GEOTECHNICAL ENGINEERING REPORT

TWIN CITY SUBSTATION POLE YARD
7212 Pioneer Highway
Stanwood, Washington

Project No. 2470.01
15 April 2022

Prepared for:
CG Engineering, Inc. and Snohomish County PUD No. 1

Prepared by:
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15 April 2022
Project No. 2470.01

CG Engineering, Inc.
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Attention: Mr. Jared Underbrink, PE, Project Manager

Subject: Geotechnical Engineering Report
Twin City Substation Pole Yard
7212 Pioneer Highway
Stanwood, Washington

Dear Jared:

In accordance with your request, Zipper Geo Associates, LLC (ZGA) has completed the subsurface exploration and geotechnical engineering evaluation for the proposed Twin City Substation Pole Yard. This report presents the findings of the subsurface exploration and geotechnical recommendations for the project. Our work was completed in general accordance with the scope of services described in our *Scope of Services and Fee Estimate – Revised*, dated 20 July 2021 which is contained in our consulting agreement that was authorized on 18 August 2021. 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 assistance, please contact us.

Respectfully submitted,
Zipper Geo Associates LLC

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Signed 4.15.22

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TABLE OF CONTENTS

FIGURES

APPENDICES

GEOTECHNICAL ENGINEERING REPORT
TWIN CITY SUBSTATION POLE YARD
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INTRODUCTION

The geotechnical engineering exploration and analysis have been completed for the proposed Twin City Substation Pole Yard in Stanwood, Washington. Two borings and 12 test pit explorations were completed to depths ranging from approximately 8 to 26-1/2 feet below the existing ground surface to evaluate subsurface conditions. Descriptive logs of the explorations are included in Appendix A and Appendix B contains a summary of laboratory testing procedures and results.

PROJECT INFORMATION

Site Location

The project site comprises two adjoining parcels containing the Twin City substation located at 7212 Pioneer Highway in Stanwood. The site is located south of Pioneer Highway at a transition between the Stillaguamish River valley at the south and an upland terrace at the north. The property encompasses approximately 19 acres that includes a forested upland at the north and the substation at the south. The site is bordered by a BNSF railroad right-of-way and agricultural property at the southwest, south, and southeast, a cemetery at the northwest, and developed residential property to the north and northeast. The project site is illustrated on the *Site and Exploration Plan*, Figure 1.

Project Description

Site work for the substation was largely completed at the end of 2020. Site work included removing trees and stripping vegetation from the substation development area, and excess soil and shredded vegetation were spread in these areas prior to hydroseeding. The District plans to construct a new pole yard in the area north and east of the substation. Plans available at the time this report was prepared indicate that proposed improvements will include both paved and gravel-surfaced access roads and material storage areas, as well as stormwater management features. Access to the pole yard will be along the existing paved road to the substation from the north along with new drive lanes in and around the pole yard. Traffic is expected to include heavily loaded vehicles, including dump trucks. Finished grades are expected to be very close to existing grades.

SITE HISTORY

According to documents provided by the District for our review, surface mining of sand and gravel took place on the property since at least the 1940s. Review of these documents and available aerial photographs suggests that past operations included mining and screening, but apparently not washing of mined materials. The photographs and documents clearly illustrate that fill material was placed in portions of the mined area as part of reclamation efforts. The design phase geotechnical exploration for the substation completed by ZGA in 20018 and 2019 included advancing borings and test pits that disclosed fill material of varied composition above native outwash sand/gravelly sand that was underlain by fine grained Transitional Beds.

SITE CONDITIONS

Surface Conditions

Ground surface elevations in the pole yard expansion area range from approximately 21 to 25 feet and reflect grading completed during the recent substation construction as well as during prior mine reclamation. The pole yard supports a sparse grass and weed growth but lacks trees as they were removed during substation construction. It is not unusual to see scattered ponded water after rain events and this is a reflection of the low infiltration rate of some of the fill material placed during mine reclamation.

Subsurface Conditions

Local Geologic Conditions

The publication *Geologic Map of the Stanwood Quadrangle, Snohomish County, Washington* (USGS, MF-1741, 1985) indicates that the site has been mapped as containing glacially consolidated granular advance outwash deposits (Qva) above fine-grained Transitional Beds (Qtb). The advance outwash consists of sand and gravelly sand and was the material extracted during previous mining. The advance outwash generally has a low fines content (the soil fraction passing the US No. 200 sieve) overall, although discrete silt and silty sand horizons are not unusual, and the facies with a low fines content may have a moderate to high permeability. The underlying Transitional Beds consist of silt and clay with secondary sand, gravel, and cobbles. The Transitional Beds are characterized by a relatively high density and low permeability, and groundwater within the advance outwash is frequently perched above the less permeable Transitional Beds.

Subsurface conditions disclosed by the borings and test pits completed for this current evaluation as well as for the substation design phase are consistent with the published mapping. Our explorations also disclosed undocumented fill material above the native soils at the substation site.

Soil Conditions

The soil descriptions presented below have been generalized for ease of report interpretation. Please refer to the exploration logs for detailed soil descriptions at the exploration locations. Variations in subsurface conditions may exist between the exploration locations and the nature and extent of variations between the explorations may not become evident until additional explorations are completed or until construction. Significant fill material is present in the floor of the former mine, much of it resultant from reclamation activity. It should be recognized that the nature and depth of fill material is such that its composition and depth may vary over relatively short distances. Subsurface conditions at specific locations are summarized below.

Subsurface conditions were evaluated during design of the substation by advancing five exploratory borings and by excavating 44 test pits. Explorations completed for this current evaluation include borings B-6 and B-7 as well as test pits TP-45 through TP-56. Approximate exploration locations, as well as pertinent surface features, are shown on Figure 1. Appendix A contains descriptive logs of the borings and test pits completed recently, as well as logs of selected borings and test pits completed during the substation design phase. Observed soil conditions are summarized below.

Each of the explorations disclosed some surficial fill with fine, fibrous, and/or woody organic material, some of which was placed during substation construction. For convenience, we describe this material as topsoil on the logs. The approximate thickness of the organics observed at the recently completed explorations, which will need to be stripped from the pole yard footprint, ranged from approximately 4 to 18 inches.

We observed non-organic fill material to depths of approximately 2 to 10.5 feet at the explorations completed in and near the proposed pole yard improvements. The fill was largely composed of soil with only minor amounts of debris; we observed minor pieces of plastic, one spray paint can, some wire, some rebar, and some concrete clasts at the locations of test pits TP-5 and TP-45 while some minor wood debris and fine organics were observed on a scattered basis. The fill typically consisted of loose to medium dense silty sand and soft to medium stiff sandy silt with a variable gravel and cobble content.

We observed native granular advance outwash below the fill at each of the exploration locations. The outwash typically consisted of sand with a variable gravel content and, overall, a relatively low fines content (the soil fraction passing the US No. 200 sieve). The approximate depth and elevation, as well as the minimum thickness, of the outwash are listed on Table 1 on the following page. The Transitional Beds consisted of both weathered brown and unweathered gray silt with secondary clay and a variable sand, gravel, and cobble content.

Table 1: Subsurface Conditions Summary

Exploration No.	Approximate Ground Surface Elevation (feet)	Approximate Depth to / Elevation of Advance Outwash (feet)	Approximate Advance Outwash Thickness (feet)	Approximate Organic Material Stripping Depth (inches)
TP-3	21	* / 13	>2	**
TP-4	21	* / 10.5	>3.5	**
TP-5	23	* / 10	>2	**
TP-6	26	* / 19	>1	**
TP-18	22	* / 14	>5	**
TP-19	22	* / 19.5	>7.5	**
TP-45	25	14 / 11	>3	18
TP-46	24	12 / 12	>6	6
TP-47	24	9.5 / 14.5	>9	12
TP-48	23	11 / 12	>7	14
TP-49	23	6 / 17	>12	10
TP-50	23	11 / 12	5	6
TP-51	23	8.5 / 14.5	>6.5	6
TP-52	22	4 / 18	>12.5	6
TP-53	22	3 / 19	>12	10
TP-54	22	2 / 20	>15.5	12
TP-55	22	10.5 / 11.5	>4.5	6
TP-56	21	9.5 / 11.5	>7.5	6
B-6	23	10.5 / 12.5	>16.5	6
B-7	22	8 / 14	15	4

*The approximate depth of the advance outwash is not provided for the test pits completed for the substation design phase exploration as grades were changed during construction.

**Approximate stripping depths are not provided for the test pits completed for the substation design phase exploration as grades were changed during construction.

Groundwater

We observed groundwater seepage within the old fill material at approximate depths of 1.5 to 7 feet while excavating test pits TP-3, TP-4, and TP-5, and at approximately 16.5 feet in the outwash while excavating test pit TP-54. Groundwater was measured previously at elevations of about 6 to 7 feet (roughly 15 to 19 feet) in the monitoring well installed at the substation location. We observed groundwater at approximate elevations of slightly less than 7 feet in the pole yard expansion area while advancing borings B-6 and B-7, and subsequently measured groundwater at the depths and elevations listed in the table below in October and December 2021. Given the extremely wet weather in October and November, it is our opinion that the groundwater levels measured in December may be interpreted as a reasonable approximation of the annual high. Groundwater tends to perch above the fine grained Transitional Bed deposits that underlie the native granular outwash and the existing fill material, as well as within the fill.

Table 2: Groundwater Measurement Summary
(depth/elevation in feet)*

Boring	Date		
	10.4.21 **(after drilling)**	**10.26.21**	**12.2.21**
B-6	16.57/6.69	15.11/7.72	13.52/9.31
B-7	15.3/6.7	14.98/6.62	12.24/9.36

It should be noted that groundwater conditions will likely vary seasonally and in response to precipitation events, land use, and other factors, and its occurrence will be influenced by the composition and density/consistency of the fill material, in particular.

CONCLUSIONS AND RECOMMENDATIONS

General Geotechnical Considerations

Based on information gathered during the field exploration, laboratory testing, and analysis, we conclude that construction of the proposed pole yard improvements is feasible from the geotechnical perspective provided that the recommendations presented herein are followed during design and construction. Selected aspects of the site conditions that should be considered during design and construction are summarized below.

- The site is mantled with a variable thickness of organic-laden fill placed during substation construction. It will be necessary to strip this material from the footprint of the proposed site improvements.

- Some of the fill material placed as part of the mine reclamation and below the recently placed surficial organics is in a loose/soft condition and will need to be densified below access roads and material storage areas.

- Much of the existing fill material has a relatively high fines content and should be considered highly moisture-sensitive. Attempting to grade the soils with a high fines content will be difficult, if not impossible, during wet weather.

- The relatively clean nature of the native advance outwash soils and some of the fill material is such that caving in excavations may occur.

- The relatively low fines content of the native outwash soils is favorable from the stormwater management perspective in that the soils have a relatively high permeability and would function well as infiltration receptor soils.

Geotechnical engineering recommendations for site grading, drainage, and other geotechnically-related aspects of the project are presented in the following sections. The recommendations contained in this report are based upon the results of and the field exploration, laboratory testing, engineering analyses, review of substation construction documents, and our current understanding of the proposed project design. ASTM and WSDOT specification codes cited herein refer to the current manual published by the American Society for Testing & Materials and the current edition of the WSDOT *Standard Specifications for Road, Bridge, and Municipal Construction* (Publication M41-10).

Geologically Hazardous Areas

Chapter 17.115.030 of the Stanwood Municipal Code (SMC) defines regulated geologically hazardous areas as follows in italics, and our conclusions regarding such areas are presented in regular text:

(1) ***Geologically Hazardous Areas****. Geologically hazardous areas include areas susceptible to erosion, sliding, earthquake, or other geological events. They pose a threat to the health and safety of citizens when incompatible development is sited in areas of significant hazard. Such incompatible development may not only place itself at risk, but also may increase the hazard to surrounding development and use. Areas susceptible to one or more of the following types of hazards shall be designated as a geologically hazardous area:*

(a) Erosion hazard;

(b) Landslide hazard;

(c) Seismic hazard; and

(d) Other geological events including tsunamis, volcanic hazards, and differential settlement.

(2) ***Erosion Hazard Areas****. Erosion hazard areas are at least those areas identified by the U.S. Department of Agriculture's Natural Resources Conservation Service as having a "moderate to severe," "severe," or "very severe" rill and inter-rill erosion hazard. On the city's critical areas maps, these are shown as areas of moderate or steep slopes. Erosion hazard areas are also those areas impacted by shore land and/or stream bank erosion.*

The proposed pole yard is nearly level and does not meet the prescriptive definition of an erosion hazard, in our opinion. However, the slope below the south side of the substation access road does meet the definition. A 25-foot buffer from the toe of the access road south slope was established during design of the substation and the proposed pole yard improvements will not require alteration of the buffer.

(3) ***Landslide Hazard Areas****. Landslide hazard areas are areas potentially subject to landslides based on a combination of geologic, topographic, and hydrologic factors. They include areas susceptible because of any combination of bedrock, soil, slope (gradient), slope aspect, structure, hydrology, or other factors. Examples of these may include, but are not limited to, the following:*

(a) Areas of historic failures, such as those areas delineated by the U.S. Department of Agriculture's Natural Resources Conservation Service as having a "severe" limitation for building site development;

(b) Areas with all three of the following characteristics:

(i) Slopes steeper than 15 percent; and

(ii) Hillsides intersecting geologic contacts with a relatively permeable sediment overlying a relatively impermeable sediment or bedrock; and

(iii) Springs or groundwater seepage;

(c) Areas that have shown movement during the Holocene epoch (from 10,000 years ago to the present) or that are underlain or covered by mass wastage debris of that epoch;

(d) Slopes that are parallel or subparallel to planes of weakness (such as bedding planes, joint systems, and fault planes) in subsurface materials;

(e) Areas potentially unstable because of rapid stream incision, stream bank erosion, and undercutting by wave action;

(f) Areas located in a canyon or on an active alluvial fan, presently or potentially subject to inundation by debris flows or catastrophic flooding; and

(g) Any area with a slope of 40 percent or steeper and with a vertical relief of 10 or more feet except areas composed of consolidated rock. A slope is delineated by establishing its toe and top and measured by averaging the inclination over at least 10 feet of vertical relief.

The proposed pole yard is nearly level and does not meet the SMC definition of a landslide hazard, in our opinion. However, the slope below the existing substation access road does meet the SMC definition of a landslide hazard. The slope is composed of well-drained granular soils and groundwater seepage has not been observed on these slopes during several site visits made during the wet winter and spring months. The access road south slope lacks surficial evidence of previous or ongoing instability.

SMC 17.115.080(1)(a)(iii) calls for a minimum 25-foot buffer from landslide hazards, and a 25-foot buffer from the toe of the access road slope was established during the substation permitting phase. The proposed pole yard improvements do not include alteration of the access road south slope or the 25-foot buffer.

(4) ***Seismic Hazard Areas***. *Seismic hazard areas are areas subject to severe risk of damage as a result of earthquake-induced ground shaking, slope failure, settlement, soil liquefaction, lateral spreading, or surface faulting. One indicator of potential for future earthquake damage is a record of earthquake damage in the past. Ground shaking is the primary cause of earthquake damage in Washington. The strength of ground shaking is primarily affected by:*

(a) The magnitude of an earthquake;

(b) The distance from the source of an earthquake;

(c) The type of thickness of geologic materials at the surface; and

(d) The type of subsurface geologic structure.

Settlement and soil liquefaction conditions occur in areas underlain by cohesionless, loose, or soft-saturated soils of low density, typically in association with a shallow groundwater table.

Based upon the observed soil conditions at the proposed pole yard location, it is our opinion that the site does not meet the SMC criteria for a seismic hazard. The site is underlain at shallow depths by glacially consolidated fine grained soils and laterally discontinuous perched groundwater that is relatively deep in the granular soil section. Consequently, the risk of significant liquefaction occurring at the pole yard site is low, in our opinion. It should also be recognized that no structures are proposed for construction in the pole yard.

(5) ***Tsunami Hazard Areas***. *Tsunami hazard areas are coastal areas and large lake shoreline areas susceptible to flooding and inundation as the result of excessive wave action derived from seismic or other geologic events.*

We did not evaluate the risk that a tsunami may present to the site.

(6) ***Lahar Hazard Areas***. *Areas susceptible to mud or debris flows from volcanic eruptions (Glacier Peak).*

The southwestern portion of the site is depicted within an area potentially susceptible to lahars (mudflows composed of volcanic debris and water) on the City of Stanwood Figure NF-7b, *Seismic/Volcanic/Lahar Hazards* map.

(7) ***Other Hazard Areas****. Geologically hazardous areas shall also include areas determined by the city to be susceptible to other geological events including mass wasting, debris flows, rock falls, and differential settlement.*

Site conditions are such that the risk of mass wasting and debris flows affecting the site is negligible, in our opinion. The existing uncontrolled fill material at the site presents a risk of differential settlement, but this can be mitigated through appropriate grading. Such methods would typically include excavation of loose uncontrolled fill material and replacing it with adequately compacted structural fill.

Earthwork

The following sections present recommendations for site preparation, subgrade preparation and placement of engineered fills on the project. Earthwork on the project should be observed and evaluated by a ZGA representative. Evaluation of earthwork should include observation and testing of structural fill, road section subgrade preparation, and subsurface drainage installations.

Site Preparation

Stripping: In preparation for grading we recommend removal of the surficial organic fill and vegetation, as well as any deleterious debris that may be encountered, from the footprint of the proposed improvements. These materials could be wasted in the areas north, east, and southeast of the site.

Existing Fill Removal: Site preparation is recommended to include selective removal of existing undocumented fill material containing deleterious debris or that is too wet to be compacted to the recommended density. Variation in the fill depth and composition should be expected, along with the moisture content (this will vary seasonally and in response to weather conditions). These materials should be evaluated during construction and removed as necessary under the observation of a ZGA representative. Our representative will identify unsuitable materials that should be removed and those that may be improved in place or re-used as structural fill. The resultant excavations should be backfilled in accordance with the subsequent recommendations for structural fill placement and compaction.

The existing undocumented fill with no more than about 3 percent organic material and lacking deleterious material may be left in place provided that it can be compacted as subsequently recommended. Existing fill that is excavated as part of construction activity may be re-used as structural fill provided that at the time of placement and compaction it is at a moisture content that allows its compaction to the required density, has no more than about 3 percent organics, and lacks deleterious debris.

Site Preparation Scheduling: We recommend that site preparation and grading take place in the drier summer and early fall months if possible. Operating wheeled and tracked equipment when the existing moisture-sensitive fill material is wet will result in significant disturbance of the soil and this will likely require its removal. This will increase construction costs. Completion of site preparation and grading under drier site and weather conditions will reduce the potential for disturbance of the moisture-sensitive soils and reduce the likelihood of subgrade disturbance and the need to replace disturbed soils with other granular fill material.

Structural Fill Placement and Compaction

All fill material should be placed in accordance with the recommendations herein for structural fill. Prior to placement, the surfaces to receive structural fill should be observed by a ZGA representative in order to verify that at least medium dense properly prepared fill or native soil is present. In the event that soft or loose soils are present at the subgrade elevation, and we expect that this will locally be the case given the nature of undocumented fill material, the soils should be compacted to a firm and non-yielding condition and to at least 95 percent of the modified Proctor maximum dry density (ASTM D 1557) prior to placing structural fill. This may require partial to complete removal of existing fill material and replacing it with compacted structural fill. In the event that the soils cannot be adequately compacted, they should be removed as necessary and replaced with other granular fill material at a moisture content that allows its compaction to the recommended density.

The suitability of soil for use as structural fill depends primarily on the gradation and moisture content of the soil when it is placed. As the amount of fines (that soil fraction passing the US No. 200 sieve) increases, soil becomes increasingly sensitive to small changes in moisture content and adequate compaction becomes more difficult, or impossible, to achieve. Generally, soils containing more than about 5 percent fines by weight (based on that soil fraction passing the US No. 4 sieve) cannot be compacted to a firm, non-yielding condition when the moisture content is more than a few percent from optimum. The optimum moisture content is that which yields the greatest soil density under a given compactive effort.

Re-use of On-site Soils: Soil expected to be encountered in excavations in the pole yard and new access road locations consists of sand and gravel with a variable silt content as well as silt with a variable sand and gravel content. We anticipate that it will be feasible to re-use the soils with a lower fines content under a relatively wide variety of weather conditions, but use of soils with more than about 5 percent fines will depend on the weather conditions at the time of placement and compaction. The native outwash, and the cleaner fill materials, are well-suited for use as structural fill. Please note that some of the fill material and the native soil (Transitional Beds) contain a high silt content. Using these materials as structural fill could be difficult due to the high fines content and moisture sensitivity.

Imported Structural Fill: We recommend that structural fill consist of a well-graded sand and gravel with a low fines content, such as the District's standard substation fill, the gradation of which is presented in the table below.

Table 3: Snohomish County PUD No. 1 Substation Import Granular Fill Gradation

US Standard Sieve Size	Percent Passing by Dry Weight Basis
2 inch	100
½ inch	56 - 100
¼ inch	40 - 78
No. 10	22 - 57
No. 40	8 - 32
No. 200	< 5

This material may be considered slightly to moderately moisture-sensitive relative to placement and compaction. It would be feasible to use other granular soils with a higher fines content as structural fill, but it should be recognized that soils with a higher fines content will be more moisture-sensitive and this may limit their use during wet weather or wet site conditions. Another advantage of using granular fill with a relatively low fines content is that it will drain better than fill with a higher fines content. The use of other fill types should be reviewed and approved by ZGA prior to their use on site.

Compaction Recommendations: Structural fill should be placed in horizontal lifts and compacted to a firm and non-yielding condition and to at least 95 percent of the modified Proctor maximum dry density using equipment and procedures that will produce the recommended moisture content and densities throughout the fill. Fill lifts should generally not exceed 10 inches in loose thickness, although the nature of the compaction equipment in use and its effectiveness will influence functional fill lift thicknesses.

Earthwork may be difficult or impossible during periods of elevated soil moisture and wet weather. If soils are stockpiled for future use and wet weather is anticipated, the stockpile should be protected with plastic sheeting that is securely anchored.

Subgrade soils that become disturbed due to elevated moisture conditions should be overexcavated to expose firm, non-yielding, non-organic soils and backfilled with compacted structural fill. We recommend that the earthwork portion of this project be completed during extended periods of dry weather if possible. If earthwork is completed during the wet season (typically November through June) it will be necessary to take extra precautionary measures to protect subgrade soils. Wet season earthwork may require additional mitigative measures beyond that which would be expected during the drier summer and fall months. This could include diversion of surface runoff around exposed soils and draining of ponded water. Once subgrades are established, it will be necessary to protect the exposed subgrade soils from construction traffic during wet weather. Placing quarry spalls or crushed recycled concrete over these areas would further protect the soils from construction traffic. Protection of subgrades should be expected in the portions of the site where silt is present at shallow depths.

If earthwork takes place during freezing conditions, we recommend allowing the exposed subgrade to thaw and then recompacting the subgrade prior to placing subsequent lifts of engineered fill. Frozen soil should not be used as structural fill.

We recommend that a ZGA representative be present during the construction phase of the project to observe earthwork operations and to perform necessary tests and observations during subgrade preparation and placement and compaction of structural fill.

Drainage: Positive drainage should be provided during construction and maintained throughout the life of the project. Uncontrolled movement of water into trenches or foundation and slab excavations during construction should be prevented.

Utility Installation Recommendations

Below-grade utilities are expected to include conduit and storm drain piping and structures. We recommend that utility trenching conform to all applicable federal, state, and local regulations, such as OSHA and WISHA, for open excavations. The existing shallow native and fill soils in the pole yard footprint are generally expected to be adequate for support of utilities. Given the site's history of mine reclamation using a variety of materials, localized removal of undocumented fill containing debris or load-sensitive organics may be necessary.

All trenches should be wide enough to allow for compaction around the haunches of pipe or conduit. If water is encountered in the excavations, it should be removed prior to fill placement. Materials, placement and compaction of utility trench backfill should be in accordance with the recommendations presented in the *Structural Fill* section of this report. In our opinion, the initial lift thickness should not exceed one foot unless recommended by the manufacturer to protect utilities from damage by compacting equipment. Light, hand operated compaction equipment may be utilized directly above utilities if damage resulting from heavier compaction equipment is of concern.

Dewatering: Depending upon the time of year that the work takes place and the depth of the utilities, excavations may encounter perched water. The contractor should be prepared to pump water from excavations as necessary to maintain a relatively dry trench condition. We anticipate that the likelihood of encountering water in excavations will be highest in areas containing fill with a high fines content and during the wetter times of year.

Temporary Excavation Slopes: We recommend that utility trenching, installation, and backfilling conform to all applicable Federal, State, and local regulations such as WISHA and OSHA regulations for open excavations. In order to maintain the function of any existing utilities that may be located near excavations, we recommend that temporary excavations not encroach upon the bearing splay of existing utilities, foundations, or slabs. The bearing splay of structures and utilities should be considered to begin at the edge of the utility, foundation, or slab and extend downward at a 1H:1V (Horizontal:Vertical) slope. If, due to space constraints, an open excavation cannot be completed without encroaching on a utility, we recommend shoring the new utility excavation with a slip box or other suitable means that provide for protection of workers and that maintain excavation sidewall integrity to the depth of the excavation.

Temporary slope stability is a function of many factors, including the following:

- The presence and abundance of groundwater;
- The type and density of the various soil strata;
- The depth of cut;
- Surcharge loadings adjacent to the excavation;
- The length of time the excavation remains open.

It is exceedingly difficult under the variable circumstances presented by uncontrolled fill material to pre-establish a safe and “maintenance-free” temporary cut slope angle. Therefore, it should be the responsibility of the contractor to maintain safe slope configurations since the contractor is continuously at the job site, able to observe the nature and condition of the cut slopes, and able to monitor the subsurface materials and groundwater conditions encountered. It may be necessary to drape temporary slopes with plastic or to otherwise protect the slopes from the elements and minimize sloughing and erosion. We do not recommend vertical slopes or cuts deeper than 4 feet if worker access is necessary. The cuts should be adequately sloped or supported to prevent injury to personnel from local sloughing and spalling. The excavation should conform to applicable Federal, State, and local regulations.

Based upon our review of WAC Chapter 296-155-66401 (Appendix A – Soil Classification), we have interpreted the existing granular fill and granular outwash soils disclosed by the explorations and likely to be present in most excavations as consistent with the Type C definition. The contractor should be responsible for determining soil types in all excavations at the time of construction and should be prepared to adequately shore or slope all excavations. Please note that some of the granular soils have a low fines content and that unsupported excavation sidewalls in these soils may slough or cave readily.

Stormwater Infiltration Considerations

The substation and access roads rely upon a small pond and three trenches for infiltration of stormwater into the site’s permeable granular soils, and we anticipate that the pole yard improvements will include similar features. We understand that stormwater management improvements for the pole yard will be designed in accordance with the Washington State Department of Ecology 2005 *Stormwater Management Manual for Western Washington* (*Manual*). Based on the findings of the field exploration, laboratory testing, our analysis, and observation of the effective existing infiltration facilities it is our opinion that stormwater infiltration for the pole yard is feasible from the geotechnical perspective as well. Geotechnical considerations regarding infiltration system analysis and design are presented below.

Current and previous explorations completed in the vicinity of the proposed pole yard encountered native outwash sand below a variable depth of fill material placed as part of previous mine reclamation activity. The outwash largely consists of sand with a variable gravel content and a relatively low fines content. The outwash serves as a receptor soil for water directed to the infiltration pond constructed northwest of the substation, and will be able to fulfill a similar role for the pole yard.

We observed the outwash at depths of approximately 2 to 14 feet below existing grade at the exploration locations. The variation can likely be attributed, in our opinion, to the non-uniform excavation that appears to have taken place when the site was operated as a sand and gravel borrow pit. The approximate thickness of the outwash observed at the test pit and boring locations ranged from at least 1 foot to greater than about 16.5 feet.

Long-term Infiltration Rate

The 2005 Ecology *Manual* describes the use of ASTM mechanical grain size distribution data to evaluate allowable long-term infiltration rates. Table 3.8 *Alternative Recommended Infiltration Rates based on ASTM Gradation Testing* lists allowable long-term infiltration rates based on studies that correlated receptor soil grain size distribution with actual infiltration system performance. The correlative values are based upon the receptor soil D_{10} values and the provenance of the soil. The D_{10} values for representative granular soil samples collected from the explorations are listed in the table below.

Table 4: Receptor Soil D_{10} Summary

Exploration / Sample	Approximate sample depth / elevation (feet)	D_{10} (mm)	Allowable long-term infiltration rate (inches/hour)*
B-6 / S-6	15 / 8	0.2	3.5
B-7 / S-5	12.5 / 9.5	0.17	3.0
TP-51 / S-4	11 / 12	0.1	2.0
TP-52/S-3	4 / 18	0.42	9.0
TP-54 / S-5	14.5 / 7.5	0.1	2.0
TP-56 / S-5	9.5 / 11.5	0.14	2.5

*Per Table 3.8 *Alternative Recommended Infiltration Rates base on ASTM Gradation Testing* per WDOE 2005 *Stormwater Management Manual for Western Washington*

Based upon the results of the grain size analysis and our experience with other projects (including the substation which has successfully operating infiltration elements), a long-term design infiltration rate of 2.6 inches/hour is recommended for the granular outwash soils. This infiltration rate is slightly lower than the value used for design of the existing infiltration pond and reflects the somewhat finer character of the outwash disclosed by the explorations completed in the pole yard expansion area.

Groundwater Considerations

Groundwater was measured at elevations of about 6 to 7 feet (roughly 15 to 19 feet below the Phase 2 expansion area grade) in 2019 and 2020 at the monitoring well installed at the substation location. We observed groundwater at approximate elevations of slightly less than 7 feet in the Phase 2 expansion area while advancing borings B-6 and B-7, and subsequently measured groundwater at the depths and elevations listed in the table below in October and December 2021. Given the extremely wet weather in October and November, it is our opinion that the groundwater levels measured in December may be interpreted as a reasonable approximation of the annual high. Groundwater tends to perch above the fine grained Transitional Bed deposits that underlie the native granular outwash and the existing fill material. It is our opinion that stormwater infiltration is feasible from the geotechnical perspective given the site’s soil and groundwater conditions.

Table 5: Groundwater Observations (depth/elevation in feet)*

Boring	Date		
	10.4.21 (after drilling)	10.26.21	12.2.21
B-6	16.57/6.69	15.11/7.72	13.52/9.31
B-7	15.3/6.7	14.98/6.62	12.24/9.36

Access Road Recommendations

The pole yard will be accessed from an extension of the existing unpaved road along the south side of the substation as well as a new short road near the north side of the substation. Internal roads will be provided as well. Both paved and unpaved roads are being considered. Vehicle traffic is expected to range from light vehicles up to heavily loaded trucks.

Unpaved Access Road Section Recommendations

Explorations disclosed variable shallow fill soils that include silty sand with a variable gravel content and silt with a variable sand and gravel content. These soils can be expected to have variable drainage characteristics and are considered to have fair to moderate support characteristics. The existing unpaved substation access road section consists of 5 inches of compacted crushed surfacing top course (CSTC) over 8 inches of compacted crushed surfacing base course (CSBC). We anticipate that this section will be adequate for areas with regular light to moderate vehicle loading. We recommend increasing the CSBC thickness to 12 inches in areas of regular heavy truck traffic (such as loaded dump trucks). We recommend that the crushed surfacing conform to criteria described in Section 9-03.9(3) of the WSDOT *Standard Specifications*. The access road subgrade should be prepared in accordance with the recommendations presented in the *Structural Fill Placement and Compaction* section of this report. We recommend compacting the subgrade soils to a depth of 12 inches to at least 95 percent of the modified Proctor maximum dry density along with the crushed surfacing.

Maintenance: Periodic maintenance in the form of grading and compaction will likely be necessary over the life of the unpaved access roads. Maintenance should be expected to also include edge delineation, cleaning drainage ditches, and removing driving surface irregularities.

Pavement Life and Maintenance: It should be realized that asphaltic pavements such as HMA are not maintenance-free. The following pavement sections represent our minimum recommendations for an average level of performance during a 20-year design life; therefore, an average level of maintenance will likely be required. Thicker asphalt, base, and subbase courses would offer better long-term performance, but would cost more initially. Conversely, thinner courses would be more susceptible to “alligator” cracking and other failure modes. As such, pavement design can be considered a compromise between a high initial cost and low maintenance costs versus a low initial cost and higher maintenance costs.

Recommended Pavement Section: The existing substation access road section consists of 3 inches of HMA over 2 inches of CSTC over 8 inches of CSBC. Pavement subgrade soils along the paved access road consist of very well-drained gravelly sand and are considered very good from the pavement support perspective. As described previously, the pole yard access road subgrade conditions will be more variable and should be considered fair, largely because of sub-section drainage characteristics. We recommend that the pavement section consist, at a minimum, of 3 inches of HMA over 2 inches (compacted thickness) of CSTC over 12 inches (compacted thickness) of CSBC.

Flexible Pavement Access Road Recommendations

Subgrade Preparation and Compaction: The subgrade should be prepared in accordance with the recommendations presented in the *Structural Fill Placement and Compaction* section of this report, and the subgrade should be compacted to at least 95 percent of the modified Proctor maximum dry density per ASTM D 1557.

HMA: We recommend that the HMA conform to Section 9-02.1(4) for PG 58-22 or PG 64-22 Performance Graded Asphalt Binder as presented in the WSDOT *Standard Specifications*. We also recommend that the gradation of the HMA aggregate conform to the aggregate gradation control points for ½-inch mixes as presented in Section 9-03.8(6), HMA Proportions of Materials.

Base Course: We recommend that the crushed surfacing conform to Section 9-03.9(3) of the WSDOT *Standard Specifications*.

Compaction and Paving: We recommend compacting the HMA to a minimum of 92 percent of the Rice (theoretical maximum) density. Placement and compaction of HMA should conform to requirements of Section 5-04 of the *Standard Specifications*.

Erosion Control

Construction phase erosion control activities are recommended to include measures intended to reduce erosion and subsequent sediment transport. We recommend that the project incorporate the following erosion and sedimentation control measures during construction:

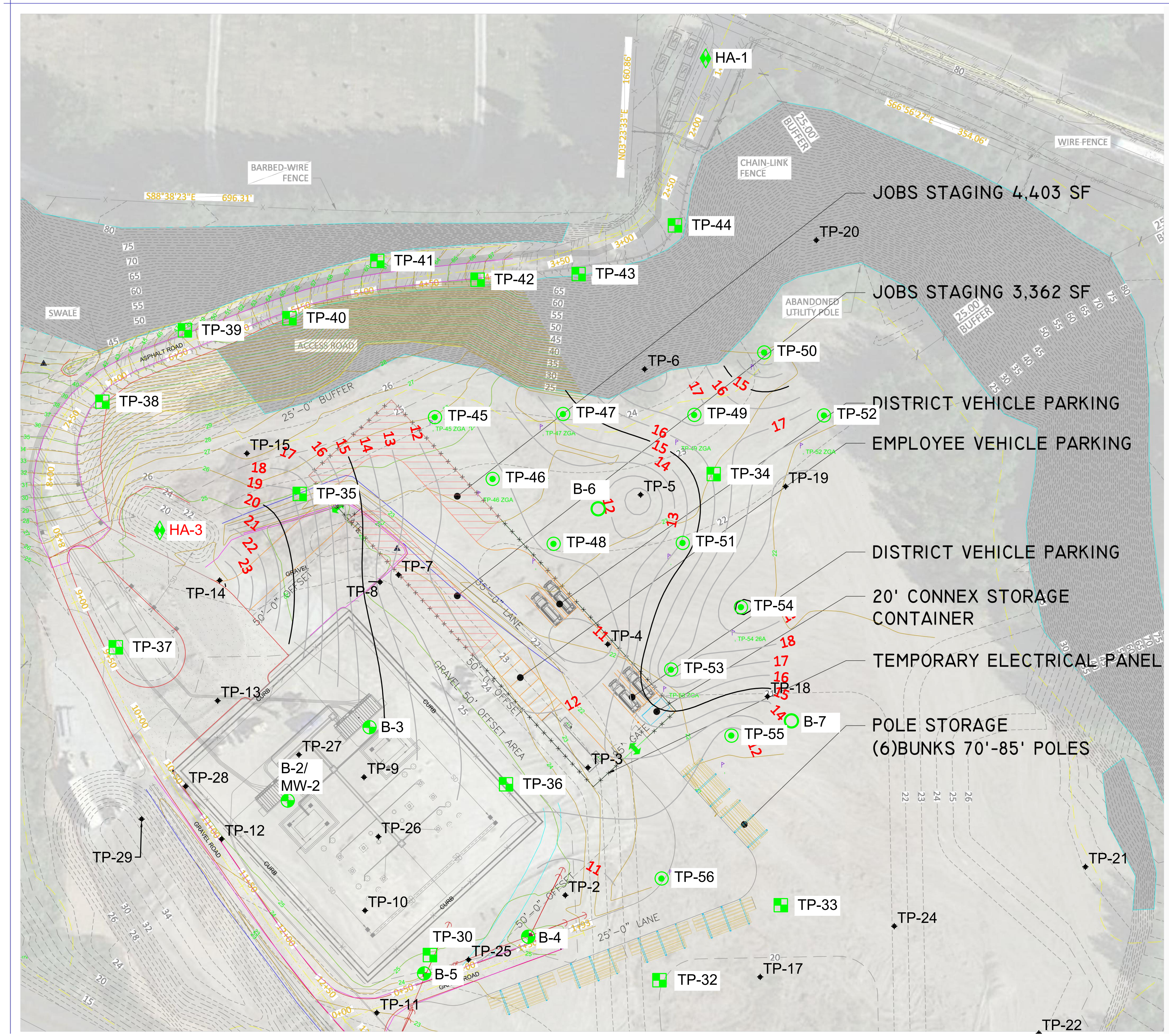
- Capturing water from low permeability surfaces and directing it away from bare soil exposures.
- Erosion control BMP inspection and maintenance: The contractor should be aware that inspection and maintenance of erosion control BMPs is critical toward their satisfactory performance. Repair and/or replacement of dysfunctional erosion control elements should be anticipated.
- Undertake site preparation, excavation, and filling during periods of little or no rainfall.
- Cover excavation surfaces with anchored plastic sheeting if surfaces will be left exposed during wet weather.
- Cover soil stockpiles with anchored plastic sheeting.
- Provide for street cleaning on an as-needed basis.
- Protect exposed soil surfaces that will be subject to vehicle traffic with crushed rock or crushed recycled concrete to reduce the likelihood of subgrade disturbance and sediment generation during wet weather or wet site conditions.
- Install perimeter siltation control fencing on the lower perimeter of work areas.

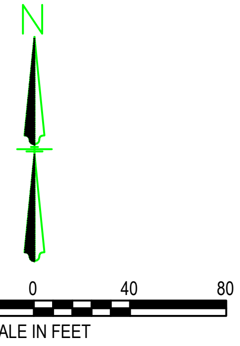
CLOSURE

The analysis and recommendations presented in this report are based, in part, on the explorations completed for this study. The number, location, and depth of the explorations were completed within the constraints of budget and site access so as to yield the information to formulate our recommendations. Project plans were in the preliminary stage at the time this report was prepared. We therefore recommend we be provided an opportunity to review the final plans and specifications when they become available in order to assess that the recommendations and design considerations presented in this report have been properly interpreted and implemented into the project design.

The performance of earthwork, pavements, and drainage features depends greatly on proper site preparation and construction procedures. We recommend that Zipper Geo Associates, LLC be retained to provide geotechnical engineering services during the earthwork-related construction phases of the project. If variations in subsurface conditions are observed at that time, a qualified geotechnical engineer could provide additional geotechnical recommendations to the contractor and design team in a timely manner as the project construction progresses.

This report has been prepared for the exclusive use of CG Engineering, Inc. the District, and their agents, for specific application to the project discussed and has been prepared in accordance with generally accepted geotechnical engineering practices. No warranties, express or implied, are intended or made. Site safety, excavation support, and dewatering requirements are the responsibility of others. In the event that changes in the nature, design, or location of the project as outlined in this report are planned, the conclusions and recommendations contained in this report shall not be considered valid unless ZGA reviews the changes and either verifies or modifies the conclusions of this report in writing.





LEGEND

◆ HA-1	HAND AUGER NUMBER AND APPROXIMATE LOCATION EXCAVATED MARCH 20, 2020
◐ B-1	TEST BORING NUMBER AND APPROXIMATE LOCATION DRILLED MARCH 2019
▨ TP-30	TEST PIT NUMBER AND APPROXIMATE LOCATION EXCAVATED MARCH 2019
• TP-1	TEST PIT NUMBER AND APPROXIMATE LOCATION EXCAVATED NOVEMBER 2017
◎ TP-1	TEST PIT NUMBER AND APPROXIMATE LOCATION EXCAVATED SEPTEMBER 2021
○ B-6	TEST BORING NUMBER AND APPROXIMATE LOCATION DRILLED OCTOBER 2021
PHASE 1	CONTOUR LINES INDICATING APPROXIMATE ELEVATION OF ADVANCE GLACIAL OUTWASH (Qva) CONTOUR INTERVAL OF 1 FOOT

NOTES

Site plan provided by Snohomish County PUD, "Twin City Substation Satellite Storage Site, "Q-1-101", on date: 4/15/22.

The interpreted outwash soil surface contours should be considered approximate and are based upon interpretation of availble subsurface information and variation between the interpreted and actual conditions may not become apparent until construction.

Twin City Substation Pole Yard
7400 Pioneer Highway
Stanwood, Washington 98292

SITE AND EXPLORATION PLAN

Date: April 2022
Job No. 2470.01

Zipper Geo Associates, LLC
19019 36th Ave. W.,Suite E
Lynnwood, WA 98036

FIGURE 1
SHT. 1 of 1

APPENDIX A
FIELD EXPLORATION AND TESTING PROCEDURES AND LOGS

FIELD EXPLORATION AND TESTING PROCEDURES AND LOGS

ZGA originally completed a design phase exploration for the Twin City substation consisting of advancing five borings (B-1 through B-5) and excavating 44 test pits (TP-1 through TP-44). Our field exploration program for this current site evaluation included completing a visual reconnaissance of the site, advancing two borings (B-6 and B-7) and excavating 12 test pits (TP-45 through TP-56). The approximate exploration locations are presented on Figure 1, the *Site and Exploration Plan*. Exploration locations were determined in the field using steel and fiberglass tapes by measuring distances from existing site features shown on the *2019 0319 Twin City Working Dwg* (dated 22 June 2021) provided by CG Engineering, Inc. The ground surface elevation at each exploration location was determined by ZGA using a laser level referenced to the north corner elevation of the substation curb. As such, the exploration locations and elevations should be considered accurate to the degree implied by the measurement methods. The following sections describe our procedures associated with the explorations. Descriptive logs of the explorations are enclosed in this appendix.

Boring Procedures

The borings were advanced using a track-mounted drill rig operated by an independent drilling company working under subcontract to ZGA. The borings were advanced using hollow stem auger drilling methods. A geotechnical engineer from our firm continuously observed the borings, logged the subsurface conditions encountered, and obtained representative soil samples. All samples were stored in moisture-tight containers and transported to our laboratory for further evaluation and testing. Samples were generally obtained by means of the Standard Penetration Test at 2.5-foot to 5-foot intervals throughout the drilling operation.

The Standard Penetration Test (ASTM D 1586) procedure consists of driving a standard 2-inch outside diameter steel split spoon sampler 18 inches into the soil with a 140-pound hammer free falling 30 inches. The number of blows required to drive the sampler through each 6-inch interval is recorded, and the total number of blows struck during the final 12 inches is recorded as the Standard Penetration Resistance, or “blow count” (N value). If a total of 50 blows are struck within any 6-inch interval, the driving is stopped and the blow count is recorded as 50 blows for the actual penetration distance. The resulting Standard Penetration Resistance values indicate the relative density of granular soils and the relative consistency of cohesive soils.

A groundwater observation well was installed at the boring B-6 and B-7 locations location following completion of drilling and sampling. The wells consist of a 10-foot long section of 2-inch inside-diameter PVC screen section with machined 0.020-inch wide slots. Washed silica sand was placed in the annular space between the screen and the boreholes. A non-machined riser was installed to the ground surface, and bentonite clay was placed around the riser. The well were finished with flush-mount metal monuments set in concrete.

The enclosed boring logs describe the vertical sequence of soils and materials encountered in each boring, based primarily upon our field classifications. Where a soil contact was observed to be gradational, our logs indicate the average contact depth. Where a soil type changed between sample intervals, we inferred the contact depth. Our logs also graphically indicate the blow count, sample type, sample number, and approximate depth of each soil sample obtained from the boring. If groundwater was encountered in a borehole, the approximate groundwater depth and date of observation are depicted on the log.

Test Pit Procedures

An independent contractor working under subcontract to ZGA excavated the test pits through the use of a tracked excavator. A geotechnical engineer from ZGA continuously observed the test pit excavations, logged the subsurface conditions, and obtained representative soil samples. The samples were stored in moisture tight containers and transported to our laboratory for further visual classification and testing.

The enclosed test pit logs indicate the vertical sequence of soils and materials encountered in each test pit, based primarily on our field classifications and supported by our subsequent laboratory testing. Where a soil contact was observed to be gradational or undulating, our logs indicate the average contact depth. We estimated the relative density and consistency of *in situ* soils by means of the excavation characteristics and by the sidewall stability. Our logs also indicate the approximate depths of any sidewall caving or groundwater seepage observed in the test pits, as well as all sample numbers and sampling locations.

We have included the logs of test pits TP-3 through TP-6, TP-18, and TP-19 from the original Twin City substation geotechnical report along with the logs of the explorations recently completed for the pole yard.

Boring Location: See Figure 1, Site and Exploration Plan
Top Elevation: 23 Feet
Date Drilled: 10/4/2021

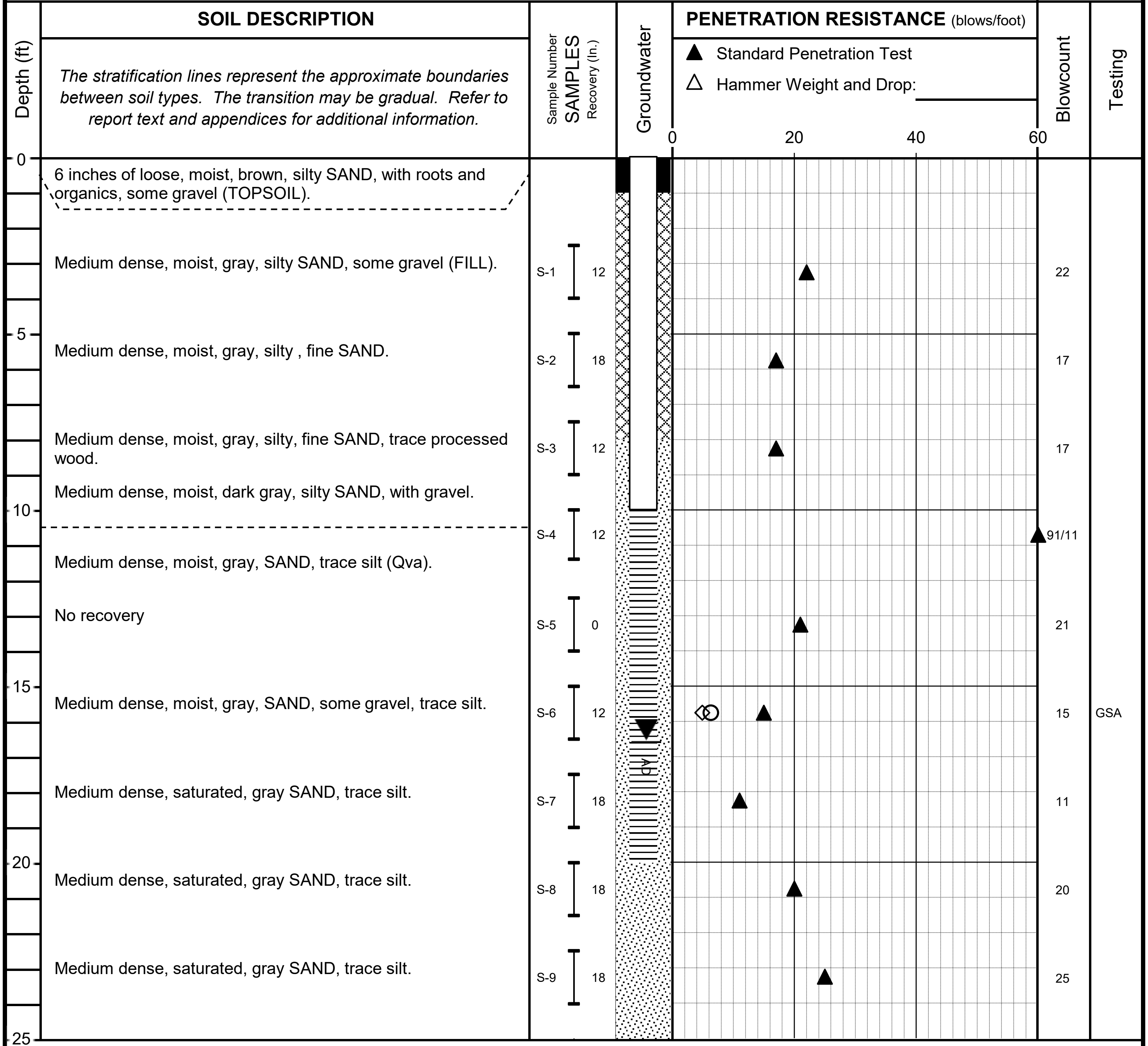
Drilling Company: Bortec 1
Drilling Method: Hollow Stem Auger
Drill Rig: EC95

Bore Hole Dia.: 8-inch
Hammer Type: Cathead
Logged by: TLW

B-6

The stratification lines represent the approximate boundaries between soil types. The transition may be gradual. Refer to report text and appendices for additional information.

SOIL DESCRIPTION	Sample Number	Recovery (In.)	Blowcount	Testing
6 inches of loose, moist, brown, silty SAND, with roots and organics, some gravel (TOPSOIL).				
Medium dense, moist, gray, silty SAND, some gravel (FILL).	S-1	12	22	
Medium dense, moist, gray, silty , fine SAND.	S-2	18	17	
Medium dense, moist, gray, silty, fine SAND, trace processed wood.	S-3	12	17	
Medium dense, moist, dark gray, silty SAND, with gravel.				
Medium dense, moist, gray, SAND, trace silt (Qva).	S-4	12	91/11	
No recovery	S-5	0	21	
Medium dense, moist, gray, SAND, some gravel, trace silt.	S-6	12	15	GSA
Medium dense, saturated, gray SAND, trace silt.	S-7	18	11	
Medium dense, saturated, gray SAND, trace silt.	S-8	18	20	
Medium dense, saturated, gray SAND, trace silt.	S-9	18	25	



SAMPLE LEGEND

- 2-inch O.D. split spoon sample
- 3-inch I.D. Shelby tube sample

GROUNDWATER LEGEND

- ░ Clean Sand
- ▨ Bentonite
- ■ Grout/Concrete
- ☰ Screened Casing
- ☐ Blank Casing
- ▼ 11/2/12 Groundwater level at time of drilling (ATD) or on date of measurement.

◇ % Fines (<0.075 mm)
○ % Water (Moisture) Content
Plastic Limit ├──○──┤ Liquid Limit
Natural Water Content

TESTING KEY

GSA = Grain Size Analysis
200W = 200 Wash Analysis
Consol. = Consolidation Test
Att. = Atterberg Limits

Twin City Substation Pole Yard
7400 Pioneer Hwy
Stanwood, Washington 98292

Project No.: 2470.01

ZipperGeo
Geoprofessional Consultants
19019 36th Ave. W, Suite E
Lynnwood, WA 98036

BORING LOG: B-6

Boring Location: See Figure 1, Site and Exploration Plan
Top Elevation: 23 Feet
Date Drilled: 10/4/2021

Drilling Company: Bortec 1
Drilling Method: Hollow Stem Auger
Drill Rig: EC95

Bore Hole Dia.: 8-inch
Hammer Type: Cathead
Logged by: TLW

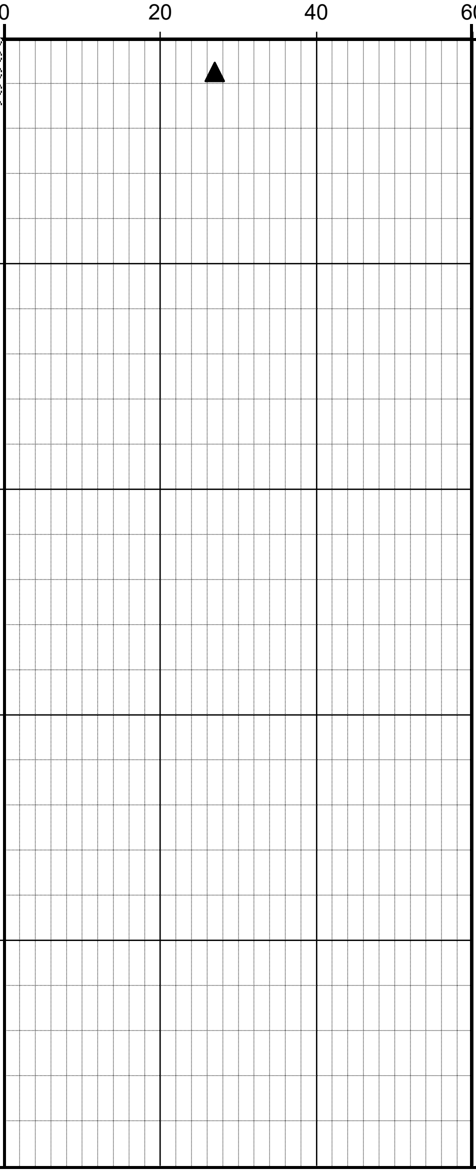
B-6

Depth (ft)	SOIL DESCRIPTION	SAMPLES Sample Number	SAMPLES Recovery (In.)	Ground Water	Blow Counts	Testing
	The stratification lines represent the approximate boundaries between soil types. The transition may be gradual. Refer to report text and appendices for additional information.					
25	Medium dense, saturated, gray SAND, trace silt.	S-10	18	▨	27	
	Boring terminated at approximately 26 1/2 feet below existing grade. Groundwater was observed at about 16 1/2 feet below existing grade.					
30						
35						
40						
45						
50						

PENETRATION RESISTANCE (blows/foot)

▲ Standard Penetration Test

△ Hammer Weight and Drop: ______



SAMPLE LEGEND

- 2-inch O.D. split spoon sample
- 3-inch I.D. Shelby tube sample

GROUNDWATER LEGEND

- ░ Clean Sand
- ▨ Bentonite
- ■ Grout/Concrete
- ☰ Screened Casing
- ☐ Blank Casing
- ▼ 11/2/12 Groundwater level at time of drilling (ATD) or on date of measurement.

TESTING KEY

GSA = Grain Size Analysis
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Att. = Atterberg Limits

◇ % Fines (<0.075 mm)

○ % Water (Moisture) Content

Plastic Limit ├──○──┤ Liquid Limit

Natural Water Content

Twin City Substation Pole Yard
7400 Pioneer Hwy
Stanwood, Washington 98292

Project No.: 2470.01

ZipperGeo
Geoprofessional Consultants
19019 36th Ave. W, Suite E
Lynnwood, WA

BORING LOG: B-6

Boring Location: See Figure 1, Site and Exploration Plan
Top Elevation: 22 Feet
Date Drilled: 10/4/2021

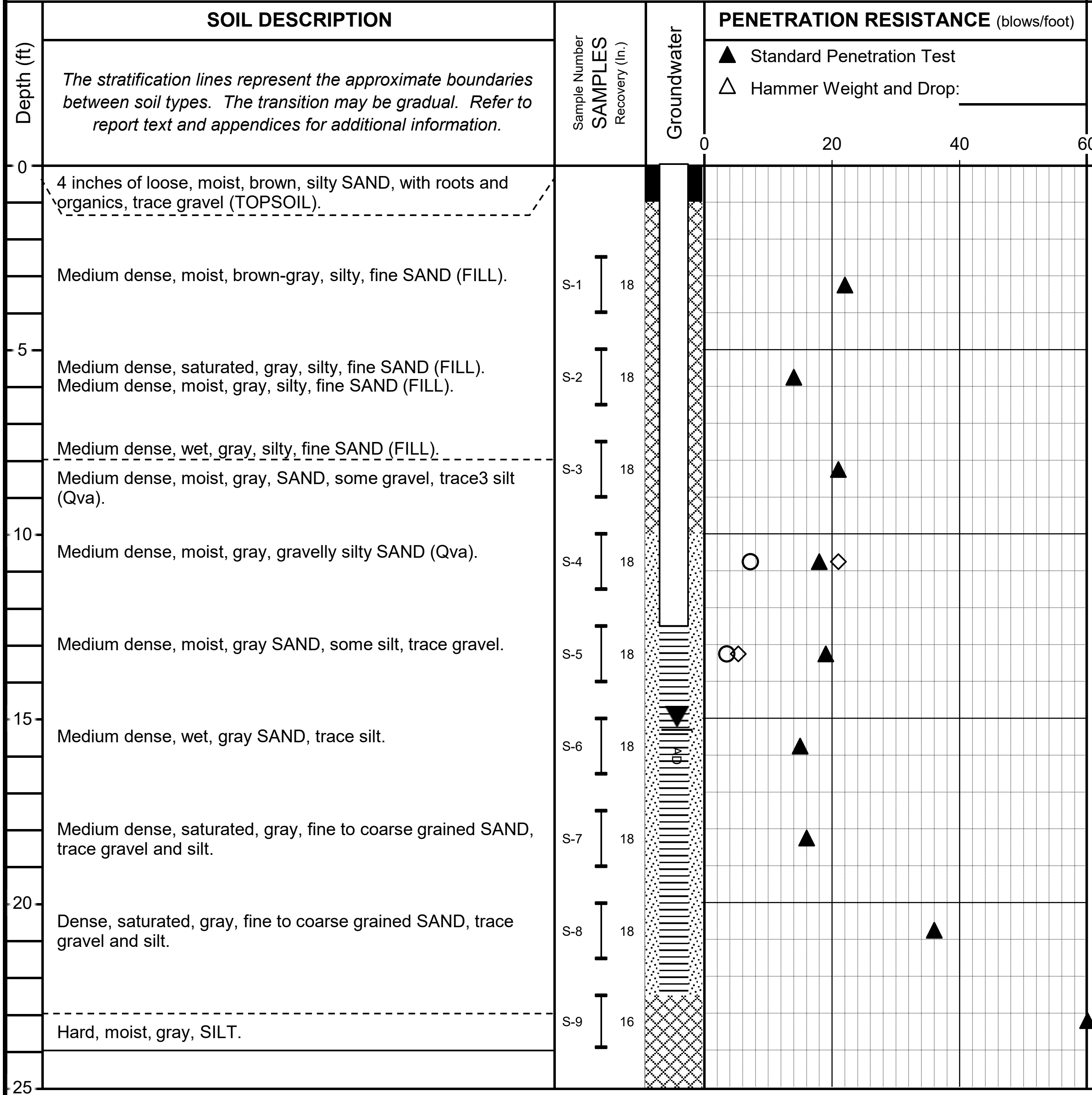
Drilling Company: Bortec 1
Drilling Method: Hollow Stem Auger
Drill Rig: EC95

Bore Hole Dia.: 8-inch
Hammer Type: Cathead
Logged by: TLW

B-7

The stratification lines represent the approximate boundaries between soil types. The transition may be gradual. Refer to report text and appendices for additional information.

SOIL DESCRIPTION	Sample Number	Recovery (In.)	Blowcount	Testing
4 inches of loose, moist, brown, silty SAND, with roots and organics, trace gravel (TOPSOIL).				
Medium dense, moist, brown-gray, silty, fine SAND (FILL).	S-1	18	22	
Medium dense, saturated, gray, silty, fine SAND (FILL). Medium dense, moist, gray, silty, fine SAND (FILL).	S-2	18	14	
Medium dense, wet, gray, silty, fine SAND (FILL). Medium dense, moist, gray, SAND, some gravel, trace3 silt (Qva).	S-3	18	21	
Medium dense, moist, gray, gravelly silty SAND (Qva).	S-4	18	18	GSA
Medium dense, moist, gray SAND, some silt, trace gravel.	S-5	18	19	GSA
Medium dense, wet, gray SAND, trace silt.	S-6	18	15	
Medium dense, saturated, gray, fine to coarse grained SAND, trace gravel and silt.	S-7	18	16	
Dense, saturated, gray, fine to coarse grained SAND, trace gravel and silt.	S-8	18	36	
Hard, moist, gray, SILT.	S-9	16	98/4	



SAMPLE LEGEND

I 2-inch O.D. split spoon sample
II 3-inch I.D. Shelby tube sample

GROUNDWATER LEGEND

░	Clean Sand
▨	Bentonite
■	Grout/Concrete
☰	Screened Casing
☐	Blank Casing
▼ 11/2/12	Groundwater level at time of drilling (ATD) or on date of measurement.

TESTING KEY

GSA = Grain Size Analysis
200W = 200 Wash Analysis
Consol. = Consolidation Test
Att. = Atterberg Limits

◇ % Fines (<0.075 mm)
○ % Water (Moisture) Content
Plastic Limit ├──○──┤ Liquid Limit
Natural Water Content

Twin City Substation Pole Yard
7400 Pioneer Hwy
Stanwood, Washington 98292

Project No.: 2470.01

ZipperGeo
Geoprofessional Consultants
19019 36th Ave. W, Suite E
Lynnwood, WA 98036

BORING LOG: B-7

Boring Location:	See Figure 1, Site and Exploration Plan	Drilling Company:	Bortec 1	Bore Hole Dia.:	8-inch
Top Elevation:	22 Feet	Drilling Method:	Hollow Stem Auger	Hammer Type:	Cathead
Date Drilled:	10/4/2021	Drill Rig:	EC95	Logged by:	TLW

B-7

Depth (ft)	SOIL DESCRIPTION *The stratification lines represent the approximate boundaries between soil types. The transition may be gradual. Refer to report text and appendices for additional information.*	Sample Number SAMPLES Recovery (In.)	Ground Water	PENETRATION RESISTANCE (blows/foot) ▲ Standard Penetration Test △ Hammer Weight and Drop: 0 20 40 60	Blow Counts	Testing
25	Boring terminated at approximately 24 feet below existing grade. Groundwater observed at about 15 1/2 feet below existing grade at time of drilling.					
30						
35						
40						
45						
50						

SAMPLE LEGEND

- I 2-inch O.D. split spoon sample
- II 3-inch I.D. Shelby tube sample

GROUNDWATER LEGEND

- ▒ Clean Sand
- ☒ Bentonite
- ■ Grout/Concrete
- ☰ Screened Casing
- ☐ Blank Casing
- ▼ 11/2/12 Groundwater level at time of drilling (ATD) or on date of measurement.

◇ % Fines (<0.075 mm)

○ % Water (Moisture) Content

Plastic Limit ├──○──┤ Liquid Limit

Natural Water Content

TESTING KEY

GSA = Grain Size Analysis

200W = 200 Wash Analysis

Consol. = Consolidation Test

Att. = Atterberg Limits

Twin City Substation Pole Yard
7400 Pioneer Hwy
Stanwood, Washington 98292

Project No.: 2470.01

ZipperGeo
Geoprofessional Consultants
19019 36th Ave. W, Suite E
Lynnwood, WA

BORING LOG: B-7

Page 2 of 1

ZIPPER GEO ASSOCIATES, LLC

19019 36th Avenue West, Suite E, Lynnwood, Washington 98036

Test Pit TP-18

Location: See Site and Exploration Plan, Figure 1
Approx. Ground Surface Elevation (feet): 22

Project: Twin City Substation
Project No: 1784.01
Date Excavated: 30 November 2017

Depth (ft)	Material Description	Sample	N_C	%M	Testing
1	1 inch TOPSOIL and fine roots above loose to medium dense, wet, mixed gray and brown, gravelly silty SAND with silt clasts and scattered cobbles (Fill)				
2					
3					
4		S-1 @ 3 feet			GSA
5					
6					
7					
8					
9	Loose to medium dense, damp to moist, brown, gravelly SAND grading to fine SAND at 10 feet (Qva)	S-2 @ 8 feet			
10					
11					
12					
13					
14	Test pit completed at approximately 13 feet. Groundwater not observed while excavating. Slight to moderate caving observed throughout.				
15					
16					
17					
	Note: N_C is the Dynamic Cone Penetrometer blow count per ASTM Special Technical Publication #399.				

Test Pit TP-19

Location: See Site and Exploration Plan, Figure 1
Approx. Ground Surface Elevation (feet): 22

Project: Twin City Substation
Project No: 1784.01
Date Excavated: 30 November 2017

Depth (ft)	Material Description	Sample	N_C	%M	Testing
1	1 inch TOPSOIL and fine roots above loose to medium dense, wet, brown, silty SAND and sandy SILT with gravel (Fill)				
2		S-1 @ 1 foot			
3					
4	Loose to medium dense, moist to wet, gray-brown, gravelly SAND grading to sandy GRAVEL at 4 feet (Qva)	S-2 @ 3.5 feet			
5					
6					
7					
8					
9					
10					
11	Test pit completed at approximately 10 feet. Groundwater not observed while excavating. Substantial caving observed throughout.				
12					
13					
14					
15					
16					
17					
	Note: N_C is the Dynamic Cone Penetrometer blow count per ASTM Special Technical Publication #399.				

Test Pit TP-45

Location: See Site and Exploration Plan, Figure 1
Approx. Ground Surface Elevation: 25 feet

Project: Twin City Sub. Pole Yard
Project No: 2470.01
Date Excavated: September 20, 2021

Depth (ft)	Material Description	Sample	%Fines	%M	Testing
1	6 inches of loose, moist, brown, SAND, with gravel, some silt, trace fine roots (TOPSOIL).	S-1 @ 0 feet			
2					
3	Soft, moist, gray, SILT, with sand and roots at 2 feet to silty SAND, trace gravel (FILL).	S-2 @ 1½ feet			
4		S-3 @ 3½ feet			
5					
6	Medium dense, moist, gray, silty SAND, with concrete and rebar, trace gravel (FILL).				
7					
8	Medium dense, moist, gray-brown, SAND, with to some gravel, trace silt (FILL).	S-4 @ 6½ feet			
9					
10					
11	-trace asphalt at about 10 feet.	S-5 @ 10 feet			
12					
13					
14					
15	Medium dense to dense, moist, gray, GRAVEL, with sand, cobbles, trace silt (Qva).	S- 6@ 14 feet			
16					
17	Medium dense to dense, moist, gray, SAND, trace gravel (Qva).	S-7 @ 16½ feet			
18	Test pit completed at approximately 17 feet. Groundwater not observed while excavating. Severe caving at about 13 ½ feet.				

Test Pit TP-46

Location: See Site and Exploration Plan, Figure 1
Approx. Ground Surface Elevation: 24 feet

Project: Twin City Sub. Pole Yard
Project No: 2470.01
Date Excavated: September 20, 2021

Depth (ft)	Material Description	Sample	%Fines	%M	Testing
1	6 inches of loose, moist, brown SAND, with silt, some gravel and lenses of clay, trace roots to 6 inches (TOPSOIL).	S-1 @ 0 feet			
2	Medium dense, moist, gray-brown SAND, with silt and gravel (Fill).				
3		S-2 @ 1½ feet			
4	Loose, moist, gray, silty SAND, with pockets of sandy SILT trace gravel (FILL).	S-3 @ 3½ feet			
5					
6	Medium dense, moist, gray-brown, SAND, with gravel and clasts of silt, trace cobbles (FILL).	S-4 @ 5½ feet			
7					
8					
9		S-5 @ 8½ feet			
10					
11					
12					
13					
14	Medium dense, wet, gray SAND, trace gravel (Qva).	S- 6@ 13½ feet			
15					
16					
17					
18		S-7 @ 17½ feet			
19	Test pit completed at approximately 18 feet. Groundwater not observed while excavating. Severe caving at about 12feet				

ZIPPER GEO ASSOCIATES, LLC

19019 36th Avenue West, Suite E, Lynnwood, Washington 98036

Test Pit TP-47

Location: See Site and Exploration Plan, Figure 1
Approx. Ground Surface Elevation: 24 feet

Project: Twin City Sub. Pole Yard
Project No: 2470.01
Date Excavated: September 20, 2021

Depth (ft)	Material Description	Sample	%Fines	%M	Testing
1	12 inches of soft, wet, gray, sandy SILT, trace roots and organics (TOPSOIL).	S-1 @ 0 feet			
2					
3	Loose, moist, gray, SAND, with gravel and boulders (FILL).	S-2 @ 2 feet			
4					
5	Medium dense, moist, gray, silty SAND, some gravel (FILL).	S-3 @ 3½ feet			
6					
7					
8					
9					
10	Medium dense, damp, gray-brown gravelly SAND, trace silt and cobbles (Qva).	S-4 @ 9 feet	3.7	3.2	GSA
11					
12					
13					
14					
15		S-5 @ 14 feet	1.0	3.0	GSA
16					
17					
18	-wet at about 18 feet.	S-6 @ 18 feet			
19	Test pit completed at approximately 18½ feet. Groundwater not observed while excavating. Severe caving at about 9 feet				

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Test Pit TP-48

Location: See Site and Exploration Plan, Figure 1
Approx. Ground Surface Elevation: 23 feet

Project: Twin City Sub. Pole Yard
Project No: 2470.01
Date Excavated: September 20, 2021

Depth (ft)	Material Description	Sample	%Fines	%M	Testing
1	Grass over 1.2 feet of mulched trees/brush (TOPSOIL).				
2	Loose, moist, gray-brown, silty SAND, with gravel and silt (FILL).	S-1 @ 1½ feet			
3					
4	Medium dense, moist, gray-brown, silty SAND, with to some gravel (FILL).	S-2 @ 3½ feet			
5					
6					
7					
8					
9		S-3 @ 8 feet			
10					
11					
12	Medium dense, gray, moist, SAND, with to trace gravel, trace cobbles and silt (Qva).				
13		S-4 @ 12 feet			
14					
15					
16					
17					
18	-wet at about 17½ feet.	S-5 @ 17½ feet			
19	Test pit completed at approximately 18 feet. Groundwater not observed. Severe caving at about 11 feet.				

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Test Pit TP-49

Location: See Site and Exploration Plan, Figure 1
Approx. Ground Surface Elevation: 23 feet

Project: Twin City Sub. Pole Yard
Project No: 2470.01
Date Excavated: September 20, 2021

Depth (ft)	Material Description	Sample	%Fines	%M	Testing
1	Loose, moist, brown, SAND, with silt and gravel, trace roots and organics (TOPSOIL).	S-1 @ 0 feet			
2	Medium dense, moist, gray-brown, SAND, with silt and gravel (FILL).				
3		S-2 @ 2½ feet			
4	Medium dense, moist, gray-brown, silty SAND, with gravel (FILL).	S-3 @ 3½ feet			
5					
6					
7	Medium dense, moist, gray, SAND, with to trace gravel, trace silt (Qva).	S-4 @ 6 feet			
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18	-wet at about 17½ feet.	S-5 @ 17½ feet			
19	Test pit completed at approximately 18 feet. Groundwater not observed while excavating. Severe caving at about 6 feet.				

Test Pit TP-50

Location: See Site and Exploration Plan, Figure 1
Approx. Ground Surface Elevation: 23 feet

Project: Twin City Sub. Pole Yard
Project No: 2470.01
Date Excavated: September 20, 2021

Depth (ft)	Material Description	Sample	%Fines	%M	Testing
1	2-6 inches of loose, wet, brown, silty SNAD, some gravel, trace roots and organics (TOPSOIL).	S-1 @ 0 feet			
2					
3	Medium dense, moist, brown, SAND, with to some silt, with gravel, trace cobbles (FILL).	S-2 @ 2 feet			
4					
5		S-3 @ 4 feet			
6					
7					
8	- with silt and silt lenses at about 7½ feet.	S-5 @ 7½ feet			
9					
10					
11	Medium dense, moist, dark gray, silty SAND, with gravel (FILL).	S-6 @ 10 feet			
12					
13					
14					
15	Medium dense, moist, gray, SAND, with silt and gravel pockets of silty SAND (Qva).	S-7 @ 14 feet			
16					
17					
18	Dense to Hard, wet, dark gray, silty SAND, some gravel to SILT, with sand.	S-8 @ 17½ feet			
19	Test pit completed at approximately 18 feet. Groundwater not observed while excavating. Caving was not observed while excavating.				

Test Pit TP-51

Location: See Site and Exploration Plan, Figure 1
Approx. Ground Surface Elevation: 23 feet

Project: Twin City Sub. Pole Yard
Project No: 2470.01
Date Excavated: September 20, 2021

Depth (ft)	Material Description	Sample	%Fines	%M	Testing
1	Loose, wet, brown, silty SAND, with roots and mulch up to ½ inch in diameter (TOPSOIL).	S-1 @ 0 feet			
2					
3	Loose, moist, brown-gray, SAND, with silt, some gravel (FILL).	S-2 @ 2½ feet			
4					
5					
6					
7					
8	Medium dense, moist, dark gray, silty SAND, with gravel (FILL).	S-3 @ 7½ feet			
9					
10					
11					
12	Medium dense, damp, gray, gravelly SAND, trace silt (Qva).	S-4 @ 11 feet	3.4	4.0	GSA
13					
14					
15		S-5 @ 14½ feet			
16	Test pit completed at approximately 15 feet. Groundwater not observed while excavating. Severe caving at about 9 feet.				
17					
18					

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Test Pit TP-52

Location: See Site and Exploration Plan, Figure 1
Approx. Ground Surface Elevation: 22 feet

Project: Twin City Sub. Pole Yard
Project No: 2470.01
Date Excavated: September 20, 2021

Depth (ft)	Material Description	Sample	%Fines	%M	Testing
1	2-6 inches of loose, moist, brown SAND, with gravel, some silt, trace roots and organics (TOPSOIL).	S-1 @ 0 feet			
2					
3	Loose, moist, gray-brown, SAND, with silt and gravel (FILL).	S-2 @ 2½ feet			
4					
5	Medium dense, moist, gray, gravelly to trace gravel SAND, trace silt (Qva).	S-3 @ 4 feet			
6					
7					
8					
9					
10					
11	-dense and silty at about 10 to 13 feet.	S-4 @ 10 feet			
12					
13					
14					
15		S-5 @ 14 feet			
16					
17		S-6 @ 16 feet			
18	Test pit completed at approximately 16½ feet. Groundwater not observed. Severe caving at about 8 feet.				

Test Pit TP-53

Location: See Site and Exploration Plan, Figure 1
Approx. Ground Surface Elevation: 22 feet

Project: Twin City Sub. Pole Yard
Project No: 2470.01
Date Excavated: September 20, 2021

Depth (ft)	Material Description	Sample	%Fines	%M	Testing
1	2-6 inches of loose, wet, brown, silty SAND, with gravel and organics (TOPSOIL).	S-1 @ 0 feet			
2	Medium dense, light brown, silty SAND, with gravel (FILL).				
3		S-2 @ 2 feet			
4	Medium dense, moist, gray, SAND, with to some gravel, trace silt (Qva).				
5		S-3 @ 4 feet			
6					
7					
8					
9					
10					
11		S-4 @ 10 feet			
12					
13					
14					
15		S-2 @ 14½ feet			
16	Test pit completed at approximately 15 feet. Groundwater not observed. Severe caving at about 4 feet.				
17					
18					

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	Test Pit TP-54 **Location:** See Site and Exploration Plan, Figure 1 **Approx. Ground Surface Elevation**: 22 feet	**Project:** Twin City Sub. Pole Yard **Project No:** 2470.01 **Date Excavated:** September 20, 2021

Depth (ft)	**Material Description**	**Sample**	**%Fines**	**%M**	**Testing**
1	Grass over, loose, wet, brown, silty SAND, with gravel and mulch and organics (TOPSOIL).	S-1 @ 0.5 feet			
2	Medium dense, moist, gray SAND, with silt and gravel (FILL).	S-2 @ 1½ feet			
3					
4	Medium dense, moist, gray, SAND, trace silt and gravel to SAND, with gravel (Qva).	S-3 @ 3½ feet			
5					
6					
7					
8					
9					
10	-sandy GRAVEL at about 9½ feet to about 12 feet.	S-4 @ 9½ feet	0.6	2.5	GSA
11					
12					
13					
14					
15	-grades to gravelly SAND, some silt	S-5 @ 14½ feet	8.4	4.1	GSA
16					
17		S-6 @ 16½ feet			
18	Test pit completed at approximately 17 feet. Groundwater was observed at about 16½ ft. while excavating.				
19	Moderate caving at about 3 feet.				

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Test Pit TP-55

Location: See Site and Exploration Plan, Figure 1
Approx. Ground Surface Elevation: 22 feet

Project: Twin City Sub. Pole Yard
Project No: 2470.01
Date Excavated: September 20, 2021

Depth (ft)	Material Description	Sample	%Fines	%M	Testing
1	6 inches of loose, moist, brown, silty SAND, with roots, organics, gravel (TOPSOIL).	S-1 @ 0 feet			
2					
3	Medium dense, moist, gray-brown, silty SAND to SAND with silt and gravel (FILL)	S-2 @ 2½ feet			
4					
5	Medium dense, moist, gray-brown, SAND, with gravel, trace silt (FILL).	S-3 @ 4 feet			
6					
7					
8					
9	Loose to medium dense, wet, dark gray, silty SAND (FILL).	S-4 @ 8½ feet			
10					
11					
12					
13					
14					
15	Medium dense, wet, gray, SAND, with gravel, trace silt (Qva).	S-5 @ 14½ feet			
16	Test pit completed at approximately 15 feet. Groundwater not observed while excavating. Caving was not observed.				
17					
18					

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Test Pit TP-56

Location: See Site and Exploration Plan, Figure 1
Approx. Ground Surface Elevation: 21 feet

Project: Twin City Sub. Pole Yard
Project No: 2470.01
Date Excavated: September 20, 2021

Depth (ft)	Material Description	Sample	%Fines	%M	Testing
1	Grass over 6 inches of loose, wet, brown, silty SAND, with gravel, roots, and organics (TOPSOIL).	S-1 @ 0 feet			
2					
3	Medium dense, moist, gray SAND, with silt to silty, with to some gravel, and pockets of hard silt (FILL).	S-2 @ 2 feet			
4					
5		S-3 @ 4 feet			
6					
7					
8	Hard, dark gray, moist, SILT, with sand (FILL).	S-4 @ 7½ feet			
9					
10	Medium dense to dense, moist, brown SAND, trace silt (Qva).	S-5 @ 9½ feet	2.1	4.3	GSA
11					
12					
13					
14					
15	-gray at about 14½ feet.	S-6 @ 14½ feet			
16	-dense at about 16 feet.				
17		S-7 @ 16½ feet			
18	Test pit completed at approximately 17 feet. Groundwater not observed while excavating. Caving was not observed.				
19					

APPENDIX B
LABORATORY TESTING PROCEDURES AND RESULTS

LABORATORY PROCEDURES AND RESULTS

A series of laboratory tests were performed during the course of this study to evaluate the index and geotechnical engineering properties of the subsurface soils. Descriptions of the types of tests performed are given below.

Visual Classification

Samples recovered from the exploration locations were visually classified in the field during the exploration program. Representative portions of the samples were carefully packaged in moisture tight containers and transported to our laboratory where the field classifications were verified or modified as required. Visual classification was generally done in accordance with ASTM D 2488. Visual soil classification includes evaluation of color, relative moisture content, soil type based upon grain size, and accessory soil types included in the sample. Soil classifications are presented on the exploration logs in Appendix A.

Moisture Content Determinations

Moisture content determinations were performed on representative samples obtained from the explorations in order to aid in identification and correlation of soil types. The determinations were made in general accordance with the test procedures described in ASTM D 2216. The results are shown on the exploration logs in Appendix A.

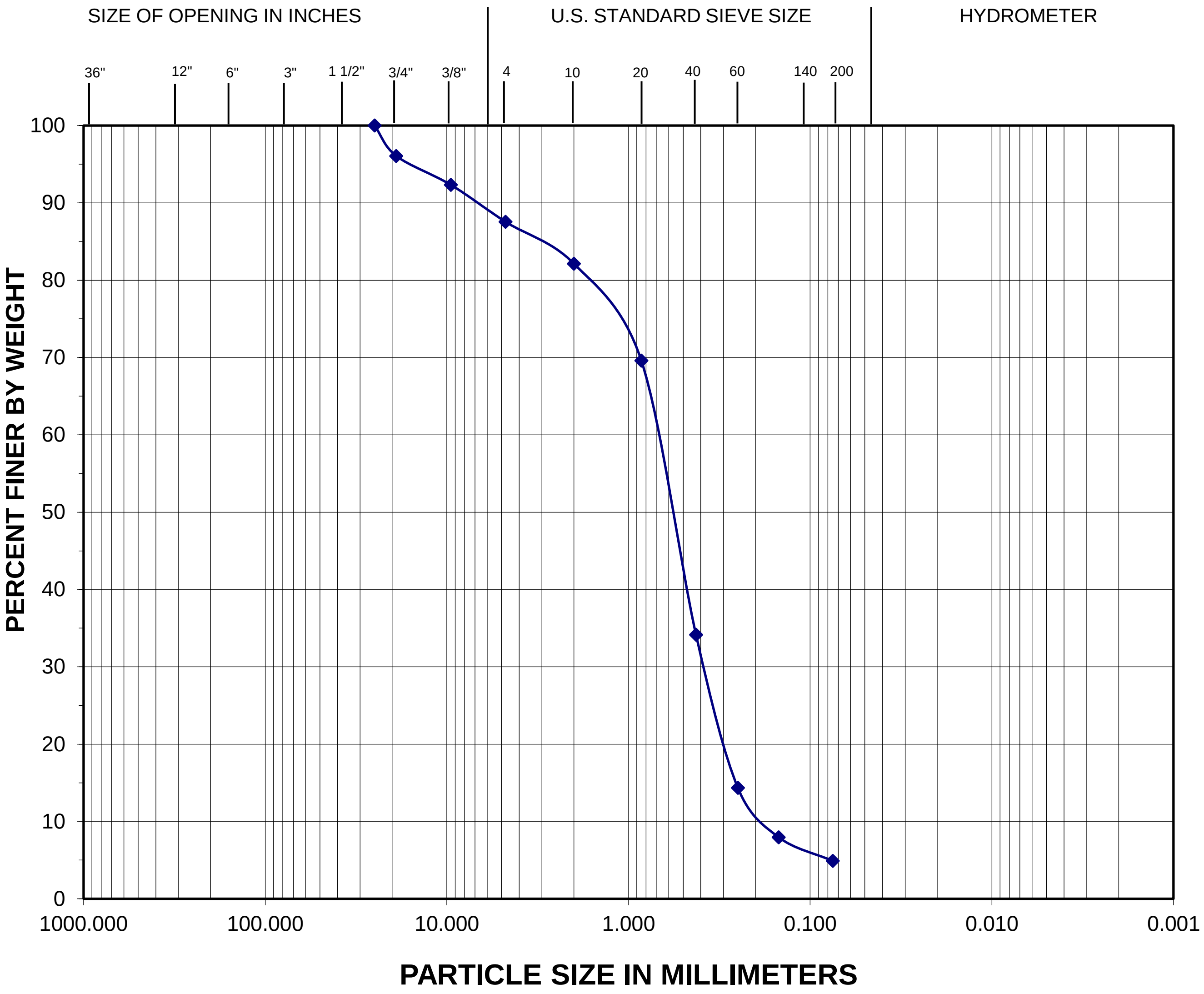
Grain Size Analysis

A grain size analysis indicates the range in diameter of soil particles included in a particular sample. Grain size analyses were performed on representative samples in general accordance with ASTM D 6913. The results of the grain size determinations for the samples were used in classification of the soils, and are presented in this appendix.

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D6913



<table>
<tr><td rowspan="2">BOULDERS</td><td rowspan="2">COBBLES</td><td>Coarse</td><td>Fine</td><td>Coarse</td><td>Medium</td><td>Fine</td><td>Silt</td><td>Clay</td></tr>
<tr><td colspan="2">GRAVEL</td><td colspan="3">SAND</td><td colspan="2">FINE GRAINED</td></tr>
</table>

Comments:

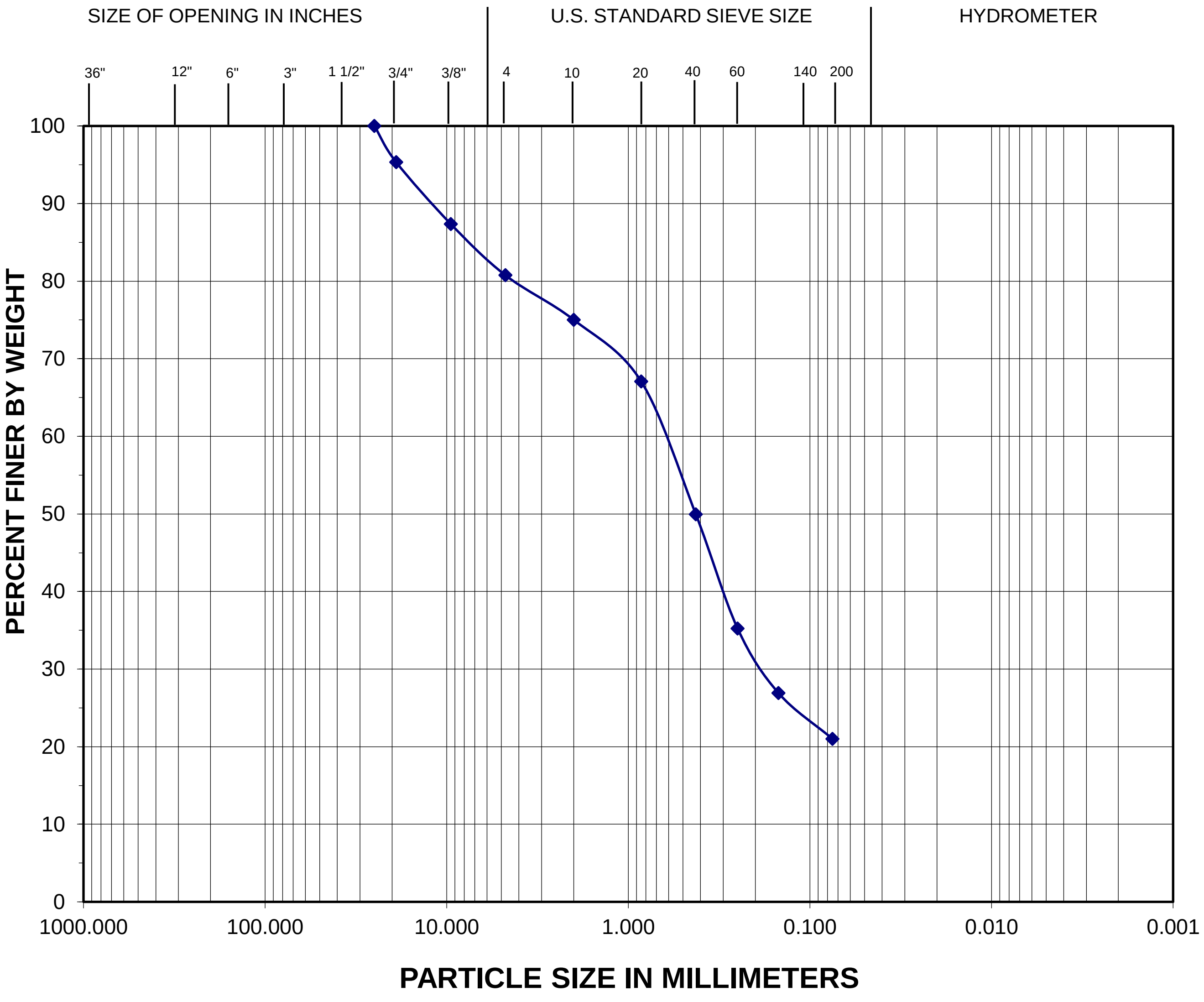
Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
B-6	S-6	15-16.5	6.3	4.9	SAND, with gravel, trace silt

Zipper Geo Associates, LLC Geotechnical and Environmental Consultants	PROJECT NO: 2470.01 DATE OF TESTING: 10/6-10/11	PROJECT NAME: Twin City Pole Yard

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D6913



BOULDERS	COBBLES	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
		GRAVEL		SAND			FINE GRAINED	

Comments:

Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
B-7	S-4	10-11.5	7.2	21.0	SAND, with silt and gravel

Zipper Geo Associates, LLC
Geotechnical and Environmental Consultants

PROJECT NO: 2470.01

DATE OF TESTING: 10/6-10/11

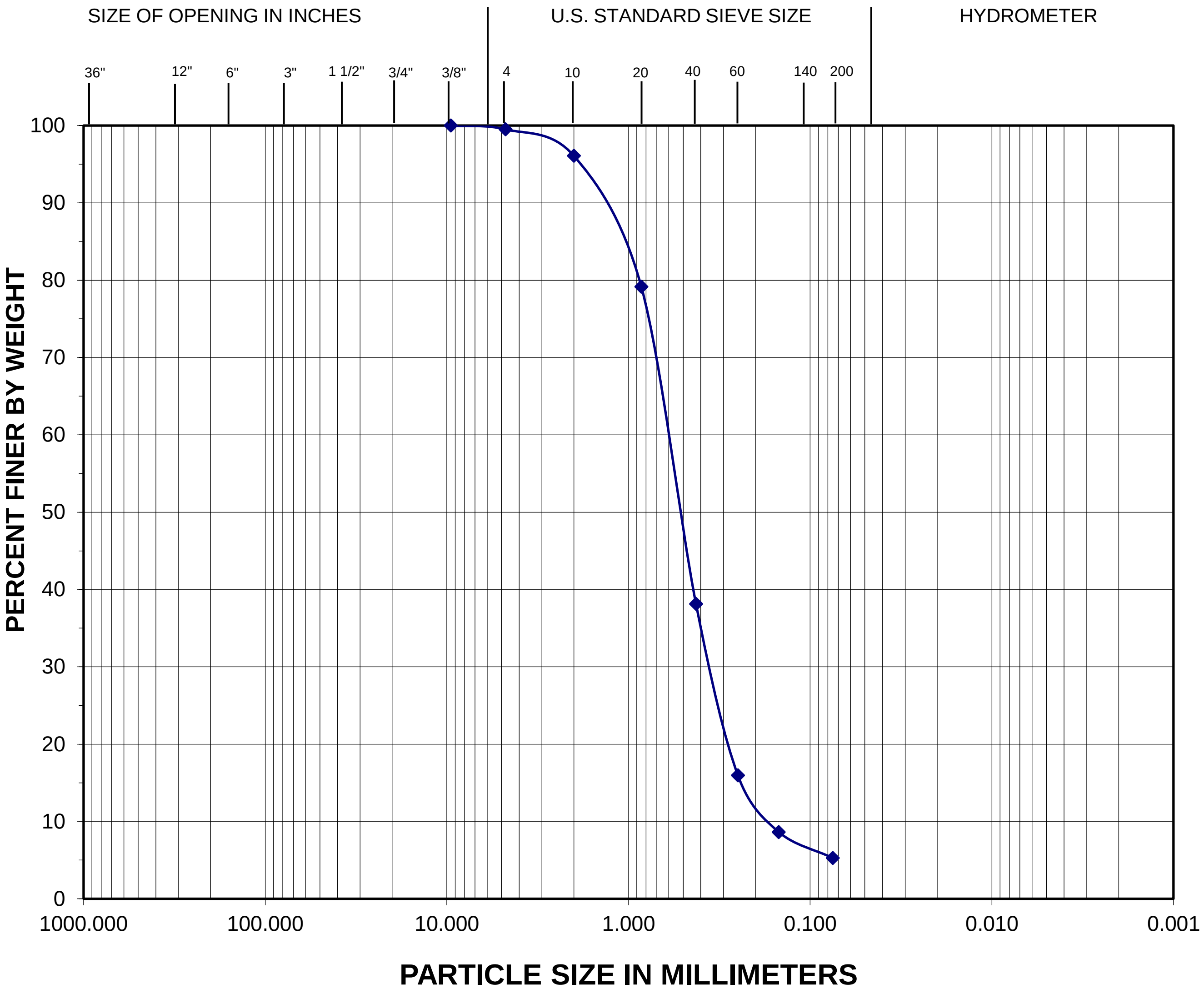
PROJECT NAME:

Twin City Pole Yard

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D6913



		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
BOULDERS	COBBLES	GRAVEL		SAND			FINE GRAINED	

Comments:

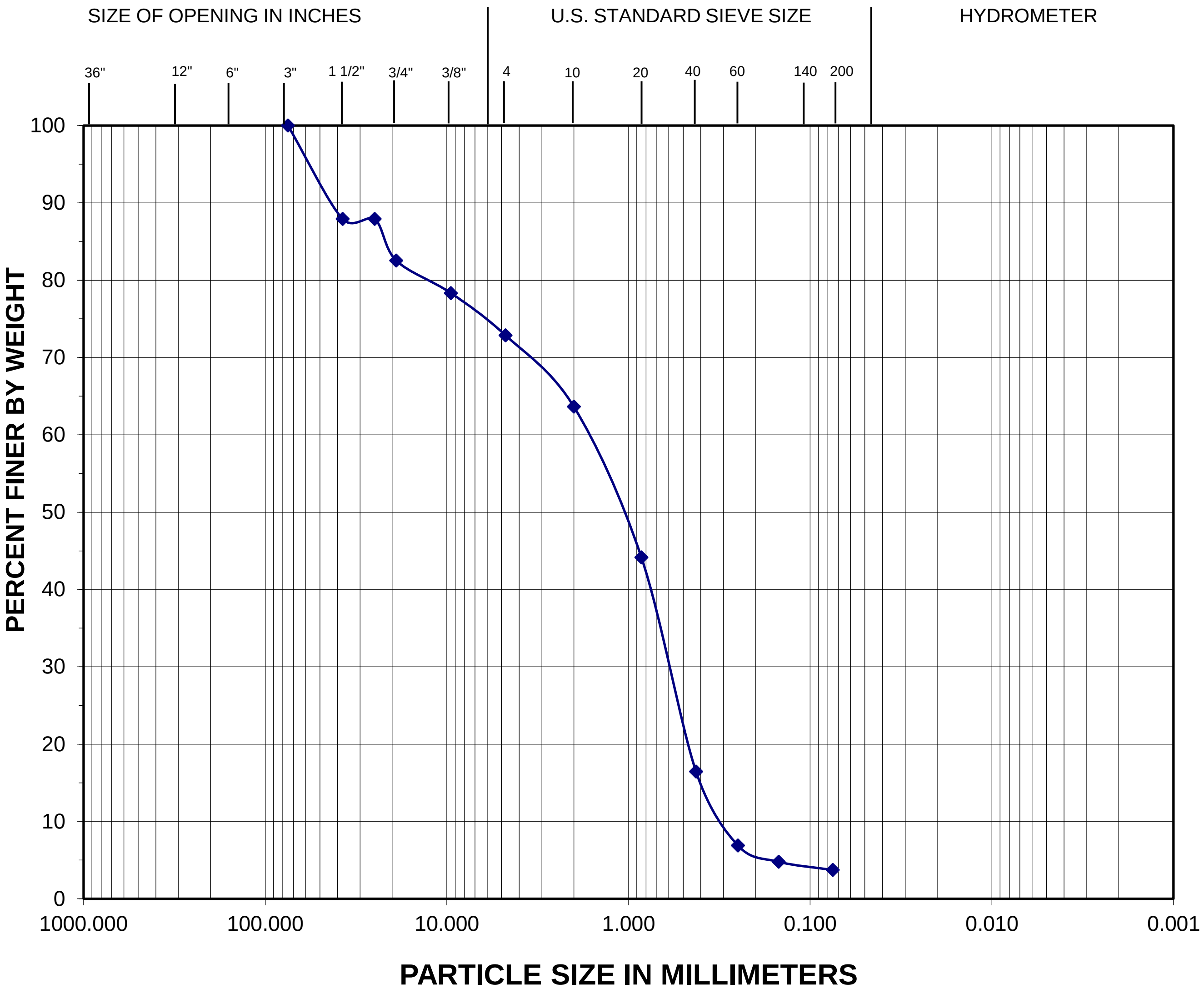
Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
B-7	S-5	12.5-14	3.5	5.3	SAND, some silt, trace gravel

Zipper Geo Associates, LLC Geotechnical and Environmental Consultants	PROJECT NO: 2470.01 DATE OF TESTING: 10/6-10/11	PROJECT NAME: Twin City Pole Yard

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D6913



BOULDERS	COBBLES	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
		GRAVEL		SAND			FINE GRAINED	

Comments:

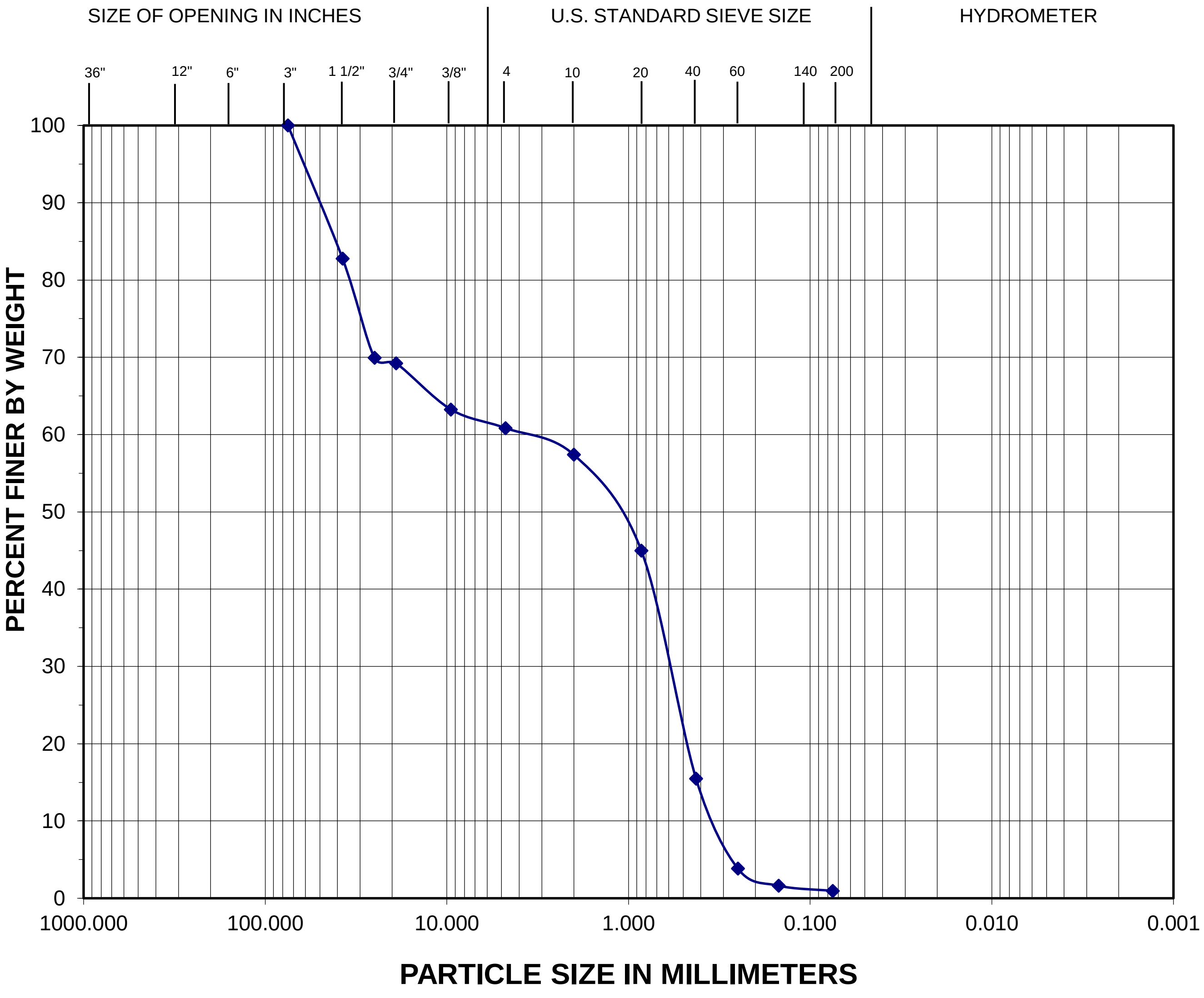
Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
TP-47	S-4	9-9.5	3.2	3.7	Gravelly SAND, trace silt

Zipper Geo Associates, LLC Geotechnical and Environmental Consultants	PROJECT NO: 2470.01 DATE OF TESTING: 10/4-10/6/21	PROJECT NAME: Twin City Pole Yard

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D6913



		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
BOULDERS	COBBLES	GRAVEL		SAND			FINE GRAINED	

Comments:

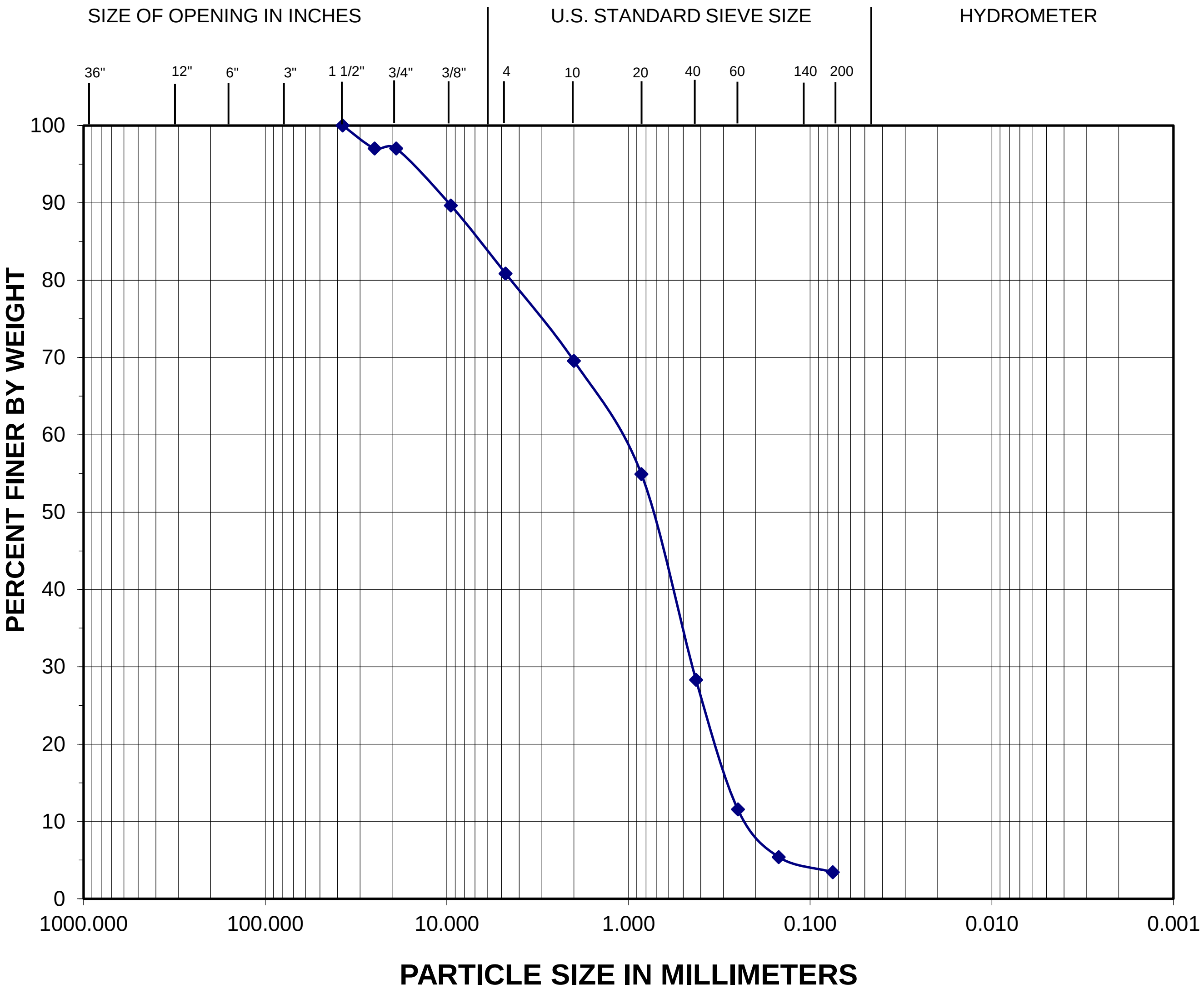
Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
TP-47	S-5	14-14.5	3.0	1.0	Gravelly SAND, trace silt

Zipper Geo Associates, LLC Geotechnical and Environmental Consultants	PROJECT NO: 2470.01 DATE OF TESTING: 10/4-10/6/21	PROJECT NAME: Twin City Pole Yard

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D6913



		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
BOULDERS	COBBLES	GRAVEL		SAND			FINE GRAINED	

Comments:

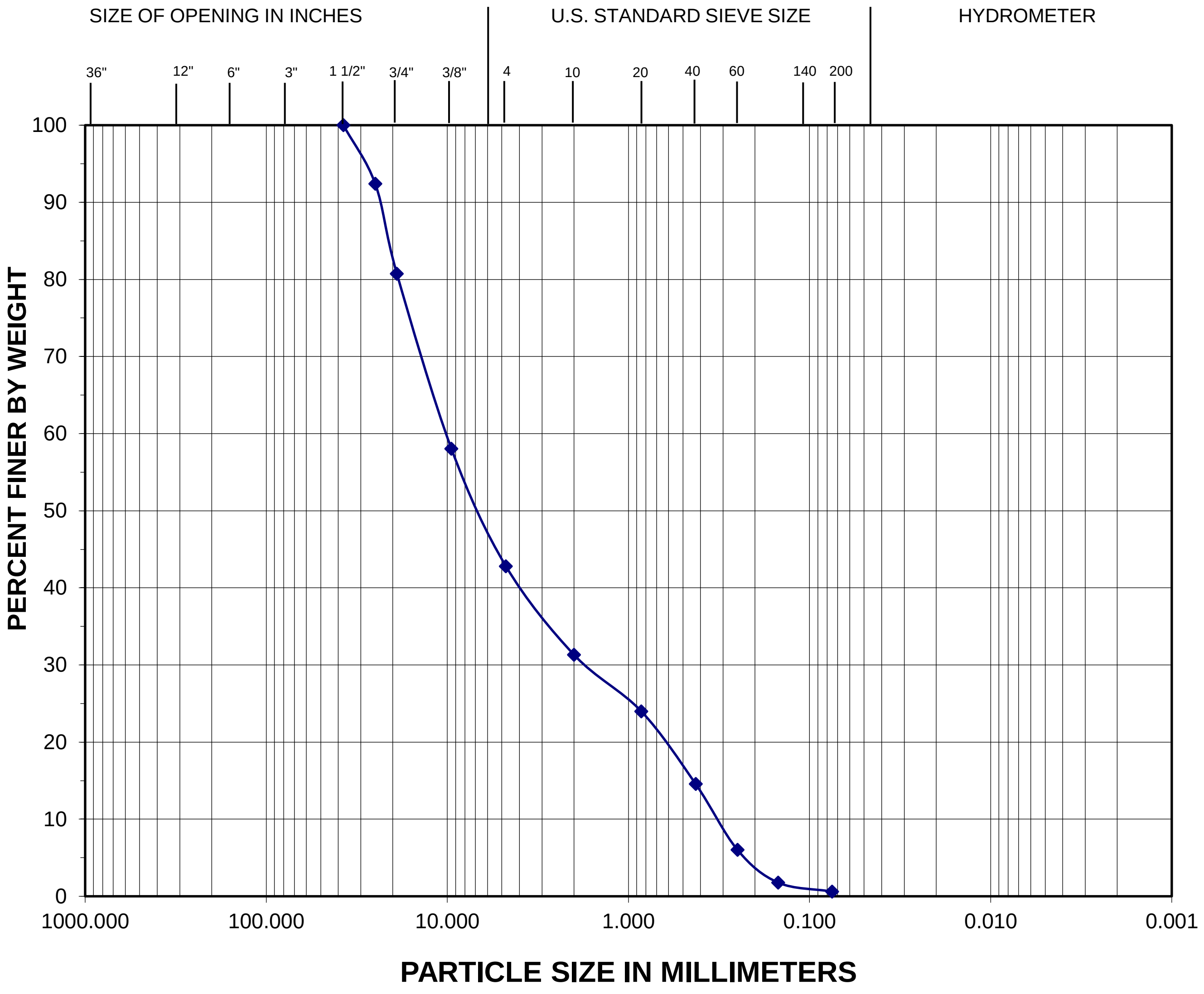
Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
TP-51	S-4	11-11.5	4.0	3.4	Gravelly SAND, trace silt

Zipper Geo Associates, LLC Geotechnical and Environmental Consultants	PROJECT NO: 2470.01 DATE OF TESTING: 10/4-10/6/21	PROJECT NAME: Twin City Pole Yard

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D6913



		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
BOULDERS	COBBLES	GRAVEL		SAND			FINE GRAINED	

Comments:

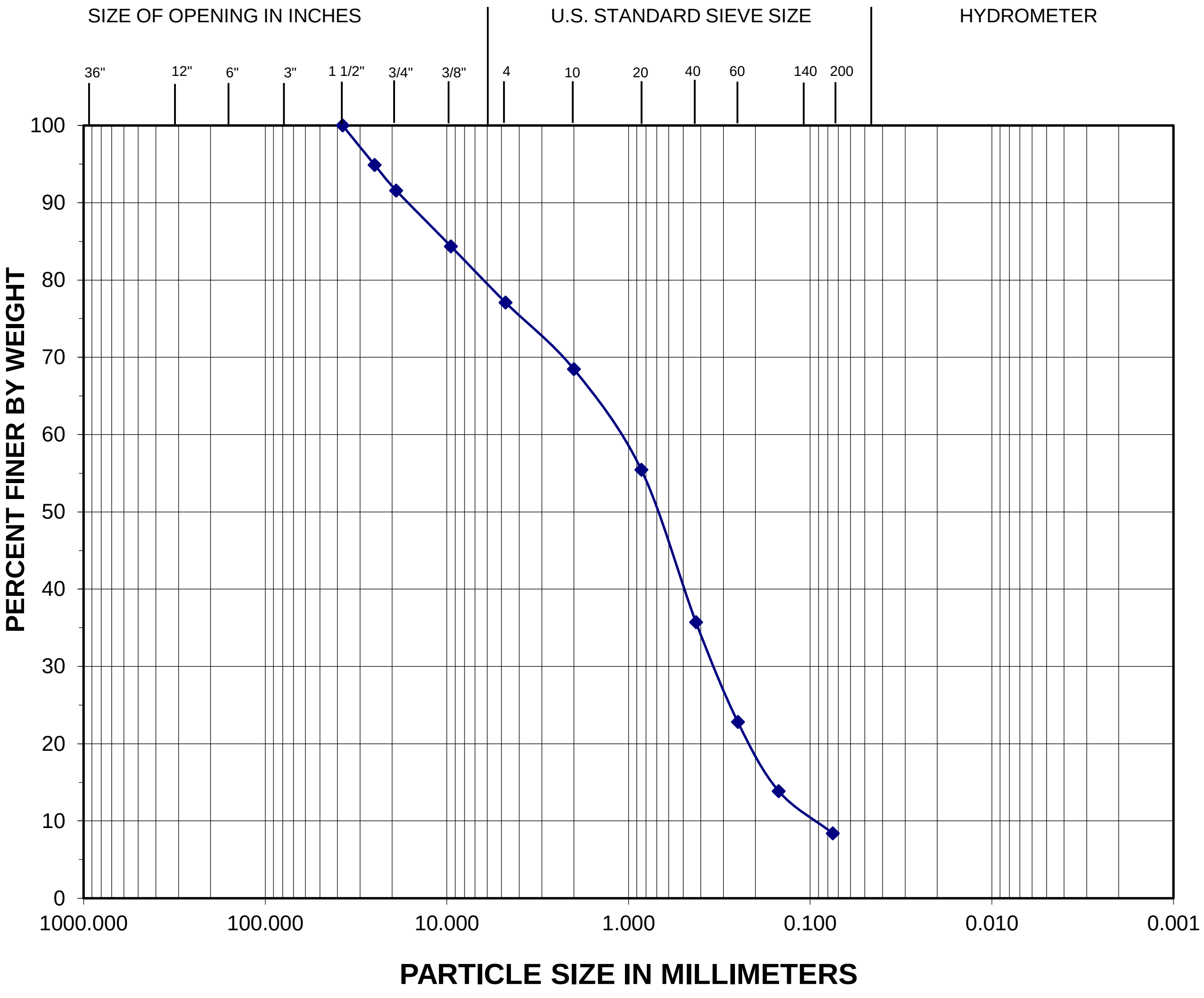
Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
TP-54	S-4	9.5-10	2.5	0.6	Sandy GRAVEL, trace silt

Zipper Geo Associates, LLC Geotechnical and Environmental Consultants	PROJECT NO: 2470.01 DATE OF TESTING: 10/4-10/6/21	PROJECT NAME: Twin City Pole Yard

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D6913



BOULDERS	COBBLES	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
		GRAVEL		SAND			FINE GRAINED	

Comments:

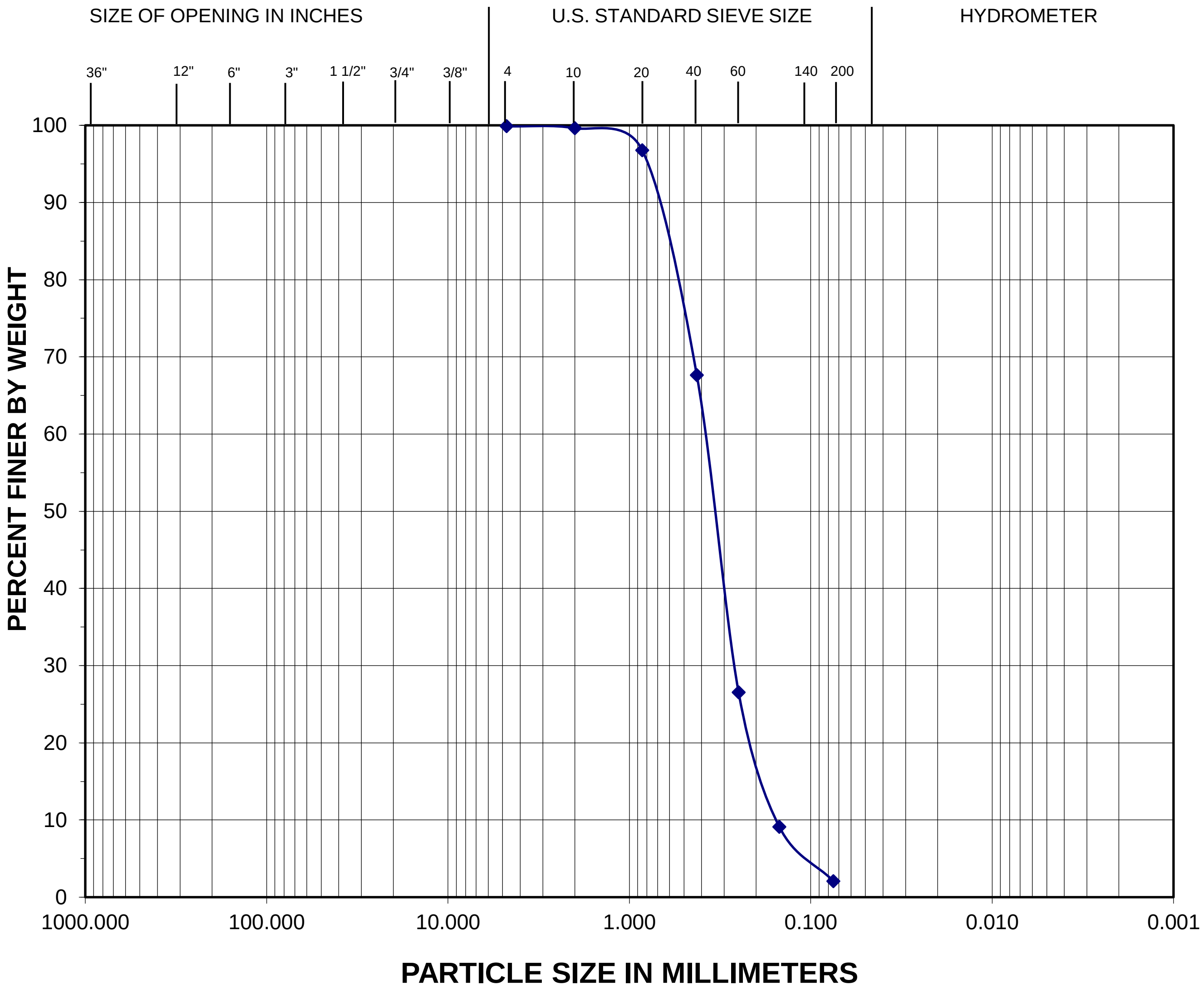
Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
TP-54	S-5	14.5-15	4.1	8.4	Gravelly SAND, some silt

Zipper Geo Associates, LLC Geotechnical and Environmental Consultants	PROJECT NO: 2470.01 DATE OF TESTING: 10/4-10/6/21	PROJECT NAME: Twin City Pole Yard

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D6913



		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
BOULDERS	COBBLES	GRAVEL		SAND			FINE GRAINED	

Comments:

Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
TP-56	S-5	9.5-10	4.3	2.1	SAND, trace silt

Zipper Geo Associates, LLC
Geotechnical and Environmental Consultants

PROJECT NO: 2470.01

DATE OF TESTING: 10/4-10/6/21

PROJECT NAME:

Twin City Pole Yard