GEOTECHNICAL REPORT

Monroe West
18614 and 18718 – 134th Street Southeast
Monroe, Washington

Project No. T-9077

Terra Associates, Inc.

Prepared for:

South Lake Ridge, LLC
c/o Land Pro Group
Lake Stevens, Washington

January 3, 2025

TERRA ASSOCIATES, Inc.
Consultants in Geotechnical Engineering, Geology
and
Environmental Earth Sciences

January 3, 2025
Project No. T-9077

South Lake Ridge, LLC
c/o Ms. Abi Toyer
Land Pro Group
10515 – 20th Street, Suite 202
Lake Stevens, Washington 98258

Subject: Geotechnical Report
Monroe West
18614 and 18718 – 134th Street Southeast
Monroe, Washington

Dear Ms. Toyer:

As requested, we have conducted a geotechnical engineering study for the subject project. The attached report presents our findings and recommendations for the geotechnical aspects of project design and construction.

In general, the soil conditions at the site consist of approximately four to ten inches of organic topsoil overlying medium dense to very dense weathered and unweathered glacial till deposits to the termination of the test pits. No groundwater seepage was observed during our subsurface explorations.

In our opinion, the soils observed on the site will be suitable for support of the proposed development, provided the recommendations presented in this report are incorporated into project design and construction.

We trust the information presented in this report is sufficient for your current needs. If you have any questions or require additional information, please call.

Sincerely yours,
TERRA ASSOCIATES, INC.

Michael J. Xenos, P.E.
Project Engineer

Carolyn S. Decker, P.E.
President

CAROLYN S. DECKER
STATE OF WASHINGTON
47016
REGISTERED PROFESSIONAL ENGINEER

1-3-25

12220 113th Avenue NE, Ste. 130, Kirkland, Washington 98034
Phone (425) 821-7777 • Fax (425) 821-4334

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Geotechnical Report
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18614 and 18718 – 134th Street Southeast
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1.0 PROJECT DESCRIPTION

A preliminary plat map prepared by Solid Ground Engineering, dated November 5, 2024, shows the project consists of developing the site with 39 townhome units along with associated access and utilities. Grading plans were not available at the time of this report. Based on existing site topography, we expect grading to be minor to moderate with cuts and fills ranging from 1 to 15 feet to achieve final building and road elevations.

We would expect that the residential structures will three-story, wood-frame buildings constructed at-grade. Foundation loads are expected to be relatively light, in the range of 4 to 8 kips per foot for bearing walls and 50 to 75 kips for isolated columns.

The recommendations in the following sections of this report are based on our understanding of the preceding design features. We should review design drawings as they become available to verify our recommendations have been properly interpreted and to supplement them, if required.

2.0 SCOPE OF WORK

We completed our work in accordance with our authorized proposal, dated July 18, 2024. Accordingly, on August 16, 2024, we observed soil and groundwater conditions in ten soil test pits excavated with a track-mounted excavator to maximum depths of approximately eight feet below existing grades. Using the information obtained from the subsurface exploration and laboratory testing, we performed analyses to develop geotechnical recommendations for project design and construction.

Specifically, this report addresses the following:

- Soil and groundwater conditions.
- Geologic Hazards per the City of Monroe Municipal Code.
- Seismic Site Class per the current International Building Code (IBC).
- Site preparation and grading.
- Excavations.
- Foundation support.
- Slab-on-grade floors.
- Stormwater facilities.
- Infiltration feasibility.

- Drainage.
- Utilities.
- Pavements.

It should be noted, recommendations outlined in this report regarding drainage are associated with soil strength, design earth pressures, erosion, and stability. Design and performance issues with respect to moisture as it relates to the structure environment are beyond Terra Associates, Inc.'s purview. A building envelope specialist or contactor should be consulted to address these issues, as needed.

3.0 SITE CONDITIONS

3.1 Surface

The site consists of two residential tax parcels totaling about 9.77 acres located at 18614 and 18718 – 134th Street Southeast in Monroe, Washington. The approximate site location is shown on Figure 1.

The site is currently developed with two single-family residences, two outbuildings, and associated access and utilities in the northern portions of the parcels. Site vegetation throughout the majority of the site consists of landscaped grass lawn and scattered collections of small- to medium-sized trees. The southern two-thirds of the western parcel is covered in brush and weeds. Site topography consists of a slope that descends from the northeast to the southwest with an overall vertical relief of approximately 120 feet. An ultrablock retaining wall approximately two and one-half feet in height supports a vertical grade transition from the backyard to the undeveloped, brush-covered portion of the western parcel.

3.2 Subsurface

In general, the soil conditions at the site consist of approximately four to ten inches of organic topsoil overlying approximately two to four feet of medium dense silty sand, sandy silt, and silt with sand with varying gravel and cobble content (weathered glacial till) overlying dense to very dense silty sand with gravel deposits with varying cobble content (unweathered glacial till) to the termination of the test pits. There were three exceptions to this general condition. The weathered material observed in the upper approximately four feet of Test Pit TP-5 consisted of medium dense silty gravel with sand. In Test Pit TP-9 we observed approximately two and one-half feet of inorganic fill material composed of medium dense silty sand with gravel overlying the weathered till deposits. In Test Pit TP-10 we did not observe any weathered till overlying the dense to very dense unweathered till deposits.

The *Geologic Map of the Lake Roesiger 7.5-Minute Quadrangle, Snohomish County, Washington* by J.D. Dragovich et al. (2015) maps the site as Lodgement Till (Qgt_v). The medium dense to very dense silty sand with gravel deposits observed in the test pits are consistent with this mapped description.

The United States Department of Agriculture Natural Resources Conservation Service (NRCS) classifies the onsite soils as Tokul gravelly medial loam material. A soil horizon, consisting of this material, is typically by glacial processes in the form of hillslopes and till plains, and is derived from volcanic ash mixed with loess over glacial till which is consistent with our exploratory findings and knowledge of the area's geologic setting.

The preceding discussion is intended to be a general review of the soil conditions encountered. For more detailed descriptions, please refer to the Test Pit Logs in Appendix A. The approximate location of the test pits are shown on the Exploration Location Plan, Figure 2.

3.3 Groundwater

We did not observe any groundwater seepage during our explorations. However, mottled soils were observed in many of the test pits near the contact between the upper weathered till and lower unweathered till, which typically indicates the presence of seasonal perched groundwater at the site. The occurrence of shallow perched groundwater is typical for sites underlain by fine-grained soils. We expect perched groundwater levels and flow rates will fluctuate seasonally and will typically reach their highest levels during and shortly following the wet winter months (November through May). Given the time of year our field work was completed and our experience with groundwater conditions in the area, the groundwater levels observed likely represent seasonal low levels.

3.4 Geologic Hazards

Section 22.80.130.A of the City of Monroe Municipal Code (MMC) defines geologic hazards as "…areas susceptible to erosion, sliding, earthquake, or other geological events." We evaluated site conditions for the presence of erosion, landslide, and seismic hazards in the discussions below.

3.4.1 Erosion Hazard Areas

Section 22.80.130.B.1 of the MMC defines Erosion Hazard Areas as "…areas identified by the U.S. Department of Agriculture's Natural Resources Conservation Service as having "severe" or "very severe" rill and inter-rill erosion hazard."

The onsite soils in the northern half of the site are classified as Tokul gravelly medial loam, 0 to 8 percent slopes, and those in the southern half are classified as Tokul gravelly medial loam, 8 to 15 percent slopes by the United States Department of Agriculture Natural Resources Conservation Service. (NRCS). With existing gradients, these soils are rated as slightly to moderately susceptible to erosion. Therefore, the site would not be classified as an erosion hazard area as defined by the MMC, in our opinion.

We did not observe any indications of significant active erosion at the site; however, the potential for soil erosion will increase during construction. In our opinion, proper implementation and maintenance of Best Management Practices (BMPs) for erosion prevention and sediment control, in conjunction with appropriate site drainage, will adequately mitigate the erosion potential in the planned development area. Erosion protection measures as required by the City of Monroe will need to be in place prior to and during grading activities at the site.

3.4.2 Landslide Hazard Areas

Section 22.80.130.B.2 of the MMC defines landslide hazard areas as "…areas potentially subject to landslides based on a combination of geologic, topographic, and hydrologic factors. They include areas susceptible because of any combination of bedrock, soil, slope (gradient), slope aspect, structure, hydrology, or other factors. Examples of these may include, but are not limited to, the following:

a. Areas of historic failure, such as:

    i. Those areas delineated by the U.S. Department of Agriculture's Natural Resources Conservation Service as having a "severe" limitation for building site development; or

    ii. Areas designated as quaternary slumps, earthflows, mudflows, lahars, or landslides on maps published by the U.S. Geological Survey or Department of Natural Resources;

b. Areas with all three of the following characteristics:

    i. Slopes steeper than fifteen percent; and

    ii. Hillsides intersecting geologic contacts with a relatively permeable sediment overlaying a relatively impermeable sediment or bedrock; and

    iii. Springs or groundwater seepage;

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

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

e. Slopes having a gradient steeper than eighty percent subject to rock fall during seismic shaking;

f. Areas potentially unstable because of rapid stream incision, stream bank erosion, and undercutting by wave action;

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

h. Any area with a slope of forty percent or steeper and with a vertical relief of ten or more feet except areas composed of consolidated rock. A slope delineated by establishing its toe and top and measured by averaging the inclination over at least ten feet of vertical relief."

Existing site topography throughout the site generally consists of a moderate slope descending from the northeast to the southwest with little to no risk of mass movement due to geologic, topography, or hydrologic factors. Grades across the site generally range from 14 to 21 percent and are underlain by glacially consolidated till. Therefore, in our opinion none of the above criteria for classification as a landslide hazard are present at the site.

3.4.3 Seismic Hazard Areas

Section 22.80.130.B.3 of the MMC defines Seismic Hazard Areas as areas "… subject to severe risk of damage as a result of earthquake-induced ground shaking, slope failure, settlement, soil liquefaction, lateral spreading, or surface failure. The strength of ground shaking is primarily affected by:

a. The magnitude of an earthquake;

b. The distance from the source of an earthquake;

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

d. The type of subsurface geological structure."

A review of a map titled *Faults and Earthquakes in Washington State*, dated 2014 by Jessica L. Czajkowski and Jeffrey D. Bowman, shows the fault nearest to the site is the southeastern flank of the Southern Whidbey Island Fault Zone and is located approximately 2.5 miles southwest of the site and is classified as "Class B". Accordingly, during a seismic event, the risk of ground rupture along a fault line at the site is low.

Liquefaction is a phenomenon where there is a reduction or complete loss of soil strength due to an increase in water pressure induced by vibrations. Liquefaction mainly affects geologically recent deposits of fine-grained sands underlying the groundwater table. Soils of this nature derive their strength from intergranular friction. The generated water pressure or pore pressure essentially separates the soil grains and eliminates this intergranular friction, thus eliminating the soil's strength.

The site is currently mapped on the Washington State DNR's *Natural Hazards Single-Topic Map* as having very low liquefaction potential. Based on the soil and groundwater conditions we observed, it is our opinion that the risk for soil liquefaction occurring at the site is negligible due to the relative density of the soils and amount of cohesive material that would be sufficient to resist the cyclical loading of a seismic event. Therefore, in our opinion, the site would not be considered a seismic hazard area as defined by the MMC.

<u>3.5 Seismic Site Class</u>

Based on soil conditions observed in the test pits, and our knowledge of the area geology, per Chapter 16 of the current International Building Code (IBC), Site Class "C" should be used in structural design.

4.0 DISCUSSION AND RECOMMENDATIONS

4.1 General

Based on our study, there are no geotechnical considerations that would preclude development of the site as currently planned. The residential buildings can be supported on conventional spread footings bearing on competent native soils, competent existing fill soils, or on structural fill placed on the competent soils observed below the organic surface horizon. Pavement and floor slabs can be similarly supported.

Most of the native and existing fill soils encountered at the site contain a sufficient amount of soil fines that will make them difficult to compact as structural fill when too wet. The ability to use the native and existing fill soils from site excavations as structural fill will depend upon its moisture content and the prevailing weather conditions at the time of construction. If grading activities will take place during winter, the owner should be prepared to import clean granular material for use as structural fill and backfill.

The following sections provide detailed recommendations regarding the preceding issues and other geotechnical design considerations. These recommendations should be incorporated into the final design drawings and construction specifications.

4.2 Site Preparation and Grading

To prepare the site for construction, all vegetation, organic surface soils, and other deleterious material should be stripped and removed from the site. Surface stripping depths of approximately four to ten inches should be expected to remove the organic surface soils and vegetation. In the developed portions of the site, demolition of existing structures should include removal of existing foundations and buried asphalt and abandonment of underground septic systems and other buried utilities. Abandoned utility pipes that fall outside of new building areas can be left in place provided they are sealed to prevent intrusion of groundwater seepage and soil. Organic topsoil will not be suitable for use as structural fill but may be used for limited depths in nonstructural areas.

Once clearing and stripping operations are complete, cut and fill operations can be initiated to establish desired building grades. Prior to placing fill, all exposed bearing surfaces should be observed by a representative of Terra Associates, Inc. to verify soil conditions are as expected and suitable for support of new fill or building elements. Our representative may request a proofroll using heavy rubber-tired equipment to determine if any isolated soft and yielding areas are present. If excessively yielding areas are observed and they cannot be stabilized in place by compaction, the affected soils should be excavated and removed to firm bearing and grade restored with new structural fill. If the depth of excavation to remove unstable soils is excessive, the use of geotextile fabrics, such as Mirafi 500X or an equivalent fabric can be used in conjunction with clean granular structural fill. Our experience has shown, in general, a minimum of 18 inches of a clean, granular structural fill placed and compacted over the geotextile fabric should establish a stable bearing surface.

Existing fill soils of limited depth may be exposed in the building areas during grading. Where these soils are exposed, we recommend compacting them in place. If the exposed fill soils are in a loose condition, we recommend over-excavating them to expose the underlying native soils and recompacting them as structural fill following the requirements outlined below.

Due to the amount of fines observed at the site, we anticipate that the soils in the project area can become easily disturbed. Some of the site soils will quickly degrade under construction traffic if shallow groundwater is encountered or rainy weather occurs during site clearing and subgrade preparation activities. Where this condition exists, consideration should be given to over excavating to a depth of two feet, placing a geotextile fabric such as, Mirafi 500X or equivalent on the over excavated subgrade, and restoring grade with two- to four-inch quarry spalls. Based on our experience, this will provide a stable surface for areas subject to heavy equipment and construction traffic.

Our study indicates that the native and existing fill soils encountered at the site contain a sufficient amount of soil fines that will make them difficult to compact as structural fill when too wet or too dry. The ability to use native and existing fill soils from site excavations as structural fill will depend upon its moisture content, the prevailing weather conditions at the time of construction, and the contractor's ability to compact the native silt soils. We recommend achieving compaction of the native silt soils using a sheep's foot roller on lifts no greater than six inches in thickness conforming to the standards outlined below. If wet soils are encountered, the contractor will need to dry the soils by aeration during dry weather conditions. Alternatively, the use of an additive, such as Portland cement, cement kiln dust (CKD), or lime to stabilize the soil moisture can be considered. If the soil is amended, additional Best Management Practices (BMPs) addressing the potential for elevated pH levels will need to be included in the Stormwater Pollution Prevention Program (SWPPP) prepared with the Temporary Erosion and Sedimentation Control (TESC) plan. Cobbles and boulders in excess of six inches in diameter should be removed from the structural fill.

If grading activities are planned during the wet winter months, or if they are initiated during the summer and extend into fall and winter, the owner should be prepared to import wet-weather structural fill. For this purpose, we recommend importing a granular soil that meets the following grading requirements:

U.S. Sieve Size	Percent Passing
6 inches	100
No. 4	75 maximum
No. 200	5 maximum*

* Based on the 3/4-inch fraction.

Prior to use, Terra Associates, Inc. should examine and test all materials imported to the site for use as structural fill.

Structural fill should be placed in uniform loose layers not exceeding 12 inches and compacted to a minimum of 95 percent of the soil's maximum dry density, as determined by American Society for Testing and Materials (ASTM) Test Designation D-1557 (Modified Proctor). The moisture content of the soil at the time of compaction should be within two percent of its optimum, as determined by this ASTM standard. In nonstructural areas, the degree of compaction can be reduced to 90 percent. For the native silt soils, the layer thickness should be reduced to six inches.

4.3 Excavations

All excavations at the site associated with confined spaces, such as utility trenches, must be completed in accordance with local, state, and federal requirements. Based on regulations outlined in the Washington Industrial Safety and Health Act (WISHA), the medium dense soils would be classified as Type C soils. The dense till soils would be classified as Type B soils. The very dense till soils would be classified as Type A soils.

Accordingly, temporary excavations in Type C soils should have their slopes laid back at an inclination of 1.5:1 (Horizontal: Vertical) or flatter, from the toe to the crest of the slope. Side slopes in Type B soils can be laid back at a slope inclination of 1:1 or flatter. For temporary excavation slopes less than 8 feet in height in Type A soils, the lower 3.5 feet can be cut to a vertical condition, with a 0.75:1 slope graded above. For temporary excavation slopes greater than 8 feet in height up to a maximum height of 12 feet, the slope above the 3.5-foot vertical portion will need to be laid back at a minimum slope inclination of 1:1. No vertical cut with a backslope immediately above is allowed for excavation depths that exceed 12 feet. In this case, a four-foot vertical cut with an equivalent horizontal bench to the cut slope toe is required. All exposed temporary slope faces that will remain open for an extended period of time should be covered with a durable reinforced plastic membrane during construction to prevent slope raveling and rutting during periods of precipitation.

Perched groundwater seepage should be anticipated within excavations during the wet winter season. We anticipate that the volume of water and rate of flow into the excavation will be relatively minor and are not expected to impact the stability of the excavations when completed, as described. Conventional sump pumping procedures, along with a system of collection trenches, if necessary, should be capable of maintaining a relative dry excavation for construction purposes.

The above information is provided solely for the benefit of the owner and other design consultants and should not be construed to imply that Terra Associates, Inc. assumes responsibility for job site safety. It is understood that job site safety is the sole responsibility of the project general contractor.

4.4 Foundation Support

The residential buildings may be supported on conventional spread footing foundations bearing on competent native soils, competent existing fill soils, or on structural fill placed above the competent soils. Foundation subgrade should be prepared as recommended in Section 4.2 of this report. Perimeter foundations exposed to the weather should bear a minimum depth of 1.5 feet below final exterior grades for frost protection. Interior foundations can be constructed at any convenient depth below the floor slab.

The native and existing fill soils will be easily disturbed by normal construction activity particularly when wet. Care will need to be exercised during construction to avoid excessively disturbing the subgrade. If disturbed, the material should be removed and footings lowered to undisturbed material or grade restored with structural fill. During wet-weather conditions, to avoid disturbance, consideration should be given to protecting the fill foundation subgrade with a four-inch layer of crushed rock or lean mix concrete.

Foundations bearing on competent soils can be dimensioned for a net allowable bearing capacity of 2,500 pounds per square foot (psf). For short-term loads, such as wind and seismic, a one-third increase in this allowable capacity can be used. With structural loading as anticipated, and this bearing stress applied, estimated total settlements are less than one- inch.

For designing foundations to resist lateral loads, a base friction coefficient of 0.35 can be used. Passive earth pressures acting on the side of the footing and buried portion of the foundation stem wall can also be considered. We recommend calculating this lateral resistance using an equivalent fluid weight of 350 pcf. We recommend not including the upper 12 inches of soil in this computation because they can be affected by weather or disturbed by future grading activity. This value assumes the foundation will be constructed neat against competent reworked native soil, or backfilled with structural fill as described in Section 4.2 of this report. The values recommended include a safety factor of 1.5.

4.5 Slab-on-Grade Floors

Slab-on-grade floors may be supported on subgrade prepared as recommended in Section 4.2 of this report. Immediately below the floor slab, we recommend placing a four-inch-thick capillary break layer composed of clean, coarse sand or fine gravel that has less than five percent passing the No. 200 sieve. This material will reduce the potential for upward capillary movement of water through the underlying soil and subsequent wetting of the floor slab.

The capillary break layer will not prevent moisture intrusion through the slab caused by water vapor transmission. Where moisture by vapor transmission is undesirable, such as covered floor areas, a common practice is to place a durable plastic membrane on the capillary break layer and then cover the membrane with a layer of clean sand or fine gravel to protect it from damage during construction and to aid in uniform curing of the concrete slab. It should be noted, if the sand or gravel layer overlying the membrane is saturated prior to pouring the slab, it will not be effective in assisting uniform curing of the slab and can actually serve as a water supply for moisture bleeding through the slab, potentially affecting floor coverings. Therefore, in our opinion, covering the membrane with a layer of sand or gravel should be avoided if floor slab construction occurs during the wet winter months and the layer cannot be effectively drained. We recommend floor designers and contractors refer to the current American Concrete Institute (ACI) Manual of Concrete Practice for further information regarding vapor barrier installation below slab-on-grade floors.

4.6 Stormwater Facilities

Site stormwater plans were not available at the time of this report.

Detention Vault

We expect the bottom of the excavations for the detention vaults will expose dense to very dense silty sand with varying gravel content. Vault foundations supported by these native soils may be designed for a net allowable bearing capacity of 6,000 psf. For short-term loads, such as seismic, a one-third increase in this allowable capacity can be used.

Vault walls should be designed as below-grade retaining walls. The magnitude of earth pressure development on engineered retaining walls will partly depend on the quality of the wall backfill. We recommend placing and compacting wall backfill as structural fill as described in Section 4.2 of this report. To prevent overstressing the walls during backfilling, heavy construction machinery should not be operated within five feet of the wall. Wall backfill in this zone should be compacted with hand-operated equipment. To prevent hydrostatic pressure development, wall drainage must also be installed. A typical wall drainage detail is shown on Figure 3.

With wall backfill placed and compacted as recommended and drainage properly installed, we recommend designing unrestrained walls for an active earth pressure equivalent to a fluid weighing 35 pounds per cubic foot (pcf). For restrained walls, an additional uniform load of 100 pounds per square foot (psf) should be added to the 35 pcf. To account for typical traffic surcharge loading, the walls can be designed for an additional imaginary height of two feet (two-foot soil surcharge).

For evaluation of below-grade walls under seismic loading, an additional uniform lateral pressure equivalent to 8H psf, where H is the height of the below-grade portion of the wall in feet, can be used. These values assume a horizontal backfill condition and that no other surcharge loading such as traffic, sloping embankments, or adjacent buildings will act on the wall. If such conditions exist, then the imposed loading must be included in the wall design. Friction at the base of foundations and passive earth pressure will provide resistance to these lateral loads. Values for these parameters are given in Section 4.5 of this report.

If it is not possible to discharge collected water at the footing invert elevation, the invert elevation of the wall drainpipe could be set equivalent to the outfall invert. For any portion of the wall that falls below the invert elevation of the wall drain, an earth pressure equivalent to a fluid weighing 85 pcf should be used.

We should review the stormwater plans when they are completed and revise our recommendations, if required.

4.7 Infiltration Feasibility

The glacially consolidated soils composed of silty sand with gravel characteristically exhibit low permeability and would not be a suitable receptor soil for discharge of development stormwater using infiltration/retention facilities. Even low impact development (LID) techniques such as rain gardens, dry wells, or permeable pavement would likely fill up during rain events, overtop, and cause minor local flooding.

4.8 Drainage

Surface

Final exterior grades should promote free and positive drainage away from the site at all times. Water must not be allowed to pond or collect adjacent to foundations or within the immediate building areas. We recommend providing a positive drainage gradient away from the building perimeter. If this gradient cannot be provided, surface water should be collected adjacent to the structures and directed to appropriate storm facilities

Subsurface

We recommend installing perimeter foundation drains adjacent to shallow foundations. The drains can be laid to grade at an invert elevation equivalent to the bottom of footing grade. The drains can consist of four-inch diameter perforated PVC pipe enveloped in washed pea gravel-sized drainage aggregate. The aggregate should extend six inches above and to the sides of the pipe. Roof and foundation drains should be tightlined separately to the storm drains. All drains should be provided with cleanouts at easily accessible locations.

4.9 Utilities

Utility pipes should be bedded and backfilled in accordance with American Public Works Association (APWA) or the local jurisdictional specifications. At a minimum, trench backfill should be placed and compacted as structural fill as described in Section 4.2 of this report. As noted, most native soils excavated on the site should be suitable for use as backfill material during dry weather conditions. However, if utility construction takes place during the wet winter months, it will likely be necessary to import suitable wet-weather fill for utility trench backfilling.

4.10 Pavements

Pavement subgrades should be prepared as described in Section 4.2 of this report. Regardless of the degree of relative compaction achieved, the subgrade must be firm and relatively unyielding before paving. The subgrade should be proofrolled with heavy rubber-tired construction equipment such as a loaded ten-yard dump truck to verify this condition.

The pavement design section is dependent upon the supporting capability of the subgrade soils and the traffic conditions to which it will be subjected. For residential access, with traffic consisting mainly of light passenger vehicles with only occasional heavy traffic, and with a stable subgrade prepared as recommended, we recommend the following pavement sections:

- Two inches of Hot Mix Asphalt (HMA) over four inches of Crushed Rock Base (CRB).

- Three and one-half inches of full depth HMA.

The paving materials used should conform to the Washington State Department of Transportation (WSDOT) specifications for half-inch class HMA and CRB.

Long-term pavement performance will depend on surface drainage. A poorly drained pavement section will be subject to premature failure as a result of surface water infiltrating into the subgrade soils and reducing their supporting capability. For optimum pavement performance, we recommend surface drainage gradients of at least two percent. Some degree of longitudinal and transverse cracking of the pavement surface should be expected over time. Regular maintenance should be planned to seal cracks when they occur.

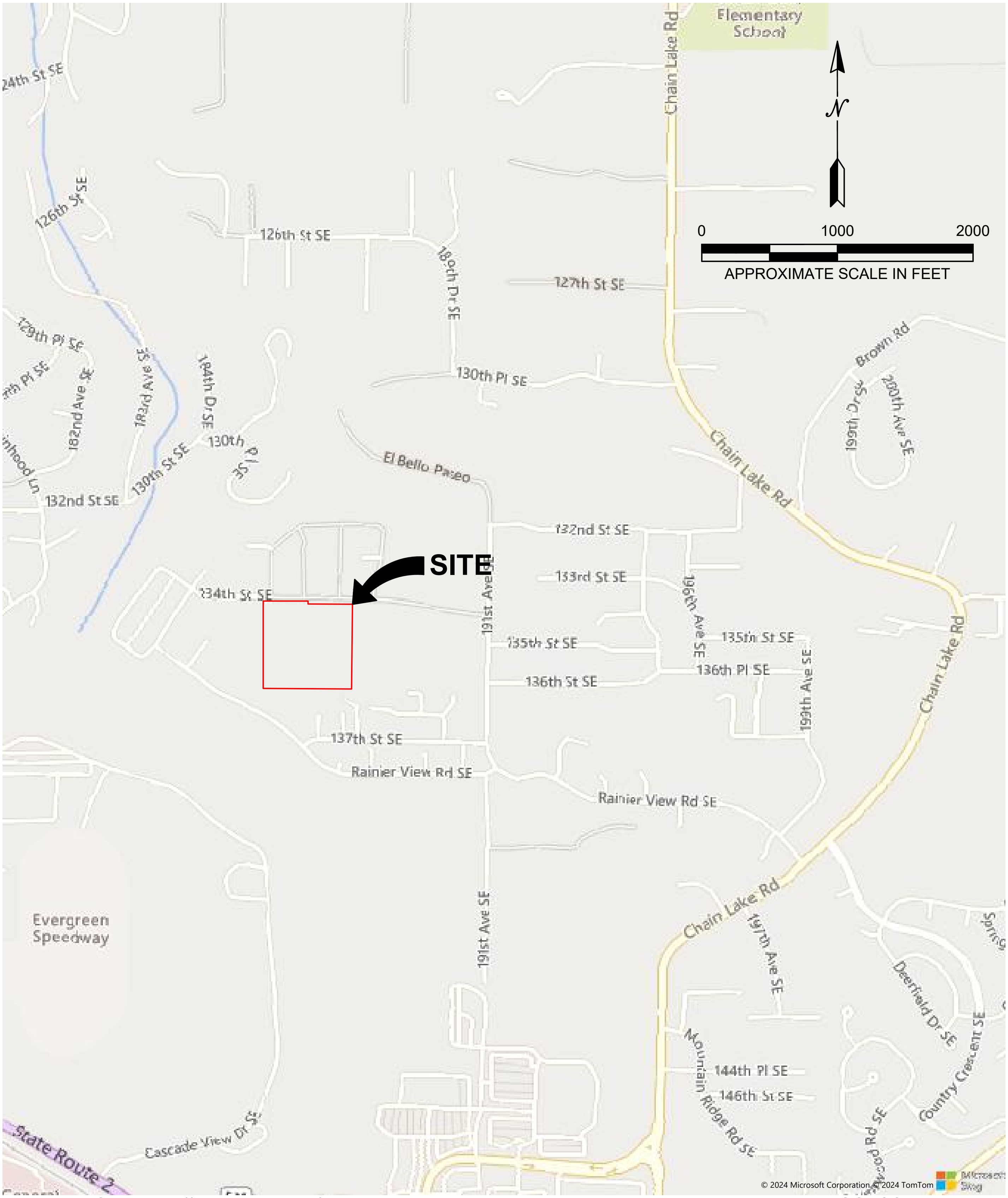
5.0 ADDITIONAL SERVICES

Terra Associates, Inc. should review the final design drawings and specifications in order to verify earthwork and foundation recommendations have been properly interpreted and implemented in project design. We should also provide geotechnical service during construction to observe compliance with our design concepts, specifications, and recommendations. This will allow for design changes if subsurface conditions differ from those anticipated prior to the start of construction.

6.0 LIMITATIONS

We prepared this report in accordance with generally accepted geotechnical engineering practices. No other warranty, expressed or implied, is made. This report is the copyrighted property of Terra Associates, Inc. and is intended for specific application to the Monroe West project in Monroe, Washington. This report is for the exclusive use of South Lake Ridge, LLC and their authorized representatives.

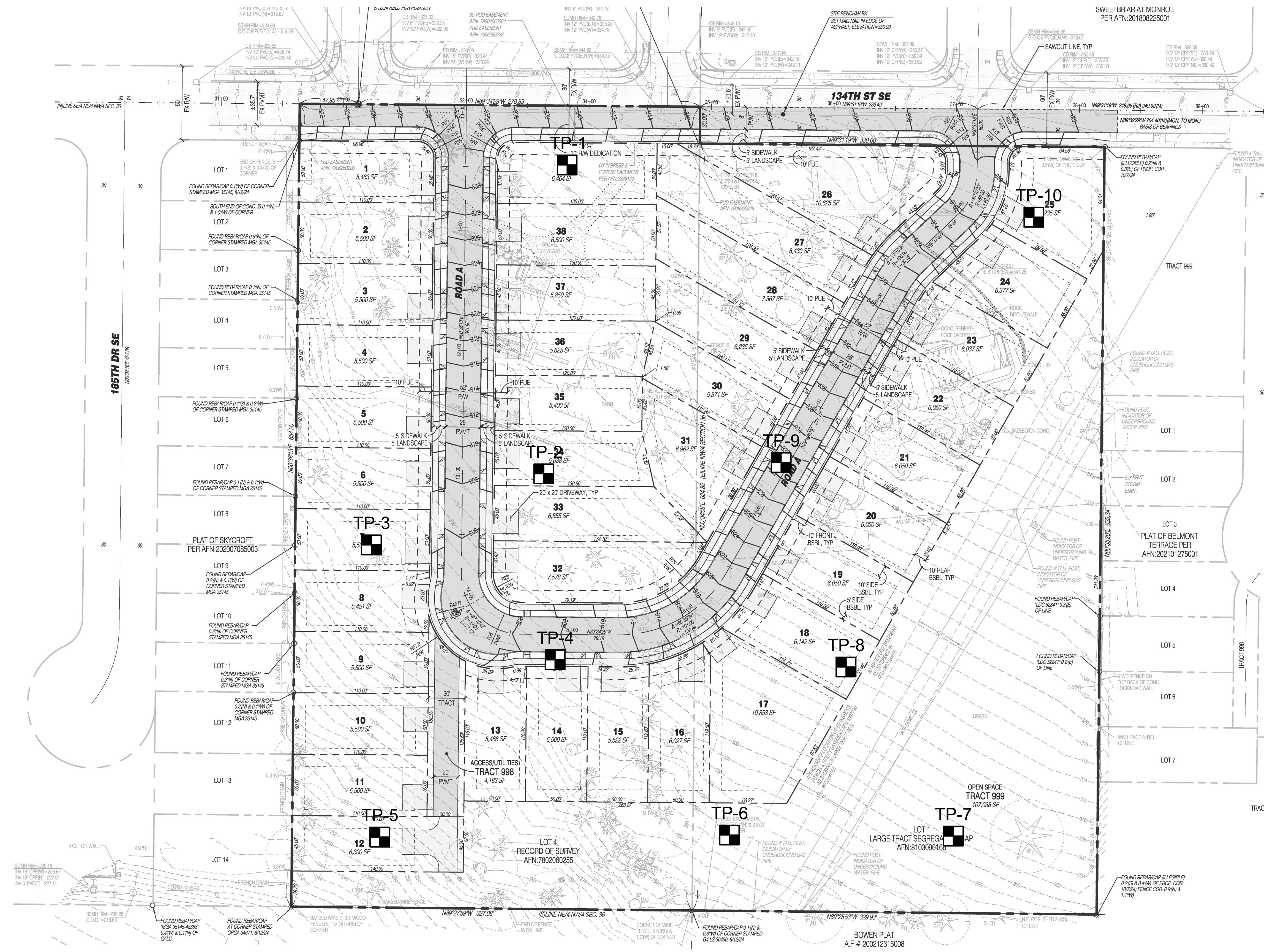
The analyses and recommendations presented in this report are based on data obtained from the subsurface explorations completed onsite. Variations in soil conditions can occur, the nature and extent of which may not become evident until construction. If variations appear evident, Terra Associates, Inc. should be requested to reevaluate the recommendations in this report prior to proceeding with construction.



REFERENCE: https://www.bing.com/maps ACCESSED 2024

Terra Associates, Inc. Consultants in Geotechnical Engineering Geology and Environmental Earth Sciences	VICINITY MAP MONROE WEST MONROE, WASHINGTON

Proj.No. T-9077	Date: JAN 2025	Figure 1



NOTE:

THIS SITE PLAN IS SCHEMATIC. ALL LOCATIONS AND DIMENSIONS ARE APPROXIMATE. IT IS INTENDED FOR REFERENCE ONLY AND SHOULD NOT BE USED FOR DESIGN OR CONSTRUCTION PURPOSES.

REFERENCE: SITE PLAN PROVIDED BY SOLID GROUND ENGINEERING.

LEGEND:

APPROXIMATE TEST PIT LOCATION

0 100 200

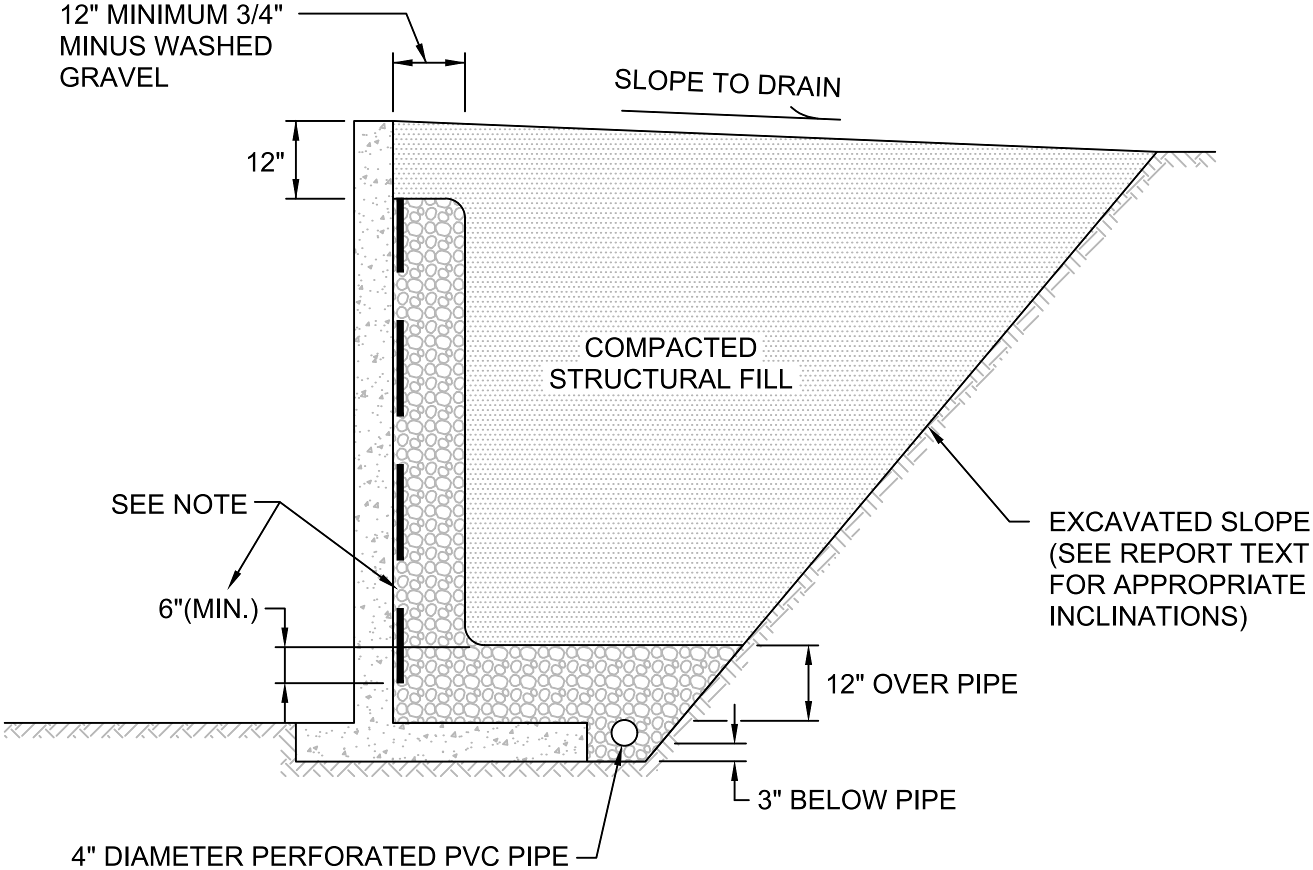
APPROXIMATE SCALE IN FEET

N

Terra Associates, Inc.
Consultants in Geotechnical Engineering
Geology and
Environmental Earth Sciences

EXPLORATION LOCATION PLAN
MONROE WEST
MONROE, WASHINGTON

Proj.No. T-9077	Date: JAN 2025	Figure 2



NOT TO SCALE

NOTE:

MIRADRAIN G100N PREFABRICATED DRAINAGE PANELS OR SIMILAR PRODUCT CAN BE SUBSTITUTED FOR THE 12-INCH WIDE GRAVEL DRAIN BEHIND WALL. DRAINAGE PANELS SHOULD EXTEND A MINIMUM OF SIX INCHES INTO 12-INCH THICK DRAINAGE GRAVEL LAYER OVER PERFORATED DRAIN PIPE.

Terra Associates, Inc. Consultants in Geotechnical Engineering Geology and Environmental Earth Sciences	TYPICAL WALL DRAINAGE DETAIL MONROE WEST MONROE, WASHINGTON		
	Proj.No. T-9077	Date: JAN 2025	Figure 3

APPENDIX A
FIELD EXPLORATION AND LABORATORY TESTING

Monroe West
Monroe, Washington

On August 16, 2024, we explored soil conditions at the site by excavating 10 test pits to maximum depths of approximately 8 feet below existing site grades using an excavator. The test pit locations were approximately determined in the field using GPS coordinates and by sighting and pacing from existing surface features. The approximate test pit locations are shown on Figure 2. The Test Pit Logs are presented as Figures A-2 through A-11.

A geotechnical engineer from our office conducted the field exploration. Our representative classified the soil conditions encountered, maintained a log of the test pit, obtained representative soil samples, and recorded water levels observed during excavation. All soil samples were visually classified in accordance with the Unified Soil Classification System (USCS) described on Figure A-1.

Representative soil samples obtained from the test pits were placed in sealed plastic bags and taken to our laboratory for further examination and testing. The moisture content of each sample was measured and is reported on the Test Pit Logs. Grain size analyses were performed on select soil samples. The results are shown on Figures A-12 and A-13.

MAJOR DIVISIONS				LETTER SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS	More than 50% material larger than No. 200 sieve size	**GRAVELS** More than 50% of coarse fraction is larger than No. 4 sieve	Clean Gravels (less than 5% fines)	GW	Well-graded gravels, gravel-sand mixtures, little or no fines.
				GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines.
			Gravels with fines	GM	Silty gravels, gravel-sand-silt mixtures, non-plastic fines.
				GC	Clayey gravels, gravel-sand-clay mixtures, plastic fines.
		SANDS More than 50% of coarse fraction is smaller than No. 4 sieve	Clean Sands (less than 5% fines)	SW	Well-graded sands, sands with gravel, little or no fines.
				SP	Poorly-graded sands, sands with gravel, little or no fines.
			Sands with fines	SM	Silty sands, sand-silt mixtures, non-plastic fines.
				SC	Clayey sands, sand-clay mixtures, plastic fines.
FINE GRAINED SOILS	More than 50% material smaller than No. 200 sieve size	**SILTS AND CLAYS** Liquid Limit is less than 50%		ML	Inorganic silts, rock flour, clayey silts with slight plasticity.
				CL	Inorganic clays of low to medium plasticity. (Lean clay)
				OL	Organic silts and organic clays of low plasticity.
		SILTS AND CLAYS Liquid Limit is greater than 50%		MH	Inorganic silts, elastic.
				CH	Inorganic clays of high plasticity. (Fat clay)
				OH	Organic clays of high plasticity.
HIGHLY ORGANIC SOILS				PT	Peat.

DEFINITION OF TERMS AND SYMBOLS

COHESIONLESS

<u>Density</u>	<u>Standard Penetration Resistance in Blows/Foot</u>
Very Loose	0-4
Loose	4-10
Medium Dense	10-30
Dense	30-50
Very Dense	>50

COHESIVE

<u>Consistancy</u>	<u>Standard Penetration Resistance in Blows/Foot</u>
Very Soft	0-2
Soft	2-4
Medium Stiff	4-8
Stiff	8-16
Very Stiff	16-32
Hard	>32

Symbol	Definition
I	2" OUTSIDE DIAMETER SPILT SPOON SAMPLER
II	2.4" INSIDE DIAMETER RING SAMPLER OR SHELBY TUBE SAMPLER
▼	WATER LEVEL (Date)
Tr	TORVANE READINGS, tsf
Pp	PENETROMETER READING, tsf
DD	DRY DENSITY, pounds per cubic foot
LL	LIQUID LIMIT, percent
PI	PLASTIC INDEX
N	STANDARD PENETRATION, blows per foot

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UNIFIED SOIL CLASSIFICATION SYSTEM
MONROE WEST
MONROE, WASHINGTON

Proj.No. T-9077	Date: JAN 2025	Figure A-1

LOG OF TEST PIT NO.TP-1

FIGURE A-2

PROJECT NAME: Monroe West **PROJ. NO:** T-9077 **LOGGED BY:** MJX

LOCATION: Monroe, Washington **SURFACE CONDITIONS:** Grass **APPROX. ELEV:** NA

DATE LOGGED: August 16, 2024 **DEPTH TO GROUNDWATER:** NA **DEPTH TO CAVING:** NA

Depth (ft)	Sample No.	Description	Consistency/ Relative Density	W (%)
0 – 3		(8-inches organic TOPSOIL) Brown SILT with sand and gravel, fine to coarse sand, fine to coarse gravel, dry, trace rootlets, occasional cobble occasional boulder. (ML) (Weathered Till)	Medium Dense	17.0 (at 1.5 ft) 8.2 (at 3 ft)
3 – 4		Gray silty SAND with gravel, fine to coarse sand, fine to coarse gravel, dry to moist, slightly mottled, trace cobbles, moderate to strong cementation. (SM) (Unweathered Till)	Dense	
4 – 8			Very Dense	7.0 (at 5 ft) 8.0 (at 8 ft)
8 – 10		Test Pit terminated at approximately 8 feet. No groundwater seepage observed. No caving observed.		

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO.TP-2

FIGURE A-3

PROJECT NAME: Monroe West **PROJ. NO:** T-9077 **LOGGED BY:** MJX

LOCATION: Monroe, Washington **SURFACE CONDITIONS:** Blackberries **APPROX. ELEV:** NA

DATE LOGGED: August 16, 2024 **DEPTH TO GROUNDWATER:** NA **DEPTH TO CAVING:** NA

Depth (ft)	Sample No.	Description	Consistency/ Relative Density	W (%)
0–3		(10-inches organic TOPSOIL) Brown sandy SILT with gravel, fine to coarse sand, fine to coarse gravel, dry, scattered rootlets, occasional cobble. (ML) (Weathered Till)	Medium Dense	13.9
3				8.3
3–8		Gray silty SAND with gravel, fine to coarse sand, fine to coarse gravel, dry to moist, trace cobbles, moderate to strong cementation. (SM) (Unweathered Till)	Very Dense	
8				7.3
8–10		Test Pit terminated at approximately 8 feet. No groundwater seepage observed. No caving observed.		

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO.TP-3

FIGURE A-4

PROJECT NAME: Monroe West **PROJ. NO:** T-9077 **LOGGED BY:** MJX

LOCATION: Monroe, Washington **SURFACE CONDITIONS:** Tall Grass **APPROX. ELEV:** NA

DATE LOGGED: August 16, 2024 **DEPTH TO GROUNDWATER:** NA **DEPTH TO CAVING:** NA

Depth (ft)	Sample No.	Description	Consistency/ Relative Density	W (%)
0		(10-inches organic TOPSOIL) Brown sandy SILT with gravel, fine to coarse sand, fine to coarse gravel, dry, trace cobbles, occasional rootlet. (ML) (Weathered Till)		
1				15.0
2			Medium Dense	
3		Gray silty SAND with gravel, fine to coarse sand, fine to coarse gravel, moist, slightly mottled, trace cobbles, moderate to strong cementation. (SM) (Unweathered Till)		12.4
4			Dense	
5				9.6
6				
7			Very Dense	
8		Test Pit terminated at approximately 8 feet. No groundwater seepage observed. No caving observed.		7.9
9				
10				

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO.TP-4

FIGURE A-5

PROJECT NAME: Monroe West **PROJ. NO:** T-9077 **LOGGED BY:** MJX

LOCATION: Monroe, Washington **SURFACE CONDITIONS:** Tall Grass **APPROX. ELEV:** NA

DATE LOGGED: August 16, 2024 **DEPTH TO GROUNDWATER:** NA **DEPTH TO CAVING:** NA

Depth (ft)	Sample No.	Description	Consistency/ Relative Density	W (%)
0		(8-inches organic TOPSOIL)		
1		Brown sandy SILT, fine to medium sand, dry, trace rootlets, trace gravel, trace cobbles. (SM) (Weathered Till)	Medium Dense	16.9
2		Gray silty SAND with gravel, fine to coarse sand, fine to coarse gravel, dry to moist, scattered cobbles, moderate to strong cementation. (SM) (Unweathered Till)		6.9
3			Dense	
4				9.2
5				
6			Very Dense	
7				
8		Test Pit terminated at approximately 8 feet. No groundwater seepage observed. No caving observed.		9.3
9				
10				

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO.TP-5

FIGURE A-6

PROJECT NAME: Monroe West **PROJ. NO:** T-9077 **LOGGED BY:** MJX

LOCATION: Monroe, Washington **SURFACE CONDITIONS:** Tall Grass **APPROX. ELEV:** NA

DATE LOGGED: August 16, 2024 **DEPTH TO GROUNDWATER:** NA **DEPTH TO CAVING:** NA

Depth (ft)	Sample No.	Description	Consistency/ Relative Density	W (%)
0–4		(4-inches organic TOPSOIL) Brown silty GRAVEL with sand, fine to coarse sand, fine to coarse gravel, dry, trace rootlets, trace cobbles, occasional boulder. (GM) (Weathered Till)	Medium Dense	14.9 (at ~1.5 ft)
4–8		Gray silty SAND with gravel, fine to coarse sand, fine to coarse gravel, moist, trace cobbles, strong cementation. (SM) (Unweathered Till)	Very Dense	10.5 (at 4 ft) 9.7 (at 8 ft)
8–10		Test Pit terminated at approximately 8 feet. No groundwater seepage observed. No caving observed.		

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO.TP-6

FIGURE A-7

PROJECT NAME: Monroe West **PROJ. NO:** T-9077 **LOGGED BY:** MJX

LOCATION: Monroe, Washington **SURFACE CONDITIONS:** Grass **APPROX. ELEV:** NA

DATE LOGGED: August 16, 2024 **DEPTH TO GROUNDWATER:** NA **DEPTH TO CAVING:** NA

Depth (ft)	Sample No.	Description	Consistency/ Relative Density	W (%)
0		(6-inches organic TOPSOIL) Brown sandy SILT with gravel, fine to coarse sand, fine to coarse gravel, dry, trace rootlets, trace cobbles, occasional boulder. (ML) (Weathered Till)	Medium Dense	14.0
4		Gray silty SAND with gravel, fine to coarse sand, fine to coarse gravel, moist, trace cobbles, strong cementation. (SM) (Unweathered Till)	Very Dense	15.1
8		Test Pit terminated at approximately 8 feet. No groundwater seepage observed. No caving observed.		7.8
10				

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO.TP-7

FIGURE A-8

PROJECT NAME: Monroe West **PROJ. NO:** T-9077 **LOGGED BY:** MJX

LOCATION: Monroe, Washington **SURFACE CONDITIONS:** Grass **APPROX. ELEV:** NA

DATE LOGGED: August 16, 2024 **DEPTH TO GROUNDWATER:** NA **DEPTH TO CAVING:** NA

Depth (ft)	Sample No.	Description	Consistency/ Relative Density	W (%)
0		(6-inches organic TOPSOIL) Brown sandy SILT with gravel, fine to coarse sand, fine to coarse gravel, dry, trace rootlets, trace cobbles. (ML) (Weathered Till)	Medium Dense	12.3
3		Gray silty SAND with gravel, fine to coarse sand, fine to coarse gravel, dry to moist, slightly mottled, trace cobbles, strong cementation. (SM) (Unweathered Till)	Very Dense	4.7
8		Test Pit terminated at approximately 8 feet. No groundwater seepage observed. No caving observed.		10.3
10				

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO.TP-8

FIGURE A-9

PROJECT NAME: Monroe West **PROJ. NO:** T-9077 **LOGGED BY:** MJX

LOCATION: Monroe, Washington **SURFACE CONDITIONS:** Grass **APPROX. ELEV:** NA

DATE LOGGED: August 16, 2024 **DEPTH TO GROUNDWATER:** NA **DEPTH TO CAVING:** NA

Depth (ft)	Sample No.	Description	Consistency/ Relative Density	W (%)
0				
		(7-inches organic TOPSOIL)		
1		Brownish-gray silty SAND with gravel, fine to coarse sand, fine to coarse gravel, dry, trace cobbles, occasional rootlet. (SM) (Weathered Till)	Medium Dense	10.8
2		Gray silty SAND with gravel, fine to coarse sand, fine to coarse gravel, dry to moist, slightly mottled, trace cobbles, moderate to strong cementation. (SM) (Unweathered Till)		7.7
3				
4				
5			Very Dense	
6				
7				
8		Test Pit terminated at approximately 8 feet. No groundwater seepage observed. No caving observed.		7.1
9				
10				

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO.TP-9

FIGURE A-10

PROJECT NAME: Monroe West **PROJ. NO:** T-9077 **LOGGED BY:** MJX

LOCATION: Monroe, Washington **SURFACE CONDITIONS:** Grass **APPROX. ELEV:** NA

DATE LOGGED: August 16, 2024 **DEPTH TO GROUNDWATER:** NA **DEPTH TO CAVING:** NA

Depth (ft)	Sample No.	Description	Consistency/ Relative Density	W (%)
0–2.5		(5-inches organic TOPSOIL) FILL: Brown silty SAND with gravel, fine to coarse sand, fine to coarse gravel, dry, trace rootlets, occasional small-sized organic fragment. (SM)	Medium Dense	5.2
2.5–3.5		Brown sandy SILT, fine to medium sand, moist, trace gravel, trace cobbles, occasional rootlet. (ML) (Weathered Till)	Medium Dense	17.6
3.5–8		Gray silty SAND with gravel, fine to coarse sand, fine to coarse gravel, moist, slightly mottled, trace cobbles, occasional boulder, moderate to strong cementation. (SM) (Unweathered Till)	Very Dense	8.6 8.6
8–10		Test Pit terminated at approximately 8 feet. No groundwater seepage observed. No caving observed.		

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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LOG OF TEST PIT NO.TP-10

FIGURE A-11

PROJECT NAME: Monroe West **PROJ. NO:** T-9077 **LOGGED BY:** MJX

LOCATION: Monroe, Washington **SURFACE CONDITIONS:** Grass **APPROX. ELEV:** NA

DATE LOGGED: August 16, 2024 **DEPTH TO GROUNDWATER:** NA **DEPTH TO CAVING:** NA

Depth (ft)	Sample No.	Description	Consistency/ Relative Density	W (%)
0–8		(6-inches organic TOPSOIL) Gray silty SAND with gravel, fine to coarse sand, fine to coarse gravel, dry to moist, slightly mottled, trace cobbles, occasional rootlet, moderate to strong cementation. (SM) (Unweathered Till)	Dense (0–3 ft) Very Dense (3–8 ft)	4.1 (1 ft) 6.7 (3 ft) 9.0 (8 ft)
8–10		Test Pit terminated at approximately 8 feet. No groundwater seepage observed. No caving observed.		

NOTE: This subsurface information pertains only to this test pit location and should not be interpreted as being indicative of other locations at the site.

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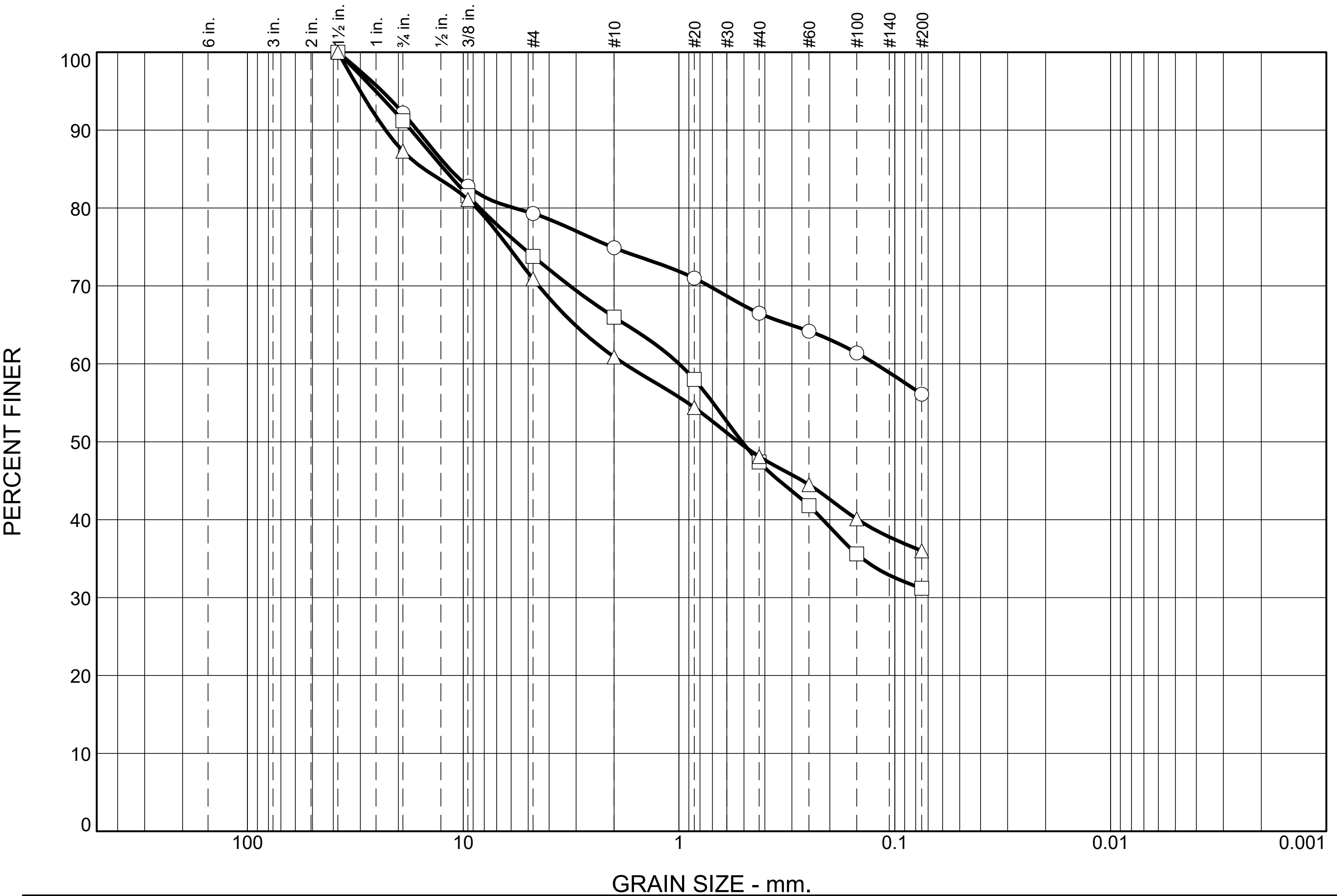
Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	7.8	12.9	4.4	8.4	10.4	56.1	
□	0.0	8.8	17.4	7.8	18.6	16.2	31.2	
△	0.0	12.7	16.4	10.0	12.8	12.1	36.0	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			11.5449	0.1229						
□			12.2513	0.9984	0.5102					
△			15.1692	1.7902	0.5312					

Material Description	USCS	AASHTO
○ SILT with sand and gravel	ML	
□ silty SAND with gravel	SM	
△ sandy SILT with gravel	ML	

Project No. T-9077 **Client:** South Lake Ridge LLC c/o Land Pro Group

Project: Monroe West

○ **Location:** Test Pit TP-1 **Depth:** -1.5 ft **Sample Number:** 1

□ **Location:** Test Pit TP-2 **Depth:** -8 ft **Sample Number:** 3

△ **Location:** Test Pit TP-3 **Depth:** -1.5 ft **Sample Number:** 1

Remarks:

○ Tested on August 21, 2024

□ Tested on August 21, 2024

△ Tested on August 21, 2024

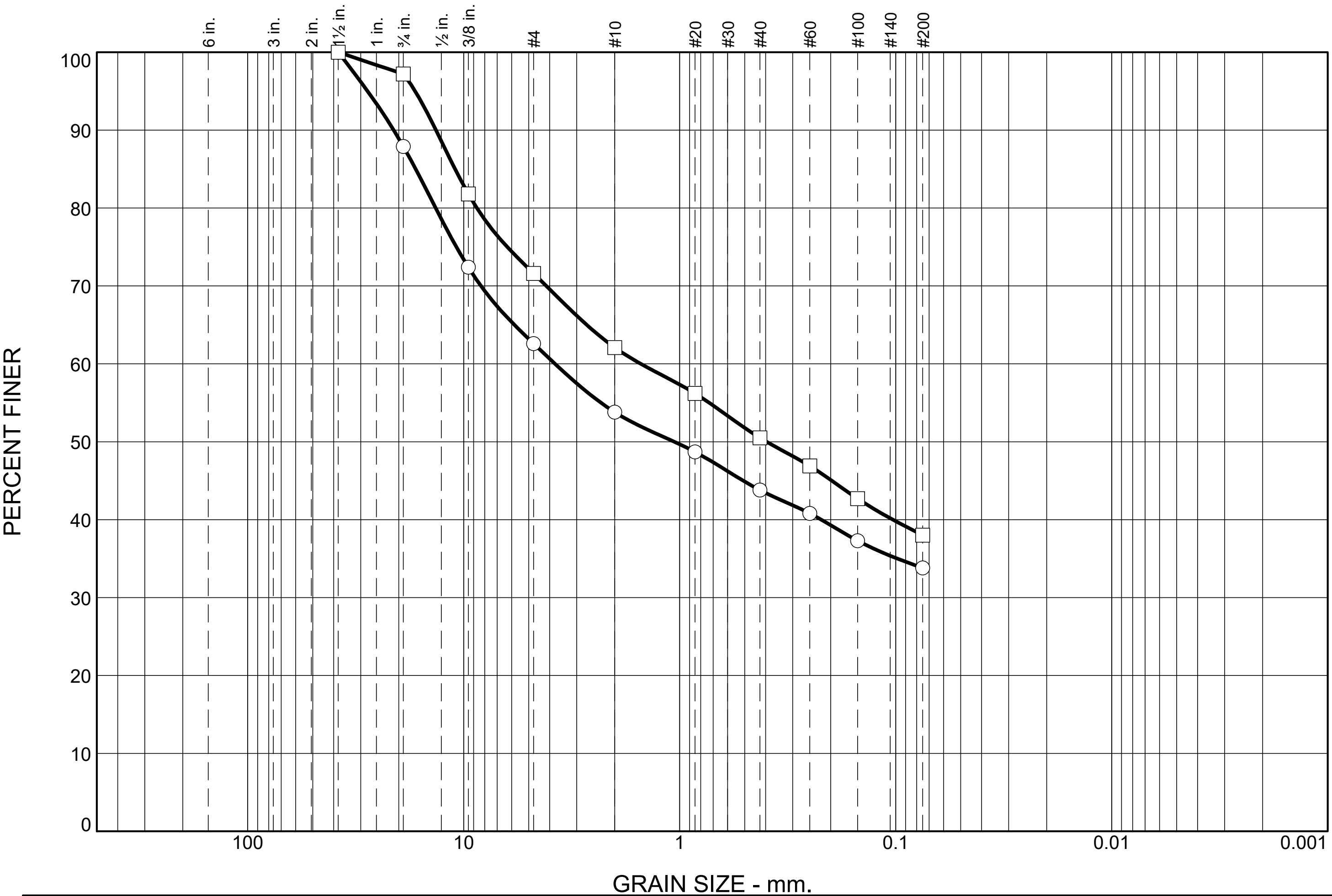
Terra Associates, Inc.

Kirkland, WA

Figure A-12

Tested By: KJ

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	12.1	25.3	8.8	10.0	10.0	33.8	
□	0.0	2.8	25.6	9.5	11.6	12.5	38.0	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			16.7042	3.7808	1.0593					
□			10.9689	1.5133	0.3963					

Material Description	USCS	AASHTO
○ silty GRAVEL with sand	GM	
□ sandy SILT with gravel	ML	

Project No. T-9077 **Client:** South Lake Ridge LLC c/o Land Pro Group

Project: Monroe West

○ **Location:** Test Pit TP-5 **Depth:** -1.5 ft **Sample Number:** 1

□ **Location:** Test Pit TP-7 **Depth:** -1.5 ft **Sample Number:** 1

Terra Associates, Inc.

Kirkland, WA

Remarks:

○ Tested on August 21, 2024

□ Tested on August 21, 2024

Figure A-13

Tested By: KJ