GEOTECHNICAL ENGINEERING REPORT

Burn Road Reservoir
12820 - 150th Street Northeast
Arlington, Washington

Project No. 2630.01
21 May 2025

Prepared for:
Snohomish County PUD No.1

Prepared by:

ZipperGeo
Geoprofessional Consultants

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Geoprofessional Consultants

Project No. 2630.01
21 May 2025

Snohomish County PUD No. 1
PO Box 1107
Everett, Washington 98206-1107

Attention: Ms. Max Selin, PE, Principal Engineer

Subject: Geotechnical Engineering Report
Burn Road Reservoir Project
12820 – 150th Street NE
Arlington, Washington 98223
PSC CW2236091

Dear Ms. Selin:

In accordance with your request and written authorization, Zipper Geo Associates, LLC (ZGA) has completed the subsurface exploration and geotechnical engineering evaluation for the proposed Burn Road Reservoir project. This report presents the findings of the subsurface exploration and geotechnical recommendations for the project. Notice to proceed was provided by the District on 9 August 2022 and our services have been provided in general accordance with our *Confirmation of Scope of Geotechnical Engineering Services and Fee Estimate* letter dated 17 August 2022. We appreciate the opportunity to be of service to you on this project. Please contact us if you have any questions concerning this report or if we may be of further assistance.

Respectfully submitted,
Zipper Geo Associates LLC

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Distribution: Addressee (1 pdf), BHC Consultants (1 pdf)

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PROPOSED BURN ROAD RESERVOIR
12820 – 150TH STREET NE
ARLINGTON, WASHINGTON

Project No. 2630.01
21 May 2025

INTRODUCTION

This report documents the subsurface conditions encountered at the site and our geotechnical engineering recommendations for the proposed project. The project description, site conditions, and our geotechnical conclusions and design recommendations are presented in the text of this report. Supporting data, including detailed exploration logs and field exploration procedures, as well as 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, and preparation of draft and final reports. The subsurface evaluation consisted of completing two geotechnical borings (B-1 and B-2) which extended to depths of approximately 20.5 to 30.5 feet, respectively, below existing grade near the proposed reservoir location.

Figure 1, the Site and Exploration Plan, presents the approximate location of our subsurface explorations. Appendix A contains a description of our field procedures and boring logs. Appendix B includes a description of the various laboratory testing procedures and the test results.

PROJECT DESCRIPTION

The proposed project entails the construction of a 3.6-million gallon water reservoir in the northern portion of the 5-acre parcel located at the address referenced above. We understand that the new reservoir will be of welded steel construction, incorporate a circular reinforced concrete foundation, and be 70 feet in diameter and about 135 feet tall. The reservoir is currently planned for construction about 130 feet southeast of an existing garage.

SITE CONDITIONS

The field exploration included a visual reconnaissance of surface conditions and advancing two borings (B-1 and B-2) to depths of approximately 25.5 feet and 30.5 feet, respectfully, on 15 September 2022. The surface and subsurface conditions are described below, while the exploration procedures and interpretive logs of the explorations are presented in Appendix A. Laboratory testing procedures are described in Appendix B, and the results are presented in Appendix B and selectively on the logs in Appendix A. The proposed site improvements and approximate exploration locations are shown on Figure 1, the Site and Exploration Plan.

Surface Conditions

The north portion of the parcel, which may be considered the project site, and adjoining 150th Street NE have somewhat undulating topography with ground surface elevations ranging from about 616 to 582 feet and an overall gentle slope downward from the southwest to the northeast. The site has been partially developed with a three-bay garage serviced by underground power. The site is landscaped with lawn and mature trees. We did not observe standing or flowing surface water on site or evidence of significant surface water erosion during our site visits.

Geologic Conditions

The *Geologic Map of the Lake Stevens Quadrangle, Snohomish County, Washington* (USGS Map MF 1742, 1985) indicates that the site is underlain by Vashon lodgement till, a glacially consolidated soil that will be well-suited for support of the reservoir. The till is also characterized by a relatively low infiltration rate, a characteristic that is not particularly favorable from the stormwater infiltration perspective.

Both borings B-1 and B-2 disclosed glacial till soils below a shallow surficial horizon of loose silty sand with trace gravel, as well as roots that extended to about 6 inches below grade. Weathered glacial till, consisting of medium dense, moist, gravelly silty sand was observed to approximately 5 feet below grade at the boring B-1 location and dense to very dense unweathered till extended to the boring's 20.5-foot termination depth. Boring B-1 disclosed dense to very dense glacial till immediately below the shallow 6-inch deep loose silty sand horizon to the boring's 30.5-foot termination depth.

Groundwater

Groundwater was not observed while advancing borings B-1 and B-2, and soil moisture contents were generally low. However, during the wetter time of year is not uncommon for groundwater to be perched within isolated sandy horizons within glacial till. A perched condition may also develop seasonally at the interface between weathered and unweathered glacial till and at the interface between fill material and underlying less permeable native soils. It should be noted that groundwater conditions and soil moisture contents are expected to vary with seasonal changes in precipitation, site utilization, and other on- and off-site factors. Therefore, groundwater levels during construction or at other times in the life of the facility may vary from the conditions we observed. The probability of seasonal perched water should be considered when developing the design and construction plans for the project.

Summary of Laboratory Testing

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

The moisture content of the native soils ranged from approximately 5 to 12 percent and averaged about 9 percent, a value that we estimate is within about 2 percent of the optimum moisture content as defined by ASTM D 1557 (modified Proctor). The fines content of the two samples of native soils we tested ranged from about 40 to 41 percent. This high fines (the soil fraction passing the US No. 200 sieve) content indicates that the native soils should be considered moisture-sensitive from the grading perspective.

CONCLUSIONS AND RECOMMENDATIONS

General Considerations

We reviewed draft plans prepared by BHC Consultants dated May 2025 prior to preparation of this final report. In our opinion, the proposed site improvements of constructing the new water reservoir and underground piping, as well as completing limited grading, appear feasible from the geotechnical perspective utilizing conventional ringwall or circular mat foundations. Given the compressive loading that will be imposed by the reservoir and water, we recommend removing the less dense weathered glacial till such that the reservoir bears upon the denser unweathered till, or well-compacted coarse granular structural fill or Controlled Density Fill (CDF) placed above unweathered glacial till. Our conclusions and recommendations are presented below.

Regulated Geologically Hazardous Areas

Chapter 30.62B.140 of the Snohomish County Code (SCC) identifies and regulates areas that are naturally susceptible to geologic events such as landslides, seismic activity, and severe erosion. Based on our review of the Snohomish County Planning and Development Services (PDS) map (https://gismaps.snoco.org) and our site observations, it is our opinion that the site does not meet the criteria for landslide, seismic, or severe erosion hazard areas as defined by the SCC. Consequently, development of the site for purposes of constructing a new water reservoir will not be encumbered with setbacks or buffers related to regulated geologically hazardous areas.

A 33 percent or steeper slope lies approximately 120 feet west of the proposed reservoir construction. However, based on our explorations and observations, the site is underlain by low permeability glacial till to at least 28 feet bgs and therefore, does not meet the criteria for a 30.91L.040 Landslide hazard area.

According to the Snohomish PDS map, no liquefiable soils are in the site's immediate vicinity, a condition confirmed by the glacially consolidated soils disclosed by the borings.

The USDA Soil Survey of Snohomish County states that the site-characteristic Tokul gravelly medial soils at (15 to 25 percent slopes) pose a moderate erosion hazard. The steepest slope segment planned to be graded, which is a bit east of the planned reservoir location, has only about 10 feet of relief and an inclination of about 18 percent; slope gradients are typically much lower.

According to the maps published by the USGS, the Darrington Devil's Fault trace is located more than 20 miles to the north and traces of the Southern Whidbey Island Fault Zone lie about 18 miles to the southwest. Consequently, the risk of ground rupture associated with a design seismic event adversely affecting the site is remote, in our opinion. Provided that design of the proposed reservoir is undertaken in a manner consistent with applicable sections of applicable codes relative to seismic design, the site does not present particular constraints toward development in comparison to nearby properties.

Seismic Considerations

Based on site location and soil conditions, the values provided below are recommended for seismic design. The values provided below are derived from the USGS US Seismic Design Maps Web Application based on data from the USGS hazard data available in 2008.

IBC Seismic Design Parameters**:** 2021 IBC Seismic Design parameters are summarized in the table below.

Criteria	Factor
2021 International Building Code (IBC) [1] Site Class	C [2]
S_s Spectral Acceleration for a Short Period	1.026g
S_1 Spectral Acceleration for a 1-Second Period	0.366g
F_a Site Coefficient for a Short Period	1.2
F_v Site Coefficient for a 1-Second Period	1.5
S_{MS} Maximum considered spectral response acceleration for a Short Period	1.231g
S_{M1} Maximum considered spectral response acceleration for a 1-Second Period	0.548g
S_{DS} Five-percent damped design spectral response acceleration for a Short Period	0.821g
S_{D1} Five-percent damped design spectral response acceleration for a 1-Second Period	0.366g

1. In general accordance with ASCE 7-16
2. The 2021 International Building Code, and by reference ASCE 7-16, considers a site soil profile determination extending a depth of 100 feet for seismic site classification. The current authorized scope did not include the required 100-foot soil profile determination. The borings advanced as part of our evaluation extended to a maximum depth of approximately 31-1/2 feet and this seismic site class definition considers that dense to very dense soils as noted on the published geologic mapping exist below the maximum depth of the subsurface exploration. Additional exploration to greater depths could be considered to confirm the conditions below the current depth of exploration, if necessary.

Site Preparation

Erosion Control Measures: Preparation for site grading and construction should begin with procedures intended to drain any ponded water that may be present and to control surface water runoff. Attempting to grade the site without adequate drainage control measures will reduce the amount of on-site soil effectively available for use as structural fill for utility trenches or backfilling around the reservoir foundation, increase the amount of select import fill material required, and ultimately increase the cost of the earthwork and foundation construction phases of the project.

The glacial till soils have a relatively low permeability which presents the potential for standing water to develop. The particular locations of surface water management features would best be determined during construction. We recommend that the contractor anticipate the need for surface water control during the wetter times of the year.

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 site soils have a high fines (soil particles finer than the US No. 200 sieve) content and are highly 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 soils. Instead, aeration, chemical treatment, or removal and replacement may be necessary.

Weathered Till Removal: Considering that the ground surface elevation of the proposed reservoir is about elevation 600 feet, and based upon conditions observed at the locations of borings B-1 and B-2, we anticipate that site preparation will require excavating approximately 4 to 5 feet (approximately elevation 595 to 596 feet) in order to remove the weathered glacial till from below the foundation and floor. Please note that the actual required excavation depth to reach the dense to very dense glacial till may vary from the depth range mentioned here depending upon variation in subsurface conditions. We recommend that the excavation be carried down to a consistent elevation below the reservoir footprint in order to have consistent bearing conditions.

Subgrade Protection:

The glacial till will be susceptible to disturbance by equipment travel and foot traffic, presenting the potential for accumulations of loose soil to develop, particularly under wet weather or wet site conditions. Therefore, we recommend protecting the glacial till subgrade once the foundation excavation is completed. We recommend placing a minimum three (3) inch thickness of CDF with a compressive strength of 200 psi or crushed surfacing base course compacted with a large self-propelled vibratory compactor to protect the subgrade.

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 the typical wetter months of late fall to mid to late spring.

Structural Fill Materials and Placement

All fill material placed as backfill around the reservoir foundation or in backfilled utility trenches should be placed in accordance with the recommendations herein for structural fill. 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. Structural fill subgrades should consist of non-organic soil surfaces that are firm and non-yielding. All structural fill should be free of organic material, debris, or other deleterious material. Individual particle size should generally be less than six (6) inches in diameter

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.

Structural fill should be placed in lifts no greater than ten (10) inches in loose thickness and each lift should be mechanically compacted to at least 95 percent of the modified Proctor maximum dry density as determined by the ASTM D 1557 test procedure. We recommend that a ZGA representative be present during grading so that an adequate number of density tests may be conducted as structural fill placement occurs. In this way, the adequacy of the earthwork may be evaluated as it proceeds. In the case of utility trench filling in municipal rights-of-way, the backfill should be placed and compacted in accordance with current Snohomish County codes and standards. Our recommendations for soil compaction as a function of location are summarized below.

RECOMMENDED SOIL COMPACTION LEVELS	
Location	**Minimum Percent Compaction***
General fill embankments and on-site utility trenches outside the reservoir foundation	95
All backfilled trenches below the reservoir	95
Upper one (1) foot below permanent vehicle access areas	95
Trench backfill in public rights-of-way	95
* *ASTM D 1557 Modified Proctor Maximum Dry Density*	

The suitability of soils for structural fill use 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 U.S. 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 five (5) percent fines by weight (based on that soil fraction passing the U.S. 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.

At the time of the subsurface evaluation, the shallow glacial till soil likely within the depth range of construction phase excavations had moisture contents that we interpreted to be within about 2 percent of the anticipated optimum moisture content relative to the till's possible use as structural fill. However, soil moisture conditions should be expected to change throughout the year. Soils with a fines content (that soil fraction passing the U.S. No. 200 sieve) greater than about five (5) percent will be sensitive to changes in moisture content relative to their use as structural fill. Selective drying of over-optimum moisture soils may be achieved by scarifying or windrowing surficial materials during dry weather. Soils that are dry of optimum may be moistened through the application of water and thorough blending to facilitate a uniform moisture distribution prior to compaction.

Re-use of Site Soils as Structural Fill: It is our opinion that the native glacial till will be adequate for use as structural fill borrow for general applications outside the reservoir's footprint, provided that the moisture content be adequately maintained. The till has a relatively high fines content, and it will not be feasible to use this material as structural fill during wet weather or wet site conditions.

Imported Structural Fill: In the event that inclement weather or wet site conditions prevent the use of on-site soil or non-select material as structural fill, we recommend that a "clean," free-draining pit-run sand and gravel or crushed rock be used. Such materials should generally contain less than five (5) percent fines, based on that soil fraction passing the ¾-inch sieve, and not contain discrete particles greater than 3 inches in diameter. CDF would be a feasible alternative to compacted structural fill and is most commonly used to backfill confined areas such as utility trenches. It should be noted that the placement of structural fill is, in many cases, weather-dependent. Delays due to inclement weather are common, even when using select granular fill. We recommend that the site grading and subsurface utility work be scheduled for the drier months, if at all possible.

We recommend limiting structural fill placed below the reservoir footprint to material meeting the criteria for crushed surfacing, base course gradation, as described in WSDOT Specification 9-03.9(3). We do not recommend using on-site soils or imported bank run sand and gravel as fill below the reservoir. As described subsequently in the Reservoir Foundation Recommendations section, CDF may be used as fill below the reservoir as an alternative to crushed surfacing base course.

Soil Stockpiling: If soils are stockpiled on site, and wet weather is anticipated, the stockpile should be protected with plastic sheeting that is securely anchored. If on-site soils become unusable, it may become necessary to import clean, granular soils to complete wet weather site work.

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. In order to maintain the function of any existing utilities, we recommend that temporary excavations not encroach upon the bearing splay of existing utilities. Likewise, utility excavations should not encroach upon the bearing splay of footings or floor slabs. The bearing splay of structures and utilities should be considered to begin about three (3) feet away from the widest point of the pipe or foundation and extend downward at a 1H:1V 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.

Utility Subgrade Preparation: We recommend that all utility subgrades be firm and unyielding and free of all soils that are loose, disturbed, or pumping. Such soils should be removed and replaced with compacted structural fill or crushed rock foundation material.

Trench Backfill: After a firm subgrade has been established, we recommend that a minimum of three (3) inches of bedding material be placed in the trench bottom. Under dry trench conditions, pipe bedding material should conform to Section 9-03.12 (3) of the WSDOT Standard Specifications. Under wet trench conditions, the fines content of the bedding should not exceed five (5) percent based on that fraction passing the U.S. No. 4 sieve. We further recommend that all bedding material extend at least four (4) inches above utilities that require protection during subsequent trench backfilling.

All trenches should be wide enough to allow for compaction around the haunches of the pipe. Otherwise, materials such as clean 5/8-inch crushed rock or pea gravel could be used to eliminate the required compaction around the pipe, with the exception of trenches that are located below the reservoir foundation. We recommend compacting all bedding below, around, and above piping located below the reservoir foundation to at least 95 percent of the modified Proctor maximum dry density.

Backfilling the remainder of the trenches could be completed with on-site soils if they can be compacted to the minimum levels recommended in Table 1. Wet soils excavated from the trenches could only be used as backfill by reducing the moisture content to within a few percent of optimum.

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.

As the cut is deepened, or as the length of time an excavation is open, the likelihood of bank failure increases; therefore, maintenance of safe slopes and worker safety should remain the responsibility of the contractor, who is present at the site, able to observe changes in the soil conditions, and monitor the performance of the excavation.

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. 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 four (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 296-155-650 -155, Part N *Excavation, Trenching, and Shoring*, we have interpreted that the existing shallow weathered till soils meet the Type C definition. The dense to very dense glacial till meets the Type A classification. The contractor should be prepared to adequately shore or slope all excavations.

Reservoir Foundation Recommendations

When our initial draft report was prepared in late 2022, we indicated our understanding that the new reservoir will be of welded steel construction and employ either a ringwall foundation or concrete slab foundation. The load imposed by the water alone was expected to be approximately 8,000 pounds per square foot (psf). The current draft plans indicate that the reservoir will employ a circular reinforced concrete mat foundation and that the loading resultant from the water under full-height conditions will be about 8,455 psf; these conditions are consistent with the originals considered when we prepared our initial draft report. Our original foundation design recommendations, which follow below, are appropriate for the reservoir conditions described in the draft May 2025 plans provided for our review.

In our opinion, the undisturbed native, dense to very dense unweathered glacial till is adequate for support of the reservoir. As described previously, we recommend constructing the foundation such that it bears upon the undisturbed, at least dense, native unweathered glacial till, or CDF with a minimum of 200 psi compressive strength or imported crushed rock structural fill compacted with a large self-propelled vibratory compactor to at least 95 percent density per ASTM D 1557. The CDF or structural fill should be placed above undisturbed dense to very dense glacial till.

Ringwall Foundation Allowable Bearing Pressure: The ringwall foundation allowable bearing pressure used for design will vary depending upon the foundation bearing width and depth below the adjacent exterior grade. We recommend considering the maximum allowable bearing pressures described in the table below for the ringwall foundation alternative. A one-third increase of these bearing pressures may be used for short-term wind or seismic loading. We can provide additional recommendations for foundation configurations not listed in the table below if necessary.

Reservoir Foundation Recommendations

Perimeter Foundation Width (feet)	**Foundation Subgrade Depth (feet)**	**Allowable Bearing Capacity (lbs/ft^2)**
3	5	10,000
4	5	12,000
5	5	13,000
3	4	9,000
4	4	10,000
5	4	11,000

Circular Slab Mat Foundation Recommendations: We recommend considering an allowable bearing pressure of 18,000 lbs/ft^2 for a circular mat foundation. This assumes a foundation slab depth of about 5 feet (expected depth to dense to very dense glacial till) and this value incorporates a factor of safety of about 2.

Lateral Resistance: We recommend using an allowable base friction value of 0.35; a factor of safety of approximately 1.5 has been applied to this value. We recommend considering a maximum allowable passive resistance (triangular distribution) of 250 pcf. This value incorporates a factor of safety of approximately 2 and assumes that the backfill placed around the foundation has been compacted to at least 95 percent of the maximum dry density. The uppermost 18 inches of foundation embedment should be neglected when calculating passive resistance.

Estimated Settlement: We estimate that total settlement of either reservoir foundation alternative will be less than one inch provided that the foundation and floor are supported by either the undisturbed native dense to very dense unweathered glacial till, or CDF or compacted crushed surfacing base course fill placed above the dense to very dense till as described previously. Foundation settlement will occur elastically as the loads are applied. We estimate that differential settlement may approach half of the total settlement.

Foundation Subgrade Protection: Under no circumstances should the reservoir foundation or floor be cast atop loose or soft soils, slough, debris, or surfaces bearing standing water. We recommend that a ZGA representative observe the condition of the foundation subgrade prior to placement of the protective

CDF recommended previously in order to verify that the bearing soils are undisturbed and that conditions are consistent with the recommendations contained within this report.

Reservoir Floor Subgrade Preparation Recommendations

Our previous recommendations regarding removal of loose to medium dense soils down to at least dense unweathered glacial till below the reservoir footprint are applicable to preparation of the reservoir floor subgrade for the ringwall foundation alternative. We recommend supporting the floor on either CDF with a 200 psi compressive strength or crushed surfacing base course compacted to at least 95 percent density per ASTM D 1557.

Stormwater Drainage Considerations

Our authorized scope of services did not include a detailed evaluation of the geotechnical feasibility of stormwater infiltration. As previously described, the explorations completed for this evaluation disclosed weathered and unweathered glacial till soils with a high fines content. Based on these conditions we anticipate that a shallow perched groundwater condition may develop during the wetter time of year. Stormwater infiltration into unweathered glacial till is typically not considered feasible because of the soil's low permeability, although infiltration into the less dense weathered horizon, albeit at low rates, is feasible in some situations. However, the probable lack of 3 to 5 feet of vertical separation between a typical infiltration feature and a likely seasonal perched groundwater condition would appear to preclude conventional infiltration per the conditions described in the *Snohomish County Drainage Manual*. Consequently, it would appear that stormwater dispersion above a vegetated flow path would be a more viable alternative from the geotechnical perspective.

The draft plans available for our review indicate that our original recommendations for final site grades sloping away from the new reservoir and other drainage-sensitive areas have been incorporated into the design. Most of the stormwater originating from impervious surfaces described will be conveyed to a dispersion trench feature to be constructed on the south side of the reservoir. The trench is at least 90 feet away from the nearest slope, and this slope has an inclination of only 13 percent. The flow path between the trench and the slope is well-vegetated, and the conditions are consistent with those suitable for dispersion as described in the *Snohomish County Drainage Manual*.

Erosion Control

We recommend that the project employ the following construction phase erosion control elements:

- Clear identification of clearing limits;
- Protecting exposed soil surfaces that will be subject to vehicle traffic with crushed rock, crushed recycled concrete, or pit run sand and gravel;
- Covering soil stockpiles with anchored plastic sheeting;

- Protecting graded surfaces outside the reservoir footprint with straw if they are exposed for more than two days during wet weather;

- Installing a siltation control fence or anchored straw or coir wattle on the downslope side of the are disturbed during construction.

We recommend that final erosion control measures include seeding exposed soil surface with a County-approved grass seed mix. The use of straw mulch above the seed will help to reduce erosion until the grass becomes established and may also speed germination.

General Comments

ZGA should be retained to review the final design plans and specifications so comments can be made regarding the interpretation and implementation of our geotechnical recommendations in the design and specifications. ZGA also should be retained to provide observation and testing services during grading, excavation, foundation constructions, and other earth-related construction phases of the project.

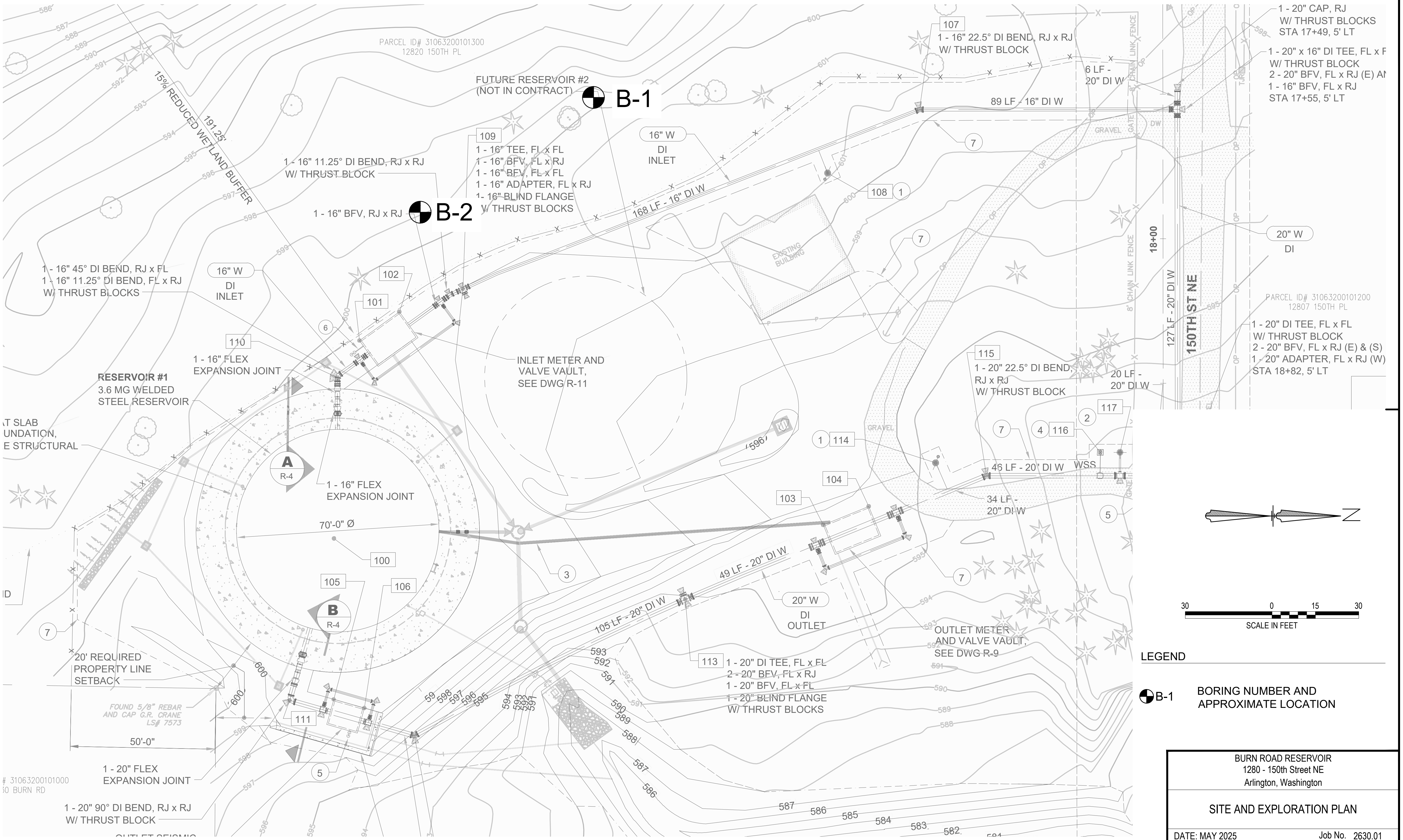
The analysis and recommendations presented in this report are based upon the data obtained from the explorations performed at the indicated locations and from other information discussed in this report. This report does not reflect potential variation in subsurface conditions across the site or due to the modifying effects of weather. The nature and extent of such variations may not become evident until during or after construction. If variations appear, we should be immediately notified so that further evaluation and supplemental recommendations can be provided.

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

This report has been prepared for the exclusive use of the District 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 ZGA reviews the changes and either verifies or modifies the conclusions of this report in writing.

CLOSURE

We appreciate the opportunity to be of service to you and would be pleased to discuss the contents of this report or other aspects of the project with you at your convenience.



LEGEND

B-1 BORING NUMBER AND APPROXIMATE LOCATION

REFERENCE: BURN ROAD RESERVOIR, RESERVOIR SITE WATER PLAN, SNOHOMISH COUNTY PUD, SHEET 8, DATED MAY 2025.

BURN ROAD RESERVOIR
1280 - 150th Street NE
Arlington, Washington

SITE AND EXPLORATION PLAN

DATE: MAY 2025
Job No. 2630.01

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 AND LOGS

Our field exploration program for this project included completing a visual reconnaissance of the site and advancing two borings (B-1 and B-2). 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 *Existing Conditions Topographical Survey*, Sheet 2 of 4, dated 15 September 2022, prepared by David Evans and Associates, Inc. The ground surface elevation at each exploration location was interpolated from the referenced plan. 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 (Boretec1) working under subcontract to ZGA. The borings were advanced using hollow stem auger drilling methods. An engineering geologist 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.

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.

Boring Location: See Figure 1, Site and Exploration Plan
Top Elevation: Apprroximately 599 feet
Date Drilled: 9/15/2022
Drilling Company: Boretec 1
Drilling Method: Hollow Stem Auger
Drill Rig: EC 95 Track Drill
Bore Hole Dia.: 8-inch
Hammer Type: Cathead
Logged by: BGF

B-1

SOIL DESCRIPTION

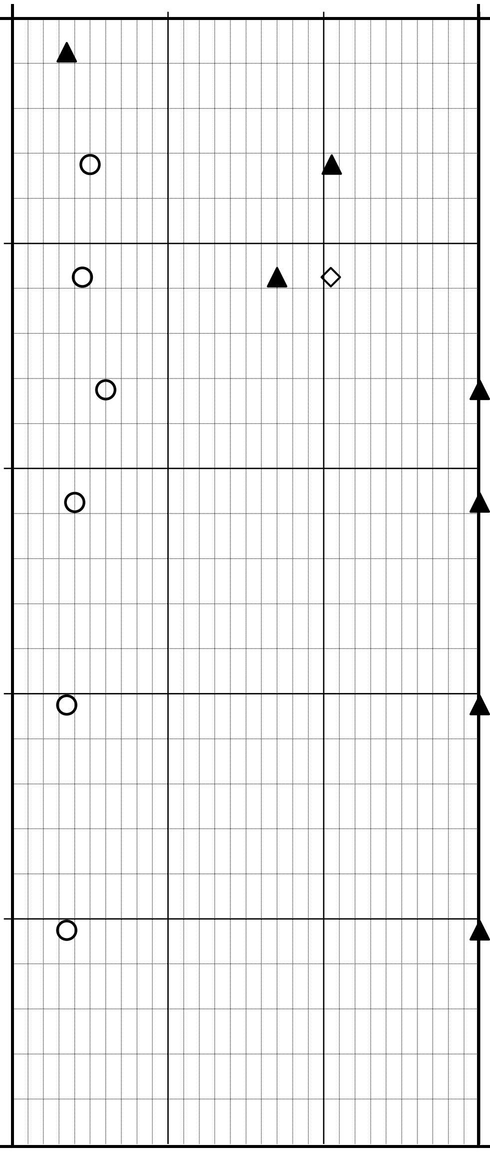
The stratification lines represent the approximate boundaries between soil types. The transition may be gradual. Refer to report text and appendices for additional information.

Depth (ft)	Soil Description	Sample Number	Recovery (In.)	Groundwater	Blow Counts	Testing
0	1 - 2 inches of well manicured grass over loose, moist, brown, silty SAND, some fine roots, trace gravel	S-1A	18		7	
	Dense, moist, light brown, gravelly silty SAND/gravelly sandy SILT (Glacial Till)	S-1	18		41	MC
5		S-2	18		34	GSA
	Grades to very dense	S-3	18		74	MC
10		S-4	18		50-5"	MC
	Hard drilling					
15	Very dense, moist, gray, silty SAND, some gravel (Glacial Till)	S-5	6		50-5"	MC
20		S-6	6		50-4"	MC
	Very hard drilling					
25						

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
- ▼ Groundwater level at time of drilling (ATD) or on date of measurement. 11/2/12

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

Burn Road 276 Reservoir
12820 150th Street NE
Arlington, WA

Date: October 2022
Project No.: 2630.01

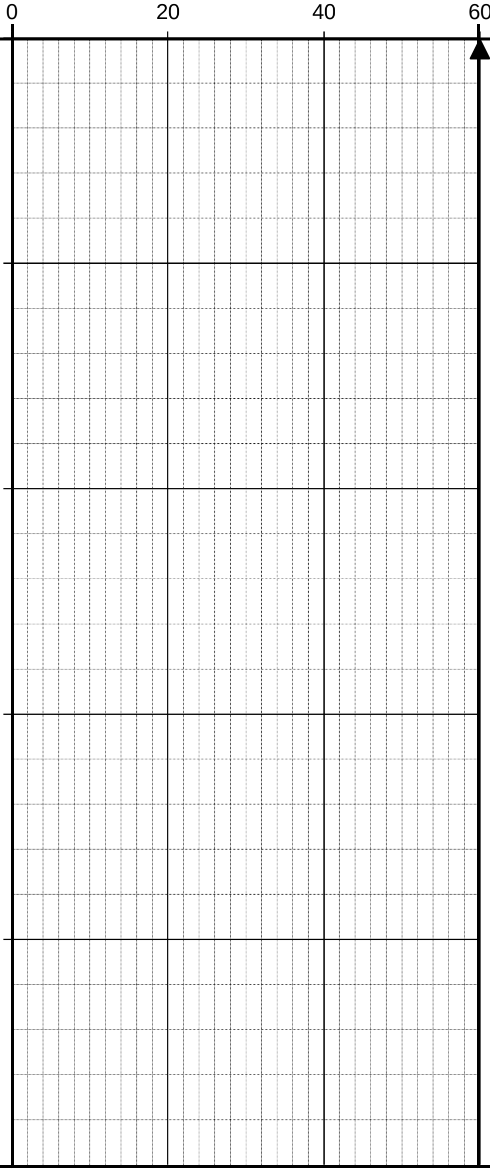
ZipperGeo
Geoprofessional Consultants
19019 36th Ave. W, Suite E
Lynnwood, WA

BORING LOG: B-1

Boring Location:	See Figure 1, Site and Exploration Plan	Drilling Company:	Boretec 1	Bore Hole Dia.:	8-inch
Top Elevation:	Apprroximately 599 feet	Drilling Method:	Hollow Stem Auger	Hammer Type:	Cathead
Date Drilled:	9/15/2022	Drill Rig:	EC 95 Track Drill	Logged by:	BGF

B-1

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.)	Groundwater	PENETRATION RESISTANCE (blows/foot) ▲ Standard Penetration Test △ Hammer Weight and Drop:	Blow Counts	Testing
25	Very dense, moist, gray, silty SAND, trace gravel	S-7 I 6		▲	50-4"	
	Boring completed at approximately 25.5 feet. Groundwater was not encountered ATD.					
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

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Geoprofessional Consultants
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Lynnwood, WA

BORING LOG: B-1

Boring Location: See Figure 1, Site and Exploration Plan
Top Elevation: Apprroximately 599 feet
Date Drilled: 9/15/2022
Drilling Company: Boretec 1
Drilling Method: Hollow Stem Auger
Drill Rig: EC 95 Track Drill
Bore Hole Dia.: 8-inch
Hammer Type: Cathead
Logged by: BGF

B-2

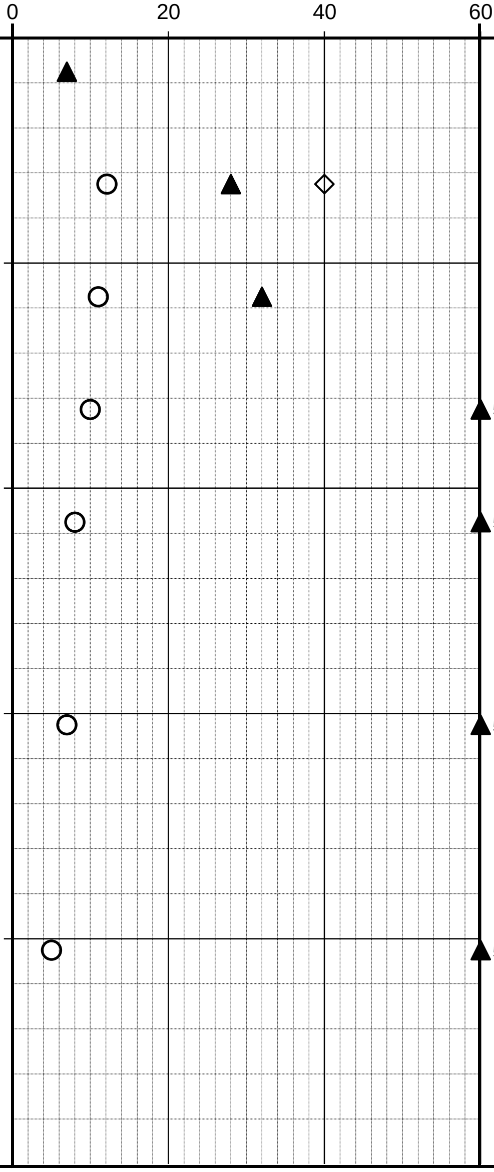
The stratification lines represent the approximate boundaries between soil types. The transition may be gradual. Refer to report text and appendices for additional information.

Depth (ft)	SOIL DESCRIPTION	SAMPLES Sample Number	SAMPLES Recovery (In.)	Blow Counts	Testing
0	1 - 2 inches of well manicured grass over loose, moist, brown, silty SAND, some fine roots, trace gravel	S-1A	18	7	
	Medium dense, moist, brown, gravelly silty SAND (Weathered Glacial Till)	S-1	18	28	GSA
5	Dense, moist, light brown, silty SAND, with gravel (Glacial Till)	S-2	18	32	MC
	Grades to very dense	S-3	10	50-3"	MC
10	Grades to light brown to gray	S-4	10	50-4"	MC
	Very hard drilling				
15	Very dense, moist, gray, silty SAND, trace gravel (Glacial Till)	S-5	6	50-5"	MC
20		S-6	6	50-5"	MC
	Boring completed at approximately 20.5 feet. Groundwater was not encountered ATD.				
25					

Groundwater

PENETRATION RESISTANCE (blows/foot)

▲ Standard Penetration Test
△ Hammer Weight and Drop: ______



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
▼ Groundwater level at time of drilling (ATD) or on date of measurement.
11/2/12

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

Burn Road 276 Reservoir
12820 150th Street NE
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Lynnwood, WA

BORING LOG: B-2

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.

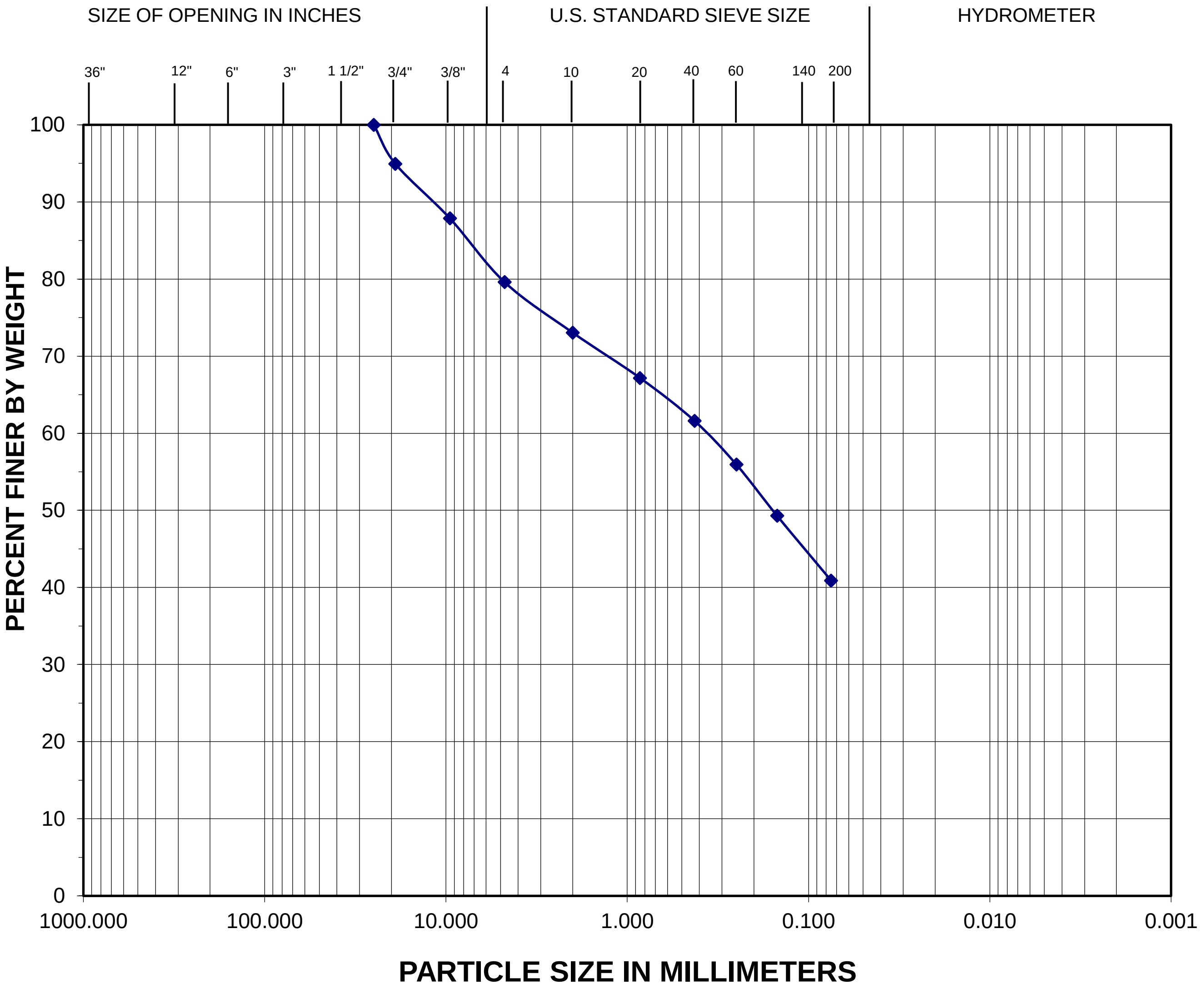
Grain Size Analysis

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



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

Comments:

Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
B-1	S-2	5	9.2	40.9	Gravelly sandy SILT

Zipper Geo Associates, LLC
Geotechnical and Environmental Consultants

PROJECT NO: 2630.01

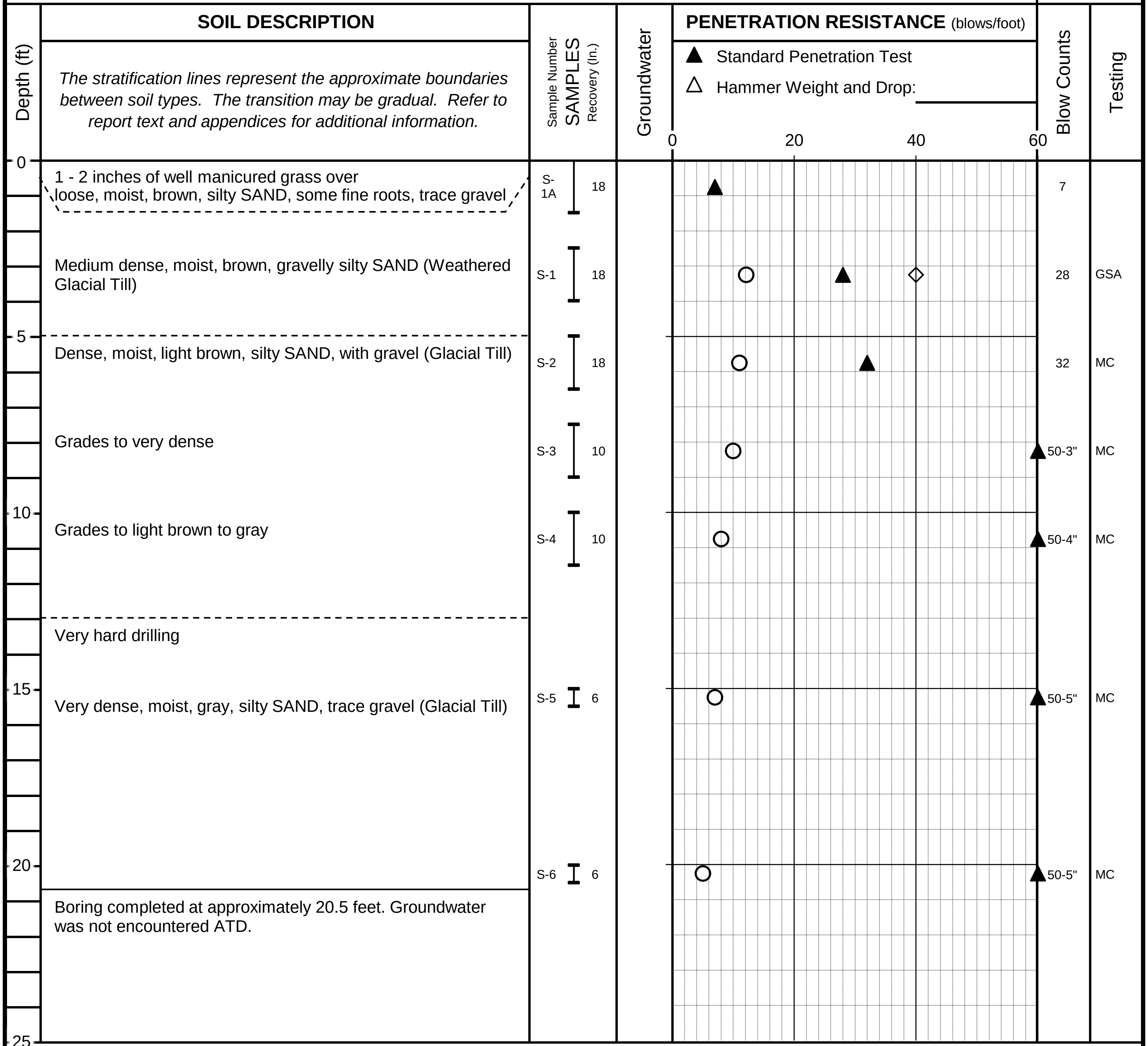
DATE OF TESTING: 9/26/2022

PROJECT NAME:

Burn Road 726 Resevoir

Boring Location: See Figure 1, Site and Exploration Plan
Top Elevation: Apprroximately 598 feet
Date Drilled: 9/15/2022
Drilling Company: Boretec 1
Drilling Method: Hollow Stem Auger
Drill Rig: EC 95 Track Drill
Bore Hole Dia.: 8-inch
Hammer Type: Cathead
Logged by: BGF

B-2



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

Depth (ft)	Soil Description	Sample Number	Recovery (In.)	Blow Counts	Testing
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	Medium dense, moist, brown, gravelly silty SAND (Weathered Glacial Till)	S-1	18	28	GSA
5	Dense, moist, light brown, silty SAND, with gravel (Glacial Till)	S-2	18	32	MC
	Grades to very dense	S-3	10	50-3"	MC
10	Grades to light brown to gray	S-4	10	50-4"	MC
	Very hard drilling				
15	Very dense, moist, gray, silty SAND, trace gravel (Glacial Till)	S-5	6	50-5"	MC
20		S-6	6	50-5"	MC
	Boring completed at approximately 20.5 feet. Groundwater was not encountered ATD.				

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

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BORING LOG: B-2