GEOTECHNICAL ENGINEERING REPORT

PROPOSED LEARNING EXPERIENCE
WILLAMETTE DRIVE NE AND CAMPUS GLEN DRIVE NE
LACEY, WASHINGTON

ZGA Project No. 2303.01
May 22, 2020

Prepared for:
LE-LACEY, WA-1-UT, LLC

Prepared by:
ZipperGeo

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

ZipperGeo
Geoprofessional Consultants

May 22, 2020

LE-LACEY, WA-1-UT, LLC
4747 Williams Drive
Georgetown, TX 78633

Attn: Mr. Jerry Frazier

RE: Geotechnical Engineering Report
Proposed Learning Experience
Willamette Drive NE and Campus Glen Drive NE
Lacey, Washington
ZGA Project No. 2303.01

Dear Mr. Frazier:

In accordance with your request and written authorization, Zipper Geo Associates, LLC (ZGA) has completed the subsurface evaluation and geotechnical engineering report for the above-referenced project. This report presents the findings of the subsurface evaluation and geotechnical recommendations for the project. Our work was completed in general accordance with our *Proposal for Geotechnical Engineering Services* (Proposal No. P19384) dated December 2, 2019. Authorization to proceed was provided by LE-LACEY, WA-1-UT, LLC via a Geotech Report Work Order dated January 15, 2020. 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,
Zipper Geo Associates LLC

THOMAS A. JONES
STATE OF WASHINGTON
29074 5/22/20
REGISTERED
PROFESSIONAL ENGINEER

Thomas A. Jones, P.E.
Principal

TABLE OF CONTENTS

Cover Photo Reference: Thurston County Assessors website

GEOTECHNICAL ENGINEERING REPORT
PROPOSED LEARNING EXPERIENCE
WILLAMETTE DRIVE NE AND CAMPUS GLEN DRIVE NE
LACEY, WASHINGTON

Project No. 2303.01
May 22, 2020

INTRODUCTION

This report presents the subsurface conditions encountered at the project site and our geotechnical engineering recommendations for the proposed project. Supporting data including field exploration procedures and detailed exploration logs, and results of laboratory testing are presented as appendices.

Our geotechnical engineering scope of services for the project included a site reconnaissance, subsurface evaluation, laboratory testing, analysis of the data, and preparation of this report. The subsurface evaluation consisted of completing seven test pits (designated TP-1 through TP-7) across the site. The test pits were excavated to depths ranging from about 10 to 12 feet below the existing ground surface.

Figure 1, the Site and Exploration Plan, presents the approximate locations of our subsurface explorations completed for this project. Appendix A contains a description of our field procedures and the exploration logs. Appendix B contains a description of the various laboratory testing procedures and the test results.

SITE DESCRIPTION

The project site consists of one tax parcel (11936340200) located at the northeast corner of the intersection of Willamette Dr. NE and Campus Glen Dr. NE in Lacey, Washington. The 1.5-acre (65,340 square foot) site is currently undeveloped. Patches of evergreen trees and a few deciduous trees are scattered across the site. Open areas are covered with weeds, grasses, blackberry vines and scotch broom. In general, the site is lower than the surrounding streets.

The majority of the site is relatively flat except around the perimeter of the site where slopes on the order of 1 to 7 feet tall dip down from the surrounding streets to the south and east and adjacent subdivision to the north. The site is bordered to the north by single-family housing, to the south by Campus Glen Drive NE, to the east by London Loop Lane, and to the west by Willamette Drive NE.

PROJECT UNDERSTANDING

Based on the plans provided to us, we understand a 10,000 square foot building will be constructed on the north side of the site. A 5,000 square foot play area will be constructed to the east of the building and parking will be provided to the south of the building and play area. We understand that some fill placement will be completed to raise site grades. Landscaped areas will be situated primarily around the perimeter of the site.

SUBSURFACE EXPLORATIONS

The geotechnical subsurface evaluation consisted of excavating seven test pits (TP-1 through TP-7) across the site on January 27, 2020. On May 8, 2020, ZGA completed 18 additional shallow test pit excavations as part of an environmental site characterization study for arsenic and lead. Five of the deeper environmental test pits (TP-8 through TP-12) have been utilized to supplement the original subsurface information used to prepare this report. The approximate locations of the explorations utilized for this report are presented on Figure 1, the Site and Exploration Plan. The results of the environmental site characterization have been submitted under separate cover.

SUBSURFACE CONDITIONS

Published Geologic Mapping

The Geologic Map of the Nisqually 7.5-minute Quadrangle, Thurston and Pierce Counties, Washington, Washington Division of Geology and Earth Resources, Open File Report 2003-10, by Walsh, T.J., Logan, R.L., Polenz, M., and Schasse, H.W., 2003, maps the site as being mantled by Vashon Till (Qvt). This material is described as an unstratified, highly compacted mixture of clay, silt, sand, and gravel deposited directly by glacial ice. It is also described as having very low permeability.

According to the USDA Natural Resources Conservation Service (NRCS), Web Soil Survey for the Thurston County Area, Washington, (http://websoilsurvey.nrcs.usda.gov), the site and surrounding area are underlain by the Alderwood gravelly sandy loam. This material is also referred to as glacial till that consists of a dense mixture of clay, silt, sand, gravel, cobbles and boulders. A perched groundwater table, described by the NRCS as a saturated zone in the soil, reportedly forms about 1.5 to 3.3 feet below the ground surface during the wet season.

All of the test pit excavations encountered material they we interpreted to be recessional outwash. In the deeper test pits, glacial till soils were encountered between approximately 3¼ and 11 feet below grade.

Soil Conditions

Soils were visually classified in general accordance with the Unified Soil Classification System. Detailed, descriptive logs of the subsurface explorations and the procedures utilized in the subsurface exploration program are presented in Appendix A. Generalized descriptions of subsurface soil conditions observed in specific areas of the site are presented below.

At the time of our explorations, the site was generally covered with weeds and grass with scattered trees and brush across most of the property. A thicker stand of mostly evergreen trees was situated along the north side of the site.

In general, the explorations encountered undocumented fill or topsoil, over recessional glacial outwash over glacial till. The following table presented a summary stratigraphy of the soils encountered in the explorations followed by a summary description of each soil unit.

ZipperGeo
Geoprofessional Consultants

Summary of Subsurface Conditions

Test Pit No.	Approx. Ground Surface Elevation (ft)	Approximate Depth Interval of Soil Unit (ft)				Total Approx. Depth (ft)
		Topsoil and/or Organic Root Mat [1]	Undocumented Fill	Recessional Outwash	Glacial Till	
TP-1	unknown	0 - ¼	¼ - 2	2 - 11	11 - 11½	11½
TP-2	unknown	0 - ¼	---	¼ - 6½	6½ - 11	11
TP-3	unknown	0 - ¼ and 3 - 3¼	¼ - 3	---	3¼ - 10½	10½
TP-4	unknown	0 - ½	---	½ - 6½	6½ - 10½	10½
TP-5	unknown	0 - ¼	¼ - 1	1 - 8¾	8¾ - 12	12
TP-6	unknown	0 - ¼ and 1½ - 1¾	¼ - 1½	1½ - 6½	6½ - 10	10
TP-7	unknown	0 - ¼ and 3 - 3¼	¼ - 3	3 - 10½	10½ - 12	12
TP-8	unknown	0 - ¼	---	¼ - 4	---	4
TP-9	unknown	0 - ¼	---	¼ - 4	---	4
TP-10	unknown	---	0 -2	2 - 4½	---	4½
TP-11	unknown	0 - ¼	---	¼ - 4	---	4
TP-12	unknown	0 - ¼ and 2¾ - 3	¼ - 2¾	3 - 4½	---	4½

1. Where two layers are shown in the Topsoil/ Organic Root Mat column, the deeper layer was encountered beneath a layer of fill.

Surface Topsoil and/or Root Mat: Organic-rich topsoil and/or a root mat was encountered in all of the test pits. In general, the root mat was about 2 to 4 inches thick. Surficial topsoil was only encountered in test pits TP- 2, TP- 4, TP-8, and TP-9 and consisted of loose silty sand with some gravel, and variable amounts of organics. The topsoil thickness ranged from about 3 to 6 inches.

Undocumented Fill: Undocumented fill soils were encountered in test pits TP-1, TP-3, TP-5, TP-6, TP-7, TP-10 and TP-12 and varied in thickness from approximately 1 to 3 feet. The fill consisted of loose to medium dense, sandy gravel with trace to some and organics. Silt fencing debris was encountered within the fill in test pit TP-1 while we did not observe debris in the fill at the other test pit locations.

Relic Topsoil: Organic-rich relic topsoil was encountered below the undocumented fill in test pits TP-3, TP-6, TP-7, and TP-12 and was generally on the order of about 3 inches thick. The relic topsoil generally consisted of loose to medium dense, moist, dark brown, silty sand with variable amounts of gravel and organics.

Recessional Outwash: Recessional outwash was encountered in all of the test pits except TP-3. The outwash generally consisted of sandy gravel with trace silt and scattered cobbles. The outwash varied in thickness from approximately 6 to 10½ feet and extended to depths of approximately 6½ to 11½ feet below grade.

Glacial Till Deposits: Soils interpreted as weathered and unweathered glacial till were encountered in test pits TP-1 through TP-7 and were somewhat variable with respect to its depth below the existing ground surface and to its fines (silt and clay size material) content. We anticipate that glacial till would have been encountered in test pits TP-8 through TP-12 had the pits been excavated to greater depths. In general, the weathered glacial till consisted of medium dense gravelly sand with silt while the unweathered glacial till consisted of dense to very dense gravelly sand with silt.

Groundwater

Groundwater seepage was encountered in test pits TP-1 through TP-7, excluding test pit TP-3, at the time of the subsurface evaluation. The seepage was interpreted to be perched groundwater that was situated above the dense to very dense glacial till soils. The zones of perched groundwater were typically about 6 inches to 1 foot thick and varied in depth from approximately 6 to 10 feet below grade, depending on the depth of the glacial till contact. The rate of flow into the excavations was estimated to be sight in all of the test pits except test pit TP-1 where it was estimated to be moderate.

Groundwater levels, flow rates and soil moisture conditions should be expected to vary. Fluctuations of the groundwater levels will likely occur due to seasonal variations in the amount of rainfall, runoff and other factors not evident at the time the explorations were performed. Therefore, groundwater levels during construction or at other times in the life of the development may be higher than indicated on the logs.

Summary of Laboratory Testing

Laboratory testing was completed on select soil samples obtained from our test pits. Laboratory testing included moisture content and grain size analysis. The results of moisture content testing are shown on the test pit logs in Appendix A. Results of the grain size analysis tests are provided in Appendix B.

Samples tested had moisture contents ranging from about 3 to 23 percent. Grain size distribution (sieve) tests indicated fines contents (silt and clay size particles passing the US No. 200 sieve) ranging from about ½ to 18 percent in the site soils.

CONCLUSIONS AND RECOMMENDATIONS

General Considerations

Based on the results of our subsurface explorations, laboratory testing, and geotechnical engineering analyses, in our opinion the proposed building can be supported on shallow foundations bearing on at least medium dense native soil or structural fill compacted to the minimum recommended levels presented in this report.

The existing fill encountered in several test pits should be considered unsuitable for foundation, floor slab, and pavement support. Fill by nature can be highly variable and could vary greatly between exploration locations. Without completely removing the fill, there is a risk that compressible fill or unsuitable material buried within the fill could result in unpredictable settlements. Therefore, we recommend that the fill be over-excavated and replaced. Based on the varying thickness of the fill, over-excavation depths should be expected to vary from about 1 to 4 feet, although some areas of thicker fill may be encountered. In general, the existing fill appears suitable for reuse as structural fill provided it is moisture conditioned and compacted to the minimum recommended levels and all deleterious materials within the fill are removed.

The following sections of this report present specific geotechnical recommendations for the project. Our recommendations are based on the observed soil conditions at specific exploration locations. Differing soil conditions than those observed at the test pit locations may become evident during construction. Our recommendations are further based on the assumption that earthwork for site grading, utilities, foundations, floor slabs, and pavements will be monitored by a geotechnical engineer from ZGA.

Geologic Hazards

Based on our understanding of the Lacey Municipal Code, the development is not within or adjacent to Geologically Sensitive Area as defined by the Lacey Municipal Code, Chapter 14.37, Geologically Sensitive Areas Protection. “Geologically sensitive area” means an area that because of its susceptibility to erosion, sliding, earthquake or other geological events, are not suited to the siting of commercial, residential, or industrial development consistent with public health or safety concerns.

“Erosion hazard area” means an area designated by the City of Lacey Environmental Protection and Resources Conservation Plan which, according to the United States Department of Agriculture Soil Conservation Service Soil Survey of Thurston County, Washington, have severe erosion hazard potential. Based on the soil conditions encountered, as well as the slope of the site, it is our opinion that the erosion potential at the site is low.

“Landslide hazard area” means an area potentially subject to landslides because of the combination of geologic, topographic, and hydrologic factors. These areas are typically susceptible to landslides because of a combination of factors, including bedrock, soil, slope gradient, slope aspect, geologic structure, ground water, or other factors. The following areas are considered to be subject to landslide hazard:

1. Any area with a combination of:

a. Slopes greater than fifteen percent; and

b. Impermeable soils (usually silt and clay) frequently interbedded with granular permeable soils (usually sand and gravel); and

c. Springs or ground water seepage.

2. Steep slopes of forty percent or greater.

3. Any area which has shown movement during the Holocene epoch (from ten thousand years ago to present) or which is underlain by mass wastage debris of that age.
4. Any area potentially unstable as a result of rapid stream incision, stream bank erosion, or undercutting by wave action.

5. Any area with slope stability designated as "I", "U", "Urs" or "Uos" by the Coastal Zone Atlas of Washington.

Based on the subsurface conditions encountered in the test pit explorations, the deeper mapped geologic conditions that include the project site, and the observed topography at the site, it is our opinion that the site is not within a landslide hazard area.

"Seismic hazard areas" means those areas subject to severe risk of earthquake damage as a result of seismically induced settlement or soil liquefaction. These conditions occur in areas underlain by cohesionless soils of low density usually in association with a shallow ground water table. Based on the subsurface conditions encountered in the test pit explorations and the deeper mapped geologic conditions that include the project site, it is our opinion that the site is not within a seismic hazard area.

Seismic Design Considerations

The seismic performance of the development was evaluated relative to seismic hazards resulting from ground shaking associated with a design seismic event with a 2,475-year return period determined in accordance with the 2015 International Building Code (IBC).

<u>Ground Fault Rupture</u>: Based on review of the USGS Quaternary Fault interactive map, the site lies about 19 miles southwest of the southern limb of the Tacoma Fault and about 5.5 miles northeast of the Olympia Structure. The age of the Tacoma Fault is less than 15,000 years and is in the slip rate category of between 0.2 and 1 mm/year while the Olympia Structure is poorly mapped with insufficient data. Based on the information described above, we estimate that the risk associated with fault surface rupture at the site is low.

<u>Liquefaction</u>: Liquefaction is a phenomenon wherein saturated cohesionless soils build up excess pore water pressures during earthquake loading. Liquefaction typically occurs in loose soils, but may occur in denser soils if the ground shaking is sufficiently strong. Based on our analysis, the risk of liquefaction at the site is low due to the high relative density of the native soil and the limited groundwater present in the form of perched groundwater.

<u>IBC Seismic Design Parameters</u>: The 2015 IBC indicates that the seismic site classification is based on the average soil and bedrock properties in the top 100 feet. The current scope does

not include a 100-foot soil profile determination. The seismic site class definition recommended in the following table considers that soils encountered at depth in our test pits continue below the termination depth as presented in the geologic maps.

IBC Seismic Design Criteria	
Parameter	**Value**
2015 International Building Code Site Classification (IBC)	Site Class D
Site Latitude/Longitude	47.0841 /-122.7535
Spectral Short-Period Acceleration, S_s	1.316g (Site Class B)
Spectral 1-Second Acceleration, S_1	0.531g (Site Class B)
Site Coefficient for a Short Period, F_a	1.00
Site Coefficient for a 1-Second Period, F_v	1.30
Spectral Acceleration for a 0.2-Second Period, S_{MS}	1.316g (Site Class D)
Spectral Acceleration for a 1-Second Period, S_{M1}	0.796g (Site Class D)
Design Short-Period Spectral Acceleration, S_{DS}	0.878g (Site Class D)
Design 1-Second Spectral Acceleration, S_{D1}	0.531g (Site Class D)

The values presented in the table above are derived from the 2015 International Building Code and ASCE 7-10. We understand that the State of Washington intends to adopt the 2018 International Building Code and by association ASCE 7-16 around July 1, 2020. The seismic design parameters will change when the new codes are adopted. We can provide updated seismic parameters upon request.

Stormwater Infiltration

We understand that that stormwater infiltration is not required on this site.

Site Preparation

Existing Utility Removal: At this time, we understand there are no known underground utilities at the site that will need to be removed.

Erosion Control Measures: Stripped surfaces and soil stockpiles are typically a source of runoff sediment. We recommend that silt fences, berms, and/or swales be installed around the downslope side of stripped areas and stockpiles in order to capture runoff water and sediment. If earthwork occurs during wet weather, we recommend that all stripped surfaces be covered with straw to reduce runoff erosion, whereas soil stockpiles should be protected with anchored plastic sheeting.

Temporary Drainage: Stripping, excavation, grading, and subgrade preparation should be performed in a manner and sequence that will provide drainage at all times and provide proper control of erosion. The near-surface site soils have a relatively low fines (silt and clay) content and are therefore less susceptible to disturbance and erosion when wet. The site should be graded to prevent water from ponding in construction areas and/or flowing into and/or over excavations. Exposed grades should be crowned, sloped, and smooth-drum rolled at the end of each day to facilitate drainage if inclement weather is forecasted. Accumulated water must be removed from subgrades and work areas immediately and prior to performing further work in the area. Equipment access may be limited and the amount of soil rendered unfit for use as structural fill may be greatly increased if drainage efforts are not accomplished in a timely manner. Successful drainage of saturated zones due to accumulations of surface water would be relatively slow due to the fines content of the surficial soils. Instead, aeration, cement treatment, or removal and replacement would be more expeditious.

Clearing and Stripping: Based on the conditions encountered in our explorations, we estimate at least the upper 3 to 6 inches of topsoil and roots will need to be removed from below areas of future pavements, structures, and areas of fill placement. Greater stripping depths may be necessary in areas with thicker vegetation and tree roots. These materials are not suitable for reuse as structural fill.

Over-Excavation of Existing Undocumented Fill: Undocumented fill was encountered in test pits TP-1, TP-3, TP-5, TP-6, TP-7, TP-10 and TP-12. The fill varied in thickness from approximately 1 to 3 feet thick. Silt fencing debris was encountered within the fill in test pit TP-1. However, we did not observe debris in the fill encountered in the other test pits. Except for test pit TP-5, a layer a relic topsoil was encountered beneath the fill that typically was about 3 inches thick. This too should be over-excavated if the organic content is deemed to be too high. It appears that most of the undocumented fill encountered would be suitable for reuse as structural fill. If debris is encountered in the fill, we recommend it be segregated and wasted from the site.

Subgrade Preparation: Once site preparation is complete, all areas that do not require over-excavation and are at design subgrade elevation or areas that will receive new structural fill should be compacted to a firm and unyielding condition. Depending on conditions encountered at the time of construction, some moisture conditioning (wetting) of subgrade soils may be required to achieve a moisture content appropriate for compaction. The extent of moisture conditioning will likely be a function of when the site earthwork takes place. A suitable moisture content is generally within ±2 percent of the soil’s optimum moisture content.

If possible, we recommend that earthwork be completed during drier periods of the year when the soil moisture content can be controlled by aeration and drying. If earthwork or construction activities take place during extended periods of wet weather, or if the in-situ moisture conditions are elevated above the optimum moisture content, the soils could become unstable or not be compactable. In the event the exposed subgrade becomes unstable, yielding, or unable to be compacted due to high moisture conditions, we recommend that the materials be removed to a sufficient depth in order to develop stable subgrade soils that can be compacted to the minimum recommended levels. The severity of construction problems will be dependent, in part, on the precautions that are taken by the contractor to protect the subgrade soils.

If protecting stable subgrades becomes necessary, either inside or outside the building pads, we recommend using crushed rock or crushed recycled concrete. The thickness of the protective layer should be determined by the contractor at the time of construction based on the moisture condition of the soil, weather conditions, and the amount of anticipated traffic.

Freezing Conditions: If earthwork takes place during freezing conditions, all exposed subgrades should be allowed to thaw and then be compacted prior to placing subsequent lifts of structural fill. Alternatively, the frozen material could be stripped from the subgrade to expose unfrozen soil prior to placing subsequent lifts of fill or foundation components. The frozen soil should not be reused as structural fill until allowed to thaw and adjusted to the proper moisture content, which may not be possible during winter months.

Structural Fill Materials and Placement

Structural fill includes any material placed below foundations, floor slabs, and pavement sections, within utility trenches, and behind retaining walls. Prior to the placement of structural fill, all surfaces to receive fill should be prepared as previously recommended in the Site Preparation section of this report.

Laboratory Testing: Representative samples of on-site and imported soils to be used as structural fill should be submitted for laboratory testing at least four days in advance of its intended use in order to complete the necessary Proctor tests.

Re-Use of Site Soils as Structural Fill: It is our opinion that the non-organic soil encountered on the site is adequate for reuse as general structural fill from a compositional standpoint provided it is placed and compacted in accordance with the recommendations presented in this report.

We recommend that site soils used as structural fill have less than 4 percent organics by weight, have no woody debris greater than ½-inch in diameter, and contain no other deleterious materials. We recommend that all pieces of organic material greater than ½-inch in diameter be picked out of the fill before it is compacted. Deleterious debris includes waste building materials, organics, and trash and, if encountered, it should be removed from the soil prior to its reuse as structural fill.

Imported Structural Fill: If additional material is required for grading and fills, the appropriate type of imported structural fill will depend on the weather conditions. During extended periods of dry weather, we recommend imported fill meet the requirements of Common Borrow as specified in Section 9-03.14(3) of the 2020 Washington State Department of Transportation, *Standard Specifications for Road, Bridge, and Municipal Construction* (WSDOT Standard Specifications). During wet weather, higher-quality (lower fines content) structural fill might be required, as Common Borrow may contain sufficient fines to be moisture sensitive. During wet weather we recommend that imported structural fill meet the requirements of Gravel Borrow as specified in Section 9-03.14(1) of the WSDOT Standard Specifications. Based on our lab test results, some the on-site soils would be classified as Common Borrow while some would be classified as Gravel Borrow.

Moisture Content: The suitability of soil for use as structural fill will depend on the prevailing weather at the time of construction, the moisture content of the soil, and the fines content (that portion passing the U.S. No. 200 sieve) of the soil. As the amount of fines increases, the soil becomes increasingly sensitive to small changes in moisture content. Soils containing more than about 5 percent fines (such as the on-site glacial till soils) cannot be consistently compacted to the appropriate levels when the moisture content is more than approximately 2 percent above or below the optimum moisture content (per ASTM D1557). Optimum moisture content is that moisture content which results in the greatest compacted dry density with a specified compactive effort.

Fill Placement: Structural fill should be placed in horizontal lifts not exceeding 10 inches in loose thickness. Each lift of fill should be compacted using compaction equipment suitable for the soil type and lift thickness. Each lift of fill should be compacted to the minimum levels recommended below based on the maximum laboratory dry density as determined by the ASTM D1557 Modified Proctor Compaction Test.

Placing Fill on Slopes: It appears that some fill will be placed on the slopes along the south and west sides of the site. Permanent fill placed on slopes steeper than 5H:1V (Horizontal:Vertical), such as along the west side of the site, should be keyed and benched into soils comprising the underlying slope. We recommend that the base downslope key be cut into undisturbed native soil. The key slot should be at least 4 feet wide and 1½ feet deep. The hillside benches cut into the native soil should be at least 4 feet in width. The intent of the benches is to provide a level surface onto which new fill can be placed and compacted. The face of the embankment should be compacted to the same relative compaction as the body of the fill. This may be accomplished by over-building the embankment and cutting back to the compacted core.

Compaction Criteria: Our recommendations for soil compaction are summarized in the following table. We recommend that a geotechnical engineer be present during grading so that an adequate number of density tests may be conducted as structural fill placement occurs.

RECOMMENDED SOIL COMPACTION LEVELS	
Location	**Minimum Percent Compaction***
All fill below building floor slabs and foundations	95
Upper 2 feet of fill below exterior slabs and pavements	95
Pavement and exterior slab fill below two feet	92
Upper two feet of utility trench backfill	95
Utility trenches below two feet	92
Landscape areas	90
* *ASTM D1557 Modified Proctor Maximum Dry Density*	

Utility Trenching and Backfilling

We recommend that utility trenching conform to all applicable federal, state, and local regulations, such as OSHA and WISHA, for open excavations. Trench excavation safety guidelines are presented in WAC Chapter 296-155 and WISHA RCW Chapter 49.17.

Trench Dewatering: Perched groundwater was encountered in most of the test pits at depths of about 6 to 10 feet below existing grades. If dewatering becomes necessary for deeper buried utilities, the appropriate type of dewatering system should be determined by the contractor based on the conditions encountered.

Utility Subgrade Preparation: We recommend that all utility subgrades be firm and unyielding and free of soils that are loose, disturbed, or pumping. Soils that pump or yield should be removed and replaced. All structural fill used to replace over-excavated soils should be compacted as recommended in the Structural Fill section of this report.

Bedding and Initial Backfill: We recommend that a minimum of 4 inches of bedding material be placed above and below all utilities or in general accordance with the utility manufacturer's recommendations and local ordinances. We recommend that pipe bedding consist of Gravel Backfill for Pipe Zone Bedding as specified in Section 9-03.12(3) of the WSDOT Standard Specifications. All trenches should be wide enough to allow for compaction around the haunches of the pipe, or material such as pea gravel should be used below the spring line of the pipes to eliminate the need for mechanical compaction in this portion of the trenches. If water is encountered in the excavations, it should be removed prior to fill placement.

Trench Backfill: 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 1 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.

Temporary and Permanent Slopes

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

- 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; and
- The length of time the excavation remains open.

It is exceedingly difficult under the variable circumstances to pre-establish a safe and "maintenance-free" temporary cut slope angle. Therefore, it should be the responsibility of the contractor to maintain safe temporary 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. Unsupported vertical slopes or cuts deeper than 4 feet are not recommended if worker access is necessary. The cuts should be adequately sloped, shored, or supported to prevent injury to personnel from local sloughing and spalling. The excavation should conform to applicable Federal, State, and Local regulations.

According to Chapter 296-155, Part N, Excavation, Trenching, and Shoring, of the Washington Administrative Code (WAC), the contractor should make a determination of excavation side slopes based on classification of soils encountered at the time of excavation. For planning purposes, the medium dense outwash soils and dense to very dense glacial soils should be classified as Type C, and Type A soils, respectively. Type B soils should be cut at 1½H:1V or flatter while Type A soils should be cut at ¾H:1V or flatter. Temporary cuts may need to be constructed at flatter angles based upon the soil moisture and groundwater conditions at the time of construction. Adjustments to the slope angles should be determined by the contractor at that time.

We recommend that all permanent cut or fill slopes constructed in native soils be designed at a 2½H:1V (Horizontal:Vertical) inclination or flatter. All permanent cut and fill slopes should be adequately protected from erosion both temporarily and permanently.

Shallow Building Foundations

In some of the test pit excavations, we encountered loose to medium dense sandy gravel with silt that was interpreted as undocumented fill. In our opinion, conventional spread footings are suitable for support of the proposed structure provided that the undocumented fill is removed and replaced below building foundation and floor slab subgrade elevations. The over-excavation depth would be limited to the thickness of the fill and any underlying unsuitable relic topsoil. We estimate that over-excavation depths will vary from 1 to 3 feet. We recommend the over-excavation extend horizontally beyond the edges of footings 8 inches for every 1 foot of over-excavation depth. Once over-excavated, the exposed subgrade should be compacted to a firm and unyielding condition. The over-excavation should then be backfilled with fill placed and compacted in accordance with the Structural Fill section of this report.

Allowable Bearing Pressure: In order to limit settlement to less than 1 inch total and ¾ inch differential, we recommend that continuous and column footings bearing on structural fill and native outwash subgrades, prepared as recommended above, be designed using a maximum allowable bearing capacity of 3,000 psf. A one-third increase of the bearing pressure may be used for short-term dynamic loads such as wind and seismic forces.

Shallow Foundation Depth and Width: For frost protection, the bottom of all exterior footings should bear at least 18 inches below the lowest adjacent outside grade, whereas the bottoms of interior footings should bear at least 12 inches below the surrounding slab surface level. We recommend that all continuous wall and isolated column footings be at least 12 and 24 inches wide, respectively.

Lateral Resistance: We recommend using allowable base friction and passive earth values of 0.35 and 325 pcf equivalent fluid pressure, respectively. We recommend that passive resistance be neglected in the upper 12 inches of embedment.

Slab-On-Grade Concrete Floors

Subgrade Preparation: After removal of topsoil and undocumented fill, we recommend that the upper 12 inches of material below the slab base be compacted to a minimum of 95 percent of the modified Proctor maximum dry density.

Slab Base: To provide a uniform slab bearing surface, capillary break, and even working surface, we recommend the on-grade slabs be underlain by a 6-inch thick layer of compacted crushed rock meeting the requirements of Crushed Surfacing Top Course as specified in Section 9-03.9(3) of the WSDOT Standard Specifications with the modification that a maximum of 7.5 percent of the material passes the U.S. No 200 sieve.

Vapor Barrier: A vapor barrier is not necessary beneath the slab on grade floor unless moisture sensitive floor coverings and/or adhesives are used. If a vapor barrier is used, we recommend using a 15-mil, puncture-resistant proprietary product such as Stego Wrap, or an approved equivalent that is classified as a Class A vapor retarder in accordance with ASTM E 1745. Overlap lengths and the appropriate tape used to seal the laps should be in accordance the vapor retarder manufacturer's recommendations. To avoid puncturing of the vapor barrier, a thin sand layer placed over the crushed gravel is recommended. When conditions warrant the use of a vapor retarder, the slab designer and slab contractor should refer to ACI 302 and ACI 360 for procedures and cautions regarding the use and placement of a vapor retarder/barrier.

Backfilled Permanent Retaining Walls

Lateral Earth Pressures: The lateral soil pressures acting on backfilled retaining walls will depend on the nature and density of the soil behind the wall, and the ability of the wall to yield in response to the earth loads. Yielding walls (i.e. walls that are free to translate or rotate) that are able to displace laterally at least 0.001H, where H is the height of the wall, may be designed for active earth pressures. Non-yielding walls (i.e. walls that are not free to translate or rotate) should be designed for at-rest earth pressures. Non-yielding walls include walls that are braced to another wall or structure, and wall corners.

Assuming that walls are backfilled and drained as described in the following paragraphs, we recommend that yielding walls supporting horizontal backfill be designed using an equivalent fluid density of 35 pcf (active earth pressure). Non-yielding walls should be designed using an equivalent fluid density of 50 pcf (at-rest earth pressure).

Surcharge pressures due to sloping backfill, adjacent footings, vehicles, construction equipment, etc. must be added to these lateral earth pressure values. For traffic loads, we recommend using an equivalent two-foot soil surcharge of about 250 psf.

Design of permanent retaining walls should consider additional earth pressure resulting from the design seismic event. For the seismic case, walls should be designed for an additional uniform, total seismic earth pressure distribution of 11H.

The above equivalent fluid pressures are based on the assumption of no buildup of hydrostatic pressure behind the wall. If groundwater is allowed to saturate the backfill soils, hydrostatic pressures will act against a retaining wall; however, if the recommended drainage system is included with each retaining wall, we do *not* expect that hydrostatic pressures will develop.

Lateral Earth Resistance: For recommended bearing capacities and lateral resistance parameters, refer to the Shallow Foundations section above.

Drainage Considerations

Surface Drainage: Final site grades should be sloped to carry surface water away from buildings and other drainage-sensitive areas. Additionally, site grades should be designed such that concentrated runoff on softscape surfaces is avoided. Any surface runoff directed towards soft-scaped slopes should be collected at the top of the slope and routed to the bottom of the slope and discharged in a manner that prevents erosion.

Subsurface Perimeter Building Drain: We recommend a permanent subsurface drainage system be installed around the perimeter of the structure. The footing drains should consist of a minimum 4-inch diameter, Schedule 40, rigid, perforated PVC pipe placed at the base of the heel of the footing with the perforations facing down. The pipe should be surrounded by a minimum of 4 inches of clean free-draining granular material conforming to WSDOT Standard Specification 9-03.12(4), Gravel Backfill for Drains. A non-woven filter fabric such as Mirafi 140N, or equivalent, should envelope the free-draining granular material. At appropriate intervals such that water backup does not occur, the drainpipe should be connected to a tightline system leading to a suitable discharge. Cleanouts should be provided for future maintenance. The tightline system must be separate from the roof drain system.

Retaining Wall Drain: We recommend that all backfilled retaining walls include a drainage aggregate zone extending a minimum of two feet from the back of wall for the full height of the wall and wide enough at the base of the wall to allow seepage to flow to the footing drain. We recommend that the drainage aggregate behind the wall consist of material meeting the requirements of WSDOT 9-03.12(2), Gravel Backfill for Walls. A minimum 4-inch diameter, perforated PVC drainpipe should be provided at the base of backfilled walls to collect and direct subsurface water to an appropriate discharge point. The pipe should be surrounded by a minimum of 4 inches of clean free-draining granular material conforming to WSDOT Standard Specification 9-03.12(4), Gravel Backfill for Drains. We recommend placing a non-woven geotextile, such as Mirafi 140N, or equivalent, around the free draining backfill material. Wall drainage systems should be independent of other drainage systems such as roof drains.

Segmental Block Retaining Walls

A geogrid-reinforced segmental block wall is a suitable wall type for this project, provided the geogrid reinforcement does not interfere with other elements of the project. Given the presence of undocumented fill on the site, some remedial earthwork may be necessary to limit settlements under the weight of the new wall and backfill. We recommend that the following soil parameters be used for segmental block wall design. ZGA can provide wall design services that would include preparing all construction drawings for such walls.

Segmental Block Wall Design Parameters			
Soil Properties	**Reinforced Backfill**	**Retained Soil**	**Foundation Soil**
Unit Weight (pcf)	130	130	130
Friction Angle (deg)	34	34	34
Cohesion (psf)	0	0	0
Acceleration Coefficient (A_S)			0.5g

We recommend that segmental block walls be designed in accordance with the 2012 AASHTO LRFD Bridge Design Specifications, 6th Edition (AASHTO Specifications). If automobile parking is provided immediately above a wall, we recommend that a guardrail or barrier be incorporated into the wall design per the AASHTO Design Specifications. ZGA can provide wall design services upon request.

Pavements

<u>Asphalt Pavements</u>

<u>Pavement Life and Maintenance:</u> It should be realized that asphaltic pavements 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. A 20-year pavement life typically assumes that an overlay will be placed after about 10 to 12 years. 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.

<u>Traffic Design Values:</u> No traffic loading was provided for this project. We have assumed relatively low traffic volumes consisting primarily of passenger cars and trucks with occasional small delivery trucks for light- and heavy-duty pavements. If traffic routes are expected across the site that could increase the estimated traffic loading, ZGA should be notified so that we can re-analyze the pavement sections.

<u>Recommended Pavement Sections:</u> For light-duty pavements (parking space areas and low volume areas), we recommend a minimum of 2½ inches of asphalt concrete over 4 inches of

crushed rock base course. For heavy-duty pavements (main access and travel paths, truck delivery areas, etc.), we recommend a minimum of 3 inches of asphalt concrete over 6 inches of crushed rock base course.

Materials and Construction: We recommend the following regarding asphalt pavement materials and pavement construction.

- Subgrade Preparation: We recommend the upper 12 inches of pavement subgrade be prepared in accordance with the recommendations presented in the Subgrade Preparation section of this report.

- Asphalt Concrete: We recommend that the asphalt concrete conform to Section 9-02.1(4) for PG 58-22 or PG 64-22 Performance Graded Asphalt Binder as presented in the 2016 WSDOT Standard Specifications. We also recommend that the gradation of the asphalt 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 aggregate base course conform to Section 9-03.9(3) of the WSDOT Standard Specifications.

- Compaction: All base material should be compacted to at least 95 percent of the maximum dry density determined in accordance with ASTM: D 1557. We recommend that asphalt be compacted to a minimum of 92 percent and a maximum of 97 percent of the theoretical maximum density.

Concrete Pavements

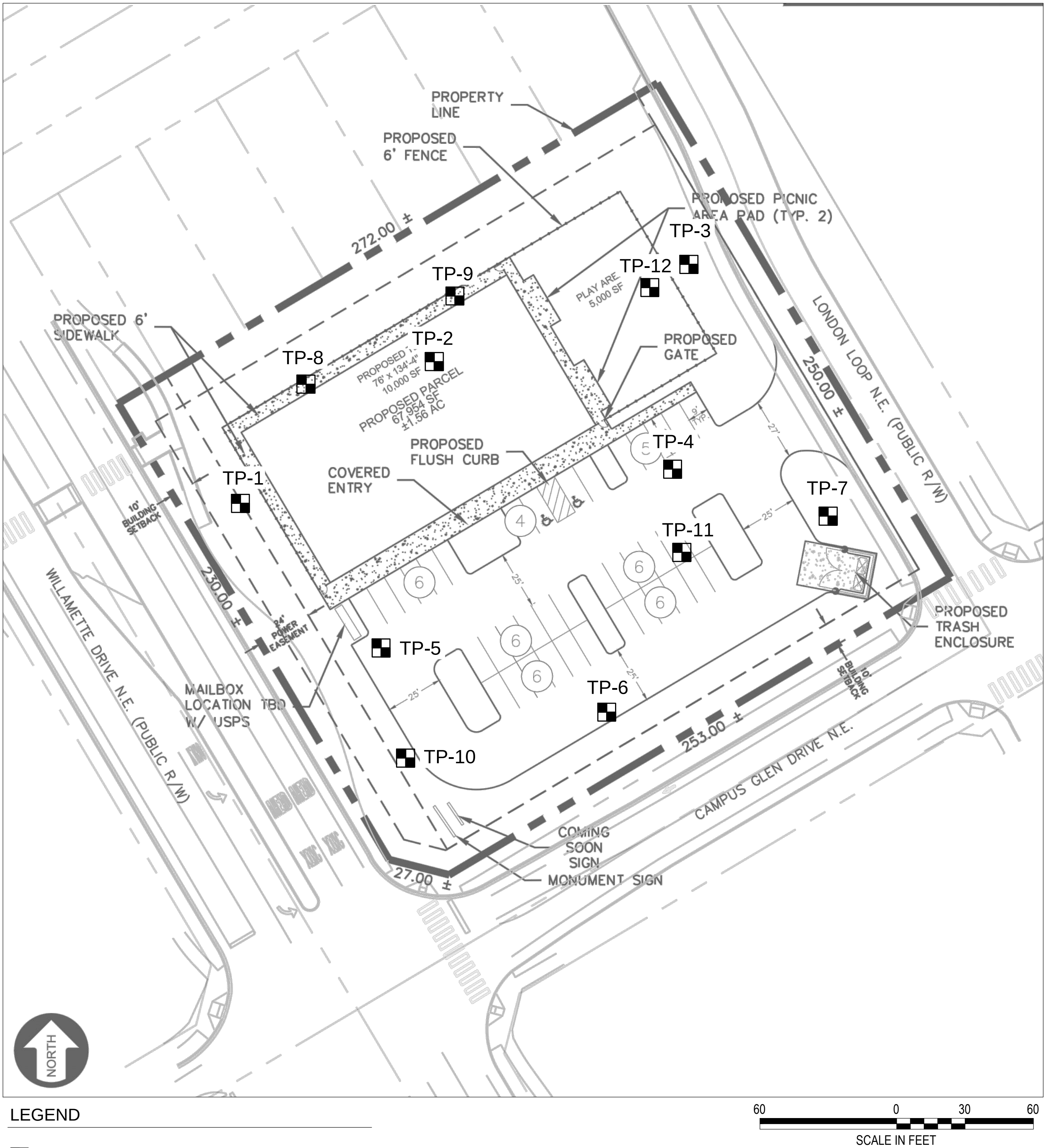
Concrete Properties and Thickness: Concrete pavement design recommendations are based on an assumed modulus of rupture of 600 psi and a minimum compressive strength of 4,000 psi for the concrete. For concrete pavement areas, we recommend a minimum of 5 inches of concrete over 3 inches of crushed aggregate base. We recommend that trash enclosure pads be a minimum of 6 inches thick and be reinforced with #4 bars with a maximum 15-inch spacing in each direction.

Concrete Pavement Joints: Given the recommended thickness of the concrete pavements, we recommend the pavement have relatively closely spaced control joints on the order of 10 feet.

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, structural fill, foundations, and pavements depend 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 LE-LACEY, WA-1-UT, LLC and their agents for specific application to the project discussed and has been prepared in accordance with generally accepted geotechnical engineering practices. No warranties, either 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 Zipper Geo Associates, LLC reviews the changes and either verifies or modifies the conclusions of this report in writing.



LEGEND

TP-1 TEST PIT NUMBER AND APPROXIMATE LOCATION

REFERENCE: PRELIMINARY SITE PLAN PREPARED FOR EMBREE ASSET GROUP, DATED FEBRUARY 19, 2020.

LACEY LEARNING EXPERIENCE WILLAMETTE DR NE AND CAMPUS GLEN DR NE LACEY, WASHINGTON	
SITE AND EXPLORATION PLAN	
DATE: MAY 2020	Job No. 2303.01
Zipper Geo Associates, LLC 19019 36th Ave. W.,Suite E Lynnwood, WA	FIGURE 1 SHT. 1 of 1

APPENDIX A

FIELD EXPLORATION PROCEDURES AND LOGS

FIELD EXPLORATION PROCEDURES

Our field exploration programs for this project included excavation of 7 test pits (TP-1 through TP-7) on January 27, 2020. On May 8, 2020, ZGA completed 18 additional shallow test pit excavations as part of an environmental site characterization study for arsenic and lead. Five of the deeper environmental test pits (TP-8 through TP-12) have been utilized to supplement the original subsurface information used to prepare this report. The approximate locations of the explorations are presented on Figure 1, the Site and Exploration Plan. Exploration locations were determined in the field by tape measuring from existing features. As such, the exploration locations should be considered accurate to the degree implied by the measurement method. The following sections describe our procedures associated with the explorations. Descriptive logs of the explorations are enclosed in this appendix. Ground surface elevations of the explorations were not determined.

Test Pits

A local excavating company (Gary's Bulldozing) working under subcontract to our firm excavated the test pits for this project using a trackhoe. A geotechnical engineer from our firm 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. After we logged each test pit, the operator backfilled each with excavated soils tamped into place. Some settlement of the backfill should be expected over time.

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.

ZIPPER GEO ASSOCIATES, LLC

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

Test Pit TP-1

Location: See Site and Exploration Plan, Figure 1
Approx. Ground Surface Elevation: N/A

Project: Lacey Learning Experience
Project No: 2303.01
Date Excavated: January 27, 2020

Depth (ft)	Material Description	Sample	N_C	%M	Testing
1	Grass mat(approx. 3 to 4 inches thick) over loose to medium dense, moist, brown, sandy GRAVEL with silt, some organics, fragment of silt fencing (Fill)	S-1 @ 1-2½ ft		14	GSA
2					
3	Medium dense, moist, brown, sandy GRAVEL with silt, scattered cobbles (Glacial Recessional Outwash)				
4					
5	Medium dense, moist, gray, sandy GRAVEL, trace silt, scattered cobbles (Glacial Recessional Outwash). Slight caving from 4.5 feet to 11 feet				
6		S-2 @ 6-7½ ft		4	GSA
7					
8					
9					
10	Perched groundwater seepage between approximately 10 and 11 feet				
11					
12	Dense to very dense, moist, gray with light soil mottling, gravelly SAND with silt (Glacial Till).	S-3 @ 11-11½ ft		10	MC
13	Test pit terminated at approximately 11½ feet. Groundwater seepage observed between approximately 10 and 11 feet at time of exploration. Slight caving observed from approximately 4½ feet to 11 feet.				
14					
15					
16					
17					

ZIPPER GEO ASSOCIATES, LLC

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

	Test Pit TP-2 **Location:** See Site and Exploration Plan, Figure 1 **Approx. Ground Surface Elevation**: N/A	**Project:** Lacey Learning Experience **Project No:** 2303.01 **Date Excavated:** January 27, 2020			
Depth (ft)	**Material Description**	**Sample**	**N$_C$**	**%M**	**Testing**
1	Grass and 3-inches of topsoil over loose to medium dense, moist, brown, sandy GRAVEL, trace silt and organics (Glacial Outwash)	S-1 @ 1½-3 ft		8	GSA
2					
3	Medium dense, moist, gray, GRAVEL with sand, trace silt, scattered cobbles (Glacial Outwash) Slight caving from 2 feet to 6.5 feet				
4					
5		S-2 @ 5-6½ ft		4	GSA
6	Perched groundwater seepage between approximately 6 and 6½ feet				
7					
8	Dense to very dense, moist, gray with light soil mottling, gravelly SAND with silt (Glacial Till)				
9					
10					
11		S-3 @ 10½-11 ft		9	MC
12	Test pit terminated at approximately 11 feet. Groundwater observed between approximately 6 and 6½ feet at time of exploration. Slight caving observed from approximately 2 feet to 6½ feet.				
13					
14					
15					
16					
17					

ZIPPER GEO ASSOCIATES, LLC

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

	Test Pit TP-3 **Location:** See Site and Exploration Plan, Figure 1 **Approx. Ground Surface Elevation**: N/A	**Project:** Lacey Learning Experience **Project No:** 2303.01 **Date Excavated:** January 27, 2020

Depth (ft)	Material Description	Sample	N_C	%M	Testing
1	Grass and thin grass mat over loose to medium dense, moist, brown, sandy GRAVEL with silt, trace organics (Fill). Plastic debris present at surface near test pit.	S-1 @ 1-2½ ft		10	GSA
2					
3					
4	Approx. 2 to 3 in. relic topsoil horizon over medium dense, moist, brown, gravelly SAND with silt (Weathered Glacial Till).				
5	Dense to very dense, moist, gray, gravelly SAND with silt (Glacial Till)	S-2 @ 5-6½ft		14	GSA
6					
7					
8					
9					
10					
11	Test pit terminated at approximately 10½ feet. Groundwater not observed at time of exploration.	S-3 @ 10½-11 ft		18	MC
12					
13					
14					
15					
16					
17					

ZIPPER GEO ASSOCIATES, LLC
19019 36th Avenue West, Suite E, Lynnwood, Washington 98036

Test Pit TP-4

Location: See Site and Exploration Plan, Figure 1
Approx. Ground Surface Elevation: N/A

Project: Lacey Learning Experience
Project No: 2303.01
Date Excavated: January 27, 2020

Depth (ft)	Material Description	Sample	N_C	%M	Testing
1	Grass and ivy over 6 inches of loose, moist, dark brown, silty SAND some gravel (Topsoil) over loose to medium dense, moist, brown, sandy GRAVEL, some silt, trace organics and burnt wood fragments. (Glacial Recessional Outwash)	S-1 @ 1½-2 ft		12	GSA
2					
3	Medium dense, moist, gray, sandy GRAVEL, trace silt, scattered cobbles (Glacial Recessional Outwash) slight caving from 2 feet to 6.5 feet				
4					
5	moderate soil mottling from 5½ feet to 6½ feet	S-2 @ 5½-7 ft		4	MC
6	perched groundwater seepage at approximately 6 feet, becomes wet				
7	Dense to very dense, moist, gray with light mottling, gravelly SAND with silt (Glacial Till)				
8					
9					
10		S-3 @ 10½-11 ft		23	MC
11	Test pit terminated at approximately 10½ feet. Groundwater observed between approximately 6 and 6½ feet at time of exploration. Slight caving observed from approximately 2 feet to 6½ feet.				
12					
13					
14					
15					
16					
17					

ZIPPER GEO ASSOCIATES, LLC

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

Test Pit TP-5

Location: See Site and Exploration Plan, Figure 1
Approx. Ground Surface Elevation: N/A

Project: Lacey Learning Experience
Project No: 2303.01
Date Excavated: January 27, 2020

Depth (ft)	Material Description	Sample	N_C	%M	Testing
1	Grass mat over loose to medium dense, moist, brown, sandy GRAVEL with silt, some organics, burnt wood fragments (Fill)				
2	Medium dense, moist, brown, sandy GRAVEL with silt, trace organics (Glacial Recessional Outwash)	S-1 @ 2 feet		8	MC
3	Medium dense, moist, gray, sandy GRAVEL, trace silt, scattered cobbles (Glacial Recessional Outwash) Slight caving from 2 feet to 9 feet				
4					
5		S-2 @ 5 feet		3	MC
6					
7					
8	Medium dense, moist, gray with light mottling, fine SAND some silt, trace gravel (Glacial Recessional Outwash) Perched groundwater seepage between approximately 8 and 9 feet				
9					
10	Dense to very dense, moist, gray with light mottling, gravelly SAND with silt (Glacial Till)				
11					
12		S-3 @ 12 feet		7	MC
13	Test pit terminated at approximately 12 feet. Groundwater observed between approximately 8 and 9 feet at time of exploration. Slight caving observed from approximately 2 feet to 9 feet.				
14					
15					
16					
17					

ZIPPER GEO ASSOCIATES, LLC

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

	Test Pit TP-6 **Location:** See Site and Exploration Plan, Figure 1 **Approx. Ground Surface Elevation**: N/A	**Project:** Lacey Learning Experience **Project No:** 2303.01 **Date Excavated:** January 27, 2020			
Depth (ft)	**Material Description**	**Sample**	**N_C**	**%M**	**Testing**
1	Grass mat over loose to medium dense, moist, brown, sandy GRAVEL with silt, some organics (Fill)	S-1 @ 1 feet		6	MC
2					
3	2 to 3 in. relic topsoil over medium dense, moist, brown, sandy GRAVEL with silt, trace organics (Glacial Outwash)				
4	Medium dense, moist, gray, sandy GRAVEL, trace silt, scattered cobbles (Glacial Outwash) Moderate caving from 3 feet to 6½ feet				
5		S-2 @ 5 feet		4	MC
6	Perched groundwater seepage between approximately 6 and 6½ feet				
7	Dense to very dense, moist, gray with light mottling, gravelly SAND with silt (Glacial Till)				
8					
9					
10		S-3 @ 10 feet		11	MC
11	Test pit terminated at approximately 10 feet. Groundwater observed between approximately 6 and 6½ feet at time of exploration. Moderate caving observed from approximately 3 feet to 6½ feet.				
12					
13					
14					
15					
16					
17					

ZIPPER GEO ASSOCIATES, LLC

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

	Test Pit TP-7 **Location:** See Site and Exploration Plan, Figure 1 **Approx. Ground Surface Elevation**: N/A	**Project:** Lacey Learning Experience **Project No:** 2303.01 **Date Excavated:** January 27, 2020			
Depth (ft)	**Material Description**	**Sample**	**N_C**	**%M**	**Testing**
1	Grass mat over loose to medium dense, moist, brown, sandy GRAVEL with silt, some organics, plastic and cardboard at surface near test pit (Fill)				
2					
3		S-1 @ 3 feet		9	GSA
4	2 to 3 in. loose to med dense, moist, dark brown, silty SAND with gravel (Relic Topsoil) over medium dense, moist, brown, sandy GRAVEL with silt, trace organics (Glacial Outwash)				
5					
6		S-2 @ 6 feet		9	MC
7	Medium dense, moist, gray, sandy GRAVEL, trace silt, scattered cobbles. (Glacial Outwash) Slight caving from 6½ feet to 10½ feet				
8					
9					
10	Perched groundwater seepage at approximately 10 and 10½ feet	S-3 @ 10 feet		8	MC
11	Dense to very dense, moist, gray with light mottling, gravelly SAND with silt (Glacial Till)				
12		S-4 @ 12 feet		8	MC
13	Test pit terminated at approximately 12 feet. Groundwater observed between approximately 10 and 10½ feet at time of exploration. Slight caving observed from approximately 6½ feet to 10½ feet.				
14					
15					
16					
17					

ZIPPER GEO ASSOCIATES, LLC
19019 36th Avenue West, Suite E, Lynnwood, Washington 98036

Test Pit TP-8

Location: See Site and Exploration Plan, Figure 1
Approx. Ground Surface Elevation: N/A

Project: Lacey Learning Experience
Project No: 2303.01
Date Excavated: May 8, 2020

Depth (ft)	Material Description	Sample	N_C	%M	Testing
1	Forest duff over loose to medium dense, moist, dark brown, SAND with silt, trace gravel, with roots (Topsoil)				
2	Medium dense, moist, brown, SAND with silt, trace gravel, with roots (Fill)				
3	Medium dense, moist, brownish gray, sandy GRAVEL, trace silt, scattered cobbles (Glacial Recessional Outwash). At approximately 2.75 feet, decreasing sand content, some cobbles.				
4					
5	Test pit terminated at approximately 4 feet. Groundwater seepage not observed at time of exploration. Caving not observed at time of exploration.				
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					

ZIPPER GEO ASSOCIATES, LLC

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

	Test Pit TP-9 **Location:** See Site and Exploration Plan, Figure 1 **Approx. Ground Surface Elevation**: N/A	**Project:** Lacey Learning Experience **Project No:** 2303.01 **Date Excavated:** May 8, 2020			
Depth (ft)	**Material Description**	**Sample**	**N_C**	**%M**	**Testing**
1	Forest duff over loose to medium dense, moist, dark brown, SAND with silt, trace gravel, trace fine roots (Topsoil)				
2	Medium dense, moist, brown, SAND with silt, some gravel, trace fine roots				
3	Dense, moist, brownish gray, sandy GRAVEL, trace silt, scattered cobbles (Glacial Recessional Outwash).				
4	At approximately 3 feet, decreasing sand content, some cobbles.				
5	Test pit terminated at approximately 4 feet. Groundwater seepage not observed at time of exploration. Caving not observed at time of exploration.				
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					

ZIPPER GEO ASSOCIATES, LLC

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

	Test Pit TP-10 **Location:** See Site and Exploration Plan, Figure 1 **Approx. Ground Surface Elevation**: N/A	**Project:** Lacey Learning Experience **Project No:** 2303.01 **Date Excavated:** May 8, 2020

Depth (ft)	Material Description	Sample	N_C	%M	Testing
1	Grass over loose to medium dense, moist, dark brown, silty SAND, some gravel, with fine roots (Fill)				
2					
3	Dense, moist, gray, sandy GRAVEL, trace silt, trace to some cobbles (Glacial Recessional Outwash). At approximately 3.5 feet, becomes light brown to yellow-brown.				
4					
5	Test pit terminated at approximately 4.5 feet. Groundwater seepage not observed at time of exploration. Caving not observed at time of exploration.				
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					

ZIPPER GEO ASSOCIATES, LLC
19019 36th Avenue West, Suite E, Lynnwood, Washington 98036

	Test Pit TP-11 **Location:** See Site and Exploration Plan, Figure 1 **Approx. Ground Surface Elevation**: N/A	**Project:** Lacey Learning Experience **Project No:** 2303.01 **Date Excavated:** May 8, 2020			
Depth (ft)	**Material Description**	**Sample**	**N_C**	**%M**	**Testing**
1	Grass over loose to medium dense, moist, brown, sandy GRAVEL, some to with silt, with fine roots				
2	Medium dense to dense, moist, gray, sandy GRAVEL, trace silt, some to with cobbles (Glacial Recessional Outwash).				
3					
4					
5	Test pit terminated at approximately 4 feet. Groundwater seepage not observed at time of exploration. Caving not observed at time of exploration.				
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					

ZIPPER GEO ASSOCIATES, LLC

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

	Test Pit TP-12 **Location:** See Site and Exploration Plan, Figure 1 **Approx. Ground Surface Elevation**: N/A	**Project:** Lacey Learning Experience **Project No:** 2303.01 **Date Excavated:** May 8, 2020			
Depth (ft)	**Material Description**	**Sample**	**N_C**	**%M**	**Testing**
1	Grass and thin grass mat over medium dense, moist, brown, sandy GRAVEL, with silt, trace to some roots, organics (Fill)				
2					
3	Approximately 2 to 3 inches of medium dense, moist, dark brown, silty SAND (Relic topsoil)				
4	Medium dense, moist, brown to gray, gravelly SAND with silt (Glacial Recessional Outwash).				
5	Test pit terminated at approximately 4.5 feet. Groundwater seepage not observed at time of exploration. Caving not observed at time of exploration.				
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					

APPENDIX B

LABORATORY TESTING PROCEDURES AND RESULTS

LABORATORY TESTING PROCEDURES

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 D2488. 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 D2216. Moisture contents are presented on the exploration logs in Appendix A.

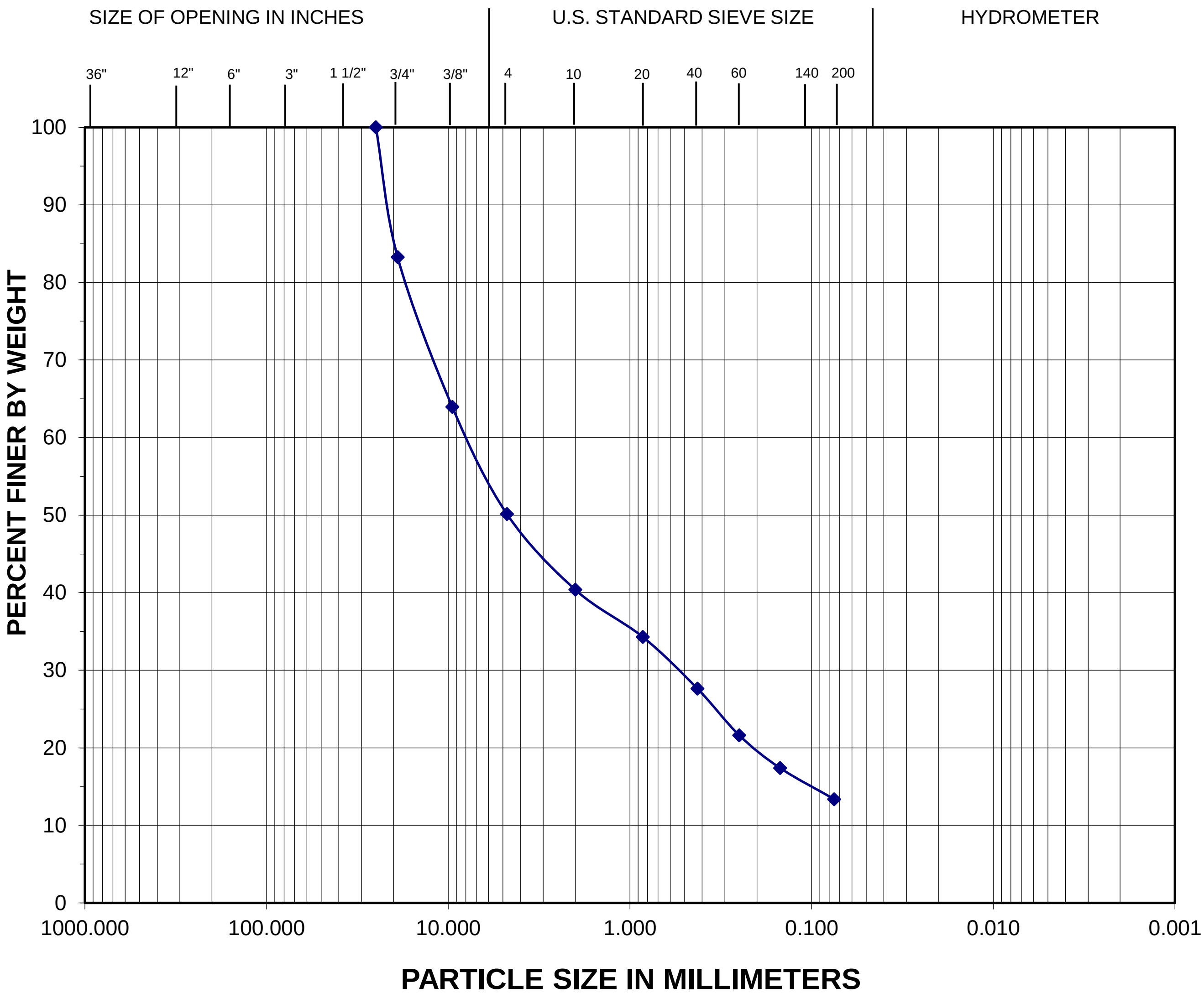
Grain Size Analysis

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 D6913. 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



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

Comments:

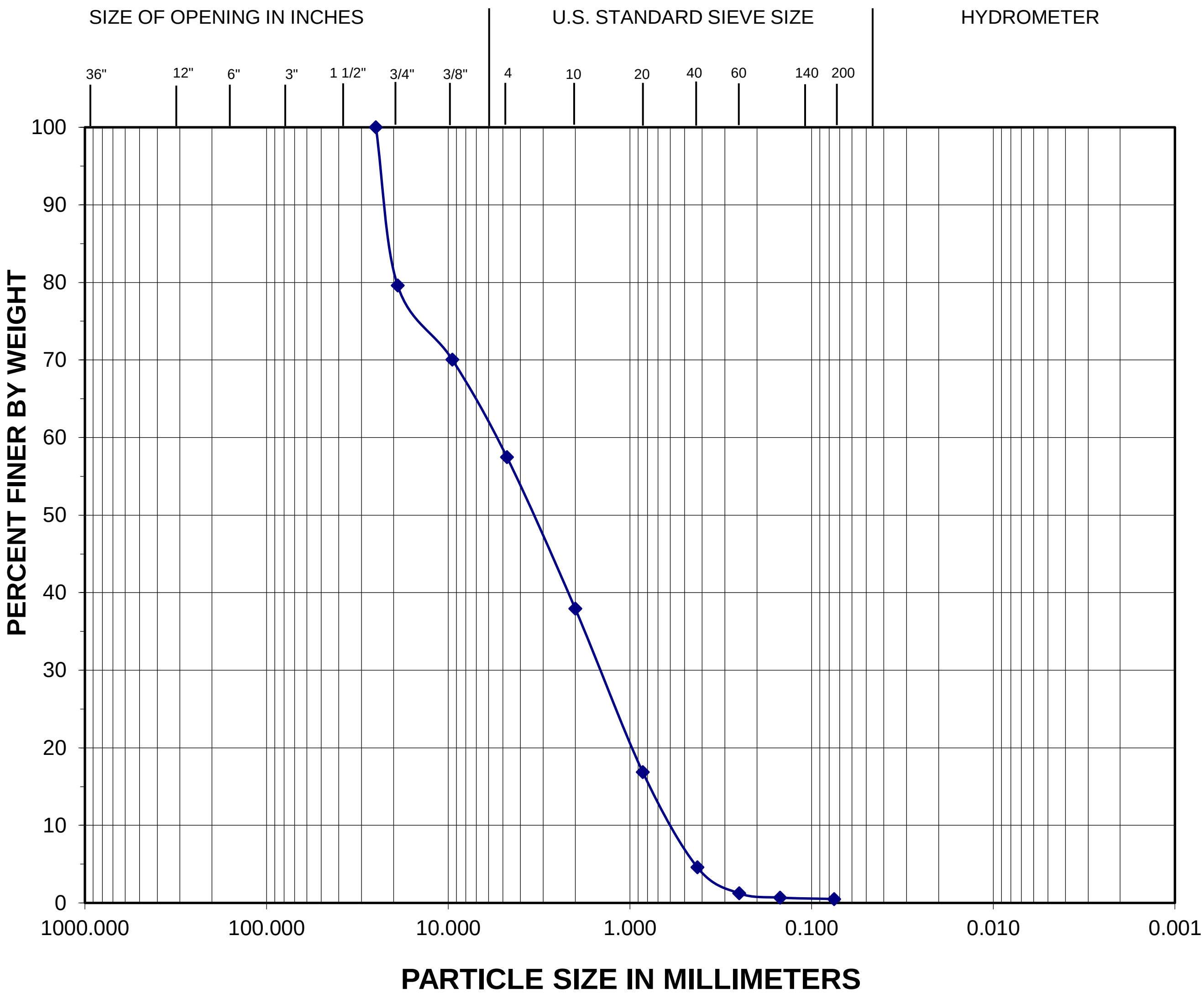
Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
TP-1	S-1	1 - 2½	14.1	13.4	Sandy GRAVEL with silt

Zipper Geo Associates, LLC Geotechnical and Environmental Consultants	PROJECT NO: 2303.01 DATE OF TESTING: 1/27/2020	PROJECT NAME: Lacey Learning Experience

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D6913



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

Comments:

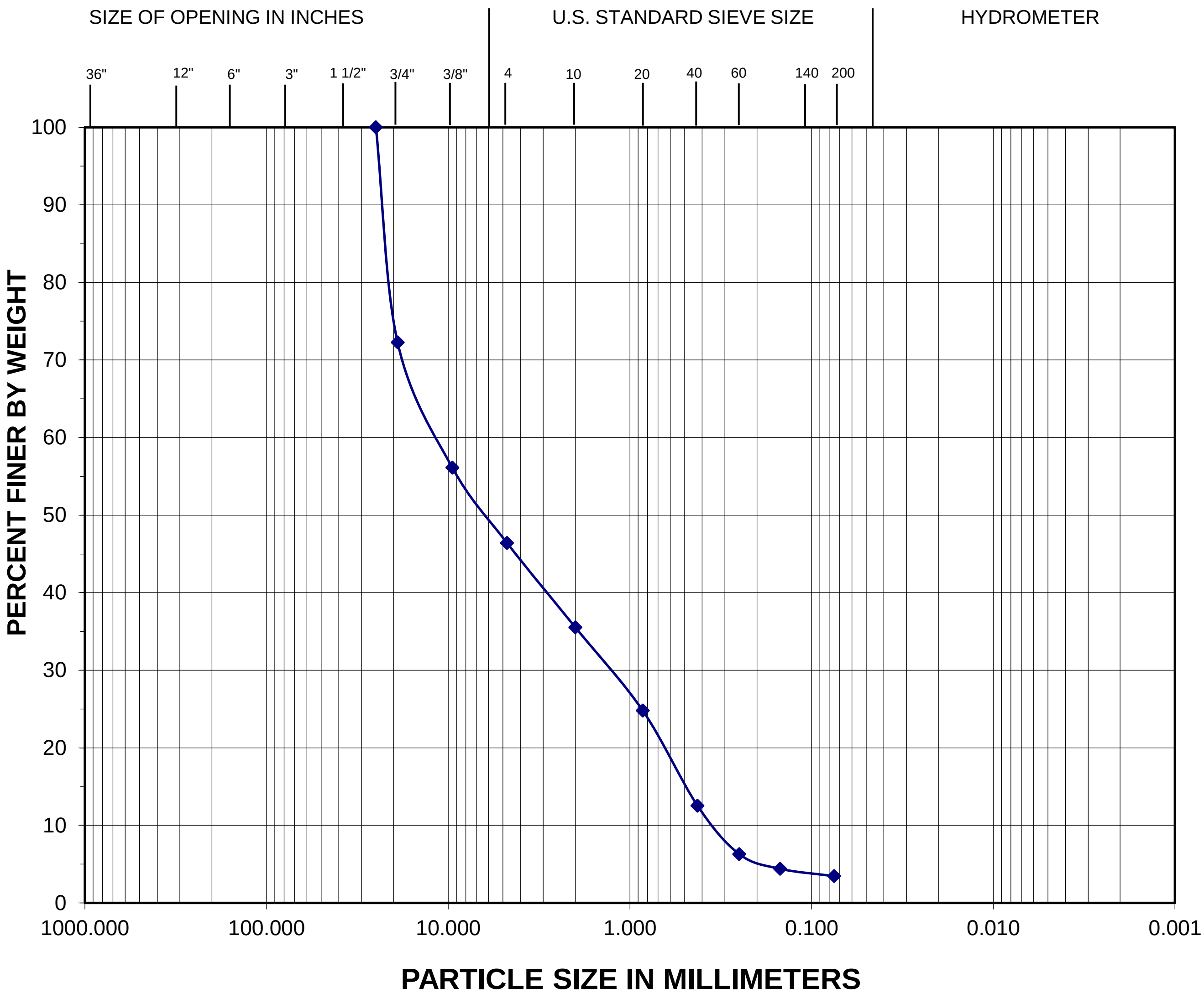
Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
TP-1	S-2	6 - 7½	4.1	0.5	Gravelly SAND trace silt

Zipper Geo Associates, LLC Geotechnical and Environmental Consultants	PROJECT NO: 2303.01 DATE OF TESTING: 1/27/2020	PROJECT NAME: Lacey Learning Experience

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D6913



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

Comments:

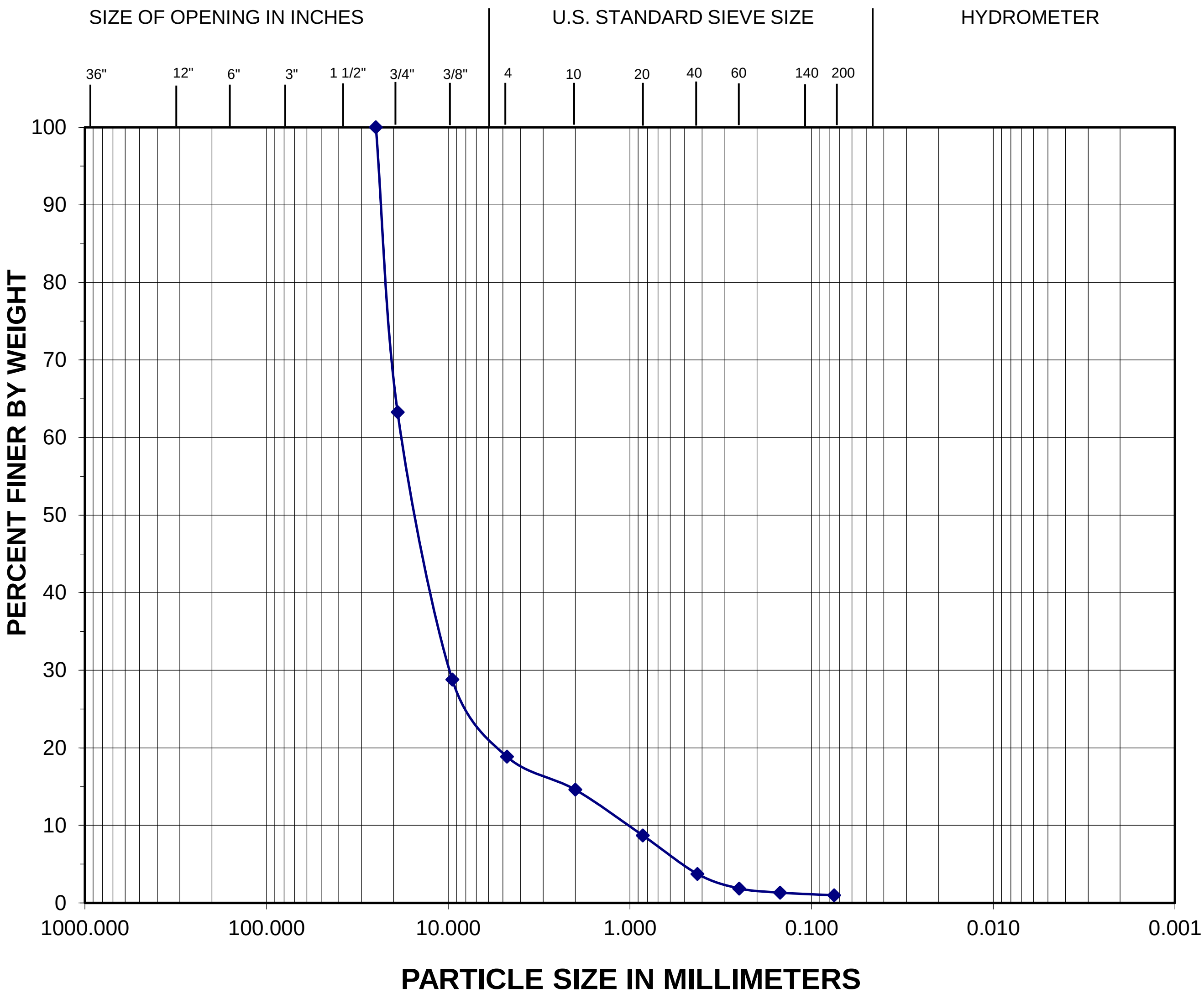
Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
TP-2	S-1	1½ - 3	7.7	3.5	Sandy GRAVEL trace silt

Zipper Geo Associates, LLC Geotechnical and Environmental Consultants	PROJECT NO: 2303.01 DATE OF TESTING: 1/27/2020	PROJECT NAME: Lacey Learning Experience

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D6913



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

Comments:

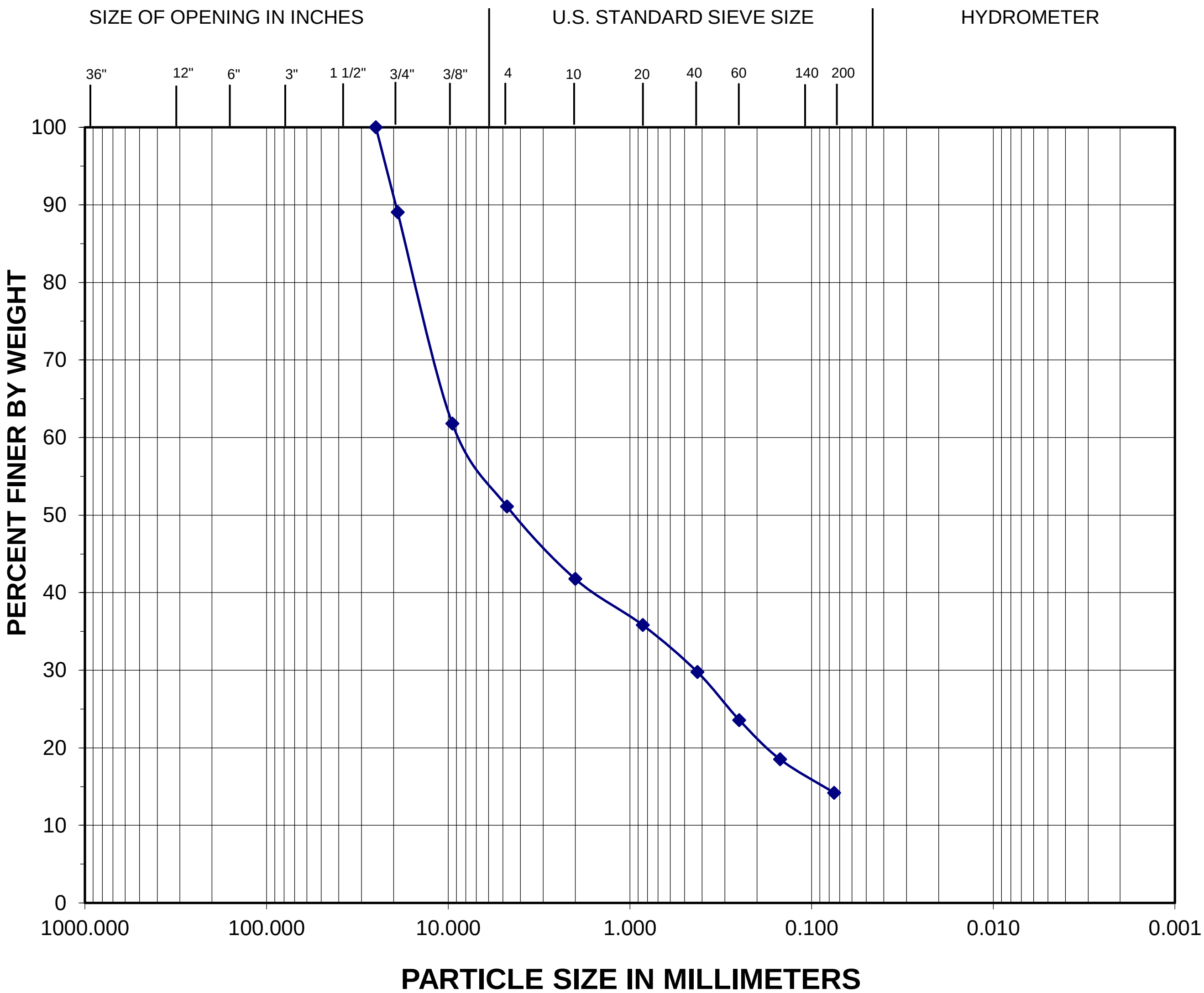
Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
TP-2	S-2	5 - 6½	3.6	1.0	GRAVEL with sand, trace silt

Zipper Geo Associates, LLC Geotechnical and Environmental Consultants	PROJECT NO: 2303.01 DATE OF TESTING: 1/27/2020	PROJECT NAME: Lacey Learning Experience

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D6913



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

Comments:

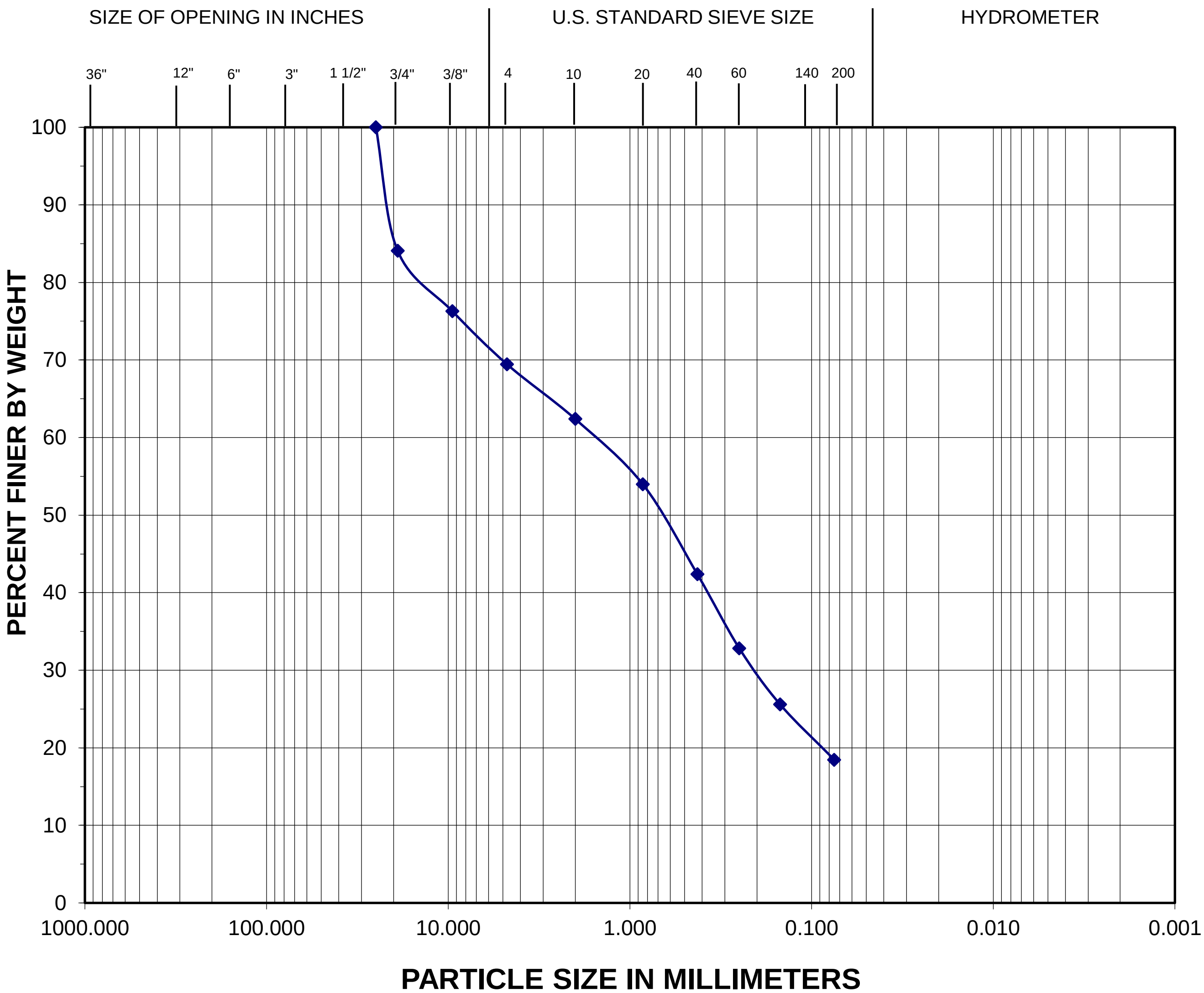
Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
TP-3	S-1	1 - 2½	10.0	14.2	Sandy GRAVEL with silt

Zipper Geo Associates, LLC Geotechnical and Environmental Consultants	PROJECT NO: 2303.01 DATE OF TESTING: 1/27/2020	PROJECT NAME: Lacey Learning Experience

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D6913



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

Comments:

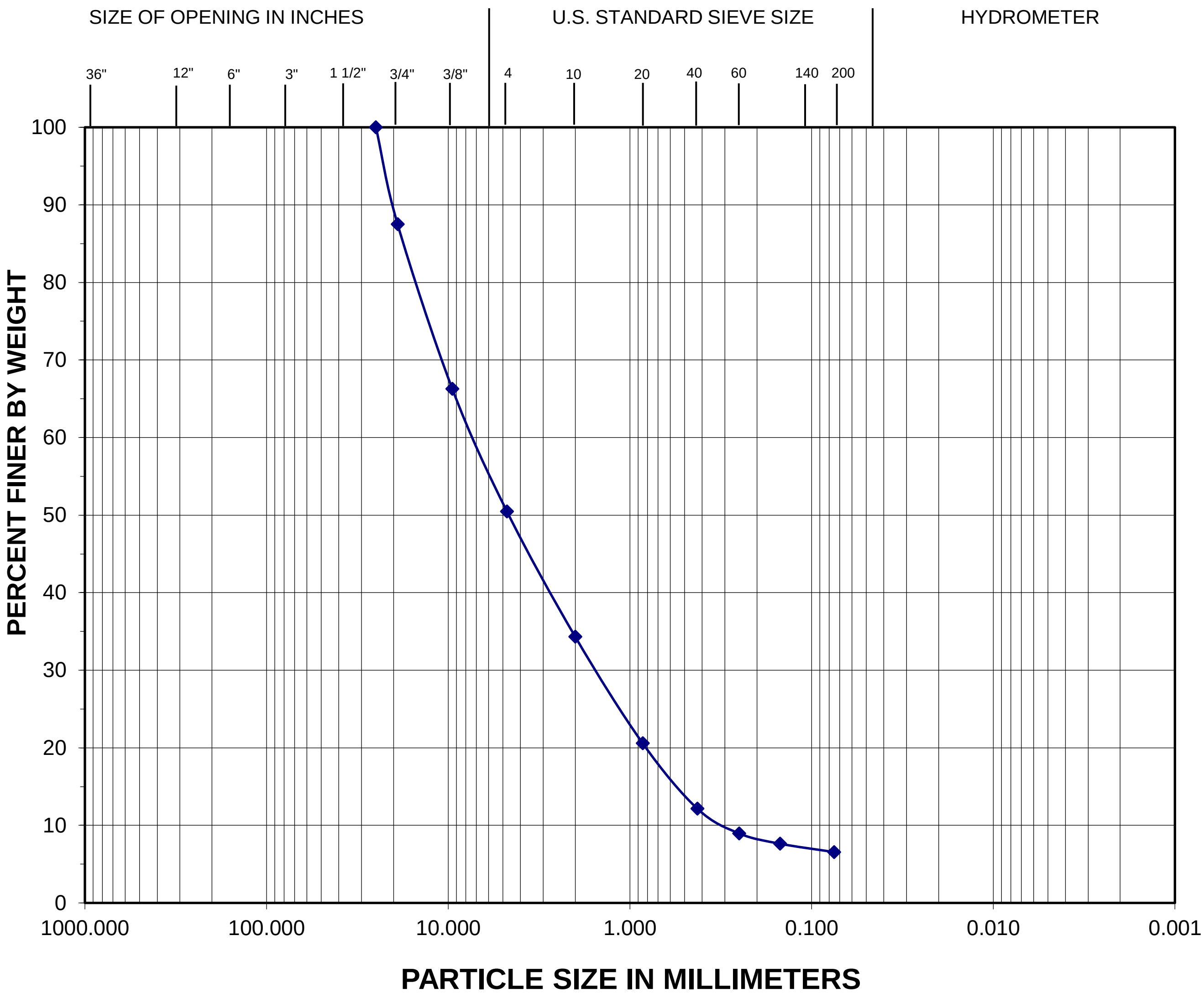
Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
TP-3	S-2	5 - 6½	14.1	18.5	Gravelly SAND with silt

Zipper Geo Associates, LLC Geotechnical and Environmental Consultants	PROJECT NO: 2303.01 DATE OF TESTING: 1/27/2020	PROJECT NAME: Lacey Learning Experience

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D6913



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

Comments:

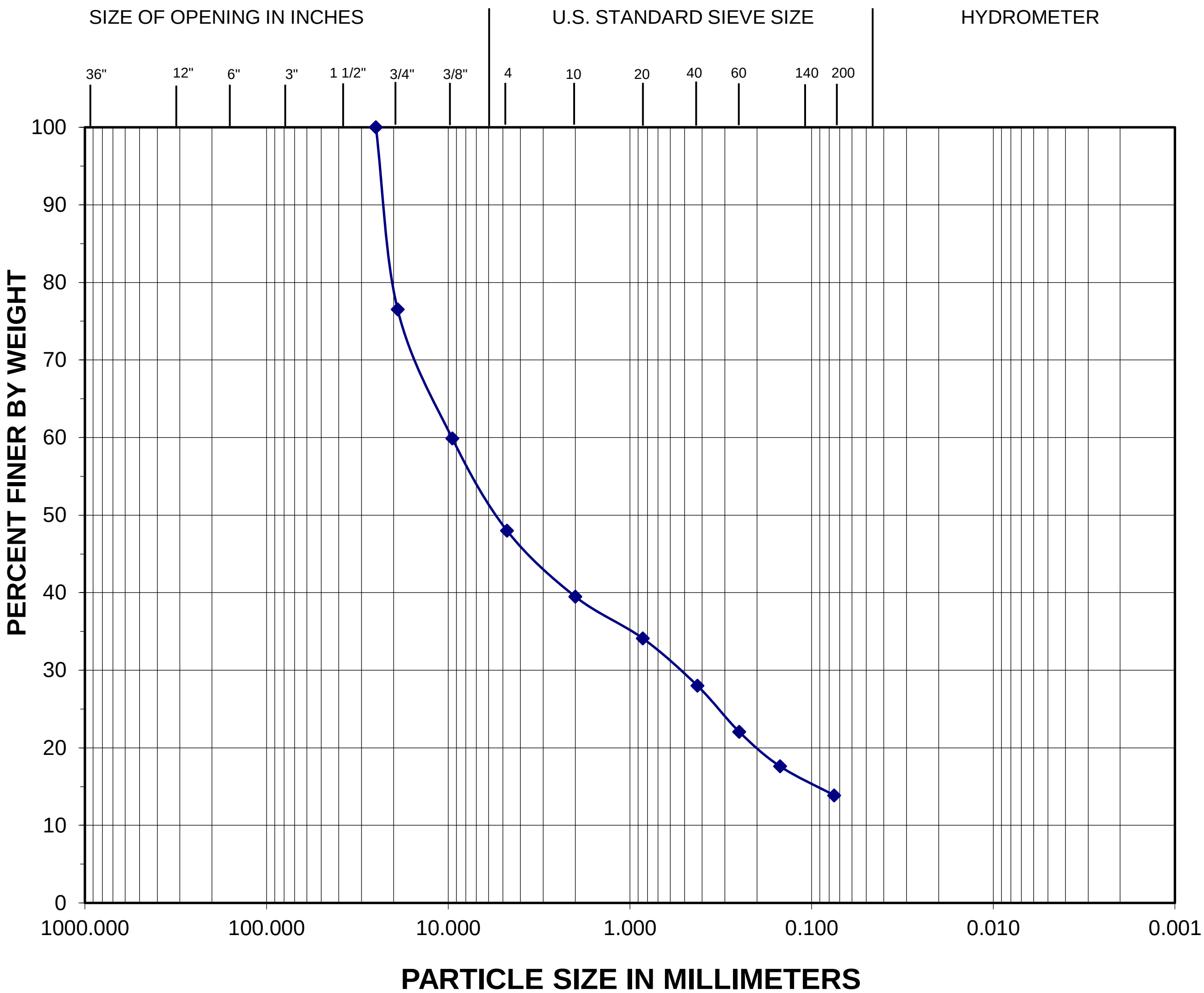
Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
TP-4	S-1	1.5 - 3	11.8	6.6	Sandy GRAVEL, some silt

Zipper Geo Associates, LLC Geotechnical and Environmental Consultants	PROJECT NO: 2303.01 DATE OF TESTING: 1/27/2020	PROJECT NAME: Lacey Learning Experience

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D6913



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

Comments:

Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
TP-7	S-1	3 - 4½	8.8	13.9	Sandy GRAVEL with silt

Zipper Geo Associates, LLC Geotechnical and Environmental Consultants	PROJECT NO: 2303.01 DATE OF TESTING: 1/27/2020	PROJECT NAME: Lacey Learning Experience