Geotechnical Survey Report

Technical Services for Terrestrial HDD Route Geotechnical Survey
Seal Rock, Oregon
January 13, 2020
Terracon Project No. 82195049

Prepared for:
Oregon State University
Corvallis, Oregon

Prepared by:
Terracon Consultants, Inc.
Portland, Oregon

January 13, 2020

Oregon State University
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Corvallis, Oregon 97333

Attn: Mr. Ben Baggett – Construction Contracts Administration
P: (541) 737 5546
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Re: Geotechnical Survey Report
Technical Services for Terrestrial HDD Route Geotechnical Survey
5400 NW Pacific Coast Highway
Seal Rock, Oregon
Terracon Project No. 82195049

Dear Mr. Baggett:

We have completed the Geotechnical Survey services for the above referenced project. This study was performed in general accordance with Terracon Proposal No. P82195049 Revision 1 dated August 20, 2019 and signed agreement with Oregon State University dated October 7, 2019. This report presents the findings of the subsurface exploration and results of the laboratory testing for the proposed project.

We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report or if we may be of further service, please contact us.

Sincerely,
Terracon Consultants, Inc.

Brice W. Plouse, PE
Geotechnical Group Leader

Kristopher T. Hauck, P.E.
Principal | Office Manager

REPORT TOPICS

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Note: This report was originally delivered in a web-based format. For more interactive features, please view your project online at client.terracon.com.

ATTACHMENTS

EXPLORATION AND TESTING PROCEDURES
PHOTOGRAPHY LOG
SITE LOCATION AND EXPLORATION PLANS
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SUPPORTING INFORMATION

Note: Refer to each individual Attachment for a listing of contents.

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5400 NW Pacific Coast Highway
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INTRODUCTION

This report presents the results of our subsurface exploration and geotechnical engineering testing services performed for the proposed PacWave Terrestrial Horizontal Directional Drilling project to be located at 5400 NW Pacific Coast Highway in Seal Rock, Oregon. The purpose of these services is to provide drilling and laboratory information relative to the construction of Horizontal Direction Drilling (HDD) techniques.

The geotechnical engineering Scope of Services for this project included the advancement of one exploration to a depth of approximately 300 feet below existing site grades.

Maps showing the site and exploration locations are shown in the **Site Location** and **Exploration Plan** sections, respectively. The results of the laboratory testing performed on soil samples obtained from the site during the field exploration are included on the exploration logs or as separate graphs in the **Exploration Results** section.

SITE CONDITIONS

The following description of site conditions is derived from our site visit in association with the field exploration and our review of publicly available topographic maps.

Item	Description
Parcel Information	The project is located at 5400 NW Pacific Coast Highway in Seal Rock, Oregon. The project will include installation of a Utility Connection and Monitoring Facility and terrestrial and offshore Horizontal Directional Drilling to run power and data cables. See **Site Location and Exploration Plans**.
Existing Improvements	The exploration was conducted at the Driftwood Beach State Recreation Site. The core location is within an asphaltic concrete parking lot.
Existing Topography (from Google Earth Pro aerial imagery)	Graded relatively flat with a slight slope to the west.

We also collected photographs at the time of our field exploration program. Representative photos are provided in our **Photography Log**.

PROJECT DESCRIPTION

Our initial understanding of the project was provided in our proposal and was discussed during project planning. A period of collaboration has transpired since the project was initiated, and our final understanding of the project conditions is as follows:

Item	Description
Information Provided	We were previously provided with the Oregon State University RFP #199778 – Technical Services for Terrestrial Horizontal Directional Drilling Route Geotechnical Survey document, Appendix A of RFP #199778 – Driftwood Beach State Recreation Site Geophysical Exploration Report and Addendum No. 1 to the RFP document. During this RFP revision we were provided with Oregon State University RFP #2020-000300 – Technical Services for Terrestrial Horizontal Directional Drilling Route Geotechnical Survey document and RFP #2020-000300 Appendix A – Technical Services for Terrestrial Seismic Survey and Evaluation Data Report: Results of Geophysical Exploration.
Project Description	The PacWave South project will be the nation's first, pre-permitted, grid-connected facility for testing utility-scale wave energy converters. The project will include an offshore wave energy test site located approximately 6 nautical miles offshore of Newport, Oregon. At the test site, various types of wave energy converters will be deployed and will be connected to the local, onshore power utility grid via four subsea and underground power cables, plus a fifth, auxiliary cable
Proposed Structure	To utilize the created energy from waves, subsea power cable installation at the "Shore Landing Site" will require Horizontal Directional Drilling (HDD) to route cables through underground conduits. The "Shore Landing HDD Routes" will run from the parking lot of Driftwood Beach State Recreation Site ("Driftwood") in Seal Rock, Oregon, under the beach bluff, beach and surf zone, to approximately 30-feet water depth offshore. The total drill path length is approximately 5,000 feet. An additional "Terrestrial HDD Route" will be drilled from the south side of the Driftwood parking lot approximately 2,400 feet to the southeast to an OSU-owned property on NW Wenger Lane on the east side of Highway 101. This property will be the site of the PacWave utility connection and monitoring facility ("UCMF"). This Terrestrial HDD Route will route cables from the UCMF buildings to the Shore Landing Site at Driftwood. It is the area under Driftwood and the Terrestrial HDD Route that are the focus of this Request for Proposals ("RFP").
Estimated Start of Construction	Summer 2020

GEOTECHNICAL CHARACTERIZATION

We have developed a general characterization of the subsurface conditions based upon our review of the subsurface exploration, laboratory data, geologic setting and our understanding of the project. This characterization forms the basis of our geotechnical understanding and provides model layer numbers to correspond to the boring log. Conditions encountered at each exploration point are indicated on the individual logs. The individual logs can be found in the **Exploration Results** section of this report.

Model Layer	Layer Name	General Description
1	**Beach, Bar and Dune Sand (Qbs)**	Holocene – Beach sand and gravel, bar sand and active dune sand; includes coastal stabilized dunes, very loose to medium dense, brown, poorly graded, fine-grained
2	**Coastal Terrace Deposits (Qtc)**	Pleistocene – Thick- to thin-bedded, planar or crossbedded, fine- and medium-grained, marine and nonmarine sand; locally contains cobble and pebble lenses, fossil wood, and carbonaceous silt beds; upper surface of terrace deposits covered locally by stabilized dune sands (older dune deposits are iron stained and contain relict soil zones), tan to brown, very dense
3	**Alsea Formation (Tal)**	Lower to upper Oligocene – Massive to thick-bedded fossiliferous tuffaceous marine siltstone with zones of laminated bedding and very fine-grained sandstone (sandstone not encountered in exploration); gray to black and blue to gray, extremely weak to weak, slightly fractured to sound

1. General Description is a combination of field observed qualities and information from *Snavely, P.D., MacLeod, N.S., Wagner, H.C., and Rau, W.W., 1976, Geologic map of the Waldport and Tidewater Quadrangles, Lincoln, Lane, and Benton Counties, Oregon: Reston, Va., U.S. Geological Survey Miscellaneous Investigations Map I-886, scale 1:62,500*.

Geology

Based on the provided RFP document, the local, shallow geology for the area can be described as Coast Terrace deposits (Qtc) with Yaquina Formation sandstone (Tyq). Mudstone (Tn) layers are expected both below and intermixed with the surface layers.

Based on the *Geologic Map of the Waldport and Tidewater Quadrangles, Lincoln, Lane, and Benton Counties, Oregon* by *Snavely P.D., MacLeod N.S., Wagner H.C., and Rau W.W. 1976,* the site is mapped as Coastal Terrace Deposits (Qtc). The material is described as thick- to thin-bedded, planar or crossbedded, fine- and medium-grained, marine and nonmarine sand; locally contains cobble and pebble lenses, fossil wood, and carbonaceous silt beds; upper surface of terrace deposits covered locally by stabilized dune sands. The geology mapped to the east of the

site is the Alsea Formation, which we interpret to have been encountered at 55 feet below ground surface at the exploration location. Based on our exploration findings, the conditions encountered in the boring are consistent with the reviewed publications.

The sequence of tuffaceous siltstone and fine-grained sandstone that forms the lower part of the Oligocene sequence of coastal Oregon is known as the Alsea Formation. The Alsea Formation occurs in the upper part of a Tertiary sequence of marine sedimentary and volcanic rocks more than 6,000 meter thick that crops out in the central part of the Oregon Coast Range. The Alsea Formation is overlain conformably by a predominantly sandstone sequence, the Yaquina Formation of late Oligocene and early Miocene age. The Alsea Formation typically consists of fossiliferous massive to medium-bedded tuffaceous siltstone and very fine grained sandstone. The sandstone commonly contains fine mica, carbonaceous material, and pumice fragments. General description is referenced to *Snavely, P.D., MacLeod, N.S., Rau, W.W., Addicott W.O., and Pearl J.E., 1975, Alsea Formation – An Oligocene Marine Sedimentary Sequence in the Oregon Coast Range: Contributions to Stratigraphy*. We believe that the current bore path of the terrestrial horizontal directional drilling will be in the Alsea formation stratigraphy.

Based on the Geologic *Map of the Ocean Floor Off Oregon and the Adjacent Continental Margin* by *Peterson C.P. Kulm L.D., and Gray J.J., 1986, GMS-42,* the geology of the offshore location, where the subsea cables and wave energy converters will be located, is mapped as Siltstone (QTpm) of the Pleistocene-late Miocene era. The map describes the area as poorly indurated siltstone and minor sandstone. This basinal deposit also blankets upper slope accretionary complex rocks. It was noted that a syncline that runs north to south is mapped about two miles west of the test site.

Seismic Hazards

Seismic hazards resulting from earthquake motions can include slope stability, liquefaction, and surface rupture due to faulting or lateral spreading. Liquefaction is the phenomenon wherein soil strength is dramatically reduced when subjected to vibration or shaking.

We reviewed the Statewide Geohazards Viewer (HazVu) published by the Oregon Department of Geology and Mineral Studies (DOGAMI) and available online at https://gis.dogami.oregon.gov/hazvu/. The viewer categorizes the expected earthquake shaking from light, moderate, strong, very strong, severe and violent; and the landslide susceptibility from low, moderate, high, and very high.

Earthquake Liquefaction Hazard: Moderate
Expected Earthquake Shaking: Severe
Landslide Susceptibility (due to earthquake): Moderate to High

Faults

The United States Geological Survey (USGS) Quaternary Fault and Fold Database of the United States published a report containing descriptions of nearby faults.

Waldport Faults (Class A) No. 886

Information	Description
Length	14 km
Strike (degrees)	N13°E
Sense of Movement	Reverse, left lateral, normal
Dip Direction	E; W
Slip-rate Category	Less than 0.2 mm/yr.
Most recent prehistoric deformation	Late Quaternary (<130 ka)
Distance from Fault	1 mile east of site

The Waldport faults are three north-northeast-striking faults that offset marine-terrace sediments and wave-cut platforms in the vicinity of Alsea Bay along the central Oregon coast. The Waldport faults offset the approximately 125 ka Yachats marine terrace 15–20 m which imply low vertical displacement rates in the late Quaternary.

Unnamed Offshore Faults (Class A) No. 785

Information	Description
Length	280 km
Strike (degrees)	N11°W
Sense of Movement	Left lateral, right lateral, normal, reverse
Dip Direction	Unknown
Slip-rate Category	Between 1.0 and 5.0 mm/yr
Most recent prehistoric deformation	Latest quaternary (<15 ka)
Distance from Fault	1.33 miles west of site

This group of faults offset accretionary wedge sediments that underlie the continental shelf and slope in the forearc of the Cascadia subduction zone ; some faults also offset the overlying sedimentary section and the underlying oceanic basalts of the subducting Juan de Fuca Plate.

Stonewall Anticline (Class A) No. 786

Information	Description
Length	70 km
Strike (degrees)	N13°W
Sense of Movement	Anticline
Dip Direction	65-70°E

Information	Description
Slip-rate Category	Between 1.0 and 5.0 mm/yr
Most recent prehistoric deformation	Latest quaternary (<15 ka)
Distance from Fault	12 miles west of site

The north-northwest-striking, west-verging, doubly plunging Stonewall anticline fold deforms sediments underlying the continental slope and shelf in the forearc of the Cascadia subduction zone. The fold is located on the continental shelf, in an area underlain by a rigid basement of Siletz River Volcanics (Siletzia terrane); folds in this region have longer wavelengths than the closely spaced folds and faults in the accretionary wedge underlying the continental slope. The Stonewall anticline folds Miocene through Pleistocene sediment, and warps a late Pleistocene sea-level lowstand wave-cut platform and an antecedent drowned stream channel of the Yaquina River. An age range of 11–14.5 ka was assumed for the latter features, so the youngest deformation occurred in the latest Quaternary.

Based on our review of the available fault information, the depth to bedrock, and the site's proximity to the nearest known faults, it is our opinion that the risk of surface rupture due to ground faulting is low.

Groundwater Conditions

The core was observed while drilling and after completion for the presence and level of groundwater. The water levels observed in the core is provided on the logs in **Exploration Results** and are summarized below.

Exploration Number	Approximate Ground Surface Elevation (feet) [1]	Approximate Elevation of Groundwater while Drilling (feet) [1]
Core #1	52	22

1. Based on elevations obtained from Google Earth and depth to the observed groundwater during explorations. Note the assumed ground surface elevation is presented on the boring logs.

Based on tidal changes we anticipate groundwater level fluctuations will occur regularly. Additional seasonal variations in the amount of rainfall, runoff and other factors not evident at the time the core was performed could impact groundwater as well. Therefore, groundwater levels during construction or at other times in the life of the structure may be higher or lower than the levels indicated on the boring logs. The possibility of groundwater level fluctuations should be considered when developing the design and construction plans for the project.

DRILLING DATA

As part of our field work we compiled multiple drilling statistics, including drillers comments to assist in design of the Horizontal Directional Drilling (HDD).

We utilized a Diedrich D-90 track drill rig between October 18, 2019 and October 24, 2019 to complete the 300-foot exploration. Below is a summary of our pertinent drilling information. The Diedrich D-90 information pack and drillers resume can be found in the **Supporting Information** section of this report, and a description of the drilling techniques and location of the explorations can be founding the **Exploration and Testing Procedures** section.

Topic	Information
Depth of Overburden	55 feet
Total Coring Footage	245 feet
Total Drilling Depth	300 feet
Static Water Level during Drilling Activities	30 ft
Type & Weight of Bit	3 7/8 inch outside diameter, staggered tooth bit; approximately 3 pounds
Drilling Fluid	EZ Mud Liquid Polymer; biodegradable

Date	Depth (feet)	Driller Notes
October 18, 2019	0 to 20	Overburden; heaving sands;
October 19, 2019	20 to 55; overburden 55 to 80; bedrock	Heaving sands below free water level of 30 feet below ground surface; switched drilling head to rotary and set mud pan; began coring with diamond core bit
October 20, 2019	80 to 140	Switched to staggered tooth, open face discharge bit for better recovery; difficult core retrieval at 80 and 100 feet; water loss from supply volume consistent (likely caused by loose sands above bedrock)
October 21, 2019	140 to 215	1,000 gallons of water used during drilling activities

Date	Depth (feet)	Driller Notes
October 22, 2019	215 to 285	450 gallons of water used during drilling activities
October 23, 2019	285 to 300	450 gallons of water used during drilling activities
October 24, 2019	N/A	Drive line on transmission broke while trying to remove augers; after communications with PacWave elected to abandon augers in place

Depth (ft)	String Rotation Rate (rpm)	Drilling Torque (ft-lb)	Rate of Penetration (ft/min.)	Supply Volume (ft^3)	Flow Rate (ft^3/sec.)	Circulation Pressure (psi)	Return Volume (ft^3)
0 to 20	N/A	N/A	2.00	N/A	N/A	N/A	N/A
20 to 55	N/A	N/A	5.00	N/A	N/A	N/A	N/A
55 to 65	1,300	1,650	0.17	33.4	0.03	200	29.0
65 to 70	1,300	1,650	0.15	33.4	0.03	200	29.0
70 to 125	1,300	1,650	0.17	60.2	0.03	200	54.5
125 to 140	1,300	1,650	0.17	60.2	0.03	200	50.9
140 to 145	1,300	1,650	0.25	60.2	0.03	200	50.9
145 to 190	1,300	1,650	0.17	60.2	0.03	200	50.9
190 to 205	1,800	1,650	0.17	60.2	0.03	200	55.6
205 to 210	1,800	1,650	0.25	60.2	0.03	200	55.6
210 to 260	1,800	1,650	0.17	60.2	0.05	500	55.6
260 to 270	1,800	1,650	0.25	60.2	0.03	500	55.6
270 to 280	1,800	1,650	0.17	60.2	0.03	500	55.6
280 to 300	1,800	1,650	0.25	60.2	0.03	500	55.6

1. All return drilling fluid noted having grey color.

Additional exploration information can be found on the exploration log in the **Exploration Results** section.

INADVERTENT DRILL FLUID RETURN ANALYSIS

We understand a major concern with Horizontal Direction Drilling (HDD) activities is the possibility of the annular pressure of the drilling fluid exceeding the limiting (confining) pressure of the soil formation. We conducted multiple laboratory tests to evaluate the soil parameters required to assist in developing the limiting pressure of the alignment. We understand the annular pressure will be developed during the HDD design stage. Strength parameters, such as cohesion, internal friction angle and shear modulus can be evaluated from the direct shear results in the **Exploration Results** section.

We understand it is generally assumed that the risk of inadvertent return is greater during pilot hole drilling than reaming, given that the drill fluid may only flow toward the Horizontal Direction Drilling (HDD) entry since the connection with the open sea drilling exit has not yet been established. We anticipate the majority of the bore paths offshore will be located in bedrock, with onshore paths encountering mostly soil.

THERMAL RESISTIVITY OF SOIL AND GROUT

The installation of cables underground requires engineering analysis to ensure the required electrical current is maintained. Items such as cable depth and the materials surrounding the cables impact efficiency of power transfer and may require forms of remediation. To assist in this design, we were asked to conduct laboratory thermal resistivity test of the overburden soils and selected bedrock samples. Results of the minimum and maximum thermal resistivity values of each tested sample are expressed below, while the full dry-out curves can be found in the **Exploration Results** section.

Thermal Resistivity Test Results Summary

Exploration	Sample Depth (feet)	Soil Description	Dry Density (pcf)	Optimum/Maximum Moisture Content (%)	Thermal Resistivity [3] @ 0% Moisture	Thermal Resistivity [3] @ Opt./Max. Moisture
Core #1	0 to 5	Dune Sand [1]	92.4	13.2	566	95
Core #1	0 to 5	Terrace Sand [1]	79.7	25.8	326	84
Core #1	100 to 105	Siltstone [2]	110.6	18.1	164	91

Thermal Resistivity Test Results Summary						
Exploration	**Sample Depth (feet)**	**Soil Description**	**Dry Density (pcf)**	**Optimum/Maximum Moisture Content (%)**	**Thermal Resistivity [3] @ 0% Moisture**	**Thermal Resistivity [3] @ Opt./Max. Moisture**
Core #1	220 to 225	Siltstone [2]	107.3	17.6	205	84

1. Recompacted sample. Results collected from sample compacted in known volume.
2. In-situ sample. Results collected from intact core sample.
3. Thermal resistivity is measured in (°C*cm)/watt.

Additionally, we understand typical Horizontal Directional Drilling (HDD) will require installation of a thermal grout between the casings and cable duct. The purpose of the grout is to aid in heat dissipation during cable operation. The grout will be installed by means of tremie tubes once the casing and duct are in place. We understand the thermal resistivity of thermal grout is largely dependent on the density of the material. If there is a concern with the thermal grouts properties Terracon is available to aid in establishing a quality control (QC) testing program for the project.

CORROSIVITY

The table below lists the results of laboratory soluble sulfate, soluble chloride, electrical resistivity, and pH testing. The values may be used to estimate potential corrosive characteristics of the on-site soils with respect to contact with the various underground materials which will be used for project construction.

Corrosivity Test Results Summary						
Exploration	**Sample Depth (feet)**	**Soil Description**	**Soluble Sulfate (%)**	**Soluble Chloride (%)**	**Electrical Resistivity (Ω-cm)**	**pH**
Core #1	10 to 11½	Dune Sand	28	53	17,460	8.24
Core #1	25 to 26½	Terrace Sand	70	53	17,945	8.21
Core #1	40 to 41½	Terrace Sand	10	82	9,700	8.01
Core #1	100 to 105	Siltstone	Not tested	Not tested	220 [1]	8.20
Core #1	200 to 205	Siltstone	Not tested	Not tested	240 [1]	8.34

1. Tested with ocean water.

Results of soluble sulfate testing indicate samples of the on-site soils tested possess negligible sulfate concentrations when classified in accordance with Table 4.3.1 of the ACI Design Manual.

Concrete should be designed in accordance with the provisions of the ACI Design Manual, Section 318, Chapter 4.

A corrosion expert should be contacted regarding steel's susceptibility to corrosion of the encountered soils.

GENERAL COMMENTS

Our analysis and opinions are based upon our understanding of the project, the geotechnical conditions in the area, and the data obtained from our site exploration. Natural variations will occur between exploration point locations or due to the modifying effects of construction or weather. The nature and extent of such variations may not become evident until during or after construction. Terracon should be retained as the Geotechnical Engineer, where noted in this report, to provide observation and testing services during pertinent construction phases. If variations appear, we can provide further evaluation and supplemental recommendations. If variations are noted in the absence of our observation and testing services on-site, we should be immediately notified so that we can provide evaluation and supplemental recommendations.

Our Scope of Services does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or conditions. If the owner is concerned about the potential for such contamination or pollution, other studies should be undertaken.

Our services and any correspondence or collaboration through this system are intended for the sole benefit and exclusive use of our client for specific application to the project discussed and are accomplished in accordance with generally accepted geotechnical engineering practices with no third-party beneficiaries intended. Any third-party access to services or correspondence is solely for information purposes to support the services provided by Terracon to our client. Reliance upon the services and any work product is limited to our client and is not intended for third parties. Any use or reliance of the provided information by third parties is done solely at their own risk. No warranties, either express or implied, are intended or made.

Site characteristics as provided are for design purposes and not to estimate excavation cost. Any use of our report in that regard is done at the sole risk of the excavating cost estimator as there may be variations on the site that are not apparent in the data that could significantly impact excavation cost. Any parties charged with estimating excavation costs should seek their own site characterization for specific purposes to obtain the specific level of detail necessary for costing. Site safety, and cost estimating including, excavation support, and dewatering requirements/design are the responsibility of others. If changes in the nature, design, or location of the project are planned, our conclusions and recommendations shall not be considered valid unless we review the changes and either verify or modify our conclusions in writing.

ATTACHMENTS

EXPLORATION AND TESTING PROCEDURES

Field Exploration

Number of Explorations	Type of Exploration	Exploration Depth (feet)	Location Latitude and Longitude
1	Core	300	44° 27' 35.48" N 124° 04' 30.75" W

Exploration Layout and Elevations: Oregon State University (OSU) provided the exploration layout and coordinates as per RFP #199778 dated July 2, 2019. The exploration location was located using a handheld GPS and site characteristics, and the approximate elevation was obtained by interpolation from the aerial photographs using Google Earth Pro. If elevations and a more precise exploration layout are desired, we recommend explorations be surveyed following completion of fieldwork.

Subsurface Exploration Procedures: We advanced the core exploration with a Terracon-operated Diedrich D90 track-mounted, hydraulic rotary core drill rig using hollow stem auger system for setting casing through overburden and soils. Soil samples were obtained at 5-foot intervals. Soil sampling was performed using split-barrel sampling procedures. In the split barrel sampling procedure, a standard 2-inch outer diameter split barrel sampling spoon is driven into the ground by a 140-pound automatic hammer falling a distance of 30 inches. The number of blows required to advance the sampling spoon the last 12 inches of a normal 18-inch penetration was recorded as the Standard Penetration Test (SPT) resistance value. The SPT resistance values, also referred to as N-values, are indicated on the boring logs at the test depths. The samples were placed in appropriate containers, taken to our soil laboratory for testing, and classified by a geotechnical engineer. In addition, we observed and recorded groundwater levels during drilling and sampling.

Upon encountering bedrock, we utilized a HQ3 wireline coring system to obtain core samples. Bedrock coring was conducted to the total planned exploration depth defined above. Water, along with drill mud and polymer, was used as a drilling fluid for bedrock coring and the spent water was containerized and disposed of off-site.

All explorations were supervised and logged by a field geologist to record field test data, classify soils, and to collect the samples from the explorations. Our exploration team prepared field boring logs as part of standard drilling operations including sampling depths, penetration distances, and other relevant sampling information. Field logs include visual classifications of materials encountered during drilling, and our interpretation of subsurface conditions between samples. Final boring logs, prepared from field logs, represent the geotechnical engineer's interpretation, and include modifications based on observations and laboratory tests**.**

Property Disturbance: Due to fluctuating tides, causing heaving sands we abandoned approximately 55 feet of hollow-stem auger at the core location. We backfilled the augers and core exploration with grout after completion. The surface at the core location was returned to the previous condition with colored concrete. Our services do not include repair of the site beyond backfilling the core location.

Best Management Practices (BMP) such as straw wattles and catch basin socks were utilized to filter and retain drilling fluid and mud run off. Excess auger cuttings, drilling fluids and muds were collected, contained and disposed of off-site.

Laboratory Testing

The project engineer reviewed field data and assigned various laboratory tests to better understand the engineering properties of various soil and rock strata. Procedural standards noted below are for reference to methodology in general. In some cases, local practices and professional judgement require method variations. Standards noted below include reference to other related standards. Such references are not necessarily applicable to describe the specific test performed.

- ASTM D6032 – 17 Standard Test Method for Determining Rock Quality Designation (RQD) of Rock Core
- ASTM D7263 – 09 Standard Test Methods for Laboratory Determination of Density (Unit Weight) of Soil Specimens
- ASTM D5607 – 16 Standard Test Method for Performing Laboratory Direct Shear Strength Tests of Rock Specimens Under Constant Normal Force
- ASTM D7012 - 14e1 Standard Test Methods for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens; Method C: Uniaxial Compressive Strength of Intact Rock Core Specimens.
- ASTM D5873 – 14 Standard Test Method for Determination of Rock Hardness by Rebound Hammer Method
- ASTM D2216 – 19 Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
- ASTM D5334 – 14 Standard Test Method for Determination of Thermal Conductivity of Soil and Soft Rock by Thermal Needle Probe Procedure
- ASTM D4318 - 17e1 Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
- ASTM D4972 – 19 Standard Test Methods for pH of Soils
- IEEE Std 81 – 201 EEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of Ground Systems; Resistivity only

The laboratory testing program often included examination of soil samples by an engineer. Based on the material's texture and plasticity, we described and classified the soil samples in accordance with the Unified Soil Classification System (USCS).

When bedrock samples were obtained, rock classification was conducted using ASTM D5079, ASTM D6032 and locally accepted practices for engineering purposes; petrographic analysis (if performed) may reveal other rock types. Rock core samples typically provide an improved specimen for this classification. Boring log rock classification was determined using the Description of Rock Properties.

Photo 1 Sample 1 .25 ft. to 1.75 ft. 10/18/2019

Photo 2 Sample 2 2.5 feet to 4.0 feet 10/18/2019

Photo 3 Sample 3 5 feet to 6.5 feet 10/18/2019

Photo 4 Sample 4 7.5 feet to 9.0 feet 10/18/2019

Photo 5 Sample 5 10 feet to 11.5’ feet 10/18/2019

Photo 6 Sample 6 15 feet to 16.5 feet 10/18/2019

Photo 7 Sample 7 20 feet to 21.5 feet 10/18/2019

Photo 8 Sample 8 25' feet to 26.5 feet 10/19/2019

Photo 9 Sample 9 30 feet to 31.5 feet 10/19/2019

Photo 10 Sample 10 35 feet to 36.5 feet 10/19/2019

Photo 11 Sample 11 40 feet to 41.5 feet 10/19/2019

Photo 12 Sample 12 45 feet to 46.5 feet 10/19/2019

Photo 13 Sample 13 50 feet to 51.5 feet 10/19/2019

Photo 14 Sample 14 55 feet to 56.5 feet 10/19/19

Photo 15 Sample 15 55 feet to 57 feet 10/19/2019

Photo 16 Sample 15 57 feet to 60 feet 10/19/2019

Photo 17 Sample 16 60 feet to 65 feet 10/19/2019

Photo 18 Sample 17 65 feet to 70 feet 10/19/2019

Photo 19 Sample 18 70 feet to 75 feet 10/20/2019

Photo 20 Sample 19 75 feet to 80 feet 10/20/2019

Photo 21 Sample 20 80 feet to 85 feet 10/20/2019

Photo 22 Sample 21 85 feet to 90 feet 10/20/2019

Photo 23 Sample 22 90 feet to 95 feet 10/20/2019

Photo 24 Sample 23 95 feet to 100 feet 10/20/2019

Photo 25 Sample 24 100 feet to 105 feet 10/20/2019

Photo 26 Sample 25 105 feet to 110 feet 10/20/2019

Photo 27 Sample 26' 110 feet to 115 feet 10/20/2019

Photo 28 Sample 27 115 feet to 120 feet 10/20/2019

Photo 29 Sample 28 120 feet to 125 feet 10/20/2019

Photo 30 Sample 29 125 feet to 130 feet 10/21/2019

Photo 31 Sample 30 130 feet to 135 feet 10/21/2019

Photo 32 Sample 31 135 feet to 140 feet 10/21/2019

Photo 33 Sample 32 140 feet to 145 feet 10/21/2019

Photo 34 Sample 33 145 feet to 150 feet 10/21/2019

Photo 35 Sample 34 150 feet to 155 feet 10/21/2019

Photo 36 Sample 35 155 feet to 160 feet 10/21/2019

Photo 37 Sample 36 160 feet to 165 feet 10/21/2019

Photo 38 Sample 37 165 feet to 170 feet 10/21/2019

Photo 39 Sample 38 170 feet to 175 feet 10/21/2019

Photo 40 Sample 39 175 feet to 180 feet 10/21/2019

Photo 41 Sample 40 180 feet to 182 feet 10/21/2019

Photo 42 Sample 40 182 feet to 187 feet 10/21/2019

Photo 43 Sample 41 187 feet to 190 feet 10/21/2019

Photo 44 Sample 42 190 feet to 195 feet 10/22/2019

Photo 45 Sample 43 195 feet to 200 feet 10/22/2019

Photo 46 Sample 44 200 feet to 205 feet 10/22/2019

Photo 47 Sample 45 205 feet to 210 feet 10/22/2019

Photo 48 Sample 46 210 feet to 215 feet 10/22/2019

Photo 49 Sample 47 215 feet to 220 feet 10/22/2019

Photo 50 Sample 48 220 feet to 225 feet 10/22/2019

Photo 51 Sample 49 225 feet to 230 feet 10/22/2019

Photo 52 Sample 50 230 feet to 235 feet 10/22/2019

Photo 53 Sample 51 235 feet to 240 feet 10/22/2019

Photo 54 Sample 52 240 feet to 245 feet 10/22/2019

Photo 55 Sample 53 245 feet to 250 feet 10/22/2019

Photo 56 Sample 54 250' feet to 255 feet 10/22/2019

Photo 57 Sample 55 255 feet to 260 feet 10/22/2019

Photo 58 Sample 56 260 feet to 265 feet 10/23/2019

Photo 59 Sample 57 265 feet to 270 feet 10/23/2019

Photo 60 Sample 58 270 to 275 feet 10/23/2019

Photo 61 Sample 59 275 feet to 280 feet 10/23/2019

Photo 62 Sample 60 280 feet to 285 feet 10/23/2019

Photo 63 Sample 61 285 feet to 288 feet 10/23/2019

Photo 64 Sample 62 288 feet to 290 feet 10/23/2019

Photo 65 Sample 63 290 feet to 295 feet 10/23/2019

Photo 66 Sample 64 295 feet to 300 feet 10/23/2019

SITE LOCATION AND EXPLORATION PLANS

Contents:

Site Location Plan
Exploration Plan

Note: All attachments are one page unless noted above.

SITE LOCATION

Terrestrial HDD Route Geotechnical Survey■ Seal Rock, OR
January 13, 2020 ■ Terracon Project No. 82195049

DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

TOPOGRAPHIC MAP IMAGE COURTESY OF THE U.S. GEOLOGICAL SURVEY
QUADRANGLES INCLUDE: WALDPORT, OR (1/1/1984).

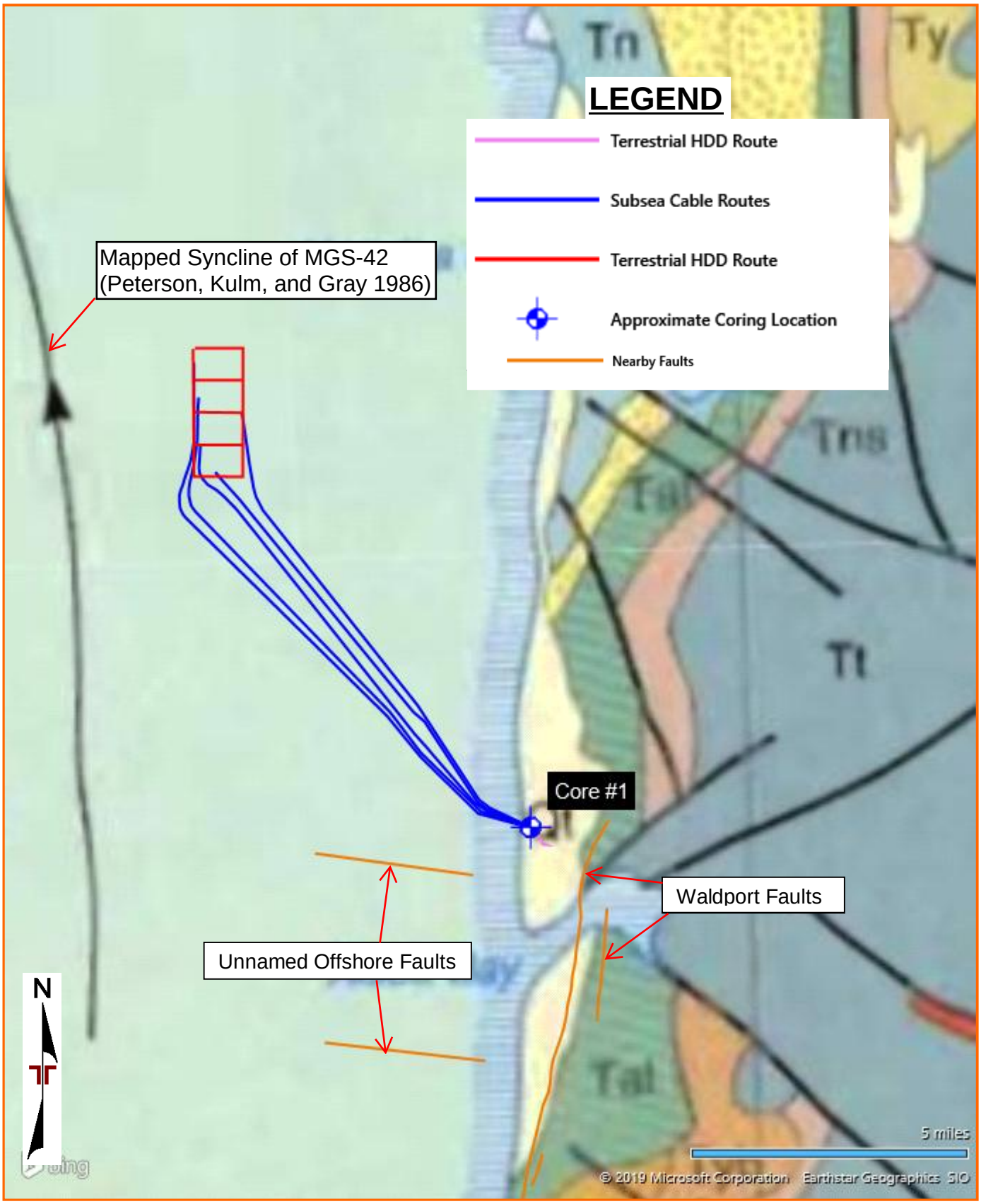

DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

GMS-42
Geologic Map of the Ocean Floor Off Oregon and the Adjacent Continental Margin
By Carolyn P. Peterson, LaVerne D. Kulm, and Jerry J. Gray

EXPLORATION RESULTS

Contents:

Exploration Logs (Core #1)
Atterberg Limits
Grain Size Distribution
Unconfined Compressive Strength (6 pages)
Direct Shear (13 pages)
Moisture Density Relationship
Relative Density Results
Corrosivity
Thermal Resistivity (4 pages)

Note: All attachments are one page unless noted above.

BORING LOG NO. Core #1

PROJECT: Terrestrial Horizontal Directional Drilling Route Geotechnical Survey

CLIENT: Oregon State University Corvallis, OR

SITE: 5400 NW Pacific Coast Highway Seal Rock, OR

LOCATION See Exploration Plan

Latitude: 44.4642° Longitude: -124.0802°

Surface Elev.: 52 (Ft.)

MODEL LAYER	GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	# of Core Pieces	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)
		0.3	52								
			FILL - ASPHALT, 3-inches thick								
1			**POORLY GRADED SAND (SP)**, trace silt and gravel, fine grained, brown, loose				18	5-4-5 N=9		4	
							17	4-4-5 N=9		5	
			medium dense	5			15	8-4-6 N=10		4	
			very loose, no gravel present				18	3-2-1 N=3		5	
			loose	10			18	4-3-2 N=5		7	
				15			17	4-4-3 N=7		5	
		20.0	32								
		20.3	**LEAN CLAY (CL)**, gray to black, medium stiff	20			17	4-3-2 N=5		5	
			POORLY GRADED SAND (SP), fine grained, light brown to tan, very loose							24	
				25			9	2-1-1 N=2		23	
		30.0	22		▽						
2			**POORLY GRADED SAND WITH SILT (SP-SM)**, trace gravel, fine grained, light tan, dense	30			15	7-17-27 N=44		23	
			very dense	35			15	16-29-43 N=72		22	
				40			16	41-30-43 N=73		23	
		45.0	7								
			POORLY GRADED SAND (SP), trace silt, very dense	45			17	24-44-40 N=84		22	
				50							

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Hollow stem augering 6-inch OD for setting casing through overburden soils and HQ3 wireline coring obtain core samples

Abandonment Method:
Exploration was backfilled with grout and capped with concrete at the completion of drilling activities.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:

Due to heaving sands and tidal changes approximately 55 feet of hollow stem auger was grouted in place.
Elevations were interpolated from aerial photographs using Google Earth Pro.

WATER LEVEL OBSERVATIONS

▽ *While drilling*

Terracon
700 NE 55th Ave
Portland, OR

Boring Started: 10-18-2019 | Boring Completed: 10-23-2019

Drill Rig: D-90 Track | Driller: Terracon - Lodi

Project No.: 82195049

BORING LOG NO. Core #1

PROJECT: Terrestrial Horizontal Directional Drilling Route Geotechnical Survey

CLIENT: Oregon State University Corvallis, OR

SITE: 5400 NW Pacific Coast Highway Seal Rock, OR

LOCATION See Exploration Plan

Latitude: 44.4642° Longitude: -124.0802°

Surface Elev.: 52 (Ft.)

DEPTH ELEVATION (Ft.)

MODEL LAYER	DEPTH	ELEVATION (Ft.)		DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	# of Core Pieces	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)
2			**POORLY GRADED SAND (SP)**, trace silt, very dense *(continued)*				17	23-28-34 N=62		30	
	55.0	-3		55			4	50/5"		28	
3			**SILTSTONE**, gray to black, fine-grained, extremely fractured, laminated bedding, unweathered, extremely weak				30	RQD = 0%	0		
			slightly fractured				30	RQD = 80%	4		
			sound	60			60	RQD = 86%	7		
			slightly fractured	65			60	RQD = 91%	9		
			gray, sound	70			60	RQD = 98%	6		
				75			60	RQD = 99%	5		
			moderately fractured, medium bedding, very weak, greater definition through fracture planes, increase in rigidity, structure more defined	80			19	RQD = 0%	7		
			laminated bedding, poor recovery	85			25	RQD = 75%	16	22 18	98 108
			slightly fractured	90			60	RQD = 80%	9		
			sound	95			60	RQD = 100%	4		
			slightly fractured	100							

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Hollow stem augering 6-inch OD for setting casing through overburden soils and HQ3 wireline coring obtain core samples

Abandonment Method:
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See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ *While drilling*

Terracon
700 NE 55th Ave
Portland, OR

Boring Started: 10-18-2019 | Boring Completed: 10-23-2019

Drill Rig: D-90 Track | Driller: Terracon - Lodi

Project No.: 82195049

BORING LOG NO. Core #1

PROJECT: Terrestrial Horizontal Directional Drilling Route Geotechnical Survey

CLIENT: Oregon State University Corvallis, OR

SITE: 5400 NW Pacific Coast Highway Seal Rock, OR

LOCATION See Exploration Plan

Latitude: 44.4642° Longitude: -124.0802°

Surface Elev.: 52 (Ft.)

MODEL LAYER	GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	# of Core Pieces	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)
3		**SILTSTONE**, gray to black, fine-grained, extremely fractured, laminated bedding, unweathered, extremely weak *(continued)*					48	RQD = 85%	13		
				105			60	RQD = 79%	15		
				110			60	RQD = 82%	8		
				115			60	RQD = 81%	7		
				120			60	RQD = 85%	9	22	102
		blue to gray, sound, laminated bedding, weak rock, brittle		125			60	RQD = 100%	1		
		medium bedding		130			60	RQD = 100%	1		
		moderately fractured		135			60	RQD = 82%	23		
		sound, laminated bedding, increase in hardness		140			60	RQD = 95%	5	21	100
		slightly fractured		145			60	RQD = 93%	8		
				150							

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Hollow stem augering 6-inch OD for setting casing through overburden soils and HQ3 wireline coring obtain core samples

Abandonment Method:
Exploration was backfilled with grout and capped with concrete at the completion of drilling activities.

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See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ *While drilling*

Terracon
700 NE 55th Ave
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Boring Started: 10-18-2019 | Boring Completed: 10-23-2019

Drill Rig: D-90 Track | Driller: Terracon - Lodi

Project No.: 82195049

BORING LOG NO. Core #1

PROJECT: Terrestrial Horizontal Directional Drilling Route Geotechnical Survey

CLIENT: Oregon State University Corvallis, OR

SITE: 5400 NW Pacific Coast Highway Seal Rock, OR

LOCATION See Exploration Plan

Latitude: 44.4642° Longitude: -124.0802°

Surface Elev.: 52 (Ft.)

MODEL LAYER	GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	# of Core Pieces	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)
3							60	RQD = 83%	11		
				155			60	RQD = 77%	11		
				160			60	RQD = 73%	9		
				165			60	RQD = 55%	16		
				170			60	RQD = 80%	7		
				175			60	RQD = 96%	6		
				180			30	RQD = 95%	3		
				185			36	RQD = 95%	2		
							36	RQD = 87%	12	18	106
				190			60	RQD = 72%	6	17	110
				195			54	RQD = 60%	17		
				200							

SILTSTONE, gray to black, fine-grained, extremely fractured, laminated bedding, unweathered, extremely weak *(continued)*

moderately fractured, massive bedding

sound, very weak

blue with gray, weak rock, increase in hardness

slightly fractured

blue to gray, sound, very weak, brittle

moderately fractured

slightly fractured, laminated bedding

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Hollow stem augering 6-inch OD for setting casing through overburden soils and HQ3 wireline coring obtain core samples

Abandonment Method:
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Notes:

WATER LEVEL OBSERVATIONS

▽ *While drilling*

Terracon
700 NE 55th Ave
Portland, OR

Boring Started: 10-18-2019 | Boring Completed: 10-23-2019

Drill Rig: D-90 Track | Driller: Terracon - Lodi

Project No.: 82195049

BORING LOG NO. Core #1

PROJECT: Terrestrial Horizontal Directional Drilling Route Geotechnical Survey

CLIENT: Oregon State University Corvallis, OR

SITE: 5400 NW Pacific Coast Highway Seal Rock, OR

LOCATION See Exploration Plan

Latitude: 44.4642° Longitude: -124.0802°

Surface Elev.: 52 (Ft.)

DEPTH ELEVATION (Ft.)

MODEL LAYER	DEPTH (Ft.)		RECOVERY (In.)	FIELD TEST RESULTS	# of Core Pieces	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)
3		**SILTSTONE**, gray to black, fine-grained, extremely fractured, laminated bedding, unweathered, extremely weak *(continued)*	60	RQD = 84%	10		
	205	massive bedding	60	RQD = 74%	12		
	210	moderately fractured	60	RQD = 55%	18		
	215	slightly fractured	60	RQD = 75%	13		
	220		60	RQD = 90%	9		
	225	sound	60	RQD = 95%	6		
	230	slightly fractured, weak rock	60	RQD = 80%	9		
	235	moderately fractured	60	RQD = 33%	16		
	240	slightly fractured, laminated bedding, very weak	60	RQD = 80%	12	20	94
	245	thick bedding, weak rock	60	RQD = 95%	10		
	250						

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Hollow stem augering 6-inch OD for setting casing through overburden soils and HQ3 wireline coring obtain core samples

Abandonment Method:
Exploration was backfilled with grout and capped with concrete at the completion of drilling activities.

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Notes:

WATER LEVEL OBSERVATIONS

▽ *While drilling*

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Project No.: 82195049

BORING LOG NO. Core #1

PROJECT: Terrestrial Horizontal Directional Drilling Route Geotechnical Survey

CLIENT: Oregon State University Corvallis, OR

SITE: 5400 NW Pacific Coast Highway Seal Rock, OR

LOCATION See Exploration Plan

Latitude: 44.4642° Longitude: -124.0802°

Surface Elev.: 52 (Ft.)

MODEL LAYER	GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	# of Core Pieces	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)
3			**SILTSTONE**, gray to black, fine-grained, extremely fractured, laminated bedding, unweathered, extremely weak *(continued)*				60	RQD = 70%	11		
			extremely weak	255			52	RQD = 72%	9		
			moderately fractured, laminated bedding, very weak	260			60	RQD = 76%	20		
			sound, weak rock	265			60	RQD = 100%	5		
			moderately fractured, medium bedding	270			60	RQD = 74%	20		
			slightly fractured	275			48	RQD = 58%	9	19	105
			laminated bedding	280			48	RQD = 82%	9	21	98
			moderately fractured, thick bedding	285			36	RQD = 80%	13		
			slightly fractured				24	RQD = 90%	5		
				290			60	RQD = 92%	10		
			sound	295			60	RQD = 88%	7	19	103
		300.0	-248	300							
		Boring Terminated at 300 Feet									

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Hollow stem augering 6-inch OD for setting casing through overburden soils and HQ3 wireline coring obtain core samples

Abandonment Method:
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Notes:

WATER LEVEL OBSERVATIONS

▽ *While drilling*

Terracon
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Portland, OR

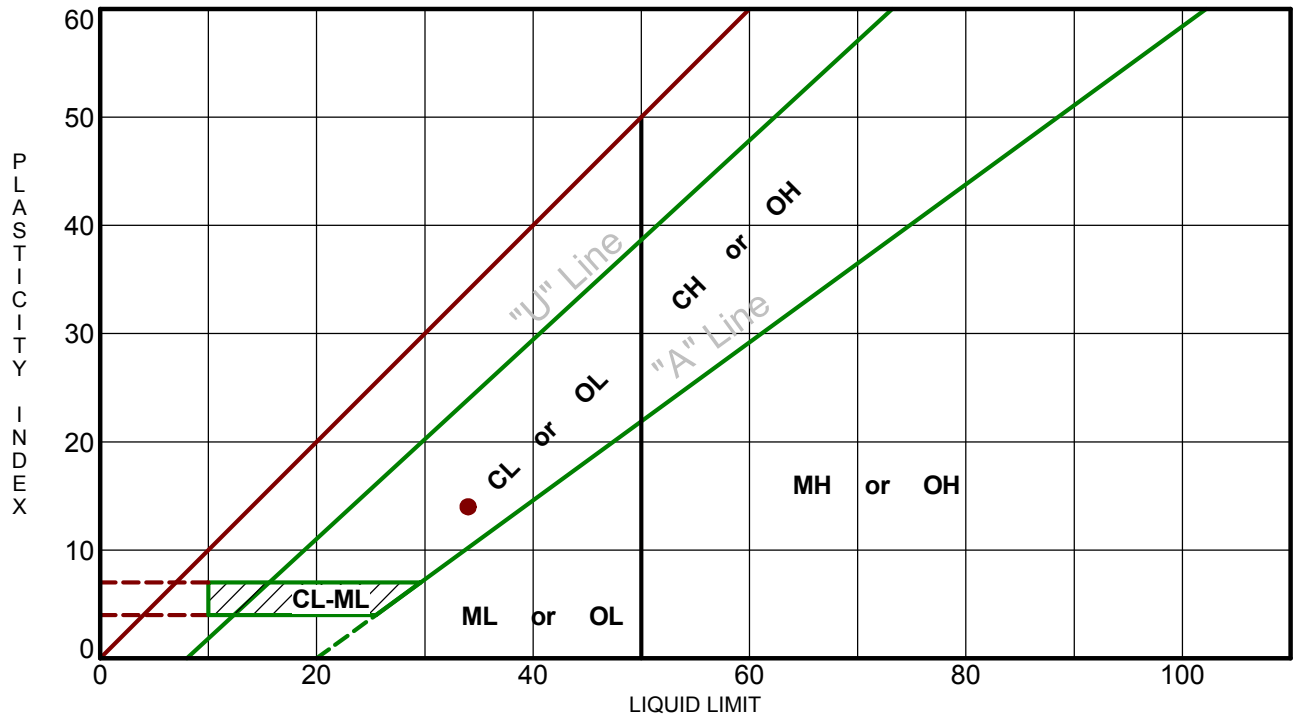
Boring Started: 10-18-2019 | Boring Completed: 10-23-2019

Drill Rig: D-90 Track | Driller: Terracon - Lodi

Project No.: 82195049

ATTERBERG LIMITS RESULTS

ASTM D4318



Boring ID	Depth	LL	PL	PI	Fines	USCS	Description
● Core #1	20 - 21.5	34	20	14		CL	Lean Clay

PROJECT: Terrestrial Horizontal Directional Drilling Route Geotechnical Survey

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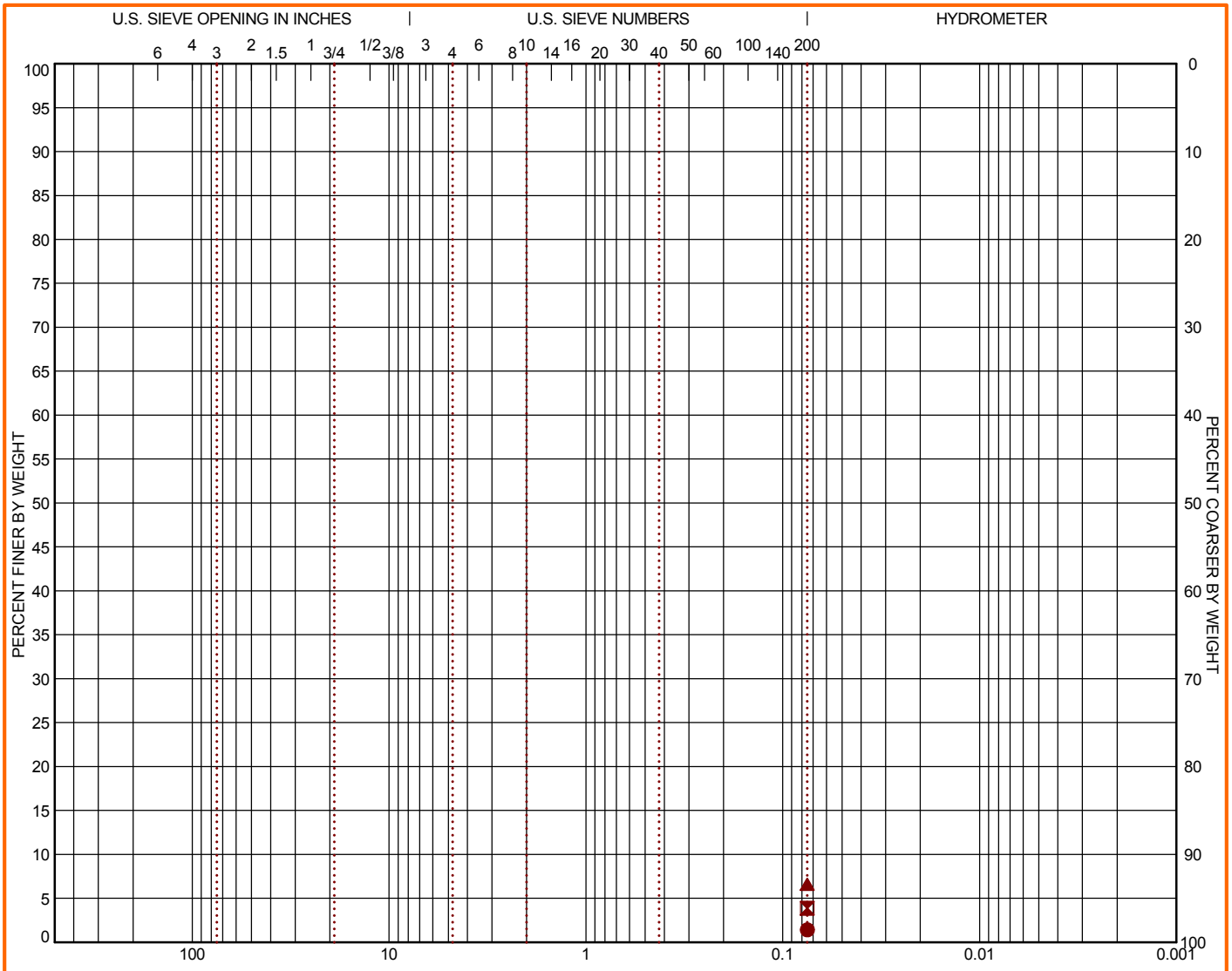
PROJECT NUMBER: 82195049

CLIENT: Oregon State University Corvallis, OR

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. ATTERBERG LIMITS 82195049 TECHNICAL SERVICE.GPJ TERRACON_DATATEMPLATE.GDT 12/31/19

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	BORING ID	DEPTH	% COBBLES	% GRAVEL	% SAND	% SILT	% FINES	% CLAY	USCS
●	Core #1	2.5 - 4					1.4		SP
⊠	Core #1	15 - 16.5					3.9		SP
▲	Core #1	30 - 31.5					6.6		SP-SM

GRAIN SIZE	●	⊠	▲
D_{60}			
D_{30}			
D_{10}			

COEFFICIENTS	●	⊠	▲
C_C			
C_U			

●		⊠		▲	
Sieve	% Finer	Sieve	% Finer	Sieve	% Finer
#200	1.42	#200	3.88	#200	6.61

SOIL DESCRIPTION	
●	Poorly Graded Sand trace Silt (SP)
⊠	Poorly Graded Sand trace Silt (SP)
▲	Poorly Graded Sand with Silt (SP-SM)

REMARKS	
●	
⊠	
▲	

PROJECT: Terrestrial Horizontal Directional Drilling Route Geotechnical Survey

SITE: 5400 NW Pacific Coast Highway Seal Rock, OR

Terracon
700 NE 55th Ave
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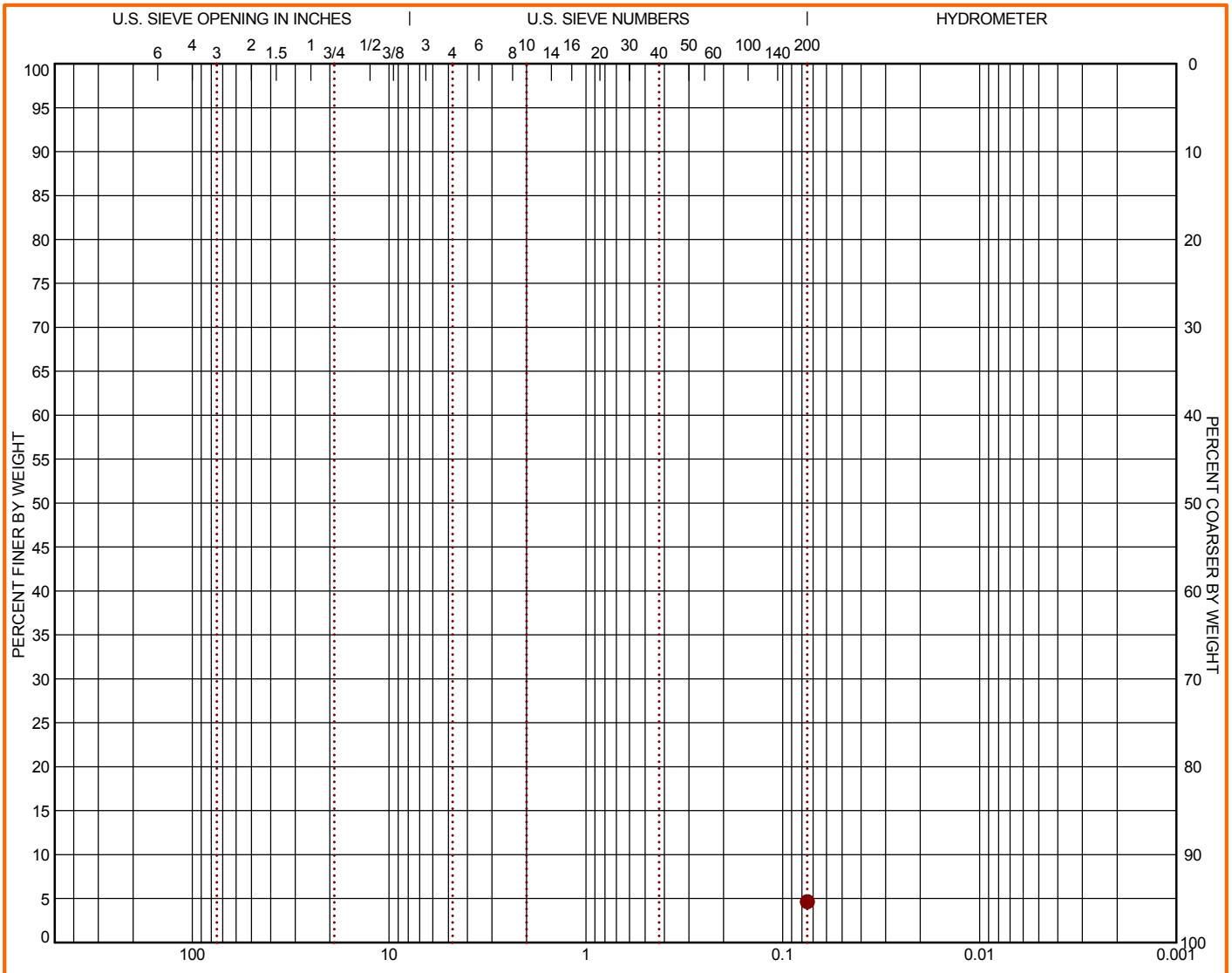
PROJECT NUMBER: 82195049

CLIENT: Oregon State University Corvallis, OR

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	BORING ID	DEPTH	% COBBLES	% GRAVEL	% SAND	% SILT	% FINES	% CLAY	USCS
●	Core #1	45 - 46.5					4.6		SP

GRAIN SIZE

	●		
D_{60}			
D_{30}			
D_{10}			

COEFFICIENTS

	●		
C_C			
C_U			

● Sieve	% Finer	Sieve	% Finer	Sieve	% Finer
#200	4.65				

SOIL DESCRIPTION

●	Poorly Graded Sand trace Silt (SP)

REMARKS

●	

PROJECT: Terrestrial Horizontal Directional Drilling Route Geotechnical Survey

SITE: 5400 NW Pacific Coast Highway Seal Rock, OR

Terracon
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Portland, OR

PROJECT NUMBER: 82195049

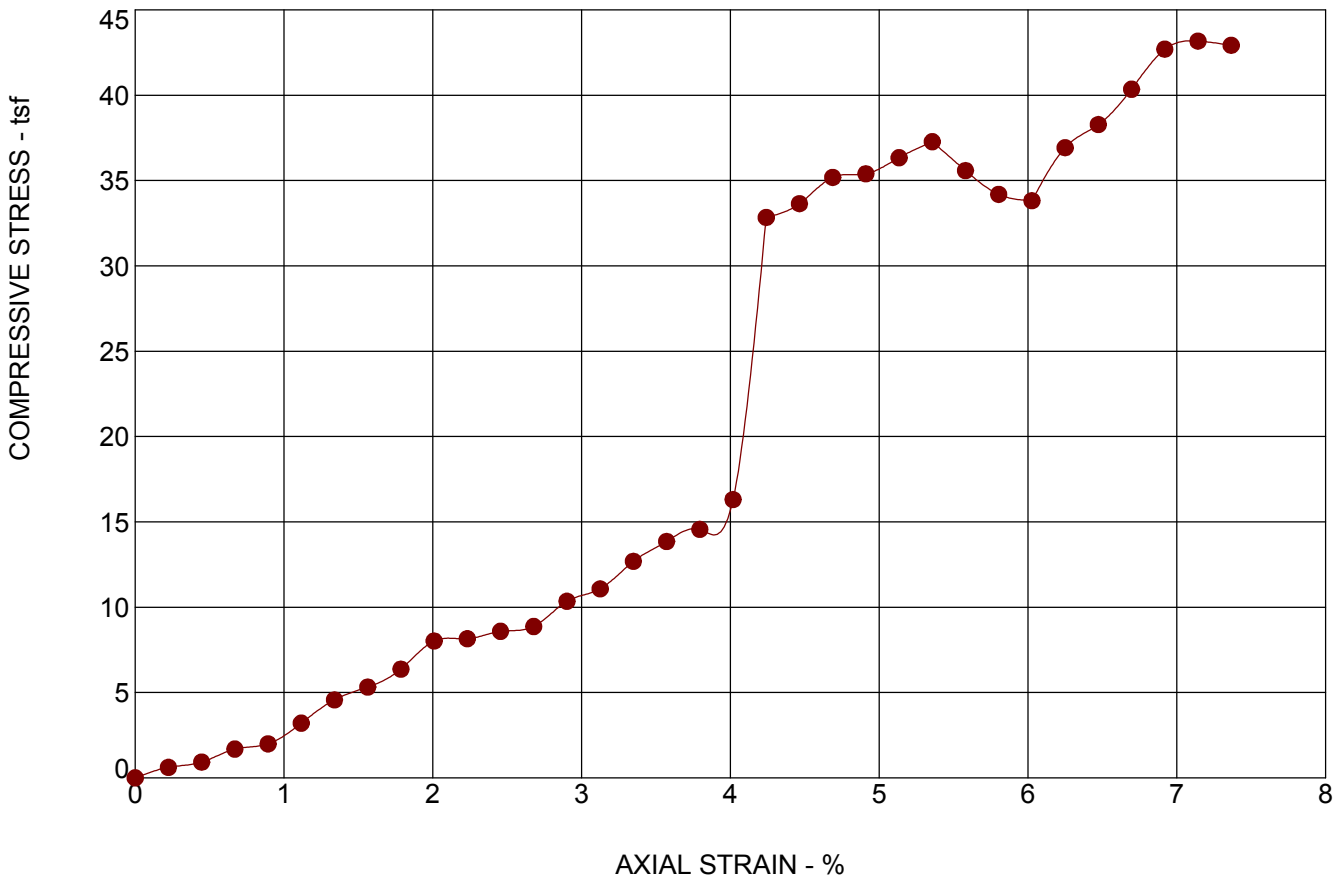
CLIENT: Oregon State University Corvallis, OR

GRAIN SIZE: USCS 1 82195049 TECHNICAL SERVICE.GPJ TERRACON_DATATEMPLATE.GDT 12/31/19

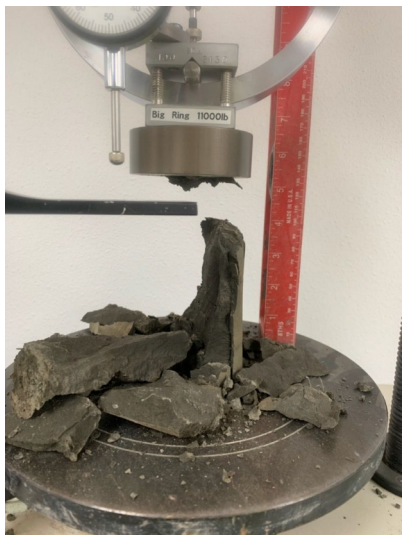
LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT.

UNCONFINED COMPRESSION TEST

ASTM D2166



SPECIMEN FAILURE PHOTOGRAPH



SPECIMEN TEST DATA

Moisture Content:	%	18
Dry Density:	pcf	108
Diameter:	in.	2.37
Height:	in.	4.48
Height / Diameter Ratio:		1.89
Calculated Saturation:	%	
Calculated Void Ratio:		
Assumed Specific Gravity:		
Failure Strain:	%	7.14
Unconfined Compressive Strength	(tsf)	43.17
Undrained Shear Strength:	(tsf)	21.58
Strain Rate:	in/min	
Remarks:		

SAMPLE TYPE: CORE

SAMPLE LOCATION: Core #1 @ 85 - 90 feet

DESCRIPTION: SILTSTONE

LL	PL	PI	Percent < #200 Sieve

PROJECT: Terrestrial Horizontal Directional Drilling Route Geotechnical Survey

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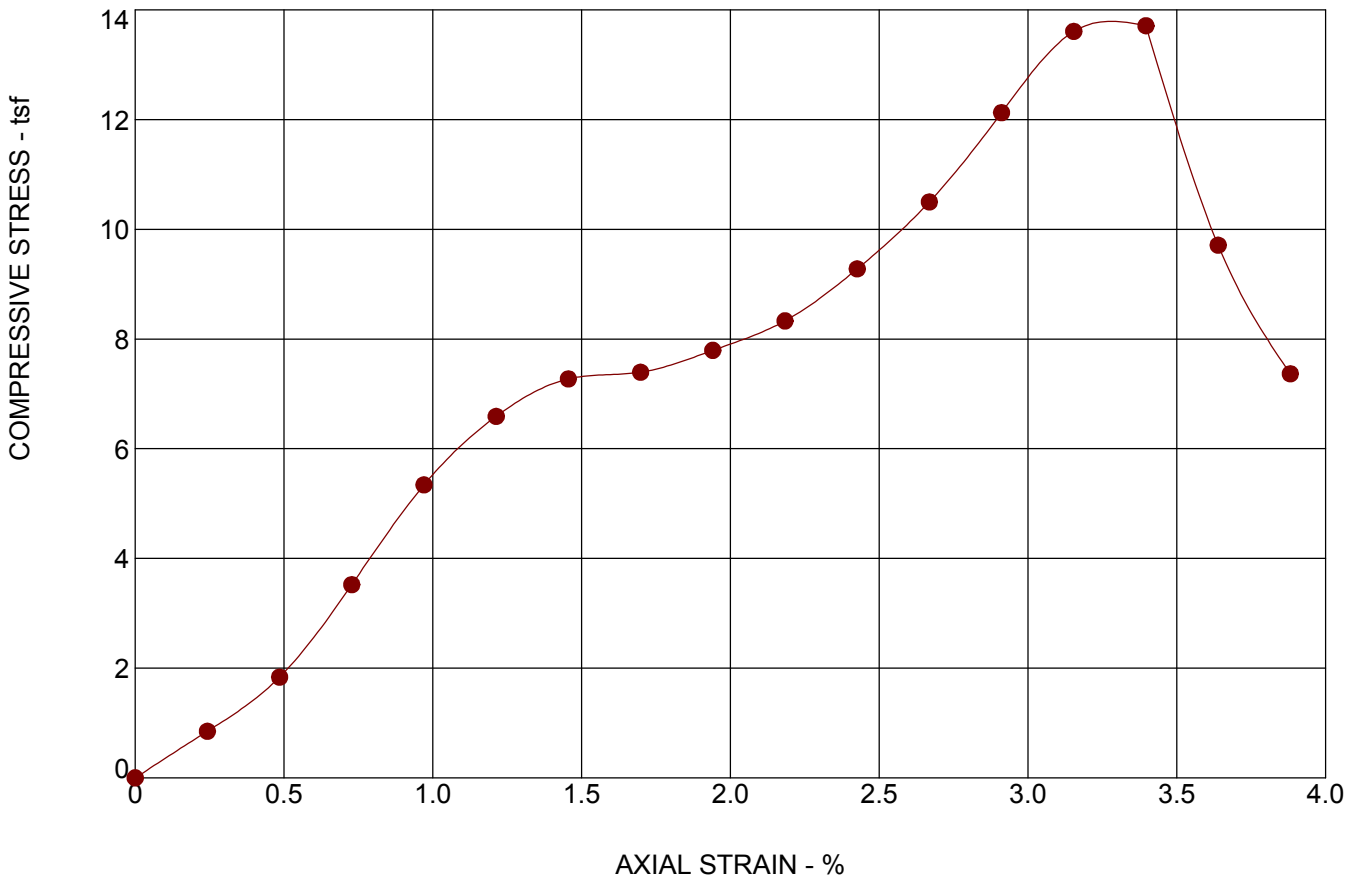
CLIENT: Oregon State University Corvallis, OR

UNCONFINED COMPRESSION TEST

ASTM D2166



SPECIMEN FAILURE PHOTOGRAPH

SPECIMEN TEST DATA

Moisture Content:	%	22
Dry Density:	pcf	98
Diameter:	in.	2.47
Height:	in.	4.12
Height / Diameter Ratio:		1.67
Calculated Saturation:	%	
Calculated Void Ratio:		
Assumed Specific Gravity:		
Failure Strain:	%	3.40
Unconfined Compressive Strength	(tsf)	13.71
Undrained Shear Strength:	(tsf)	6.86
Strain Rate:	in/min	
Remarks:		

SAMPLE TYPE: CORE

SAMPLE LOCATION: Core #1 @ 86 - 86.33 feet

DESCRIPTION: SILTSTONE

LL	PL	PI	Percent < #200 Sieve

PROJECT: Terrestrial Horizontal Directional Drilling Route Geotechnical Survey

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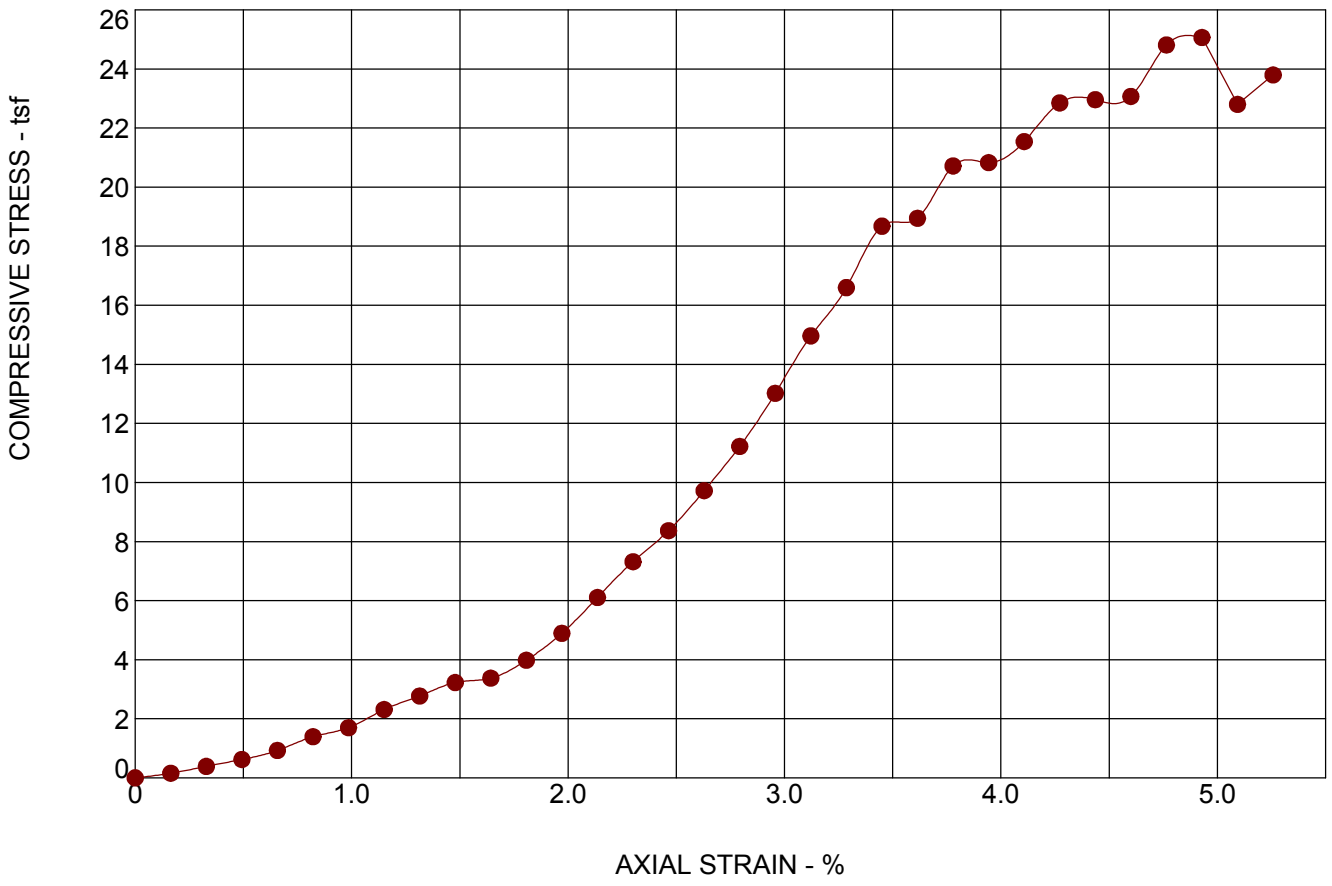
LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. UNCONFINED WITH PHOTOS 82195049 TECHNICAL SERVICE.GPJ TERRACON_DATATEMPLATE.GDT 11/21/19

UNCONFINED COMPRESSION TEST

ASTM D2166



SPECIMEN FAILURE PHOTOGRAPH

SPECIMEN TEST DATA

Moisture Content:	%	18
Dry Density:	pcf	106
Diameter:	in.	2.36
Height:	in.	6.09
Height / Diameter Ratio:		2.58
Calculated Saturation:	%	
Calculated Void Ratio:		
Assumed Specific Gravity:		
Failure Strain:	%	4.93
Unconfined Compressive Strength	(tsf)	25.06
Undrained Shear Strength:	(tsf)	12.53
Strain Rate:	in/min	
Remarks:		

SAMPLE TYPE: CORE

SAMPLE LOCATION: Core #1 @ 187 - 190 feet

DESCRIPTION: SILTSTONE

LL	PL	PI	Percent < #200 Sieve

PROJECT: Terrestrial Horizontal Directional Drilling Route Geotechnical Survey

SITE: 5400 NW Pacific Coast Highway Seal Rock, OR

Terracon
700 NE 55th Ave
Portland, OR

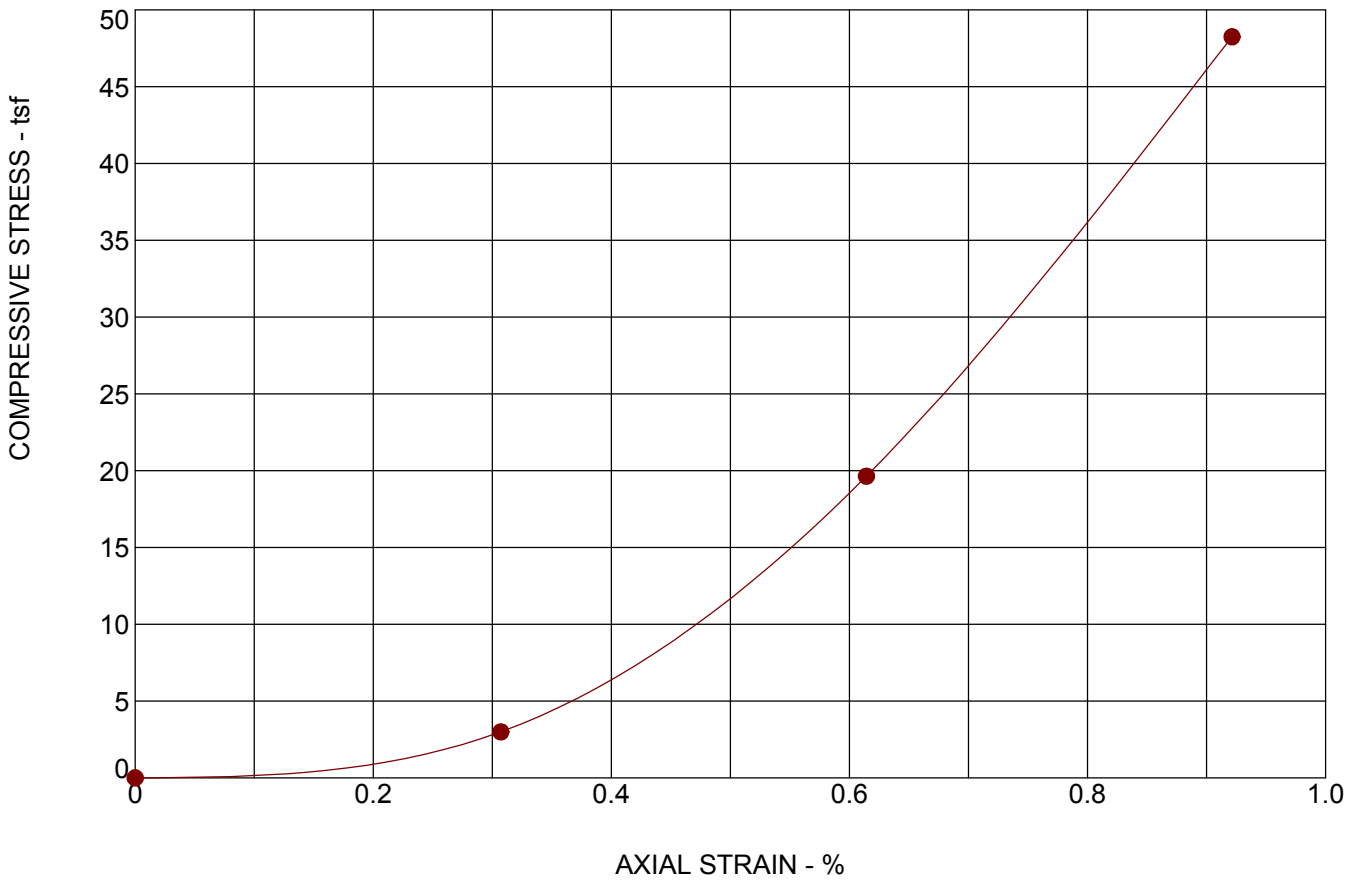
PROJECT NUMBER: 82195049

CLIENT: Oregon State University Corvallis, OR

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. UNCONFINED WITH PHOTOS 82195049 TECHNICAL SERVICE.GPJ TERRACON_DATATEMPLATE.GDT 11/21/19

UNCONFINED COMPRESSION TEST

ASTM D2166



SPECIMEN FAILURE PHOTOGRAPH

SPECIMEN TEST DATA

Moisture Content:	%	17
Dry Density:	pcf	110
Diameter:	in.	2.34
Height:	in.	3.26
Height / Diameter Ratio:		1.39
Calculated Saturation:	%	
Calculated Void Ratio:		
Assumed Specific Gravity:		
Failure Strain:	%	0.92
Unconfined Compressive Strength	(tsf)	48.25
Undrained Shear Strength:	(tsf)	24.12
Strain Rate:	in/min	
Remarks:		

SAMPLE TYPE: CORE

SAMPLE LOCATION: Core #1 @ 191.5 - 191.75 feet

DESCRIPTION: SILTSTONE

LL	PL	PI	Percent < #200 Sieve

PROJECT: Terrestrial Horizontal Directional Drilling Route Geotechnical Survey

SITE: 5400 NW Pacific Coast Highway Seal Rock, OR

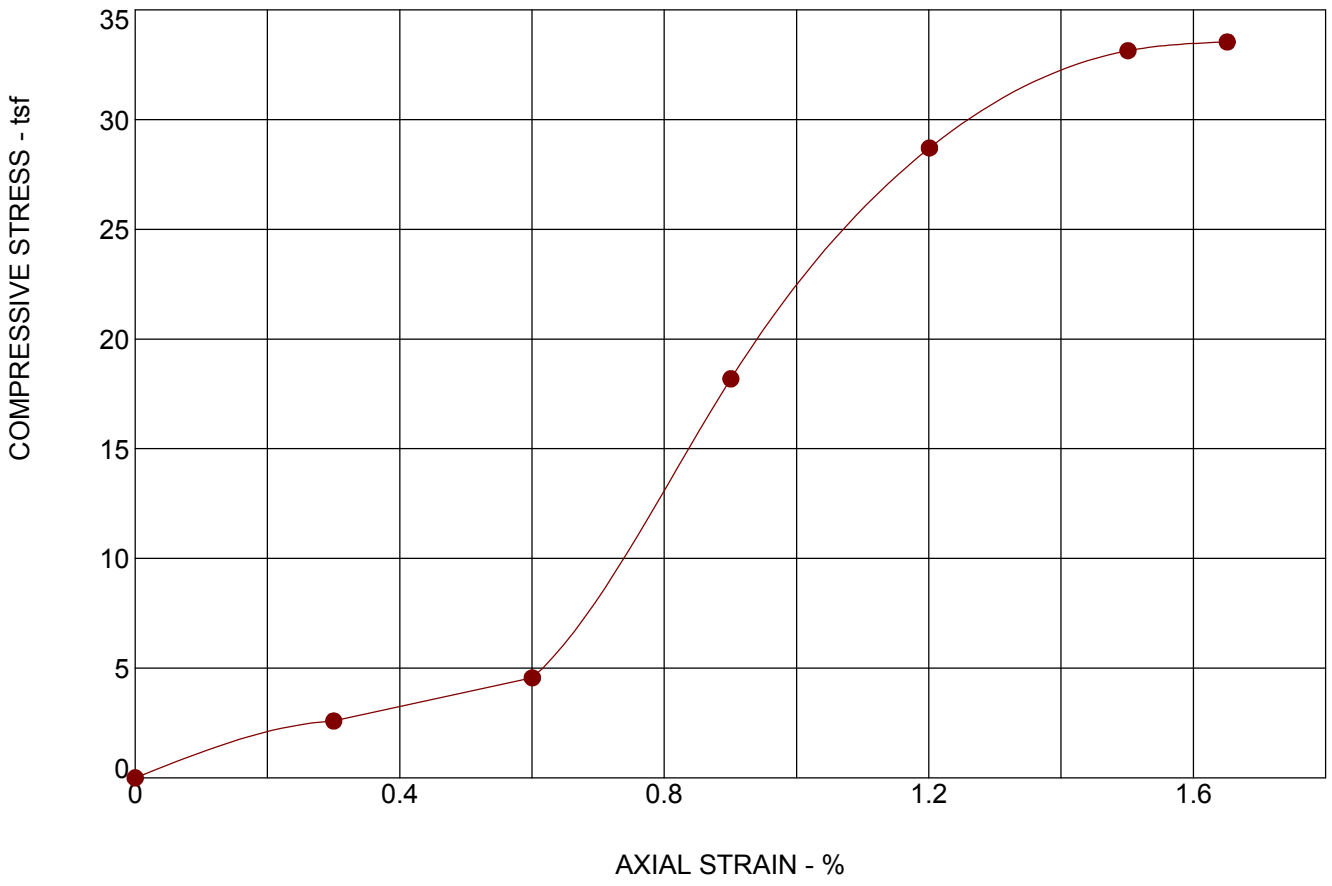
Terracon
700 NE 55th Ave
Portland, OR

PROJECT NUMBER: 82195049

CLIENT: Oregon State University Corvallis, OR

UNCONFINED COMPRESSION TEST

ASTM D2166



SPECIMEN FAILURE PHOTOGRAPH

SPECIMEN TEST DATA

Moisture Content:	%	19
Dry Density:	pcf	105
Diameter:	in.	2.38
Height:	in.	3.33
Height / Diameter Ratio:		1.40
Calculated Saturation:	%	
Calculated Void Ratio:		
Assumed Specific Gravity:		
Failure Strain:	%	1.65
Unconfined Compressive Strength	(tsf)	33.54
Undrained Shear Strength:	(tsf)	16.77
Strain Rate:	in/min	
Remarks:		

SAMPLE TYPE:

SAMPLE LOCATION: Core #1 @ 279.5 feet

DESCRIPTION: SILTSTONE

LL	PL	PI	Percent < #200 Sieve

PROJECT: Terrestrial Horizontal Directional Drilling Route Geotechnical Survey

SITE: 5400 NW Pacific Coast Highway Seal Rock, OR

Terracon
700 NE 55th Ave
Portland, OR

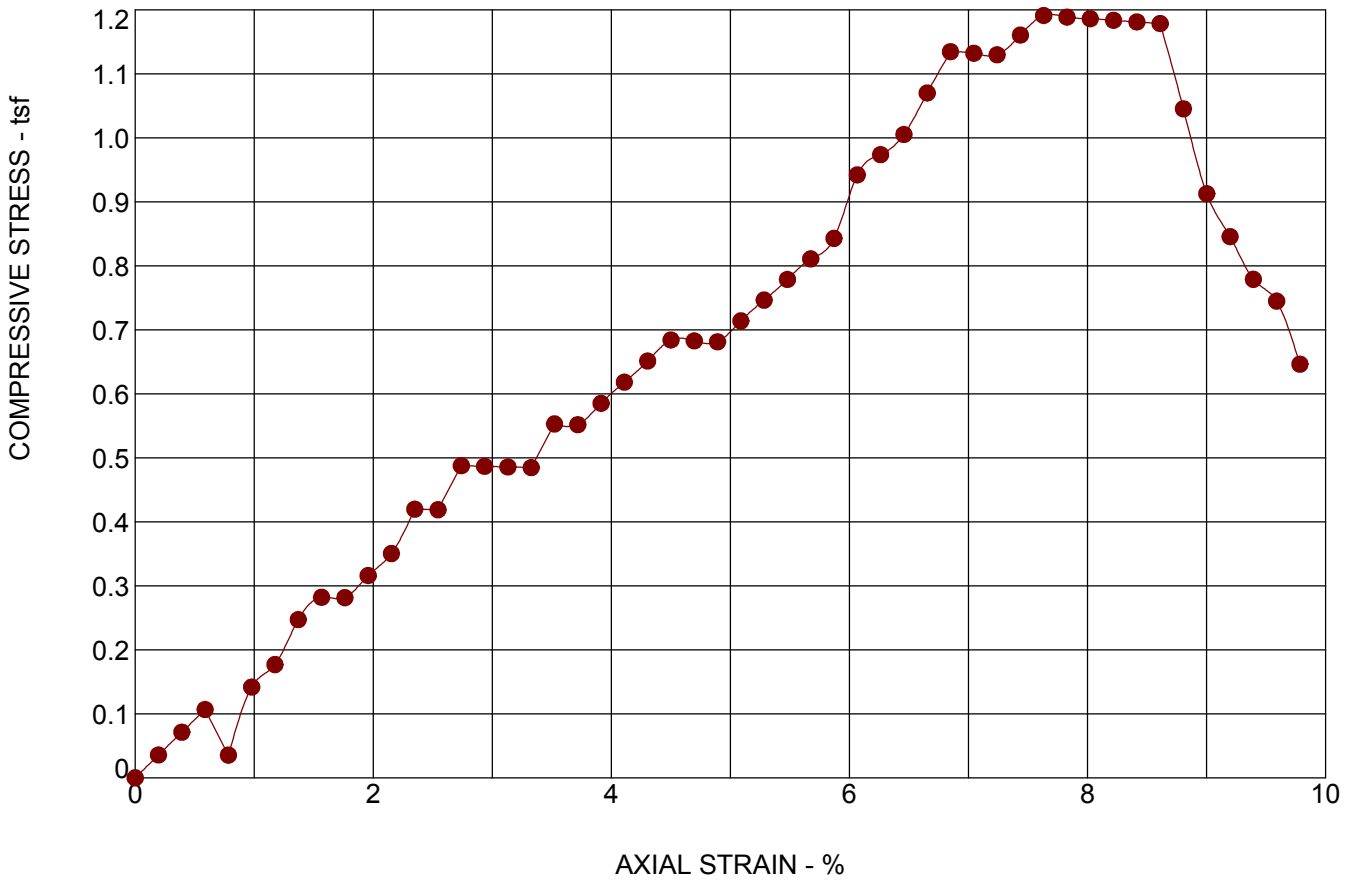
PROJECT NUMBER: 82195049

CLIENT: Oregon State University Corvallis, OR

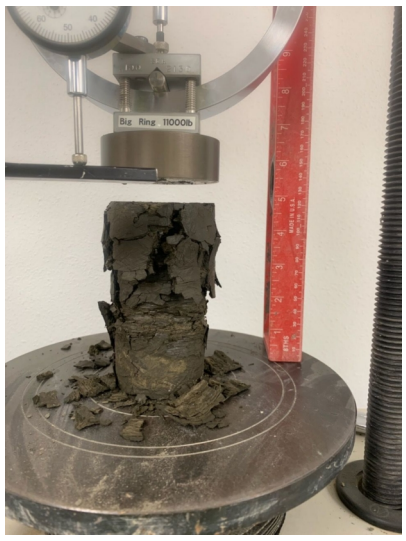
LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. UNCONFINED WITH PHOTOS 82195049 TECHNICAL SERVICE.GPJ TERRACON_DATATEMPLATE.GDT 11/21/19

UNCONFINED COMPRESSION TEST

ASTM D2166



SPECIMEN FAILURE PHOTOGRAPH



SPECIMEN TEST DATA

Moisture Content:	%	21
Dry Density:	pcf	98
Diameter:	in.	2.46
Height:	in.	5.11
Height / Diameter Ratio:		2.08
Calculated Saturation:	%	
Calculated Void Ratio:		
Assumed Specific Gravity:		
Failure Strain:	%	7.63
Unconfined Compressive Strength	(tsf)	1.19
Undrained Shear Strength:	(tsf)	0.60
Strain Rate:	in/min	
Remarks:		

SAMPLE TYPE: CORE

SAMPLE LOCATION: Core #1 @ 280 - 285 feet

DESCRIPTION: SILTSTONE

LL	PL	PI	Percent < #200 Sieve

PROJECT: Terrestrial Horizontal Directional Drilling Route Geotechnical Survey

SITE: 5400 NW Pacific Coast Highway Seal Rock, OR

Terracon
700 NE 55th Ave
Portland, OR

PROJECT NUMBER: 82195049

CLIENT: Oregon State University Corvallis, OR

Terracon

DIRECT SHEAR STRENGTH of ROCK SPECIMENS UNDER CONSTANT NORMAL FORCE ASTM D 5607

Laboratory Services Group *192 Exchange Boulevard* *Glendale Heights, IL 60139* *Phone: (630) 717-4263* *Fax: (630) 357-9489*

Project No.: 82195049 Tested By: WPQ Date: 12/20/2019
Project Name: Terrestrial Horizontal Directional Drilling Calculated By: WPQ Date: 12/23/2019
Route Geotechnical Survey Checked By: KP Date: 12/23/2019
Core No.: 1 Sample No.: 17 Depth (ft): 60.0-65.0
Rock Description: Dark Gray Claystone

Rock Sample Moisture Condition: [X] As Received [ ] In-Situ [ ] Saturated [ ] Oven Dry

Discontinuity Type: [ ] Joint [ ] Bedding Plane [ ] Cleavage [ ] Saw-Cut

Angle of Discontinuity to Core Axis: -

Filling Type and Description: [X] None [ ] Partial [ ] Complete [ ] Clay [ ] Shale [ ] Healed [ ] Mineral

Roughness Description: [ ] Planar [ ] Stepped [ ] Undulating [ ] Slickensides

Asperities: [ ] Rounded [ ] Jagged [ ] Smooth

Area of Shear Surface: 4.48 in^2

	Maximum Shear			Residual Shear		
	Test 1	Test 2	Test 3	Test 1	Test 2	Test 3
Normal Stress σ_n (psi)	51.0	61.5	70.5	51.0	61.5	70.5
Peak Shear Stress τ max (psi)	359.4	397.2	468.5	257.3	327.5	200.3

Peak Shear

For Normal Stress Range 51.0 to 70.5 psi

Angle of Friction ϕ 79.8 °

Cohesion 70.5 psi

Residual Shear

For Normal Stress Range 51.0 to 70.5 psi

Angle of Friction 76.5 °

Cohesion 0.0 psi

Joint Roughness Sketch

51.0 psi Specimen = 12-14

61.5 psi Specimen = 14-16

70.5 psi Specimen = 8-10

Remarks:

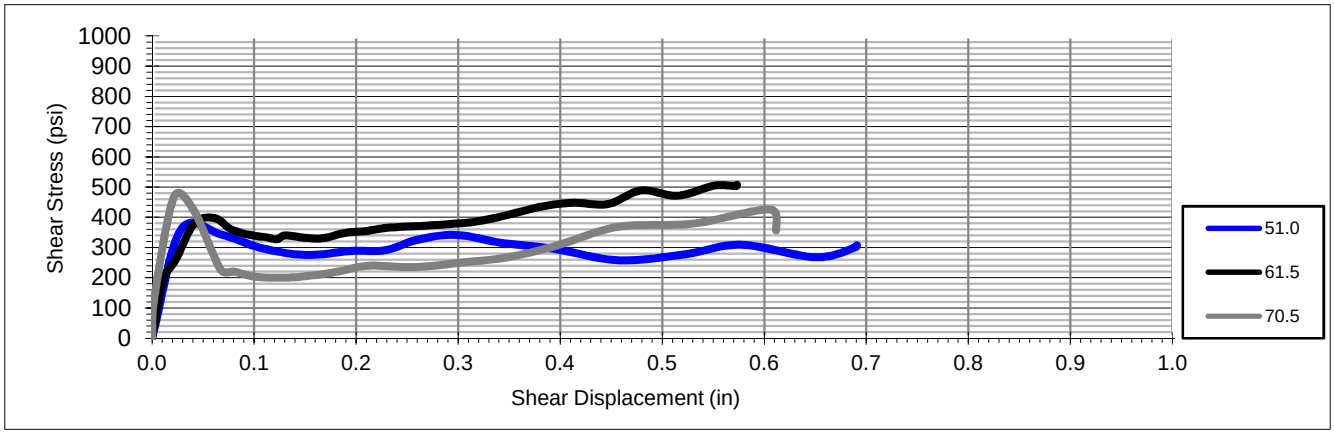
Terracon

DIRECT SHEAR STRENGTH of ROCK SPECIMENS UNDER CONSTANT NORMAL FORCE ASTM D 5607

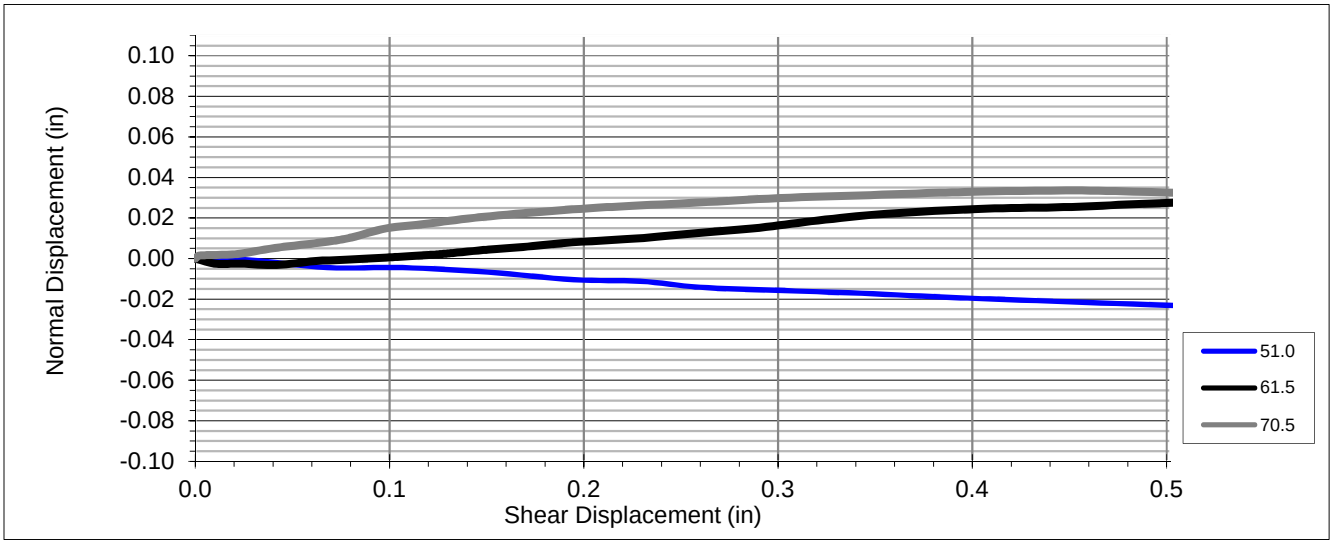
Laboratory Services Group *192 Exchange Boulevard* *Glendale Heights, IL 60139* *Phone: (630) 717-4263* *Fax: (630) 357-9489*

Project No.	82195049		Tested By:	WPQ	Date: 12/20/2019
Project Name:	Terrestrial Horizontal Directional Drilling		Calculated By:	WPQ	Date: 12/23/2019
Boring No.	Route Geotechnical Survey		Checked By:	WPQ	Date: 12/23/2019
Core No.:	1	Sample No.: 17	Depth (ft):	60.0-65.0	

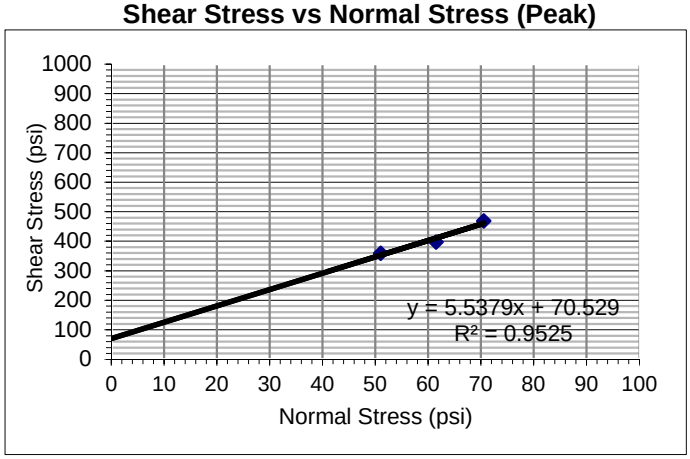
Shear Stress Vs Shear Displacement



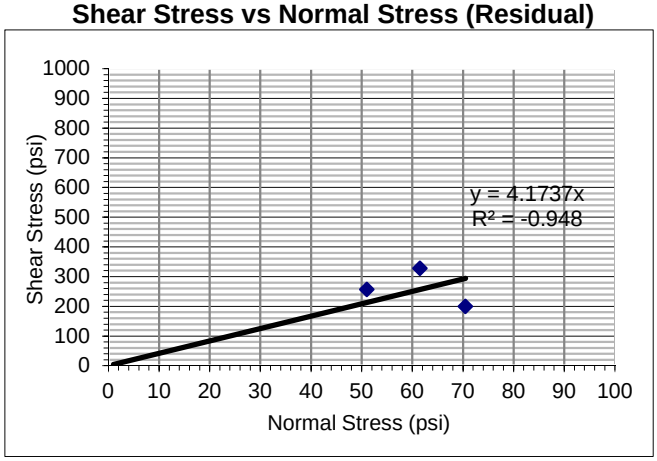
Normal Displacement Vs Shear Displacement



Shear Stress vs Normal Stress (Peak)



Shear Stress vs Normal Stress (Residual)



Project No. 82195049

Project Name: Terrestrial Horizontal Directional Drilling
Route Geotechnical Survey

Core No.: 1 Sample No.: 17

Depth (ft): 60.0-65.0

		Area (in^2)
Dia 1 (in)	2.389	4.483
Dia 2 (in)	2.387	4.473
Dia 3 (in)	2.388	4.478

Area (in^2)	Normal Stress (psi)	Peak Stress (psi)	Residual Stress (psi)
4.483	51.0	359.4	257.3
4.473	61.5	397.2	327.5
4.478	70.5	468.5	200.3

51.0 Normal Load (psi)

Shear Displacement (in)	Shear Load (lb)	Normal Displacement (in)	Area (in^2)	Shear Stress (psi)
0.0000	0	0.0000	4.48	0.00
0.0283	1611	-0.0007	4.48	359.39
0.0679	1538	-0.0045	4.48	343.12
0.1067	1339	-0.0045	4.48	298.75
0.1507	1233	-0.0067	4.48	275.08
0.1947	1293	-0.0104	4.48	288.39
0.2290	1306	-0.0112	4.48	291.35
0.2596	1458	-0.0142	4.48	325.37
0.2983	1531	-0.0156	4.48	341.64
0.3431	1412	-0.0171	4.48	315.02
0.3938	1326	-0.0194	4.48	295.79
0.4580	1153	-0.0216	4.48	257.33
0.5229	1246	-0.0238	4.48	278.04
0.5773	1386	-0.0261	4.48	309.10
0.6504	1200	-0.0276	4.48	267.68
0.6899	1352	-0.0283	4.48	301.71
0.6907	1379	-0.0283	4.48	307.62

61.5 Normal Load (psi)

Shear Displacement (in)	Shear Load (lb)	Normal Displacement (in)	Area (in^2)	Shear Stress (psi)
0.0000	0	0.0000	4.47	0.00
0.0108	849	-0.0025	4.47	189.70
0.0235	1167	-0.0025	4.47	260.83
0.0418	1707	-0.0032	4.47	381.62
0.0615	1777	-0.0013	4.47	397.19
0.0761	1624	-0.0006	4.47	363.10
0.0888	1551	0.0000	4.47	346.79
0.1014	1515	0.0006	4.47	338.64
0.1116	1495	0.0013	4.47	334.19
0.1224	1465	0.0019	4.47	327.52
0.1306	1521	0.0025	4.47	340.12
0.1509	1485	0.0044	4.47	331.97
0.1686	1482	0.0057	4.47	331.23
0.1889	1558	0.0076	4.47	348.27
0.2092	1584	0.0089	4.47	354.20
0.2308	1634	0.0101	4.47	365.32
0.2593	1657	0.0127	4.47	370.51
0.2904	1687	0.0152	4.47	377.18
0.3170	1724	0.0184	4.47	385.33
0.3481	1823	0.0215	4.47	407.54
0.3804	1942	0.0234	4.47	434.22
0.4115	2005	0.0247	4.47	448.30
0.4470	1985	0.0253	4.47	443.86
0.4793	2188	0.0266	4.47	489.06
0.5148	2108	0.0279	4.47	471.28
0.5509	2257	0.0285	4.47	504.62

70.5 Normal Load (psi)

Shear Displacement (in)	Shear Load (lb)	Normal Displacement (in)	Area (in^2)	Shear Stress (psi)
0.0000	0	0.0000	4.48	0.00
0.0022	593	0.0015	4.48	132.35
0.0216	2098	0.0022	4.48	468.45
0.0410	1891	0.0052	4.48	422.32
0.0671	1018	0.0082	4.48	227.27
0.0806	987	0.0104	4.48	220.30
0.0985	916	0.0149	4.48	204.63
0.1193	897	0.0171	4.48	200.27
0.1440	909	0.0201	4.48	202.88
0.1783	975	0.0231	4.48	217.69
0.2118	1072	0.0253	4.48	239.46
0.2581	1053	0.0276	4.48	235.11
0.3006	1115	0.0298	4.48	249.04
0.3476	1197	0.0313	4.48	267.33
0.3961	1369	0.0328	4.48	305.62
0.4565	1650	0.0335	4.48	368.33
0.5296	1696	0.0320	4.48	378.78
0.6056	1907	0.0328	4.48	425.80
0.6116	1607	0.0320	4.48	358.75
0.6116	1599	0.0320	4.48	357.00

	0.5725	2251	0.0298	4.47	503.14
	0.5731	2271	0.0298	4.47	507.59

Project No. 82195049
Project Name: Terrestrial Horizontal Directional Drilling Route Geotechnical Survey
Core No.: 1
Sample No.: 17
Depth: 60.0-65.0

51.0 psi Normal Stress Point

61.5 psi Normal Stress Point

70.5 psi Normal Stress Point

Terracon

DIRECT SHEAR STRENGTH of ROCK SPECIMENS UNDER CONSTANT NORMAL FORCE ASTM D 5607

Laboratory Services Group *192 Exchange Boulevard* *Glendale Heights, IL 60139* *Phone: (630) 717-4263* *Fax: (630) 357-9489*

Project No.: 82195049 Tested By: WPQ Date: 12/20/2019
Project Name: Terrestrial Horizontal Directional Drilling Calculated By: WPQ Date: 12/23/2019
Route Geotechnical Survey Checked By: KP Date: 12/23/2019
Core No.: 1 Sample No.: 37 Depth (ft): 160.0-165.0
Rock Description: Dark Gray Claystone

Rock Sample Moisture Condition: [X] As Received [ ] In-Situ [ ] Saturated [ ] Oven Dry

Discontinuity Type: [ ] Joint [ ] Bedding Plane [ ] Cleavage [ ] Saw-Cut

Angle of Discontinuity to Core Axis: -

Filling Type and Description: [X] None [ ] Partial [ ] Complete [ ] Clay [ ] Shale [ ] Healed [ ] Mineral

Roughness Description: [ ] Planar [ ] Stepped [ ] Undulating [ ] Slickensides

Asperities: [ ] Rounded [ ] Jagged [ ] Smooth

Area of Shear Surface: 4.49 in^2

	Maximum Shear			Residual Shear		
	Test 1	Test 2	Test 3	Test 1	Test 2	Test 3
Normal Stress σ_n (psi)	81.4	93.8	106.7	81.4	93.8	106.7
Peak Shear Stress τ max (psi)	728.9	712.0	847.4	454.7	512.0	159.8

Peak Shear

For Normal Stress Range 81 to 107 psi

Angle of Friction ϕ 78.0 °

Cohesion 318.9 psi

Residual Shear

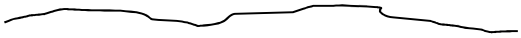
For Normal Stress Range 81 to 107 psi

Angle of Friction 75.3 °

Cohesion 0.0 psi

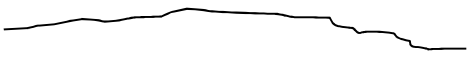
Joint Roughness Sketch

81.4 psi Specimen = 14-16



93.8 psi Specimen = 10-12

106.7 psi Specimen = 14-16



Remarks:

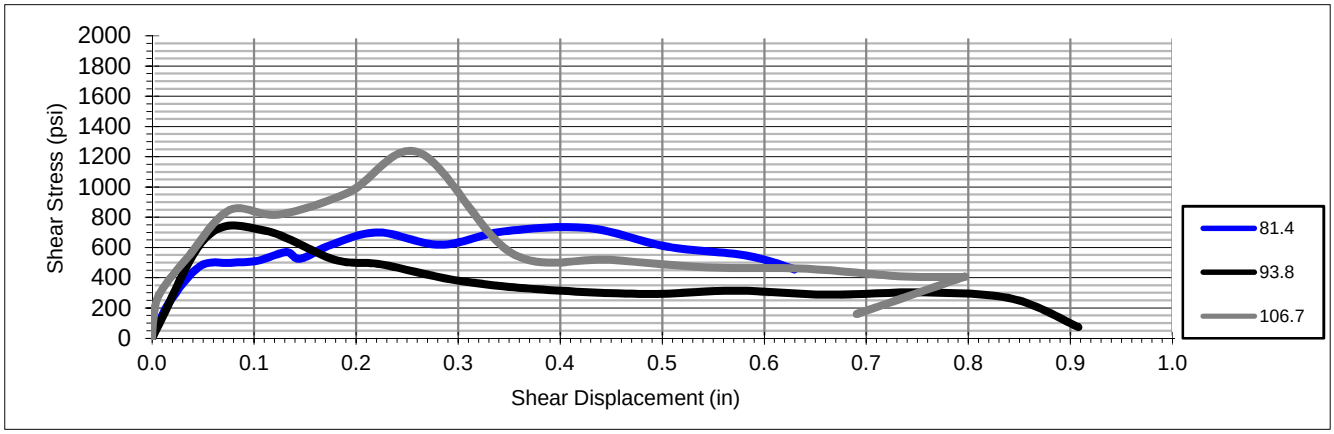
Terracon

DIRECT SHEAR STRENGTH of ROCK SPECIMENS UNDER CONSTANT NORMAL FORCE ASTM D 5607

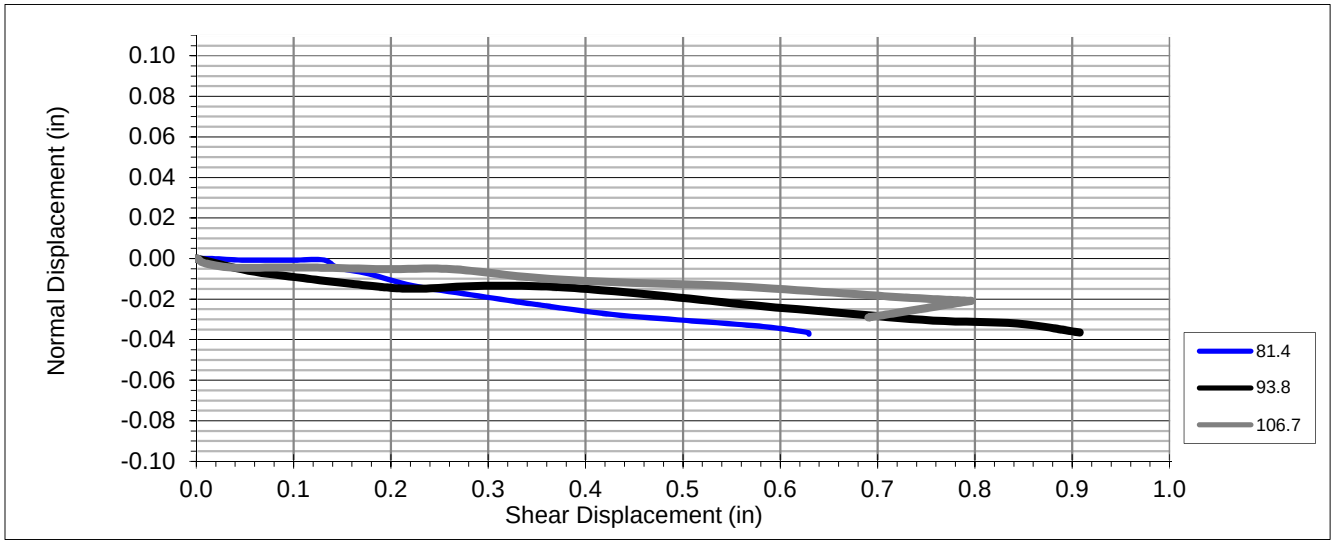
Laboratory Services Group *192 Exchange Boulevard* *Glendale Heights, IL 60139* *Phone: (630) 717-4263* *Fax: (630) 357-9489*

Project No.	82195049	Tested By:	WPQ	Date:	12/20/2019
Project Name:	Terrestrial Horizontal Directional Drilling	Calculated By:	WPQ	Date:	12/23/2019
Boring No.	Route Geotechnical Survey	Checked By:	WPQ	Date:	12/23/2019
Core No.:	1 Sample No.: 37	Depth (ft):	160.0-165.0		

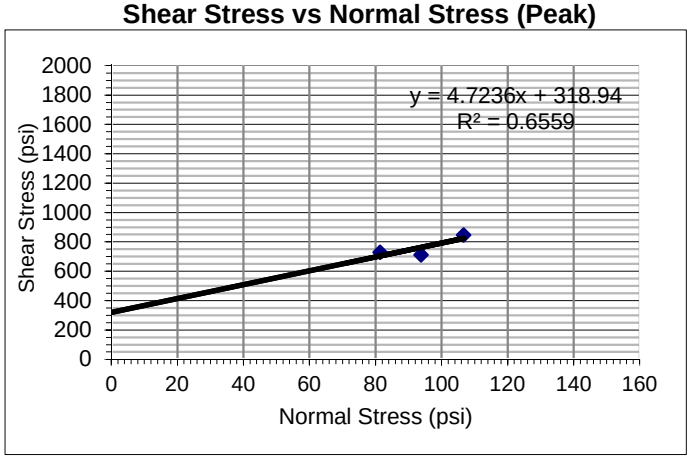
Shear Stress Vs Shear Displacement



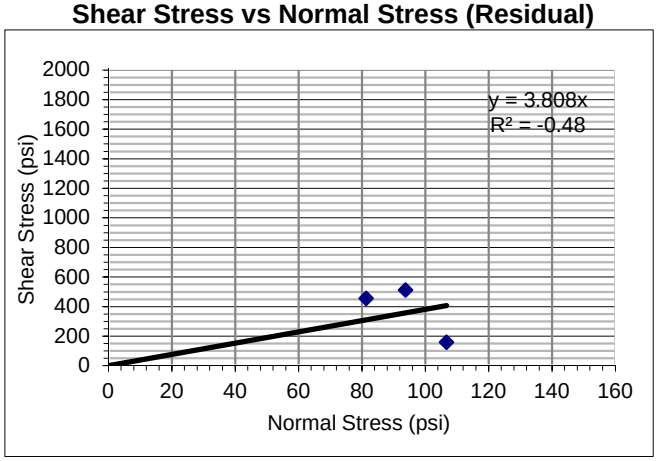
Normal Displacement Vs Shear Displacement



Shear Stress vs Normal Stress (Peak)



Shear Stress vs Normal Stress (Residual)



Project No. 82195049

Project Name: Terrestrial Horizontal Directional Drilling
Route Geotechnical Survey

Core No.: 1 Sample No.: 37

Depth (ft): 160.0-165.0

		Area (in^2)	Area (in^2)	Normal Stress (psi)	Peak Stress (psi)	Residual Stress (psi)
Dia 1 (in)	2.392	4.494	4.494	81.4	728.9	454.7
Dia 2 (in)	2.399	4.518	4.518	93.8	712.0	512.0
Dia 3 (in)	2.396	4.510	4.510	106.7	847.4	159.8

81.4 Normal Load (psi)					93.8 Normal Load (psi)					106.7 Normal Load (psi)				
Shear Displacement (in)	Shear Load (lb)	Normal Displacement (in)	Area (in^2)	Shear Stress (psi)	Shear Displacement (in)	Shear Load (lb)	Normal Displacement (in)	Area (in^2)	Shear Stress (psi)	Shear Displacement (in)	Shear Load (lb)	Normal Displacement (in)	Area (in^2)	Shear Stress (psi)
0.0000	0	0.0000	4.49	0.00	0.0000	0	0.0000	4.52	0.00	0.0000	0	0.0000	4.51	0.00
0.0164	1037	0.0000	4.49	230.83	0.0537	3034	-0.0060	4.52	671.46	0.0015	614	0.0000	4.51	136.19
0.0470	2137	-0.0007	4.49	475.55	0.1104	3217	-0.0097	4.52	712.03	0.0082	1368	-0.0022	4.51	303.26
0.0768	2238	-0.0007	4.49	498.11	0.1783	2351	-0.0134	4.52	520.43	0.0365	2473	-0.0045	4.51	548.41
0.1037	2301	-0.0007	4.49	512.00	0.2245	2207	-0.0149	4.52	488.50	0.0761	3822	-0.0045	4.51	847.44
0.1313	2558	-0.0007	4.49	569.23	0.2961	1739	-0.0134	4.52	384.94	0.1246	3691	-0.0045	4.51	818.38
0.1454	2363	-0.0045	4.49	525.88	0.3767	1466	-0.0142	4.52	324.52	0.1932	4357	-0.0052	4.51	966.08
0.1768	2792	-0.0075	4.49	621.30	0.4833	1322	-0.0186	4.52	292.58	0.2618	5539	-0.0052	4.51	1228.17
0.2223	3143	-0.0134	4.49	699.41	0.5728	1419	-0.0231	4.52	314.16	0.3528	2530	-0.0097	4.51	561.12
0.2827	2776	-0.0179	4.49	617.83	0.6623	1299	-0.0268	4.52	287.40	0.4483	2337	-0.0119	4.51	518.14
0.3446	3174	-0.0224	4.49	706.35	0.7571	1369	-0.0306	4.52	302.94	0.5437	2113	-0.0134	4.51	468.50
0.4274	3276	-0.0276	4.49	728.92	0.8436	1174	-0.0320	4.52	259.78	0.6414	2069	-0.0164	4.51	458.82
0.5042	2722	-0.0306	4.49	605.68	0.9077	331	-0.0365	4.52	73.36	0.7332	1848	-0.0194	4.51	409.80
0.5825	2457	-0.0335	4.49	546.71	0.9077	335	-0.0365	4.52	74.22	0.7966	1829	-0.0209	4.51	405.56
0.6288	2059	-0.0365	4.49	458.19						0.7966	1840	-0.0209	4.51	407.98
0.6295	2043	-0.0373	4.49	454.72						0.6907	721	-0.0291	4.51	159.81
										0.6914	732	-0.0291	4.51	162.23

Project No. 82195049
Project Name: Terrestrial Horizontal Directional Drilling Route Geotechnical Survey
Core No. 1
Sample No.: 37
Depth (ft): 160.0-165.0

81.4 psi Normal Stress Point

93.8 psi Normal Stress Point

106.7 psi Normal Stress Point

Terracon

DIRECT SHEAR STRENGTH of ROCK SPECIMENS UNDER CONSTANT NORMAL FORCE ASTM D 5607

Laboratory Services Group *192 Exchange Boulevard* *Glendale Heights, IL 60139* *Phone: (630) 717-4263* *Fax: (630) 357-9489*

Project No.: 82195049 Tested By: WPQ Date: 12/20/2019
Project Name: Terrestrial Horizontal Directional Drilling Calculated By: WPQ Date: 12/23/2019
Route Geotechnical Survey Checked By: KP Date: 12/23/2019
Core No.: 1 Sample No.: 58 Depth (ft): 260.0-265.0
Rock Description: Dark Gray Claystone

Rock Sample Moisture Condition: [X] As Received [ ] In-Situ [ ] Saturated [ ] Oven Dry

Discontinuity Type: [ ] Joint [ ] Bedding Plane [ ] Cleavage [ ] Saw-Cut

Angle of Discontinuity to Core Axis: -

Filling Type and Description: [X] None [ ] Partial [ ] Complete [ ] Clay [ ] Shale [ ] Healed [ ] Mineral

Roughness Description: [ ] Planar [ ] Stepped [ ] Undulating [ ] Slickensides

Asperities: [ ] Rounded [ ] Jagged [ ] Smooth

Area of Shear Surface: 4.47 in^2

	Maximum Shear			Residual Shear		
	Test 1	Test 2	Test 3	Test 1	Test 2	Test 3
Normal Stress σ_n (psi)	123.5	134.5	147.0	123.5	134.5	147.0
Peak Shear Stress τ max (psi)	670.3	740.3	791.5	230.7	151.4	192.2

Peak Shear

For Normal Stress Range 124 to 147 psi

Angle of Friction ϕ 79.0 °

Cohesion 41.2 psi

Residual Shear

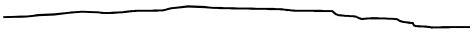
For Normal Stress Range 124 to 147 psi

Angle of Friction 54.5 °

Cohesion 0.0 psi

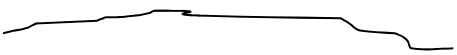
Joint Roughness Sketch

123.5 psi Specimen = 8-10



134.5 psi Specimen = 12-14

147.0 psi Specimen = 8-10



Remarks:

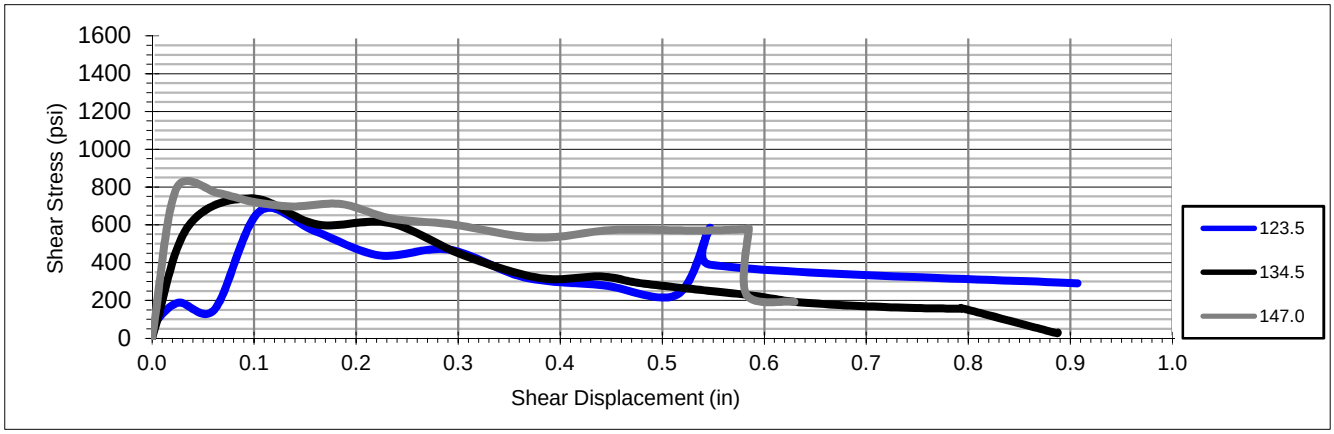
Terracon

DIRECT SHEAR STRENGTH of ROCK SPECIMENS UNDER CONSTANT NORMAL FORCE ASTM D 5607

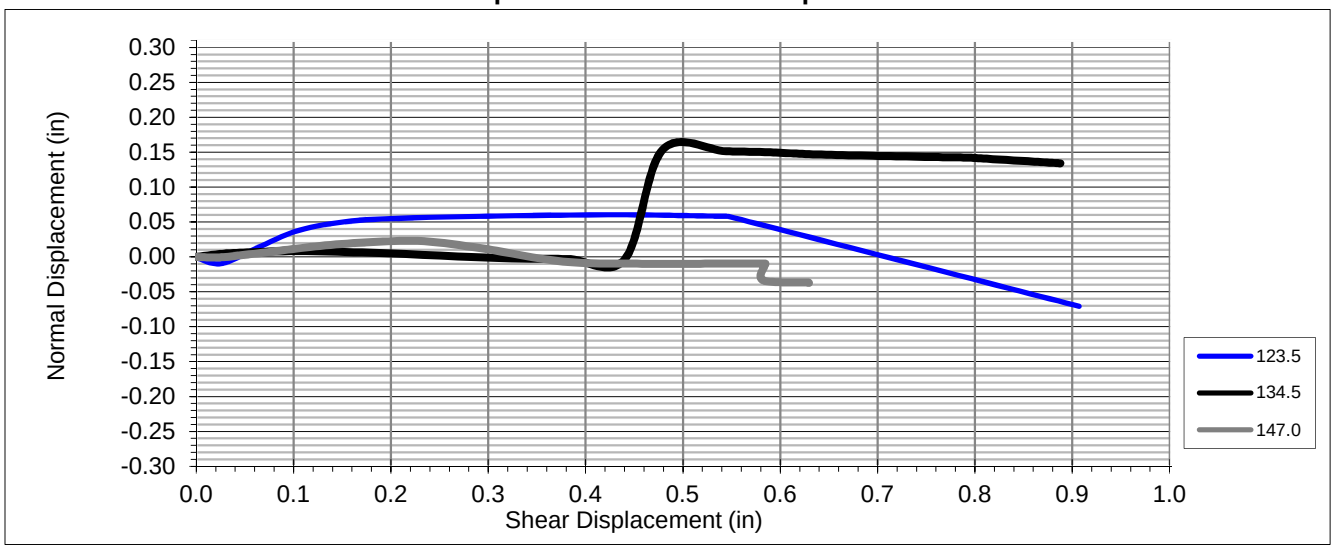
Laboratory Services Group *192 Exchange Boulevard* *Glendale Heights, IL 60139* *Phone: (630) 717-4263* *Fax: (630) 357-9489*

Project No.	82195049	Tested By:	WPQ	Date:	12/20/2019
Project Name:	Terrestrial Horizontal Directional Drilling	Calculated By:	WPQ	Date:	12/23/2019
Boring No.	Route Geotechnical Survey	Checked By:	WPQ	Date:	12/23/2019
Core No.:	1 Sample No.: 58	Depth (ft):	260.0-265.0		

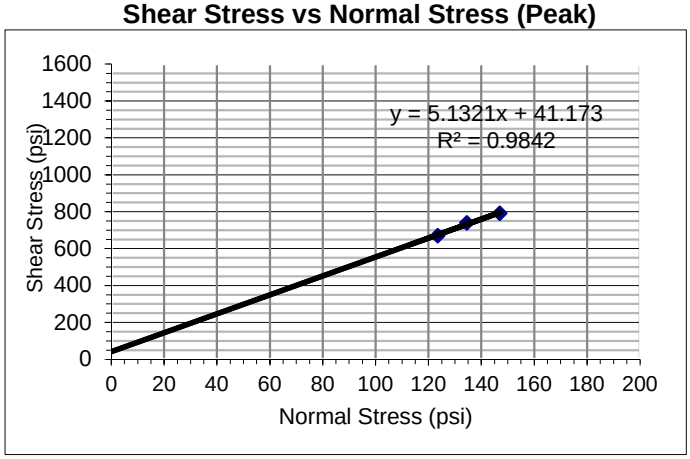
Shear Stress Vs Shear Displacement



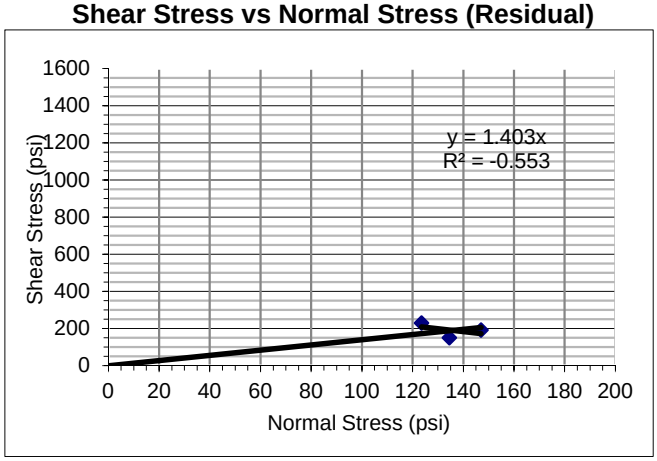
Normal Displacement Vs Shear Displacement



Shear Stress vs Normal Stress (Peak)



Shear Stress vs Normal Stress (Residual)



Project No. 82195049

Project Name: Terrestrial Horizontal Directional Drilling
Route Geotechnical Survey

Core No.: 1 Sample No.: 58

Depth (ft): 260.0-265.0

		Area (in^2)
Dia 1 (in)	2.386	4.471
Dia 2 (in)	2.388	4.478
Dia 3 (in)	2.387	4.477

Area (in^2)	Normal Stress (psi)	Peak Stress (psi)	Residual Stress (psi)
4.471	123.5	670.3	230.7
4.478	134.5	740.3	151.4
4.477	147.0	791.5	192.2

123.5 Normal Load (psi)

Shear Displacement (in)	Shear Load (lb)	Normal Displacement (in)	Area (in^2)	Shear Stress (psi)
0.0000	0	0.0000	4.47	0.00
0.0000	267	-0.0007	4.47	59.79
0.0254	841	-0.0097	4.47	187.99
0.0612	677	0.0119	4.47	151.36
0.1052	2997	0.0380	4.47	670.29
0.1596	2533	0.0514	4.47	566.49
0.2230	1960	0.0559	4.47	438.29
0.2909	2096	0.0581	4.47	468.82
0.3647	1441	0.0596	4.47	322.30
0.4423	1250	0.0604	4.47	279.58
0.5147	1032	0.0589	4.47	230.73
0.5467	2615	0.0581	4.47	584.81
0.5467	1741	0.0581	4.47	389.46
0.9070	1299	-0.0708	4.47	290.44

134.5 Normal Load (psi)

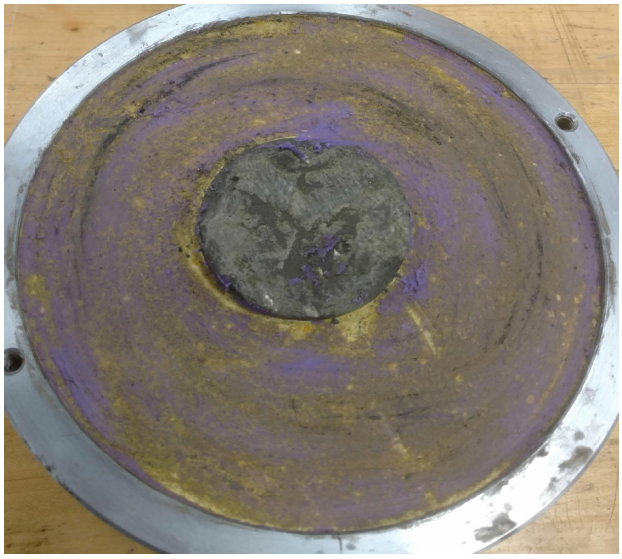
Shear Displacement (in)	Shear Load (lb)	Normal Displacement (in)	Area (in^2)	Shear Stress (psi)
0.0000	0	0.0000	4.48	0.00
0.0351	2636	0.0052	4.48	588.73
0.0970	3315	0.0082	4.48	740.26
0.1619	2695	0.0067	4.48	601.79
0.2327	2730	0.0030	4.48	609.63
0.3051	1965	-0.0015	4.48	438.94
0.3804	1423	-0.0030	4.48	317.87
0.4401	1462	-0.0037	4.48	326.58
0.4791	1302	0.1535	4.48	290.87
0.5445	1126	0.1513	4.48	251.36
0.5900	1006	0.1498	4.48	224.61
0.6377	843	0.1468	4.48	188.34
0.7295	728	0.1438	4.48	162.48
0.7929	700	0.1423	4.48	156.38
0.7929	716	0.1423	4.48	159.86
0.8869	117	0.1341	4.48	26.13
0.8877	133	0.1341	4.48	29.62

147.0 Normal Load (psi)

Shear Displacement (in)	Shear Load (lb)	Normal Displacement (in)	Area (in^2)	Shear Stress (psi)
0.0000	0	0.0000	4.48	0.00
0.0239	3543	-0.0007	4.48	791.46
0.0641	3441	0.0052	4.48	768.60
0.0985	3233	0.0112	4.48	722.16
0.1380	3121	0.0171	4.48	697.18
0.1857	3178	0.0216	4.48	710.02
0.2342	2836	0.0224	4.48	633.59
0.2946	2692	0.0119	4.48	601.45
0.3767	2382	-0.0067	4.48	532.17
0.4527	2564	-0.0097	4.48	572.87
0.5363	2548	-0.0097	4.48	569.30
0.5833	2587	-0.0097	4.48	577.87
0.5848	2603	-0.0097	4.48	581.44
0.5825	1030	-0.0335	4.48	230.02
0.6288	867	-0.0365	4.48	193.58
0.6295	860	-0.0373	4.48	192.15

Project No. 82195049
Project Name: Terrestrial Horizontal Directional Drilling Route Geotechnical Survey
Core No. 1
Sample No. 58
Depth (ft): 260.0-265.0

123.5 psi Normal Stress Point

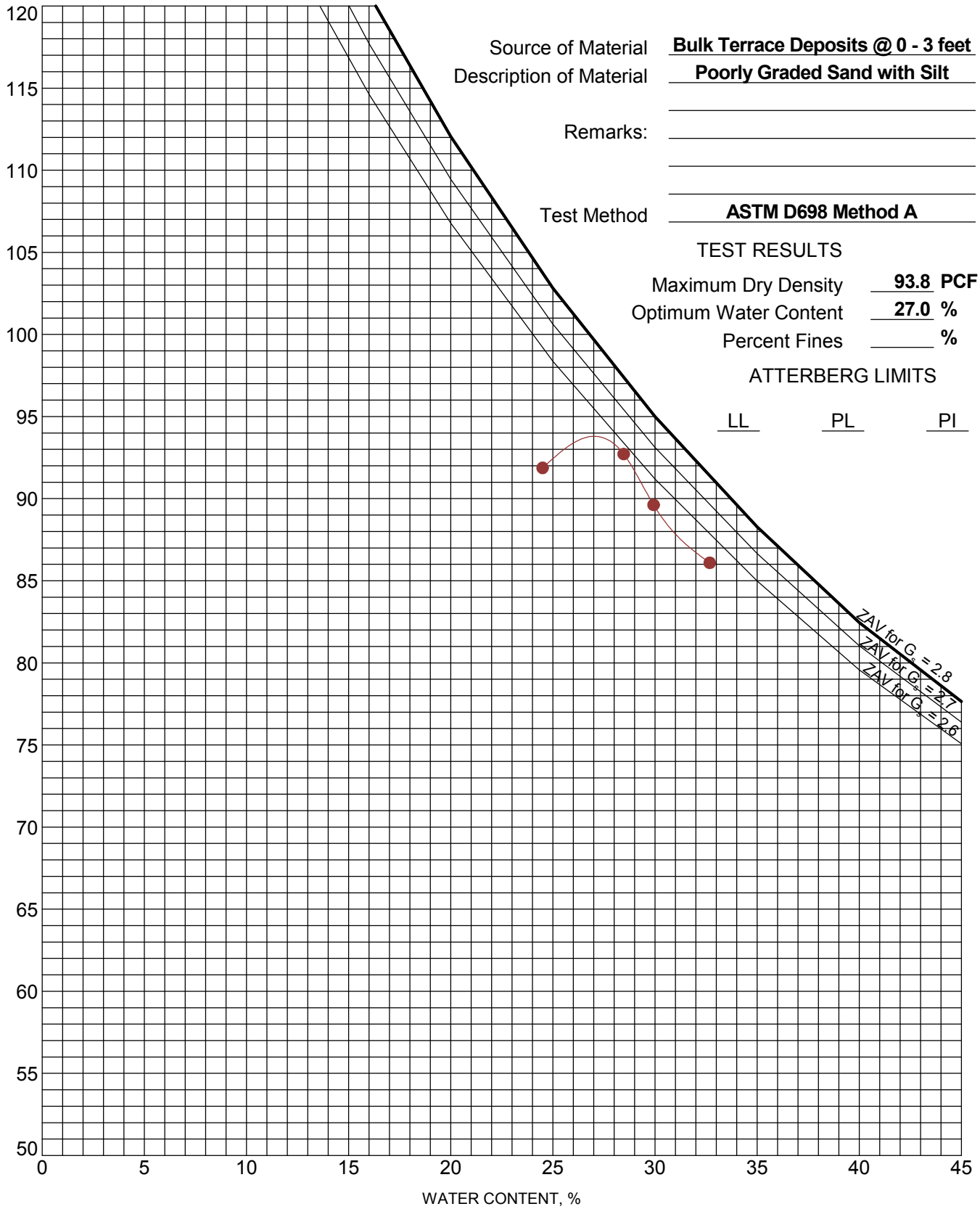


134.5 psi Normal Stress Point

147.0 psi Normal Stress Point

MOISTURE-DENSITY RELATIONSHIP

ASTM D698/D1557



Source of Material: **Bulk Terrace Deposits @ 0 - 3 feet**

Description of Material: **Poorly Graded Sand with Silt**

Remarks:

Test Method: **ASTM D698 Method A**

TEST RESULTS

Maximum Dry Density	**93.8**	**PCF**
Optimum Water Content	**27.0**	**%**
Percent Fines		**%**

ATTERBERG LIMITS

LL	PL	PI

PROJECT: Terrestrial Horizontal Directional Drilling Route Geotechnical Survey

SITE: 5400 NW Pacific Coast Highway Seal Rock, OR

Terracon
700 NE 55th Ave
Portland, OR

PROJECT NUMBER: 82195049

CLIENT: Oregon State University Corvallis, OR

Report Number: 82195049.0000

Client

Oregon State University
644 SW 13th Street
Corvallis, Oregon 97333

Project

Technical Services for Terrestrial HDD Rout Geotechnical Survey
#2020-000300
5400 NW Pacific Coast Highway
Seal Rock, Oregon
Project Number: 82195049

Material Information

Source of Material: Bulk Beach Deposit
Proposed Use: Unknown

Sample Information

Sample Date: 10/24/2019 **Sample Time:** Unknown
Sampled By: Portland
Sample Location: Bulk Beach Deposit

Sample Description: Clean Fine Sand

Laboratory Test Data

Test Procedures: ASTM D4253 and D4254
Maximum Density Test Method: 1B
Minimum Density Test Method: A
Nominal Mold Size, (cf): 0.1

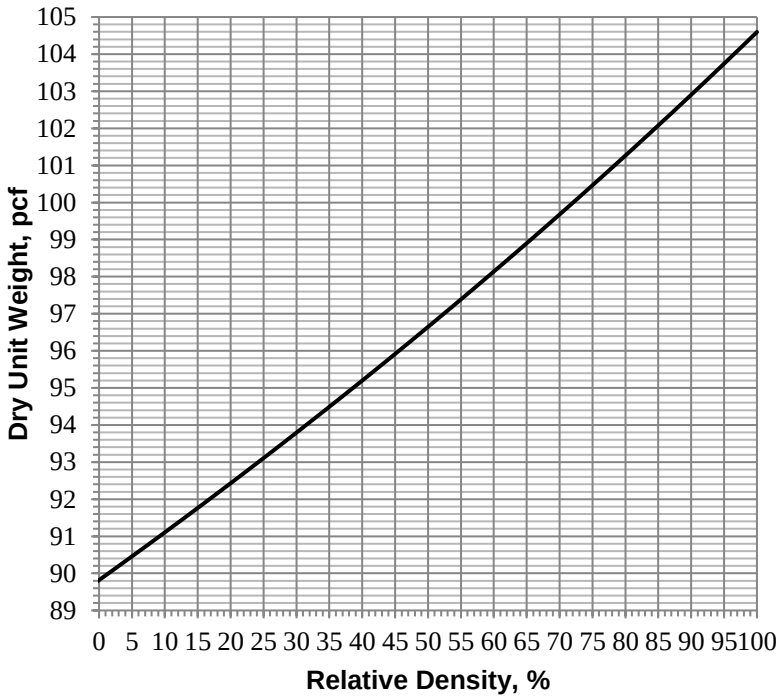
Maximum Dry Unit Weight (pcf) **104.6**
Minimum Dry Unit Weight (pcf) **89.8**

Selected Values (For Information Only)

Dry Density at Relative Density (%):

70% = 99.7 pcf
75% = 100.5 pcf
80% = 101.3 pcf

Relative Density Chart



Services: Drilling services
Terracon Rep: BWP
Reported To: Dan Hellin
Contractor: Terracon

CHEMICAL LABORATORY TEST REPORT

Project Number: 82195049
Service Date: 11/27/19
Report Date: 12/09/19
Task:

Terracon
750 Pilot Road, Suite F
Las Vegas, Nevada 89119
(702) 597-9393

Client

Oregon State University

Project

Technical Services for Terrestrial Horizontal Directional Drilling Route Geotechnical Study

Sample Submitted By: Terracon (82) **Date Received:** 11/22/2019 **Lab No.: 19-1355**

Results of Corrosion Analysis

Sample Number	S-5	S-8	S-11
Sample Location	Core #1	Core #1	Core #1
Sample Depth (ft.)	10.0-11.5	25.0-26.5	40.0-41.5
pH Analysis, ASTM G 51	8.24	8.21	8.01
Water Soluble Sulfate (SO4), ASTM C 1580 (mg/kg)	28	70	10
Chlorides, ASTM D 512, (mg/kg)	53	53	82
Resistivity, ASTM G 57, (ohm-cm)	17460	17945	9700

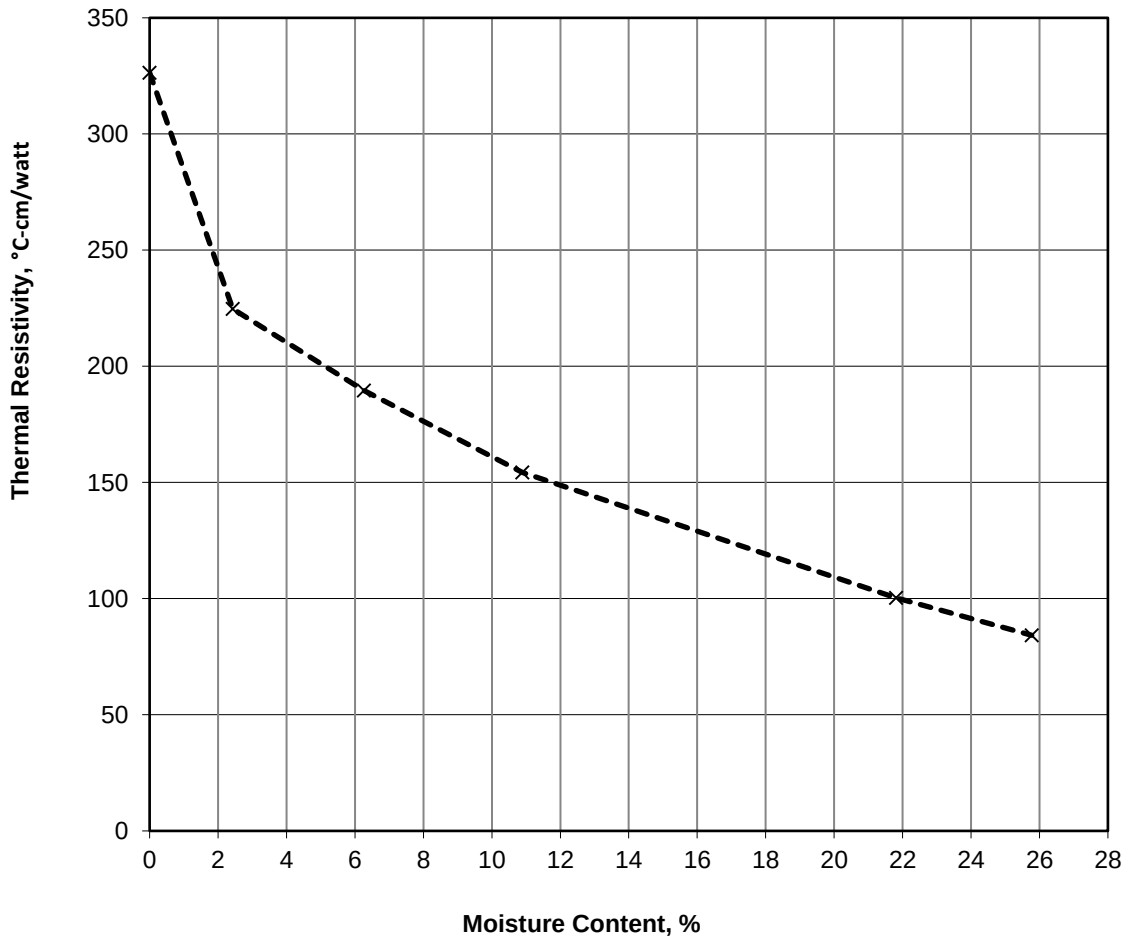
Analyzed By: Trisha Campo

Trisha Campo
Chemist

Project Name: OSU Terrestrial HDD
Project Number: 82195049
Sample ID: Bulk Terrace Sand
Soil Type: Silty Sand
Standard/Modified Proctor: ASTM D 698-A
Max Dry Density, pcf: 93.8
Optimum Moisture Content, %: 27.0
Target % Compaction: 85
Sample Dry Density, pcf: 80
Sample % Compaction: 85
As-received Moisture Content, %: 24.5

Thermal Resistivity Test Results		
Moisture Content (%)	Thermal Resistivity (˚C-cm/watt)	Temperature (°C)
0.0	326	20.6
2.4	225	19.6
6.3	190	19.6
10.9	154	21.2
21.8	100	20.4
25.8	84	19.4

Thermal Resistivity Dry-Out Curve

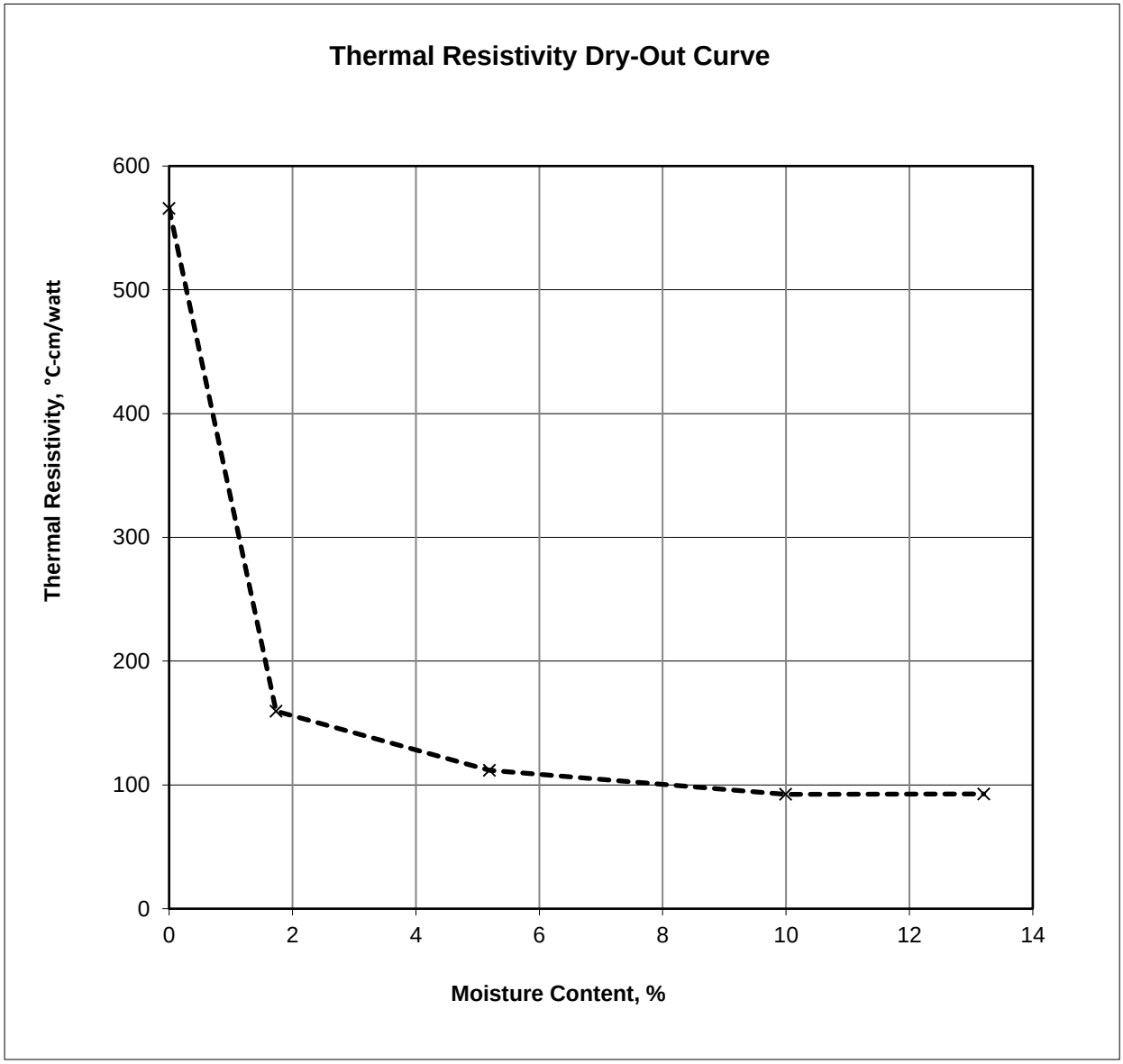


Date: 12/9/2020 | Run By: JAE | Reviewed By: BWP

Terracon

Project Name: OSU Terrestrial Horiz. Drilling
Project Number: 82195049
Sample ID: Bulk Beach Sand
Soil Type: Poorly Graded Sand
Density Method: ASTM D4253/D4254
Max Dry Density, pcf: 92.4
Optimum Moisture Content, %: 15.0
Target % Compaction: 100
Sample Dry Density, pcf: 92.8
Sample % Compaction: 100
As-received Moisture Content, %: 4.5

Thermal Resistivity Test Results		
Moisture Content (%)	Thermal Resistivity (°C-cm/watt)	Temperature (°C)
0.0	566	23.2
1.7	160	21.9
5.2	112	19.1
10.0	92	19.6
13.2	93	22.4



Date: 12/30/19 | Run By: JAE | Reviewed By: BWP

Terracon

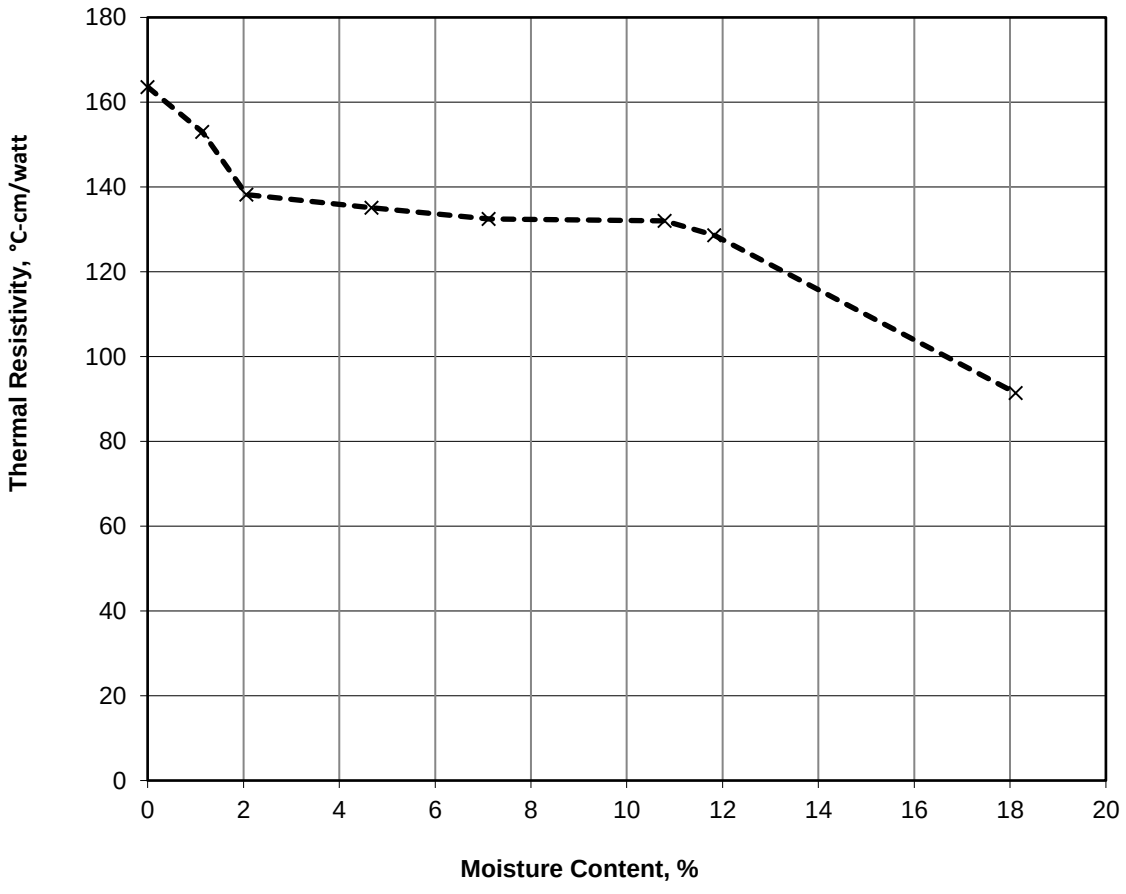
Project Name: OSU Terrestrial Horiz. Drilling
Project Number: 82195049

Thermal Resistivity Test Results

Sample ID: CORE #1, 100-105ft
Soil Type: Siltstone
Sample Dry Density, pcf: 110.6
Comments: Difference between 11.8 and 18.1 percent thermal resisitivity readings possibly due to development of microfissures in sample.

Moisture Content (%)	Thermal Resistivity (˚C-cm/watt)	Temperature (°C)
0.0	164	21.2
1.1	153	21.7
2.1	138	20.8
4.7	135	20.8
7.1	133	21.2
10.8	132	21.2
11.8	129	23.2
18.1	91	20.2

Thermal Resistivity Dry-Out Curve



Date: 12/30/19 | Run By: BWP | Reviewed By: KTH

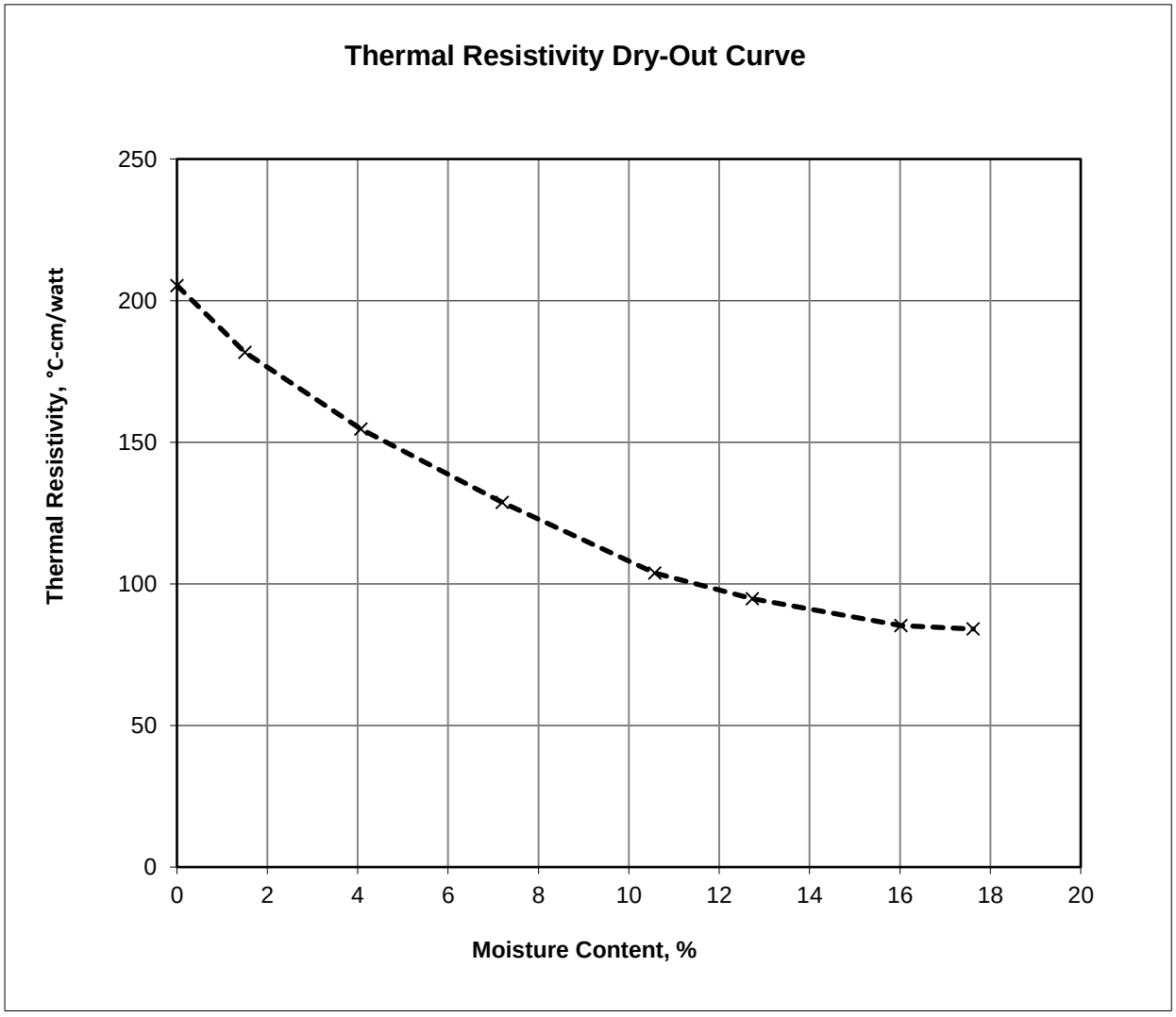
Terracon

Project Name: OSU Terrestrial Horiz. Drilling
Project Number: 82195049

Thermal Resistivity Test Results

Sample ID: CORE #1, 220-225ft
Soil Type: Siltstone
Sample Dry Density, pcf: 107.3

Moisture Content (%)	Thermal Resistivity (˚C-cm/watt)	Temperature (°C)
0.0	205	21.6
1.5	182	21.7
4.1	155	21.7
7.2	129	22.4
10.6	104	17.5
12.7	95	17.6
16.0	85	19.5
17.6	84	21.5



Date: 12/30/19	Run By: BWP	Reviewed By: KTH

Terracon

SUPPORTING INFORMATION

Contents:

General Notes
Unified Soil Classification System
Description of Rock Properties
Diedrich D-90 Track Rig Information
Driller (Bill Bradberry) Resume

Note: All attachments are one page unless noted above.

GENERAL NOTES

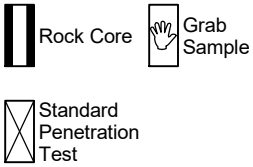
DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

Technical Services for Terrestrial Horizontal Directional Drilling Route Geotechnical Survey ■ Seal Rock, OR

Terracon Project No. 82195049

Terracon GeoReport

SAMPLING



WATER LEVEL

Water Initially Encountered

Water Level After a Specified Period of Time

Water Level After a Specified Period of Time

Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations.

FIELD TESTS

N	**Standard Penetration Test Resistance (Blows/Ft.)**
(HP)	**Hand Penetrometer**
(T)	**Torvane**
(DCP)	**Dynamic Cone Penetrometer**
UC	**Unconfined Compressive Strength**
(PID)	**Photo-Ionization Detector**
(OVA)	**Organic Vapor Analyzer**

DESCRIPTIVE SOIL CLASSIFICATION

Soil classification is based on the Unified Soil Classification System. Coarse Grained Soils have more than 50% of their dry weight retained on a #200 sieve; their principal descriptors are: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; they are principally described as clays if they are plastic, and silts if they are slightly plastic or non-plastic. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse-grained soils are defined on the basis of their in-place relative density and fine-grained soils on the basis of their consistency.

LOCATION AND ELEVATION NOTES

Unless otherwise noted, Latitude and Longitude are approximately determined using a hand-held GPS device. The accuracy of such devices is variable. Surface elevation data annotated with +/- indicates that no actual topographical survey was conducted to confirm the surface elevation. Instead, the surface elevation was approximately determined from topographic maps of the area.

STRENGTH TERMS

RELATIVE DENSITY OF COARSE-GRAINED SOILS (More than 50% retained on No. 200 sieve.) Density determined by Standard Penetration Resistance		CONSISTENCY OF FINE-GRAINED SOILS (50% or more passing the No. 200 sieve.) Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance			BEDROCK	
Descriptive Term (Density)	**Standard Penetration or N-Value Blows/Ft.**	**Descriptive Term (Consistency)**	**Unconfined Compressive Strength Qu, (tsf)**	**Standard Penetration or N-Value Blows/Ft.**	**Standard Penetration or N-Value Blows/Ft.**	**Descriptive Term (Consistency)**
Very Loose	0 - 3	Very Soft	less than 0.25	0 - 1	< 20	Weathered
Loose	4 - 9	Soft	0.25 to 0.50	2 - 4	20 - 29	Firm
Medium Dense	10 - 29	Medium Stiff	0.50 to 1.00	4 - 8	30 - 49	Medium Hard
Dense	30 - 50	Stiff	1.00 to 2.00	8 - 15	50 - 79	Hard
Very Dense	> 50	Very Stiff	2.00 to 4.00	15 - 30	>79	Very Hard
		Hard	> 4.00	> 30		

RELATIVE PROPORTIONS OF SAND AND GRAVEL		RELATIVE PROPORTIONS OF FINES	
Descriptive Term(s) of other constituents	Percent of Dry Weight	**Descriptive Term(s) of other constituents**	**Percent of Dry Weight**
Trace	<15	Trace	<5
With	15-29	With	5-12
Modifier	>30	Modifier	>12

GRAIN SIZE TERMINOLOGY		PLASTICITY DESCRIPTION	
Major Component of Sample	**Particle Size**	**Term**	**Plasticity Index**
Boulders	Over 12 in. (300 mm)	Non-plastic	0
Cobbles	12 in. to 3 in. (300mm to 75mm)	Low	1 - 10
Gravel	3 in. to #4 sieve (75mm to 4.75 mm)	Medium	11 - 30
Sand	#4 to #200 sieve (4.75mm to 0.075mm	High	> 30
Silt or Clay	Passing #200 sieve (0.075mm)		

UNIFIED SOIL CLASSIFICATION SYSTEM

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]					Soil Classification	
					Group Symbol	Group Name [B]
Coarse-Grained Soils: More than 50% retained on No. 200 sieve	**Gravels:** More than 50% of coarse fraction retained on No. 4 sieve	**Clean Gravels:** Less than 5% fines [C]	Cu ³ 4 and 1 £ Cc £ 3 [E]		GW	Well-graded gravel [F]
			Cu < 4 and/or [Cc<1 or Cc>3.0] [E]		GP	Poorly graded gravel [F]
		Gravels with Fines: More than 12% fines [C]	Fines classify as ML or MH		GM	Silty gravel [F, G, H]
			Fines classify as CL or CH		GC	Clayey gravel [F, G, H]
	Sands: 50% or more of coarse fraction passes No. 4 sieve	**Clean Sands:** Less than 5% fines [D]	Cu ³ 6 and 1 £ Cc £ 3 [E]		SW	Well-graded sand [I]
			Cu < 6 and/or [Cc<1 or Cc>3.0] [E]		SP	Poorly graded sand [I]
		Sands with Fines: More than 12% fines [D]	Fines classify as ML or MH		SM	Silty sand [G, H, I]
			Fines classify as CL or CH		SC	Clayey sand [G, H, I]
Fine-Grained Soils: 50% or more passes the No. 200 sieve	**Silts and Clays:** Liquid limit less than 50	**Inorganic:**	PI > 7 and plots on or above “A”		CL	Lean clay [K, L, M]
			PI < 4 or plots below “A” line [J]		ML	Silt [K, L, M]
		Organic:	Liquid limit - oven dried	< 0.75	OL	Organic clay [K, L, M, N]
			Liquid limit - not dried			Organic silt [K, L, M, O]
	Silts and Clays: Liquid limit 50 or more	**Inorganic:**	PI plots on or above “A” line		CH	Fat clay [K, L, M]
			PI plots below “A” line		MH	Elastic Silt [K, L, M]
		Organic:	Liquid limit - oven dried	< 0.75	OH	Organic clay [K, L, M, P]
			Liquid limit - not dried			Organic silt [K, L, M, Q]
Highly organic soils:	Primarily organic matter, dark in color, and organic odor				PT	Peat

[A] Based on the material passing the 3-inch (75-mm) sieve.

[B] If field sample contained cobbles or boulders, or both, add “with cobbles or boulders, or both” to group name.

[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.

[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay.

[E] $Cu = D_{60}/D_{10}$ $\quad Cc = \dfrac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains ³ 15% sand, add “with sand” to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H] If fines are organic, add “with organic fines” to group name.

[I] If soil contains ³ 15% gravel, add “with gravel” to group name.

[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29% plus No. 200, add “with sand” or “with gravel,” whichever is predominant.

[L] If soil contains ³ 30% plus No. 200 predominantly sand, add “sandy” to group name.

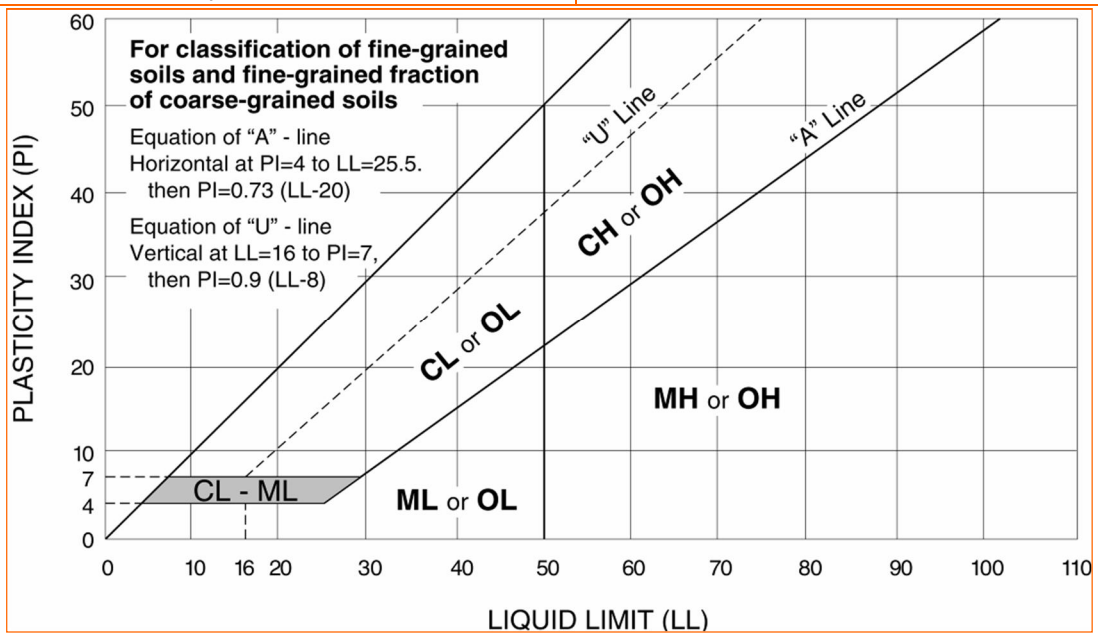
[M] If soil contains ³ 30% plus No. 200, predominantly gravel, add “gravelly” to group name.

[N] PI ³ 4 and plots on or above “A” line.

[O] PI < 4 or plots below “A” line.

[P] PI plots on or above “A” line.

[Q] PI plots below “A” line.



DESCRIPTION OF ROCK PROPERTIES

WEATHERING	
Term	**Description**
Unweathered	No visible sign of rock material weathering, perhaps slight discoloration on major discontinuity surfaces.
Slightly weathered	Discoloration indicates weathering of rock material and discontinuity surfaces. All the rock material may be discolored by weathering and may be somewhat weaker externally than in its fresh condition.
Moderately weathered	Less than half of the rock material is decomposed and/or disintegrated to a soil. Fresh or discolored rock is present either as a continuous framework or as corestones.
Highly weathered	More than half of the rock material is decomposed and/or disintegrated to a soil. Fresh or discolored rock is present either as a discontinuous framework or as corestones.
Completely weathered	All rock material is decomposed and/or disintegrated to soil. The original mass structure is still largely intact.
Residual soil	All rock material is converted to soil. The mass structure and material fabric are destroyed. There is a large change in volume, but the soil has not been significantly transported.

STRENGTH OR HARDNESS		
Description	**Field Identification**	**Uniaxial Compressive Strength, psi (MPa)**
Extremely weak	Indented by thumbnail	40-150 (0.3-1)
Very weak	Crumbles under firm blows with point of geological hammer, can be peeled by a pocket knife	150-700 (1-5)
Weak rock	Can be peeled by a pocket knife with difficulty, shallow indentations made by firm blow with point of geological hammer	700-4,000 (5-30)
Medium strong	Cannot be scraped or peeled with a pocket knife, specimen can be fractured with single firm blow of geological hammer	4,000-7,000 (30-50)
Strong rock	Specimen requires more than one blow of geological hammer to fracture it	7,000-15,000 (50-100)
Very strong	Specimen requires many blows of geological hammer to fracture it	15,000-36,000 (100-250)
Extremely strong	Specimen can only be chipped with geological hammer	>36,000 (>250)

DISCONTINUITY DESCRIPTION			
Fracture Spacing (Joints, Faults, Other Fractures)		**Bedding Spacing (May Include Foliation or Banding)**	
Description	**Spacing**	**Description**	**Spacing**
Extremely close	< ¾ in (<19 mm)	**Laminated**	< ½ in (<12 mm)
Very close	¾ in – 2-1/2 in (19 - 60 mm)	**Very thin**	½ in – 2 in (12 – 50 mm)
Close	2-1/2 in – 8 in (60 – 200 mm)	**Thin**	2 in – 1 ft. (50 – 300 mm)
Moderate	8 in – 2 ft. (200 – 600 mm)	**Medium**	1 ft. – 3 ft. (300 – 900 mm)
Wide	2 ft. – 6 ft. (600 mm – 2.0 m)	**Thick**	3 ft. – 10 ft. (900 mm – 3 m)
Very Wide	6 ft. – 20 ft. (2.0 – 6 m)	**Massive**	> 10 ft. (3 m)

Discontinuity Orientation (Angle): Measure the angle of discontinuity relative to a plane perpendicular to the longitudinal axis of the core. (For most cases, the core axis is vertical; therefore, the plane perpendicular to the core axis is horizontal.) For example, a horizontal bedding plane would have a 0-degree angle.

ROCK QUALITY DESIGNATION (RQD) [1]	
Description	**RQD Value (%)**
Very Poor	0 - 25
Poor	25 – 50
Fair	50 – 75
Good	75 – 90
Excellent	90 - 100

1. The combined length of all sound and intact core segments equal to or greater than 4 inches in length, expressed as a percentage of the total core run length.

Reference: U.S. Department of Transportation, Federal Highway Administration, Publication No FHWA-NHI-10-034, December 2009
Technical Manual for Design and Construction of Road Tunnels – Civil Elements

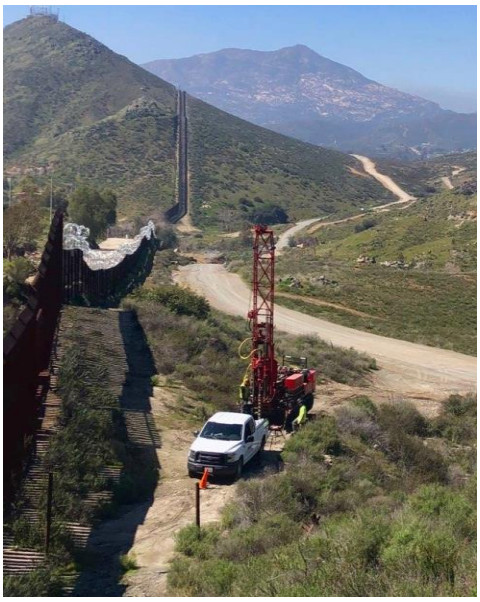
Terracon Exploration Team

2018 DIEDRICH D-90 REMOTE TRACK DRILL– LODI, CA

Terracon's D-90 remote track is our premiere, all purpose drill rig for the environmental and geotechnical exploration services. With up to 12,121 fl. Lbs. of spindle torque, it can power through most any job. Whether it is the D-90's ability to be mounted on a variety of carries, or its superior drilling capability with augers, mud rotary, or rock coring, you can be sure you have a versatile drill that has the ability to get you where you need to go and the power to get the job done.

Specification

- Serial # 508
- Power Source: John Deere, 4 Cylinder Turbo Diesel, Liquid Cooled
- Torque: 1st gear, low range 12,121 ft. lbs. (1646 Nm)
- Clutch & Transmission: 13 in (330 mm)
- Push/Retract Force: Up-32,515 lbs. (145 kN) / Down-18,064 lbs. (80 kN)
- Spindle Speed: 1st gear – 70 to 78 RPM; 5th gear – 566 to 630 RPM
- Rotary Box: #100, triple stand chain drive, totally enclosed and running in oil
- Right Angel Drive: Heavy duty spiral bevel gear box totally enclosed and running in oil-bath
- Trailer Dimensions: 84' x 42'
- Loaded Height: 13'-6"
- Water Pumps: Fordia KF50M piston pump and SPX50 hose pump
- Ground Speed: 0-6 MPH
- Water Tank: 220 Gallon Capacity
- Mast Height Folded: 10'-1"
- Mast Height Raised: 28'-3"
- Rig Dimensions: 8' W x 25'-5" L
- Rig Weight: 25,000 lbs
- Ground Pressure: 4.2 – 8.0 PSI



Geotech Services

- Coring na/hq/pq wireline (triple barrel/standard barrel)
  - Rated to 1500 linear feet
- Packer testing (dual packer testing/open hole/through core steal)
- Instrumentation (slope indicators/vibrating piezometers/cathodic protection etc.)
- Well installation (piezometer/solinist/packer nested)
- Mud Rotary
- Air Rotary
- Odex/stradex
- Down hole hammer
- Casing advancer
- Solid flight auger
- Hollow stem auger
  - Depths of 150 feet to 300 feet
- Pressure meter testing

We supply limited access rigs, track/truck mounted.

Environmental Services

- Hollow-stem auger (sizes 4 ¼", 6 ¼", 8 ¼") continuous sampler/cme/spt continuous
- Water sample (hydropunch)
- Water/Soil (simal pobe)
- Wells-2"/4"/6" vapor wells
- Odex/air rotary (cyclone containment to drums)
- Mud Rotary (4" to 10-7/8" hole)
- Completions concrete well finish
- Development of wells (surge, bail, pump)
- Well abandonments

William (Bill) Bradberry
LEAD DRILLER

PROFESSIONAL EXPERIENCE
Bill Bradberry is the Lead Driller in Terracon's Lodi, California office. He has 15+ years of drilling experience for geotechnical and environmental projects throughout the United States. Bill serves as an operator and driller for exploration service projects and oversees aspects of rig maintenance, personnel training, health and safety, and project documentation. He is highly experienced in performing drilling services for wells, including submersible pump, airlifting, and injection wells, as well as soil sampling using hydropunch, simal probing, and Packer testing methods. Mr. Bradberry is also experienced in drilling using methods such as hollow stem auger (HSA), sonic, mud rotary, air rotary, direct push, reverse circulation, diamond bit coring, and standard penetration testing (SPT). He is responsible for managing monitoring well installation and drilling activities.

Bill is known for overcoming difficult situations as they arise in the field, ensuring that all tasks are performed safely and efficiently. Bill puts a strong focus on safety by performing morning pre-work onsite safety meetings and ensures that everyone around his work area is trained on how to safely interact while equipment is operating or moving. Bill is known for meeting client expections and requests with ease and in a timely manner.

DRILLING RIGS OPERATED
Gefco 50K
Shram 4200
Versa Drill 1500
Fraste Track
Fraste Truck Flooded Reverse Rig
Mobile B81, B61
CME 55/55(300)/75/85/95 Truck/Track, Buggy
Acker Renegade
Marl M11/M10
Gus Pesh Sonic with Speed Increaser
Terra Sonic Track/Truck
Semco Truck Mounted
Diedrich Track/Truck Mounted

CORING TECHNIQUES
Reverse Circulation Mud Coring
Air Coring (Foam Injestion)
Wet Rotary Coring

PROJECT EXPERIENCE
Freeport Mines – Arizona
HQ coring to depth up to 4000+ ft.

Tetra Tech Coal/Void Investigation – Wyoming
Air coring and wet rotary coring at a 45 degree angle to depths of 350+ ft.

HWY 7/HWY 34 Reconstruction with Yeh and Associates
HQ Coring Duel Packer Testing, PQ Coring, ODEX/NQ Coring
Depths up to 200 ft.

CERTIFICATIONS
40-hr HAZWOPER

BNSF Railroad Safety trained

Class A Driver's License

CPR/First Aid Certified

WORK HISTORY
Terracon, 2014-Present

Cascade drilling 2013 to 2014

Gregg Drilling, 2010-2013

WDC Exploration and Wells 2002-2010

Rocky Mountain Flats
Auger/HQ Coring, Setting instrumentation rocktest pipe in core hole, Vibration Piezometer (2 inch piezometer wells)
Depths up to 60 ft

Phillips 66 Pipeline – Montana, Idaho, Wyoming, Utah, Colorado
Auger, ODEX Semetrics, NQ Coring, HQ Coring
Depths up to 275 ft

High Speed Rail – Dallas & Houston, Texas
Auger, NQ Coring
Depths up to 250 ft

Marathon Pipeline HDD Crossing
Auger, HQ Coring
Depths up to 225 ft

Various Windfarms
Auger, ODEX Semetrics, NQ Coring, HQ Coring
Wet rotary and Air rotary
Depths up to 100 ft