REPORT ON

GEOTECHNICAL ENGINEERING SERVICES FOR ASTORIA PIPELINE ROAD WATERLINE CLATSOP COUNTY, OREGON

by
Haley & Aldrich, Inc.
Portland, Oregon

for
Tetra Tech, Inc.
Portland, Oregon

File No. 0208388-000
August 2024

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27 August 2024
File No. 0208388-000

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Attention: Matt Huxley, P.E.
Jesse Fields, P.E.

Subject: Geotechnical Engineering Services for Astoria Pipeline Road Waterline
Pipeline Road
Clatsop County, Oregon

Dear Matt Huxley and Jesse Fields:

Haley & Aldrich, Inc. (Haley & Aldrich) is pleased to submit to Tetra Tech, Inc., our draft geotechnical report for the Astoria Pipeline Road Waterline project (Project) in Clatsop County, Oregon for the City of Astoria (City).

The existing pipeline, constructed in 1963, is the sole transmission main that delivers water from the City's watershed/treatment facility to City limits and is approximately 10 miles long. The pipeline traverses rugged, undeveloped land and crosses through or near multiple landslides. This Project includes the design of approximately 3650 feet of replacement waterline in four areas along the alignment designated Sites 1 through 4 as shown on Figure 1. Haley & Aldrich previously performed a geologic hazard evaluation of the four sites to look at possible realignments/reroute of the transmission and/or mitigation potential. The results of that evaluation indicated that reroute was not feasible for the identified sites, so the transmission line will be replaced and upgraded in generally the same alignment as the current pipeline. (Refer to our 15 March 2024 Geologic Hazards Report for discussion regarding the hazards and reroute evaluation.)

This report contains the results of our research, explorations, and provides recommendations and considerations for the design and construction of the proposed Project, specifically related to excavation and trench stabilization considerations.

We appreciate the opportunity to provide our services to you on this Project. If you have any questions, please contact us.

Sincerely yours,
HALEY & ALDRICH, INC.

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Technical Specialist

David Burger, C.E.G.
Senior Engineering Geologist

Daniel J. Trisler, P.E., G.E.
Principal Geotechnical Engineer

Enclosures

https://haleyaldrich.sharepoint.com/sites/CityofAstoria/Shared Documents/0208388.Astoria Pipeline Road Waterline Resilience/Deliverables/Geotech Report/Final/2024_0827_HAI_AstoriaWaterlineGeotechReport_F.docx

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SIGNATURE PAGE FOR

REPORT ON
GEOTECHNICAL ENGINEERING SERVICES FOR ASTORIA PIPELINE ROAD WATERLINE CLATSOP COUNTY, OREGON

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1. Introduction

This report presents our geotechnical assessments and recommendations for the Pipeline Road Waterline Resilience project (Project) near the City of Astoria (City) in Clatsop County, Oregon. The Project seeks to reroute the pipeline away from and/or mitigate potential geologic hazards at four locations previously identified along the pipeline alignment. We completed a detailed geologic hazards evaluation of the four locations and developed preliminary recommendations for reroute and mitigation. We also consulted with Tetra Tech, Inc. (Tetra Tech) and the City about various approaches for addressing the geologic hazard present along the Project, which were outlined by Tetra Tech in an alternatives report. This report provides geotechnical recommendations for the design and construction of the preferred approach chosen by the City.

1.1 PROJECT UNDERSTANDING

Our understanding of the Project is based on conversations with the City, the project team, and review of the Project Request for Qualifications (RFQ). We understand that the City plans to replace 3,650 feet in four areas of transmission waterline located along Pipeline Road between the City water supply and the City limits. The new 24-inch or larger high-density polyethylene (HDPE) line will replace the existing 21-inch concrete cylinder pipe (CCP) line built in 1963. The pipeline will be constructed parallel to the existing waterline and moved out of landslide prone areas where possible.

1.2 PROJECT BACKGROUND

The City’s water transmission main (waterline) was constructed in 1963. The waterline is a 10-mile-long, 21-inch-diameter CCP pipeline that runs from Bear Creek Dam in a forested portion of Clatsop County to the City’s Reservoir #2 within City limits. Based on information provided in the City’s Water Distribution Plan completed in 2000, the waterline does not have restraints at joints within the limits of this project and can experience separation of joints due to pressure in the static condition.

The waterline route transits the Oregon Coast Range, which is subject to landslides under normal conditions and even more vulnerable in the case of a large earthquake. Landslides have directly affected the pipeline in the past, including temporarily severing water services to the City. Haley & Aldrich, Inc. (Haley & Aldrich; formerly Hart Crowser, Inc.) performed a geotechnical resilience study for the Pipeline Road Waterline in November 2019 (Hart Crowser, 2019). The study included evaluating the existing waterline route, determining its vulnerability to landslides in the event of a large earthquake, and identifying possible new routes that would be more resilient and less susceptible to failure. Haley & Aldrich conducted a geologic reconnaissance of the alignment to locate and map areas of potential instability, past instability, and other relevant landforms. The study identified 42 locations along the waterline that were vulnerable to landslide activity and identified four areas where the waterline could potentially be rerouted around landslide hazards, labeled Site 1 through 4 and shown on Figure 1. The potential reroutes at the four identified areas formed the basis for this scope of work.

In support of this specific Project, Haley & Aldrich performed a more detailed supplemental geologic hazards evaluation of the four sites in 2023 to further evaluate the waterline reroute and/or mitigation strategies. This work focused a geologic reconnaissance of the alignment and the reroute locations identified in the 2019 work. The reconnaissance located areas of potential instability, past instability, located and interpreted relevant landslides, and identified areas for the potential realignment to avoid localized geologic hazards. Details of this evaluation are provided in the Geologic Hazards Report (Haley & Aldrich, 2024) and are summarized for each site below:

- **Site 1:** The waterline replacement was recommended for reroute along a revised potential reroute alignment shown on Figures 4a and 4b based on identified geohazards near the existing waterline alignment that could be better avoided.
- **Sites 2, 3, and 4:** The waterline replacement was not recommended for reroute along these potential reroute alignments proposed during the 2019 work based on geohazards identified near the proposed reroutes which could not be avoided.

As discussed above, it was determined that the potential pipeline reroute was feasible only at Site 1 and we recommended the pipeline be replaced within the current alignment at Sites 2, 3, and 4. Subsequently, the City determined that there was insufficient pressure within the existing system to install the pipeline within the recommended reroute alignment at Site 1, which is at a higher elevation than the current waterline alignment. Therefore, the City has elected to not pursue any potential realignments, and will replace and upgrade the pipeline within the existing alignment at Sites 1 through 4.

In conversations with Tetra Tech and the City, we understand that pipeline design and hazard mitigation would be limited to the pipeline only due to budget constraints, and not include slope stabilization or mitigation of identified geologic hazards outside of the pipeline trench (i.e., roadway or slopes above/below the roadway). The City has elected to use HDPE pipe in the replaced line based on the Alternatives Analysis conducted by Tetra Tech (Tetra Tech, 2024a). Based on that decision, Tetra Tech developed a 30% plan set (Tetra Tech, 2024b) with input from Haley & Aldrich showing the currently proposed preferred transmission main alignment that follows the pre-existing alignment with minor adjustments generally adjacent to the current alignment. This 30% plan set was used as the basis for the development of our geotechnical design and construction recommendations contained within this report. We understand that the 60% project drawings have renamed Sites 1 through 4, with Site 1 now referred to as Site A, Site 2 as Site B, and Sites 3 and 4 combined into Site C.

2. Purpose and Scope

The purpose of our work was to evaluate the subsurface conditions and provide geotechnical engineering recommendations for design and construction recommendations in support the design of the Pipeline Road Waterline Seismic Resilience Project for the City. We completed the following tasks in general accordance with our Services Agreement dated 30 August 2023.

- Met with the design team to discuss areas of specific geotechnical concern.
- Completed a subsurface exploration program along the Project alignment to characterize the subsurface conditions, including the following:
    - exploring the sites by drilling 10 hollow-stem auger borings to depths of 11.5 to 31.5 feet below ground surface (bgs);
    - observing the explorations, logging subsurface conditions, collecting representative soil and bedrock samples, and transporting the samples to our laboratory for further visual examination and testing;

  - collecting standard penetration test (SPT), Modified California, or Shelby Tube samples at 2.5- to 5-foot intervals;
  - drumming and hauling the borehole spoils and disposing of them at an off-site location; and
  - backfilling the boreholes in accordance with state regulations.
- Performed laboratory testing on samples collected from our explorations including *in situ* moisture content, Atterberg limits, grain size distribution, and corrosivity.
- Developed recommendations and consideration for earthwork and construction.
- Prepared this draft geotechnical report outlining our findings and recommendations.
- Provided project management and support services, including coordinating staff and subcontractors, and conducting telephone consultations and email communication.

3. Site Conditions

3.1 GEOLOGIC AND SOIL MAPPING AND GEOLOGIC HAZARD

As part of the Geologic Hazards Report (Haley & Aldrich, 2024), Haley & Aldrich performed a geologic reconnaissance and reviewed the geologic and soil mapping in the area of the existing alignment and proposed reroute alignments. Refer to the Geologic Hazards Report (Haley & Aldrich, 2024) for detailed discussion regarding these topics. The location of the project is shown on Figure 1. Site geology and soil mapping are shown on Figures 2 and 3, respectively. The existing and proposed pipeline alignments with mapped geohazards at Sites 1 through 4 are shown on Figures 4A, 4B, 5A, and 6A. Subsurface profiles are shown on Figures 4C, 5B, and 6B. Our findings are summarized in the figures included in this report.

3.2 SUBSURFACE CONDITIONS

3.2.1 General

Our understanding of subsurface conditions is based on our research, the work completed in 2019, and the recent information collected from our field explorations and geologic reconnaissance. Specifically, 10 borings (designated B-1-1 through B-4-10) were advanced using a truck-mounted drill rig utilizing hollow stem auger to depths ranging from 11.5 to 31.5 feet bgs. Borings B-1-1 through B-1-5 were completed at Site 1 with B-1-3 located on the 2019 potential reroute alignment for that area. Borings B-2-6 and B-2-7 were completed at Site 2, while B-3-8 through B-4-10 were completed at Sites 3 and 4. Locations of our borings are shown on Figures 4A, 4B, 5A, 5B, 6A, and 6B.

The boring logs are included in Appendix A. Laboratory test results are provided on the exploration logs and described in Appendix B.

The subsurface information used for this study represents conditions at discrete locations across the Project alignment. Figures 4C, 5B, and 6B show select subsurface profiles which represent conceptual interpretations of soil and bedrock conditions between select explorations. Actual conditions between or below discrete explorations could vary from that shown on the profiles or exploration logs. The nature and extent of any variations in subsurface conditions may not become evident until construction begins. If significant variations are observed at that time, we may need to modify our conclusions and recommendations accordingly to reflect actual site conditions.

3.2.2 Soil Conditions

The subsurface conditions encountered in our explorations typically consisted of varying amounts of roadway construction fill and colluvium/landslide deposits underlain by the Youngs Bay Member of the Astoria Formation. A description of each material encountered is provided below following by a discussion of groundwater conditions.

3.2.2.1 Fill

Fill soils were encountered in all our borings except B-1-5 and B-3-8. Fill soils, when encountered, typically ranged from 3 to 6 feet in thickness. In Site 1, no fill was encountered at the southern end of the pipe alignment in boring B-1-5; and at Site 3, no fill was encountered at the northern end of the pipe alignment in boring B-3-8. The fill in Site 1 typically consists of medium stiff clay and silt with varying amounts of sand and trace amounts of gravel and organic debris. In Site 2,3, and 4, fill soil typically consisted of loose clayey sand with varying amounts of gravel and silt.

SPT "blow counts” in the fill ranged from 3 to 9 blows per foot (bpf), with an average of 6 bpf.

Laboratory testing performed on select samples indicated *in situ* moisture content generally range between 12 and 68 percent. The fine-grained materials in this unit typically have medium to high plasticity with plasticity indices that range from 24 to 43.

We anticipate that soils excavated for the waterline trench will be partially in this unit.

3.2.2.2 Colluvium/Landslide Deposits

Colluvium/landslide deposits were encountered in Site 1, in borings B-1-1 through B-1-4, to depths ranging from 8 to 20 feet bgs; and in Site 3, in boring B-3-9, to a depth of 12 feet bgs. This unit was not encountered in Sites 2 or 4. Soil of this unit consists of soft to medium stiff lean clay with varying amounts of sand, wood debris, and roots.

SPT blow counts in this material ranged from 2 to 16 bpf, with an average of 7 bpf.

Laboratory testing performed on select samples in this material indicate that the soils have a high plasticity with plasticity indices that range from 30 to 39.

Where encountered in Sites 1 and 3, we anticipate that soils excavated for the waterline trench will terminate in this unit.

3.2.2.3 Youngs Bay Member of the Astoria Formation

The Youngs Bay Member of the Astoria Formation is locally divided into mudstone and sandstone units, both of which were encountered in our explorations. Mudstone is a fine-grained sedimentary rock consisting of a mixture of clay and silt-sized particles. Terms such as “claystone” and “siltstone” are often used in place of mudstone, although these refer to rocks whose grain size falls within much narrower ranges. Sandstone is described as clean, medium- to coarse-grained, thick to very thick-bedded, and friable arkosic sandstone that contains large mica flakes.

The bedrock encountered in all borings was typically weathered to a soil-like condition with rock structures and has been described in the boring logs as a fine- or coarse-grained soil with a separate rock description. All of our explorations terminated within this unit.

At Site 1, this unit was encountered as shallow as 1.5 feet bgs at the southern end of the alignment in boring B-1-5 and as great as a depth of 20 feet bgs. This unit typically consists of extremely soft to very soft (R0 to R1) moderately weathered to predominately decomposed mudstone. In some explorations like in borings B-1-2 and B-1-4, sandstone was encountered interbedded with the mudstone. The sandstone was observed to be very soft to soft (R1 to R2) and predominantly weathered. SPT blow counts in this material ranged from 6 bpf to 50 blows per 3 inches, with an average of 25 bpf, which indicates a soil-like consistency/relative density of very stiff or medium dense.

At Site 2, this unit was encountered approximately 3 to 5 feet bgs and is described as extremely soft to medium hard (R0 to R3), fresh to slightly weathered sandstone with interbedded layers of soft to medium hard (R2 to R3), fresh to slightly weathered mudstone. SPT blow counts in this material ranged from 7 to 46 bpf, with an average of 16 bpf, which indicates a soil-like consistency/relative density of very stiff or medium dense.

At Sites 3 and 4, this unit was encountered approximately 1 to 12 feet bgs and is described as extremely soft to very soft (R0 to R1) moderately weathered to predominately decomposed sandstone interbedded with very soft (R0), moderately weathered to predominantly decomposed mudstone. SPT blow counts in this material ranged from 6 to 86 bpf, with an average of 38 bpf, which indicates a soil-like consistency/relative density of hard or dense.

Laboratory testing performed on select samples of bedrock indicated *in situ* moisture content generally range between 14 and 44 percent. The fine-grained materials in this unit typically have medium to high plasticity with plasticity indices that range from 13 to 30.

3.2.3 Groundwater Conditions

Limited groundwater data exists for the Project area. Groundwater was not encountered in our explorations; however, the sampler was observed to be wet upon extraction at 15 feet bgs in boring B-1-3, likely indicating a zone of perched water within fine-grained material. We also completed a search for nearby well logs to estimate regional groundwater. One well was located in the Project vicinity but approximately 200 feet lower in elevation, and water was observed approximately 130 feet bgs. As such, we anticipate that a regional groundwater table will not be encountered during construction. However, due to the fine-grained nature of the majority of the materials encountered, it is feasible that zones of perched water may be encountered in excavations.

4. Geotechnical Recommendations

This section of the report presents our recommendations regarding the geotechnical aspects of design and construction for the project. We have developed our recommendations based on our discussions with the project team, review of the 30% plans, and the subsurface conditions revealed by our explorations and research. If the nature or location of the proposed improvements are different than we have assumed, Haley & Aldrich should be notified so we can review, change, and/or confirm our recommendations.

4.1 GENERAL CONDITIONS

Based on our explorations, testing, and research, it is our opinion that the proposed Project is feasible from a geotechnical perspective, provided the recommendations in this report are included in design and construction. We offer the following general summary of our conclusions.

- The Project alignment passes through and near multiple geologic hazards as discussed in the Geologic Hazards Report.
  - The proposed improvements are primarily geared toward upgrading the transmission line to utilize a more resilient pipe material (HDPE pipe) and joints, with limited localized realignment to avoid geologic hazards, where possible.
  - The currently proposed replacement waterline follows the existing waterline alignment and may still be subject to the adverse effects of the geologic hazards (e.g., creep or distinct movements of landslide).
- The Project alignment is typically underlain by deposits of fill with areas and layers of colluvium and/or landslide debris. Bedrock, consisting of variably weathered mudstone and sandstone, was generally encountered at variable depths at the locations explored.
  - The fill soils encountered in Site 1 typically consisted of medium stiff clay and silt with varying amounts of sand and trace amounts of gravel and organic debris. Fill soils encountered in Sites 2, 3 and 4 typically consisted of loose clayey sand with varying amounts of gravel and silt.
  - Colluvium/landslide deposits encountered in Sites 1 and 3 typically consists of soft to medium stiff lean clay with varying amounts of sand, wood debris, and roots. These soils were not encountered in Sites 2 or 4.
  - Interbedded layers of mudstone and sandstone of the Youngs Bay Member of the Astoria Formation were encountered throughout the Project alignment. Shallow exposures of this material ranged from decomposed to moderately weathered and extremely soft to soft, which is the approximate soil-like consistency/relative density equivalent of very stiff/medium dense. The degree of weathering decreases and hardness increases with depth.
- Regional groundwater is not expected to be encountered within the anticipated depths of excavation. However, we expect perched water may be encountered at shallow depths atop or within the fine-grained site soils. Additionally, the existing and proposed waterline trenches may serve as conduits that collect and concentrate localized perched water and surface runoff. Therefore, the contractor shall be prepared to encounter water flow in proposed trenches.
- Handling of and excavation into the site soils should be accomplished with conventional earthwork equipment, although difficult excavation may be encountered in the sandstone and fresh to slightly weathered mudstone units of the Youngs Bay Member of the Astoria Formation. Additionally, the soils encountered in Sites 2, 3, and 4 are coarse-grained with very little in the way of a stabilizing matrix of finer materials; therefore, caving conditions should be anticipated.

The following sections present our specific recommendations for earthwork, drainage, and structural components of the Project.

4.2 EARTHWORK

4.2.1 Demolition, Clearing, and Grubbing

The alignment should be cleared and grubbed of existing vegetation where present. All existing buried and utilities structures within the alignment should be removed. Demolition, clearing, grubbing, and general site preparation should be completed in conformance with Oregon Standard Specifications for Construction (OSS) Section 00310 – Removal of Structures and Obstructions, Section 00320 – Clearing and Grubbing, and other relevant sections.

All depressions created by the tree removal and demolition of existing structures should be excavated to firm soil or bedrock prior to the placement of utilities or backfill. All loose soil and vegetation should be removed from the areas to receive fill.

4.2.2 Subgrade Preparation

All fills and backfills should be founded on firm competent soil or bedrock. It is anticipated that firm competent soil and bedrock will be encountered at variable depths. We recommend that a representative of Haley & Aldrich observe the subgrade soils prior to the placement of new fill or backfill.

The placement of mass fills is expected to be limited; however, if localized fills are placed on sloping areas, it should be verified by a representative of Haley & Aldrich that the proposed fill placement area is not a geologic hazard. Where fills are less than 5 feet thick and are placed on slopes 5H:1V or flatter, they can be placed on a cleared, firm subgrade. Where fills are placed on slopes steeper than 5H:1V, the subgrade should be benched into competent materials. This may require significant excavations and possibly the installation of subdrains within benches and keyways. Haley & Aldrich should be contacted to evaluate the placement of any fills on slopes steeper than 5H:1V or mass fills greater than 5 feet in thickness.

The soils which will be exposed in the base of excavations within the majority of the pipeline alignment are generally expected to be soft to medium stiff native sandy silt or very soft to soft weathered sandstone and mudstone. The bases of trenches founded on granular weathered sandstone materials are generally expected to be suitable for support of the proposed waterline; however, loose pre-existing fills or colluvium/landslide debris may require surficial compaction. Where fine-grained soils or heavily weathered siltstone are present, particularly if water seepage is also present, soft conditions may require the placement of a stabilization layer.

If soft subgrade conditions are encountered, the base of the excavation should extend an additional 12 to 24 inches below the base of the planned excavation. Following this overexcavation, a separation geotextile should be placed to provide separation between the subgrade and backfill in conformance with OSS Section 00350.41. Then, 12 to 24 inches of structural fill (quarry spalls or similar approved materials) should be placed as a stabilization layer. (If desired, the upper 6 inches of structural fill may be replaced by crushed surfacing base course [base rock] to provide a choker course.) The presence of these materials will help to provide a stable working base for construction.

4.2.3 Excavation

Excavations for trenching and buried structures will be completed into varied materials, including fill, colluvium/landslide deposits, and the Youngs Bay Member of the Astoria Formation. It is our opinion that conventional earthmoving equipment in proper working condition should be capable of making necessary general excavations for utility trenches and buried structures, although difficult excavation may be encountered in the sandstone and fresh to slightly weathered mudstone units of the Youngs Bay Member of the Astoria Formation. It may be possible that ripping of the bedrock is required. Additionally, the soils encountered in Sites 2, 3, and 4 are coarse-grained with very little in the way of a stabilizing matrix of finer materials; therefore, caving conditions should be anticipated.

Temporary soil cuts associated with site excavations that are greater than 4 feet in depth should be adequately sloped back to prevent sloughing and collapse, in accordance with specifications provided in OSS 00330 – Earthwork and OSS 00405 – Trench Excavation, Bedding, and Backfill. We also recommend the guidelines provided in Section 16.3.26 – Temporary Shoring and Cut Slopes of the Oregon Department of Transportation (ODOT) Geotechnical Design Manual (ODOT, 2023) and the Occupational Safety and Health Administration (OSHA) Standard 1926 Subpart P – Soil Classification, be followed. According to OSHA guidelines, we expect the existing site soils would generally be considered Type B. However, if groundwater is encountered within the excavation limits of the pipe trench, then excavations may need to be shored.

Because of the variables involved, actual slope angles required for stability in temporary cut areas can only be estimated before construction. We recommend that stability of temporary construction slopes be the responsibility of the contractor since the contractor is in control of the construction operation and is continuously at the site to observe the nature and condition of the subsurface.

4.2.4 Permanent Cut Slope

Permanent cut slopes should be completed in accordance with the specifications provided in OSS Section 00330.41 – Excavation. Permanent cut slopes up to approximately 10 feet tall are anticipated to be required for the Project. If cut slopes exceed this height, Haley & Aldrich should be contacted to assess the stability these cuts.

Permanent cut slopes should not exceed a gradient of 2H:1V. Where soft surficial soils are encountered in the exposed face of cut slopes, they may need to be excavated and replaced with structural fill, as described in *Section 4.2.6 - Structural Fill.*

4.2.5 Shoring and Dewatering

The contractor should be responsible for implementing the appropriate shoring and dewatering techniques as necessary to maintain a stable working base.

We anticipate that trench boxes/shields may likely be required where excavations are deeper than 4 feet or unstable. Trench shields are a safety feature used to protect workers, but do not prevent caving of trench sidewalls. As such, the contractor should anticipate that sidewall caving may occur and additional backfill volume may be required. Also, the presence of caved material will limit the ability to properly backfill and compact the trenches, which may require additional contractor effort. If movement-sensitive buried utilities or other improvements are proximate to the trenches, then shields should not be used. This includes areas where collapse of a sidewall of a trench against the shield could disrupt an adjacent utility.

In general, due to the granular nature of some of the site soils and weak nature of other fine-grained soils, it is feasible that collapse against a shield could cause disruption a horizontal distance away from the trench equal to 0.5 to 1 times the trench depth. Without trench shields, excavations are expected to cave back at least 1 to 1.5 times the trench depth. Care shall be taken when pulling and/or removing the box shields, as the caving of the subsurface soil may undermine the existing utilities and other nearby improvements, resulting in subgrade instability and/or need for future utility repairs. The placement of sand or gravel in the voids between the box shields and the sidewalls of the trenches can help reduce the potential for caving, although may make movement of the boxes more difficult.

While excavation below the regional groundwater is not anticipated, perched water will likely be encountered when performing the trench excavations. If heavy seepage is present, then the installation of a crushed rock drainage layer at least 12 inches thick under the bedding layer may be required to facilitate sump pumping within the trench and to provide additional pipe support. The drainage layer should be constructed with open, free-draining crushed rock materials with a 1 1/2- to 3/4-inch gradation, conforming to OSS Section 00430.11; compaction of this layer is not typically done. To protect this open material from fines migrating into this crushed rock from the native soils or this crushed rock migrating into the subgrade, potentially causing pipeline settlement, the non-woven geotextile described above should be considered under and along the sides of this drainage layer. For ease of construction and to assure the bedding material does not migrate into the drainage layer, current practice on recent water line projects is to wrap the entire drainage layer with the non-woven drainage geotextile creating a “burrito wrap” under the bedding layer. Alternatively, sump pumping may be performed through a 3-inch minus stabilization material provided it is free of fines and "burrito-wrapped" to prevent the migration of fines into the stabilization material.

4.2.6 Structural Fill

All backfill placed at the project shall be considered structural fill, unless specifically noted by the City engineer. Materials used for structural fill should meet the appropriate specifications provided in the OSS (ODOT, 2024). All placement and compaction of fill should also be done in conformance with the OSS, except as otherwise approved by the City and Tetra Tech.

The following is a brief description of some acceptable materials that may be specified for this project.

4.2.6.1 Bedding and Pipe Zone Backfill

The pipe bedding and pipe zone backfill material should be a 3/4-inch – 0 base aggregate material in conformance with City Standard Special Provisions Section 02630.10 meeting the requirements of the City’s Standard Special Provisions Section 00405 – Trench Excavation, Bedding, and Backfill specifications and compacted to 92 percent of the maximum dry density as determined by ASTM International (ASTM) D 1557. The thickness of the bedding material should be a minimum of 6 inches and in conformance with the City’s standard pipe bedding details. We also recommend that the bedding material be used for backfill around the pipe zone and extends at least 1 foot above the crown of the pipe.

If soft subgrade conditions are observed during construction, a geotextile and stabilization fabric may need to be placed at the base of the excavation prior to the placement of bedding materials. Refer to *Section 4.2.2 - Subgrade Preparation* for details regarding subgrade stabilization.

4.2.6.2 Pipe Trench Backfill

Trench backfill would typically consist of Class B backfill in accordance with City's Standard Special Provisions Section 00405 – Trench Excavation, Bedding, and Backfill specifications and compacted to 92 percent of the maximum dry density as determined by ASTM D 1557. However, due to the remote nature of the site, we understand that re-use of the native soil for Pipe Trench Backfill may be desired where the pipeline is located outside of the roadway. Refer to *Section 4.2.6.5* for a discussion of reuse of native soils as Pipe Trench Backfill.

4.2.6.3 Base Aggregate

Imported granular material used as base aggregate (base rock) should be clean, crushed rock or crushed gravel and sand that is fairly well-graded between coarse and fine. The base aggregate should meet the specifications provided in OSS 00641 – Aggregate Subbase, Base, and Shoulders Base Aggregate, depending upon application.

4.2.6.4 Stabilizing Aggregate

Stabilization material used at the base of soft trench excavations or above native soil backfill in the trenches should consist of a clean, angular, crushed rock (such as ballast or quarry spalls). The material should have a maximum particle size of 4 inches, a nominal size between of 2 and 4 inches, less than 5 percent by dry weight passing the U.S. Standard No. 4 Sieve, and at least two mechanically fractured faces. The material should be free of organic matter and other deleterious material. Material meeting the specifications of OSS 00330.15 – Selected Stone Backfill is acceptable for use; recycled glass shall not be used.

Stabilization material should be separated from the base of soft or fine-grained subgrades with a layer of subgrade geotextile that meets the specifications provided in OSS 02320.20 – Geotextile Property Values for subgrade geotextile (separation). The geotextile should be installed in conformance with the specifications provided in OSS 00350 – Geosynthetic Installation.

Stabilization material should be placed atop in lifts between 12 and 18 inches thick and be compacted to a well-keyed condition with appropriate compaction equipment without using vibratory action. In trench excavations, a walk behind segmented pad roller or a pinwheel on an excavator typically can provide adequate compaction if carefully used.

4.2.6.5 On-Site Materials

The on-site materials that are anticipated to be encountered in excavations will typically consist of fine-grained silt and clay with varying amounts of sand, siltstone and sandstone bedrock, and gravel associated with surficial grading/winterization of the roadway. Due to their fine-grained and moist to wet nature, these materials are generally <u>not</u> considered suitable for use as engineered fill and trench backfill. However, due to the remote location of the Project, we understand there is a desire to reuse the on-site material where the pipeline is located outside of the roadway as a cost-saving measure. We recommend the following conditions be met for reuse of on-site material:

- Organics content is less than 3 percent by volume;
- Oversize material (greater than 1.5 inches) should not be included in the pipe bedding zone, within 2 feet of the tops of pipes or sides of structures, or within 3 feet of finished subgrade;
- Soil is free of contaminated and deleterious materials consisting of asphalt/concrete, debris from existing pipes, buried structures, etc.; and
- The contractor must consult with the City and their consultants during construction to agree on means and methods of compacting and testing of on-site native materials before use of such materials will be approved.

If fine-grained soils are re-used for Pipe Trench Backfill (above the bedding and pipe zone backfill), then the material shall be placed in maximum 18-inch level lifts and compacted with a pin-wheel compactor mounted on an excavator or backhoe. If fine-grained soils are re-used for general structural fill outside of the roadway, then the material shall be placed in maximum 12-inch level lifts and compacted with a sheepsfoot or pin-wheel compactor.

To the extent possible, based on the moisture content of the soil, all backfill or fill shall be compacted to a firm and unyielding condition, as determined by the City inspectors. Excessively wet or pumping soils may be required to be removed and replaced with drier materials or imported granular materials.

It should be understood that if native soils are used as Pipe Trench Backfill, future settlement of the trench backfill over the pipe may occur. Also, if native soil is reused as general structural fill, then pumping or rutting of exposed surfaces may occur.

4.3 TRENCH REINFORCEMENT

In areas where pipelines and their associated improvements cross through an identified geohazard, and/or where retrogressive failures may encroach into the pipeline alignment, trench reinforcement measures may be used.

Where trench reinforcement measures are considered, a minimum of 3 feet of overexcavation below the base of the pipe bedding material should be completed. The trench width in these areas should be a minimum of 6 feet wide. The base of the excavation should be smoothed to the satisfaction of the engineer or geologist observing the grading operation. Following the acceptance of the base of the overexcavation, the use of a Miragrid 5XT biaxial geogrid, or approved equivalent, should be placed at the base of the excavation. Approximately three, 12-inch-thick layers of fully encapsulated, “burrito-wrapped”, geogrid reinforced select granular fill should be placed up to the base of the pipe bedding zone. The geogrid should be placed as continuous panels within each encapsulation layer. At the top of each layer, the geogrid panels should be overlapped a minimum of 2 feet to provide full encapsulation. The select granular fill shall consist of Aggregate Base or approved equivalent.

Geogrid panels should maintain full contact with the adjacent panels along the pipeline alignment within the reinforcement zone. In cases where the pipeline alignment bends or turns, overlaps with the adjacent geogrid panel may be required. The contractor should ensure that granular backfill is placed between overlaps to satisfy the manufacturer’s specifications. Above the geogrid reinforcement zone, placement of the pipe bedding, pipe zone, and trench backfill shall be completed in accordance with the recommendations described above.

4.4 RETAINING STRUCTURES

We understand that a retaining structure may be required upslope of the waterline at Site 1 near Station (Sta.) 45, as shown on Figure 4a (Sta. 4+75 on Sheet C-101 of the 30% drawings included in Appendix C), to provide access to a relocated air release valve.

We anticipate the retaining structure will consist of a segmental block wall. The design should be based on the soil parameters presented in Table 1 below.

Table 1. Retaining Wall Design Parameters

Material	Parameter	Design Value
Native Soil	Moist Unit Weight (γ)	115 pcf
	Friction Angle (ϕ')	28°
	Active Earth Pressure Coefficient (K_a) – level backslope	0.36
	Active Earth Pressure Coefficient (K_a) – 2H:1V backslope	0.63
	At Rest Earth Pressure Coefficient (K_o)	0.53
	Passive Earth Pressure Coefficient (K_p) – level backslope	2.8
	Passive Earth Pressure Coefficient (K_p) – 2H:1V backslope	6.5

Note:

pcf = pounds per cubic foot

If the wall will be over 6 feet tall, we should be contacted to evaluate global stability.

4.5 DRAINAGE

4.5.1 Surface Drainage

During site work, the contactor should be made responsible for temporary drainage of surface water as necessary to direct runoff away from the new trench, and to prevent standing water and/or erosion at the working surface. During rough and finished grading of the Project, the contractor should keep all trench excavations free of standing water.

4.5.2 Culvert at Station 16+25

We understand that the inlet of the existing culvert in Site 1 near Sta. 162, as shown on Figure 4b (Sta. 16+25 on Sheet C-102 of the 30% drawings included in Appendix C), will intersect or be near the new waterline trench. This could lead to a preferential drainage path through the pipe backfill. As such, the pipe trench will need a protective measure to prevent direct infiltration into the waterline trench backfill. These measures could include a minimum of 2 feet of low permeability material placed and compacted over the pipe trench or a geosynthetic liner.

Separately, at the culvert outlet, it would be prudent to install riprap protection to protect the slope below the outlet where erosion and retrogression has been observed. Alternatively, the culvert pipe can be extended further down the slope and an energy dissipation device installed at the outlet to reduce further erosion.

5. Limitations

We completed this work in general accordance with our contract, dated 30 August 2023. This report is for the exclusive use of Tetra Tech, the City and their design consultants for specific application to the subject project and project alignment.

Our report is intended to provide our opinion of geotechnical parameters for design and construction of the proposed waterline project. Our opinions and recommendations are based on our interpretation of subsurface exploration data encountered in specific locations. Our conclusions should not be construed as a warranty or guarantee of subsurface conditions or future site performance.

Within the limitations of scope, schedule, and budget, our services have been executed in accordance with generally accepted practices in the field of geotechnical engineering in this area at the time this report was prepared. No warranty, express or implied, should be understood.

References

1. Burmister, D.M., 1948. The importance and practical use of relative density in soil mechanics: Proceedings of ASTM, v. 48:1249.

2. Haley & Aldrich, Inc., 2024. Geologic Hazards Report on Astoria Pipeline Road Waterline. Dated 15 March 2024.

3. Hart Crowser, Inc. (Hart Crowser), 2019. Geotechnical Hazard Assessment, Pipeline Road Water Transmission Main Resiliency Study, Astoria, Oregon. Dated 14 November 2019.

4. Oregon Department of Transportation (ODOT), 2023. Geotechnical Design Manual, May 2023.

5. ODOT, 2024. Oregon Standard Specifications for Construction (OSS).

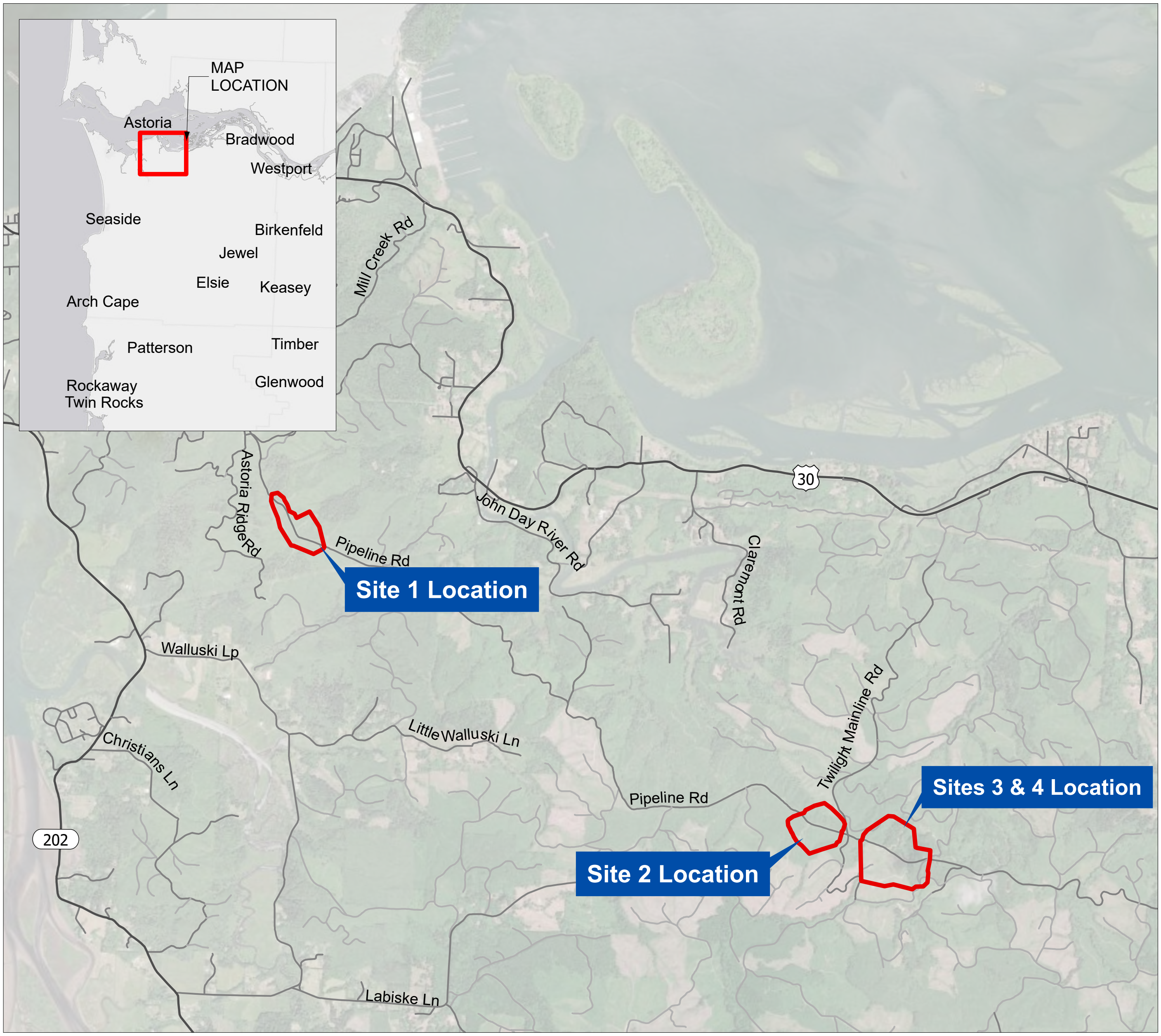
6. Occupational Safety and Health Administration (OSHA), 2015. Technical Manual Section V, http://www.osha.gov/dts/osta/otm/otm_v/otm_v_2.html.

7. Tetra Tech, Inc. (Tetra Tech), 2024a. Pipeline Road Waterline Resiliency Technical Memorandum, Waterline Improvement Alternatives Evaluation. Dated 19 March 2024.

8. Tetra Tech, 2024b. City of Astoria Pipeline Road Waterline Resiliency, 30% Design Submittal. Dated 19 March 2024.

https://haleyaldrich.sharepoint.com/sites/CityofAstoria/Shared Documents/0208388.Astoria Pipeline Road Waterline Resilience/Deliverables/Geotech Report/Final/2024_0827_HAI_AstoriaWaterlineGeotechReport_F.docx

FIGURES



BASEMAP REFERENCE

1. STREET CENTERLINES FROM OREGON SPATIAL DATA LIBRARY, ACCESSED ON 5 DECEMBER 2023.
2. ORTHOIMAGERY FROM ESRI (MAXAR), 2019.

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ASTORIA PIPELINE ROAD WATERLINE
PIPELINE ROAD
CLATSOP COUNTY, OREGON

VICINITY MAP

0208388-000	JUNE 2024	FIGURE 1

\\haleyaldrich\share\granite\2023\P208388-PROMO-Astoria-PipelineRd-Waterline\GIS\ArcGIS\Astoria-Figures\Astoria-Figures.aprx; 6/17/2024; slamothe

BASEMAP REFERENCE

1. REGIONAL GEOLOGY FROM OREGON GEOLOGIC DATA COMPILATION, ACCESSED ONLINE 12/5/2023.

0 0.38 0.75 1.5
MILES

N

RELEVANT MAP UNIT DESCRIPTION

Qal	QUATERNARY ALLUVIUM
Tac2	ASTORIA FORMATION, CANNON BEACH MEMBER
Tay1	ASTORIA FORMATION, YOUNGS BAY MEMBER; SANDSTONE UNIT
Tay2	ASTORIA FORMATION, YOUNGS BAY MEMBER; SANDSTONE UNIT
Tay	ASTORIA FORMATION, YOUNGS BAY MEMBER

▪▪▪▪▪	PIPELINE ROAD
—	TRANSMISSION WATERLINE

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PIPELINE ROAD
CLATSOP COUNTY, OREGON

REGIONAL GEOLOGY MAP

0208388-000	JUNE 2024	FIGURE 2

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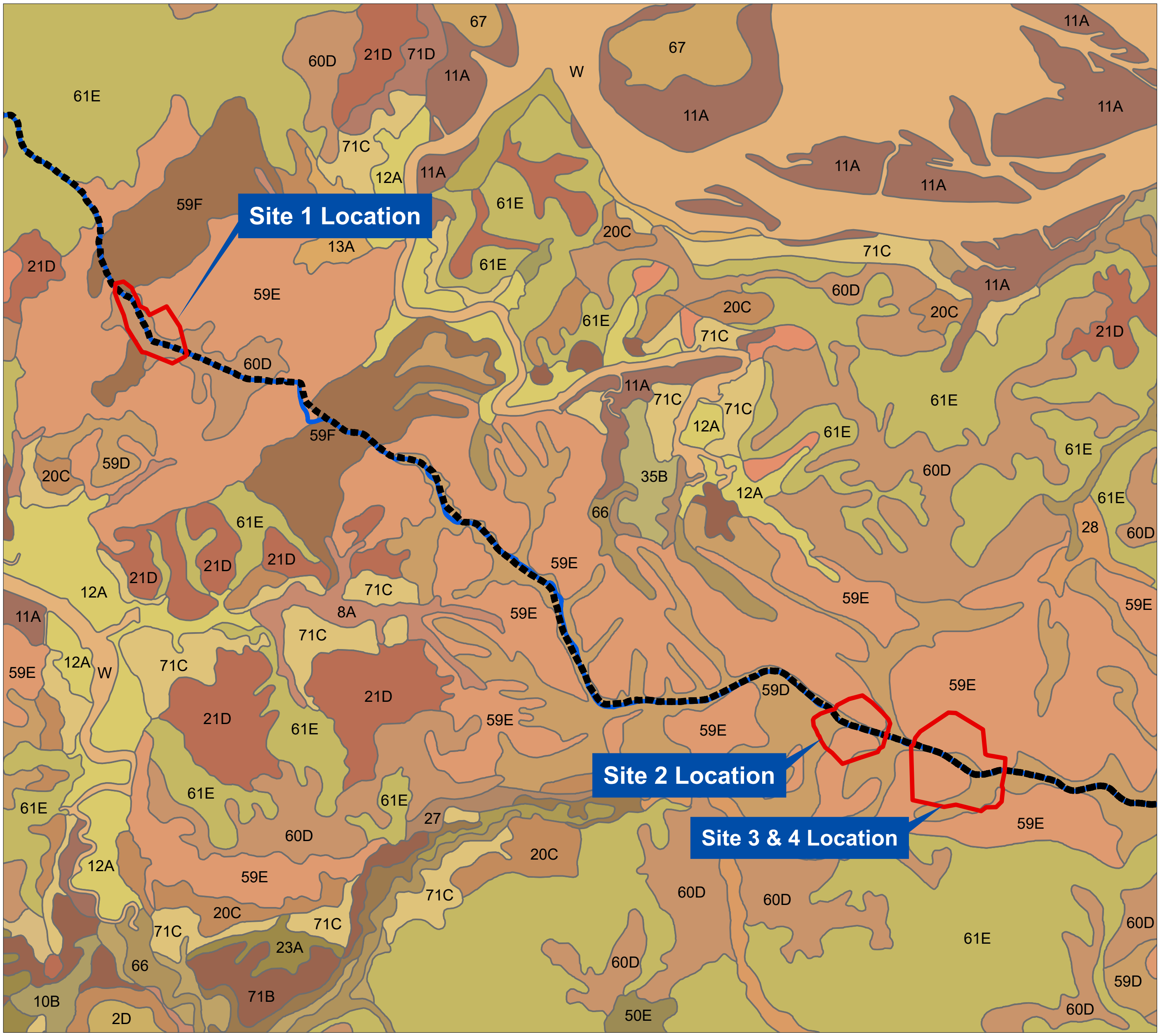

BASEMAP REFERENCE

1. SOIL DATA FROM NATURAL RESOURCES CONSERVATION SERVICE, US DEPARTMENT OF AGRICULTURE; WEB SOIL SURVEY, ACCESSED ONLINE ON 12/5/2023.

0 0.38 0.75 1.5
MILES

N

RELEVANT MAP UNIT DESCRIPTION

59D	SVENSEN LOAM, 3 TO 30 PERCENT SLOPES
59E	SVENSEN LOAM, 30 TO 60 PERCENT SLOPES
59F	SVENSEN LOAM, 60 TO 90 PERCENT SLOPES
60D	TEMPLETON MEDIAL SILT LOAM, 3 TO 30 PERCENT SLOPE

▪▪▪▪▪	PIPELINE ROAD
━	TRANSMISSION WATERLINE

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NRCS SOIL MAP

0208388-000	JUNE 2024	FIGURE 3

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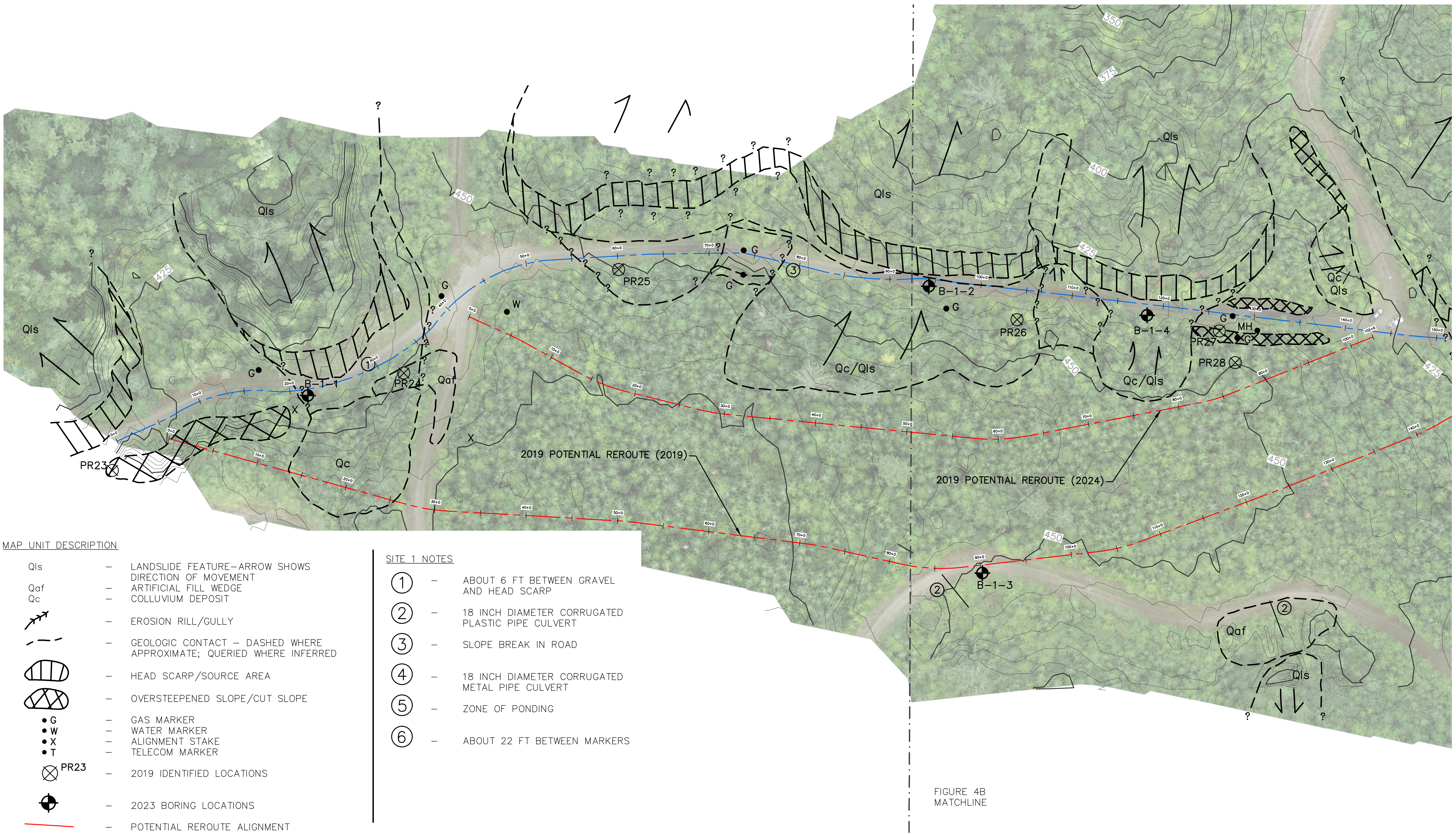

MAP UNIT DESCRIPTION

Qls – LANDSLIDE FEATURE–ARROW SHOWS DIRECTION OF MOVEMENT
Qaf – ARTIFICIAL FILL WEDGE
Qc – COLLUVIUM DEPOSIT
– EROSION RILL/GULLY
– GEOLOGIC CONTACT – DASHED WHERE APPROXIMATE; QUERIED WHERE INFERRED
– HEAD SCARP/SOURCE AREA
– OVERSTEEPENED SLOPE/CUT SLOPE
● G – GAS MARKER
● W – WATER MARKER
● X – ALIGNMENT STAKE
● T – TELECOM MARKER
⊗ PR23 – 2019 IDENTIFIED LOCATIONS
– 2023 BORING LOCATIONS
🟥 – POTENTIAL REROUTE ALIGNMENT
🟦 – EXISTING ALIGNMENT

SITE 1 NOTES

① – ABOUT 6 FT BETWEEN GRAVEL AND HEAD SCARP
② – 18 INCH DIAMETER CORRUGATED PLASTIC PIPE CULVERT
③ – SLOPE BREAK IN ROAD
④ – 18 INCH DIAMETER CORRUGATED METAL PIPE CULVERT
⑤ – ZONE OF PONDING
⑥ – ABOUT 22 FT BETWEEN MARKERS

REFERENCES

1. HIGH RESOLUTION ORTHOIMAGERY CAPTURED BY HALEY & ALDRICH ON 05 SEPTEMBER 2023.
2. CONTOURS CALCULATED FROM LIDAR–DERIVED DIGITAL ELEVATION MODEL. CONTOUR INTERVAL = 5FT.
3. RECONNAISSANCE LEVEL GEOLOGIC MAPPING PERFORMED 19 SEPTEMBER BY D. BURGER & D. KNAPP.
4. ALIGNMENT STATIONING PROVIDED BY H&A.

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ASTORIA PIPELINE ROAD WATERLINE
PIPELINE ROAD
CLATSOP COUNTY, OREGON

SITE 1 FEATURE MAP

0208388-000
JUNE 2024
FIGURE 4A

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REFERENCES

1. SEE FIGURE 4A FOR LEGEND AND REFERENCE.

50 0 50 100
SCALE FEET

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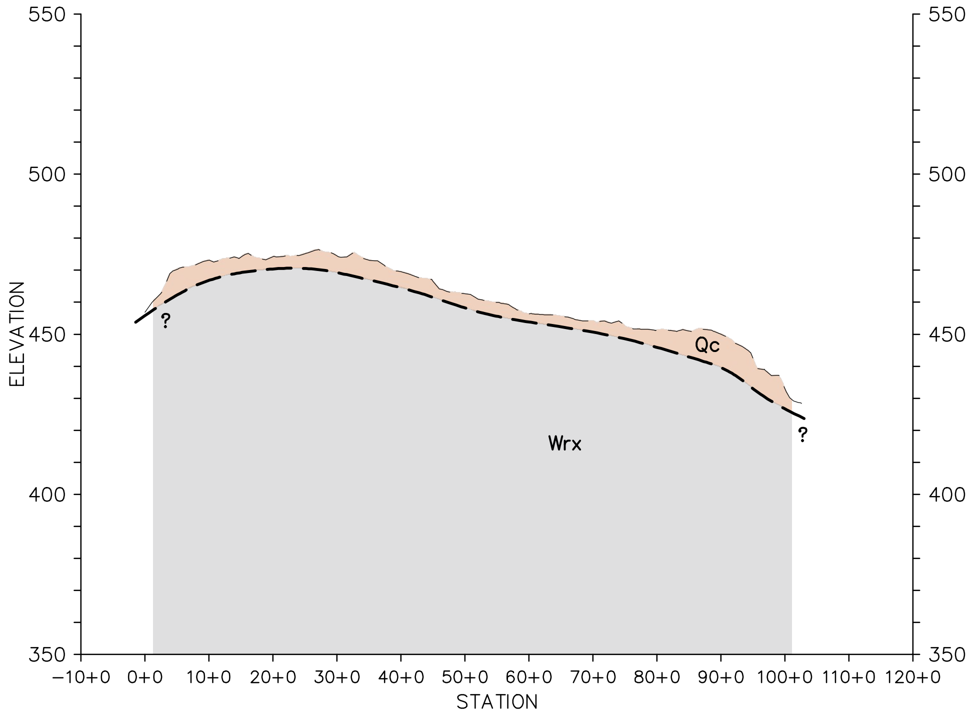
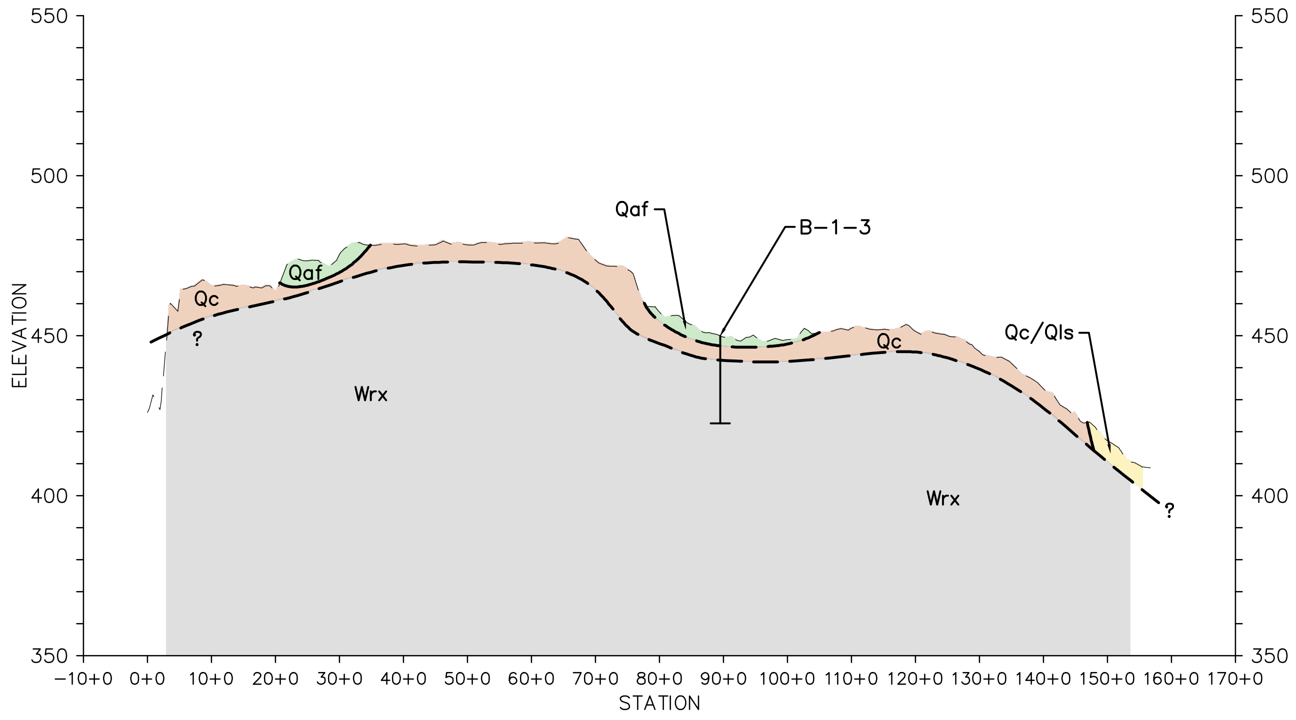
SITE 1 FEATURE MAP

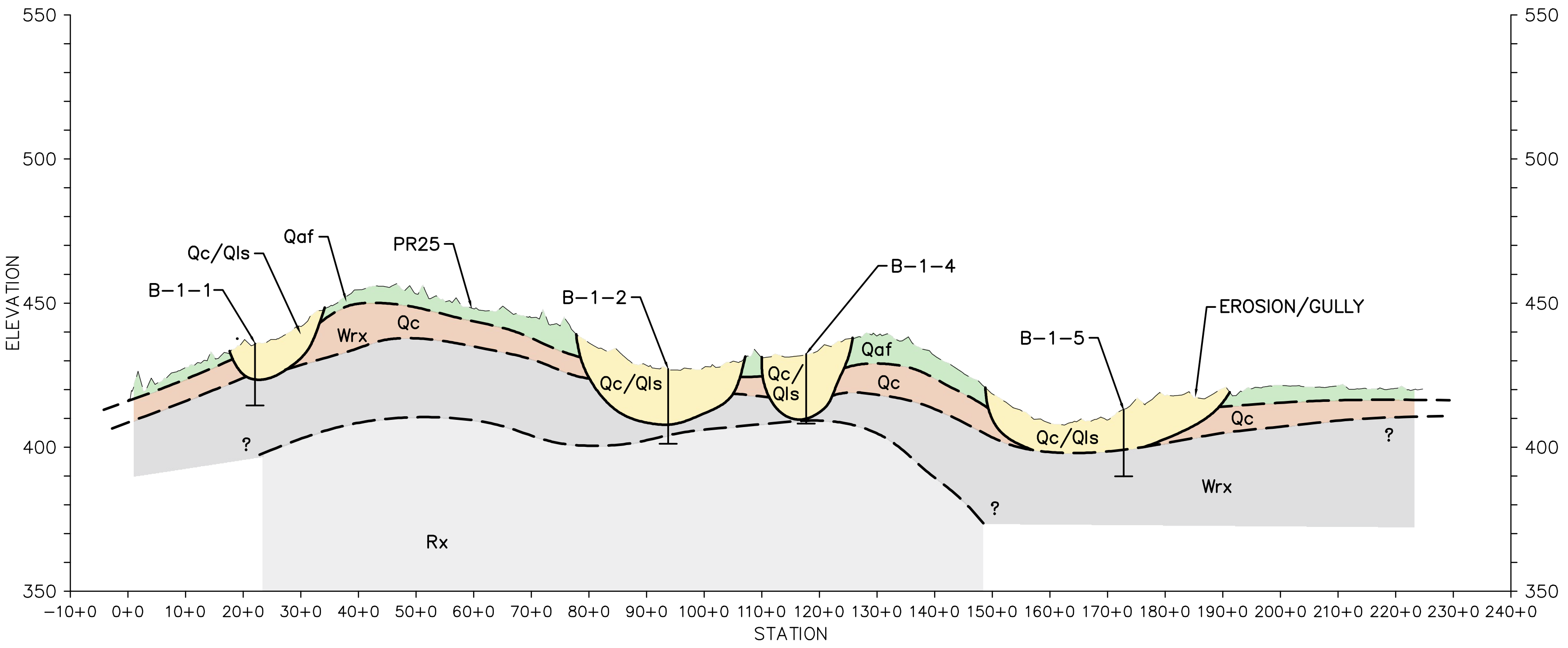
0208388-000	JUNE 2024	FIGURE 4B



ALIGNMENT – REVISED POTENTIAL REROUTE (2024)



ALIGNMENT – POTENTIAL REROUTE (2019)



ALIGNMENT – EXISTING

LEGEND

Qaf – ARTIFICIAL FILL
Qc – COLLUVIUM
Qls – LANDSLIDE DEPOSIT
Wrx – WEATHERED BEDROCK; DECOMPOSED TO VERY INTENSELY WEATHERED
Rx – BEDROCK

*NOTE: SURBSURFACE PROFILE CONSIDERED
APPROXIMATE AND SCHEMATIC.
5X VERTICAL EXAGGERATION APPLIED

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CLATSOP COUNTY, OREGON

SITE 1 PROFILES

0208388-000
JUNE 2024
FIGURE 4C

SITE 2 NOTES

① – PONDING IN ROAD

② – EXPOSED STEEL PIPE IN ROAD – CONNECTION COLLAR CRACKED

REFERENCES

1. SEE FIGURE 4A FOR LEGEND AND REFERENCE.

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SITE 2 FEATURE MAP

0208388-000	JUNE 2024	FIGURE 5A

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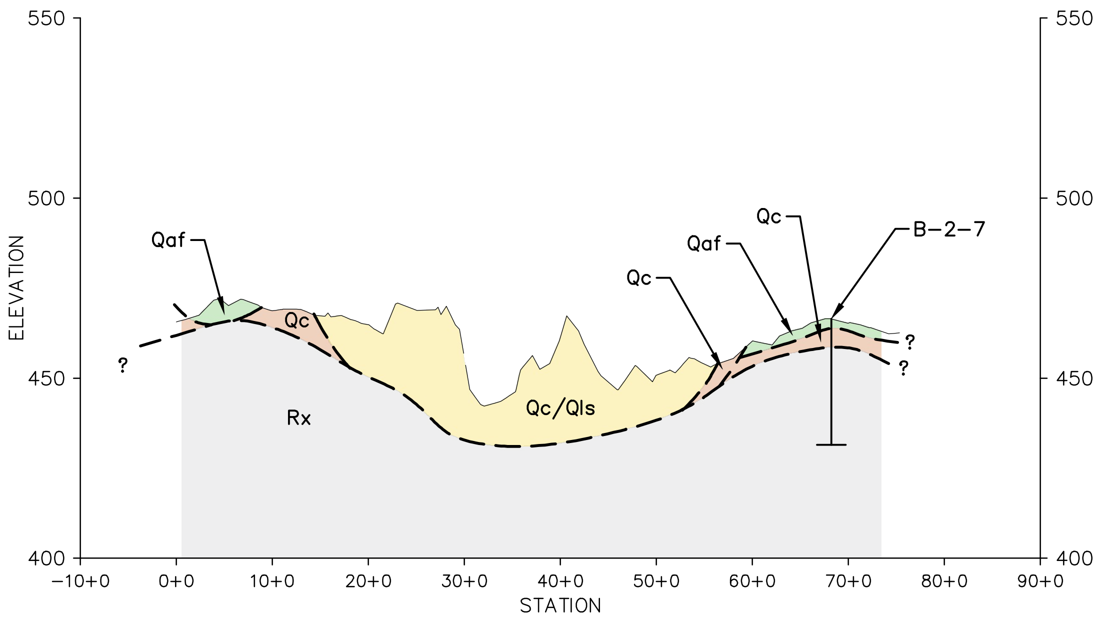
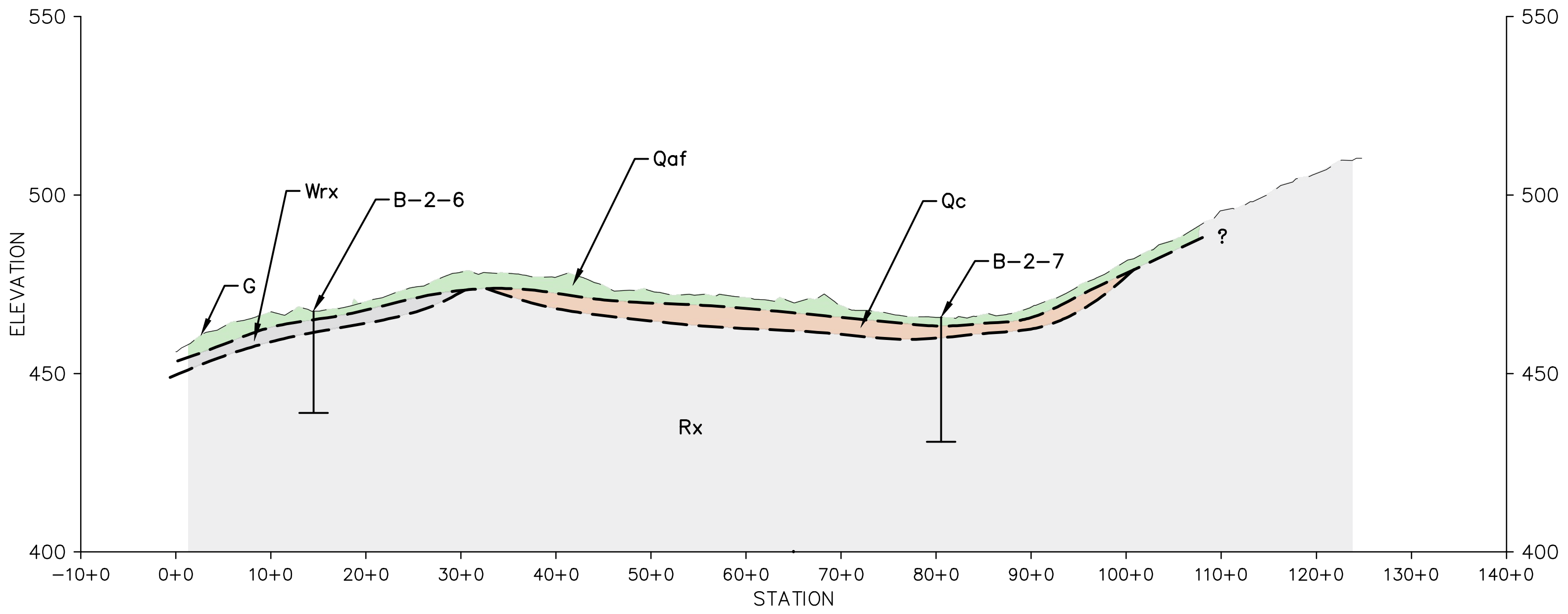


ALIGNMENT – POTENTIAL REROUTE (2019)



ALIGNMENT – EXISTING

LEGEND

Qaf – ARTIFICIAL FILL
Qc – COLLUVIUM
Qls – LANDSLIDE DEPOSIT
Wrx – WEATHERED BEDROCK; DECOMPOSED TO VERY INTENSELY WEATHERED
Rx – BEDROCK

*NOTE: SURBSURFACE PROFILE CONSIDERED
APPROXIMATE AND SCHEMATIC.
5X VERTICAL EXAGGERATION APPLIED

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SITE 2 PROFILES

0208388-000
JUNE 2024
FIGURE 5B

SITES 3 & 4 NOTES

① – SETTLEMENT/CREEP OF ROADFILL

② – OLD ACCESS ROAD/UTILITY EASEMENT

REFERENCES

1. SEE FIGURE 4A FOR LEGEND AND REFERENCE.

50 0 50 100
SCALE FEET

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PIPELINE ROAD
CLATSOP COUNTY, OREGON

SITES 3 AND 4 FEATURE MAP

0208388-000	JUNE 2024	FIGURE 6A

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SITES 3 & 4 NOTES

① – SETTLEMENT/CREEP OF ROADFILL

② – OLD ACCESS ROAD/UTILITY EASEMENT

REFERENCES

1. SEE FIGURE 4A FOR LEGEND AND REFERENCE.

50 0 50 100
SCALE FEET

N

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PIPELINE ROAD
CLATSOP COUNTY, OREGON

SITES 3 AND 4 FEATURE MAP

0208388-000	JUNE 2024	FIGURE 6B

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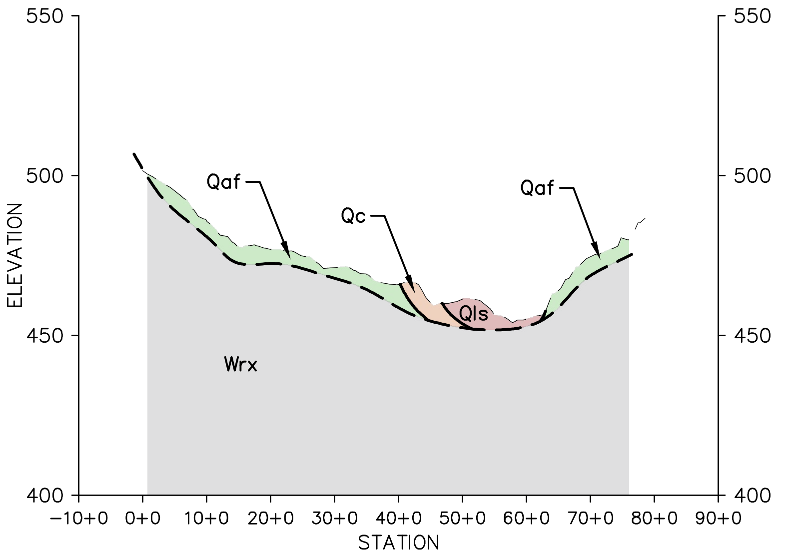
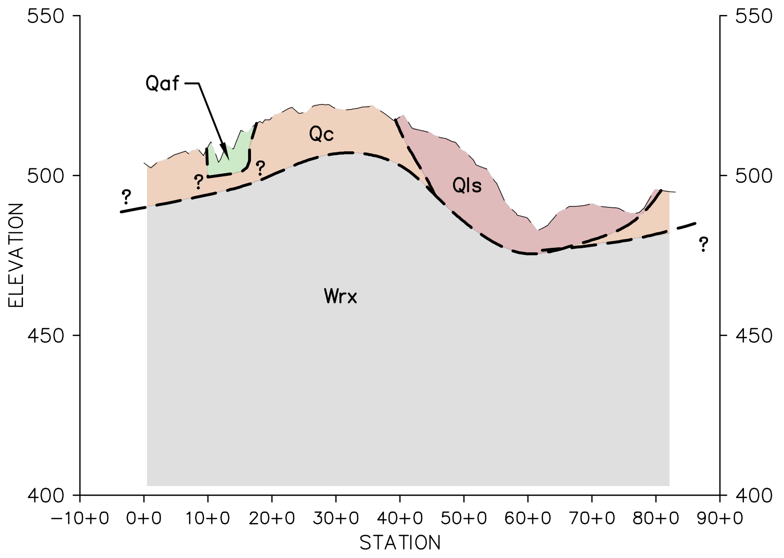
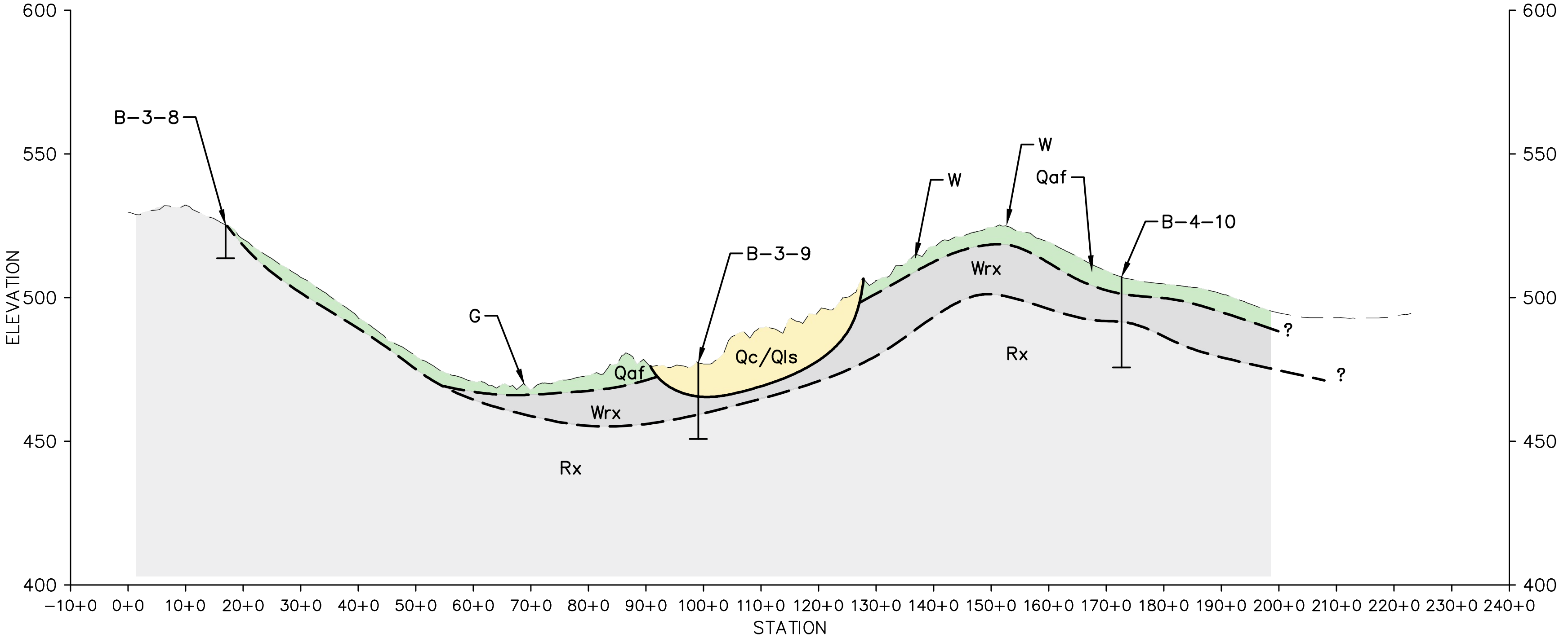


SITE 3 ALIGNMENT – POTENTIAL REROUTE (2019)



SITE 4 ALIGNMENT – POTENTIAL REROUTE (2019)



SITE 3 AND 4 ALIGNMENT – EXISTING

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LEGEND

Qaf – ARTIFICIAL FILL
Qc – COLLUVIUM
Qls – LANDSLIDE DEPOSIT
Wrx – WEATHERED BEDROCK; DECOMPOSED TO VERY INTENSELY WEATHERED
Rx – BEDROCK

*NOTE: SURBSURFACE PROFILE CONSIDERED
APPROXIMATE AND SCHEMATIC.
5X VERTICAL EXAGGERATION APPLIED

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SITES 3 AND 4 PROFILES

0208388-000	JUNE 2024	FIGURE 6C

APPENDIX A

Exploration Logs

APPENDIX A

Exploration Logs

Haley & Aldrich, Inc. (Haley & Aldrich) evaluated subsurface soil and groundwater conditions at the site by advancing 10 borings designated B-1-1 through B-4-10 using a truck-mounted drill rig utilizing hollow stem auger operated by Western States Soil Conservation, Inc., of Hubbard, Oregon, to depths ranging from 11.5 to 31.5 feet below ground surface. The explorations were coordinated and overseen by geotechnical staff from Haley & Aldrich. Logs of the borings are included in this appendix.

Materials encountered in the explorations were classified in the field in general accordance with ASTM International (ASTM) Standard Practice D 2488 "Standard Practice for the Classification of Soils (Visual-Manual Procedure)".

Soil samples were obtained from the borings using the following methods:

- Sampling using a standard penetration test (SPT) split-barrel sampler was completed in general conformance with ASTM Test Method D 1586 "Standard Method for Penetration Test and Split-Barrel Sampling of Soils". The sampler was driven with a 140-pound auto-trip hammer falling 30 inches. The N-value, or number of blows required to drive the sampler 1 foot or as otherwise indicated into the soils, is shown adjacent to the sample symbols on the boring log. Disturbed samples were obtained from the sampler for subsequent classification and testing.
- Sampling using a Modified California sampler was in general conformance with ASTM Test Method D 3550 "Standard Practice for Thick Wall, Ring-Lined, Split Barrel, Drive Sampling of Soils". The sampler was driven using a 140-pound hammer falling 30 inches, just as with the SPT samples. The raw field blow counts obtained while driving the Modified California sampler were multiplied by a reduction factor of 63 percent to provide an adjusted equivalent SPT N-value that is shown on the log. The reduction factor was determined per the methodology outlined in Burmister (1948). Disturbed samples were obtained from the sampler for subsequent classification and testing.
- Undisturbed samples of fine-grained soils were collected using a 3-inch-diameter thin-walled steel (Shelby) tube sampler in general conformance with ASTM Test Method D 1587 "Standard Practice for Thin-Walled Tube Sampling of Fine-Grained Soils for Geotechnical Purposes". The sample was obtained by pressing a thin-walled metal tube into the soil at the bottom of the boring using the drill rig. After retrieval, the tubes were sealed in the field using wax to prevent soil movement and moisture gain or loss. Relatively undisturbed samples were obtained from the tubes for subsequent classification and testing.

Sampling intervals are shown on the exploration logs included in this appendix.

The exploration logs in this appendix show our interpretation of the exploration, sampling, and testing data. The logs indicate the depth where the soils change. Note that the change may be gradual. In the field, we classified the samples taken from the explorations according to the methods presented on the *Figure A-1 - Key to Exploration Logs*. This figure also provides a legend explaining the symbols and abbreviations used in the logs.

The approximate locations of the explorations are shown on Figures 4 through 6. Prior to completion of the explorations, the latitude and longitude coordinate for each exploration was interpreted from Google Earth and downloaded to a hand-held Garmin GPS unit. The GPS unit was then used to locate the exploration in the field.

Sample Description

Identification of soils in this report is based on visual field and laboratory observations which include density/consistency, moisture condition, grain size, and plasticity estimates and should not be construed to imply field nor laboratory testing unless presented herein. ASTM D 2488 visual-manual identification methods were used as a guide. Where laboratory testing confirmed visual-manual identifications, then ASTM D 2487 was used to classify the soils.

Relative Density/Consistency

Soil density/consistency in borings is related primarily to the standard penetration resistance (N). Soil density/consistency in test pits and probes is estimated based on visual observation and is presented parenthetically on the logs.

SAND or GRAVEL Relative Density	N (Blows/Foot)	SILT or CLAY Consistency	N (Blows/Foot)
Very loose	0 to 4	Very soft	0 to 1
Loose	5 to 10	Soft	2 to 4
Medium dense	11 to 30	Medium stiff	5 to 8
Dense	31 to 50	Stiff	9 to 15
Very dense	>50	Very stiff	16 to 30
		Hard	>30

Moisture

Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

USCS Soil Classification Chart (ASTM D 2487)

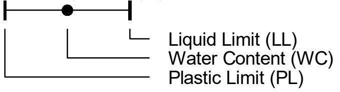
Major Divisions			Symbols		Typical Descriptions
			Graph	USCS	
Coarse Grained Soils More than 50% of Material Retained on No. 200 Sieve	Gravel and Gravelly Soils More than 50% of Coarse Fraction Retained on No. 4 Sieve	Clean Gravels *(<5% fines)*	▨	GW	Well-Graded Gravel; Well-Graded Gravel with Sand
			▨	GP	Poorly Graded Gravel; Poorly Graded Gravel with Sand
		Gravels *(5-12% fines)*	▨	GW-GM	Well-Graded Gravel with Silt; Well-Graded Gravel with Silt and Sand
			▨	GW-GC	Well-Graded Gravel with Clay; Well-Graded Gravel with Clay and Sand
			▨	GP-GM	Poorly Graded Gravel with Silt; Poorly Graded Gravel with Silt and Sand
			▨	GP-GC	Poorly Graded Gravel with Clay; Poorly Graded Gravel with Clay and Sand
		Gravels with Fines *(>12% fines)*	▨	GM	Silty Gravel; Silty Gravel with Sand
			▨	GC	Clayey Gravel; Clayey Gravel with Sand
	Sand and Sandy Soils More than 50% of Coarse Fraction Passing No. 4 Sieve	Sands with few Fines *(<5% fines)*	▨	SW	Well-Graded Sand; Well-Graded Sand with Gravel
			▨	SP	Poorly Graded Sand; Poorly Graded Sand with Gravel
		Sands *(5-12% fines)*	▨	SW-SM	Well-Graded Sand with Silt Well-Graded Sand with Silt and Gravel
			▨	SW-SC	Well-Graded Sand with Clay; Well-Graded Sand with Clay and Gravel
			▨	SP-SM	Poorly Graded Sand with Silt; Poorly Graded Sand with Silt and Gravel
			▨	SP-SC	Poorly Graded Sand with Clay; Poorly Graded Sand with Clay and Gravel
		Sands with Fines *(>12% fines)*	▨	SM	Silty Sand; Silty Sand with Gravel
			▨	SC	Clayey Sand; Clayey Sand with Gravel
Fine Grained Soils More than 50% of Material Passing No. 200 Sieve	Silts		▨	ML	Silt; Silt with Sand or Gravel; Sandy or Gravelly Silt
			▨	MH	Elastic Silt; Elastic Silt with Sand or Gravel; Sandy or Gravelly Elastic Silt
	Silty Clay *(based on Atterberg Limits)*		▨	CL-ML	Silty Clay; Silty Clay with Sand or Gravel; Gravelly or Sandy Silty Clay
	Clays		▨	CL	Lean Clay; Lean Clay with Sand or Gravel; Sandy or Gravelly Lean Clay
			▨	CH	Fat Clay; Fat Clay with Sand or Gravel; Sandy or Gravelly Fat Clay
	Organics		▨	OL/OH	Organic Soil; Organic Soil with Sand or Gravel; Sandy or Gravelly Organic Soil
Highly Organic *(>50% organic material)*			▨	PT	Peat - Decomposing Vegetation - Fibrous to Amorphous Texture

Minor Constituents

Minor Constituents	Estimated Percentage
Sand, Gravel	
Trace	<5
Few	5 - 15
Cobbles, Boulders	
Trace	<5
Few	5 - 10
Little	15 - 25
Some	30 - 45

Soil Test Symbols

%F	Percent Passing No. 200 Sieve
AL	Atterberg Limits (%)



CA	Chemical Analysis
CAUC	Consolidated Anisotropic Undrained Compression
CAUE	Consolidated Anisotropic Undrained Extension
CBR	California Bearing Ratio
CIDC	Consolidated Drained Isotropic Triaxial Compression
CIUC	Consolidated Isotropic Undrained Compression
CK0DC	Consolidated Drained k0 Triaxial Compression
CK0DSS	Consolidated k0 Undrained Direct Simple Shear
CK0UC	Consolidated k0 Undrained Compression
CK0UE	Consolidated k0 Undrained Extension
CRSCN	Constant Rate of Strain Consolidation
DS	Direct Shear
DSS	Direct Simple Shear
DT	In Situ Density
GS	Grain Size Classification
HYD	Hydrometer
ILCN	Incremental Load Consolidation
K0CN	k0 Consolidation
kc	Constant Head Permeability
kf	Falling Head Permeability
MD	Moisture Density Relationship
OC	Organic Content
OT	Tests by Others
P	Pressuremeter
PID	Photoionization Detector Reading
PP	Pocket Penetrometer
SG	Specific Gravity
TRS	Torsional Ring Shear
TV	Torvane
UC	Unconfined Compression
UUC	Unconsolidated Undrained Triaxial Compression
VS	Vane Shear
WC	Water Content (%)

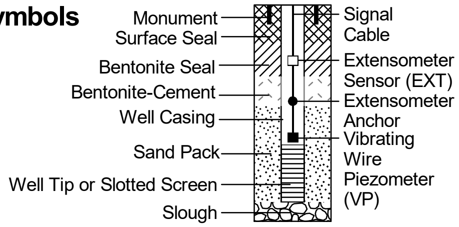
Groundwater Indicators

▽	Groundwater Level on Date or At Time of Drilling (ATD)
▼	Groundwater Level on Date Measured in Piezometer
♀	Groundwater Seepage (Test Pits)

Sample Symbols

☒	1.5" I.D. Split Spoon	◧	Rock Core Run	☒	Grab
◩	3.0" I.D. Split Spoon	▨	Sonic Core	▥	Cuttings
◧	Modified California Sampler	◫	Thin-walled Sampler	◫	Push Probe

Well Symbols



HALEY ALDRICH

Project: Astoria Pipeline Road Waterline
Location: Clatsop County, Oregon
Project No.: 0208388-000

Key to Exploration Logs

Figure A-1
Sheet 1 of 1

Scale of Relative Rock Weathering

Term	Description
Fresh	Crystals are bright. Discontinuities may show some minor surface staining. No discoloration in rock fabric.
Slightly Weathered	Rock mass is generally fresh. Discontinuities are stained and may contain clay. Some discoloration in rock fabric. Decomposition extends up to 1 inch into rock.
Moderately Weathered	Rock mass is decomposed 50% or less. Significant portions of rock show discoloration and weathering effects. Crystals are dull and show visible chemical alteration. Discontinuities are stained and may contain secondary mineral deposits.
Predominantly Decomposed	Rock mass is more than 50% decomposed. Rock can be excavated with geologist's pick. All discontinuities exhibit secondary mineralization. Complete discoloration of rock fabric. Surface of core is friable and usually pitted due to washing out of highly altered minerals by drilling water.
Decomposed	Rock mass is completely decomposed. Original rock "fabric" may be evident. May be reduced to soil with hand pressure.

Scale of Relative Rock Hardness

Hardness Designation	Term	Field Identification	Uniaxial Compressive Strength
R0	Extremely Soft	Can be indented with difficulty by thumbnail. May be moldable or friable with finger pressure.	< 100 psi
R1	Very Soft	Crumbles under firm blows with point of a geology pick. Can be peeled by a pocket knife. Scratched with fingernail.	100 - 1000 psi
R2	Soft	Can be peeled by a pocket knife with difficulty. Cannot be scratched with fingernail. Shallow indentation made by firm blow of geology pick.	1000 - 4000 psi
R3	Medium Hard	Can be scratched by knife or pick. Specimen can be fractured with a single firm blow of hammer/geology pick.	4000 - 8000 psi
R4	Hard	Can be scratched with knife or pick only with difficulty. Several hard hammer blows required to fracture specimen.	8000 - 16000 psi
R5	Very Hard	Cannot be scratched by knife or sharp pick. Specimen require many blows of hammer to fracture or chip. Hammer rebounds after impact.	> 16000 psi

Joint and Bedding Spacing Terms

Spacing	Joint Spacing Terms	Bedding/Foliation Spacing Terms
Less than 2 inches	Very Close	Very Thin (laminated)
2 inches to 1 foot	Close	Thin
1 foot to 3 feet	Moderately Close	Medium
3 feet to 10 feet	Wide	Thick
More than 10 feet	Very Wide	Very Thick (massive)

HA-KEY TO EXP LOGS (SOIL/ROCK) ODOT-2 - \\HALEYALDRICH.COM\SHARE\SEA_DATA\GINT\HC_LIBRARY.GLB - 6/7/24 12:46 - \\HALEYALDRICH.COM\SHARE\PDX_DATA\NOTEBOOKS\0208388-000_ASTORIA_PIPELINE_ROAD_WATERLINE_RESILIENCE\FIELD DATA\PERM_GINT FILES\0208388-000_ASTORIA PIPELINE RD WATERLINE RESILIENCE_GINT.GPJ - kbubel

HALEY ALDRICH

Project: Astoria Pipeline Road Waterline
Location: Clatsop County, Oregon
Project No.: 0208388-000

Key to Exploration Logs

Figure **A-1**
Sheet **2 of 3**

Stratification Terms

Term	Characteristics
Laminations	Thin beds (<1 cm)
Fissile	Tendency to break along laminations.
Parting	Tendency to break parallel to bedding.
Foliation	Non-depositional (e.g., segregation and layering of minerals in metamorphic rock)

Igneous Rock Textures

Texture	Grain Size
Pegmatitic	Very large; diameters measured in inches or feet
Phaneritic	Can be seen with the naked eye
Porphyritic	Grained of two widely different sizes
Aphanitic	Cannot be seen with the naked eye
Glassy	No grains present

Pyroclastic Rocks

Rock Name	Characteristics
Cinders	Uncemented glassy and vesicular ejecta 4-32 mm size
Tuff Breccia (Agglomerate)	Composed of ejecta >32mm size, in ash/tuff matrix, indurated
Lapilli Tuff	Composed of ejecta 4-32 mm size, in ash/tuff matrix, indurated
Tuff	Cemented volcanic ash particles <4mm size, indurated
Pumice	Excessively vesiculated glassy lava

Degree of Vesicularity

Designation	Percentage of Cavities (by volume) of Total Sample
Some Vesicules	5 to 25 Percent
Highly Vesicular	15 to 50 Percent
Scoriaceous	Greater than 50 Percent

Other Terms:

Core Recover (CR) = the ratio of core recovered to the core run length expressed as a percentage.

Rock Quality Designation (RQD) = the percentage of rock core recovered in intact pieces of 4 inches or more in length in the length of a core run. Does not include mechanical breaks caused by drilling.

Reference:

Oregon Department of Transportation (ODOT), 1987. *Soil and Rock Classification Manual*, May 1987.

Sample Description

Identification of soils in this report is based on visual field and laboratory observations which include density/consistency, moisture condition, grain size, and plasticity estimates and should not be construed to imply field nor laboratory testing unless presented herein. ASTM D 2488 visual-manual identification methods were used as a guide. Where laboratory testing confirmed visual-manual identifications, then ASTM D 2487 was used to classify the soils.

Relative Density/Consistency

Soil density/consistency in borings is related primarily to the standard penetration resistance (N). Soil density/consistency in test pits and probes is estimated based on visual observation and is presented parenthetically on the logs.

SAND or GRAVEL Relative Density	N (Blows/Foot)	SILT or CLAY Consistency	N (Blows/Foot)
Very loose	0 to 4	Very soft	0 to 1
Loose	5 to 10	Soft	2 to 4
Medium dense	11 to 30	Medium stiff	5 to 8
Dense	31 to 50	Stiff	9 to 15
Very dense	>50	Very stiff	16 to 30
		Hard	>30

Moisture

Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

USCS Soil Classification Chart (ASTM D 2487)

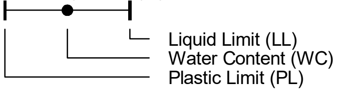
Major Divisions			Symbols		Typical Descriptions
			Graph	USCS	
Coarse Grained Soils More than 50% of Material Retained on No. 200 Sieve	Gravel and Gravelly Soils More than 50% of Coarse Fraction Retained on No. 4 Sieve	Clean Gravels *(<5% fines)*		GW	Well-Graded Gravel; Well-Graded Gravel with Sand
				GP	Poorly Graded Gravel; Poorly Graded Gravel with Sand
		Gravels *(5-12% fines)*		GW-GM	Well-Graded Gravel with Silt; Well-Graded Gravel with Silt and Sand
				GW-GC	Well-Graded Gravel with Clay; Well-Graded Gravel with Clay and Sand
				GP-GM	Poorly Graded Gravel with Silt; Poorly Graded Gravel with Silt and Sand
				GP-GC	Poorly Graded Gravel with Clay; Poorly Graded Gravel with Clay and Sand
		Gravels with Fines *(>12% fines)*		GM	Silty Gravel; Silty Gravel with Sand
				GC	Clayey Gravel; Clayey Gravel with Sand
	Sand and Sandy Soils More than 50% of Coarse Fraction Passing No. 4 Sieve	Sands with few Fines *(<5% fines)*		SW	Well-Graded Sand; Well-Graded Sand with Gravel
				SP	Poorly Graded Sand; Poorly Graded Sand with Gravel
		Sands *(5-12% fines)*		SW-SM	Well-Graded Sand with Silt Well-Graded Sand with Silt and Gravel
				SW-SC	Well-Graded Sand with Clay; Well-Graded Sand with Clay and Gravel
				SP-SM	Poorly Graded Sand with Silt; Poorly Graded Sand with Silt and Gravel
				SP-SC	Poorly Graded Sand with Clay; Poorly Graded Sand with Clay and Gravel
		Sands with Fines *(>12% fines)*		SM	Silty Sand; Silty Sand with Gravel
				SC	Clayey Sand; Clayey Sand with Gravel
Fine Grained Soils More than 50% of Material Passing No. 200 Sieve	Silts			ML	Silt; Silt with Sand or Gravel; Sandy or Gravelly Silt
				MH	Elastic Silt; Elastic Silt with Sand or Gravel; Sandy or Gravelly Elastic Silt
	Silty Clay *(based on Atterberg Limits)*			CL-ML	Silty Clay; Silty Clay with Sand or Gravel; Gravelly or Sandy Silty Clay
	Clays			CL	Lean Clay; Lean Clay with Sand or Gravel; Sandy or Gravelly Lean Clay
				CH	Fat Clay; Fat Clay with Sand or Gravel; Sandy or Gravelly Fat Clay
	Organics			OL/OH	Organic Soil; Organic Soil with Sand or Gravel; Sandy or Gravelly Organic Soil
Highly Organic *(>50% organic material)*				PT	Peat - Decomposing Vegetation - Fibrous to Amorphous Texture

Minor Constituents

	Estimated Percentage
Sand, Gravel	
Trace	<5
Few	5 - 15
Cobbles, Boulders	
Trace	<5
Few	5 - 10
Little	15 - 25
Some	30 - 45

Soil Test Symbols

%F	Percent Passing No. 200 Sieve
AL	Atterberg Limits (%)



CA	Chemical Analysis
CAUC	Consolidated Anisotropic Undrained Compression
CAUE	Consolidated Anisotropic Undrained Extension
CBR	California Bearing Ratio
CIDC	Consolidated Drained Isotropic Triaxial Compression
CIUC	Consolidated Isotropic Undrained Compression
CK0DC	Consolidated Drained k0 Triaxial Compression
CK0DSS	Consolidated k0 Undrained Direct Simple Shear
CK0UC	Consolidated k0 Undrained Compression
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CRSCN	Constant Rate of Strain Consolidation
DS	Direct Shear
DSS	Direct Simple Shear
DT	In Situ Density
GS	Grain Size Classification
HYD	Hydrometer
ILCN	Incremental Load Consolidation
K0CN	k0 Consolidation
kc	Constant Head Permeability
kf	Falling Head Permeability
MD	Moisture Density Relationship
OC	Organic Content
OT	Tests by Others
P	Pressuremeter
PID	Photoionization Detector Reading
PP	Pocket Penetrometer
SG	Specific Gravity
TRS	Torsional Ring Shear
TV	Torvane
UC	Unconfined Compression
UUC	Unconsolidated Undrained Triaxial Compression
VS	Vane Shear
WC	Water Content (%)

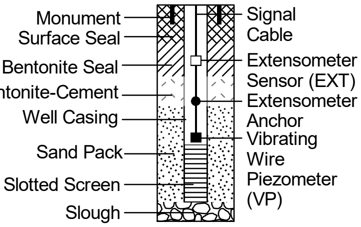
Groundwater Indicators

∇	Groundwater Level on Date or At Time of Drilling (ATD)
▼	Groundwater Level on Date Measured in Piezometer
♀	Groundwater Seepage (Test Pits)

Sample Symbols

☒	1.5" I.D. Split Spoon	◧	Rock Core Run	☒	Grab
◩	3.0" I.D. Split Spoon	▩	Sonic Core	▥	Cuttings
◧	Modified California Sampler	◫	Thin-walled Sampler	◫	Push Probe

Well Symbols



HALEY ALDRICH

Project: Astoria Pipeline Road Waterline
Location: Clatsop County, Oregon
Project No.: 0208388-000

Key to Exploration Logs

Figure **A-1**
Sheet **1 of 1**

Scale of Relative Rock Weathering

Term	Description
Fresh	Crystals are bright. Discontinuities may show some minor surface staining. No discoloration in rock fabric.
Slightly Weathered	Rock mass is generally fresh. Discontinuities are stained and may contain clay. Some discoloration in rock fabric. Decomposition extends up to 1 inch into rock.
Moderately Weathered	Rock mass is decomposed 50% or less. Significant portions of rock show discoloration and weathering effects. Crystals are dull and show visible chemical alteration. Discontinuities are stained and may contain secondary mineral deposits.
Predominantly Decomposed	Rock mass is more than 50% decomposed. Rock can be excavated with geologist's pick. All discontinuities exhibit secondary mineralization. Complete discoloration of rock fabric. Surface of core is friable and usually pitted due to washing out of highly altered minerals by drilling water.
Decomposed	Rock mass is completely decomposed. Original rock "fabric" may be evident. May be reduced to soil with hand pressure.

Scale of Relative Rock Hardness

Hardness Designation	Term	Field Identification	Uniaxial Compressive Strength
R0	Extremely Soft	Can be indented with difficulty by thumbnail. May be moldable or friable with finger pressure.	< 100 psi
R1	Very Soft	Crumbles under firm blows with point of a geology pick. Can be peeled by a pocket knife. Scratched with fingernail.	100 - 1000 psi
R2	Soft	Can be peeled by a pocket knife with difficulty. Cannot be scratched with fingernail. Shallow indentation made by firm blow of geology pick.	1000 - 4000 psi
R3	Medium Hard	Can be scratched by knife or pick. Specimen can be fractured with a single firm blow of hammer/geology pick.	4000 - 8000 psi
R4	Hard	Can be scratched with knife or pick only with difficulty. Several hard hammer blows required to fracture specimen.	8000 - 16000 psi
R5	Very Hard	Cannot be scratched by knife or sharp pick. Specimen require many blows of hammer to fracture or chip. Hammer rebounds after impact.	> 16000 psi

Joint and Bedding Spacing Terms

Spacing	Joint Spacing Terms	Bedding/Foliation Spacing Terms
Less than 2 inches	Very Close	Very Thin (laminated)
2 inches to 1 foot	Close	Thin
1 foot to 3 feet	Moderately Close	Medium
3 feet to 10 feet	Wide	Thick
More than 10 feet	Very Wide	Very Thick (massive)

HALEY ALDRICH

Project: Astoria Pipeline Road Waterline
Location: Clatsop County, Oregon
Project No.: 0208388-000

Key to Exploration Logs

Figure **A-1**
Sheet **2 of 3**

Stratification Terms

Term	Characteristics
Laminations	Thin beds (<1 cm)
Fissile	Tendency to break along laminations.
Parting	Tendency to break parallel to bedding.
Foliation	Non-depositional (e.g., segregation and layering of minerals in metamorphic rock)

Igneous Rock Textures

Texture	Grain Size
Pegmatitic	Very large; diameters measured in inches or feet
Phaneritic	Can be seen with the naked eye
Porphyritic	Grained of two widely different sizes
Aphanitic	Cannot be seen with the naked eye
Glassy	No grains present

Pyroclastic Rocks

Rock Name	Characteristics
Cinders	Uncemented glassy and vesicular ejecta 4-32 mm size
Tuff Breccia (Agglomerate)	Composed of ejecta >32mm size, in ash/tuff matrix, indurated
Lapilli Tuff	Composed of ejecta 4-32 mm size, in ash/tuff matrix, indurated
Tuff	Cemented volcanic ash particles <4mm size, indurated
Pumice	Excessively vesiculated glassy lava

Degree of Vesicularity

Designation	Percentage of Cavities (by volume) of Total Sample
Some Vesicules	5 to 25 Percent
Highly Vesicular	15 to 50 Percent
Scoriaceous	Greater than 50 Percent

Other Terms:

Core Recover (CR) = the ratio of core recovered to the core run length expressed as a percentage.

Rock Quality Designation (RQD) = the percentage of rock core recovered in intact pieces of 4 inches or more in length in the length of a core run. Does not include mechanical breaks caused by drilling.

Reference:

Oregon Department of Transportation (ODOT), 1987. *Soil and Rock Classification Manual*, May 1987.

HALEY ALDRICH

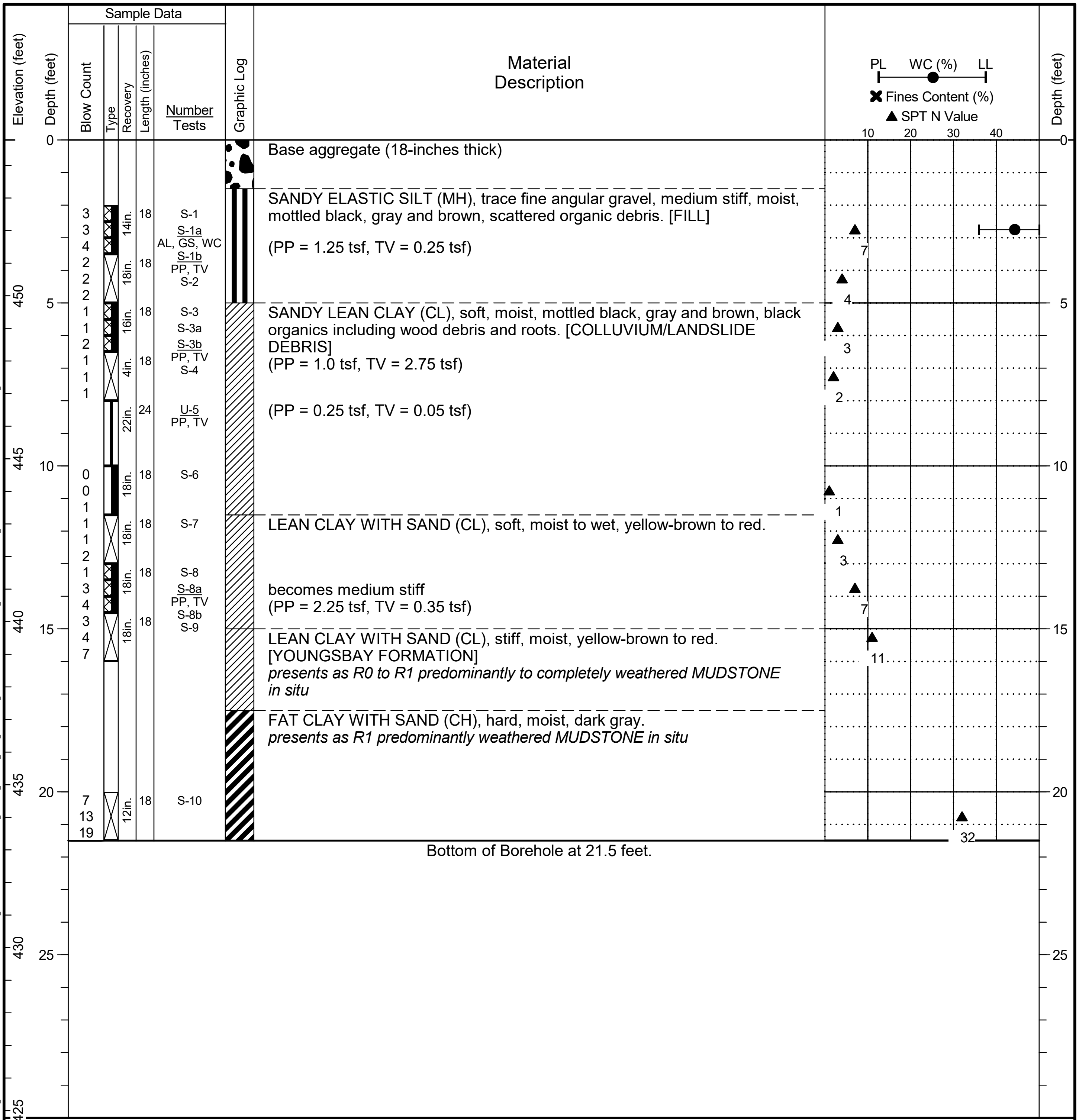
Project: Astoria Pipeline Road Waterline
Location: Clatsop County, Oregon
Project No.: 0208388-000

Key to Exploration Logs

Figure **A-1**
Sheet **3 of 3**

Date Started: 10/03/2023
Date Completed: 10/03/2023
Logged by: D. Knapp
Checked by: K. Ahrens
Location: Lat: 46.095481 Long: 123.464984 (WGS 84)
Ground Surface Elevation: 454.78 feet (NAVD 88)
Comments: In situ relative hardness designation, R, based on ODOTs Soil and Rock Classification Manual. Blow counts for >1.5" split spoon adjusted to approximate SPT N-values (see report text).

Drilling Contractor/Crew: Western States Soil Conservation, Inc. / Shane/Brandon
Drilling Method: Hollow Stem Auger
Rig Model/Type: CME-75 / Truck-mounted drill rig
Hammer Type: Auto-hammer
Hammer Weight (pounds): 140
Hammer Drop Height (inches): 30
Measured Hammer Efficiency (%): Not Available
Hole Diameter: 8 inches
Well Casing Diameter: NA
Total Depth: 21.5 feet
Depth to Groundwater: Not Identified



Depth (feet)	Material Description
0	Base aggregate (18-inches thick)
	SANDY ELASTIC SILT (MH), trace fine angular gravel, medium stiff, moist, mottled black, gray and brown, scattered organic debris. [FILL] (PP = 1.25 tsf, TV = 0.25 tsf)
5	SANDY LEAN CLAY (CL), soft, moist, mottled black, gray and brown, black organics including wood debris and roots. [COLLUVIUM/LANDSLIDE DEBRIS] (PP = 1.0 tsf, TV = 2.75 tsf) (PP = 0.25 tsf, TV = 0.05 tsf)
	LEAN CLAY WITH SAND (CL), soft, moist to wet, yellow-brown to red. becomes medium stiff (PP = 2.25 tsf, TV = 0.35 tsf)
15	LEAN CLAY WITH SAND (CL), stiff, moist, yellow-brown to red. [YOUNGSBAY FORMATION] *presents as R0 to R1 predominantly to completely weathered MUDSTONE in situ*
	FAT CLAY WITH SAND (CH), hard, moist, dark gray. *presents as R1 predominantly weathered MUDSTONE in situ*

Blow Count	Recovery	Length (inches)	Number Tests
3 3 4	14in.	18	S-1 S-1a AL, GS, WC S-1b PP, TV
2 2 2	18in.	18	S-2
1 1 2	16in.	18	S-3 S-3a S-3b PP, TV
1 1 1	4in.	18	S-4
	22in.	24	U-5 PP, TV
0 0 1	18in.	18	S-6
1 1 2	18in.	18	S-7
1 3 4	18in.	18	S-8 S-8a PP, TV S-8b
3 4 7	18in.	18	S-9
7 13 19	12in.	18	S-10

Bottom of Borehole at 21.5 feet.

General Notes:
1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Material stratum lines are interpretive and actual changes may be gradual. Solid lines indicate distinct contacts and dashed lines indicate gradual or approximate contacts.
3. USCS designations are based on visual-manual identification (ASTM D 2488), unless otherwise supported by laboratory testing (ASTM D 2487).
4. Groundwater level, if indicated, is at time of drilling/excavation (ATD) or for date specified. Level may vary with time.
5. Location and ground surface elevations are approximate.

HALEY ALDRICH
Project: Astoria Pipeline Road Waterline
Location: Clatsop County, Oregon
Project No.: 0208388-000

Boring Log
B-1-1

Figure **A-2**
Sheet **1 of 1**

Date Started: 10/03/2023
Date Completed: 10/03/2023
Drilling Contractor/Crew: Western States Soil Conservation, Inc. / Shane/Brandon
Logged by: D. Knapp
Checked by: K. Ahrens
Drilling Method: Hollow Stem Auger
Location: Lat: 46.094982 Long: 123.464322 (WGS 84)
Rig Model/Type: CME-75 / Truck-mounted drill rig
Ground Surface Elevation: 447.25 feet (NAVD 88)
Hammer Type: Auto-hammer
Comments: In situ relative hardness designation, R, based on ODOTs Soil and Rock Classification Manual. Blow counts for >1.5" split spoon adjusted to approximate SPT N-values (see report text).
Hammer Weight (pounds): 140
Hammer Drop Height (inches): 30
Measured Hammer Efficiency (%): Not Available
Hole Diameter: 8 inches
Well Casing Diameter: NA
Total Depth: 26.0 feet
Depth to Groundwater: Not Identified

Blow Count	Recovery	Length (inches)	Number Tests
3 3 4	18in.	18	S-1 S-1a S-1b PP, TV
1 2 3	12in.	18	S-2 AL, WC
1 2 3	18in.	18	S-3 S-3a S-3b PP, TV
1 1 3	9in.	18	S-4
2 3 6	18in.	18	S-5 S-5a S-5b PP, TV
3 6 10	16in.	18	S-6
15 17 8	18in.	18	S-7 S-7a GS S-7b
3 10 12	18in.	18	S-8
8 13 19	18in.	18	S-9
5 8 12	18in.	18	S-10 S-10a S-10b PP, TV
7 8 7	18in.	18	S-11
11 16 19	18in.	18	S-12
36 26 20	18in.	18	S-13 S-13a S-13b PP, TV
27 61	12in.	12	S-14
31 56	12in.	12	S-15

Material Description

Base aggregate (18-inches thick)

LEAN CLAY WITH SAND (CL), medium stiff, moist, yellow-brown to brown with red mottling, trace organic debris. [FILL]

(PP = 1.75 tsf, TV = 9.45 tsf)

SANDY ELASTIC SILT (MH), trace fine sand, trace angular gravel, medium stiff, moist, brown, wood debris.

LEAN CLAY WITH SAND (CL), soft, moist, yellow-brown to tan with orange mottling, micaceous, medium plasticity, iron oxide staining. [COLLUVIUM/LANDSLIDE DEBRIS]

(PP = 3.0 tsf, TV = 0.30 tsf)

grades to stiff
(PP = 2.5 tsf, TV = 0.35 tsf)
grades to very stiff

CLAYEY SAND (SC), medium dense, moist, yellow-brown to tan with orange mottling. [YOUNGSBAY FORMATION]
presents as R1 moderately to predominantly weathered SANDSTONE in situ

FAT CLAY (CH), very stiff, moist, gray.
presents as R1 moderately to predominantly weathered MUDSTONE in situ
grades to hard

grades to very stiff

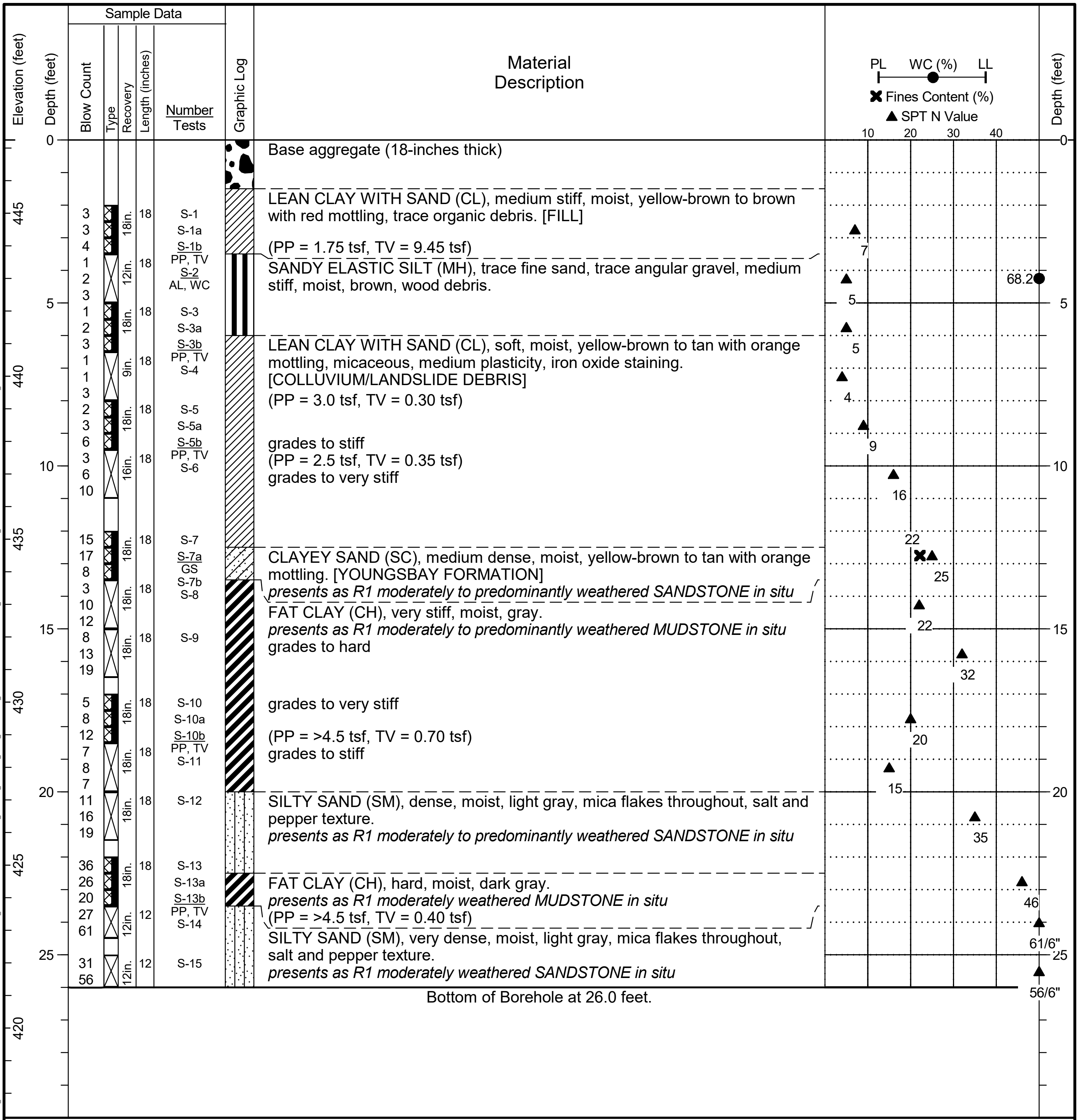
(PP = >4.5 tsf, TV = 0.70 tsf)
grades to stiff

SILTY SAND (SM), dense, moist, light gray, mica flakes throughout, salt and pepper texture.
presents as R1 moderately to predominantly weathered SANDSTONE in situ

FAT CLAY (CH), hard, moist, dark gray.
presents as R1 moderately weathered MUDSTONE in situ
(PP = >4.5 tsf, TV = 0.40 tsf)

SILTY SAND (SM), very dense, moist, light gray, mica flakes throughout, salt and pepper texture.
presents as R1 moderately weathered SANDSTONE in situ

Bottom of Borehole at 26.0 feet.



General Notes:
1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Material stratum lines are interpretive and actual changes may be gradual. Solid lines indicate distinct contacts and dashed lines indicate gradual or approximate contacts.
3. USCS designations are based on visual-manual identification (ASTM D 2488), unless otherwise supported by laboratory testing (ASTM D 2487).
4. Groundwater level, if indicated, is at time of drilling/excavation (ATD) or for date specified. Level may vary with time.
5. Location and ground surface elevations are approximate.

HALEY ALDRICH

Project: Astoria Pipeline Road Waterline
Location: Clatsop County, Oregon
Project No.: 0208388-000

Boring Log
B-1-2

Figure **A-3**
Sheet **1 of 1**

Date Started: 10/05/2023 Date Completed: 10/05/2023
Logged by: D. Knapp Checked by: K. Ahrens
Location: Lat: 46.094767 Long: 123.464652 (WGS 84)
Ground Surface Elevation: 469.94 feet (NAVD 88)
Comments: In situ relative hardness designation, R, based on ODOTs Soil and Rock Classification Manual. Blow counts for >1.5" split spoon adjusted to approximate SPT N-values (see report text).

Drilling Contractor/Crew: Western States Soil Conservation, Inc. / Shane/Brandon
Drilling Method: Hollow Stem Auger
Rig Model/Type: CME-75 / Truck-mounted drill rig
Hammer Type: Auto-hammer
Hammer Weight (pounds): 140 Hammer Drop Height (inches): 30
Measured Hammer Efficiency (%): Not Available
Hole Diameter: 8 inches Well Casing Diameter: NA
Total Depth: 26.5 feet Depth to Groundwater: Not Identified

Elevation (feet)	Depth (feet)	Blow Count	Type	Recovery	Length (inches)	Number Tests	Graphic Log	Material Description	PL WC (%) LL / ▲ SPT N Value
	0							Base aggregate (8-inches thick)	
								SANDY LEAN CLAY WITH GRAVEL (CL), medium stiff, moist to wet, black to gray-brown. [FILL]	
		1 3 5		18in.	18	S-1 S-1a S-1b			▲ 8
		3 4 5		18in.	18	PP, TV S-2		SANDY LEAN CLAY (CL), medium stiff, moist, tan to light brown. [COLLUVIUM] (PP = 3.75 tsf, TV = 0.40 tsf)	▲ 9
465	5	4 6 9		14in.	18	S-3 S-3a S-3b		grades to stiff, pockets of clayey sand (PP = 4.0 tsf, TV = 0.45 tsf)	▲ 15
		4 3 5		16in.	18	PP, TV S-4			▲ 8
		4 6 8		16in.	18	S-5 S-5a AL, WC S-5b		ELASTIC SILT (MH), trace fine sand, stiff, moist, dark gray, blocky structure. [YOUNGSBAY FORMATION] *presents as R0 predominantly weathered MUDSTONE in situ* (PP = 4.25 tsf, TV = 0.55 tsf)	▲ 14 ●
460	10	4 5 6		18in.	18	PP, TV S-6			▲ 11
		5 6 6		18in.	18	S-7 S-7a S-7b		grades to trace fine to coarse angular gravel	▲ 12
		4 4 5		12in.	18	PP, TV S-8		FAT CLAY (CH), trace fine to medium sand, stiff, moist, dark gray. (PP = >4.5 tsf, TV = 0.55 tsf) *presents as R0 predominantly weathered MUDSTONE in situ*	▲ 9
455	15	3 4 8		16in.	18	S-9 S-9a S-9b		(sampler wet) (PP = 3.5 tsf, TV = 0.55 tsf)	▲ 12
		5 7 10		18in.	18	PP, TV S-10			▲ 17
450	20	3 3 5		18in.	18	S-11		CLAYEY SAND (SC), loose, wet, gray, micaceous. *presents as R0 predominantly weathered SANDSTONE in situ*	▲ 8
								FAT CLAY WITH SAND (CH), trace fine angular gravel, medium stiff, moist, dark gray, blocky structure. *presents as R0 predominantly weathered MUDSTONE in situ*	
445	25	3 6 24		18in.	18	S-12		SANDY LEAN CLAY (CL), very stiff, moist, dark gray, frequent seams and pockets of light gray fine to medium sand. *presents as R1 moderately to predominantly weathered MUDSTONE in situ*	▲ 30
								Bottom of Borehole at 26.5 feet.	

SPT N Value scale: 10 20 30 40

General Notes:
1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Material stratum lines are interpretive and actual changes may be gradual. Solid lines indicate distinct contacts and dashed lines indicate gradual or approximate contacts.
3. USCS designations are based on visual-manual identification (ASTM D 2488), unless otherwise supported by laboratory testing (ASTM D 2487).
4. Groundwater level, if indicated, is at time of drilling/excavation (ATD) or for date specified. Level may vary with time.
5. Location and ground surface elevations are approximate.

HALEY ALDRICH

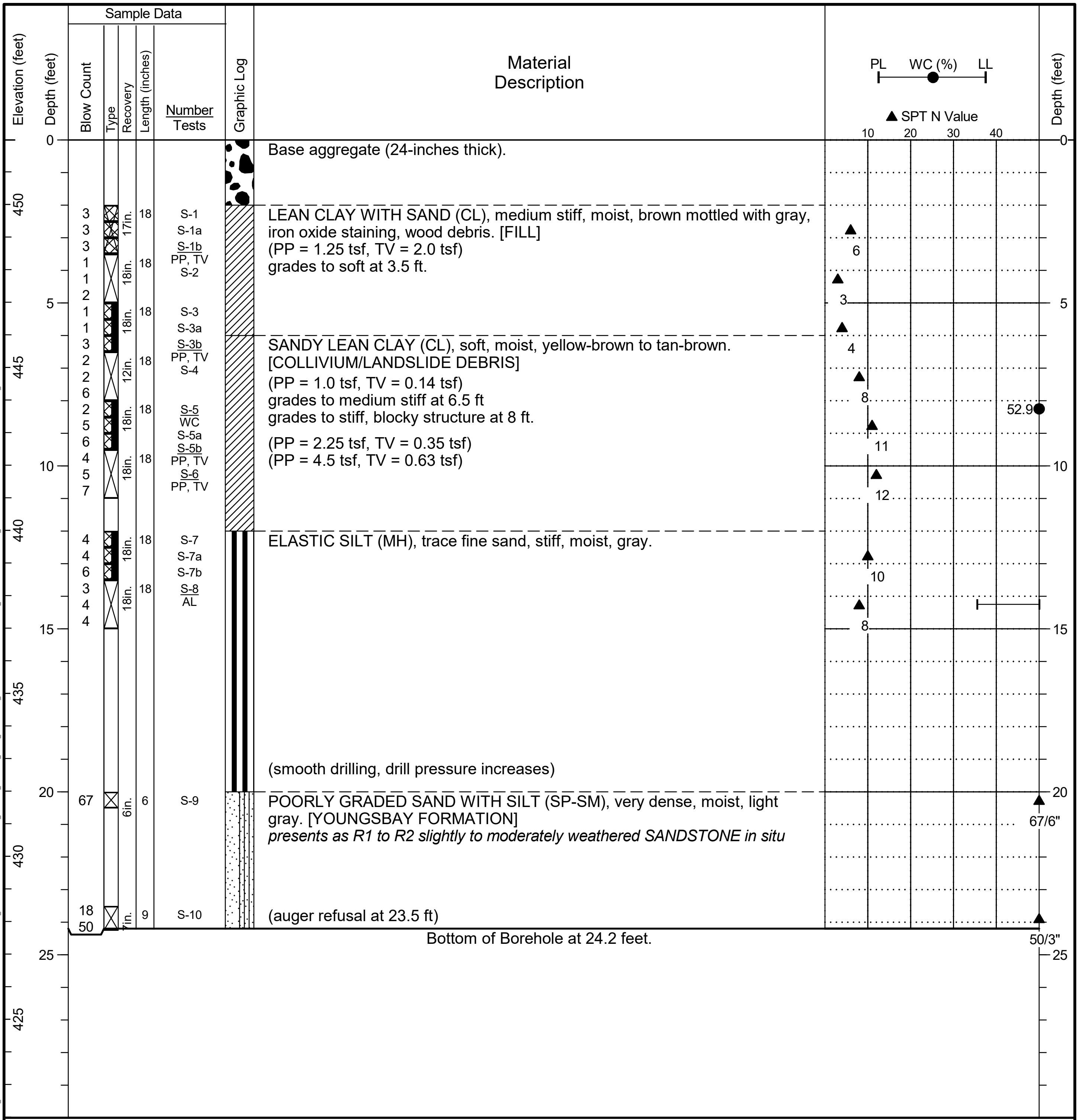
Project: Astoria Pipeline Road Waterline
Location: Clatsop County, Oregon
Project No.: 0208388-000

Boring Log
B-1-3

Figure **A-4**
Sheet **1 of 1**

Date Started: 10/03/2023
Date Completed: 10/03/2023
Logged by: D. Knapp
Checked by: K. Ahrens
Location: Lat: 46.094767 Long: 123.464652 (WGS 84)
Ground Surface Elevation: 451.98 feet (NAVD 88)
Comments: In situ relative hardness designation, R, based on ODOTs Soil and Rock Classification Manual. Blow counts for >1.5" split spoon adjusted to approximate SPT N-values (see report text).

Drilling Contractor/Crew: Western States Soil Conservation, Inc. / Shane/Brandon
Drilling Method: Hollow Stem Auger
Rig Model/Type: CME-75 / Truck-mounted drill rig
Hammer Type: Auto-hammer
Hammer Weight (pounds): 140
Hammer Drop Height (inches): 30
Measured Hammer Efficiency (%): Not Available
Hole Diameter: 8 inches
Well Casing Diameter: NA
Total Depth: 24.2 feet
Depth to Groundwater: Not Identified



Sample Data				
Blow Count	Type	Recovery	Length (inches)	Number Tests
3 3 3		17in.	18	S-1 S-1a S-1b PP, TV
1 1 2		18in.	18	S-2
1 1 3		18in.	18	S-3 S-3a S-3b PP, TV
2 2 6		12in.	18	S-4
2 5 6		18in.	18	S-5 WC S-5a S-5b PP, TV
4 5 7		18in.	18	S-6 PP, TV
4 4 6		18in.	18	S-7 S-7a S-7b
3 4 4		18in.	18	S-8 AL
67		6in.	6	S-9
18 50		7in.	9	S-10

Material Description

Base aggregate (24-inches thick).

LEAN CLAY WITH SAND (CL), medium stiff, moist, brown mottled with gray, iron oxide staining, wood debris. [FILL]
(PP = 1.25 tsf, TV = 2.0 tsf)
grades to soft at 3.5 ft.

SANDY LEAN CLAY (CL), soft, moist, yellow-brown to tan-brown. [COLLIVIUM/LANDSLIDE DEBRIS]
(PP = 1.0 tsf, TV = 0.14 tsf)
grades to medium stiff at 6.5 ft
grades to stiff, blocky structure at 8 ft.
(PP = 2.25 tsf, TV = 0.35 tsf)
(PP = 4.5 tsf, TV = 0.63 tsf)

ELASTIC SILT (MH), trace fine sand, stiff, moist, gray.

(smooth drilling, drill pressure increases)

POORLY GRADED SAND WITH SILT (SP-SM), very dense, moist, light gray. [YOUNGSBAY FORMATION]
presents as R1 to R2 slightly to moderately weathered SANDSTONE in situ

(auger refusal at 23.5 ft)

Bottom of Borehole at 24.2 feet.

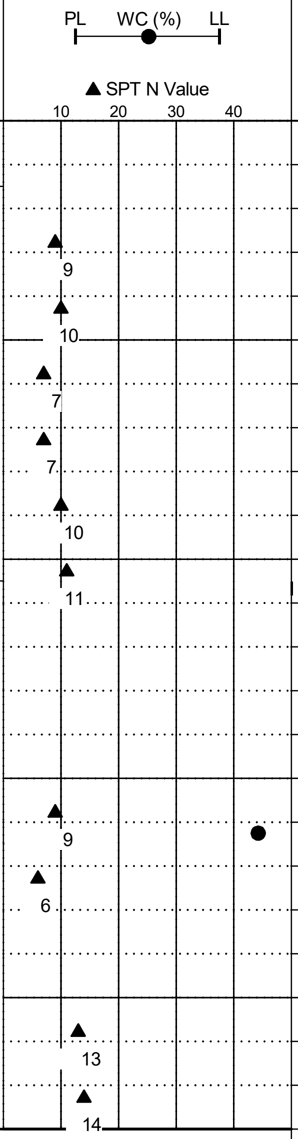
General Notes:
1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Material stratum lines are interpretive and actual changes may be gradual. Solid lines indicate distinct contacts and dashed lines indicate gradual or approximate contacts.
3. USCS designations are based on visual-manual identification (ASTM D 2488), unless otherwise supported by laboratory testing (ASTM D 2487).
4. Groundwater level, if indicated, is at time of drilling/excavation (ATD) or for date specified. Level may vary with time.
5. Location and ground surface elevations are approximate.

Date Started: 10/02/2023
Date Completed: 10/02/2023
Logged by: D. Knapp
Checked by: K. Ahrens
Location: Lat: 46.094325 Long: 123.463766 (WGS 84)
Ground Surface Elevation: 431.99 feet (NAVD 88)
Comments: In situ relative hardness designation, R, based on ODOTs Soil and Rock Classification Manual. Blow counts for >1.5" split spoon adjusted to approximate SPT N-values (see report text).

Drilling Contractor/Crew: Western States Soil Conservation, Inc. / Shane/Brandon
Drilling Method: Hollow Stem Auger
Rig Model/Type: CME-75 / Truck-mounted drill rig
Hammer Type: Auto-hammer
Hammer Weight (pounds): 140
Hammer Drop Height (inches): 30
Measured Hammer Efficiency (%): Not Available
Hole Diameter: 8 inches
Well Casing Diameter: NA
Total Depth: 23.0 feet
Depth to Groundwater: Not Identified

Elevation (feet)	Depth (feet)	Blow Count	Recovery	Length (inches)	Number Tests	Material Description
	0					Base aggregate (18-inches thick)
430		3 5 4	18in.	18	S-1 S-1a S-1b	SANDY LEAN CLAY (CL), stiff, moist, tan to yellow-brown, iron oxide staining. [YOUNGSBAY FORMATION] *presents as R0 to R1 slightly to moderately weathered SILTSTONE in situ* (PP = 4.0 tsf, TV = 0.1 tsf)
		2 4 6	16in.	18	PP, TV S-2	
	5	3 3 4	18in.	18	S-3 S-3a S-3b	pockets of interbedded clayey sand grades to medium stiff (PP = 2.2 tsf, TV = 0.15 tsf)
425		3 3 4	16in.	18	PP, TV S-4	
		2 4 6	18in.	18	S-5 S-5a S-5b	grades to stiff (PP = 2.0 tsf, TV = 0.15 tsf)
	10	3 4 7	18in.	18	PP, TV S-6a S-6b AL	ELASTIC SILT (MH), trace fine sand, trace fine to coarse angular gravel, stiff, moist, gray, increase in plasticity. *presents as R0 to R1 slightly to moderately weathered MUDSTONE in situ*
420						
	15	2 4 5	18in.	18	S-7 S-7a S-7b	(PP = 3.5 tsf, TV = 0.21 tsf)
415		3 3 3	18in.	18	PP, TV, WC S-8	SANDY LEAN CLAY WITH GRAVEL (CL), medium stiff, moist, gray. *presents as R0 to R1 slightly to moderately weathered MUDSTONE in situ*
	20	5 6 7	18in.	18	S-9 S-9a S-9b	grades to stiff (PP = 3.75 tsf)
410		4 4 10	6in.	18	PP S-10	

Bottom of Borehole at 23.0 feet.



General Notes:
1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Material stratum lines are interpretive and actual changes may be gradual. Solid lines indicate distinct contacts and dashed lines indicate gradual or approximate contacts.
3. USCS designations are based on visual-manual identification (ASTM D 2488), unless otherwise supported by laboratory testing (ASTM D 2487).
4. Groundwater level, if indicated, is at time of drilling/excavation (ATD) or for date specified. Level may vary with time.
5. Location and ground surface elevations are approximate.

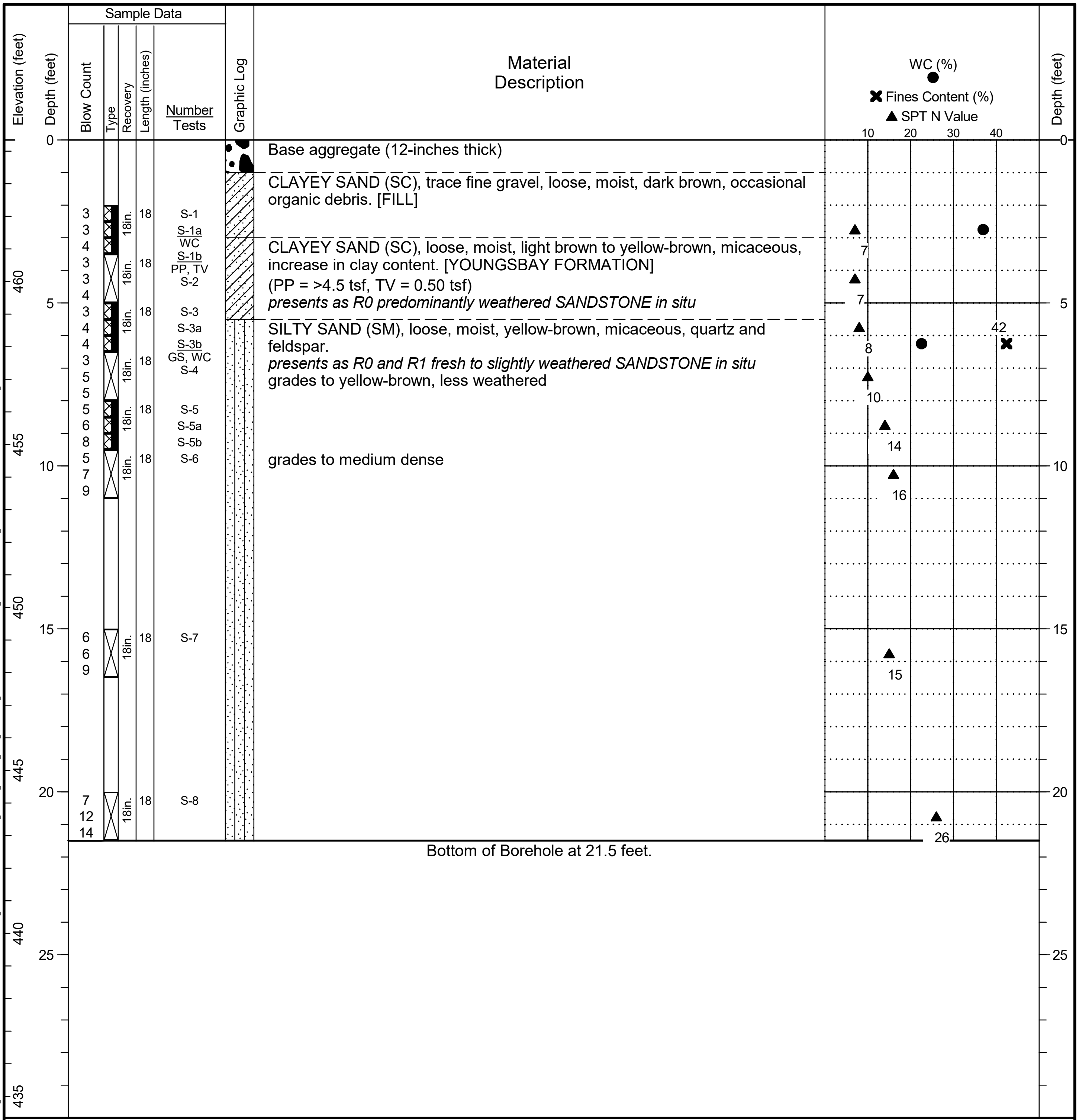
Project: Astoria Pipeline Road Waterline
Location: Clatsop County, Oregon
Project No.: 0208388-000

Boring Log
B-1-5

Figure **A-6**
Sheet **1 of 1**

Date Started: 10/05/2023
Date Completed: 10/05/2023
Logged by: D. Knapp
Checked by: K. Ahrens
Location: Lat: 46.081585 Long: 123.423191 (WGS 84)
Ground Surface Elevation: 464.34 feet (NAVD 88)
Comments: In situ relative hardness designation, R, based on ODOTs Soil and Rock Classification Manual. Blow counts for >1.5" split spoon adjusted to approximate SPT N-values (see report text).

Drilling Contractor/Crew: Western States Soil Conservation, Inc. / Shane/Brandon
Drilling Method: Hollow Stem Auger
Rig Model/Type: CME-75 / Truck-mounted drill rig
Hammer Type: Auto-hammer
Hammer Weight (pounds): 140
Hammer Drop Height (inches): 30
Measured Hammer Efficiency (%): Not Available
Hole Diameter: 8 inches
Well Casing Diameter: NA
Total Depth: 21.5 feet
Depth to Groundwater: Not Identified



Blow Count	Type	Recovery	Length (inches)	Number Tests
3 3 4		18in.	18	S-1 S-1a WC S-1b PP, TV
3 3 4		18in.	18	S-2
3 4 4		18in.	18	S-3 S-3a S-3b GS, WC
3 5 5		18in.	18	S-4
5 6 8		18in.	18	S-5 S-5a S-5b
5 7 9		18in.	18	S-6
6 6 9		18in.	18	S-7
7 12 14		18in.	18	S-8

Material Description

Base aggregate (12-inches thick)

CLAYEY SAND (SC), trace fine gravel, loose, moist, dark brown, occasional organic debris. [FILL]

CLAYEY SAND (SC), loose, moist, light brown to yellow-brown, micaceous, increase in clay content. [YOUNGSBAY FORMATION]
(PP = >4.5 tsf, TV = 0.50 tsf)
presents as R0 predominantly weathered SANDSTONE in situ

SILTY SAND (SM), loose, moist, yellow-brown, micaceous, quartz and feldspar.
presents as R0 and R1 fresh to slightly weathered SANDSTONE in situ
grades to yellow-brown, less weathered

grades to medium dense

Bottom of Borehole at 21.5 feet.

General Notes:
1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Material stratum lines are interpretive and actual changes may be gradual. Solid lines indicate distinct contacts and dashed lines indicate gradual or approximate contacts.
3. USCS designations are based on visual-manual identification (ASTM D 2488), unless otherwise supported by laboratory testing (ASTM D 2487).
4. Groundwater level, if indicated, is at time of drilling/excavation (ATD) or for date specified. Level may vary with time.
5. Location and ground surface elevations are approximate.

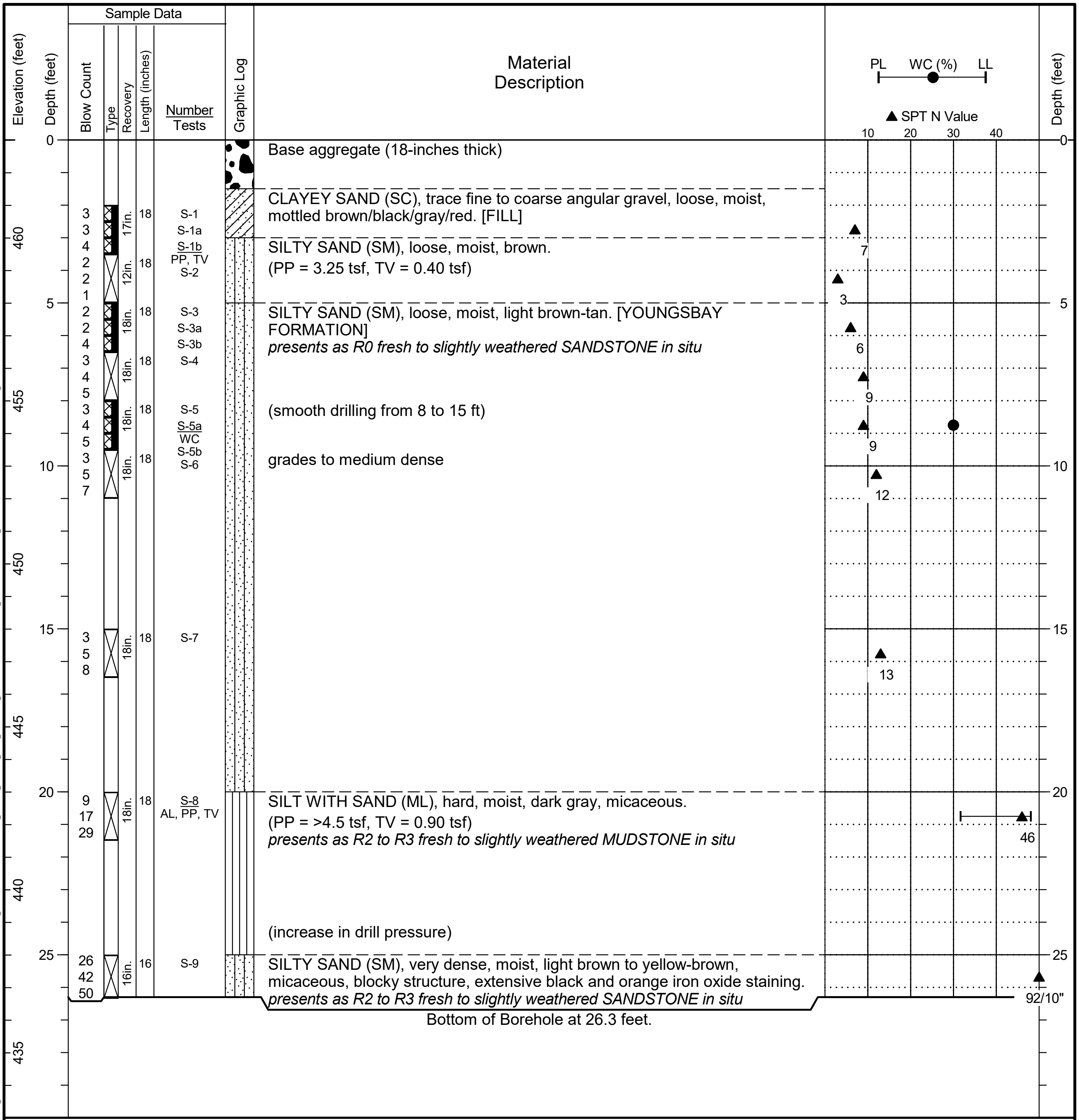
HALEY ALDRICH
Project: Astoria Pipeline Road Waterline
Location: Clatsop County, Oregon
Project No.: 0208388-000

Boring Log
B-2-6

Figure **A-7**
Sheet **1 of 1**

Date Started: 10/04/2023
Date Completed: 10/04/2023
Logged by: D. Knapp
Checked by: K. Ahrens
Location: Lat: 46.081407 Long: 123.422254 (WGS 84)
Ground Surface Elevation: 463.01 feet (NAVD 88)
Comments: In situ relative hardness designation, R, based on ODOTs Soil and Rock Classification Manual. Blow counts for >1.5" split spoon adjusted to approximate SPT N-values (see report text).

Drilling Contractor/Crew: Western States Soil Conservation, Inc. / Shane/Brandon
Drilling Method: Hollow Stem Auger
Rig Model/Type: CME-75 / Truck-mounted drill rig
Hammer Type: Auto-hammer
Hammer Weight (pounds): 140
Hammer Drop Height (inches): 30
Measured Hammer Efficiency (%): Not Available
Hole Diameter: 8 inches
Well Casing Diameter: NA
Total Depth: 26.3 feet
Depth to Groundwater: Not Identified



Depth (feet)	Blow Count	Recovery	Length (inches)	Number Tests	SPT N Value
	3 3 4	17in.	18	S-1 S-1a S-1b	7
	2 2 1	12in.	18	PP, TV S-2	3
5	2 2 4	18in.	18	S-3 S-3a S-3b	6
	3 4 5	18in.	18	S-4	9
	3 4 5	18in.	18	S-5 S-5a WC S-5b	9
10	3 5 7	18in.	18	S-6	12
15	3 5 8	18in.	18	S-7	13
20	9 17 29	18in.	18	S-8 AL, PP, TV	46
25	26 42 50	16in.	16	S-9	92/10"

Material Description

Base aggregate (18-inches thick)

CLAYEY SAND (SC), trace fine to coarse angular gravel, loose, moist, mottled brown/black/gray/red. [FILL]

SILTY SAND (SM), loose, moist, brown.
(PP = 3.25 tsf, TV = 0.40 tsf)

SILTY SAND (SM), loose, moist, light brown-tan. [YOUNGSBAY FORMATION]
presents as R0 fresh to slightly weathered SANDSTONE in situ

(smooth drilling from 8 to 15 ft)

grades to medium dense

SILT WITH SAND (ML), hard, moist, dark gray, micaceous.
(PP = >4.5 tsf, TV = 0.90 tsf)
presents as R2 to R3 fresh to slightly weathered MUDSTONE in situ

(increase in drill pressure)

SILTY SAND (SM), very dense, moist, light brown to yellow-brown, micaceous, blocky structure, extensive black and orange iron oxide staining.
presents as R2 to R3 fresh to slightly weathered SANDSTONE in situ

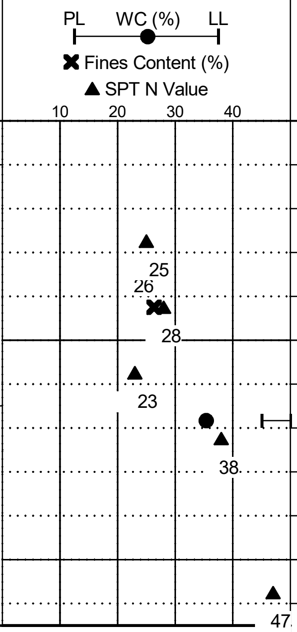
Bottom of Borehole at 26.3 feet.

General Notes:
1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Material stratum lines are interpretive and actual changes may be gradual. Solid lines indicate distinct contacts and dashed lines indicate gradual or approximate contacts.
3. USCS designations are based on visual-manual identification (ASTM D 2488), unless otherwise supported by laboratory testing (ASTM D 2487).
4. Groundwater level, if indicated, is at time of drilling/excavation (ATD) or for date specified. Level may vary with time.
5. Location and ground surface elevations are approximate.

Date Started: 10/05/2023
Date Completed: 10/05/2023
Logged by: D. Knapp
Checked by: K. Ahrens
Location: Lat: 46.081029 Long: 123.420298 (WGS 84)
Ground Surface Elevation: 520.00 feet (NAVD 88)
Comments: In situ relative hardness designation, R, based on ODOTs Soil and Rock Classification Manual. Blow counts for >1.5" split spoon adjusted to approximate SPT N-values (see report text).

Drilling Contractor/Crew: Western States Soil Conservation, Inc. / Shane/Brandon
Drilling Method: Hollow Stem Auger
Rig Model/Type: CME-75 / Truck-mounted drill rig
Hammer Type: Auto-hammer
Hammer Weight (pounds): 140
Hammer Drop Height (inches): 30
Measured Hammer Efficiency (%): Not Available
Hole Diameter: 8 inches
Well Casing Diameter: NA
Total Depth: 11.5 feet
Depth to Groundwater: Not Identified

Elevation (feet)	Depth (feet)	Blow Count	Type	Recovery	Length (inches)	Number Tests	Material Description
520	0						Base aggregate (12-inches thick)
							SILTY SAND (SM), medium dense, moist, light brown to yellow-brown. [YOUNGSBAY FORMATION] *presents as R0 to R1 fresh to slightly weathered SANDSTONE in situ*
		7 12 13		18in.	18	S-1 S-1a S-1b	
		9 14 14		18in.	18	S-2 GS	grades to red-brown iron oxide staining
515	5	8 11 12		18in.	18	S-3 S-3a S-3b	grades to light gray (increase in drill pressure)
		6 16 22		18in.	18	S-4a AL, WC S-4b	ELASTIC SILT (MH), hard, moist, light brown to red-brown, micaceous. *presents as R0 to R1 fresh to slightly weathered MUDSTONE in situ* SILTY SAND (SM), dense, moist, light brown, iron oxide staining. *presents as R0 to R1 fresh to slightly weathered SANDSTONE in situ*
510	10	16 18 29		18in.	18	S-5	
							Bottom of Borehole at 11.5 feet.
505	15						
500	20						
495	25						



General Notes:
1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Material stratum lines are interpretive and actual changes may be gradual. Solid lines indicate distinct contacts and dashed lines indicate gradual or approximate contacts.
3. USCS designations are based on visual-manual identification (ASTM D 2488), unless otherwise supported by laboratory testing (ASTM D 2487).
4. Groundwater level, if indicated, is at time of drilling/excavation (ATD) or for date specified. Level may vary with time.
5. Location and ground surface elevations are approximate.

HALEY ALDRICH

Project: Astoria Pipeline Road Waterline
Location: Clatsop County, Oregon
Project No.: 0208388-000

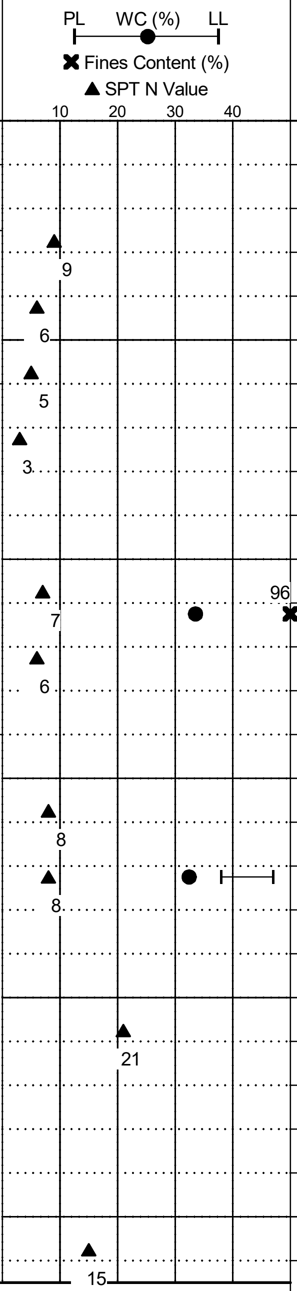
Boring Log
B-3-8

Figure **A-9**
Sheet **1 of 1**

Date Started: 10/04/2023 Date Completed: 10/04/2023
Logged by: D. Knapp Checked by: K. Ahrens
Location: Lat: 46.080722 Long: 123.415226 (WGS 84)
Ground Surface Elevation: 469.69 feet (NAVD 88)
Comments: In situ relative hardness designation, R, based on ODOTs Soil and Rock Classification Manual. Blow counts for >1.5" split spoon adjusted to approximate SPT N-values (see report text).

Drilling Contractor/Crew: Western States Soil Conservation, Inc. / Shane/Brandon
Drilling Method: Hollow Stem Auger
Rig Model/Type: CME-75 / Truck-mounted drill rig
Hammer Type: Auto-hammer
Hammer Weight (pounds): 140 Hammer Drop Height (inches): 30
Measured Hammer Efficiency (%): Not Available
Hole Diameter: 8 inches Well Casing Diameter: NA
Total Depth: 26.5 feet Depth to Groundwater: Not Identified

Elevation (feet)	Depth (feet)	Blow Count	Recovery	Length (inches)	Number Tests	Material Description
	0					Base aggregate (12-inches thick)
						CLAYEY GRAVEL WITH SAND (GC), loose, moist, black-brown, subrounded to angular gravel, scattered wood debris. [FILL]
		13 5 4	18in.	18	S-1 S-1a S-1b	CLAYEY SAND (SC), loose, moist, brown with orange-red mottling, micaceous. (PP = 3.0 tsf, TV = 0.35 tsf)
		2 2 4	18in.	18	PP, TV S-2	
465	5	1 2 3	14in.	18	S-3 S-3a S-3b	SANDY LEAN CLAY (CL), soft, moist, brown with orange mottling, stratified. [COLLUVIUM/LANDSLIDE DEBRIS] (PP = 2.0 tsf, TV = 0.50 tsf)
		1 1 2	16in.	18	PP, TV S-4	
			25in.	24	U-5	
460	10	3 3 4	18in.	18	S-6 PP, TV S-6a S-6b	(PP = 0.75 tsf, TV = 0.45 tsf) (PP = 2.75 tsf, TV = 0.45 tsf)
		1 2 4	18in.	18	GS, PP, TV, WC S-7	LEAN CLAY (CL), medium stiff, moist to wet, brown-gray, micaceous. [YOUNGSBAY FORMATION] *presents as R0 moderately to predominantly weathered MUDSTONE in situ*
						(increase in drill pressure at 14 ft)
455	15	2 4 4	18in.	18	S-8 S-8a S-8b	SILTY SAND (SM), loose, moist, gray with orange mottling, micaceous, iron oxide staining. *presents as R0 moderately to predominantly weathered SANDSTONE in situ* (PP = 2.0 tsf, TV = 0.25 tsf)
		2 3 5	18in.	18	PP, TV S-9 AL, WC	
450	20	6 10 11	18in.	18	S-10	grades to medium dense
445	25	4 6 9	18in.	18	S-11	
	26.5					Bottom of Borehole at 26.5 feet.
440						



General Notes:
1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Material stratum lines are interpretive and actual changes may be gradual. Solid lines indicate distinct contacts and dashed lines indicate gradual or approximate contacts.
3. USCS designations are based on visual-manual identification (ASTM D 2488), unless otherwise supported by laboratory testing (ASTM D 2487).
4. Groundwater level, if indicated, is at time of drilling/excavation (ATD) or for date specified. Level may vary with time.
5. Location and ground surface elevations are approximate.

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Date Started: 10/04/2023
Date Completed: 10/04/2023
Logged by: D. Knapp
Checked by: K. Ahrens
Location: Lat: 46.080448 Long: 123.414294 (WGS 84)
Ground Surface Elevation: 504.01 feet (NAVD 88)
Comments: In situ relative hardness designation, R, based on ODOTs Soil and Rock Classification Manual. Blow counts for >1.5" split spoon adjusted to approximate SPT N-values (see report text).

Drilling Contractor/Crew: Western States Soil Conservation, Inc. / Shane/Brandon
Drilling Method: Hollow Stem Auger
Rig Model/Type: CME-75 / Truck-mounted drill rig
Hammer Type: Auto-hammer
Hammer Weight (pounds): 140
Hammer Drop Height (inches): 30
Measured Hammer Efficiency (%): Not Available
Hole Diameter: 8 inches
Well Casing Diameter: NA
Total Depth: 31.5 feet
Depth to Groundwater: Not Identified

Sample Data

Blow Count	Type	Recovery	Length (inches)	Number Tests
3 3 3		14in.	18	S-1 WC S-1a S-1b PP, TV
3 4 12		12in.	18	S-2 S-2a S-2b
11 15 18		14in.	18	S-3 S-3a S-3b
11 16 21		18in.	18	S-4
10 22 30		16in.	18	S-5 S-5a S-5b
14 22 28		18in.	18	S-6 GS, WC
9 22 32		18in.	18	S-7 S-7a S-7b
13 27 59		18in.	18	S-8
13 26 39		18in.	18	S-9 S-9a S-9b
16 27 39		18in.	18	S-10
16 30 36		18in.	18	S-11
18 29 40		18in.	18	S-12

Material Description

Base aggregate (18-inches thick)

CLAYEY SAND (SC), trace fine to coarse gravel, loose, moist, yellow-brown/black/brown mottling. [FILL]

(PP = >4.5 tsf, TV = 0.40 tsf)

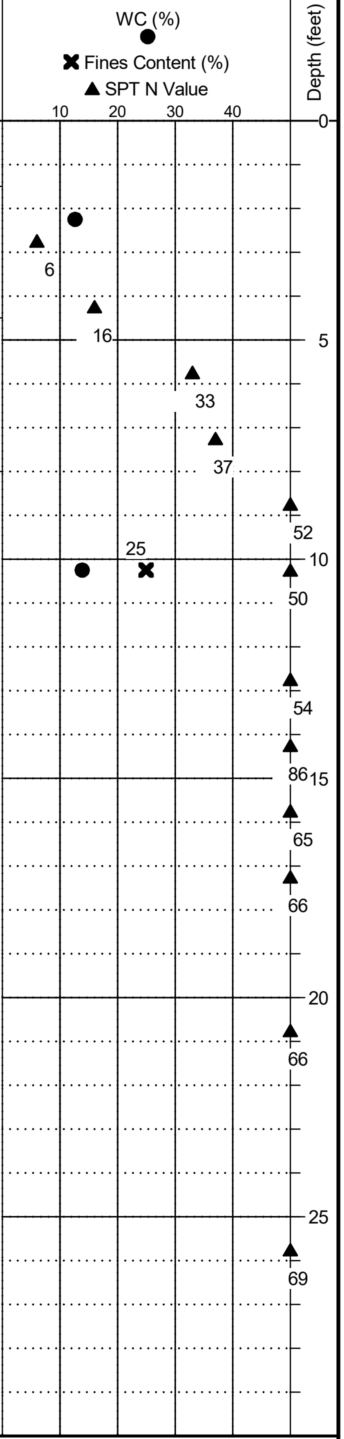
(contact at 4.25 ft, increased drill pressure)

SILTY SAND (SM), dense, moist, light brown, micaceous. [YOUNGSBAY FORMATION]
presents as R0 to R1 moderately to predominantly weathered SANDSTONE in situ

SILTY SAND (SM), very dense, moist, light brown, frequent seams of silt and clay, iron oxide staining.
presents as R2 to R3 slightly to moderately weathered SANDSTONE in situ

grades to homogeneous

pocket of red-orange material from 20 to 20.5 ft
(slow auger advance and smooth firm drilling from 20 to 25 ft)



Elevation (feet): 500, 495, 490, 485, 480, 475
Depth (feet): 0, 5, 10, 15, 20, 25

General Notes:
1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Material stratum lines are interpretive and actual changes may be gradual. Solid lines indicate distinct contacts and dashed lines indicate gradual or approximate contacts.
3. USCS designations are based on visual-manual identification (ASTM D 2488), unless otherwise supported by laboratory testing (ASTM D 2487).
4. Groundwater level, if indicated, is at time of drilling/excavation (ATD) or for date specified. Level may vary with time.
5. Location and ground surface elevations are approximate.

HALEY ALDRICH

Project: Astoria Pipeline Road Waterline
Location: Clatsop County, Oregon
Project No.: 0208388-000

Boring Log
B-4-10

Figure **A-11**
Sheet 1 of 2

Date Started: 10/04/2023 Date Completed: 10/04/2023
Logged by: D. Knapp Checked by: K. Ahrens
Location: Lat: 46.080448 Long: 123.414294 (WGS 84)
Ground Surface Elevation: 504.01 feet (NAVD 88)
Comments: In situ relative hardness designation, R, based on ODOTs Soil and Rock Classification Manual. Blow counts for >1.5" split spoon adjusted to approximate SPT N-values (see report text).

Drilling Contractor/Crew: Western States Soil Conservation, Inc. / Shane/Brandon
Drilling Method: Hollow Stem Auger
Rig Model/Type: CME-75 / Truck-mounted drill rig
Hammer Type: Auto-hammer
Hammer Weight (pounds): 140 Hammer Drop Height (inches): 30
Measured Hammer Efficiency (%): Not Available
Hole Diameter: 8 inches Well Casing Diameter: NA
Total Depth: 31.5 feet Depth to Groundwater: Not Identified

Elevation (feet)	Depth (feet)	Sample Data: Blow Count	Type	Recovery	Length (inches)	Number Tests	Graphic Log	Material Description	WC (%) ● / ✖ Fines Content (%) / ▲ SPT N Value (10 20 30 40)	Depth (feet)
	30	16 28 49	☒	18in.	18	S-13	▨	SILTY SAND (SM), very dense, moist, light brown, frequent seams of silt and clay, iron oxide staining. *(continued)*	▲ 77	30
								Bottom of Borehole at 31.5 feet.		
470	35									35
465	40									40
460	45									45
455	50									50
450	55									55
445										

General Notes:
1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Material stratum lines are interpretive and actual changes may be gradual. Solid lines indicate distinct contacts and dashed lines indicate gradual or approximate contacts.
3. USCS designations are based on visual-manual identification (ASTM D 2488), unless otherwise supported by laboratory testing (ASTM D 2487).
4. Groundwater level, if indicated, is at time of drilling/excavation (ATD) or for date specified. Level may vary with time.
5. Location and ground surface elevations are approximate.

HALEY ALDRICH

Project: Astoria Pipeline Road Waterline
Location: Clatsop County, Oregon
Project No.: 0208388-000

Boring Log
B-4-10

Figure **A-11**
Sheet **2 of 2**

APPENDIX B

Laboratory Testing

APPENDIX B

Laboratory Testing

GENERAL

A geotechnical laboratory testing program was performed for this study to evaluate the index and geotechnical engineering properties of the site soils. Representative disturbed and relatively undisturbed samples were selected for testing. The tests performed and the procedures followed are outlined below.

LABORATORIES

Soil samples obtained from the explorations were transported to our in-house laboratory and evaluated to confirm or modify field classifications, as well as to evaluate engineering properties of the soils encountered. Representative samples were selected for testing in our laboratory, while select samples were also shipped to CERCO Analytical Inc. of Concord, California. The specific tests conducted are outlined below and summarized on Figure B-1. The test results are included in this appendix, and where noted, included on the exploration logs in Appendix A.

VISUAL CLASSIFICATIONS

Soil samples from the explorations were visually classified in the field and then taken to our laboratory where the classifications were verified in a relatively controlled laboratory environment. The classifications of selected samples were checked by laboratory tests, such as water content, grain size distribution determination, fines content determinations, and Atterberg limits determinations. Classifications were made in general accordance with ASTM International (ASTM) D 2487 “Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)”.

HALEY & ALDRICH LABORATORY TESTING

Water Content

Moisture contents of samples were obtained in general accordance with ASTM Test Method D 2216. The results of the moisture content tests completed on samples from the explorations are presented on the exploration logs included in Appendix A and on Figure B-1 in this appendix.

Atterberg Limits

Atterberg limits (liquid limit, plastic limit, and plasticity index) for selected fine-grained soil samples were determined in general accordance with ASTM Test Method D 4318. The plastic limit is defined as the moisture content where the soil becomes brittle. The liquid limit is defined as the moisture content where the soil begins to act similar to a liquid. The plasticity index is the difference between the liquid and plastic limits. The results of the Atterberg limits analysis and the plasticity characteristics are plotted on Figure B-2, summarized on Figure B-1, and shown graphically on the appropriate exploration logs in Appendix A.

Grain Size Distribution

Sieve analysis and hydrometer tests were performed on selected samples to determine the quantitative distribution of particle sizes in the original sample. The tests were performed in general accordance with ASTM D 6913 for the sieve analysis and D 421 and 422 for the hydrometer analysis. The test results are indicated on the exploration logs included in Appendix A and on Figure B-3 in this appendix.

CERCO ANALYTICAL INC. TESTING

A suite of tests was completed by CERCO Analytical, Inc. to help evaluate the corrosivity of the site soils. The tests are described below, and the results summarized in Table B-1 below. The lab report from CERCO Analytical is included at the end of this appendix.

Redox

The oxidation-reduction potential of the soil in water was obtained in general accordance with ASTM D 1498.

pH

The pH value of the samples was obtained in general accordance with ASTM D 4972.

Soil Resistivity

The resistivity of the samples was obtained in general accordance with ASTM G57.

Sulfate

The concentration of sulfide in the samples was obtained in general accordance with ASTM D 4327.

Chloride

The concentration of chloride in the samples was obtained in general accordance with ASTM D 4327.

Table B-1 - Corrosion Potential Test Results

Sample ID (Depth)	Parameter	Test Result	Corrosion Potential Identified by CERCO
B-1-1, S-3 (5 - 6 feet)	pH[a]	4.48	Corrosive
	Resistivity (Ohm-cm[b])	1,900	
	Redox (mV[c])	170	
	Chloride (mg/kg[d])	N.D.	
	Sulfate (mg/kg)	64	
B-1-3, S-2 (3.5 - 5 feet)	pH	5.21	Moderately Corrosive
	Resistivity (Ohm-cm)	3,700	
	Redox (mV)	170	
	Chloride (mg/kg)	N.D.	
	Sulfate (mg/kg)	N.D.	
B-2-7, S-2 (3.5 - 5 feet)	pH	4.65	Mildly Corrosive
	Resistivity (Ohm-cm)	29,000	
	Redox (mV)	190	
	Chloride (mg/kg)	N.D.	
	Sulfate (mg/kg)	N.D.	
B-3-9, S-3 (5 – 5.5 feet)	pH	7.15	Moderately Corrosive
	Resistivity (Ohm-cm)	3,700	
	Redox (mV)	180	
	Chloride (mg/kg)	N.D.	
	Sulfate (mg/kg)	N.D.	

Notes:

a. pH = hydrogen ion activity
b. Ohm-cm = ohms per centimeter
c. mV = millivolt
d. mg/kg = milligrams per kilogram
e. N.D. = not detected

Exploration	Sample ID	Depth	Gravel (%)	Sand (%)	Fines (%)	Liquid Limit	Plastic Limit	Water Content (%)	USCS Group Symbol	Soil Description
B-1-1	S-1	2.0								
B-1-1	S-1a	2.5				60	36	44.3	MH	SANDY ELASTIC SILT
B-1-1	S-1b	3.0								
B-1-1	S-2	3.5								
B-1-1	S-3	5.0								
B-1-1	S-3a	5.5								
B-1-1	S-3b	6.0								
B-1-1	S-4	6.5								
B-1-1	U-5	8.0								
B-1-1	S-6	10.0								
B-1-1	S-7	11.5								
B-1-1	S-8	13.0								
B-1-1	S-8a	13.5								
B-1-1	S-8b	14.0								
B-1-1	S-9	14.5								
B-1-1	S-10	20.0								
B-1-2	S-1	2.0								
B-1-2	S-1a	2.5								
B-1-2	S-1b	3.0								
B-1-2	S-2	3.5				107	64	68.2	MH	ELASTIC SILT
B-1-2	S-3	5.0								
B-1-2	S-3a	5.5								
B-1-2	S-3b	6.0								
B-1-2	S-4	6.5								
B-1-2	S-5	8.0								
B-1-2	S-5a	8.5								
B-1-2	S-5b	9.0								
B-1-2	S-6	9.5								
B-1-2	S-7	12.0								
B-1-2	S-7a	12.5	0.0	77.8	22.2				SM	SILTY SAND
B-1-2	S-7b	13.0								
B-1-2	S-8	13.5								
B-1-2	S-9	15.0								
B-1-2	S-10	17.0								
B-1-2	S-10a	17.5								
B-1-2	S-10b	18.0								
B-1-2	S-11	18.5								
B-1-2	S-12	20.0								
B-1-2	S-13	22.0								
B-1-2	S-13a	22.5								
B-1-2	S-13b	23.0								
B-1-2	S-14	23.5								
B-1-2	S-15	25.0								
B-1-3	S-1	2.0								
B-1-3	S-1a	2.5								
B-1-3	S-1b	3.0								
B-1-3	S-2	3.5								

HALEY ALDRICH

Project: Astoria Pipeline Road Waterline
Location: Clatsop County, Oregon
Project No.: 0208388-000

Summary of Laboratory Results

Figure **B-1**
Sheet **1 of 4**

Exploration	Sample ID	Depth	Gravel (%)	Sand (%)	Fines (%)	Liquid Limit	Plastic Limit	Water Content (%)	USCS Group Symbol	Soil Description
B-1-3	S-3	5.0								
B-1-3	S-3a	5.5								
B-1-3	S-3b	6.0								
B-1-3	S-4	6.5								
B-1-3	S-5	8.0								
B-1-3	S-5a	8.5				75	51	41.7	MH	ELASTIC SILT
B-1-3	S-5b	9.0								
B-1-3	S-6	9.5								
B-1-3	S-7	12.0								
B-1-3	S-7a	12.5								
B-1-3	S-7b	13.0								
B-1-3	S-8	13.5								
B-1-3	S-9	15.0								
B-1-3	S-9a	15.5								
B-1-3	S-9b	16.0								
B-1-3	S-10	16.5								
B-1-3	S-11	20.0								
B-1-3	S-12	25.0								
B-1-4	S-1	2.0								
B-1-4	S-1a	2.5								
B-1-4	S-1b	3.0								
B-1-4	S-2	3.5								
B-1-4	S-3	5.0								
B-1-4	S-3a	5.5								
B-1-4	S-3b	6.0								
B-1-4	S-4	6.5								
B-1-4	S-5	8.0						52.9		
B-1-4	S-5a	8.5								
B-1-4	S-5b	9.0								
B-1-4	S-6	9.5								
B-1-4	S-7	12.0								
B-1-4	S-7a	12.5								
B-1-4	S-7b	13.0								
B-1-4	S-8	13.5				74	35		MH	ELASTIC SILT
B-1-4	S-9	20.0								
B-1-4	S-10	23.5								
B-1-5	S-1	2.0								
B-1-5	S-1a	2.5								
B-1-5	S-1b	3.0								
B-1-5	S-2	3.5								
B-1-5	S-3	5.0								
B-1-5	S-3a	5.5								
B-1-5	S-3b	6.0								
B-1-5	S-4	6.5								
B-1-5	S-5	8.0								
B-1-5	S-5a	8.5								
B-1-5	S-5b	9.0								

Exploration	Sample ID	Depth	Gravel (%)	Sand (%)	Fines (%)	Liquid Limit	Plastic Limit	Water Content (%)	USCS Group Symbol	Soil Description
B-1-5	S-6a	9.5								
B-1-5	S-6b	10.3				80	50		MH	ELASTIC SILT
B-1-5	S-7	15.0								
B-1-5	S-7a	15.5								
B-1-5	S-7b	16.0						44.2		
B-1-5	S-8	16.5								
B-1-5	S-9	20.0								
B-1-5	S-9a	20.5								
B-1-5	S-9b	21.0								
B-1-5	S-10	21.5								
B-2-6	S-1	2.0								
B-2-6	S-1a	2.5						36.9		
B-2-6	S-1b	3.0								
B-2-6	S-2	3.5								
B-2-6	S-3	5.0								
B-2-6	S-3a	5.5								
B-2-6	S-3b	6.0	0.0	57.6	42.4			22.6	SM	SILTY SAND
B-2-6	S-4	6.5								
B-2-6	S-5	8.0								
B-2-6	S-5a	8.5								
B-2-6	S-5b	9.0								
B-2-6	S-6	9.5								
B-2-6	S-7	15.0								
B-2-6	S-8	20.0								
B-2-7	S-1	2.0								
B-2-7	S-1a	2.5								
B-2-7	S-1b	3.0								
B-2-7	S-2	3.5								
B-2-7	S-3	5.0								
B-2-7	S-3a	5.5								
B-2-7	S-3b	6.0								
B-2-7	S-4	6.5								
B-2-7	S-5	8.0								
B-2-7	S-5a	8.5						30.0		
B-2-7	S-5b	9.0								
B-2-7	S-6	9.5								
B-2-7	S-7	15.0								
B-2-7	S-8	20.0				48	32		ML	SILT WITH SAND
B-2-7	S-9	25.0								
B-3-8	S-1	2.0								
B-3-8	S-1a	2.5								
B-3-8	S-1b	3.0								
B-3-8	S-2	3.5	0.6	73.0	26.3				SM	SILTY SAND
B-3-8	S-3	5.0								
B-3-8	S-3a	5.5								
B-3-8	S-3b	6.0								
B-3-8	S-4a	6.5				58	45	35.4	MH	ELASTIC SILT

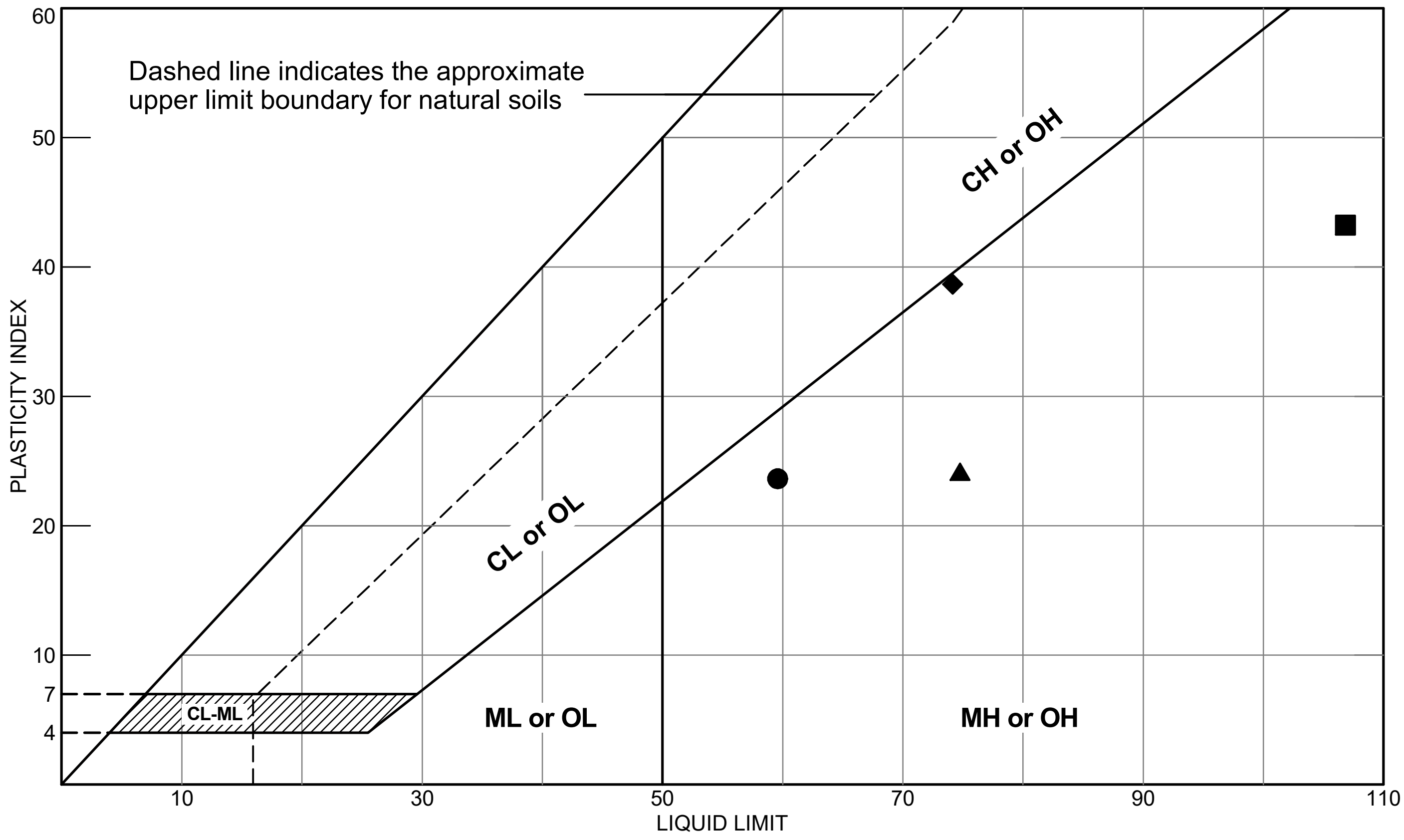
Exploration	Sample ID	Depth	Gravel (%)	Sand (%)	Fines (%)	Liquid Limit	Plastic Limit	Water Content (%)	USCS Group Symbol	Soil Description
B-3-8	S-4b	7.2								
B-3-8	S-5	10.0								
B-3-9	S-1	2.0								
B-3-9	S-1a	2.5								
B-3-9	S-1b	3.0								
B-3-9	S-2	3.5								
B-3-9	S-3	5.0								
B-3-9	S-3a	5.5								
B-3-9	S-3b	6.0								
B-3-9	S-4	6.5								
B-3-9	U-5	8.0								
B-3-9	S-6	10.0								
B-3-9	S-6a	10.5								
B-3-9	S-6b	11.0	0.0	0.0	95.8			33.5		
B-3-9	S-7	11.5								
B-3-9	S-8	15.0								
B-3-9	S-8a	15.5								
B-3-9	S-8b	16.0								
B-3-9	S-9	16.5				47	38	32.4	SM	SILTY SAND
B-3-9	S-10	20.0								
B-3-9	S-11	25.0								
B-4-10	S-1	2.0						12.6		
B-4-10	S-1a	2.5								
B-4-10	S-1b	3.0								
B-4-10	S-2	3.5								
B-4-10	S-2a	4.0								
B-4-10	S-2b	4.5								
B-4-10	S-3	5.0								
B-4-10	S-3a	5.5								
B-4-10	S-3b	6.0								
B-4-10	S-4	6.5								
B-4-10	S-5	8.0								
B-4-10	S-5a	8.5								
B-4-10	S-5b	9.0								
B-4-10	S-6	9.5	0.0	0.0	24.9			13.9		
B-4-10	S-7	12.0								
B-4-10	S-7a	12.5								
B-4-10	S-7b	13.0								
B-4-10	S-8	13.5								
B-4-10	S-9	15.0								
B-4-10	S-9a	15.5								
B-4-10	S-9b	16.0								
B-4-10	S-10	16.5								
B-4-10	S-11	20.0								
B-4-10	S-12	25.0								
B-4-10	S-13	30.0								

HALEY ALDRICH

Project: Astoria Pipeline Road Waterline
Location: Clatsop County, Oregon
Project No.: 0208388-000

Summary of Laboratory Results

Figure **B-1**
Sheet **4 of 4**



Location and Description	LL	PL	PI	-#200	MC%	USCS
● **Source:** B-1-1 **Sample No.:** S-1a **Depth:** 2.5 to 3.0 SANDY ELASTIC SILT	60	36	24	NT	44	MH
■ **Source:** B-1-2 **Sample No.:** S-2 **Depth:** 3.5 to 5.0 ELASTIC SILT	107	64	43	NT	68	MH
▲ **Source:** B-1-3 **Sample No.:** S-5a **Depth:** 8.5 to 9.0 ELASTIC SILT	75	51	24	NT	42	MH
◆ **Source:** B-1-4 **Sample No.:** S-8 **Depth:** 13.5 to 15.0 ELASTIC SILT	74	35	39	NT	NT	MH

Remarks:

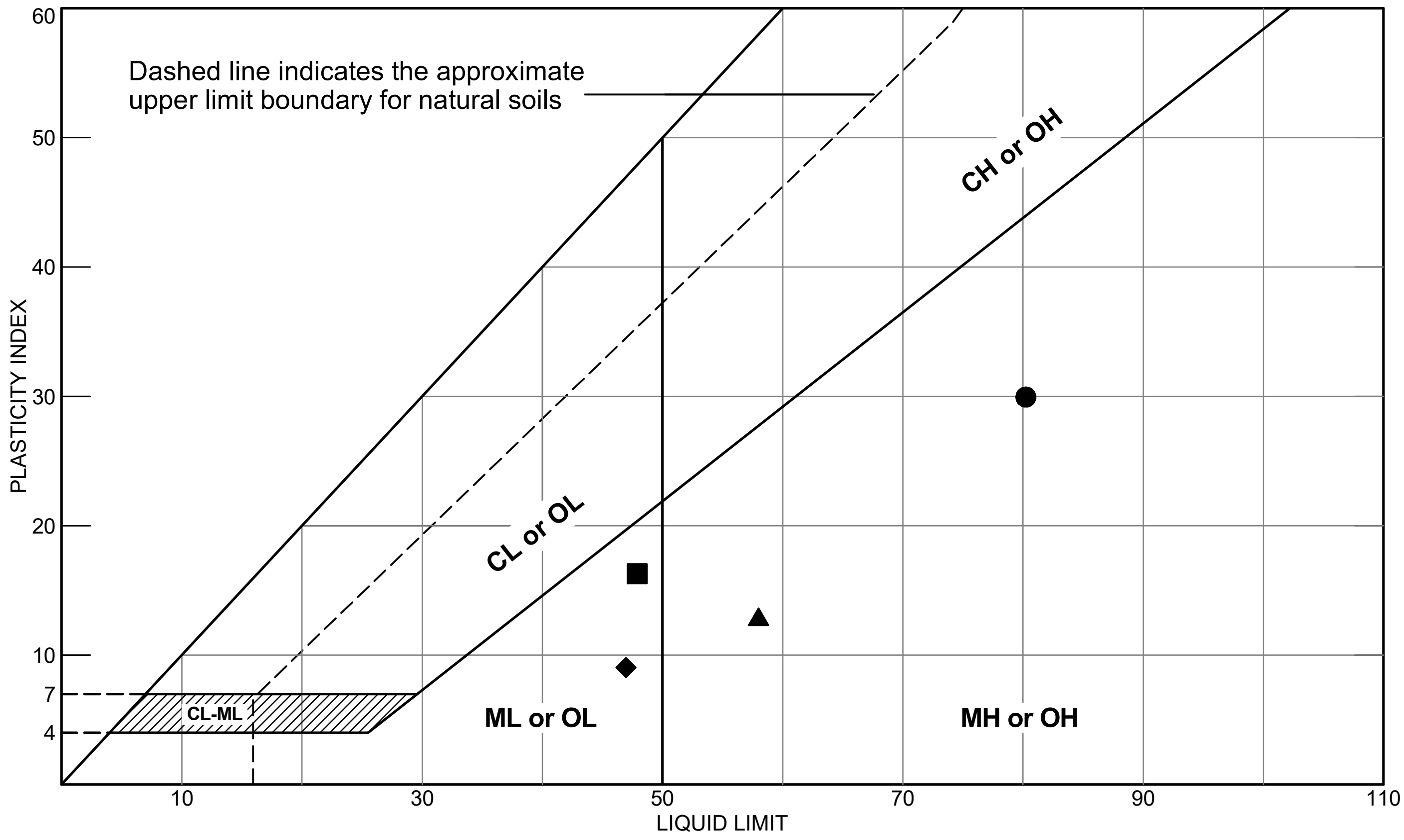
●
■
▲
◆

HALEY ALDRICH

Project: Astoria Pipeline Road Waterline
Location: Clatsop County, Oregon
Project No.: 0208388-000

Liquid Limit, Plastic Limit, and Plasticity Index

Figure **B-2**
Sheet **1 of 2**



Location and Description			LL	PL	PI	-#200	MC%	USCS
● **Source:** B-1-5 ELASTIC SILT	**Sample No.:** S-6b	**Depth:** 10.3 to 11.0	80	50	30	NT	NT	MH
■ **Source:** B-2-7 SILT WITH SAND	**Sample No.:** S-8	**Depth:** 20.0 to 21.5	48	32	16	NT	NT	ML
▲ **Source:** B-3-8 ELASTIC SILT	**Sample No.:** S-4a	**Depth:** 6.5 to 7.2	58	45	13	NT	35	MH
◆ **Source:** B-3-9 SILTY SAND	**Sample No.:** S-9	**Depth:** 16.5 to 18.0	47	38	9	NT	32	SM

Remarks:

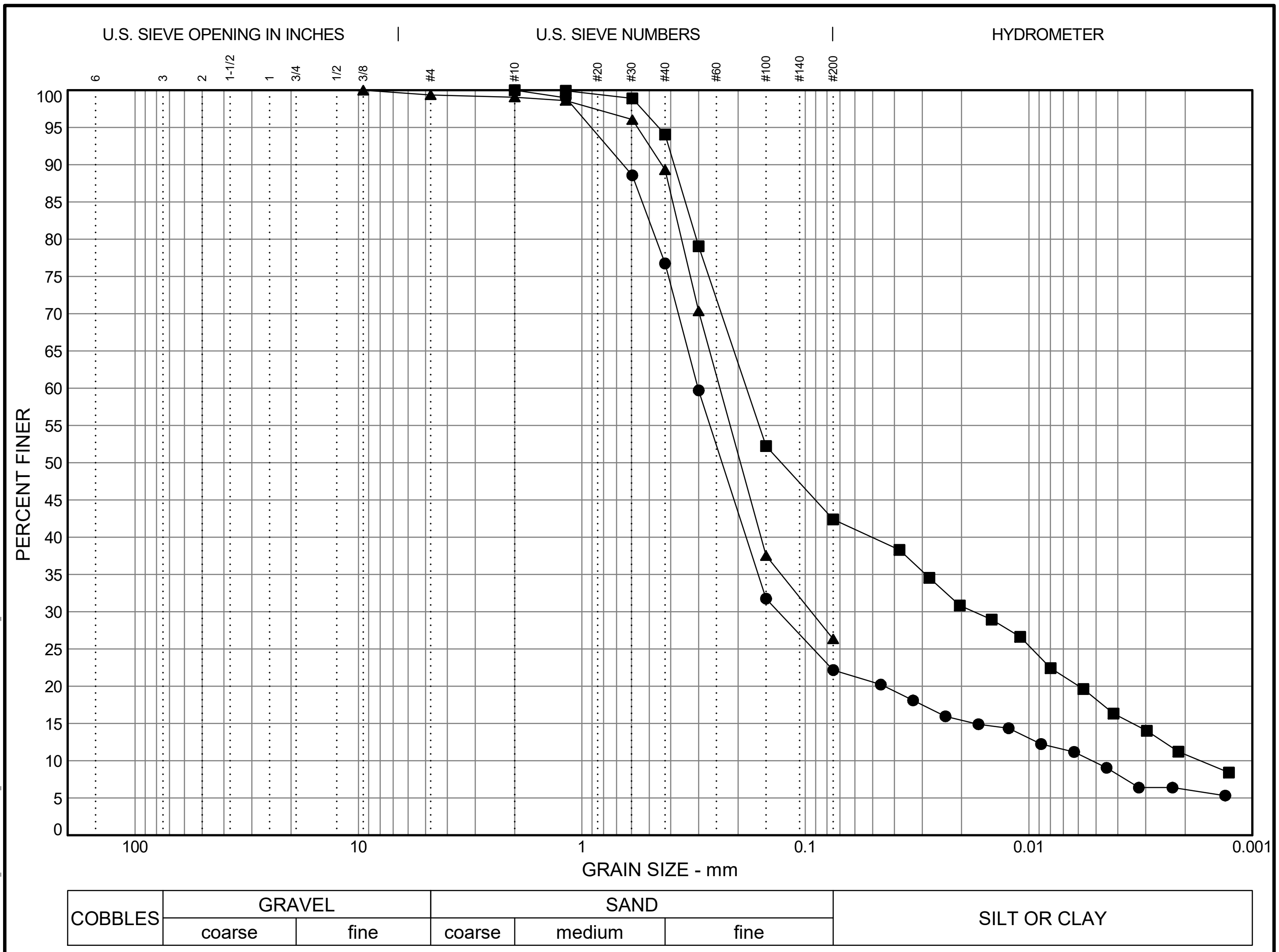
●
■
▲
◆

HALEY ALDRICH

Project: Astoria Pipeline Road Waterline
Location: Clatsop County, Oregon
Project No.: 0208388-000

Liquid Limit, Plastic Limit, and Plasticity Index

Figure **B-2**
Sheet **2 of 2**



Location and Description			% Cobbles	% Gravel	% Sand	% Silt	% Clay	MC%	USCS
● **Source:** B-1-2 SILTY SAND	**Sample No.:** S-7a	**Depth:** 12.5 to 13.0	0.0	0.0	77.8	12.4	9.7	NT	SM
■ **Source:** B-2-6 SILTY SAND	**Sample No.:** S-3b	**Depth:** 6.0 to 6.5	0.0	0.0	57.6	24.1	18.2	23	SM
▲ **Source:** B-3-8 SILTY SAND	**Sample No.:** S-2	**Depth:** 3.5 to 5.0	0.0	0.6	73.0	26.3		NT	SM

☒	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.537	0.302	0.236	0.132	0.017	0.005	11.09	57.85
■			0.344	0.183	0.128	0.018	0.003	0.002	0.99	107.14
▲			0.393	0.241	0.195	0.094				

Remarks:

●

■

▲

HALEY ALDRICH

Project: Astoria Pipeline Road Waterline
Location: Clatsop County, Oregon
Project No.: 0208388-000

Particle-Size Analysis

Figure **B-3**
Sheet **1 of 1**

HA GRAIN SIZE - C:\USERS\TMERLIN\ONEDRIVE - HALEYALDRICH.COM\DESKTOP\HC_LIBRARY.GLB - 11/27/23 13:29 - \\HALEYALDRICH.COM\SHARE\PDX_DATA\NOTEBOOKS\0208388-000_ASTORIA_PIPELINE_ROAD_WATERLINE_RESILIENCE\FIELD DATA\PERM_GINT FILES\0208388-000_ASTORIA PIPELINE RD WATERLINE RESILIENCE_GINT.GPJ - tmerlin

CERCO
analytical
1100 Willow Pass Court, Suite A
Concord, CA 94520-1006
925 **462 2771** Fax. 925 **462 2775**
www.cercoanalytical.com

30 November, 2023

Job No. 2311043
Cust. No. 12468

Ms. Kayla Ahrens
Haley & Aldrich
6420 S. Macadam Ave | Suite 100
Portland, OR 97239

Subject: Project No.: 0208388-000
Project Name: Astoria Pipeline Road Waterline
Corrosivity Analysis –ASTM Test Methods

Dear Ms. Ahrens:

Pursuant to your request, CERCO Analytical has analyzed the soil samples submitted on November 27, 2023. Based on the analytical results, this brief corrosivity evaluation is enclosed for your consideration.

Based upon the resistivity measurements, Sample No.001 is classified as "corrosive", Samples No.002 and No.004 are classified as "moderately corrosive" and Sample No.003 is classified as "mildly corrosive". All buried iron, steel, cast iron, ductile iron, galvanized steel and dielectric coated steel or iron should be properly protected against corrosion depending upon the critical nature of the structure. All buried metallic pressure piping such as ductile iron firewater pipelines should be protected against corrosion.

The chloride ion concentrations reflect none detected with a reporting limit of 15 mg/kg.

The sulfate ion concentrations ranged from none detected to 64 mg/kg and are determined to be insufficient to damage reinforced concrete structures and cement mortar-coated steel at these locations.

The pH of the soils ranged from 4.48 to 7.15, which does present corrosion problems for buried iron, steel, mortar-coated steel and reinforced concrete structures. Soils with a pH of <6.0 are considered to be corrosive to buried iron, steel, mortar-coated steel and reinforced concrete structures. Therefore, corrosion prevention measures need to be considered for structures to be placed in this acidic soil.

The redox potentials ranged from 170-mV to 190-mV. All samples are indicative of potentially "moderately corrosive" soils resulting from anaerobic soil conditions.

This corrosivity evaluation is based on general corrosion engineering standards and is non-specific in nature. For specific long-term corrosion control design recommendations or consultation, please call *JDH Corrosion Consultants, Inc. at (925) 927-6630.*

We appreciate the opportunity of working with you on this project. If you have any questions, or if you require further information, please do not hesitate to contact us.

Very truly yours,
CERCO ANALYTICAL, INC.
for
J. Darby Howard, Jr., P.E.
President

JDH/jdl
Enclosure

CERCO
analytical
1100 Willow Pass Court, Suite A
Concord, CA 94520-1006
925 462 2771 Fax. 925 462 2775
www.cercoanalytical.com

Client: Haley & Aldrich, Inc.
Client's Project No.: 0208388-000
Client's Project Name: Astoria Pipeline Road Waterline
Date Sampled: Not Indicated
Date Received: 27-Nov-23
Matrix: Soil
Authorization: Signed Chain of Custody

Date of Report: 30-Nov-2023

Job/Sample No.	Sample I.D.	Redox (mV)	pH	Conductivity (umhos/cm)*	Resistivity (100% Saturation) (ohms-cm)	Sulfide (mg/kg)*	Chloride (mg/kg)*	Sulfate (mg/kg)*
2311043-001	B-1-1, S-3 @ 5-6'	170	4.48	-	1,900	-	N.D.	64
2311043-002	B-1-3, S-2 @ 3.5-5.0'	170	5.21	-	3,700	-	N.D.	N.D.
2311043-003	B-2-7, S-2 @ 3.5-5.0'	190	4.65	-	29,000	-	N.D.	N.D.
2311043-004	B-3-9, S-3 @ 5.0-5.5'	180	7.15	-	3,700	-	N.D.	N.D.

Method:	ASTM D1498	ASTM D4972	ASTM D1125M	ASTM G57	ASTM D4658M	ASTM D4327	ASTM D4327
Reporting Limit:	-	-	10	-	50	15	15
Date Analyzed:	29-Nov-2023	29-Nov-2023	-	28-Nov-2023	-	29-Nov-2023	29-Nov-2023

* Results Reported on "As Received" Basis

N.D. - None Detected

Julia Clauson
Chemist

<u>Quality Control Summary</u> - All laboratory quality control parameters were found to be within established limits

APPENDIX C

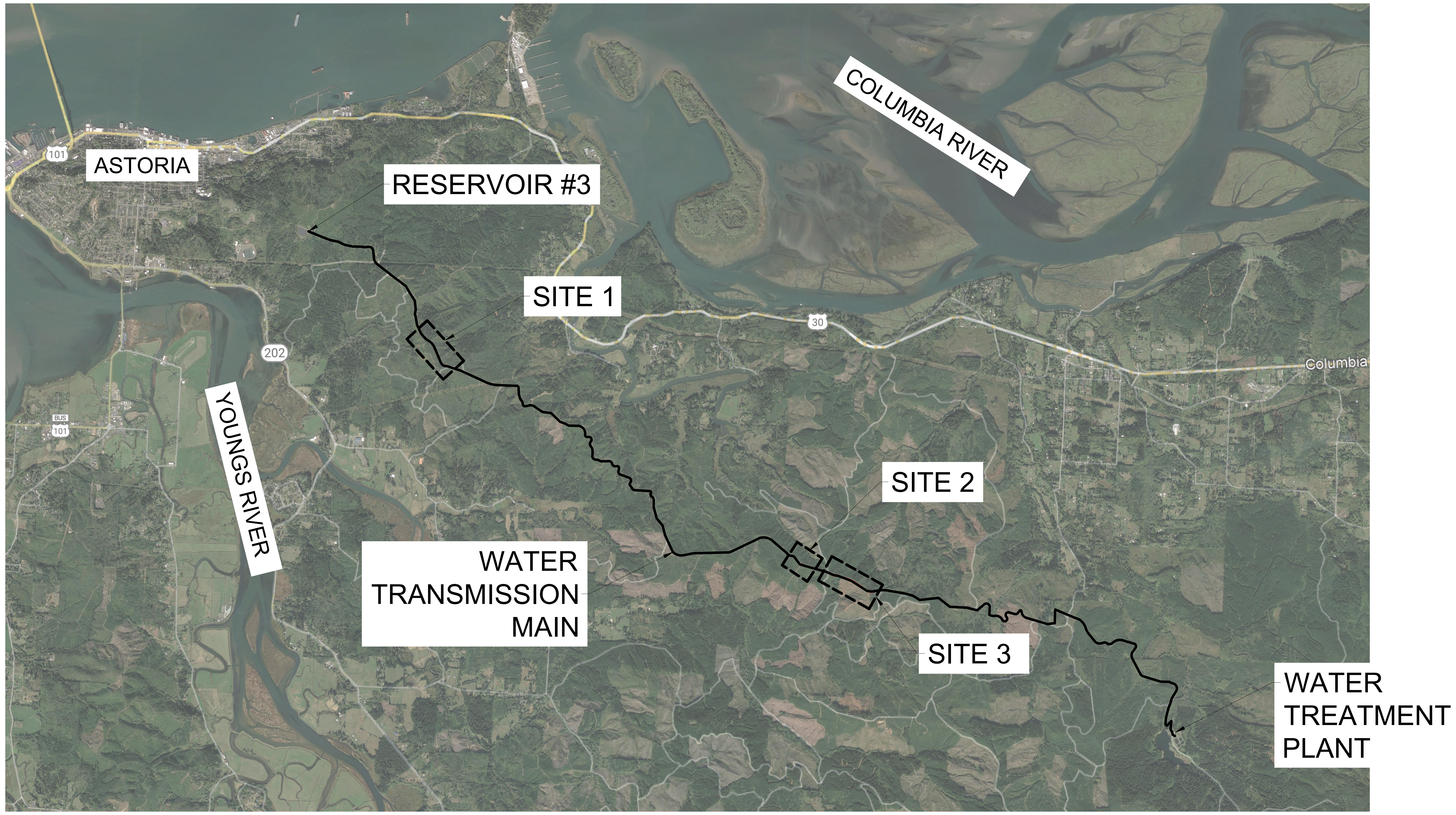
30% Design Submittal Plans

CITY OF ASTORIA

CITY OF ASTORIA
PIPELINE ROAD WATERLINE RESILIENCY
30% DESIGN SUBMITTIAL

15350 SW SEQUOIA PKWY STE 220
PORTLAND, OR 97224
(503) 684-9097
www.tetratech.com

TETRA TECH



NOTICE TO EXCAVATORS:

ATTENTION: OREGON LAW REQUIRES YOU TO FOLLOW RULES ADOPTED BY THE OREGON UTILITY NOTIFICATION CENTER. THOSE RULES ARE SET FORTH IN OAR 952–001–0010 THROUGH OAR 952–001–0090. YOU MAY OBTAIN COPIES OF THE RULES BY CALLING THE CENTER.
(NOTE: THE TELEPHONE NUMBER FOR THE OREGON UTILITY NOTIFICATION CENTER IS 503–232–1987).

POTENTIAL UNDERGROUND FACILITY OWNERS

Dig Safely.

Call the Oregon One-Call Center
DIAL 811 or 1-800-332-2344

EMERGENCY TELEPHONE NUMBERS

CITY OF ASTORIA
PUBLIC WORKS (503) 325–3524

30 PERCENT
DESIGN
REVIEW
NOT
FOR
CONSTRUCTION

PROJECT LOCATION:

Pipeline Road, Astoria, Oregon

CLIENT INFORMATION:

CITY OF ASTORIA
1095 DUANE ST.
ASTORIA, OREGON 97103

Tt PROJECT No.:

200-12636-23001

CLIENT PROJECT No.:

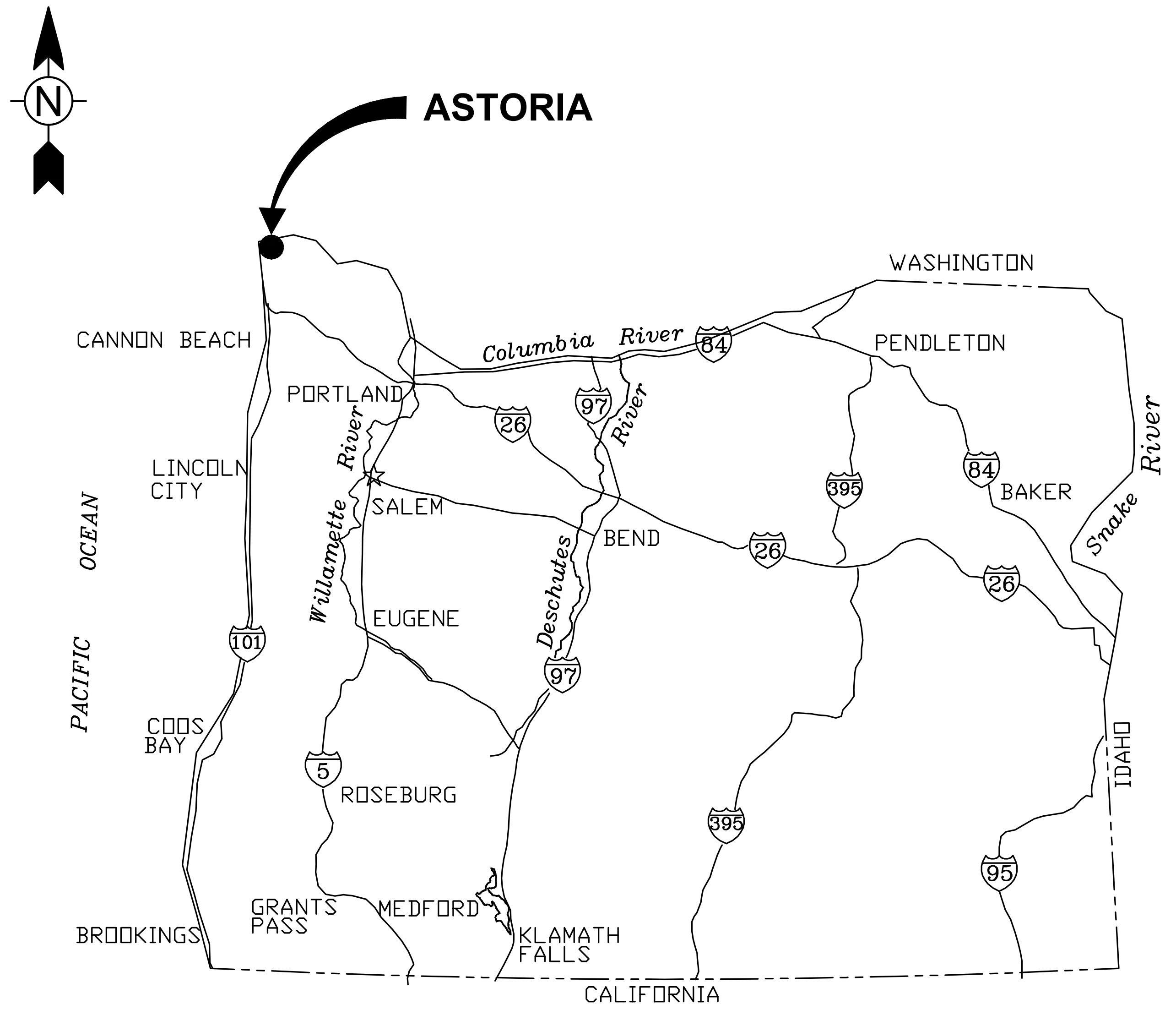
PROJECT DESCRIPTION / NOTES:

REPLACEMENT OF 3 SEGMENTS OF 21" CONCRETE CYLINDER PIPE WITH HDPE PIPE TOTALING APPROXIMATELY 5,500-LF.
1963 PIPELINE RECORD DRAWING APPROXIMATE STATIONING REFERENCES:
SITE 1: 149+00 TO 160+00
SITE 2: 390+00 TO 405+00
SITE 3: 420+00 TO 435+00

ISSUED:

30% DESIGN SUBMITTAL - MARCH 19, 2024

LOCATION MAP:



HORIZONTAL DATUM

THE HORIZONTAL DATUM AND BASIS OF BEARINGS IS NAD 83 (2011) EPOCH 2010.00 OREGON NORTH 3601, INTERNATIONAL FEET. GPS OBSERVATIONS UTILIZING THE OREGON REAL TIME NETWORK (ORGN) WERE HELD AT CONTROL POINT NUMBER 200, 201, 300, 301 AND 400-403. TERRESTRIAL GROUND MEASUREMENTS WERE TAKEN BETWEEN ALL INTERVISIBLE CONTROL POINTS. TRIMBLE BUSINESS CENTER VERSION 2023.10 WAS USED TO ADJUST THE CONTROL NETWORKS.

VERTICAL DATUM

VERTICAL DATUM: THE VERTICAL DATUM IS NAVD 88 ALSO UTILILIZING THE OREGON REAL TIME NETWORK (ORGN)

ALL DISTANCES SHOWN ARE GROUND DISTANCES UNLESS OTHERWISE NOTED.

THE LOCATION AND DESCRIPTION OF ALL SURVEY MARKERS SHOWN HEREON ARE BASED ON FIELD OBSERVATIONS TAKEN IN DECEMBER, 2023, UNLESS OTHERWISE INDICATED.

THIS TOPOGRAPHIC SURVEY DRAWING ACCURATELY REPRESENTS SURFACE FEATURES LOCATED DURING THE COURSE OF THIS SURVEY. UNDERGROUND UTILITIES SHOWN HEREON ARE BASED SOLELY UPON INFORMATION PROVIDED BY OTHERS AND PACE ENGINEERS, INC. DOES NOT ACCEPT RESPONSIBILITY OR ASSUME LIABILITY FOR THEIR ACCURACY OR COMPLETENESS. CONTRACTOR/ENGINEERS SHALL VERIFY EXACT SIZE AND LOCATION PRIOR TO CONSTRUCTION.
CALL FOR LOCATE: UTILITY LOCATION SERVICE: 811

ARV	AIR RELEASE VALVE
C	COPPER
CB	CATCH BASIN
CI	CAST IRON
CONC	CONCRETE
DI	DUCTILE IRON
E	ELECTRIC
HDPE	HIGH-DENSITY POLYETHYLENE
HYD	HYDRANT
IE	INVERTED ELEVATION
OH	OVERHEAD POWER
PVC	POLYVINYL CHLORIDE
SCO	SANITARY CLEAN OUT
SSMH	SANITARY SEWER MANHOLE
ST	STORM
TYP.	TYPICAL
UT	UNDERGROUND COMMUNICATIONS
VC	VITRIFIED CLAY
W	WATER
WV	WATER VALVE

LEGEND

	CONTROL POINTS
	POWER POLE
☼	LIGHT POLE
⌒	GUY ANCHOR
EM ☐	ELECTRIC METER
☐G	GAS LINE MARKER
TJ	TELECOM JUNCTION BOX
⊗	WATER VALVE
W ☐	WATER LINE MARKER
FH	FIRE HYDRANT
⊥	SIGN
○	ARV MANHOLE
SD ○	STORMWATER MANHOLE
CB ☐	STORMWATER CATCH BASIN
MB	MAILBOX
✿	DECIDUOUS TREE
✳	EVERGREEN TREE
❀	SHRUBS
— — — —	EXISTING GRAVEL ROAD
— W —	EXISTING WATER LINE
· · · · ·	GEO HAZARD BOUNDARY
—W—	PROPOSED WATER LINE
— SS —	SANITARY SEWER MAIN
— UE —	UNDERGROUND ELECTRIC
— OE —	OVERHEAD ELECTRIC
— G —	GAS LINE
– – – – –	MAJOR CONTOUR
- - - - - -	MINOR CONTOUR
—— – – ——	PROPERTY LINE (APPROXIMATE)

TETRA TECH

www.tetratech.com
15350 SW SEQUOIA PKWY STE 220
PORTLAND, OR 97224
(503) 684-9097

30 PERCENT
DESIGN REVIEW
NOT FOR
CONSTRUCTION

CITY OF ASTORIA

MARK	DATE	DESCRIPTION	BY

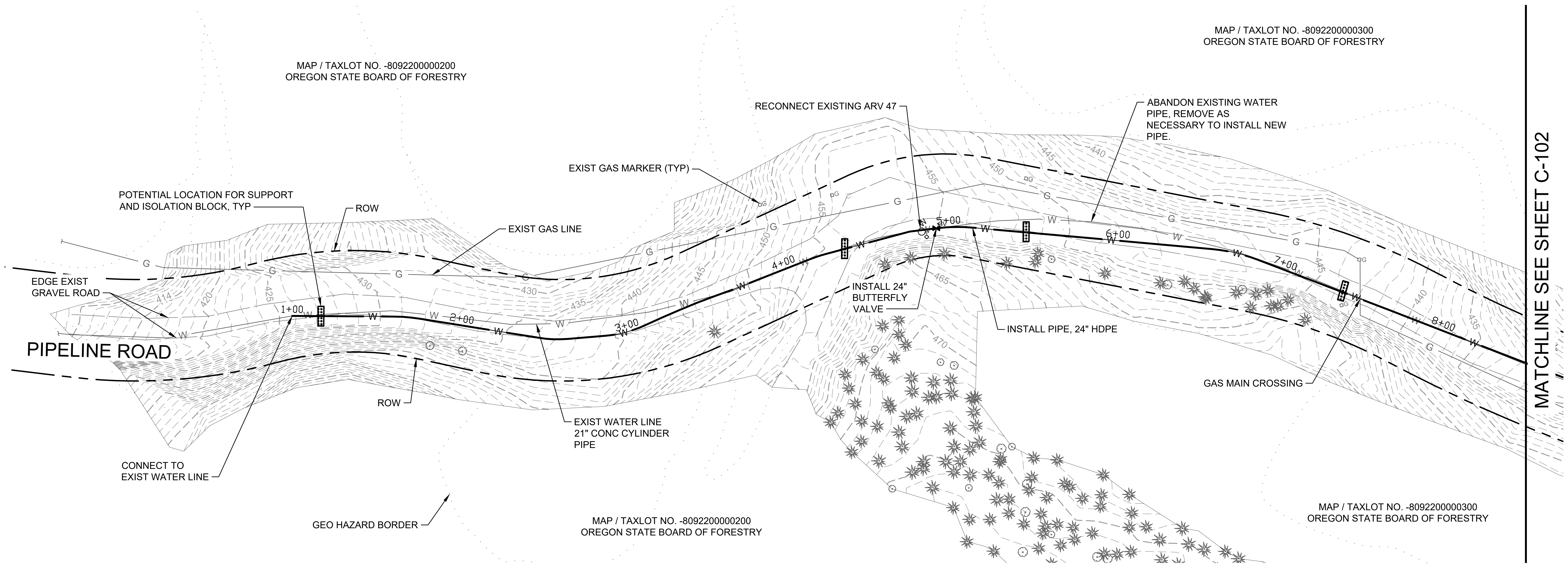
CITY OF ASTORIA

CIVIL LEGEND AND GENERAL NOTES

PROJ: 200-12636-23001
DESN: JRF
DRWN: KJV
CHKD: MJH

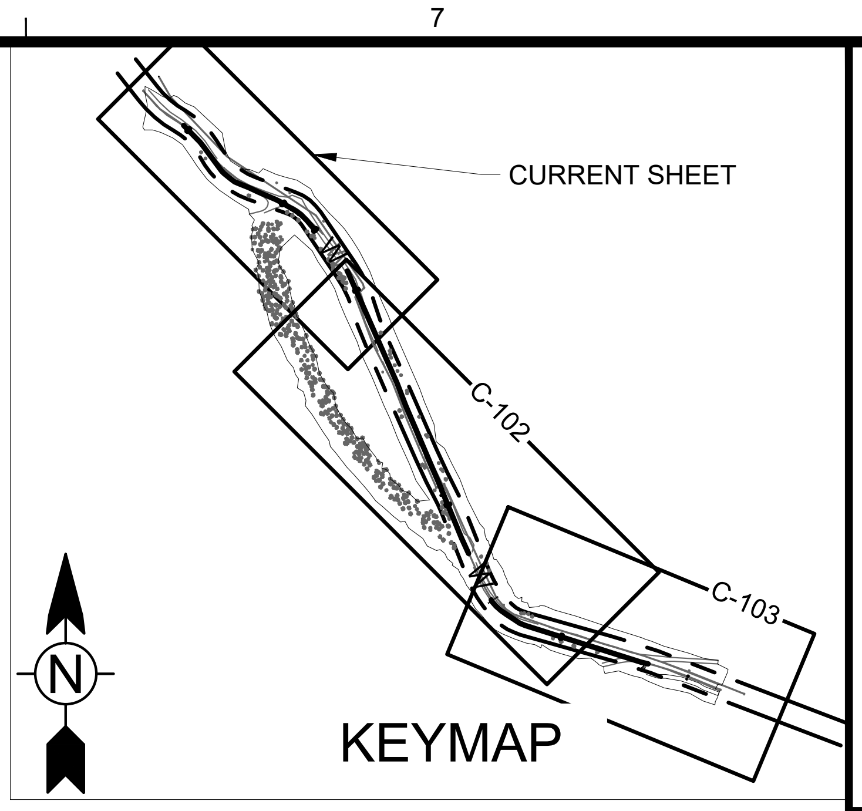
C-001

Bar Measures 1 inch, otherwise drawing not to scale



PLAN

SCALE: 1" = 40'



GENERAL NOTES

1. WHERE WATERLINE IS PARALLEL TO GAS MAIN, PROVIDE A MINIMUM OF 10-FT SEPARATION BETWEEN OUTSIDE PIPE WALLS. COORDINATE WITH WITH NORTHWEST NATURAL.
2. CONTRACTOR TO VERIFY LOCATION AND DEPTH OF EXISTING UTILITIES PRIOR TO CONSTRUCTION.
3. FINAL DEPTH AND SIZING OF SUPPORT AND ISOLATION BLOCKS TO BE DETERMINED BASED ON SITE SPECIFIC OBSERVATIONS OF PIPELINE EXCAVATIONS DURING CONSTRUCTION.
4. FINAL LOCATIONS OF SUPPORT AND ISOLATION BLOCKS TO BE DETERMINED BASED ON SITE-SPECIFIC OBSERVATIONS OF PIPELINE EXCAVATIONS DURING CONSTRUCTION. ASSUME LOCATIONS ARE +/- 20 FEET FROM THOSE SHOWN.
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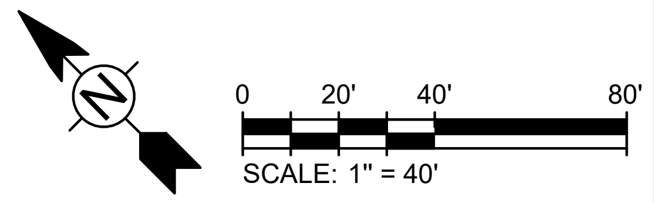

Bar Measures 1 inch, otherwise drawing not to scale

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30 PERCENT
DESIGN REVIEW
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CONSTRUCTION

CITY OF ASTORIA

MARK	DATE	DESCRIPTION	BY

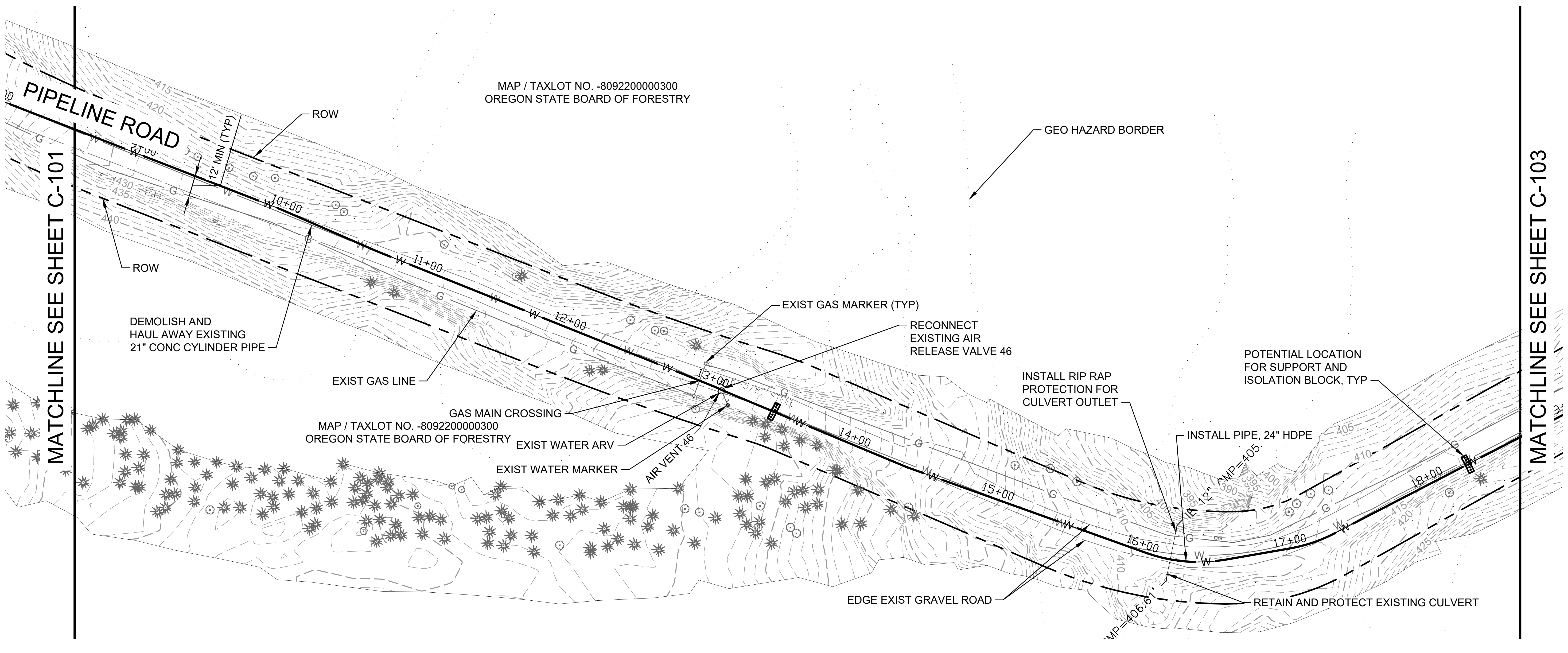
CITY OF ASTORIA

SITE 1
PLAN AND PROFILE
1+00 TO 8+00

PROJ:	200-12636-23001
DESN:	JRF
DRWN:	KJV
CHKD:	MJH

C-101

3/19/2024 6:05:52 PM - C:\USERS\KATELIN.VANDEHEY\DC\ACCDOCS\TETRA TECH INC\200-12636-23001 ASTORIA PIPELINE\PROJECT FILES\CAD\SHEETFILES\C-101 SITE 1 - 0+00 TO 8+00.DWG - VANDEHEY, KATELIN



PLAN

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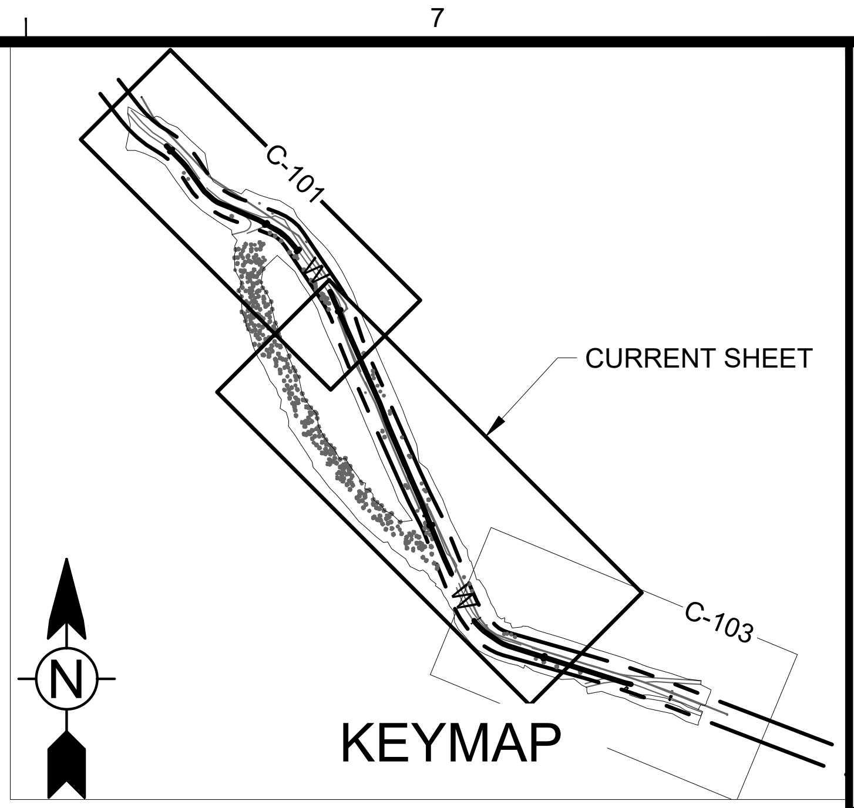

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0 25' 50' 100'
SCALE: 1" = 50'

Bar Measures 1 inch, otherwise drawing not to scale

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CONSTRUCTION

CITY OF ASTORIA

MARK	DATE	DESCRIPTION	BY

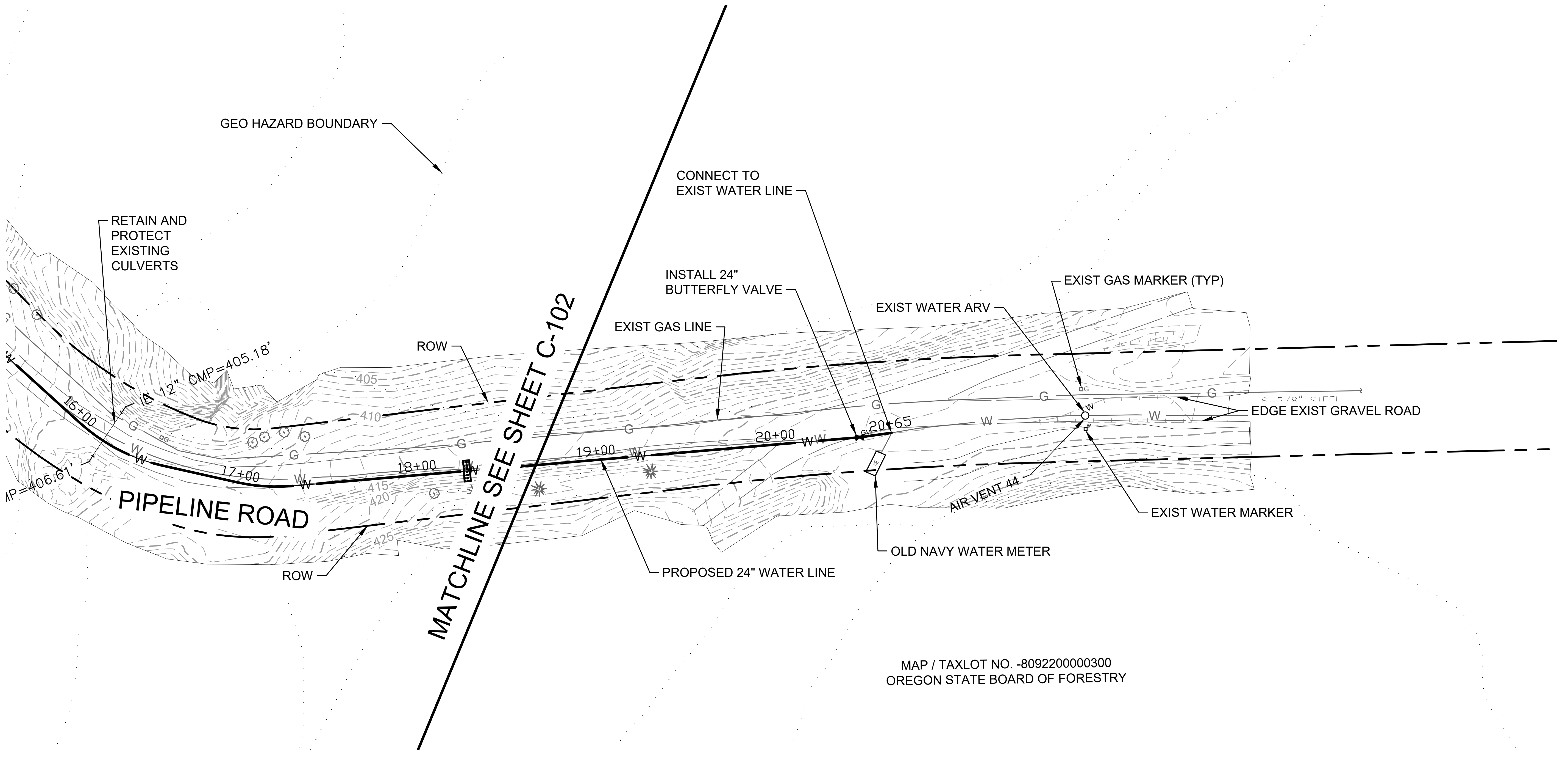
CITY OF ASTORIA

SITE 1
PLAN AND PROFILE
8+00 TO 18+00

PROJ: 200-12636-23001
DESN: JRF
DRWN: KJV
CHKD: MJH

C-102
Sheet

3/19/2024 6:07:31 PM - C:\USERS\KATELIN.VANDEHEY\DC\ACCDOCS\TETRA TECH INC\200-12636-23001 ASTORIA PIPELINE\PROJECT FILES\CAD\SHEETFILES\C-102 SITE 1 - 8+00 TO 16+00.DWG - VANDEHEY, KATELIN



PLAN

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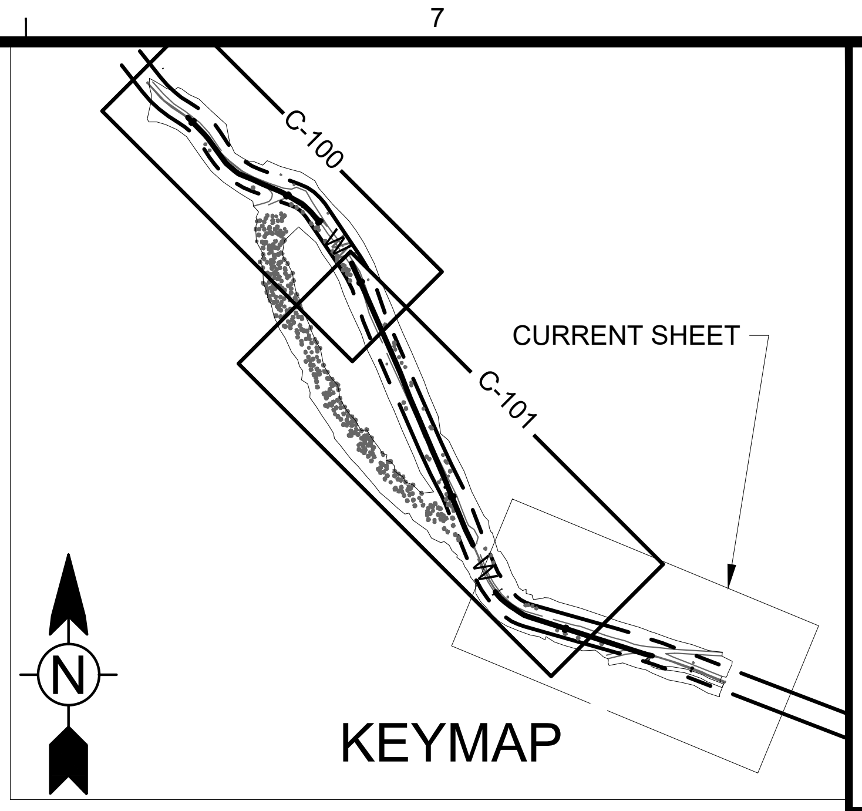

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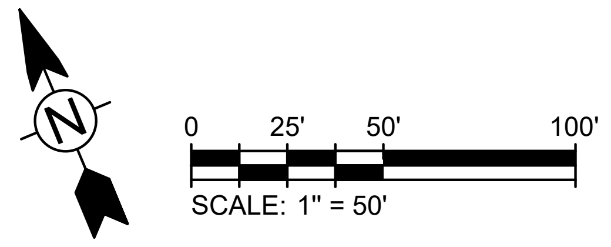

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PORTLAND, OR 97224
(503) 684-9097

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DESIGN REVIEW
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CONSTRUCTION

CITY OF ASTORIA

MARK	DATE	DESCRIPTION	BY

CITY OF ASTORIA

SITE 1
PLAN AND PROFILE
18+00 TO 20+75

PROJ:	200-12636-23001
DESN:	JRF
DRWN:	KJV
CHKD:	MJH

C-103

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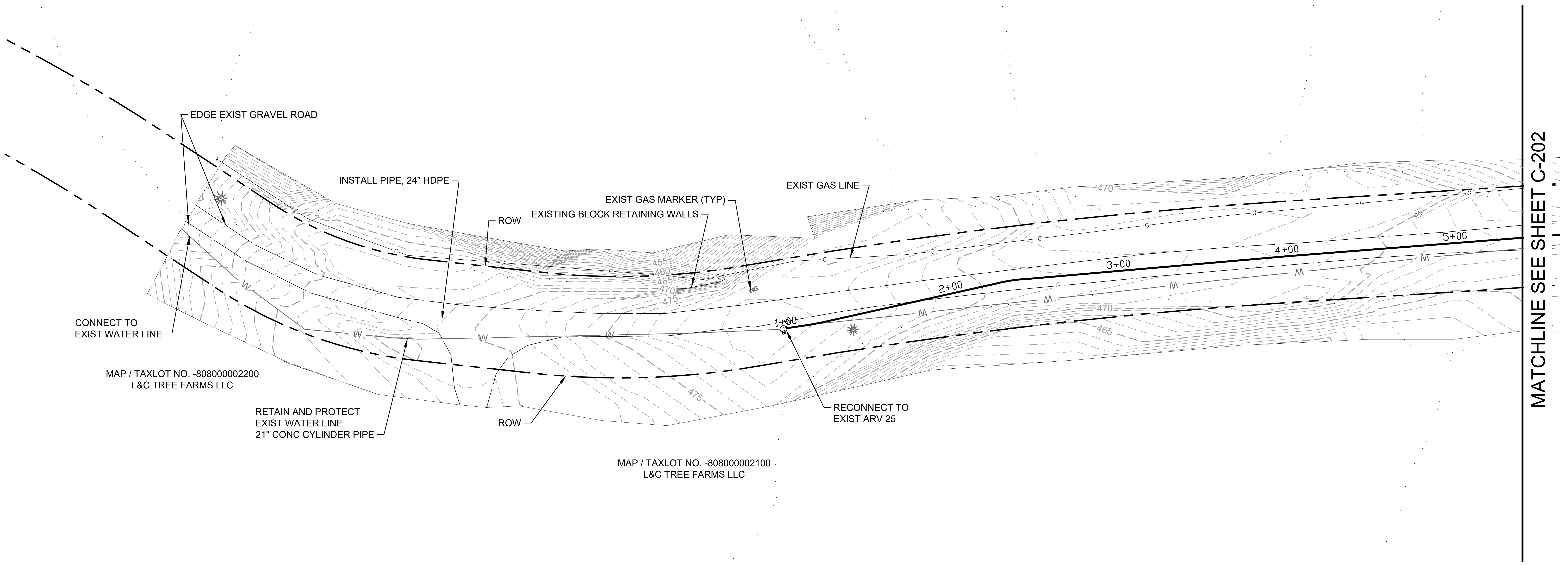
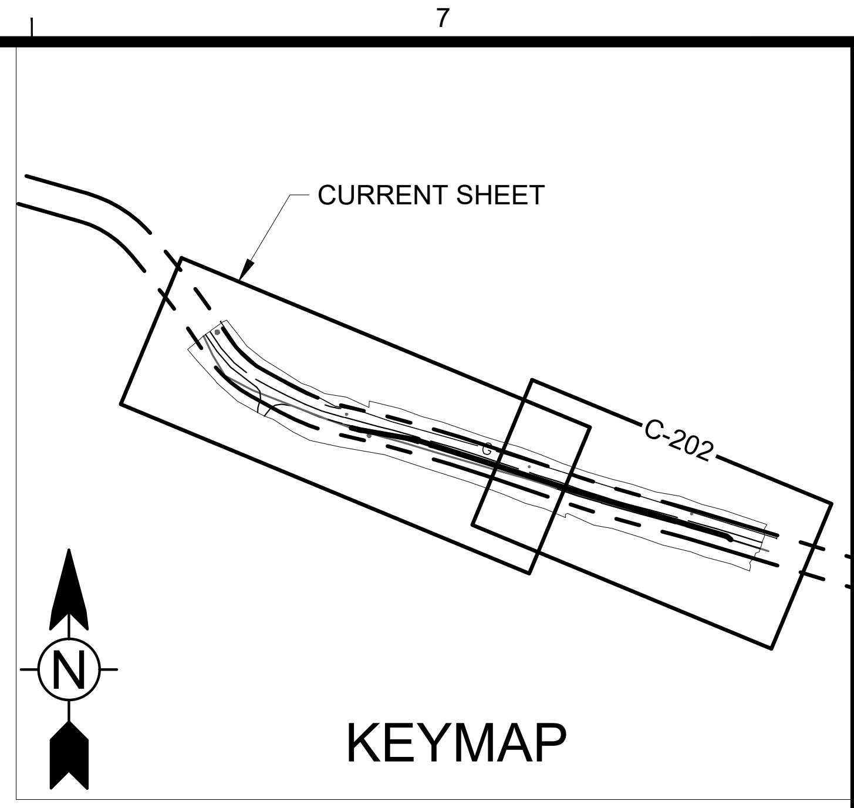
Bar Measures 1 inch, otherwise drawing not to scale



PLAN

SCALE: 1" = 40'



KEYMAP

GENERAL NOTES

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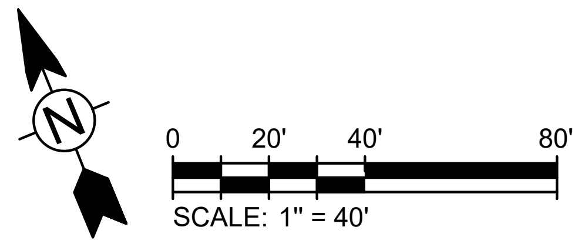

Bar Measures 1 inch, otherwise drawing not to scale

TETRA TECH

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DESIGN REVIEW
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CONSTRUCTION

CITY OF ASTORIA

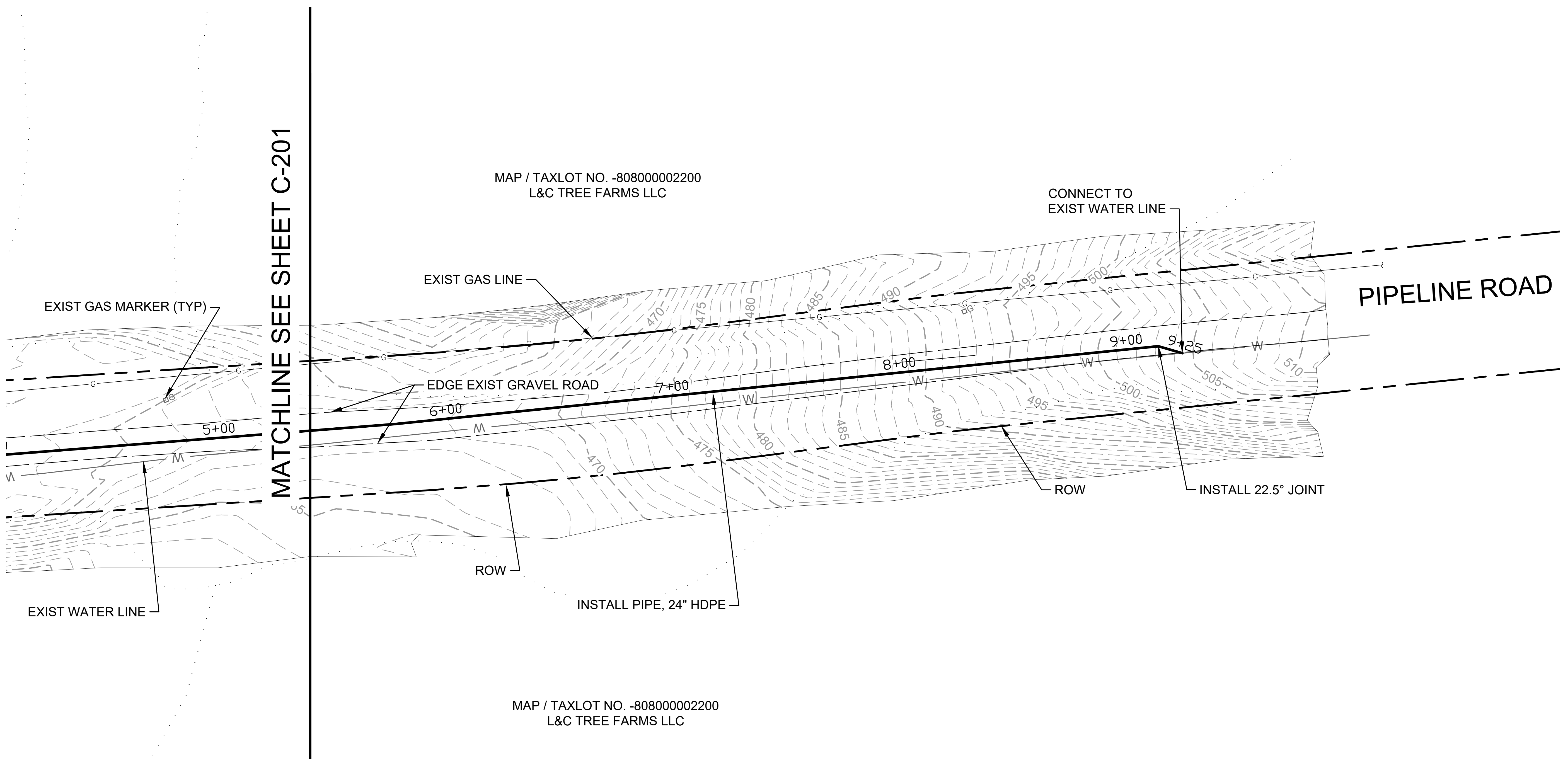
MARK	DATE	DESCRIPTION	BY

CITY OF ASTORIA

SITE 2
PLAN AND PROFILE
1+00 TO 5+00

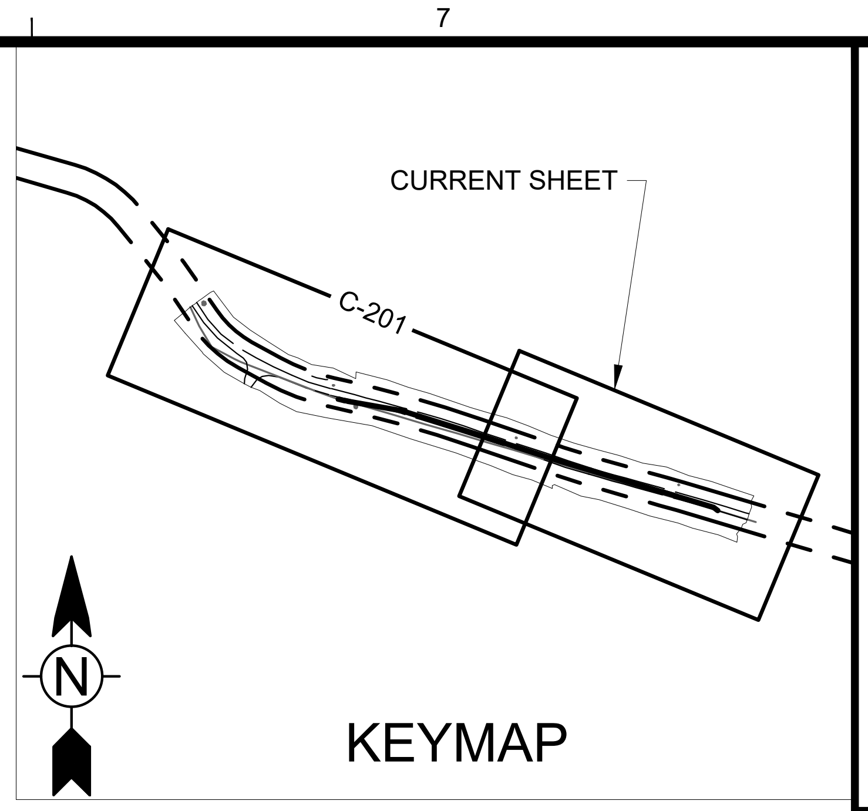
PROJ: 200-12636-23001
DESN: JRF
DRWN: KJV
CHKD: MJH

C-201



PLAN

SCALE: 1" = 40'



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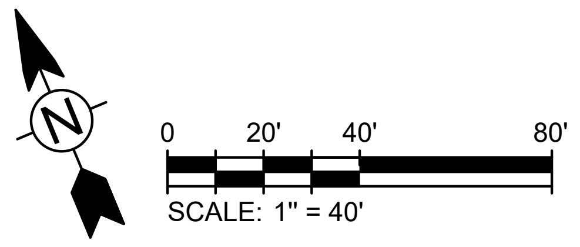

Bar Measures 1 inch, otherwise drawing not to scale

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PORTLAND, OR 97224
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30 PERCENT
DESIGN REVIEW
NOT FOR
CONSTRUCTION

CITY OF ASTORIA

MARK	DATE	DESCRIPTION	BY

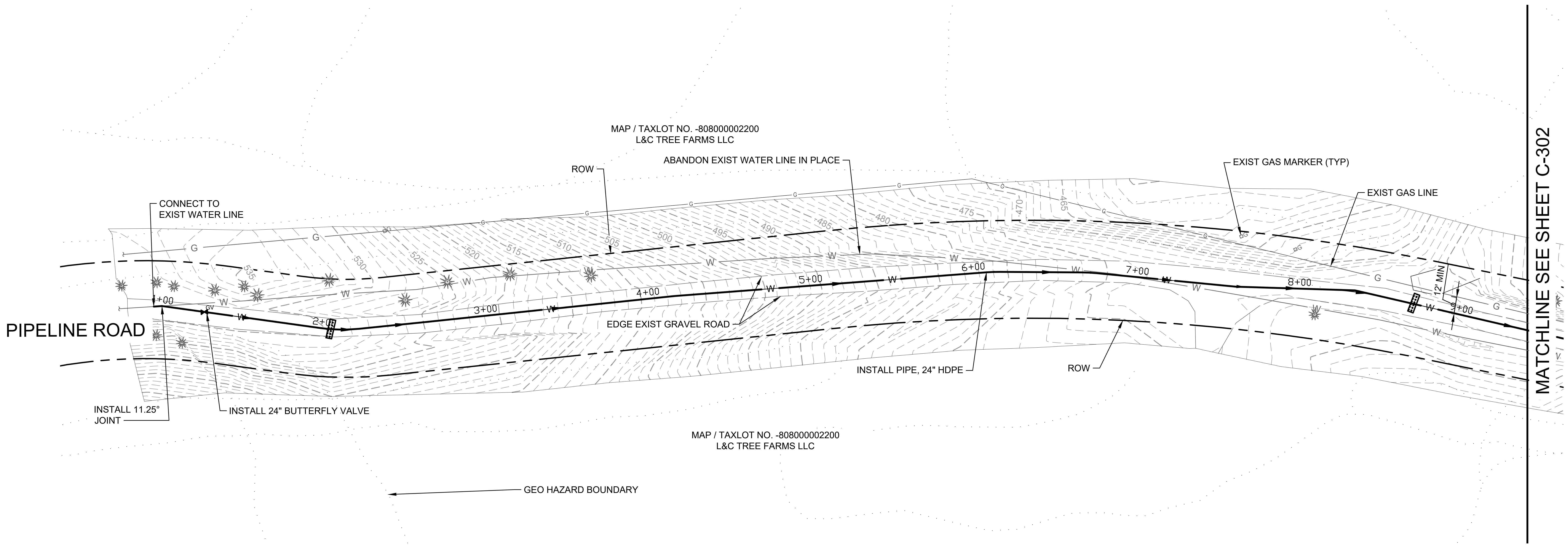
CITY OF ASTORIA

SITE 2
PLAN AND PROFILE
5+00 TO 9+30

PROJ: 200-12636-23001
DESN: JRF
DRWN: KJV
CHKD: MJH

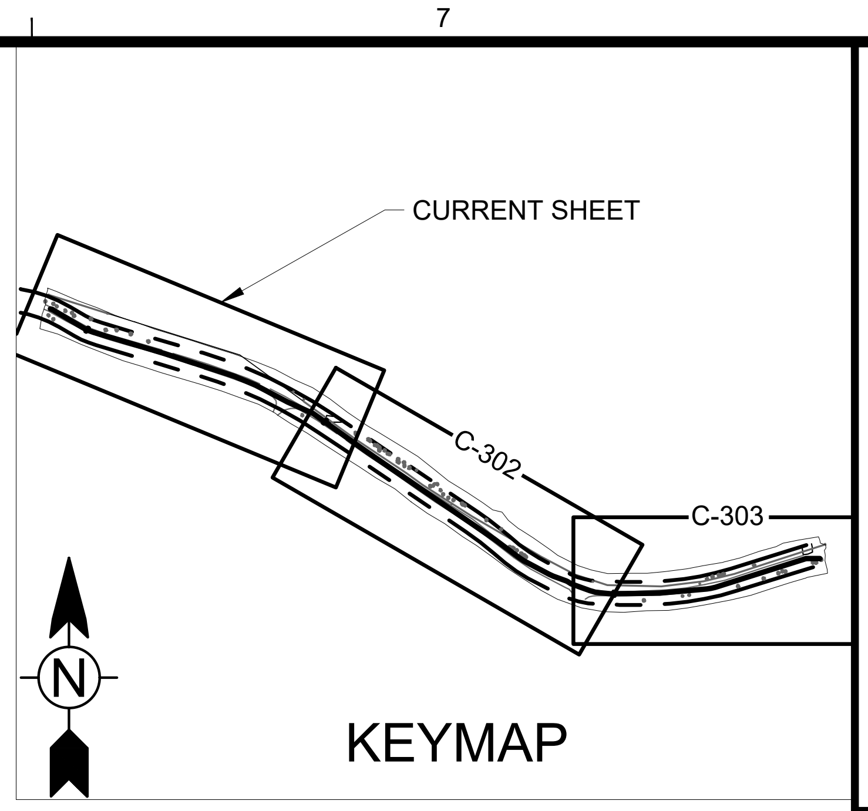
C-202

3/19/2024 6:13:00 PM - C:\USERS\KATELIN.VANDEHEY\DCACCDOCS\TETRA TECH INC\200-12636-23001 ASTORIA PIPELINE\PROJECT FILES\CAD\SHEETFILES\C-301 SITE 3 - 0+00 TO 10+00.DWG - VANDEHEY, KATELIN



PLAN

SCALE: 1" = 40'



KEYMAP

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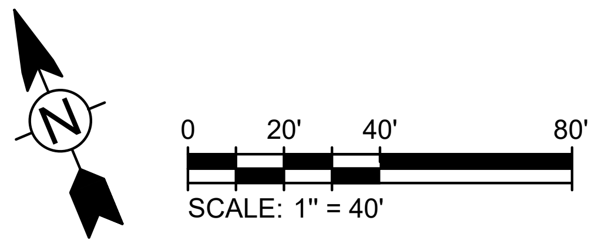

SCALE: 1" = 40'

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PORTLAND, OR 97224
(503) 684-9097

30 PERCENT
DESIGN REVIEW
NOT FOR
CONSTRUCTION

CITY OF ASTORIA

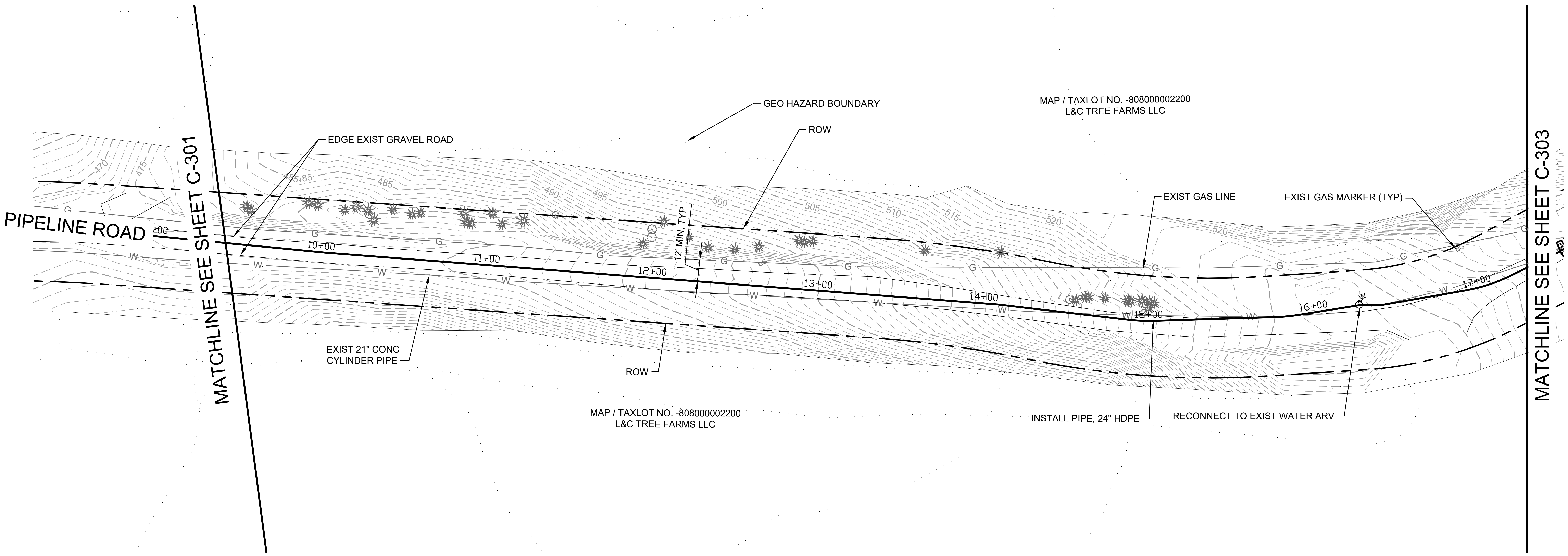
MARK	DATE	DESCRIPTION	BY

CITY OF ASTORIA

SITE 3
PLAN AND PROFILE
1+00 TO 9+00

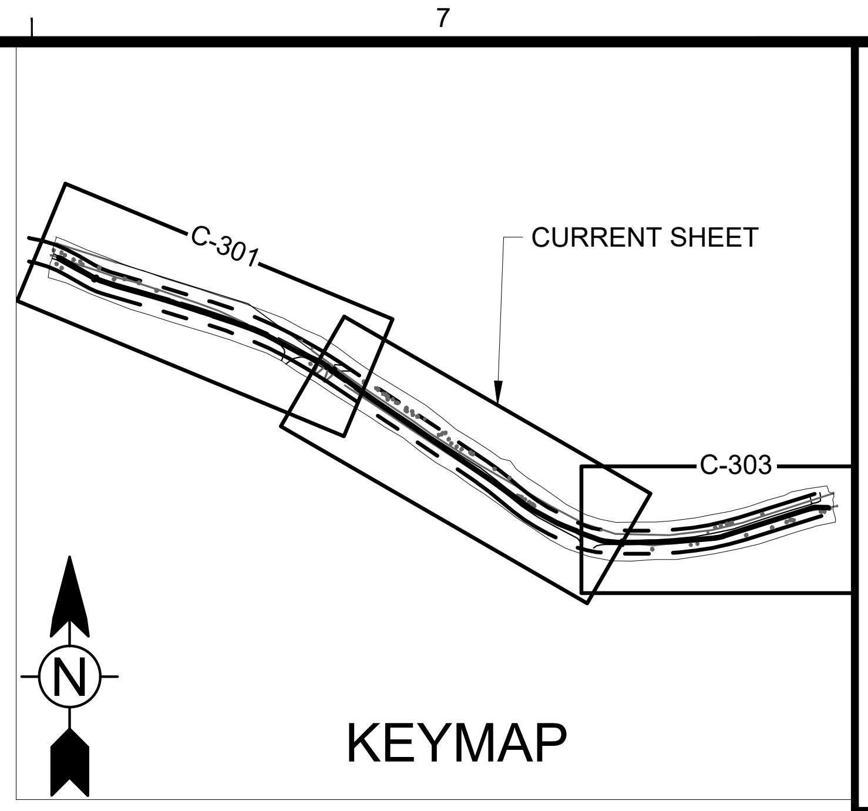
PROJ: 200-12636-23001
DESN: JRF
DRWN: KJV
CHKD: MJH

C-301



PLAN

SCALE: 1" = 40'



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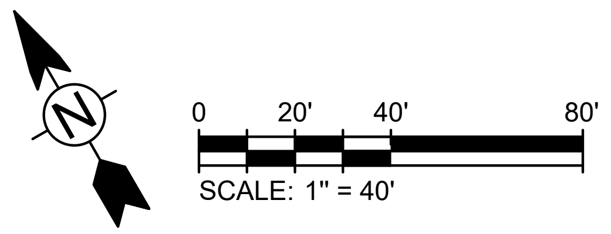

SCALE: 1" = 40'

Bar Measures 1 inch, otherwise drawing not to scale

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www.tetratech.com
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PORTLAND, OR 97224
(503) 684-9097

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DESIGN REVIEW
NOT FOR
CONSTRUCTION

CITY OF ASTORIA

MARK	DATE	DESCRIPTION	BY

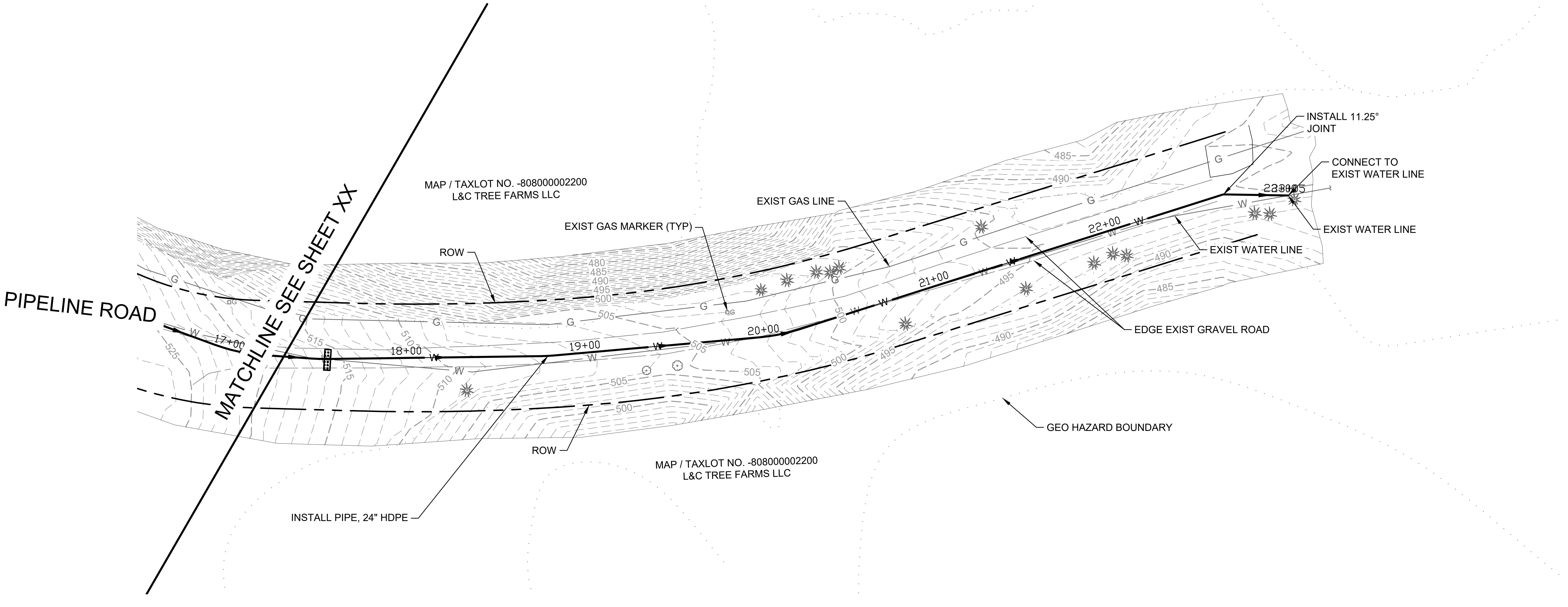
CITY OF ASTORIA

SITE 3
PLAN AND PROFILE
9+00 TO 17+00

PROJ:	200-12636-23001
DESN:	JRF
DRWN:	KJV
CHKD:	MJH

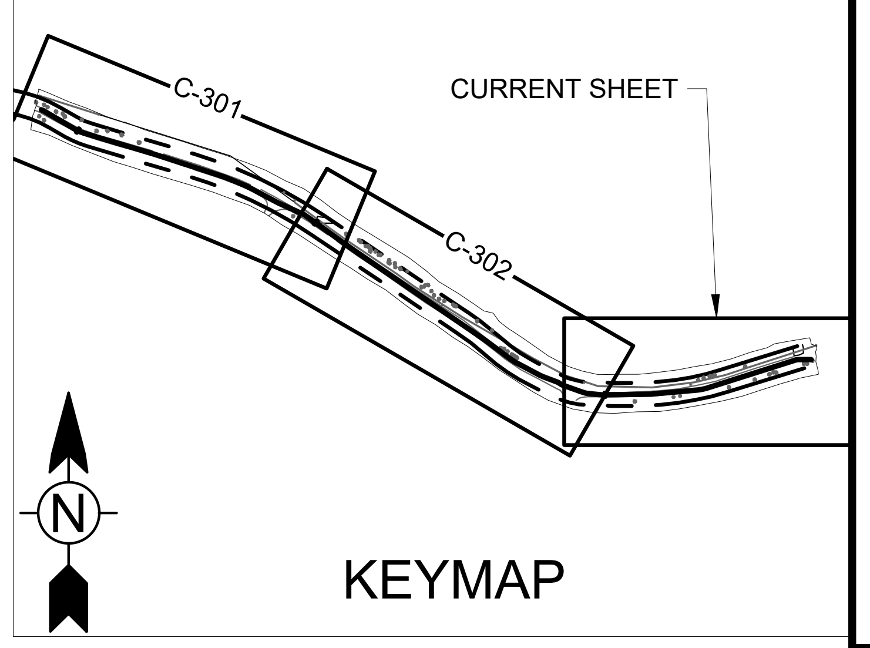
C-302

3/19/2024 6:13:45 PM - C:\USERS\KATELIN.VANDEHEY\DC\ACCDOCS\TETRA TECH INC\200-12636-23001 ASTORIA PIPELINE\PROJECT FILES\CAD\SHEETFILES\C-302 SITE 3 - 8+00 TO 16+00.DWG - VANDEHEY, KATELIN



PLAN

SCALE: 1" = 40'



GENERAL NOTES

1. WHERE WATERLINE IS PARALLEL TO GAS MAIN, PROVIDE A MINIMUM OF 10-FT SEPARATION BETWEEN OUTSIDE PIPE WALLS. COORDINATE WITH WITH NORTHWEST NATURAL.
2. CONTRACTOR TO VERIFY LOCATION AND DEPTH OF EXISTING UTILITIES PRIOR TO CONSTRUCTION.
3. FINAL DEPTH AND SIZING OF SUPPORT AND ISOLATION BLOCKS TO BE DETERMINED BASED ON SITE SPECIFIC OBSERVATIONS OF PIPELINE EXCAVATIONS DURING CONSTRUCTION.
4. FINAL LOCATIONS OF SUPPORT AND ISOLATION BLOCKS TO BE DETERMINED BASED ON SITE-SPECIFIC OBSERVATIONS OF PIPELINE EXCAVATIONS DURING CONSTRUCTION. ASSUME LOCATIONS ARE +/- 20 FEET FROM THOSE SHOWN.
5. WHERE THE EXISTING PIPE INTERFERES WITH THE INSTALLATION OF THE NEW PIPE, CONTRACTOR TO REMOVE AND HAUL AWAY.

N

0 20' 40' 80'
SCALE: 1" = 40'

Bar Measures 1 inch, otherwise drawing not to scale

TETRA TECH
www.tetratech.com
15350 SW SEQUOIA PKWY STE 220
PORTLAND, OR 97224
(503) 684-9097

30 PERCENT
DESIGN REVIEW
NOT FOR
CONSTRUCTION

CITY OF ASTORIA

MARK	DATE	DESCRIPTION	BY

CITY OF ASTORIA

SITE 3
PLAN AND PROFILE
17+00 TO 23+10

PROJ:	200-12636-23001
DESN:	JRF
DRWN:	KJV
CHKD:	MJH

C-303

3/19/2024 6:14:13 PM - C:\USERS\KATELIN.VANDEHEY\DC\ACCDOCS\TETRA TECH INC\200-12636-23001 ASTORIA PIPELINE\PROJECT FILES\CAD\SHEETFILES\C-303 SITE 3 - 16+00 TO 22+00.DWG - VANDEHEY, KATELIN