	51.26	2.026
358	16.10	6.32	51.55	2.014
359	16.14	6.31	51.83	2.001
360	16.19	6.30	52.12	1.989
361	16.23	6.28	52.40	1.976
362	16.28	6.27	52.68	1.964
363	16.32	6.26	52.97	1.951
364	16.37	6.25	53.25	1.939
365	16.41	6.23	53.53	1.927
366	16.46	6.22	53.81	1.914
367	16.51	6.21	54.09	1.902
368	16.55	6.19	54.37	1.890
369	16.60	6.18	54.65	1.878
370	16.64	6.16	54.93	1.866
371	16.69	6.15	55.21	1.854
372	16.73	6.13	55.48	1.841
373	16.78	6.12	55.76	1.829
374	16.82	6.10	56.03	1.817
375	16.87	6.08	56.31	1.805
376	16.91	6.07	56.58	1.793
377	16.96	6.05	56.86	1.781
378	17.00	6.03	57.13	1.769
379	17.05	6.01	57.40	1.758
380	17.09	5.99	57.67	1.746
381	17.14	5.97	57.94	1.734
382	17.18	5.95	58.21	1.722
383	17.23	5.93	58.48	1.710
384	17.27	5.91	58.74	1.699

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385	17.32	5.89	59.01	1.687
386	17.36	5.87	59.28	1.675
387	17.41	5.85	59.54	1.664
388	17.45	5.83	59.80	1.652
389	17.50	5.81	60.07	1.641
390	17.54	5.78	60.33	1.629
391	17.59	5.76	60.59	1.618
392	17.63	5.74	60.85	1.606
393	17.68	5.71	61.10	1.595
394	17.72	5.69	61.36	1.584
395	17.77	5.66	61.62	1.572
396	17.81	5.64	61.87	1.561
397	17.86	5.61	62.13	1.550
398	17.90	5.59	62.38	1.538
399	17.95	5.56	62.63	1.527
400	17.99	5.53	62.88	1.516
401	18.04	5.50	63.13	1.505
402	18.08	5.48	63.38	1.494
403	18.13	5.45	63.62	1.483
404	18.17	5.42	63.87	1.472
405	18.22	5.39	64.11	1.461
406	18.26	5.36	64.35	1.450
407	18.31	5.33	64.60	1.439
408	18.35	5.30	64.83	1.428
409	18.40	5.27	65.07	1.417
410	18.44	5.24	65.31	1.407
411	18.49	5.21	65.55	1.396
412	18.53	5.18	65.78	1.385
413	18.58	5.15	66.01	1.374
414	18.62	5.12	66.24	1.364
415	18.67	5.08	66.47	1.353
416	18.71	5.05	66.70	1.343
417	18.76	5.02	66.93	1.332
418	18.80	4.98	67.16	1.322
419	18.85	4.95	67.38	1.311
420	18.90	4.91	67.60	1.301
421	18.94	4.88	67.82	1.290
422	18.99	4.84	68.04	1.280
423	19.03	4.81	68.26	1.270
424	19.08	4.77	68.48	1.259
425	19.12	4.73	68.69	1.249
426	19.17	4.70	68.90	1.239
427	19.21	4.66	69.11	1.229
428	19.26	4.62	69.32	1.219
429	19.30	4.58	69.53	1.209
430	19.35	4.54	69.74	1.199
431	19.39	4.50	69.94	1.189
432	19.44	4.47	70.14	1.179
433	19.48	4.43	70.34	1.169
434	19.53	4.39	70.54	1.159
435	19.57	4.34	70.74	1.149
436	19.62	4.30	70.93	1.140
437	19.66	4.26	71.13	1.130
438	19.71	4.22	71.32	1.120
439	19.75	4.18	71.51	1.110
440	19.80	4.14	71.69	1.101
441	19.84	4.09	71.88	1.091
442	19.89	4.05	72.06	1.082
443	19.93	4.01	72.24	1.072
444	19.98	3.96	72.42	1.063
445	20.02	3.92	72.60	1.053
446	20.07	3.87	72.78	1.044
447	20.11	3.83	72.95	1.035

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448	20.16	3.78	73.12	1.025
449	20.20	3.73	73.29	1.016
450	20.25	3.69	73.46	1.007
451	20.29	3.64	73.62	0.998
452	20.34	3.59	73.79	0.989
453	20.38	3.55	73.95	0.980
454	20.43	3.50	74.11	0.971
455	20.47	3.45	74.26	0.962
456	20.52	3.40	74.42	0.953
457	20.56	3.35	74.57	0.944
458	20.61	3.30	74.72	0.935
459	20.65	3.25	74.87	0.926
460	20.70	3.20	75.01	0.917
461	20.74	3.15	75.16	0.909
462	20.79	3.10	75.30	0.900
463	20.83	3.05	75.44	0.891
464	20.88	2.99	75.57	0.883
465	20.92	2.94	75.71	0.874
466	20.97	2.89	75.84	0.866
467	21.01	2.83	75.97	0.857
468	21.06	2.78	76.09	0.849
469	21.10	2.73	76.22	0.840
470	21.15	2.67	76.34	0.832
471	21.19	2.62	76.46	0.824
472	21.24	2.56	76.58	0.816
473	21.29	2.51	76.69	0.807
474	21.33	2.45	76.80	0.799
475	21.38	2.39	76.91	0.791
476	21.42	2.34	77.02	0.783
477	21.47	2.28	77.12	0.775
478	21.51	2.22	77.22	0.767
479	21.56	2.16	77.32	0.759
480	21.60	2.11	77.42	0.751
481	21.65	2.05	77.51	0.743
482	21.69	1.99	77.60	0.735
483	21.74	1.93	77.69	0.728
484	21.78	1.87	77.78	0.720
485	21.83	1.81	77.86	0.712
486	21.87	1.75	77.94	0.705
487	21.92	1.69	78.02	0.697
488	21.96	1.62	78.09	0.690
489	22.01	1.56	78.16	0.682
490	22.05	1.50	78.23	0.675
491	22.10	1.44	78.30	0.667
492	22.14	1.37	78.36	0.660
493	22.19	1.31	78.42	0.653
494	22.23	1.25	78.48	0.645
495	22.28	1.18	78.53	0.638
496	22.32	1.12	78.59	0.631
497	22.37	1.05	78.64	0.624
498	22.41	0.99	78.68	0.617
499	22.46	0.92	78.72	0.610
500	22.50	0.85	78.76	0.603
501	22.55	0.79	78.80	0.596
502	22.59	0.72	78.84	0.589
503	22.64	0.65	78.87	0.582
504	22.68	0.58	78.89	0.575
505	22.73	0.52	78.92	0.568
506	22.77	0.45	78.94	0.562
507	22.82	0.38	78.96	0.555
508	22.86	0.31	78.97	0.548
509	22.91	0.24	78.99	0.542
510	22.95	0.17	79.00	0.535

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511	23.00	0.10	79.00	0.529
512	23.04	0.03	79.00	0.522
513	23.09	-0.05	79.00	0.516
514	23.13	-0.12	79.00	0.509
515	23.18	-0.19	78.99	0.503
516	23.22	-0.26	78.98	0.497
517	23.27	-0.34	78.97	0.491
518	23.31	-0.41	78.95	0.484
519	23.36	-0.48	78.93	0.478
520	23.40	-0.56	78.91	0.472
521	23.45	-0.63	78.88	0.466
522	23.49	-0.71	78.85	0.460
523	23.54	-0.78	78.82	0.454
524	23.59	-0.86	78.78	0.448
525	23.63	-0.94	78.74	0.442
526	23.68	-1.01	78.70	0.437
527	23.72	-1.09	78.65	0.431
528	23.77	-1.17	78.60	0.425
529	23.81	-1.24	78.54	0.419
530	23.86	-1.32	78.49	0.414
531	23.90	-1.40	78.43	0.408
532	23.95	-1.48	78.36	0.403
533	23.99	-1.56	78.29	0.397
534	24.04	-1.64	78.22	0.392
535	24.08	-1.72	78.14	0.386
536	24.13	-1.80	78.06	0.381
537	24.17	-1.88	77.98	0.375
538	24.22	-1.96	77.89	0.370
539	24.26	-2.04	77.80	0.365
540	24.31	-2.13	77.71	0.360
541	24.35	-2.21	77.61	0.355
542	24.40	-2.29	77.51	0.350
543	24.44	-2.38	77.41	0.344
544	24.49	-2.46	77.30	0.339
545	24.53	-2.54	77.18	0.334
546	24.58	-2.63	77.07	0.330
547	24.62	-2.71	76.95	0.325
548	24.67	-2.80	76.82	0.320
549	24.71	-2.88	76.69	0.315
550	24.76	-2.97	76.56	0.310
551	24.80	-3.06	76.43	0.306
552	24.85	-3.14	76.29	0.301
553	24.89	-3.23	76.14	0.296
554	24.94	-3.32	76.00	0.292
555	24.98	-3.41	75.84	0.287
556	25.03	-3.50	75.69	0.283
557	25.07	-3.59	75.53	0.278
558	25.12	-3.67	75.36	0.274
559	25.16	-3.76	75.20	0.270
560	25.21	-3.85	75.02	0.265
561	25.25	-3.95	74.85	0.261
562	25.30	-4.04	74.67	0.257
563	25.34	-4.13	74.48	0.253
564	25.39	-4.22	74.30	0.248
565	25.43	-4.31	74.10	0.244
566	25.48	-4.40	73.91	0.240
567	25.52	-4.50	73.71	0.236
568	25.57	-4.59	73.50	0.232
569	25.61	-4.68	73.29	0.228
570	25.66	-4.78	73.08	0.225
571	25.70	-4.87	72.86	0.221
572	25.75	-4.97	72.64	0.217
573	25.79	-5.06	72.41	0.213

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574	25.84	-5.16	72.18	0.209
575	25.88	-5.25	71.95	0.206
576	25.93	-5.35	71.71	0.202
577	25.98	-5.45	71.47	0.199
578	26.02	-5.54	71.22	0.195
579	26.07	-5.64	70.97	0.191
580	26.11	-5.74	70.71	0.188
581	26.16	-5.84	70.45	0.185
582	26.20	-5.94	70.18	0.181
583	26.25	-6.04	69.91	0.178
584	26.29	-6.14	69.64	0.175
585	26.34	-6.24	69.36	0.171
586	26.38	-6.34	69.08	0.168
587	26.43	-6.44	68.79	0.165
588	26.47	-6.54	68.50	0.162
589	26.52	-6.64	68.20	0.159
590	26.56	-6.74	67.90	0.156
591	26.61	-6.85	67.59	0.152
592	26.65	-6.95	67.28	0.149
593	26.70	-7.05	66.96	0.147
594	26.74	-7.15	66.64	0.144
595	26.79	-7.26	66.32	0.141
596	26.83	-7.36	65.99	0.138
597	26.88	-7.47	65.65	0.135
598	26.92	-7.57	65.31	0.132
599	26.97	-7.68	64.97	0.130
600	27.01	-7.78	64.62	0.127
601	27.06	-7.89	64.27	0.124
602	27.10	-8.00	63.91	0.122
603	27.15	-8.11	63.55	0.119
604	27.19	-8.21	63.18	0.117
605	27.24	-8.32	62.81	0.114
606	27.28	-8.43	62.43	0.112
607	27.33	-8.54	62.05	0.109
608	27.37	-8.65	61.66	0.107
609	27.42	-8.76	61.27	0.104
610	27.46	-8.87	60.87	0.102
611	27.51	-8.98	60.47	0.100
612	27.55	-9.09	60.06	0.098
613	27.60	-9.20	59.65	0.095
614	27.64	-9.31	59.23	0.093
615	27.69	-9.42	58.81	0.091
616	27.73	-9.53	58.38	0.089
617	27.78	-9.65	57.95	0.087
618	27.82	-9.76	57.51	0.085
619	27.87	-9.87	57.07	0.083
620	27.91	-9.99	56.62	0.081
621	27.96	-10.10	56.17	0.079
622	28.00	-10.21	55.71	0.077
623	28.05	-10.29	55.25	0.075
624	28.09	-10.36	54.78	0.073
625	28.14	-10.44	54.31	0.071
626	28.18	-10.52	53.84	0.070
627	28.23	-10.59	53.36	0.068
628	28.27	-10.67	52.88	0.066
629	28.32	-10.74	52.40	0.064
630	28.37	-10.82	51.91	0.063
631	28.41	-10.90	51.43	0.061
632	28.46	-10.98	50.93	0.060
633	28.50	-11.05	50.44	0.058
634	28.55	-11.13	49.93	0.056
635	28.59	-11.21	49.43	0.055
636	28.64	-11.29	48.92	0.053

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637	28.68	-11.37	48.41	0.052
638	28.73	-11.45	47.90	0.051
639	28.77	-11.53	47.38	0.049
640	28.82	-11.61	46.86	0.048
641	28.86	-11.69	46.33	0.046
642	28.91	-11.77	45.80	0.045
643	28.95	-11.85	45.27	0.044
644	29.00	-11.93	44.74	0.043
645	29.04	-12.01	44.20	0.041
646	29.09	-12.09	43.65	0.040
647	29.13	-12.17	43.11	0.039
648	29.18	-12.25	42.56	0.038
649	29.22	-12.34	42.00	0.037
650	29.27	-12.42	41.44	0.036
651	29.31	-12.50	40.88	0.034
652	29.36	-12.58	40.32	0.033
653	29.40	-12.67	39.75	0.032
654	29.45	-12.75	39.17	0.031
655	29.49	-12.83	38.60	0.030
656	29.54	-12.92	38.02	0.029
657	29.58	-13.00	37.43	0.028
658	29.63	-13.09	36.84	0.027
659	29.67	-13.17	36.25	0.027
660	29.72	-13.26	35.65	0.026
661	29.76	-13.34	35.06	0.025
662	29.81	-13.43	34.45	0.024
663	29.85	-13.51	33.84	0.023
664	29.90	-13.60	33.23	0.022
665	29.94	-13.68	32.62	0.021
666	29.99	-13.77	32.00	0.021
667	30.03	-13.86	31.38	0.020
668	30.08	-13.95	30.75	0.019
669	30.12	-14.03	30.12	0.019
670	30.17	-14.12	29.48	0.018
671	30.21	-14.21	28.84	0.017
672	30.26	-14.30	28.20	0.016
673	30.30	-14.38	27.56	0.016
674	30.35	-14.47	26.90	0.015
675	30.39	-14.56	26.25	0.015
676	30.44	-14.65	25.59	0.014
677	30.48	-14.74	24.93	0.013
678	30.53	-14.83	24.26	0.013
679	30.57	-14.92	23.59	0.012
680	30.62	-15.01	22.92	0.012
681	30.66	-15.10	22.24	0.011
682	30.71	-15.19	21.55	0.011
683	30.76	-15.28	20.87	0.010
684	30.80	-15.37	20.18	0.010
685	30.85	-15.47	19.48	0.009
686	30.89	-15.56	18.78	0.009
687	30.94	-15.65	18.08	0.008
688	30.98	-15.74	17.37	0.008
689	31.03	-15.83	16.66	0.007
690	31.07	-15.93	15.94	0.007
691	31.12	-16.02	15.22	0.007
692	31.16	-16.11	14.50	0.006
693	31.21	-16.21	13.77	0.006
694	31.25	-16.30	13.03	0.005
695	31.30	-16.40	12.30	0.005
696	31.34	-16.49	11.56	0.005
697	31.39	-16.58	10.81	0.004
698	31.43	-16.68	10.06	0.004
699	31.48	-16.78	9.31	0.004

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700	31.52	-16.87	8.55	0.003
701	31.57	-16.97	7.78	0.003
702	31.61	-17.06	7.02	0.003
703	31.66	-17.16	6.24	0.002
704	31.70	-17.26	5.47	0.002
705	31.75	-17.35	4.69	0.002
706	31.79	-17.45	3.90	0.001
707	31.84	-17.55	3.11	0.001
708	31.88	-17.64	2.32	0.001
709	31.93	-17.74	1.52	0.000
710	31.97	-17.84	0.72	0.000
711	32.02	-17.64	-0.40	0.000
712	32.06	-17.44	-0.79	-0.001
713	32.11	-17.24	-1.17	-0.001
714	32.15	-17.03	-1.55	-0.001
715	32.20	-16.83	-1.91	-0.002
716	32.24	-16.63	-2.26	-0.002
717	32.29	-16.43	-2.61	-0.002
718	32.33	-16.23	-2.94	-0.003
719	32.38	-16.03	-3.27	-0.003
720	32.42	-15.82	-3.59	-0.003
721	32.47	-15.62	-3.90	-0.003
722	32.51	-15.42	-4.20	-0.004
723	32.56	-15.22	-4.49	-0.004
724	32.60	-15.02	-4.77	-0.004
725	32.65	-14.82	-5.04	-0.005
726	32.69	-14.62	-5.31	-0.005
727	32.74	-14.41	-5.56	-0.006
728	32.78	-14.21	-5.80	-0.006
729	32.83	-14.01	-6.04	-0.006
730	32.87	-13.81	-6.27	-0.007
731	32.92	-13.61	-6.48	-0.007
732	32.96	-13.41	-6.69	-0.007
733	33.01	-13.20	-6.89	-0.008
734	33.06	-13.00	-7.08	-0.008
735	33.10	-12.80	-7.26	-0.008
736	33.15	-12.60	-7.44	-0.009
737	33.19	-12.40	-7.60	-0.009
738	33.24	-12.20	-7.75	-0.010
739	33.28	-12.00	-7.90	-0.010
740	33.33	-11.79	-8.03	-0.010
741	33.37	-11.59	-8.16	-0.011
742	33.42	-11.39	-8.28	-0.011
743	33.46	-11.19	-8.39	-0.012
744	33.51	-10.99	-8.48	-0.012
745	33.55	-10.79	-8.57	-0.012
746	33.60	-10.58	-8.66	-0.013
747	33.64	-10.38	-8.73	-0.013
748	33.69	-10.18	-8.79	-0.014
749	33.73	-9.98	-8.84	-0.014
750	33.78	-9.78	-8.89	-0.015
751	33.82	-9.58	-8.92	-0.015
752	33.87	-9.37	-8.95	-0.015
753	33.91	-9.17	-8.97	-0.016
754	33.96	-8.97	-8.97	-0.016
755	34.00	-8.77	-8.97	-0.017
756	34.05	-8.57	-8.96	-0.017
757	34.09	-8.37	-8.94	-0.018
758	34.14	-8.17	-8.92	-0.018
759	34.18	-7.96	-8.88	-0.019
760	34.23	-7.76	-8.83	-0.019
761	34.27	-7.56	-8.78	-0.020
762	34.32	-7.36	-8.71	-0.020

				report
763	34.36	-7.16	-8.64	-0.021
764	34.41	-6.96	-8.55	-0.021
765	34.45	-6.75	-8.46	-0.022
766	34.50	-6.55	-8.36	-0.022
767	34.54	-6.35	-8.25	-0.023
768	34.59	-6.15	-8.13	-0.023
769	34.63	-5.95	-8.00	-0.024
770	34.68	-5.75	-7.86	-0.024
771	34.72	-5.55	-7.72	-0.025
772	34.77	-5.34	-7.56	-0.026
773	34.81	-5.14	-7.40	-0.026
774	34.86	-4.94	-7.22	-0.027
775	34.90	-4.74	-7.04	-0.027
776	34.95	-4.54	-6.84	-0.028
777	34.99	-4.34	-6.64	-0.028
778	35.04	-4.13	-6.43	-0.029
779	35.08	-3.93	-6.21	-0.030
780	35.13	-3.73	-5.98	-0.030
781	35.17	-3.53	-5.75	-0.031
782	35.22	-3.33	-5.50	-0.031
783	35.26	-3.13	-5.24	-0.032
784	35.31	-2.92	-4.98	-0.032
785	35.35	-2.72	-4.70	-0.033
786	35.40	-2.52	-4.42	-0.034
787	35.45	-2.32	-4.13	-0.034
788	35.49	-2.12	-3.82	-0.035
789	35.54	-1.92	-3.51	-0.036
790	35.58	-1.72	-3.19	-0.036
791	35.63	-1.51	-2.86	-0.037
792	35.67	-1.31	-2.53	-0.037
793	35.72	-1.11	-2.18	-0.038
794	35.76	-0.91	-1.82	-0.039
795	35.81	-0.71	-1.46	-0.039
796	35.85	-0.51	-1.08	-0.040
797	35.90	-0.30	-0.70	-0.040
798	35.94	-0.10	-0.30	-0.041
799	35.99	0.10	0.10	-0.042

The above data can be selected using mouse, then copy and paste into Excel to create graphics

APPENDIX D

Bioremediation Design Parameters

Table D-1
Volume Estimates
Bioremediation Design Parameters
Blaine Marina, Inc. Site – Blaine, Washington

Bio Quick Estimate

Injection Volume Estimate

Large Excavation:	5200	SF (minus sloped walls)	**Comparison to injection well grid (15 ft centers):**	
	3	FT GW rise	23.1	wells
	0.3	Porosity		
	4680	CF Volume		
	35,006	Gallons	1,514.70	gal/well

Infiltration Trenches

Trench	3	FT Width	
	30	FT Length	
	8	FT freeboard above w.t.	Shallowest groundwater measured at site was 8 ft bgs
	0.3	Porosity	
	216	Trench Volume (CF)	
each	1,616	Trench Volume (Gal)	
2 trenches	3,231.36		

	38,238	**Calculated total site Injection Volume**
	40,000	**Roundup**

Site Total per injection event	40,000	gallons
Pumping Time at 50 gpm	800.00	minutes
	13.33	hours

Table D-2
Estimating Ammonium Nitrate Requirements
Bioremediation Design Parameters
Blaine Marina, Inc. Site – Blaine, Washington

Ratio to initial nitrate concentration	1x	2x	3x	4x	5x	6x	7x	8x	9x	10x
Nitrate concentration (mg-N/L)	225	450	675	900	1,125	1,350	1,575	1,800	2,025	2,250
Nitrate concentration (mg/L)	1,000	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000
	Pounds per 1,000 gallons									
Ammomium nitrate fertilizer[a]	15	30	45	60	75	90	105	120	135	150
Monoammonium phosphate fertilizer[b]	2.5	5	7.5	10	12.5	15	17.5	20	22.5	25
Yeast extract[c]	1	1	1	1	1	1	1	1	1	1
	Pounds per 40,000 gallons - initial injection volume									
Ammomium nitrate fertilizer[a]	600	1,200	1,800	2,400	3,000	3,600	4,200	4,800	5,400	6,000
Monoammonium phosphate fertilizer[b]	100	200	300	400	500	600	700	800	900	1,000
Yeast extract[c]	40	40	40	40	40	40	40	40	40	40

[a] Wilbur Ellis CAN-27 (27-0-0) or equivalent

[b] Wilbur Ellis Perfection 11-52-0 monoammonium phosphate or equivalent

[c] Cascade Columbia Yeast hydrolysate enzymatic or equivalent

mg-N/L = milligram per liter as nitrate.

Table D-3
Stoichimetry of TPH Biodegradation with Nitrate
Bioremediation Design Parameters
Blaine Marina, Inc. Site – Blaine, Washington

The design approach is empirical (based on results at other similar sites), not stoichiometric . However, a discussion of the stoichiometry is presented for information below.

If fully used for total petroleum hydrocarbon (TPH) degradation, it takes about 5 lbs of nitrate to degrade 1 lb of TPH/benzene, toluene, ethylbenzene, and xylenes (BTEX), as follows. The reaction for benzene mineralization using nitrate as the terminal electron acceptor (below) is used to estimate the mass of nitrate required for degradation of TPH components.

$$6NO_3^- + 6H^+ + C_6H_6 \rightarrow 6CO_2 + 6H_2O + 3N_2$$

As indicated in the formula above, six moles of nitrate are necessary to degrade one mole of benzene. The formula weights for nitrate and benzene are 62 grams/mole and 78 grams/mole, respectively. Therefore, 4.77 grams of nitrate [6 moles x nitrate molecular weight (62)/ benzene molecular weight (78)] are required for degradation of 1 gram of benzene. Similar ratios apply for toluene (4.71:1), ethylbenzene (4.67:1), and xylenes (4.67:1), and comparable ratios are expected for other gas-range petroleum hydrocarbons. The resulting mass ratio of approximately 5:1 (nitrate:BTEX/TPH) is based on the assumption that all nitrate is used by micro-organisms to obtain energy through degradation of TPH components.

The ammonium nitrate fertilizer used as the nitrate source contains about 5% by weight inert dolomite material. Based on molecular weight, about 80% of the remaining material is composed of nitrate and 20% is ammonium. Therefore, the 600 lbs of ammonium nitrate fertilizer planned for the first 40,000-gallon injection contains about 456 lbs of nitrate (600x0.95x0.80= 456 lbs nitrate). Based on the TPH stoichiometry noted above, this 456 lbs of nitrate could degrade about 91 lbs of TPH (corresponds to about 13 gallons of diesel).

The stoichiometry is interesting, but of limited usefulness because we don't know how much TPH mass will remain following excavation, but is likely to be substantially more than the equivalent of 13 gallons of diesel. For this reason, the work plan anticipates multiple injections with anticipated increasing concentrations of nitrate. Nitrate concentration changes will be based on monitoring results that will evaluate the distribution and longevity of injected nitrate.