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Prepared for:

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Unalaska Department of Public Safety Building
Geotechnical Engineering Report

Project No. 181209

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PND Project No. 181209

PND ENGINEERS, INC.

Table of Contents

Table of Figures

List of Tables

UNALASKA DPS BUILDING PROJECT

Executive Summary

This summary should be used with the entirety of the geotechnical report for design and construction purposes. This section does not include specific details that are covered in the report, which must be read to develop a comprehensive understanding of the site. Limitations of this summary and report are provided in Section 5.0.

PND's geotechnical scope of work included 10 test borings advanced up to 60 feet below ground surface (bgs) and 6 test pits excavated up to 15 feet bgs.

The findings of our exploration indicate the site is acceptable for the proposed development. The primary geotechnical considerations include:

Soil Conditions: Historically, the project location was a shallow lake. This lake was filled in 1989 using excavated rock material from a nearby project. Generally, the site is underlain by 15 feet of medium to very dense Sandy Gravel with Silt and Boulders over 10 feet of loose to very loose silty sand with organics, peat, and ash over a variable depth of loose to dense silty gravel and sands atop bedrock varying in depth from approximately 11 to 50 feet bgs. The loose organic layer is potentially liquefiable and may result in wide spread settlement of the site during a seismic event.

Groundwater: Groundwater was encountered across the site at an approximate depth of 20 feet bgs.

Foundations: Foundations should be supported on piles driven and seated in bedrock. Piles may require drilling to advance through boulders in the fill. Pile lengths will not be affected by the difference in loads of single- or two-story developments.

Slab-on-grade: Concrete slab floors should be structurally reinforced and supported on pile supported grade beams to avoid damage from settlement during a liquefaction event.

Pavements: Pavement sections in parking areas and drive lanes should consist of a minimum of 2 inches of asphalt overlying 4 inches of base course. The subbase should consist of 24 inches of non-frost-susceptible classified material.

Building and Pavement Location: The building will require a pile foundation regardless of where it is placed on the site. Locating the building to the north west side of the site would place it over more consistent subsurface conditions and likely reduce the average length of the piles. This would locate the building further from the road, which is consistent with the development of adjacent lots. There is little difference in the subsurface conditions between the east and west sides of the lot. Pavements for parking or drop off within 50 feet of Airport Beach road may require subexcavation to remove near surface organics.

UNALASKA DPS BUILDING PROJECT
Geotechnical Report

1. INTRODUCTION

This report presents the geotechnical data collected and the analysis performed by PND Engineers, Inc. (PND) in support of the Unalaska Department of Public Safety (DPS) building project. This project will relocate DPS operations from the existing DPS building and its current location on Safety Way to the southeast corner of the intersection at Captains Bay Road and Airport Beach Road to a new lot located on Lavelle Lane between the existing Iliuliuk Medical Center and Unalaska City Hall. The objective of the geotechnical investigation was to determine the properties and quality of subsurface soils at the proposed location of the new building site.

PND performed the work in accordance with the fee proposal delivered to Jensen Yorba Wall, Inc. on April 9, 2019.

The Geotechnical Report begins with a project background which includes an exploration narrative, description of the site geology, geomorphology, climate and permafrost soil features. Section 3 presents the as-built borehole locations, discusses laboratory testing, and summarizes the soil properties developed from the lab testing program and field logs. All data is presented in the report appendices.

The report contains two appendices:

- ✓ **Appendix A –Test Pit Logs** presents the complete borehole log set from the exploratory borings of this investigation.
- ✓ **Appendix B – Summary of Lab and Field Characteristics** presents the complete summary of results from the lab testing program and field characteristics for all the samples.

2. BACKGROUND

The project background includes an exploration narrative, description of the site geology, geomorphology, climate, and seismic considerations.

The proposed project includes constructing a new DPS building at a vacant site located between the existing Iliuliuk Medical Center and Unalaska City Hall. The purpose of this investigation was to assist in evaluating the suitability of the site for constructing the new DPS building at the proposed location and determining the most appropriate location on the site for the new structure. Prior to performing this investigation, little was known about the quality of subsurface materials located at this site.

Historically, the proposed location was a shallow lake as shown in Figure 2-1. This lake was filled during construction of the UniSea Port Development project in 1989 using excavated material from that project.

Figure 2-1. Proposed Site Prior to Fill Placement (pre-1989)

Figure 2-2. Existing Conditions of Proposed Project Site

2.1 Exploration

The geotechnical investigation began on Monday August 26, 2019 and was completed on Tuesday September 10, 2019. The investigation consisted of ten (10) boreholes and six (6) test pits. The total depth below existing ground surface of each borehole varied depending on the depth to bedrock. The average total borehole depth to bedrock was approximately 35 feet. Borehole and test pit locations and depths are shown in Table 2-1. During the planning phase of the investigation, an estimated location for the new DPS building was provided on an architectural concept drawing; however, the exact location of new structure has yet to be determined. The locations of the boreholes and test pits performed during the investigation were positioned to provide information regarding subsurface soils at the estimated location of the new DPS building while also providing subsurface soil characteristics and suitability of the site as a whole. This approach gathered the maximum amount of information possible for use in determining the most suitable location for the new structure. It should be noted that the locations provided in Table 2-1 were obtained with a handheld GPS unit with a typical error of ±3 feet and are approximate.

Table 2-1. Borehole and Test Pit Summary

Borehole ID	Latitude*	Longitude*	Overburden Thickness (ft)	Rock Core Length Obtained (ft)	Total Depth (ft)
BH-1	166° 32' 17.3040" W	53° 52' 20.8524" N	11.5	10	25
BH-2	166° 32' 17.0844" W	53° 52' 21.5688" N	43	9	54
BH-3	166° 32' 18.3876" W	53° 52' 20.9964" N	48	10.5	60.5
BH-4	166° 32' 18.3408" W	53° 52' 21.5112" N	47.5	3.5	51
BH-5	166° 32' 17.9268" W	53° 52' 21.7452" N	46.5	10	50
BH-6	166° 32' 19.1544" W	53° 52' 21.3420" N	49.5	7.5	57.5
BH-7	166° 32' 19.1472" W	53° 52' 21.7164" N	26.5	9.25	49.75
BH-8	166° 32' 18.7512" W	53° 52' 22.1016" N	20	10	30.5
BH-9	166° 32' 19.5612" W	53° 52' 21.6192" N	25.5	8	33.5
BH-10	166° 32' 20.6808" W	53° 52' 22.4076" N	32	11	46.5
TP-1	166° 32' 16.4112" W	53° 52' 21.0252" N	N/A	N/A	8
TP-2	166° 32' 18.3264" W	53° 52' 21.6804" N	N/A	N/A	14
TP-3	166° 32' 17.2320" W	53° 52' 20.4600" N	N/A	N/A	11
TP-4	166° 32' 19.5720" W	53° 52' 22.2024" N	N/A	N/A	14
TP-4a	166° 32' 19.5648" W	53° 52' 21.7164" N	N/A	N/A	15
TP-5	166° 32' 20.5332" W	53° 52' 22.1484" N	N/A	N/A	15

Field Exploration Equipment and Methods

Discovery Drilling, Inc. performed the drilling for the geotechnical exploration using a Geoprobe 6712DT drill rig to advance boreholes. Drilling and sampling methods consisted a combination of air rotary, Standard Penetration Testing (SPT) and NQ3 rock coring. Field sampling used a 3-inch outside diameter (O.D) Modified SPT split spoon sampler. The sampler was advanced using a 340-pound automatic drop hammer free-falling 30 inches. The sampler was advanced for a distance of 24-inches to obtain each sample, measuring hammer blows at 6-inch intervals. The number of blows required to drive the sampler each 6-inch interval was recorded on the borehole logs. The blow counts shown on the borehole logs are field values that have not been corrected for overburden, rod length, sample size, or other factors. Corrected blow counts are located in Appendix B. After advancing the sampler to obtain a 24-inch sample,

air rotary methods were used to clear the hole of slough and material not captured by the sampler and to continue advancing the borehole to the top of the next sample depth.

Generally, the Modified SPT testing was performed at 2.5-foot intervals beginning 2 feet below ground surface (bgs) and continuing to a depth of 10 feet bgs. Testing was performed at 5-foot intervals thereafter until refusal of the sampler or drilling action indicated that bedrock had been encountered. Refusal is defined as requiring more than 50 hammer blows to advance the sampler past a single 6-inch interval. Upon reaching bedrock, the sampler was retrieved from the borehole and an NQ3 rock core barrel was installed on the drill and advanced an additional 10 feet into bedrock. The recovered soils were field classified following the United Soils Classification System (USCS) according to ASTM D2487 and representative samples were shipped to PND's Anchorage Soil-Material Lab for field verification and lab testing. Soil types and depths are described in Section 3.3.

Figure 2-3. Discovery Drilling at BH-3

Geotechnical test pit exploration was performed by Northern Alaska Contractors, LLC using a CAT 330 tracked excavator. The Contractor made special effort to preserve the vegetative mat and top soil during excavation activities, where present. The salvaged vegetative mat was laid over the disturbed area and lightly compacted using the underside of the excavator bucket once the test pit was backfilled to the appropriate elevation. In areas where vegetation was not present, the Contractor used a combination of the underside of the excavator bucket and a vibratory compactor for compaction while backfilling the test pits.

The field sampling consisted of grab samples from either the test pit floor, side, or the excavator bucket at selected intervals in the test pits. Samples collected during the field investigation are intended to represent homogenous soil layers below the ground surface.

Figure 2-4. Test Pit Excavation

2.2 Geology, Geomorphology and Climate

Surface Conditions

Historically, the project location was a shallow lake. This lake was filled in 1989 using excavated material from a nearby project. Currently, a majority of the existing project site is gravel parking. The southeastern portion (approximately 1/4) of the site consists of a skate park atop a paved surface. Further southeast, between the skate park and Airport Beach Road, exists a slightly elevated portion of the site that is vegetated in grass and native plants typical of Unalaska Island.

The topography increases gradient to the northwest of the site towards Haystack Hill. This is a steep hill with grass vegetation. This hill becomes an exposed rock cliff to the southwest of the site, behind the Iliuliuk Medical Center. A rock cliff also exists to the southeast of the site on the opposite side of Airport Beach Road.

Although surrounded by steep topography, the site itself is relatively level. The site generally slopes toward the north for drainage at a 2.5-4.5% slope. Sheet flow from the site is captured in a drainage ditch that exists between the project site and the paved Raven Way. This ditch carries runoff water southeast along Raven Way to a catch basin at the intersection of Raven Way and Airport Beach Road.

Climate

Unalaska sits within a maritime climate zone with temperatures influenced by open water in the summer and offshore sea ice in the winter. The average daily temperatures recorded in Unalaska range from 36 to 57°F, with a mean annual temperature of 40°F. Extreme temperatures have been recorded from -5 to 79°F (Alaska Climate Summary).

Annual precipitation averages about 57 inches water equivalent, which includes approximately 91 inches of snow (Alaska Climate Summary). The average recorded wind speed at the Unalaska NOAA meteorological station is about 11 mph.

Table 2-2. Climate Summary

Average Air Temperature	40.1 °F
Average Thawing Index	3,100 °F-Days
Design Thawing Index	5,100 °F-Days
Average Freezing Index	200 °F-Days
Design Freezing Index	600 °F-Days

Regional Geology

The Aleutian Trench is located south of Unalaska Island. Subduction along the Aleutian Trench is the major tectonic force affecting the geology of the region. The subduction zone forms a linear belt of volcanoes parallel to the trench that makes up the Ring of Fire. Volcanoes are common in the Unalaska area. The eastern Aleutian volcanoes overlie continental and marine sedimentary rocks that range in age from mid-Paleozoic to Holocene, volcanic rocks of late Mesozoic and mid—Tertiary age (less than 65 million years old), and plutonic rocks of the Laska-Aleutian range batholith that range from the Jurassic to early Tertiary age. Glacial erosion is prominent throughout the island in the form of U-shaped valleys, cirques, and various ice-scoured features.

Seismic Considerations

The Unalaska area is part of the Aleutian Islands and is located in one of the most seismically active zones in the world. Large magnitude earthquakes are common to the area and could result in damage to manmade structures. Any non-engineered loose fills may fail in a large seismic event. The failures may consist of settlement and/or slope failures due to liquefaction. Unalaska Island sits approximately 108 miles north of the Aleutian Megathrust Subduction Zone Interface which is the primary source of all seismicity at or near the project site. The convergence and slip along the Megathrust is estimated to be about 2.2 to 2.9 inches per year in a north-northwest direction (Alaska Earthquake Information Center, AEIC). The Megathrust was the locus of the 1964 moment magnitude, Mw, 9.2 Alaska earthquake, which ruptured approximately 500 miles along the strike of the subduction zone interface (Shennan et al., 2009). Several earthquakes of magnitude over 8.0 have been recorded along the Aleutian chain including many larger than Mw of 6.0 (AEIC).

3. SUBSURFACE and SITE CHARACTERIZATION

The following section summarizes the soil characteristics of the geotechnical exploration conducted at the project site. The characterizations and index variables are based on lab testing and field logging from this exploration. The following sections present test hole locations and discuss the laboratory testing program and results. The final section presents a summary of material and soil properties.

3.1 As-Built Borehole Locations

A total of ten (10) boreholes and six (6) test pits were performed during this investigation. As-built locations are shown below.

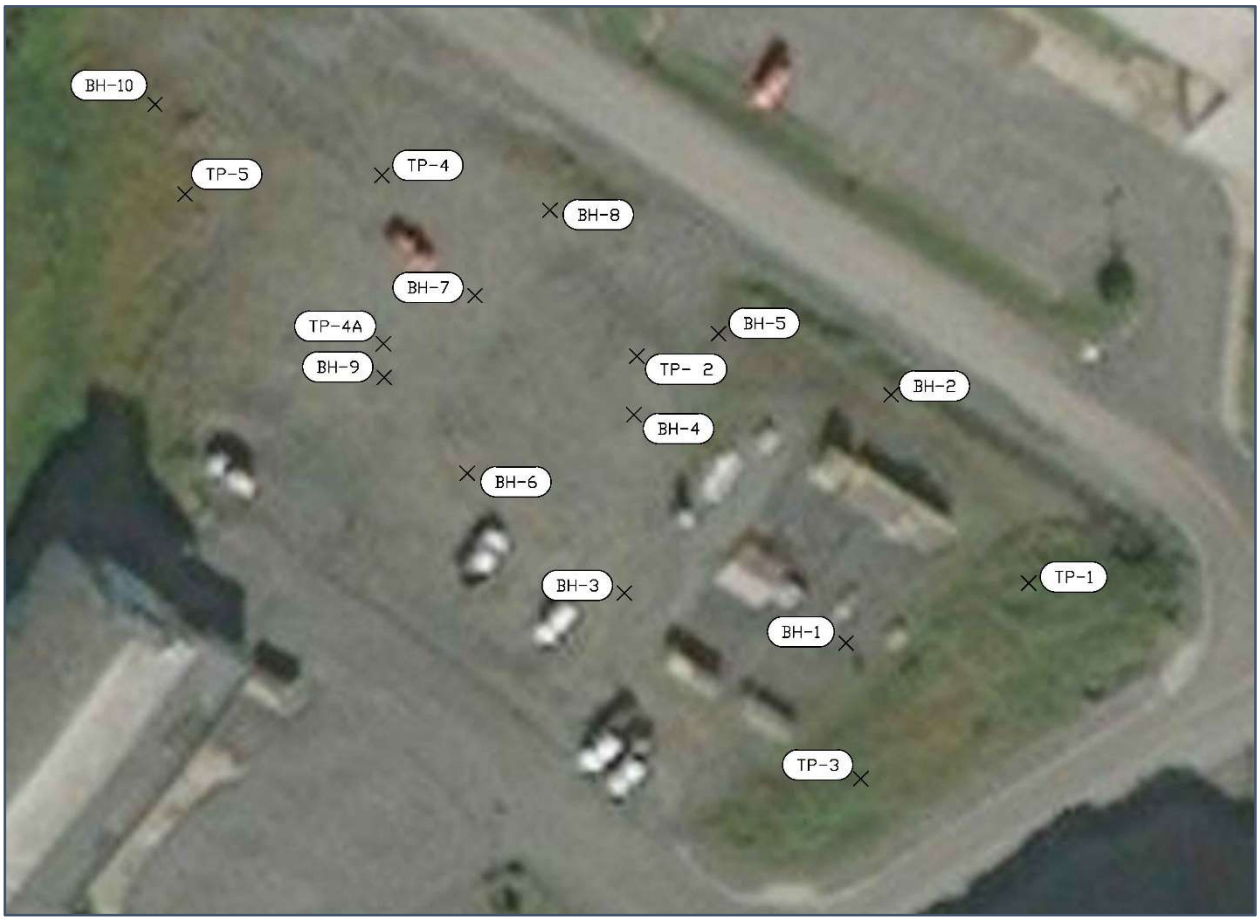

Figure 3-3-1. As-Built Borehole Locations

3.2 Laboratory Characterization

The samples were transported to PND's geotechnical laboratory in Anchorage for testing. All tests were performed to ASTM standards where applicable. A total of nineteen (19) lab tests were performed. The lab test summary is shown in Table 3-1.

Lab characterizations included the following listed tests.

- Moisture Content/Classification *(ASTM D4318)*
- Description and Identification of Soils—Visual-Manual Procedure *(ASTM D2487, D2488)*
- Particle Size Analysis *(ASTM D422)*

Table 3-1. Lab Test Summary

Test Type	Quantity
Moisture Content with Classification (ASTM D2487 / D2488 / D2216)	13
Gradation of Soils (ASTM D6913)	6
Total Lab Tests	19

Full sieve stack gradations were performed on select coarse grained materials. Visual-Manual classifications and moisture contents were performed on select fine-grained materials. The samples chosen for testing were representative of the strata found at the site

The results of the laboratory testing program are shown in *Appendix B – Summary of Lab and Field Characterizations.* Lab results are also shown in the borehole logs at corresponding columns with given soil lithologies.

3.3 Soil Properties in Summary

Soil Lithology

The subsurface soils consist of a general fill layer overlying a silty sand with organics/peat layer followed by gradually increasing gravel percentage and decreasing organic content until bedrock. This matches the anticipated conditions based on local accounts of a former lake area that was filled with general fill material.

The fill material contained several large cobbles and boulders throughout (mostly 8”-18” but also up to 4 ft+ in size). These boulders were discovered during excavation of test pits. Drilling did not indicate the presence of boulders of this size. The boulders did seem “brittle” or soft and it is plausible that the sampler could have driven through and broken pieces of a boulder if it did not hit one directly. Pieces such as this were found within some samples.

There was also a layer of geotextile fabric found consistently during test pit excavation. This geotextile layer was between the fill and native lakebed material.

The idealized soil layers and properties encountered are provided in Table 3-2.

Table 3-2. Idealized Soil Properties

Layer	Depth (ft)	Total Unit Weight (pcf)	ϕ'_{peak} (deg)	c' (psf)
Sandy Gravel with Silt and Boulders	0 – 15	135	38	-
Silty Sand with Organics and Peat	15-25	60	26	-
Silt and Sand with Gravel	25-30	115	32	-
Silty Gravel with Sand	30-35	125	34	
Bedrock	35+			

Gradation curves are located in Appendix B.

Near Surface Soils

Surface soils encountered were generally sandy gravels and gravels with sand and silt that have a USACE frost susceptibility classification F-1. This results in a degree of frost susceptibility that is low and suitable for use as subgrade material.

Bedrock

Bedrock was encountered throughout the site. Core samples were taken to confirm the presence of bedrock and assess its quality. Core samples averaged 9 feet in length. Bedrock quality at the site varies and is moderately to very intensely fractured and is considered soft to hard rock. Bedrock cores had RQD values that ranged between 0 and 81 percent that did not appear to correlate with depth. Bedrock quality classifications are found on the borehole logs.

Depth to bedrock was variable and was shallowest (11.5 feet) at BH-1 nearest Airport Beach Road. Progressing north-northwest into the site, the bedrock quickly drops off and is deepest (43 to 49.5 feet)

in the vicinity of BH-2 through BH-6 on the opposite side of the skate park. The depth to bedrock decreases to between 20 and 30 feet in the area of BH-7 through BH-9 and continues near this depth for the remainder of the site. A summary of bedrock depths is provided in Table 3-3.

Table 3-3. Depth to Top of Bedrock

Borehole	Depth (ft bgs)
BH-1	11.5
BH-2	43
BH-3	47.75
BH-4	47.5
BH-5	40
BH-6	49.5
BH-7	26.5
BH-8	20.5
BH-9	23.5
BH-10	32

SLOPE STABILITY

Permanent slopes greater than 24-inches are not anticipated as part of this project. All slopes should be constructed at a 2 to 1 (horizontal to vertical) slope. A side slope of 2:1 (horizontal to vertical) is recommended for temporary slopes, and 3:1 (horizontal to vertical) for permanent slopes in the in-situ soils, and 2:1 (horizontal to vertical) for permanent slopes with engineered materials.

GROUNDWATER

Groundwater was found on each borehole except for BH-1. This borehole was the shortest of the investigation due to relatively shallow bedrock that was above the groundwater table found in the remainder of the site. Generally, groundwater was encountered at approximately 20 feet bgs throughout the investigated area.

4. ENGINEERING RECOMMENDATIONS

4.1 Engineering Conclusions

The site investigation and subsequent analysis indicates several problematic subsurface conditions: 1) areas of the site contain potentially liquefiable soils between 20’ and 30’ deep; and 2) the entire site includes a high-moisture, loose organic layer. As discussed in this section, both these conditions can lead to long-term settlement risks for shallow foundations (spread footings) and will impact the selection and performance of deep foundation solutions.

The following sections provide discussion and recommendations for the conditions described above as other design parameters that apply to this project.

4.2 Design Parameters

4.2.1 Seismic Criteria and Liquefaction Potential

The new Unalaska Public Safety building is located in one of the most seismically active regions of the world. Structural performance during a seismic event is a critical consideration for this facility. The IBC assigns risk categories in accordance with the risk associated with unacceptable performance during the design earthquake. Risk Categories range from Category II (Life Safety) for most typical buildings to Category IV (Immediate Occupancy) for essential facilities. Description of performance for the categories is presented in the table below. The Unalaska Public Safety Building is intended to remain operational after the design earthquake, and should be considered Category IV.

Table 4-1. Performance of Risk Categories

	Immediate Occupancy (IO), Risk Category IV, Essential Facility	Life Safety (LS) Risk Category II
Overall Damage	Light.	Moderate. Retains margin against collapse.
Description	No permanent drift. Structure substantially retains original strength and stiffness.	Some residual strength and stiffness left in all stories. Gravity load bearing elements function. Some permanent drift.
General Information	Some structural repair required, but not necessary for reoccupancy.	Repair possible, but may not be economical. Structural repairs or bracing may be required prior to reoccupancy.

Seismic design parameters, based upon maps provided by USGS (www.usgs.gov/) and ASCE 7-10 are provided in Table 4-2. Seismic design for all structures shall comply with the appropriate design code.

Table 4-2. Seismic Design Parameters per ASCE 7-10

Return Period	2475 years (2% in 50 years)
Risk Category	IV
Site Class	D
Peak Ground Acceleration	0.5
S_s (0.2 sec period acceleration)	1.5
S_1 (1.0 sec period acceleration)	0.6
Moment Magnitude, Mw	7.4

The site class was determined based on the procedure as outlined in ASCE 7-10 Minimum Design Loads for Buildings and Other Structures.

Liquefaction potential of the soil was assessed due to the site's proximity to the Aleutian Megathrust Subduction Zone. Earthquake-induced liquefaction generally occurs under particular conditions, including a high groundwater table, strong earthquake ground shaking of long duration, and loose uniform sands. All of these factors must be present and work in conjunction simultaneously for liquefaction to occur. During a liquefaction event, the ground will subside and begin to act similar to a fluid allowing foundation elements to move vertically and laterally through the soil with little resistance.

A liquefaction analysis performed on the soils indicated that potentially liquefiable soils exist in areas of the site. The soil layers most susceptible to liquefaction correspond to the very loose to medium loose

sandy layers that are present below the ground water elevation. These soils are predominantly found in the areas of BH-2, BH-3, and BH-5; however, the designer should be aware that liquefiable soils may also be present in other areas of the site such as BH-4 and BH-6. These soils will impact foundation design for the structure and deep foundation is best suited to mitigate liquefaction potential at this site.

4.2.2 Foundation Considerations

The soil type, consistency, density, heave/swell/collapse potential, ground water table, and depth to and type of bedrock are all considered in the type of foundation recommended for the proposed infrastructure.

In general, foundation designs should be consistent with the current edition of the IBC with any local amendments or requirements for footing depths. A frost-protected foundation designed and installed in accordance with ASCE 31-01 is recommended to protect against seasonal frost action.

Shallow Foundations

A shallow foundation should not be used at this site due to the significant risk of excessive settlement from liquefaction as well as the long-term settlement potential over the life of the structure despite subsurface materials providing adequate bearing support. A shallow foundation is unlikely to provide the performance necessary to allow immediate occupancy after a major seismic event.

Shallow foundations are typically reinforced concrete footings such as spread or strip footings. Shallow foundations are typically the most appropriate option when there are favorable subsurface conditions. The general fill material that was used to fill the former lake was found to be well compacted and generally suitable for use as a subgrade with a bearing capacity of 3,000 psf. However, the surcharge added by a new structure may cause settlement in the underlying ash and organic layer that limits the allowable bearing pressure that can actually be used for foundation design. The extent to which the underlying layer affects the design will be dependent on the foundation loading requirements and tolerable settlement. If a shallow foundation is desired, an analysis should be performed during foundation design to determine the magnitude of stress that is transferred from the fill material to the underlying layer. If this stress creates undesirable settlement then a deep foundation should be used. Settlement parameters are provided in Section 4.2.3.

New foundations should bear on firm mineral strata. Any surface pavement, organic layers, volcanic ash, muck, debris or other undesirable material should be removed. The bottom of footings at the exterior of the building should be at least 24 inches below the finished grade. Interior footings should be at least 18 inches below the finished floor elevation. Any soft material found at the limit of the excavation should be removed and replaced with structural fill material.

Deep Foundations

A deep foundation system with grade beams should be used to support the new structure for protection against long-term settlement and liquefaction potential. Deep foundations typically consist of piles or piers that are driven or drilled to a depth that provides adequate support for the structure. Deep foundations systems range in size and installation complexity from small piles easily installed with portable equipment to large piles/piers requiring large cranes and impact hammers. Deep foundation system can also reduce site excavation when compared to the excavation requirements for shallow foundations. Deep foundations are generally costlier than a shallow foundation and are used only when subsurface soils are inadequate to support a shallow foundation.

A deep foundation system derives load carrying capacity in two ways. One way is through friction between the pile surface and adjacent soil, known as skin friction. The other means for deriving load carrying capacity is through end bearing of the pile tip and the soil layer that the tip bears against. If a deep foundation system is used at this site, the foundation piles should be installed to bear on bedrock to develop compression resistance. Due to the fractured nature of the rock surface, piles should be fitted with a driving shoe and driven to a refusal of 100 blows per foot, with an impact hammer properly sized for the load, to ensure the pile is firmly seated in the rock.

The uplift resistance of a typical pile is based only on skin friction. The uplift resistance capable of being achieved through skin friction at this site may be limited during seismic events and only the gravel fill above the liquefiable layer should be considered for resistance. The grade beam system and floor slabs will provide resistance a well. If additional resistance is needed, a micropile can be installed to meet project loading requirements. A micropile consists of a pile casing installed to bear on bedrock with the addition of a high-strength steel tendon that is installed into bedrock and grouted in place. A micropile derives uplift resistance through a rock anchor tendon and the bond strength. Uplift resistance is discussed further in Section 4.2.5.

Test pit excavation found large cobbles and boulders throughout the general fill material located at this site. Some of these boulders were larger than 36 inches in a single dimension. The sampler spoon was generally able to drive through any cobbles or boulders present at the site and hit refusal due to a boulder only once during the investigation. The remainder of sampler refusals were confirmed to be bedrock. Nevertheless, the presence of these boulders may cause issues during pile installation and the Contractor should be prepared to remove or drill through obstructions during pile installation.

4.2.3 Settlement

The native organic material that is found throughout the site approximately between 15 – 25 feet below ground surface is susceptible to settlement. Modified SPT testing found these soils to be very loose to loose. Additionally, these soils had a high organic and moisture content. These factors indicate a soil with limited bearing capacity and a high potential for both primary and secondary settlement.

The following range of values should be considered when analyzing potential settlement of this layer:

Table 4-3. Consolidation Parameters

Primary Compression Index, C_c	1.5-4
Secondary Compression Index Ratio, C_α / C_c	0.04-0.06
Coefficient of Consolidation, C_v	0.31-1.55 $in^2/s \times 10^{-4}$

4.2.4 Lateral Load Resistance

Lateral loads on footings and grade beams will be resisted by passive earth pressures developed against the footing block and frictional resistance against the base of the footing. PND recommends a passive resistance (equivalent fluid pressure) of 200 pcf that includes a factor of safety of 2. A coefficient of friction of 0.45 is recommended to be used for resistance of footings to lateral sliding, assuming concrete footings cast directly against sand and gravel.

4.2.5 Uplift Resistance

Uplift loads may occur in some foundation elements due to overturning moments that occur as a result of wind and seismic forces. Uplift loads may be resisted by the weight of the footing and soil within the limits of a truncated pyramid above the top of the footing. The shape of the truncated pyramid will vary with material type and density. Uplift resistance may also be resisted by the weight of the grade beams and supported concrete slabs. For the sand and gravel that is present in the upper layers at this site, the pyramid should be defined by a 30-degree angle from the vertical extending upward from the top of the footing.

Uplift resistance can also be provided by skin friction of piles installed at the site. An estimated uplift resistance for an 8" diameter pipe pile at this site is approximately 3.5 kips. This value is primarily attributed to the layer of general fill since the variable depth of bedrock limits the thickness of quality material available to provide uplift resistance in some areas of the site.

The bond strength of the rock at this site is estimated to be approximately 120 psi for use in micropile design.

It should be noted that multiple BH's had difficulty during coring with a lack of return water coming to the surface through the drill casing. Typically, while coring water is pumped into the hole through the core barrel at a faster rate than it can dissipate into the rock, with the excess coming back out of the hole. Many boreholes on this did not have return water coming out of the hole. This generally occurred in areas of highly fractured rock. It is recommended that water pressure testing and pre-grouting methods performed in accordance with PTI DC35.1 – Recommendations for Prestressed Rock and Soil Anchors are considered during construction; particularly in areas of the site where bedrock exhibited low RQD values (<50%) and intense fracturing.

4.2.6 Floor Support

Concrete slabs-on-grade should not be used for floors at this site due to excessive settlement risk. Floors of any type should be supported on grade beams and design for the appropriate spans and loads.

If slabs-on-grade are used elsewhere on site, a minimum of 4 inches compacted base course over 24" of non-frost susceptible subbase is recommended to support all on-grade slabs. The subgrade soils should be proof-rolled prior to placement of classified fill and be free of debris, organics, silts or clays, or other deleterious material.

4.2.7 Pavement Recommendations

The paved areas of the project site should follow the following minimum recommendations:

Pavement sections should consist of a minimum of 2 inches of asphalt overlying 4 inches of base course. The subbase should consist of 24 inches of non-frost-susceptible classified material. The subgrade soils should be proof-rolled prior to placement of classified fill and be free of debris, organics, silts or clays, or other deleterious material.

4.3 Construction Recommendations

All earthworks should be performed according to the project specifications and in accordance with local, state, and federal laws and regulations.

4.3.1 Site Preparation

All trees, small brush, surface organics, pavements, existing building foundations, and surface debris should be removed prior to starting any earthwork. Subgrade soils should be proof-rolled or otherwise compacted prior to placement of any fill material.

4.3.2 Excavations

Temporary excavations of soil should be performed with care and follow Alaska State Labor and OSHA regulations or other agency guidelines and recommendations for trenching and slope angles based on soil types encountered. Permanent excavations should either be retained or sloped to meet long-term stability requirements.

Excavations should be performed utilizing a backhoe with a smooth-bladed bucked from outside the excavation to minimize disturbance of the subgrade soils. Soils that are disturbed, pumped, or rutted by construction activity should be removed prior to placement of any structural, classified, or unclassified fill as recommended in this report. Excavation slopes of 2:1 (horizontal to vertical) should be used.

4.3.3 Drainage and Control of Water

Parking and apron areas should have positive gradients toward drainage structures and away from buildings. Site grading should be established to provide drainage of surface water or roof drainage away from the proposed building and towards suitable drainage structures.

The ground immediately adjacent to the building foundation should slope away at a minimum of 5 percent for a minimum distance of 10 feet, or as far as allowed by property boundaries, as measured perpendicular to the face of the wall. Grading should be designed to prevent ponding of surface water except where retention ponds or similar devices are intended. Free-draining soils should be used as backfill around foundations.

4.3.4 Fill and Compaction – General Recommendations

All fill material should be free from lumps, organics, debris, or other deleterious material, and should be durable and sound. A vibratory steel drum roller should be used to compact structural fill. Lightweight or hand operated compactors may be used when compacting near existing structures, utilities, and/or new footings to avoid destressing and/or causing settlement below the structure.

Hauling or grading equipment should not be used in lieu of appropriate compaction equipment. Any disturbance of fill material, by hauling or other equipment, should be re-compacted to required densities. The number of passes required to meet the compaction requirement will depend upon the size of compaction equipment used and the layer thickness. Each layer should be compacted as recommended in this report and field verified to confirm adequate densities are achieved.

Foundation soil should be protected from freezing during construction. No frozen soil should be used as fill, nor should any fill be placed over frozen soil. Any frozen soil should be removed and replaced with suitable fill.

4.3.5 Classified Fill and Compaction

Classified fill is material containing no muck, frozen material, roots, sod or other deleterious matter with a plasticity index not greater than 6 as tested by ATM 204 and ATM 205. Classified fill should be placed in loose lifts not exceeding 12 inches in thicknesses if a large vibratory compactor is used, or not exceeding

4 inches in thickness if a hand compactor is used. Each lift of structural fill should be compacted to at least 95% of the Modified Proctor Maximum Density (ASTM D1557).

4.3.6 Utilities Recommendations

Excavations and placement of utilities should be carried out in accordance with the applicable utility specifications. Utility locates should be performed prior to commencement of construction activities.

Trenching should be accordance with OSHA safety standards, Trench widths should be at least 3 feet wide or the diameter of the pipe or conduit plus 12 inches, whichever is smaller. Water and sewer pipe shall be placed so there is a minimum of 4 feet of cover or be insulated. Electrical conduit and cables should have at least 18 inches of cover. Pipes and conduit should be bedded with a minimum of 6 inches below, 12 inches on each side, and 6 inches above the pipe or conduit. Bedding should be comprised of NFS material, placed in lifts not to exceed 8 inches thick and compacted to 95% Modified Proctor Maximum Density (ASTM D1557).

5. LIMITATIONS and CLOSURE

The information submitted in this report is based on our interpretation of data from a field and lab geotechnical investigation conducted for this project and other sources discussed in this report. Effort was made to obtain information which is representative of the actual conditions at the site. However, actual subsurface conditions will vary and additional information may be discovered that could impact our recommendations. If conditions significantly different from those indicated in this report are encountered by subsequent investigations or during construction, the recommendations of this report should be reviewed by PND.

This report was prepared by PND Engineers, Inc. for use on this project only, and may not be used in any manner that would constitute a detriment to PND. PND is not responsible for conclusions, opinions or recommendations made by others based on data presented in this report.

This report is submitted to Jensen Yorba Wall, Inc. by PND. PND appreciates the opportunity to work with you on this project.

Sincerely,

PND Engineers, Inc.

Paul Kendall, PE
Principal

Michael Gemmell, PE
Senior Engineer

6. REFERENCES

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APPENDIX A — BOREHOLE LOGS

LOG OF BOREHOLE BH-01

Project: Unalaska DPS
Project Number: 181209

Horizontal Datum: WGS 84
Latitude: 53.87247 °N Longitude: 166.53813 °W

Logged By: MJG
Reviewed By:
Review Date:

Depth (25 ft)	Drill Method	Sample Type	Recovery	Sample #	Soil Classification	Symbol	Graphic Log	Blows/ 6 in.	Other Tests	Size Distribution
0	AR				Loose, blue-gray poorly graded **GRAVEL**; **GP**. Sub-angular gravel (max. 2.5-inch). With PEAT.	GP		2 2 3 7		
5								4 3 3 2		
					Loose, orange-brown **Ash** with Fibrous Organics	ASH		1 0 6 17		
10					Gray **SILTY GRAVEL**; **GM**. Sub-angular gravel (max. 2.5-inch).	GM		27		
					Gray poorly graded **GRAVEL with SAND**; **GPs**. Angular gravel (max. 1.5-inch). With Rock Fragments.	GPs		19 50/3"		
					Reddish BEDROCK ; **BR**. Very Hard, Slightly Fractured.	BR		50/0"	RQD=77%	
15	NQ3									
	NQ3				Greenish gray BEDROCK ; **BR**. Porous Rock, Hard, Intensely Fractured.				RQD=0%	
20	NQ3								RQD=33%	
	NQ3				Reddish BEDROCK ; **BR**. Very Hard, Slightly Fractured.				RQD=68%	
25										

◆ Blows per foot
▲ Salinity ppt
● Moisture %
10 20 30 40

Borehole terminated at 25 ft
Client: JENSEN YORBA WALL, INC.
Drill Start: 9/3/2019

Drilling Contractor: Discovery Drilling
Drill Equipment: GeoProbe 6712 DT
Driller: SM

LOG OF BOREHOLE BH-02

Project: Unalaska DPS
Project Number: 181209

Horizontal Datum: WGS 84
Latitude: 53.87267 °N Longitude: 166.53808 °W

Logged By: MJG
Reviewed By:
Review Date:

Depth (54 ft)	Drill Method	Sample Type	Recovery	Sample #	Soil Classification	Symbol	Graphic Log	Blows/ 6 in.	Other Tests	Size Distribution
0	AR	Sh		01	Dense, light green poorly graded **GRAVEL**; **GP**. Sub-rounded/sub-angular gravel (max. 1.5-inch). With COBBLES.	GP		12 14 10 16		
5					Dense, gray poorly graded **GRAVEL with SAND**; **GPs**. Sub-angular gravel (max. 1.5-inch).	GPs		10 12 11 11		
					Medium-dense, greenish gray **SILTY GRAVEL**; **GM**. Angular gravel (max. 2-inch). With Fibrous PEAT.	GM		9 13 12 11		
10					Medium-dense, orange-brown poorly graded **GRAVEL with SAND**; **GPs**. Angular gravel (max. 2.5-inch).	GPs		5 6 5 6		
15					Loose, greenish gray poorly graded **SANDY GRAVEL**; **sGP**. Sub-angular gravel (max. 1-inch). Trace ORGANIC.	sGP		4 3 5 5		
					Dark Brown **Ash** with Fibrous Organics	ASH		1 1		
20					Loose, brown poorly graded **SAND**; **SP**. With Fibrous PEAT. 1/2" Clay layer @21'.	SP		1 3		
25		Sh		08	Medium-dense, brownish gray **SILTY SAND with GRAVEL**; **SMg**. Sub-rounded gravel (max. 1-inch). 1/4" dark gray SAND layer @30'.	SMg		9 10 10 9		
30										

◆ Blows per foot
△ Salinity ppt
● Moisture %
10 20 30 40

Borehole terminated at 54 ft
Client: JENSEN YORBA WALL, INC.
Drill Start: 8/30/2019

Drilling Contractor: Discovery Drilling
Drill Equipment: GeoProbe 6712 DT
Driller: SM

LOG OF BOREHOLE BH-02

Project: Unalaska DPS
Project Number: 181209

Horizontal Datum: WGS 84
Latitude: 53.87267 °N Longitude: 166.53808 °W

Logged By: MJG
Reviewed By:
Review Date:

Depth (54 ft)	Drill Method	Sample Type	Recovery	Sample #	Soil Classification	Symbol	Graphic Log	Blows/ 6 in.	Other Tests	Size Distribution
30					Medium-dense, gray poorly graded **SANDY GRAVEL**; **sGP**. Sub-rounded/sub-angular gravel (max. 1.5-inch).	sGP		8 10 8 8		
35		Sh		10	Very dense, greenish gray **SILTY, SANDY GRAVEL**; **sGM**. Sub-rounded gravel (max. 1-inch). 3/4" Wet Silty Sand layer @40'.	sGM		34 27 37 50		Gravel = 46% Sand = 40% Fines = 13%
40					Blue-gray BEDROCK ; **BR**. Weathered Rock.			34 50/5"		
45	NQ3				Reddish BEDROCK ; **BR**. Very Hard, Intensely Fractured.	BR		50/1"	RQD=52% RQD=12%	
	NQ3								RQD=0%	
50	NQ3									

◆ Blows per foot
▲ Salinity ppt
● Moisture %
10 20 30 40

Borehole terminated at 54 ft
Client: JENSEN YORBA WALL, INC.
Drill Start: 8/30/2019

Drilling Contractor: Discovery Drilling
Drill Equipment: GeoProbe 6712 DT
Driller: SM

LOG OF BOREHOLE BH-03

Project: Unalaska DPS
Project Number: 181209

Horizontal Datum: WGS 84
Latitude: 53.87250 °N Longitude: 166.53843 °W

Logged By: MJG
Reviewed By:
Review Date:

Depth (60.5 ft)	Drill Method	Sample Type	Recovery	Sample #	Soil Classification	Symbol	Graphic Log	Blows/ 6 in.	Other Tests	Size Distribution
0	AR	Sh		01	Very dense, orange-gray well-graded **GRAVEL with SILT and SAND**; **(GW-GM)s**. Angular gravel (max. 2.5-inch). With COBBLES.	(GW-GM)s		47 22 12 14		Gravel = 71% Sand = 24% Fines = 6%
5		Sh		02	Medium-dense, dark gray poorly graded **GRAVEL**; **GP**. Angular gravel (max. 2.5-inch). With COBBLES.	GP		7 6 9 9		
10		Sh		03	Medium-dense, dark gray poorly graded **GRAVEL with SILT and SAND**; **(GP-GM)s**. Sub-angular gravel (max. 1-inch). With COBBLES.	(GP-GM)s		8 11 10 8		Gravel = 62% Sand = 29% Fines = 9%
15								5 2 3 2		
20		Sh		04	Very loose, **Ash** with Fibrous Organics	Ash		2 0 1 1	105%	
25					Loose, brown poorly graded **SAND**; **SP**. With ORGANICS.	SP		1 2 2 2		
30										

Blows per foot
Salinity ppt
Moisture % (10 20 30 40)

P N D

Borehole terminated at 60.5 ft
Client: JENSEN YORBA WALL, INC.
Drill Start: 8/31/2019

Drilling Contractor: Discovery Drilling
Drill Equipment: GeoProbe 6712 DT
Driller: SM

LOG OF BOREHOLE BH-03

Project: Unalaska DPS
Project Number: 181209

Horizontal Datum: WGS 84
Latitude: 53.87250 °N Longitude: 166.53843 °W

Logged By: MJG
Reviewed By:
Review Date:

Depth (60.5 ft)	Drill Method	Sample Type	Recovery	Sample #	Soil Classification	Symbol	Graphic Log	Blows/ 6 in.	Other Tests	Size Distribution
30					Gray **SILT with GRAVEL**; **MLg**. Angular gravel (max. 3/4-inch).	MLg		4 3 6 3		
		Sh		06						
35					Loose, orange-brown **SILTY SAND**; **SM**. Rock Fragments @38'.	SM		3 2 4 7		
		Sh		07						
40					Gray poorly graded **SAND**; **SP**.	SP			Heave	
45					Dense, gray poorly graded **SANDY GRAVEL**; **sGP**. Sub-rounded/sub-angular gravel (max. 1-inch).	sGP		4 9 15 34		
50	NQ3				Reddish BEDROCK ; **BR**. Hard to Very Hard, Intensely to Moderately Fractured.	BR			RQD=0%	
55	NQ3								RQD=44%	
60	NQ3								RQD=15%	

Blows per foot
Salinity ppt
Moisture %
10 20 30 40

Borehole terminated at 60.5 ft
Client: JENSEN YORBA WALL, INC.
Drill Start: 8/31/2019

Drilling Contractor: Discovery Drilling
Drill Equipment: GeoProbe 6712 DT
Driller: SM

LOG OF BOREHOLE BH-03

Project: Unalaska DPS Project Number: 181209	Horizontal Datum: WGS 84 Latitude: 53.87250 °N Longitude: 166.53843 °W	Logged By: MJG Reviewed By: Review Date:

Depth (60.5 ft)	Drill Method	Sample Type	Recovery	Sample #	Soil Classification	Symbol	Graphic Log	Blows/ 6 in.	Blows per foot / Salinity ppt / Moisture % (10 20 30 40)	Other Tests	Size Distribution
60											

Borehole terminated at 60.5 ft
Client: JENSEN YORBA WALL, INC.
Drill Start: 8/31/2019

Drilling Contractor: Discovery Drilling
Drill Equipment: GeoProbe 6712 DT
Driller: SM

LOG OF BOREHOLE BH-04

Project: Unalaska DPS
Project Number: 181209

Horizontal Datum: WGS 84
Latitude: 53.87265 °N Longitude: 166.53843 °W

Logged By: MJG
Reviewed By:
Review Date:

Depth (51 ft)	Drill Method	Sample Type	Recovery	Sample #	Soil Classification	Symbol	Graphic Log	Blows/ 6 in.	Blows per foot / Salinity ppt / Moisture % (10 20 30 40)	Other Tests	Size Distribution
0	AR				Light gray poorly graded **GRAVEL with SAND**; **GPs**.	GPs					
15					Light brown poorly graded **SAND with GRAVEL**; **SPg**.	SPg					
20					Loose, orange-brown **SILTY SAND**; **SM**. With Fibrous ORGANIC.	SM		72 4 4 3			
25											
30											

Borehole terminated at 51 ft
Client: JENSEN YORBA WALL, INC.
Drill Start: 9/2/2019

Drilling Contractor: Discovery Drilling
Drill Equipment: GeoProbe 6712 DT
Driller: SM

LOG OF BOREHOLE BH-04

Project: Unalaska DPS
Project Number: 181209

Horizontal Datum: WGS 84
Latitude: 53.87265 °N Longitude: 166.53843 °W

Logged By: MJG
Reviewed By:
Review Date:

Depth (51 ft)	Drill Method	Sample Type	Recovery	Sample #	Soil Classification	Symbol	Graphic Log	Blows/ 6 in.	Blows per foot / Salinity ppt / Moisture % (10 20 30 40)	Other Tests	Size Distribution
30					Dark gray poorly graded **GRAVEL with SAND**; **GPs**.	GPs					
35											
40					Dark gray poorly graded **SAND**; **SP**.	SP					
45					No ice-bonded, gray poorly graded **GRAVEL with SAND**; **GPs**.	GPs					
	NQ3				Gray BEDROCK ; **BR**. Hard to Very Hard, Intensely to Moderately Fractured.	BR				RQD=12%	
50											

Borehole terminated at 51 ft
Client: JENSEN YORBA WALL, INC.
Drill Start: 9/2/2019

Drilling Contractor: Discovery Drilling
Drill Equipment: GeoProbe 6712 DT
Driller: SM

LOG OF BOREHOLE BH-05

Project: Unalaska DPS
Project Number: 181209

Horizontal Datum: WGS 84
Latitude: 53.87270 °N Longitude: 166.53832 °W

Logged By: MJG
Reviewed By:
Review Date:

Depth (50 ft)	Drill Method	Sample Type	Recovery	Sample #	Soil Classification	Symbol	Graphic Log	Blows/ 6 in.	Blows per foot / Salinity ppt / Moisture % (10 20 30 40)	Other Tests	Size Distribution
0	HSA				Dense, gray poorly graded **GRAVEL**; **GP**. Angular gravel (max. 2-inch). With COBBLES.	GP		8 14 14 9			
5		Sh		03	Medium-dense, gray **SILTY, GRAVELLY SAND**; **gSM**. Sub-angular gravel (max. 2-inch). With COBBLES.	gSM		3 21 12 8 5 6 6 7			Gravel = 39% Sand = 46% Fines = 14%
10		Sh		04	Medium-dense, greenish gray poorly graded **GRAVELLY SAND**; **gSP**. Sub-angular gravel (max. 2-inch).	gSP		4 8 4 7			
15					Loose, brown poorly graded **SAND with SILT**; **SP-SM**. Angular gravel (max. 2-inch). With ORGANICS.	SP-SM		4 2 1 2			
20		Sh		06	Very loose, brown **Ash** with Fibrous Organics	ASH		1 0 1 1			
25					Medium-dense, dark gray poorly graded **SANDY GRAVEL**; **sGP**. Sub-rounded/sub-angular gravel (max. 1.5-inch). 1' SAND @30'.			3 3 8 6			
30											

Borehole terminated at 50 ft
Client: JENSEN YORBA WALL, INC.
Drill Start: 8/28/2019

Drilling Contractor: Discovery Drilling
Drill Equipment: GeoProbe 6712 DT
Driller: DV

LOG OF BOREHOLE BH-05

Project: Unalaska DPS
Project Number: 181209

Horizontal Datum: WGS 84
Latitude: 53.87270 °N Longitude: 166.53832 °W

Logged By: MJG
Reviewed By:
Review Date:

Depth (50 ft)	Drill Method	Sample Type	Recovery	Sample #	Soil Classification	Symbol	Graphic Log	Blows/ 6 in.	Other Tests	Size Distribution
30						sGP		6 6 6	Heave	
35	AR				Blue-gray BEDROCK ; **BR**.			30 50 50/3		
40	NQ3				BEDROCK ; **BR**. Purple Blue Green Rock. Moderately Soft, Intensely to Moderately Fractured.					
					Orange-gray BEDROCK ; **BR**. Moderately Soft, Very Intensely Fractured.	BR			RQD=9%	
45	NQ3								RQD=0%	
50										

Blows per foot
Salinity ppt
Moisture %
10 20 30 40

Borehole terminated at 50 ft
Client: JENSEN YORBA WALL, INC.
Drill Start: 8/28/2019

Drilling Contractor: Discovery Drilling
Drill Equipment: GeoProbe 6712 DT
Driller: DV

LOG OF BOREHOLE BH-06

Project: Unalaska DPS
Project Number: 181209

Horizontal Datum: WGS 84
Latitude: 53.87260 °N Longitude: 166.53865 °W

Logged By: MJG
Reviewed By:
Review Date:

Depth (57.5 ft)	Drill Method	Sample Type	Recovery	Sample #	Soil Classification	Symbol	Graphic Log	Blows/ 6 in.	Blows per foot / Salinity ppt / Moisture % (10 20 30 40)	Other Tests	Size Distribution
0					Dark brown **PEAT**; **PT**.	PT					
					Gray poorly graded **SAND with GRAVEL**; **SPg**.	SPg					
5					Gray poorly graded **GRAVEL with SAND**; **GPs**.	GPs					
10					Light brown poorly graded **SAND with GRAVEL**; **SPg**.	SPg					
					Gray poorly graded **GRAVEL with SAND**; **GPs**.	GPs					
20 ▽					**Ash** with Fibrous Organics	ASH					
25	AR				Brown poorly graded **GRAVEL with SAND**; **GPs**. 6" SAND @39.5'.						
30											

Borehole terminated at 57.5 ft
Client: JENSEN YORBA WALL, INC.
Drill Start: 9/1/2019

Drilling Contractor: Discovery Drilling
Drill Equipment: GeoProbe 6712 DT
Driller: SM

LOG OF BOREHOLE BH-06

Project: Unalaska DPS
Project Number: 181209

Horizontal Datum: WGS 84
Latitude: 53.87260 °N Longitude: 166.53865 °W

Logged By: MJG
Reviewed By:
Review Date:

Depth (57.5 ft)	Drill Method	Sample Type	Recovery	Sample #	Soil Classification	Symbol	Graphic Log	Blows/ 6 in.	Other Tests	Size Distribution
30						GPs				
35										
40		Sh		01	Dense, dark gray **SILTY, SANDY GRAVEL**; **sGM**. Angular gravel (max. 1-inch).	sGM		15 6 15 43		
45		Sh		02	Light gray poorly graded **GRAVELLY SAND**; **gSP**.	gSP		45 50/4"		
50	NQ3				Dark gray BEDROCK ; **BR**. Hard to Very Hard, Intensely Fractured.	BR		50/2"	RQD=21%	
	NQ3								RQD=0%	
55	NQ3								RQD=11%	

Blows per foot
Salinity ppt
Moisture %
10 20 30 40

Borehole terminated at 57.5 ft
Client: JENSEN YORBA WALL, INC.
Drill Start: 9/1/2019

Drilling Contractor: Discovery Drilling
Drill Equipment: GeoProbe 6712 DT
Driller: SM

LOG OF BOREHOLE BH-07

Project: Unalaska DPS
Project Number: 181209

Horizontal Datum: WGS 84
Latitude: 53.87270 °N Longitude: 166.53865 °W

Logged By: MJG
Reviewed By:
Review Date:

Depth (49.75 ft)	Drill Method	Sample Type	Recovery	Sample #	Soil Classification	Symbol	Graphic Log	Blows/ 6 in.	Other Tests	Size Distribution
0	AR				Dark gray poorly graded **GRAVEL with SAND**; **GPs**. Angular gravel (max. 2-inch). Trace ORGANIC.	GPs		10		
					Very dense, light gray poorly graded **GRAVELLY SAND**; **gSP**. Sub-angular gravel .	gSP		37 37 50/4"		
5					Dense, gray poorly graded **GRAVEL**; **GP**. Sub-angular gravel (max. 2.5-inch).	GP		20 13 8 4 10 28 16 14		
10		Sh		05	Medium-dense, gray **SILTY, GRAVELLY SAND**; **gSM**. Angular gravel (max. 2-inch). With COBBLES and ORGANICS.	gSM		6 7 7 7		
15					Medium-dense, gray poorly graded **GRAVEL with SAND**; **GPs**. Angular gravel (max. 2.5-inch). PEAT @16.5'.	GPs		9 8 6 2		
					Dark brown **Ash** with Fibrous Organics	ASH				
20		Sh		07	Loose, orange-brown **Ash** with Fibrous Organics			1 2 2 4	71%	
25					Blue-gray BEDROCK ; **BR**.			50/2"		
30										

Blows per foot
Salinity ppt
Moisture %
10 20 30 40

Borehole terminated at 49.75 ft
Client: JENSEN YORBA WALL, INC.
Drill Start: 8/27/2019

Drilling Contractor: Discovery Drilling
Drill Equipment: GeoProbe 6712 DT
Driller: DV

LOG OF BOREHOLE BH-07

Project: Unalaska DPS
Project Number: 181209

Horizontal Datum: WGS 84
Latitude: 53.87270 °N Longitude: 166.53865 °W

Logged By: MJG
Reviewed By:
Review Date:

Depth (49.75 ft)	Drill Method	Sample Type	Recovery	Sample #	Soil Classification	Symbol	Graphic Log	Blows/ 6 in.	Blows per foot / Salinity ppt / Moisture % (10 20 30 40)	Other Tests	Size Distribution
30						BR		50/3"			
35								50/1"			
40	NQ3				BEDROCK ; **BR**. Blue Green Rock. Moderately Hard to Moderately Soft, Moderately to Slightly Fractured.					RQD=72.5%	
45	NQ3									RQD=77%	
	NQ3				Greenish gray BEDROCK ; **BR**. Moderately Soft, Intensely Fractured.					RQD=0%	

Borehole terminated at 49.75 ft
Client: JENSEN YORBA WALL, INC.
Drill Start: 8/27/2019

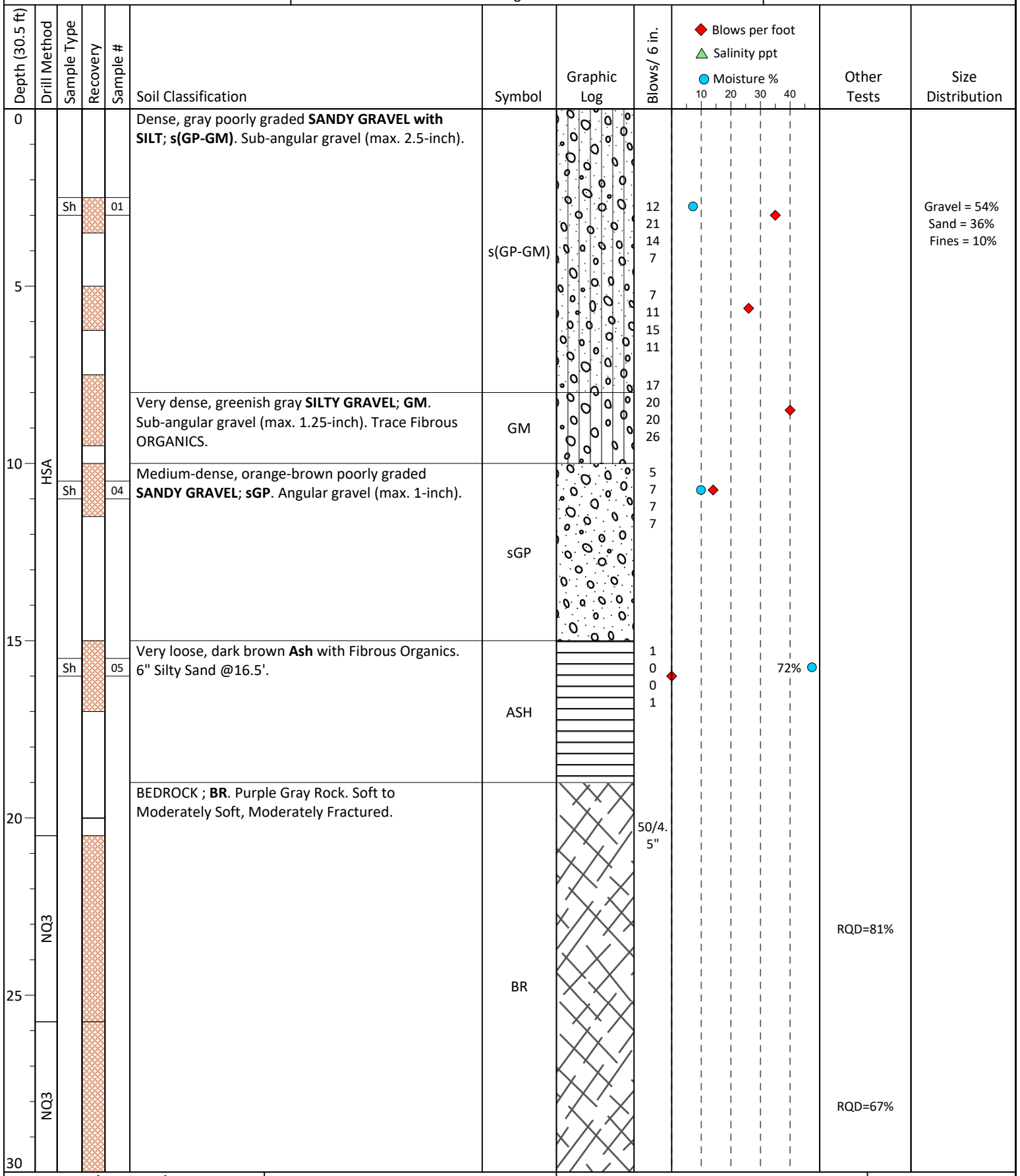
Drilling Contractor: Discovery Drilling
Drill Equipment: GeoProbe 6712 DT
Driller: DV

LOG OF BOREHOLE BH-08

Project: Unalaska DPS
Project Number: 181209

Horizontal Datum: WGS 84
Latitude: 53.87280 °N Longitude: 166.53855 °W

Logged By: MJG
Reviewed By:
Review Date:



Borehole terminated at 30.5 ft
Client: JENSEN YORBA WALL, INC.
Drill Start: 8/28/2019

Drilling Contractor: Discovery Drilling
Drill Equipment: GeoProbe 6712 DT
Driller: DV

LOG OF BOREHOLE BH-08

Project: Unalaska DPS Project Number: 181209	Horizontal Datum: WGS 84 Latitude: 53.87280 °N Longitude: 166.53855 °W	Logged By: MJG Reviewed By: Review Date:

Depth (30.5 ft)	Drill Method	Sample Type	Recovery	Sample #	Soil Classification	Symbol	Graphic Log	Blows/ 6 in.	Blows per foot / Salinity ppt / Moisture % (10 20 30 40)	Other Tests	Size Distribution
30											

Borehole terminated at 30.5 ft
Client: JENSEN YORBA WALL, INC.
Drill Start: 8/28/2019

Drilling Contractor: Discovery Drilling
Drill Equipment: GeoProbe 6712 DT
Driller: DV

LOG OF BOREHOLE BH-09

Project: Unalaska DPS
Project Number: 181209

Horizontal Datum: WGS 84
Latitude: 53.87267 °N Longitude: 166.53877 °W

Logged By: MJG
Reviewed By:
Review Date:

Depth (33.5 ft)	Drill Method	Sample Type	Recovery	Sample #	Soil Classification	Symbol	Graphic Log	Blows/ 6 in.	Blows per foot / Salinity ppt / Moisture % (10 20 30 40)	Other Tests	Size Distribution
0	AR	Sh		01	Dense, brown poorly graded **SANDY GRAVEL with SILT**; **s(GP-GM)**. Sub-rounded/sub-angular gravel (max. 1-inch).	s(GP-GM)		11 12 26			Gravel = 58% Sand = 32% Fines = 9%
5	AR				Medium-dense, light gray poorly graded **GRAVEL with SAND**; **GPs**. Sub-angular gravel (max. 2-inch).	GPs		9 6 9 8 8			
	AR	Sh		03				20 22 15 13			
10	AR				Medium-dense, light gray poorly graded **SANDY GRAVEL**; **sGP**. Sub-angular gravel (max. 2.5-inch). With COBBLES.	sGP		8 6 6 9			
15	AR	Sh		05	Very loose, dark brown **Ash** with Fibrous Organics	ASH		4 2 1 1	72%		
20 ▽	AR				Loose, orange-brown poorly graded **SAND**; **SP**. Trace ORGANICS.	SP		1 2 2 4			
25	NQ3				Blue-gray BEDROCK ; **BR**. Moderately Soft, Intensely Fractured.	BR		50/4"		RQD=22%	
30											

Borehole terminated at 33.5 ft
Client: JENSEN YORBA WALL, INC.
Drill Start: 9/1/2019

Drilling Contractor: Discovery Drilling
Drill Equipment: GeoProbe 6712 DT
Driller: SM

LOG OF BOREHOLE BH-09

Project: Unalaska DPS
Project Number: 181209

Horizontal Datum: WGS 84
Latitude: 53.87267 °N Longitude: 166.53877 °W

Logged By: MJG
Reviewed By:
Review Date:

Depth (33.5 ft)	Drill Method	Sample Type	Recovery	Sample #	Soil Classification	Symbol	Graphic Log	Blows/ 6 in.	Blows per foot / Salinity ppt / Moisture % (10 20 30 40)	Other Tests	Size Distribution
30	NQ3									RQD=78%	

Borehole terminated at 33.5 ft
Client: JENSEN YORBA WALL, INC.
Drill Start: 9/1/2019

Drilling Contractor: Discovery Drilling
Drill Equipment: GeoProbe 6712 DT
Driller: SM

LOG OF BOREHOLE BH-10

Project: Unalaska DPS
Project Number: 181209

Horizontal Datum: WGS 84
Latitude: 53.87288 °N Longitude: 166.53908 °W

Logged By: MJG
Reviewed By:
Review Date:

Depth (46.5 ft)	Drill Method	Sample Type	Recovery	Sample #	Soil Classification	Symbol	Graphic Log	Blows/ 6 in.	Other Tests	Size Distribution
0	AR	Sh		01	Dense, gray poorly graded **GRAVEL with SAND**; **GPs**. Angular gravel (max. 2-inch). With COBBLES. 6" Sandy Gravel @5'.	GPs		8 8 10 16		
5		Sh		02				11		
		Sh		03				15 10 15		
		Sh		04				12		
		Sh		05	Medium-dense, blue-gray poorly graded **GRAVEL**; **GP**. Angular gravel (max. 2-inch). With COBBLES.	GP		11 21 20		
10		Sh		06				6 8 5 7		
15								4 3 2 13		
		Sh		07	Very loose, dark brown **Ash** with Fibrous Organics	ASH		0 1 0 1		
25		Sh		08	Orange-brown **SILTY SAND**; **SM**. Trace Gravel.	SM		1 2 1 2	71%	
30										

Blows per foot
Salinity ppt
Moisture %
10 20 30 40

Borehole terminated at 46.5 ft
Client: JENSEN YORBA WALL, INC.
Drill Start: 8/26/2019

Drilling Contractor: Discovery Drilling
Drill Equipment: GeoProbe 6712 DT
Driller: DV

LOG OF BOREHOLE BH-10

Project: Unalaska DPS
Project Number: 181209

Horizontal Datum: WGS 84
Latitude: 53.87288 °N Longitude: 166.53908 °W

Logged By: MJG
Reviewed By:
Review Date:

Depth (46.5 ft)	Drill Method	Sample Type	Recovery	Sample #	Soil Classification	Symbol	Graphic Log	Blows/ 6 in.	Blows per foot / Salinity ppt / Moisture % (10 20 30 40)	Other Tests	Size Distribution
30								50/5"			
					Blue-gray BEDROCK ; **BR**. Very Hard Rock, Very Intensely Fractured.						
35	NQ3					BR		18 50/3"		RQD=50% RQD=20%	
40					BEDROCK ; **BR**. Purple Gray Rock. Moderately Hard, Slightly Fractured.					RQD=77%	
45											

Borehole terminated at 46.5 ft
Client: JENSEN YORBA WALL, INC.
Drill Start: 8/26/2019

Drilling Contractor: Discovery Drilling
Drill Equipment: GeoProbe 6712 DT
Driller: DV

LOG OF BOREHOLE TP-01

Project: Unalaska DPS
Project Number: 181209

Horizontal Datum: WGS 84
Latitude: 53.87250 °N Longitude: 166.53790 °W

Logged By: MJG
Reviewed By:
Review Date:

Depth (7.5 ft)	Drill Method	Sample Type	Recovery	Sample #	Soil Classification	Symbol	Graphic Log	Blows/ 6 in.	Blows per foot / Salinity ppt / Moisture % (10 20 30 40)	Other Tests	Size Distribution
0	TP				**PEAT**; **PT**.	PT					
		GR		01	Gray **SILTY GRAVEL with SAND**; **GMs**. Sub-rounded/sub-angular gravel . With Organics and COBBLES.	GMs					
		GR		02	**SILTY, GRAVELLY SAND**; **gSM**.	gSM					
		GR		03	**SILTY SAND**; **SM**. Top of Bedrock @7.5'.	SM					
5		GR		04							

Borehole terminated at 7.5 ft
Client: JENSEN YORBA WALL, INC.
Drill Start: 9/10/2019

Drilling Contractor: NAC
Drill Equipment: 330C Excavator
Driller:

LOG OF BOREHOLE TP-02

Project: Unalaska DPS Project Number: 181209	Horizontal Datum: WGS 84 Latitude: °N Longitude: °W	Logged By: MJG Reviewed By: Review Date:

Depth (14 ft)	Drill Method	Sample Type	Recovery	Sample #	Soil Classification	Symbol	Graphic Log	Blows/ 6 in.	Blows per foot / Salinity ppt / Moisture % (10 20 30 40)	Other Tests	Size Distribution
0	TP	GR		01	Gray poorly graded **SANDY GRAVEL**; **sGP**. Sub-rounded/sub-angular gravel (max. 3-inch).	sGP					
		GR		02							
		GR		03	Brownish gray poorly graded **GRAVEL with SAND**; **GPs**. (max. 3-inch). With Organic Wood, COBBLES, and BOULDERS.	GPs					
5		GR		04							
10											

P N D	**Borehole terminated at 14 ft** Client: JENSEN YORBA WALL, INC. Drill Start: 9/10/2019	Drilling Contractor: NAC Drill Equipment: 330C Excavator Driller:	Page: 1 of 1

LOG OF BOREHOLE TP-03

Project: Unalaska DPS
Project Number: 181209

Horizontal Datum: WGS 84
Latitude: 53.87235 °N Longitude: 166.53812 °W

Logged By: MJG
Reviewed By:
Review Date:

Depth (11 ft)	Drill Method	Sample Type	Recovery	Sample #	Soil Classification	Symbol	Graphic Log	Blows/ 6 in.	Blows per foot / Salinity ppt / Moisture % (10 20 30 40)	Other Tests	Size Distribution
0	TP				**PEAT**; **PT**. Interbedded Sand with Junk Materials.	PT					
		GR		01	Brownish gray poorly graded **GRAVEL with SAND**; **GPs**. (max. 3-inch). With Organics.	GPs					
		GR		02	Brownish gray poorly graded **SAND**; **SP**.	SP					
5		GR		03	Brown **SILTY, SANDY GRAVEL**; **sGM**. Sub-rounded/sub-angular gravel (max. 5-inch). With COBBLES.	sGM					
		GR		04	Dark brown **PEAT**; **PT**. Tree Roots.	PT					
		GR		05	Orange-brown **SILTY SAND**; **SM**. Interbeeded ASH Layer @8.5'. Top of Bedrock @11'.	SM					
10											

Borehole terminated at 11 ft
Client: JENSEN YORBA WALL, INC.
Drill Start: 9/10/2019

Drilling Contractor: NAC
Drill Equipment: 330C Excavator
Driller:

LOG OF BOREHOLE TP-04

Project: Unalaska DPS
Project Number: 181209

Horizontal Datum: WGS 84
Latitude: °N Longitude: °W

Logged By: MJG
Reviewed By:
Review Date:

Depth (16 ft)	Drill Method	Sample Type	Recovery	Sample #	Soil Classification	Symbol	Graphic Log	Blows/ 6 in.	Blows per foot / Salinity ppt / Moisture % (10 20 30 40)	Other Tests	Size Distribution
0	TP	GR		01	Greenish gray poorly graded **SANDY GRAVEL**; **sGP**. Sub-angular gravel (max. 3-inch). With COBBLES.	sGP					
		GR		02							
5		GR		03	Greenish gray poorly graded **GRAVEL with SAND**; **GPs**. With BOULDERS.	GPs					
					Dark brown **PEAT**; **PT**.	PT					
10		GR		04	Light brown poorly graded **SANDY GRAVEL**; **sGP**. Sub-rounded/sub-angular gravel (max. 2-inch). With COBBLES. Boulders @11'.	sGP					
15		GR		05	Dark brown **SILTY, GRAVELLY SAND**; **gSM**. With Organics. Geotextile Fabric @15'.	gSM					
		GR		06							

Borehole terminated at 16 ft
Client: JENSEN YORBA WALL, INC.
Drill Start: 9/10/2019

Drilling Contractor: NAC
Drill Equipment: 330C Excavator
Driller:

LOG OF BOREHOLE TP-04a

Project: Unalaska DPS
Project Number: 181209

Horizontal Datum: WGS 84
Latitude: °N Longitude: °W

Logged By: MJG
Reviewed By:
Review Date:

Depth (16 ft)	Drill Method	Sample Type	Recovery	Sample #	Soil Classification	Symbol	Graphic Log	Blows/ 6 in.	Blows per foot / Salinity ppt / Moisture % (10 20 30 40)	Other Tests	Size Distribution
0	TP	GR		01	Gray poorly graded **SANDY GRAVEL**; **sGP**. Sub-rounded/sub-angular gravel (max. 3-inch). With COBBLES, BOULDERS, Tree Branches, and Trace Fibrous Organics..	sGP					
		GR		01a							
		GR		02							
5		GR		03							
10											
15		GR		04	Dark brown **SILTY SAND**; **SM**. With Organics. Geotextile Fabric @15'.	SM					

Borehole terminated at 16 ft
Client: JENSEN YORBA WALL, INC.
Drill Start: 9/10/2019

Drilling Contractor: NAC
Drill Equipment: 330C Excavator
Driller:

LOG OF BOREHOLE TP-05

Project: Unalaska DPS
Project Number: 181209

Horizontal Datum: WGS 84
Latitude: °N Longitude: °W

Logged By: MJG
Reviewed By:
Review Date:

Depth (15 ft)	Drill Method	Sample Type	Recovery	Sample #	Soil Classification	Symbol	Graphic Log	Blows/ 6 in.	Blows per foot / Salinity ppt / Moisture % (10 20 30 40)	Other Tests	Size Distribution
0	TP	GR		01	Brown poorly graded **SANDY GRAVEL**; **sGP**. Sub-rounded/sub-angular gravel (max. 3-inch). With COBBLES, BOULDERS, and Trace Organics.	sGP					
5		GR		02							
		GR		03							
10		GR		04							
15											

Borehole terminated at 15 ft
Client: JENSEN YORBA WALL, INC.
Drill Start: 9/10/2019

Drilling Contractor: NAC
Drill Equipment: 330C Excavator
Driller:

APPENDIX B — Summary of Lab and Field Characteristics

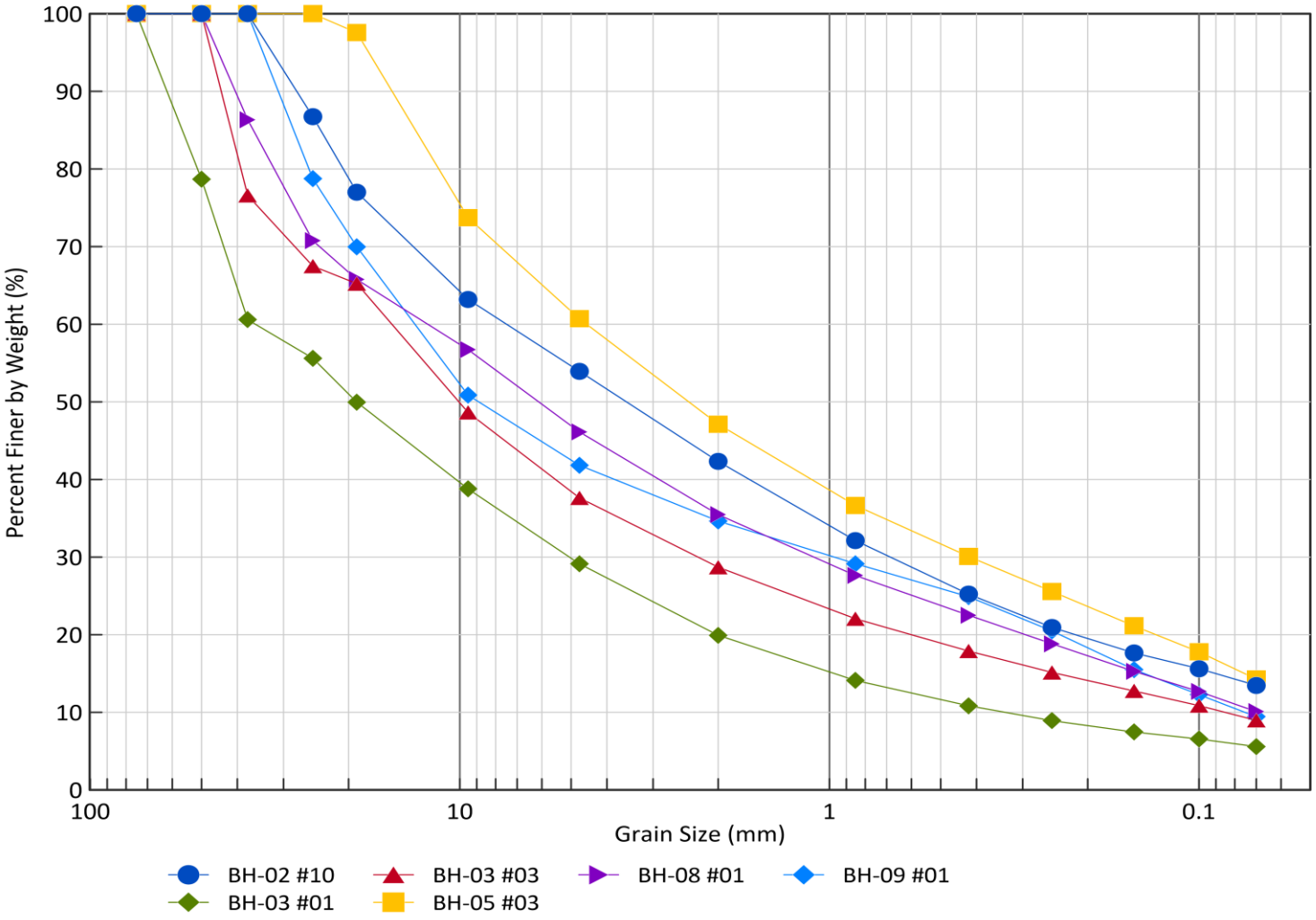
Grain Size Distribution

Client: JENSEN YORBA WALL, INC.
Project: Unalaska DPS
Project #: 181209

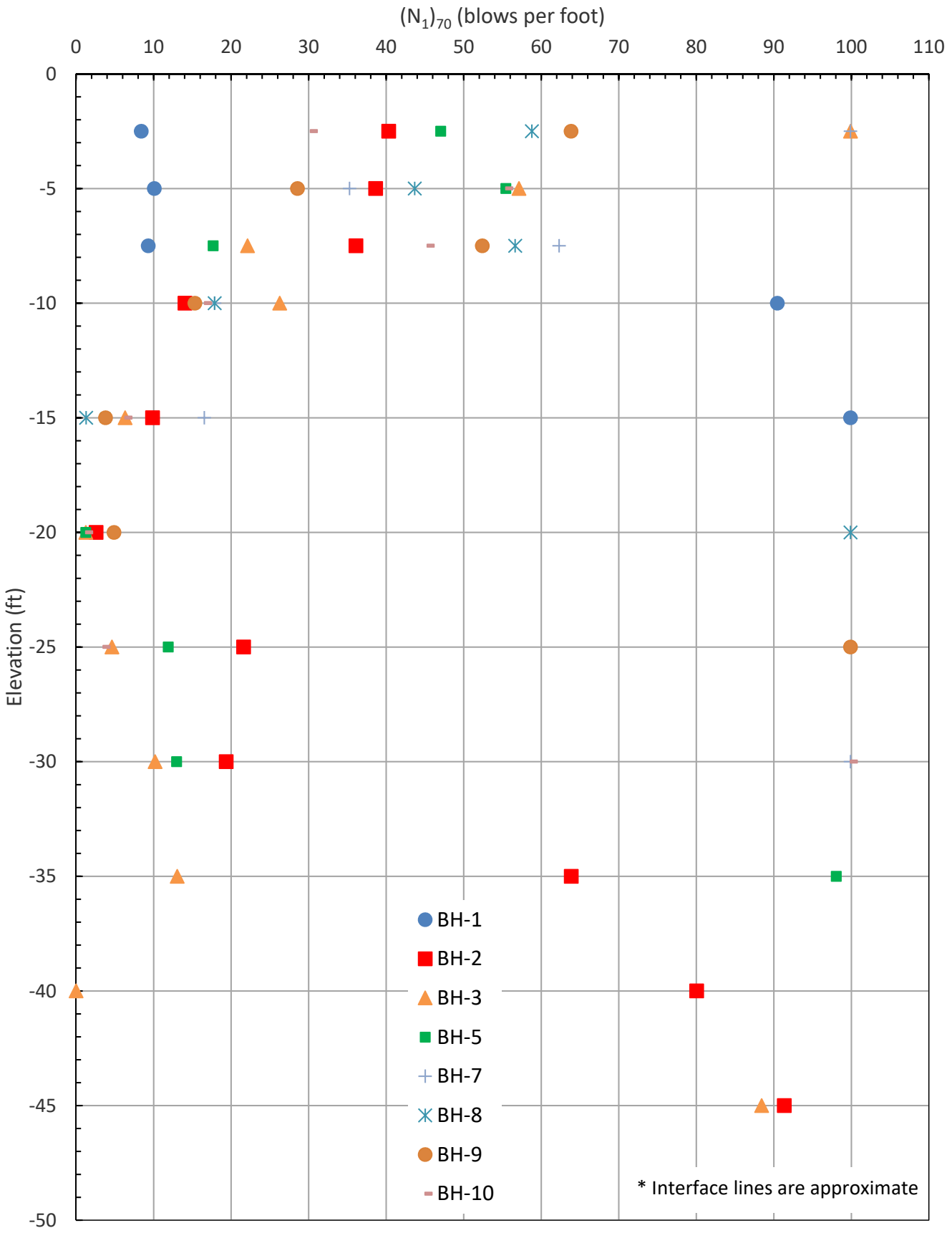
PND ENGINEERS, INC.

COBBLE	GRAVEL		SAND		
	coarse	fine	coarse	medium	fine

US Sieve Opening (in.)						US Sieve Numbers							
3	2	1.5	1	¾	⅜	#4	#10	#20	#40	#60	#100	#140	#200



Borehole	Sample #	From	To	Laboratory Classification	Gradation (%)			D50	P10
					Gravel	Sand	Fines		
BH-02	10	35.5	36	sGM	46.1	40.5	13.5	3.5	42.3
BH-03	01	5.5	6	(GW-GM)s	70.9	23.6	5.6	19.0	19.9
BH-03	03	10.5	11	(GP-GM)s	62.4	28.7	9.0	10.1	28.7
BH-05	03	8	8.5	gSM	39.3	46.4	14.2	2.4	47.1
BH-08	01	2.5	3	s(GP-GM)	53.9	36.0	10.0	6.1	35.5
BH-09	01	3	3.5	s(GP-GM)	58.2	32.4	9.4	8.9	34.6


$(N_1)_{70}$ (blows per foot)
0
10
20
30
40
50
60
70
80
90
100
110
Elevation (ft)
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
BH-1
BH-2
BH-3
BH-5
BH-7
BH-8
BH-9
BH-10
* Interface lines are approximate