Geotechnical Engineering Report

Salem 23rd & Center Apartments Development
Salem, Oregon

for
Greenlight Development

March 2, 2023

GeoEngineers
Earth Science + Technology

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1200 NW Naito Parkway, Suite 180
Portland, Oregon 97209
503.624.9274

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File No. 25088-005-00

March 2, 2023

Prepared for:

Greenlight Development
3050 SE Division Street, No. 270
Portland, Oregon 97202

Attention: Tim Lawler

Prepared by:

GeoEngineers, Inc.
333 High Street NE, Suite 102
Salem, Oregon 97301
971.304.3078

Blayne C. Sandau, EIT
Geotechnical Engineer

Julio C. Vela, PhD, PE, GE
Principal

REGISTERED PROFESSIONAL ENGINEER
60333
03/02/23
OREGON
FEBRUARY 08, 2000
JULIO C VELA

EXPIRES: 06/30/24

BCS:JCV:leh

GeoEngineers

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1.0 INTRODUCTION

This geotechnical report summarizes our geotechnical engineering services provided for the proposed Salem 23rd & Center Apartments Development in Salem, Oregon. The proposed project is listed as two local addresses (2561 Center Street NE and 755 Medical Center Drive NE) in Salem, Oregon split by a public roadway (Medical Center Drive NE). The site location is shown in the Vicinity Map, Figure 1.

Two different preliminary site development drawings for the project were provided to us by Greenlight Development (Greenlight) dated December 30, 2022 (initial concept) and February 14, 2023. Preliminary plan drawings indicate that the project will consist of 21 (initial concept SD01) and 17 (alternate concept SD00) apartment buildings and one community building, and associated asphalt paved parking areas and access roadways from 23rd Street NE.

We completed on-site subsurface explorations including test pits and drilled borings in order to evaluate soil and groundwater conditions at the site as a basis for developing geotechnical engineering recommendations presented in this report. A site plan showing the explorations completed for the project is presented in the Site Plan, Figure 2.

Our recommendations for earthwork assume that maximum cuts and fills for site grading in structural areas will be less than 3 feet each and our recommendations for structural development on the site are based on assumed column and wall loads of up to 60 kips and 3 kips per lineal foot (klf), respectively. Floor loads will be 100 pounds per square foot (psf) or less.

2.0 SCOPE OF SERVICES

Our specific scope of services is detailed in our January 24, 2023, proposal to you. Our services were authorized on January 31, 2023. In general, our scope of services included: reviewing selected geotechnical information about the site; performing a geologic reconnaissance; exploring subsurface soil and groundwater conditions; collecting representative soil samples; completing relevant laboratory testing and geotechnical analyses; and providing this geotechnical report with our conclusions, findings, and design recommendations.

3.0 SITE CONDITIONS

3.1. Site Geology

The geology of the site is mapped by the State of Oregon Department of Geology and Mineral Industries *Geologic Map of the Rickreall and Salem West Quadrangles, Oregon* as being underlain by quaternary, middle terrace deposits, which they define as semiconsolidated gravel, sand, silt, and clay forming very flat terraces of major extent along the Willamette River that generally consists of 10 to 30 feet of silty clay, and surficial interbedded very fine sand and silt material believed to be primarily related to Willamette Silts or the equivalent of the "fine-grained facies" of the catastrophic flood deposits of Madin (1990), including fragments and boulders up to 4 feet in diameter.

3.2. Surface Conditions

The overall site is approximately 9.85 acres of a mix of largely undeveloped grassy areas and partially, or formerly, developed areas including filled areas where former building stood on site, as well as the north to northeast aligned asphalt concrete paved Medical Center Drive NE, which runs through the middle of the property, and paved parking areas and drive aisles associated with the medical facilities that bound the property to the North. Existing site vegetation generally consists of sparse landscaped shrubbery associated with former development, open grasses, weed covered margins, and deciduous and coniferous trees scattered throughout.

The site is bounded to the south by Franzen Street NE and Center Street NE, to the west by Medical Center Drive NE in the southern portion and Lee Mission Cemetery in the Northern portion, by 23rd Street NE to the east, and by existing commercial medical facilities to the north. Site topography is variable, generally sloping down to the south and to the southwest with generally level areas between downward grades.

3.3. Subsurface Conditions

We explored subsurface conditions at the site by advancing three drilled borings (B-1 through B-3), excavating 14 test pits (TP-1 through TP-14), two direct cone penetration (DCP) tests, and conducting two infiltration tests at a depth of approximately 4 feet below the ground surface (bgs) on February 7 and February 8, 2023. Drilled borings and test pits were advanced to approximate depths of between 20½ to 41½ feet and 3 to 15 feet bgs, respectively. Approximate locations of the explorations completed at the site are presented in Figure 2. Logs of GeoEngineers explorations completed for this study are presented in Appendix A.

Soil samples obtained at select depth intervals and were transported to GeoEngineers laboratory for further evaluation. Selected samples were tested for determination of moisture content and percent fines. A description of the laboratory testing and the test results are presented in Appendix A.

3.3.1. Soil Conditions

In general, subsurface conditions at the site are consistent with the mapped site geology, except where fill was encountered, and generally consist of soft to very stiff silt with varying sand and organic content observed to extend up to 35 feet bgs, underlain by dense gravel with sand or very dense sand underlain by dense gravel. Fill from demolition of previously existing structures and grading activities at the site is generally comprised of recycled concrete (crushed and processed to generally 1-inch minus sized material) with brick and occasional plastic, glass, wire, and rebar debris observed to extend to variable depths of 1½ to 6½ feet bgs in our explorations. Fill depth extends to depths of 10 to 12 feet in the footprints of buildings previously on site.

3.3.2. Groundwater

Areal groundwater was observed at approximately 14¼ feet bgs to 14½ feet bgs in B-1 and B-3. Potentially perched groundwater was observed at 7½ feet in B-2 but was not observed in our other explorations. Soil conditions observed in our explorations suggest that seasonal groundwater or perched groundwater may be encountered at or just below 7½ feet bgs. we expect that groundwater will be present at shallow depths in a perched condition during wet times of the year or during extended periods of wet weather. Some exfiltrating groundwater conditions (upward flowing from perched conditions upslope) may be encountered in downslope areas, especially after prolonged periods of wet weather. Groundwater conditions at the site are expected to vary seasonally due to rainfall events and other factors not observed in our explorations.

3.3.1. Potentially Liquefiable Soils

Soils encountered in on-site borings at depths of approximately 15 to 25 feet bgs consisted of loose fine-grained sand with varying amounts of silt. Based on in-place consistency and laboratory testing as described below in this report, the loose saturated sands are susceptible to liquefaction during a design seismic event. Liquefaction-induced settlement is estimated to be on the order of 1 to 3 inches. As discussed below, this does not preclude development of the site provided the magnitude of potential settlement is accounted for in structural design.

3.3.2. Buried Fill and Structural Features From Structures Previously On Site

Based on historical site information provided by Greenlight and on historical images from online sources, we understand that at least three buildings, one with a parking deck attached, and associated paved parking and drives previously occupied the southern portion of the site. Based on the records provided, basements between two of the buildings were connected by an underground tunnel (common in the Salem area for public hospital buildings such as those that previously occupied the site to the east). Those buildings were demolished and we understand that below grade voids resulting from demolition were backfilled by placing and compacting recycled/processed concrete and asphalt from the structural demolition.

We observed in test pits in areas formerly occupied by those structures that the processed material was generally 1-inch or smaller and generally well-graded for the material type. The material was very dense in place and consistent with depth indicating uniform placement and significant compactive effort. In test pit TP-6 a concrete slab was encountered at a depth of 3 feet bgs. We moved over 10 feet two different times from the original location and encountered the same slab at the same depth indicating that at least at that location full demolition had not been accomplished. This may present itself in other areas of the site as well.

We understand that a geophysical study is being prepared for the project by others that may indicate the extent of such buried features. If buried structural debris is encountered in proposed structural areas, it should be completely excavated and removed from structural footprints.

4.0 INFILTRATION TESTING

As requested by the project team, we conducted two on-site infiltration tests to assist in the evaluation of the site for stormwater infiltration design at the exploration location as shown in Figure 2 at a depth of 4 feet bgs.

On site testing was conducted in general accordance with the professional encased falling head procedure outlined in Division 004 of the City of Salem Design Standards (COSDS). Our general procedure included drilling an 8-inch diameter hole to insert a 6-inch diameter polyvinyl chloride (PVC) pipe for the encased falling head procedure at a depth of 4 feet bgs.

The encased PVC pipe was filled with clean water to approximately 1 foot above the soil at the bottom of the drilled hole. The initial fill of water did not drain into the soil within 10 minutes, so the water level was maintained, and the soil allowed to saturate for 4 to 6 hours at the test location. The levels were checked, and the test pits were refilled to 12 inches above the soil in the bottom of the test pits at the end of each hour. The drop-in water level was measured during three, hour-long iterations at both locations. Field test results are summarized in Table 1.

TABLE 1. FIELD MEASURED INFILTRATION RESULTS

Infiltration Test No.	Location	Depth (feet)	USCS Material Type	Field Measured Infiltration Rate[1] (in/hr)
B-1/IT-1	See Site Plan	4	ML	0 – 0.1
B-3/IT-2	See Site Plan	4	ML	2.0

Notes:

[1] Appropriate factors should be applied to the field-measured infiltration rate, based on the design methodology and specific system used.

USCS = Unified Soil Classification System

in/hr = inches per hour.

The infiltration rates shown in Table 1 represents a field-measured infiltration rate. The rate summarized for IT-1 indicates 0 inches per hour (in/hr) because minimal to no infiltration (drop in water levels) was observed during the testing period. Field measurements are limited to the accuracy of equipment employed to conduct the test. Actual long-term infiltration rates of the on-site soils are likely greater than 0 in/hr if measured out over very long-time frames (much longer than the time frames prescribed in the testing standards). A field-measured rate of 0 in/hr generally indicates infiltration less than ⅛ inch per hour, which is about the limit of the field measuring equipment.

In addition, field-measured rates represent a relatively short-term infiltration rate, and factors of safety have not been applied for the type of infiltration system being considered, or for variability that may be present across large areas in the on-site soil. In our opinion, and consistent with the state of the practice, correction factors should be applied to this measured rate to reflect the localized area of testing relative to the field sizes.

Appropriate correction factors should also be applied by the project civil engineer to account for long-term infiltration parameters. From a geotechnical perspective, we recommend a factor of safety (correction factor) of at least 2 be applied to the field infiltration values to account for potential soil variability with depth and location within the area tested. In addition, the stormwater system design engineer should determine and apply appropriate remaining correction factor values, or factors of safety, to account for repeated wetting and drying that occur in this area, degree of in-system filtration, frequency and type of system maintenance, vegetation, potential for siltation and bio-fouling, etc., as well as system design correction factors for overflow or redundancy, and base and facility size.

The actual depths, lateral extent and estimated infiltration rates can vary from the values presented above. Field testing/confirmation during construction is often required in large or long systems or other situations where soil conditions may vary within the area where the system is constructed. The results of this field testing might necessitate that the infiltration locations be modified to achieve the design infiltration rate.

The infiltration flow rate of a focused stormwater system like a drywell or small infiltration box or pond typically diminishes over time as suspended solids and precipitates in the stormwater further clog the void spaces between the soil particles or cake on the infiltration surface or in the engineered media. The serviceable life of an infiltration media in a stormwater system can be extended by pre-filtering or with on-going accessible maintenance. Eventually, most systems will fail and will need to be replaced or have media regenerated or replaced.

We recommend that infiltration systems include an overflow that is connected to a suitable discharge point. Also, infiltration systems can cause localized, high groundwater levels and should not be located near basement walls, retaining walls or other embedded structures unless these are specifically designed to account for the resulting hydrostatic pressure. Infiltration locations should not be located on sloping ground, unless it is approved by a geotechnical engineer, and should not be infiltrated at a location that allows for flow to travel laterally toward a slope face, such as a mounded water condition or too close to a slope face that could cause instability of the slope.

4.1. Suitability of Infiltration System

Successful design and implementation of stormwater infiltration systems and whether a system is suitable for a development depends on several site-specific factors. Stormwater infiltration systems are generally best suited for sites having sandy or gravelly soil with saturated hydraulic conductivities greater than 2 in/hr. Sites with silty or clayey soil, are generally not well- suited for long-term stormwater infiltration or as a sole method of stormwater infiltration. Soils that have fine-grained matrices are susceptible to volumetric change and softening during wetting and drying cycles. Fine-grained soils also have large variations in the magnitude of infiltration rates because of bedding and stratification that occurs during alluvial deposition, and often have thin layers of less permeable or impermeable soil within a larger layer.

As a result of fine-grained soil conditions and relatively low field measured infiltration rates, we recommend infiltration of stormwater not be used in the upper soils observed in B-1 as the sole method of stormwater management at this site unless those design factors can be otherwise accounted for by increasing infiltration area or coupling with other methods of stormwater disposal. At a minimum, an overflow method should be provided for the overall system.

5.0 CONCLUSIONS

Based on our explorations, testing and analyses, it is our opinion that the site is suitable for the proposed project from a geotechnical standpoint, provided the recommendations in this report are incorporated into project design, and implemented during construction. We offer the following conclusions regarding geotechnical engineering design and construction at the site.

- Existing site structures and structural features designated for removal should be demolished and completely removed from the site. Processed fill that was compacted as part of prior demolition on site is suitable to remain in place and provide structural support. If large pieces of structural debris are encountered, they should be removed from all structural areas.
- Existing utilities below proposed structural areas, including proposed buildings and roads, should be relocated or abandoned and grouted full if left in place.

- Surface conditions at the site consist primarily of vegetated areas covered with grasses and weeds. Therefore, clearing, stripping, grubbing, and light logging will be required. We anticipate a stripping depth of approximately 6 inches bgs to remove the topsoil layer. Grubbing and deeper excavations up to several feet will be required to remove the root zones of areas of thick shrubs or trees.

  Cleared, stripped and grubbed materials should be hauled off-site and properly disposed unless otherwise allowed by the project specifications for other uses such as landscaping, stockpiling or on-site burning.

- The native soils at the site below the topsoil zone are suitable to use as structural fill if they are properly moisture conditioned and compacted. Because the site soils have a moisture content that is currently wet of optimum, they will become significantly disturbed from construction traffic, particularly during wet weather. Wet weather construction practices will be required over exposed native soils and to protect exposed subgrades, except during the dry summer months.
- Groundwater was encountered during our explorations and based on our experience and our observations, perched groundwater and shallow groundwater conditions may be present during periods of persistent rainfall.
- Proposed structures can be satisfactorily supported on continuous and isolated shallow foundations supported on the firm native soils encountered beneath the fill or on structural fill that extends to the firm native soils. If soft soils are encountered in proposed foundation areas, continuous or shallow foundations should be founded on a minimum 2-foot thick granular bearing pad (Crushed rock compacted as structural fill) that extend laterally 1 foot from the edge of footings.
- Slabs on grade for proposed structures can be satisfactorily supported on Aggregate Base that is founded on the firm native soils encountered below site fill. We recommend that slabs-on-grade be provided with proper moisture control by constructing the aggregate base as a capillary and thermal break and providing a vapor barrier for moisture-sensitive applications.
- Based on the assumed design loads described in the "Introduction" section of this report and a maximum fill depth of 3 feet to raise site grades in structural areas, we estimate total static settlements will be less than 1 inch for foundations constructed as recommended. If larger structural loads are anticipated, we should review and reassess the estimated settlement.
- The site is generally subject to liquefaction and could experience up to 1 to 3 inches of liquefaction-induced settlement during a design seismic event depending on the elevation of the groundwater table at the time of the design event. Site structures should be designed to tolerate settlements of this magnitude as discussed with the project team.
- Standard pavement sections as summarized in this report, consisting of asphalt concrete (AC) over Aggregate Base and/or Aggregate Subbase, over properly prepared subgrade, can be used to support the estimated traffic loads provided the pavement sections are designed and constructed as recommended in this report.

6.0 EARTHWORK RECOMMENDATIONS

6.1. Site Preparation

In general, initial site preparation and primary earthwork operations will include stripping and grubbing of upper organics, mass grading to create level working surfaces and raise site grades in building areas, excavating and filling for pavements, foundations, and utilities, recompacting (dry weather) or replacing (wet weather) near surface disturbed soils, demolition of existing structural features if encountered, fine grading to establish final grades, and relocating live utilities.

All existing utilities in the proposed earthwork construction areas should be identified prior to excavation. Live utility lines beneath proposed structures should be completely removed or filled with grout to reduce potential settlement of new structures. Soft or loose soil encountered in utility line excavations should be removed and replaced with structural fill where it is located within structural areas.

Debris materials generated during demolition of existing improvements or relocation of utilities should be transported off site for disposal. Existing voids and new depressions created during site preparation, and resulting from removal of existing utilities, or other subsurface elements, should be cleaned of loose soil or debris down to firm soil and backfilled with compacted structural fill. Disturbance to a greater depth should be expected if site preparation and earthwork are conducted during period of wet weather.

6.1.1. Demolition

All structures and belowground structures to be demolished should be completely removed from proposed structural areas and for a margin of at least 3 feet around proposed structural areas. Proposed structural areas are areas where new structures will be built, including building pads and roadways. Existing utilities that will be abandoned on site should be identified prior to construction. Abandoned utility lines should be completely removed or filled with grout if abandoned and left in place to reduce potential settlement or caving in the future. Materials generated during demolition should be transported off site and properly disposed.

6.1.2. Clearing and Grubbing

Site clearing will be required to remove site vegetation, including grass and weeds that are designated for removal. Following clearing and grubbing, excavations up to several feet may be required to remove the root zones of shrubs and trees if encountered. Deeper excavations, up to 6 or 8 feet may be required to remove the root zones of large trees. Roots larger than ½ inch in diameter should be removed. Excavations to remove root zones should be done with a smooth bucket to minimize subgrade disturbance. Portions of the site are heavily vegetated and previously buried roots are also expected, even in the current grassy areas of the site. Grubbed materials should be hauled off site and properly disposed unless otherwise allowed by the project specifications for other uses such as landscaping, stockpiling or on-site burning.

Existing voids and new depressions created during demolition, clearing, grubbing or other site preparation activities, should be excavated to firm soil and backfilled with Imported Select Structural Fill. Greater depths of disturbance should be expected if site preparation and earthwork are conducted during periods of wet weather.

6.1.3. Stripping

Based on our observations at the site, we estimate that the depth of stripping should be on the order of about 6 to 12 inches. Greater stripping depths may be required to remove localized zones of loose or organic soil, and in areas where moderate to heavy vegetation are present, or where surface disturbance from prior use has occurred. The actual stripping depth should be based on field observations at the time of construction. Stripped material should be transported off site for disposal unless otherwise allowed by the project specifications for other uses such as landscaping.

6.2. Subgrade Preparation and Evaluation

Upon completion of site preparation activities, exposed subgrades should be proof-rolled with a fully loaded dump truck or similar heavy rubber-tired construction equipment where space allows to identify soft, loose, or unsuitable areas. Probing may be used for evaluating smaller areas or where proof-rolling is not practical. Proof-rolling and probing should be conducted prior to placing fill and should be performed by a representative of GeoEngineers who will evaluate the suitability of the subgrade and identify areas of yielding that are indicative of soft or loose soil. If soft or loose zones are identified during proof-rolling or probing, these areas should be excavated to the extent indicated by our representative and replaced with structural fill.

As discussed in Section 6.8 of this report, because of the fines content native silty sand and gravel soil can be sensitive to small changes in moisture content and will be difficult, or not possible, to compact adequately during wet weather. While tilling and compacting the subgrade is the economical method for subgrade improvement, it will likely only be possible during extended dry periods and following moisture-conditioning of the soil.

During wet weather, or when the exposed subgrade is wet or unsuitable for proof-rolling, the prepared subgrade should be evaluated by observing excavation activity and probing with a steel foundation probe. Observations, probing and compaction testing should be performed by a member of our staff. Wet soil that has been disturbed due to site preparation activities or soft or loose zones identified during probing should be removed and replaced with compacted structural fill.

6.3. Subgrade Protection and Wet Weather Considerations

The soils at the site are highly susceptible to moisture. Wet weather construction practices will be necessary if work is performed during periods of wet weather. If site grading will occur during wet weather conditions, it will be necessary to use track-mounted equipment, load removed material into trucks supported on gravel haul roads, use gravel working pads and employ other methods to reduce ground disturbance. The contractor should be responsible to protect the subgrade during construction.

Earthwork planning should include considerations for minimizing subgrade disturbance. We provide the following recommendations if wet weather construction is considered:

- The ground surface in and around the work area should be sloped so that surface water is directed to a sump or discharge location. The ground surface should be graded such that areas of ponded water do not develop. Measures should be taken by the contractor to prevent surface water from collecting in excavations and trenches. Measures should be implemented to remove surface water from the work areas.
- Earthwork activities should not take place during periods of heavy precipitation.
- Slopes with exposed soils should be covered with plastic sheeting or similar means.
- The site soils should not be left in a disturbed or uncompacted state and exposed to moisture. Sealing the surficial soils by rolling with a smooth-drum roller prior to periods of precipitation may reduce the extent to which these soils become wet or unstable.

- Construction activities should be scheduled so that the length of time that soils are left exposed to moisture is reduced to the extent practicable.
- Construction traffic should be restricted to specific areas of the site, preferably areas that are not susceptible to wet weather disturbance such as haul roads and areas that are adequately surfaced with working pad materials.
- When on-site soils are wet of optimum, they are easily disturbed and will not provide adequate support for construction traffic nor for the proposed development. The use of granular haul roads and staging areas will be necessary to support heavy construction traffic. Generally, a 12- to 16-inch-thick mat of Imported Select Structural Fill should be sufficient for light staging areas for the building pad and light staging activities but is not expected to be adequate to support repeated heavy equipment or truck traffic. The thickness of the Imported Select Structural Fill for haul roads and areas with repeated heavy construction traffic should be increased to between 18 and 24 inches. The actual thickness of haul roads and staging areas should be determined at the time of construction and based on the contractor's approach to site development and the amount and type of construction traffic.
- The base rock (Aggregate Base and Aggregate Subbase) thicknesses described in the "Pavement Recommendations" sections of this report are intended to support post-construction design traffic loads. The design base rock thicknesses will likely not support repeated heavy construction traffic during site construction or during pavement construction. A thicker base rock section as described above for haul roads will likely be required to support construction traffic.
- During periods of wet weather, concrete should be placed as soon as practical after preparing foundation excavations. Foundation bearing surfaces should not be exposed to standing water. Should water infiltrate and pool in the excavation, the water should be removed, and the foundation subgrade should be re-evaluated before placing reinforcing steel or concrete. Foundation subgrade protection, such as a 3- to 4-inch thickness of Aggregate Base/Aggregate Subbase or lean concrete, may be necessary if footing excavations are exposed to extended wet weather conditions.

During wet weather, or when the exposed subgrade is wet or unsuitable for proof-rolling, the prepared subgrade should be evaluated by observing excavation activity and probing with a steel foundation probe. Observations and probing should be performed by a member of our staff. Wet soil that has been disturbed due to site preparation activities, or soft or loose zones identified during probing, should be removed, and replaced with Imported Select Structural Fill.

6.4. Soil Amendment with Cement

As an alternative to the using Imported Select Structural Fill material for wet weather structural fill, an experienced contractor may be able to amend the on-site soil with Portland cement concrete (PCC) to obtain suitable support properties. It is often less costly to amend on-site soils than to remove and replace soft soils with imported granular materials. We also considered lime amendment for the site soils. However, based on our experience on nearby sites, in-place soil moisture contents, observed soil types and processing speed, cement amendment would be more suitable at this site than lime amendment. Single pass tilling depths for cement amendment equipment is typically 18 inches or less. However, multiple tilling passes may be required to adequately blend in the cement with the soils and to sufficiently process the soils. It may also be necessary to place the recommended cement quantities in multiple passes between tilling passes, which requires intermediate compaction.

The contractor should be responsible for selecting the means and methods to construct the amended soil without disturbing exposed subgrades. We recommend low ground-pressure (such as balloon-tired) cement spreading equipment be required. We have observed other methods used for spreading that have resulted in significant site disturbance and high remedial costs. For example, we have observed amendment efforts using a spreader truck equipped with road tires pulled by track-mounted equipment that resulted in significant disturbance to the work area and required re-working large areas of cement-amended product at additional expense.

Areas of standing water, or areas where traffic patterns are concentrated and disturbing the subgrade, will also create a need for higher amounts of cement to be applied and additional tilling for better mixing and cement hydration prior to final compaction.

Successful use of soil amendment depends on the use of correct mixing techniques, the soil moisture content at the time of amendment and amendment quantities. Specific recommendations, based on exposed site conditions for soil amending, can be provided if necessary. However, for preliminary planning purposes, it may be assumed that a minimum of 5 percent cement (by dry weight, assuming a unit weight of 100 pounds per cubic foot [pcf]) will be sufficient for improving on-site soils. Treatment depths of 12 to 16 inches are typical (assuming a seven-day unconfined compressive strength of at least 80 pounds per square inch [psi]), although they may be adjusted in the field depending on site conditions. Soil amending should be conducted in accordance with the specifications provided in Oregon Structural Specialty Code (OSSC) 00344 (Treated Subgrade).

We recommend a target strength for cement-amended soils of 80 psi. The amount of cement used to achieve this target generally varies with moisture content and soil type. It is difficult to predict field performance of soil-to-cement amendment due to variability in soil response and we recommend laboratory testing to confirm expectations. However, for preliminary design purposes, 4 to 5 percent cement by weight of dry soil can generally be used when the soil moisture content does not exceed approximately 20 percent. If the soil moisture content is in the range of 20 to 35 percent, 5 to 7 percent by weight of dry soil is recommended. The amount of cement added to the soil should be adjusted based on field observations and performance.

PCC-amended soil is hard and has low permeability; therefore, this soil does not drain well nor is it suitable for planting. Future landscape areas should not be cement amended, if practical, or accommodations should be planned for drainage and planting. Cement amendment should not be used if runoff during construction cannot be directed away from adjacent low-lying wet areas and active waterways and drainage paths.

When used for constructing pavement, staging, or haul road subgrades, the amended surface should be protected from abrasion by placing a minimum 4-inch thickness of base rock material (Aggregate Base/Aggregate Subbase). To prevent strength loss during curing, cement-amended soil should be allowed to cure for a minimum of 4 days prior to placing the base rock. The base rock typically becomes contaminated with soil during construction. Contaminated base rock should be removed and replaced with clean base rock in pavement areas to meet the required thickness(es) in the "Pavement Recommendations" section to this report.

It is not possible to amend soil during heavy or continuous rainfall. Work should be completed during suitable weather conditions.

6.5. Dewatering

As discussed in the "Groundwater" section of this report, groundwater was encountered in our explorations. However, we do not expect groundwater to be a major factor during shallow excavations and earthwork. Excavations that extend into saturated/wet soils, or excavations that extend into perched groundwater, should be dewatered. Sump pumps are expected to adequately address groundwater encountered in shallow excavations. In addition to groundwater seepage, surface water inflow to the excavations during the wet season can be problematic. Provisions for surface water control during earthwork and excavations should be included in the project plans and should be installed prior to commencing earthwork.

6.6. Permanent Slopes

Permanent cut and fill slopes, where incorporated into the grading plan, should not exceed 2H:1V (horizontal to vertical). The slopes should be planted with appropriate vegetation to provide protection against erosion as soon as possible after grading. Buildings, access roads and pavements should be located at least 10 feet from the top of new fill slopes or existing slopes. Placement of fill near the top of the existing slope should be limited to 2 feet or less in thickness. If the grading plan requires additional fill, we should be contacted to evaluate the impact of the additional loading on the slope. Surface water runoff should be collected and directed away from slopes to prevent water from running down the face of the slope.

6.7. Trench Shoring

All trench excavations should be made in accordance with applicable Occupational Safety and Health Administration (OSHA) and state regulations. In our opinion, native soils are generally OSHA Type B. Temporary excavations deeper than 4 feet should be shored or laid back at an inclination of 1H:1V or flatter if workers are required to enter. Excavations made to construct footings or other structural elements should be laid back or shored at the surface as necessary to prevent soil from falling into excavations.

It should be expected that unsupported cut slopes will experience some sloughing and raveling if exposed to water. Plastic sheeting, placed over the exposed slope and directing water away from the slope, will reduce the potential for sloughing and erosion of cut slopes during wet weather.

The contractor is responsible for shoring methods and shoring system design. Shoring systems should be designed by a professional engineer before installation.

In our opinion, the contractor will be in the best position to observe subsurface conditions continuously throughout the construction process and to respond to the soil and groundwater conditions. Construction site safety is generally the sole responsibility of the contractor, who also is solely responsible for the means, methods, and sequencing of the construction operations and choices regarding excavations and shoring.

Under no circumstances should the information provided by GeoEngineers be interpreted to mean that GeoEngineers is assuming responsibility for construction site safety or the contractor's activities; such responsibility is not being implied and should not be inferred.

6.8. Structural Fill and Backfill

6.8.1. General

Structural areas include areas beneath foundations, floor slabs, pavements, and any other areas intended to support structures or within the influence zone of structures. Fill intended for use in structural areas should meet the criteria for structural fill presented below. All structural fill soils should be free of debris, clay balls, roots, organic matter, frozen soil, man-made contaminants, particles with greatest dimension exceeding 4 inches (3-inch-maximum particle size in building footprints) and other deleterious materials.

The suitability of soil for use as structural fill will depend on the gradation and moisture content of the soil. As the amount of fines in the soil matrix increases, the soil becomes increasingly more sensitive to small changes in moisture content and achieving the required degree of compaction becomes more difficult or impossible. Recommendations for suitable fill material are provided in the following sections.

6.8.2. On-Site Soils

On-site near surface soil consists of native grayish brown silt with varying clay and sand content. On-site soils can be used as structural fill, provided the material meets the above requirements, although due to moisture sensitivity, this material will likely be unsuitable as structural fill during most of the year. If the soil is too wet to achieve satisfactory compaction, moisture conditioning by drying back the material will be required. If the material cannot be properly moisture conditioned, we recommend using imported material for structural fill. The properly prepared and compacted on-site soils in the tilled zone qualify as structural fill provided, they meet the recommendations in the "Subgrade Improvement for the Tilled Zone" section 5.2 of this report.

An experienced geotechnical engineer from GeoEngineers should determine the suitability of on-site soil encountered during earthwork activities for reuse as structural fill.

6.8.3. Imported Select Structural Fill

Imported Select Structural Fill may be used as structural fill and should consist of pit or quarry run rock, crushed rock, or crushed gravel and sand that is fairly well-graded between coarse and fine sizes (approximately 25 to 65 percent passing the U.S. No. 4 sieve). It should have less than 5 percent passing the U.S. No. 200 sieve and have a minimum of 75 percent fractured particles according to American Association of State Highway and Transportation Officials (AASHTO) TP-61.

6.8.4. Aggregate Base

Aggregate base material located under floor slabs and pavements and crushed rock used in footing overexcavations should consist of imported clean, durable, crushed angular rock. Such rock should be well-graded, have a maximum particle size of 1 inch and have less than 5 percent passing the U.S. No. 200 sieve (3 percent for retaining walls). In addition, aggregate base shall have a minimum of 75 percent fractured particles according to AASHTO TP-61 and a sand equivalent of not less than 30 percent based on AASHTO T-176.

6.8.5. Aggregate Subbase

Aggregate Subbase material should consist of imported, clean, durable, crushed angular rock. Such rock should be well-graded, have a maximum particle size of 1½ inches, have less than 5 percent passing the

U.S. No. 200 sieve and meet the gradation requirements in Oregon Department of Transportation (ODOT) Standard Section 00331. In addition, aggregate base shall have a minimum of 75 percent fractured particles according to AASHTO TP-61 and a sand equivalent of not less than 30 percent based on AASHTO T-176.

6.8.6. Trench Backfill

Backfill for pipe bedding and in the pipe zone should consist of well-graded granular material with a maximum particle size of ¾ inch and less than 5 percent passing the U.S. No. 200 sieve. The material should be free of organic matter and other deleterious materials. Further, the backfill should meet the pipe manufacturer's recommendations. Above the pipe zone backfill, Imported Select Structural Fill may be used as described above.

6.8.7. Fill Placement and Compaction

Structural fill should be compacted at moisture contents that are within 3 percent of the optimum moisture content as determined by ASTM International (ASTM) Test Method D 1557 (Modified Proctor). The optimum moisture content varies with gradation and should be evaluated during construction. Fill material that is not near the optimum moisture content should be moisture conditioned prior to compaction.

Fill and backfill material should be placed in uniform, horizontal lifts and compacted with appropriate equipment. The appropriate lift thickness will vary depending on the material and compaction equipment used. Fill material should be compacted in accordance with Table 2. It is the contractor's responsibility to select appropriate compaction equipment and place the material in lifts that are thin enough to meet these criteria. However, in no case should the loose lift thickness exceed 18 inches.

TABLE 2. COMPACTION CRITERIA

Fill Type	Compaction Requirements		
	Percent Maximum Dry Density Determined by ASTM Test Method D 1557 at ± 3% of Optimum Moisture		
	0 to 2 Feet Below Subgrade	> 2 Feet Below Subgrade	Pipe Zone
Fine-grained soils (non-expansive)	92	92	----
Imported Granular, maximum particle size < 1¼ inch	95	95	----
Imported Granular, maximum particle size 1¼ inch to 6 inches (3-inch-maximum under building footprints)	n/a (proof-roll)	n/a (proof-roll)	----
Retaining Wall Backfill*	92	92	-----
Nonstructural Zones	90	90	90
Trench Backfill	95	90	90

Note:

* Measures should be taken to prevent overcompaction of the backfill behind retaining walls. We recommend placing the zone of backfill located within 5 feet of the wall in lifts not exceeding about 6 inches in loose thickness and compacting this zone with hand-operated equipment such as a vibrating plate compactor or a jumping jack.

A representative from GeoEngineers should evaluate compaction of each lift of fill. Compaction should be evaluated by compaction testing unless other methods are proposed for oversized materials and are approved by GeoEngineers during construction. These other methods typically involve procedural placement and compaction specifications together with verification requirements such as proof-rolling.

7.0 STRUCTURAL DESIGN RECOMMENDATIONS

7.1. Foundation Support Recommendations

Proposed apartment structures can be satisfactorily founded on continuous wall or isolated column footings supported on firm native soils encountered below upper disturbed soils or on structural fill placed over firm native soils. Exterior footings should be established at least 18 inches below the lowest adjacent grade. The recommended minimum footing depth is greater than the anticipated frost depth. Interior footings can be founded a minimum of 12 inches below the top of the first-floor slab. Isolated column and continuous wall footings should have minimum widths of 24 and 18 inches, respectively. We have assumed that the column loads will be 40 kips or less, wall loads will be 3 klf or less, and floor loads for slabs on grade will be 125 psf or less for the proposed buildings. If design loads exceed these values, our recommendations may need to be revised.

7.1.1. Foundation Subgrade Preparation

The subgrades beneath proposed structural elements should be prepared as described below and in the "Earthworks Recommendations" section of this report. We recommend loose or disturbed soils resulting from foundation excavation be removed before placing reinforcing steel and concrete. Foundation bearing surfaces should not be exposed to standing water. If water infiltrates and pools in the excavation, the water, along with any disturbed soil, should be removed before placing reinforcing steel and concrete. A thin gravel layer consisting of Aggregate Base or Aggregate Subbase material can be placed at the base of foundation excavations to help protect the subgrade from weather and light foot traffic. The layer thickness for the gravel layer should be determined at the time of construction but is typically 3 to 4 inches. The gravel layer should be compacted as described in the "Fill Placement and Compaction" section.

In some areas of the site, soft soils were encountered near the surface. Where soft soils are encountered in foundation subgrades, soft soils should be overexcavated and replaced with a minimum 2 feet thick granular bearing pad consisting of crushed rock structural fill compacted in accordance with section 6.8.7.

We recommend GeoEngineers observe all foundation subgrades before placing concrete forms and reinforcing steel to determine that bearing surfaces have been adequately prepared and the soil conditions are consistent with those observed during our explorations.

7.1.2. Isolated Spread Footings

We recommend conventional footings be proportioned using a maximum allowable bearing pressure of 2,500 psf if supported on firm native soils or on structural fill placed over firm native soils. This bearing pressure applies to the total of dead and long-term live loads and may be increased by one-third when considering earthquake or wind loads. This is a net bearing pressure. The weight of the footing and overlying backfill can be ignored in calculating footing sizes.

7.1.3. Foundation Settlement

Foundations designed and constructed as recommended are expected to experience settlements of less than 1 inch. Differential settlements of up to one half of the total settlement magnitude can be expected between adjacent footings supporting comparable loads.

7.1.4. Lateral Resistance

Lateral loads can be resisted by a combination of friction between the footing and the supporting soil, and by the passive lateral resistance of the soil surrounding the embedded portions of the footings. A coefficient of friction between the concrete and soil of 0.35 and a passive lateral resistance corresponding to an equivalent fluid density of 250 pcf may be used for design. These values are appropriate for foundation elements that are poured directly against the native soils or surrounded by compacted structural fill.

The passive earth pressure and friction components may be combined, provided the passive component does not exceed two-thirds of the total.

The passive earth pressure value is based on the assumptions that the adjacent grade is level and static groundwater remains below the base of the footing throughout the year. The top 1 foot of soil should be neglected when calculating passive lateral earth pressures unless the adjacent area is covered with pavement. The lateral resistance values do not include safety factors.

7.2. Drainage Consideration

We recommend the ground surface be sloped away from the buildings at least 5 percent for a minimum distance of 10 feet measured perpendicular to the face of the wall in accordance with section 1804.4 of the 2018 International Building Code (IBC). All downspouts should be tightlined away from the building foundation areas and should also be discharged into a stormwater disposal system. Downspouts should not be connected to footing drains.

Although not required based on groundwater depths observed in our explorations, if perimeter footing drains are used for below-grade structural elements or crawlspaces, they should be installed at the base of the exterior footings. The perimeter footing drains should be provided with cleanouts and should consist of at least 4-inch-diameter perforated pipe placed on a 3-inch bed of and surrounded by 6 inches of drainage material enclosed in a non-woven geotextile such as Mirafi 140N (or approved equivalent) to prevent fine soil from migrating into the drain material. We recommend against using flexible tubing for footing drainpipes. The perimeter drains should be sloped to drain by gravity to a suitable discharge point, preferably a storm drain. We recommend that the cleanouts be covered and placed in flush-mounted utility boxes. Water collected in roof downspout lines must not be routed to the footing drain lines.

7.3. Floor Slabs

Satisfactory subgrade support for floor slabs on grade supporting the planned 100 psf floor loads can be obtained provided the floor slab subgrade is described in the “Earthworks Recommendations” section of this report. Slabs should be reinforced according to their proposed use and per the structural engineer’s recommendations. Subgrade support for concrete slabs can be obtained from the firm native soils underlying the tilled zone or on structural fill placed over firm native soils.

Subgrade materials should meet the requirements for aggregate base rock as presented in Section 5.9 of this report. Subgrade heave resulting from freezing of high moisture soil could compromise the structural integrity of concrete slabs. A thermal barrier is typically installed directly beneath floor slabs under deep freezer or between deep freezer and floor slabs to prevent freezing and expansion of subgrade soil. The freezer manufacturer should be consulted to determine if freezer use and operating temperature warrant installation of a thermal barrier. Additional measures such as subsurface air vents of fluid-circulation pipe systems placed beneath the floor slab, can be implemented to further reduce potential frozen subgrade.

We recommend that fill used to raise site grades for the proposed building and building addition consist of imported granular material in accordance with Section 5.9 of this report. Granular fill material is less prone to retaining moisture than the native fine-grained site soils. Static groundwater levels are not expected to rise near the groundwater surface.

If dry on-grade slabs are required, for example at interior spaces where adhesives are used to anchor carpet or tile to the slab, a waterproof liner may be placed as a vapor barrier below the slab. The vapor barrier should be selected by the structural engineer and should be accounted for in the design floor section and mix design selection for the concrete, to accommodate the effect of the vapor barrier on concrete slab curing. Load-bearing concrete slabs should be designed assuming a modulus of subgrade reaction (k) of 150 psi per inch. We estimate that concrete slabs constructed as recommended will settle less than ½ inch. Floor slab subgrades should be evaluated according to the “Subgrade Evaluation” section of this report.

7.4. Conventional Retaining Walls

7.4.1. Drainage

Positive drainage is imperative behind retaining structures. This can be accomplished by providing a drainage zone behind the wall consisting of free-draining material and perforated pipes to collect and dispose the water. The drainage material should consist of Aggregate Base having less than 3 percent passing the U.S. No. 200 sieve. The wall drainage zone should extend horizontally at least 18 inches from the back of the wall.

A perforated smooth-walled rigid drainpipe having a minimum diameter of 4 inches should be placed at the bottom of the drainage zone along the entire length of the wall, with the pipe invert at or below the base of the wall footing. The drainpipes should discharge to a tightline leading to an appropriate collection and disposal system. An adequate number of cleanouts should be incorporated into the design of the drains to provide access for regular maintenance. Roof downspouts, perimeter drains, or other types of drainage systems should not be connected to retaining wall drain systems.

7.4.2. Concrete Retaining Walls

Retaining structures free to rotate slightly around the base should be designed for active earth pressures using an equivalent fluid unit weight (efp) of 37 pcf when the ground surface extends level behind the wall equal to a distance of at least twice the height of the wall, and 68 pcf for an inclined slope of 2H:1V above the wall. For lesser slopes between flat and 2H:1V, the efp can be linearly interpolated between the recommended values. The efp value is based on the following assumptions.

- The walls will not be restrained against rotation when the backfill is placed.

- Walls are 8 feet or less in total wall support height.
- The backfill within 2 feet of the wall consists of free-draining granular materials.
- Grades above the top of the walls are no steeper than a 2H:1V slope.
- Total wall heights are determined based on a level front slope from the base of the wall.
- Hydrostatic pressures do not develop, and drainage will be provided behind the wall.

Seismically induced lateral forces on permanent below-grade building walls can be calculated using a dynamic force equal to 10.5H psf, where H is the wall height. This seismic force should be applied with the centroid located at 0.6H from the wall base. These values assume that the wall is vertical and unrestrained and the backfill behind the wall is horizontal.

For site retaining walls, seismic lateral earth pressures should be computed as a part of retaining wall design using the Mononobe-Okabe equation or another method appropriate to the selected wall system.

Retaining walls, including foundation walls that are restrained against rotation during backfilling, should be designed for an at-rest equivalent fluid unit weight of 58 pcf when the ground surface extends level behind the wall equal to a distance of at least twice the height of the wall, and 85 pcf for an inclined slope of 2H:1V above the wall. For lesser slopes between flat and 2H:1V, the efp can be linearly interpolated between the recommended values.

Surcharge loads applied closer than one-half of the wall height should be considered as uniformly distributed horizontal pressures equal to one-third of the distributed vertical surcharge pressure. Footings for retaining walls should be designed as recommended for shallow foundations. Backfill should be placed and compacted as recommended for structural fill.

Re-evaluation of our recommendations will be required if the retaining wall design criteria for the project vary from these assumptions.

We recommend that GeoEngineers be retained to review the retaining wall design to confirm that it meets the requirements in our report. The retaining wall designer should perform global stability analysis of the proposed wall.

7.5. Seismic Design

Parameters provided on Table 3 are based on the conditions encountered during our subsurface exploration program and the procedure and requirements outlined in the 2018 IBC. Per American Society of Civil Engineers (ASCE) 7-16 Section 11.4.8, a site-specific response analysis is required for site class F sites, and a ground motion hazard analysis or site-specific response analysis is required to determine the design ground motions for structures on Site Class D and E sites with S_1 greater than or equal to 0.2g.

For this project, the site is classified as site class F because of the potentially liquefiable soils; therefore, the provisions of 11.4.8 are applicable. Alternatively, the parameters listed on Table 3 may be used to determine the design ground motions if the exceptions provided in ASCE 7-16 Supplement 3 are met. The applicable exceptions for the project site listed in ASCE 7-16 Supplement 3 are provided below for reference. If it is desirable to avoid these exceptions, a ground motion hazard analysis would need to be completed to determine the design seismic parameters for the site.

From ASCE 7-16 Supplement 3

Exception: A ground motion hazard analysis not required:

1. Where the values of the parameter S_{M1} determined by Eq. (11.4-2) is increased by 50% for all applications of S_{M1} in the standard. And:
2. The resulting value of the parameter S_{D1} determined by Eq. (11.4-4) shall be used for all applications of S_{D1} in the standard.

TABLE 3. MAPPED 2018 IBC SEISMIC DESIGN PARAMETERS

Parameter	Recommended Value[1,2,3]
Site Class	D/F
Mapped Spectral Response Acceleration at Short Period (S_S)	0.815 g
Mapped Spectral Response Acceleration at 1 Second Period (S_1)	0.408 g
Site Modified Peak Ground Acceleration (PGA_M)	0.462 g
Site Amplification Factor at 0.2 second period (F_a)	1.174
Site Amplification Factor at 1.0 second period (F_v)	1.892
Design Spectral Acceleration at 0.2 second period (S_{DS})	0.638 g
Design Spectral Acceleration at 1.0 second period (S_{D1})[(4)]	0.772 g

Note:

[1] Parameters developed based on Latitude 44.941864° and Longitude -123.007679° using the ATC Hazards online tool.

[2] These values are only valid if the structural engineer utilizes Exception 1 of ASCE 7-16 Supplement 3 Exception 1.

[3] These values are only valid for structures with a fundamental period of vibration less than 0.5 seconds.

[4] Increased by a factor of 1.5 per ASCE 7-16 Supplement 3 Exception 1.

7.5.1. Liquefaction Potential

Liquefaction is a phenomenon caused by a rapid increase in pore water pressure that reduces the effective stress between soil particles to near zero. The excessive buildup of pore water pressure results in the sudden loss of shear strength in a soil. Granular soil, which relies on interparticle friction for strength, is susceptible to liquefaction until the excess pore pressures can dissipate. Sand boils and flows observed at the ground surface after an earthquake are the result of excess pore pressures dissipating upwards, carrying soil particles with the draining water. In general, loose, saturated sand soil with low silt and clay contents is the most susceptible to liquefaction. Low plasticity, silty sand may be moderately susceptible to liquefaction under relatively higher levels of ground shaking.

As discussed in Section 3.3.2 of this report, groundwater was encountered during our explorations at approximately 14½ feet bgs. The site soils below the groundwater table are expected to include silt with varying amounts of sand that is considered moderately susceptible to liquefaction for the design earthquake event. Current analytical methods, based on soil index properties and relative density, estimate that post-liquefaction settlement could range from about 1 to 3 inches for the design earthquake event.

As discussed above, site structures should be designed to tolerate magnitudes of settlement of 1 to 3 inches and be safe against collapse. If higher performance levels are required where less settlement is a part of design, mitigation measures to limit the effects of liquefaction will be required. Mitigation measures may include some form of ground improvement such as rammed aggregate piers (RAP) or soil mixing, or structural improvements such as installation of piles to support structures or thickened mat slab foundations to limit structural differential settlements can be considered. Based on discussions with the project team, structural consideration will be given to designing the timber structures to tolerate those potential settlements.

8.0 PAVEMENT RECOMMENDATIONS

8.1. Dynamic Cone Penetrometer (DCP) Field Testing and Resilient Modulus (M_R)

We conducted three DCP tests in general accordance with ASTM D 6951 to estimate the subgrade resilient modulus (M_R) at each test location as shown in Figure 2. We recorded penetration depth of the cone versus hammer blow count and terminated testing at depths varying between 28 and 34 inches below the existing ground surface.

We plotted depth of penetration versus blow count and visually assessed regions where slopes of the data were relatively constant using equation from the ODOT Pavement Design Guide to estimate the moduli using a conversion coefficient, C_f = 0.35. Table 4 lists our estimate of the subgrade resilient modulus at each test location based on data obtained in the upper 18 inches below the upper topsoil.

TABLE 4. ESTIMATED SUBGRADE RESILIENT MODULI BASED ON DCP TESTING

DCP Number	Estimated Resilient Modulus (psi)
DCP-1	4,800
DCP-2	4,850

8.2. Drainage

Long-term performance of pavements is influenced significantly by drainage conditions beneath the pavement section. Positive drainage can be accomplished by crowning the subgrade with a minimum 2 percent cross slope and establishing grades to promote drainage.

8.3. On-site Asphalt Concrete Pavement Sections

Pavement subgrades should be prepared in accordance with Section 6.0 of this report. Our pavement recommendations assume that traffic at the site will consist of occasional truck traffic and passenger cars. We do not have specific information on the frequency and type of vehicles that will use the area; however, we have based our design analysis on traffic consisting of two heavy trucks per day to account for delivery- and service-type vehicles and passenger car traffic for the heavy-duty pavement sections, and passenger car traffic only for the light-duty pavement sections.

Our pavement recommendations are based on the following assumptions:

- The pavement subgrades, fill subgrades and site earthwork used to establish road grades below the Aggregate Subbase and Aggregate Base materials have been prepared as described in the "Earthwork Recommendations" section of this report.

- A resilient modulus of 20,000 psi has been estimated for compacted Aggregate Subbase and Aggregate Base materials.
- A resilient modulus of 4,800 psi was estimated for firm native soils below the topsoil or structural fill placed on firm native soils below the topsoil.
- Initial and terminal serviceability indices of 4.2 and 2.0, respectively.
- Reliability and standard deviations of 75 percent and 0.45, respectively.
- Structural coefficients of 0.42 and 0.10 for the asphalt and base rock, respectively.
- A 20-year design life.

If any of the noted assumptions vary from project design use, our office should be contacted with the appropriate information so that the pavement designs can be revised or confirmed adequate.

The recommended minimum pavement sections are provided in Table 5. Pavement recommendations for “On-Site Local Roads” are for roadways within the development only.

An alternate pavement section using Aggregate Subbase material is provided below because it may be more applicable during wet-weather construction where a gravel haul road or working surface is needed to support construction traffic. Wet weather construction recommendations are provided in the “Earthworks Recommendations” section of this report. The sub-base material can be incorporated into the gravel working blankets and haul roads provided the material meets the minimum thickness in Table 5 and meets the specifications for Aggregate Subbase. Working blanket and haul road materials that pump excessively, or have excessive fines from construction traffic, should be removed and replaced with specified materials prior to constructing roadways over those areas.

If cement amendment is used during site development, as described in the “Earthwork Recommendations” section of this report, it may be possible to reduce the amount of aggregate base for the pavement sections. This will depend on several factors, including the prevailing weather conditions, depth of amendment and condition of the subgrade after amendment. GeoEngineers can provide additional information for on-site pavement sections if cement amendment will be used during construction.

The recommended pavement sections assume that final improvements surrounding the pavement will be designed and constructed such that stormwater or excess irrigation water from landscape areas does not infiltrate below the pavement section into the crushed base.

TABLE 5. MINIMUM ON-SITE PAVEMENT SECTION THICKNESS

Section	Minimum Asphalt Thickness (inches)	Minimum Aggregate Base Thickness (inches)	Minimum Aggregate Sub-Base Thickness (inches)	Assumed Traffic Loading (Design Life ESAL’s)
Light Duty (general automobile parking areas)	3	6	-	<10,000
	3	4	12	
Heavy Duty (drive aisles and heavy delivery areas)	3.5	9	-	50,000
	3.5	4	12	

The aggregate base course should conform to the "Aggregate Base" section of this report and be compacted to at least 95 percent of the maximum dry density (MDD) determined in accordance with AASHTO T-180/ASTM Test Method D 1557.

The AC pavement should conform to Section 00745 of the most current edition of the ODOT Standard Specifications for Highway Construction. The Job Mix Formula should meet the requirements for a ½-inch Dense Graded Level 2 Mix. The AC should be PG 64-22 grade meeting the ODOT Standard Specifications for Asphalt Materials. AC pavement should be compacted to 92.0 percent at Maximum Theoretical Unit Weight (Rice Gravity) of AASHTO T-209.

TABLE 6. PAVEMENT SECTION RECOMMENDATIONS WITH CEMENT AMENDED SUB-BASE

Minimum Asphalt Thickness (inches)	Minimum Aggregate Base Thickness (inches)	Minimum Cement Amended Subgrade Thickness (inches)
3.0	4	12

Cement amendment may be used during site development, as described above, or to reduce the pavement section thickness. The exact design of the amount of cement to be used should be determined based on the condition of the subgrade at the time of construction and the prevailing weather conditions but should likely be between 3 and 6 percent. We recommend the minimum thickness of amendment be 12 inches. GeoEngineers can provide additional information regarding cement volumes at the time of construction. The minimum pavement sections, with a 12-inch-thick cement amended soil section, are provided in Table 6 above.

9.0 DESIGN REVIEW AND CONSTRUCTION SERVICES

Recommendations provided in this report are based on the assumptions and preliminary design information stated herein. We welcome the opportunity to review and discuss construction plans and specifications for this project as they are being developed. In addition, GeoEngineers should be retained to review the geotechnical-related portions of the plans and specifications to evaluate whether they are in conformance with the recommendations provided in this report.

Satisfactory foundation and earthwork performance depends to a large degree on quality of construction. Sufficient monitoring of the contractor's activities is a key part of determining that the work is completed in accordance with the construction drawings and specifications. Subsurface conditions observed during construction should be compared with those encountered during the subsurface explorations. Recognition of changed conditions often requires experience; therefore, qualified personnel should visit the site with sufficient frequency to detect whether subsurface conditions change significantly from those anticipated.

We recommend that GeoEngineers be retained to observe construction at the site to confirm that subsurface conditions are consistent with the site explorations, and to confirm that the intent of project plans and specifications relating to earthwork, pavement and foundation construction are being met.

10.0 LIMITATIONS

We have prepared this report for the exclusive use of Greenlight Development and their authorized agents and/or regulatory agencies for the proposed Salem 23rd & Center Apartments Development located at the area listed as 2561 Center Street NE and 755 Medical Center Drive NE in Salem, Oregon.

This report is not intended for use by others and the information contained herein is not applicable to other sites. No other party may rely on the product of our services unless we agree in advance and in writing to such reliance.

Within the limitations of scope, schedule, and budget, our services have been executed in accordance with generally accepted practices in the area at the time this report was prepared. No warranty or other conditions, express or implied, should be understood.

Please refer to Appendix B titled "Report Limitations and Guidelines for Use" for additional information pertaining to use of this report.

11.0 REFERENCES

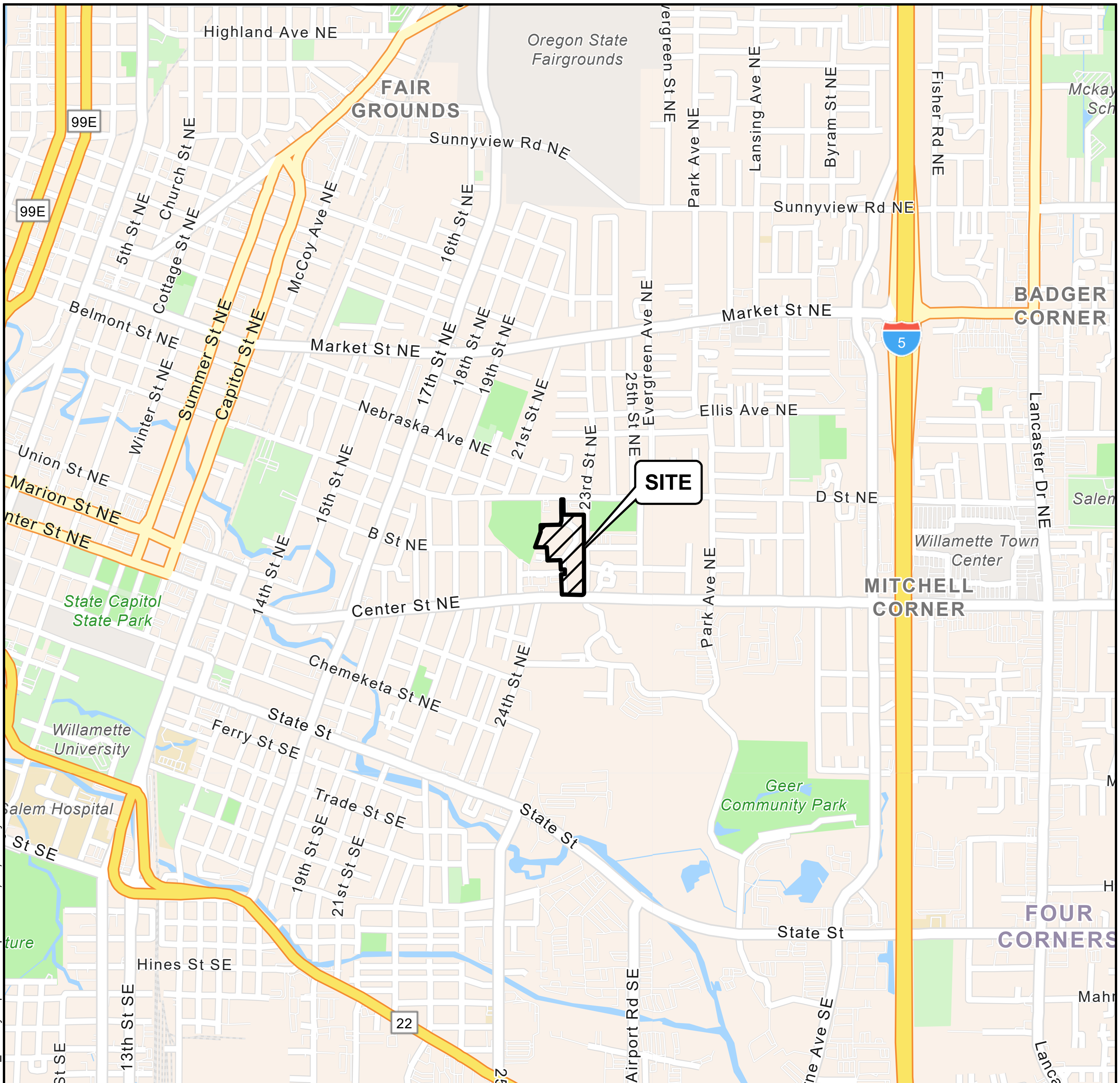
International Code Council. 2018. 2018 International Building Code.

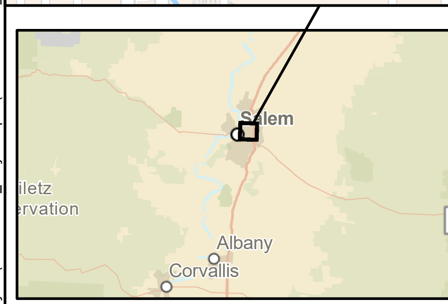
Madin, I. P. 1990. Earthquake Hazard Geology Maps of the Portland Metropolitan Area, Oregon: Test and Map Explanation, DOGAMI Open File Report 0-90-2.

Occupational Safety and Health Administration (OSHA) Technical Manual Section V: Chapter 2, Excavations: Hazard Recognition in Trenching and Shoring: http://www.osha.gov/dts/osta/otm/otm_v/otm_v_2.html.

Bela, L. J. 1981. Geologic Map of the Rickreal and Salem West Quadrangles, Oregon: Oregon Department of Geology and Mineral Industries, Geologic Map Series 18, 2 plates, 1:24,000 scale.

FIGURES





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Feet

Source(s):
- ESRI

Coordinate System: NAD 1983 UTM Zone 10N

Disclaimer: This figure was created for a specific purpose and project. Any use of this figure for any other project or purpose shall be at the user's sole risk and without liability to GeoEngineers. The locations of features shown may be approximate. GeoEngineers makes no warranty or representation as to the accuracy, completeness, or suitability of the figure, or data contained therein. The file containing this figure is a copy of a master document, the original of which is retained by GeoEngineers and is the official document of record.

Vicinity Map

23rd Street NE Apartments Development
Salem, Oregon

GeoEngineers

Figure 1

P:\25\25088005\GIS\25088005 Project\25088005 Project.aprx\25088005 Project Date Exported: 02/27/23 by ccabrera

Legend

- DCP Number and Approximate Location
- Boring Number and Approximate Location
- Test Pit Number and Approximate Location
- Project Area

N

0 100

Feet

Source(s):
- Bing Imagery
- Marion County

Coordinate System: NAD 1983 StatePlane Oregon North FIPS 3601 Feet

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Site Plan

23rd Street NE Apartments Development
Salem, Oregon

GeoEngineers

Figure 2

APPENDICES

APPENDIX A
Field Explorations and Laboratory Testing

APPENDIX A
FIELD EXPLORATIONS AND LABORATORY TESTING

Field Explorations

Soil and groundwater conditions at the proposed Salem 23rd & Center Apartments Development project were explored on February 7 and 8, 2023, by completing three drilled borings (B-1 to B-6), excavating 14 test pits (TP-1 through TP-14), and advancing two dynamic cone penetration (DCP) soundings. Exploratory borings and test pits were extended to depths between 21½ and 41½ feet and 3 to 15 feet below the ground surface (bgs), respectively, at the approximate locations shown on Figure 2. The test pits and drilled borings were advanced using either a track- or truck-mounted drill rig and a Hitachi Zaxis 135US excavator, respectively, owned and operation by Western States Soil Conservation Inc.

The borings and test pits were continuously monitored by a qualified staff from our office who maintained detailed logs of subsurface explorations, visually classified the soil encountered and obtained representative soil samples from the borings. Representative soil samples were obtained from each boring at approximate 2½ foot depth intervals using a 1-inch, inside-diameter, standard split spoon sampler. The samplers were driven into the soil using a 140 pound hammer, free-falling 30 inches on each blow. The number of blows required to drive the sampler each of three, 6-inch increments of penetration were recorded in the field. The sum of the blow counts for the last two, 6-inch increments of penetration is reported on the boring logs as the ASTM International (ASTM) Test Method D 1556 Standard Penetration Test (SPT) N-value.

DCP soundings were performed by a qualified geotechnical staff member from our office who recorded blow count versus cumulative penetration depth. This penetration resistance data was compared to the nearby borings where a detailed log of subsurface explorations was maintained, the soils encountered were visually classified and representative soil samples from the borings were obtained.

Recovered soil samples from exploratory borings were visually classified in the field in general accordance with ASTM D 2488 and the classification chart listed in Key to Exploration Logs, Figure A-1. Logs of the borings are presented in Figures A-2 through A-7. The logs are based on interpretation of the field and laboratory data and indicate the depth at which subsurface materials or their characteristics change, although these changes might actually be gradual.

Laboratory Testing

Soil samples obtained from the explorations were visually classified in the field and in our laboratory using the Unified Soil Classification System (USCS) and ASTM classification methods. ASTM Test Method D 2488 was used to visually classify the soil samples, while ASTM D 2487 was used to classify the soils based on laboratory tests results. A discussion of laboratory tests performed is provided below.

Moisture Content

Moisture content tests were completed in general accordance with ASTM D 2216 for representative samples obtained from the explorations. The results of these tests are presented on the exploration logs in Appendix A at the depths at which the samples were obtained.

Percent Passing U.S. No. 200 Sieve (%F)

Selected samples were "washed" through the U.S. No. 200 mesh sieve to estimate the relative percentages of coarse- and fine-grained particles in the soil. The percent passing value represents the percentage by weight of the sample finer than the U.S. No. 200 sieve. These tests were conducted to verify field descriptions and to estimate the fines content for analysis purposes. The tests were conducted in accordance with ASTM D 1140, and the results are shown on the exploration logs in Appendix A at the respective sample depths.

SOIL CLASSIFICATION CHART

MAJOR DIVISIONS			GRAPH	LETTER	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS MORE THAN 50% RETAINED ON NO. 200 SIEVE	GRAVEL AND GRAVELLY SOILS MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVELS (LITTLE OR NO FINES)		GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES
				GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)		GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
				GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
	SAND AND SANDY SOILS MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE	CLEAN SANDS (LITTLE OR NO FINES)		SW	WELL-GRADED SANDS, GRAVELLY SANDS
				SP	POORLY-GRADED SANDS, GRAVELLY SAND
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		SM	SILTY SANDS, SAND - SILT MIXTURES
				SC	CLAYEY SANDS, SAND - CLAY MIXTURES
FINE GRAINED SOILS MORE THAN 50% PASSING NO. 200 SIEVE	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS, ROCK FLOUR, CLAYEY SILTS WITH SLIGHT PLASTICITY
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS SILTY SOILS
				CH	INORGANIC CLAYS OF HIGH PLASTICITY
				OH	ORGANIC CLAYS AND SILTS OF MEDIUM TO HIGH PLASTICITY
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

NOTE: Multiple symbols are used to indicate borderline or dual soil classifications

Sampler Symbol Descriptions

- 2.4-inch I.D. split barrel / Dames & Moore (D&M)
- Standard Penetration Test (SPT)
- Shelby tube
- Piston
- Direct-Push
- Bulk or grab
- Continuous Coring

Blowcount is recorded for driven samplers as the number of blows required to advance sampler 12 inches (or distance noted). See exploration log for hammer weight and drop.

"P" indicates sampler pushed using the weight of the drill rig.

"WOH" indicates sampler pushed using the weight of the hammer.

ADDITIONAL MATERIAL SYMBOLS

GRAPH	LETTER	TYPICAL DESCRIPTIONS
	AC	Asphalt Concrete
	CC	Cement Concrete
	CR	Crushed Rock/ Quarry Spalls
	SOD	Sod/Forest Duff
	TS	Topsoil

Groundwater Contact

Measured groundwater level in exploration, well, or piezometer

Measured free product in well or piezometer

Graphic Log Contact

Distinct contact between soil strata

Approximate contact between soil strata

Material Description Contact

Contact between geologic units

Contact between soil of the same geologic unit

Laboratory / Field Tests

%F	Percent fines
%G	Percent gravel
AL	Atterberg limits
CA	Chemical analysis
CP	Laboratory compaction test
CS	Consolidation test
DD	Dry density
DS	Direct shear
HA	Hydrometer analysis
MC	Moisture content
MD	Moisture content and dry density
Mohs	Mohs hardness scale
OC	Organic content
PM	Permeability or hydraulic conductivity
PI	Plasticity index
PL	Point load test
PP	Pocket penetrometer
SA	Sieve analysis
TX	Triaxial compression
UC	Unconfined compression
UU	Unconsolidated undrained triaxial compression
VS	Vane shear

Sheen Classification

NS	No Visible Sheen
SS	Slight Sheen
MS	Moderate Sheen
HS	Heavy Sheen

NOTE: The reader must refer to the discussion in the report text and the logs of explorations for a proper understanding of subsurface conditions. Descriptions on the logs apply only at the specific exploration locations and at the time the explorations were made; they are not warranted to be representative of subsurface conditions at other locations or times.

Key to Exploration Logs

GeoEngineers

Figure A-1

Drilled	Start 2/7/2023	End 2/7/2023	Total Depth (ft)	20.5	Logged By / Checked By	Driller	Drilling Method	Hollow-stem Auger

Surface Elevation (ft) / Vertical Datum	Undetermined	Hammer Data	Autohammer 140 (lbs) / 30 (in) Drop	Drilling Equipment	CME55 Track rig
Latitude / Longitude	44.940155 / -123.007145	System / Datum	Decimal Degrees / WGS84	See "Remarks" section for groundwater observed	

Notes:

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name / Testing	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0							ML	Brown silt with sand (medium stiff, moist)			
			18	5		1						
	5		18	6		2			With occasional organic matter and debris			
			18	5		3		ML	Tan-brown silt (medium stiff, moist)			
	10		18	2		4			Becomes soft			
	15		16	6		5A / %F / 5B		ML	Gray silt (medium stiff, moist)	35.1	75.8	Groundwater observed at approximately 14½ feet below ground surface during drilling
									Becomes dark gray, sandy and wet			Driller notes harder digging at 17 feet
	20		6	50/6"		6		GP	Gray fine to coarse gravel with sand (very dense, wet)			

Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on . Vertical approximated based on .

Log of Boring B-1

GeoEngineers

Project: 23rd Street NE Apartments Development
Project Location: Stayton, Oregon
Project Number: 25088-005-00

Figure A-2
Sheet 1 of 1

Drilled	Start: 2/7/2023	End: 2/7/2023	Total Depth (ft)	35.25	Logged By / Checked By	Driller	Drilling Method	Hollow-stem Auger

Surface Elevation (ft) / Vertical Datum	Undetermined	Hammer Data	Autohammer 140 (lbs) / 30 (in) Drop	Drilling Equipment	CME55 Track rig
Latitude / Longitude	44.941908 / -123.008445	System / Datum	Decimal Degrees / WGS84	See "Remarks" section for groundwater observed	

Notes:

Elevation (feet)	Depth (feet)	Interval Recovered (in)	Blows/foot	Collected Sample	Sample Name / Testing	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0						ML	Brown silt with sand (very stiff, moist)			
		8	0		1						
	5	18	5		2			Becomes medium stiff with occasional organic debris			
		15	6		3		ML	Brown silt with sand (medium stiff, moist)			Water table at 7½ foot sample
	10	18	9		4			Becomes sandy and stiff			
	15	18	5		5 / %F			Becomes medium stiff	23.4	80.5	
	20	15	2		6 / %F			Becomes soft and wet with sand	36.1	91.2	
		21.6			7						
	25	18	9		8		ML	Grayish brown silt with sand (medium stiff, moist)			
	30										

Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on . Vertical approximated based on .

Log of Boring B-2

GEOENGINEERS

Project: 23rd Street NE Apartments Development
Project Location: Stayton, Oregon
Project Number: 25088-005-00

Figure A-3
Sheet 1 of 2

Date:2/27/23 Path:P:\25\25088005\GINT\2508800500.GPJ DBLibrary/Library:GEOENGINEERS_DF_STD_US_JUNE_2017.GLB/GEI8_GEOTECH_STANDARD_%F_NO_GW

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name / Testing	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	30		18	6		9		GP-GM	Gray fine to coarse gravel with sand (dense, wet)			Driller notes harder at 32 feet
	35		3	39		10						

Log of Boring B-2 (continued)

GEOENGINEERS

Project: 23rd Street NE Apartments Development

Project Location: Stayton, Oregon

Project Number: 25088-005-00

Figure A-3

Sheet 2 of 2

Drilled	Start 2/7/2023	End 2/7/2023	Total Depth (ft)	41.5	Logged By / Checked By	Driller	Drilling Method	Hollow-stem Auger

Surface Elevation (ft) / Vertical Datum	Undetermined	Hammer Data	Autohammer 140 (lbs) / 30 (in) Drop	Drilling Equipment	CME55 Track rig
Latitude / Longitude	44.942822 / -123.006786	System / Datum	Decimal Degrees / WGS84	See "Remarks" section for groundwater observed	

Notes:

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name / Testing	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0							ML	Brown silt with sand and black and brown organic debris (very stiff, moist)			
			18	14		1						
	5		18	8		2		ML	Brown fine sandy silt (stiff, moist)			
			18	2		3			Becomes very soft with organic matter			
			24			4						
	10		18	5		5			Becomes medium stiff			
	15		18	1		6 %F			Becomes wet	35.3	92.5	Groundwater observed at approximately 14.22 feet below ground surface during drilling
	20		18	2		7						
	25		18	7		8						
	30											

Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on . Vertical approximated based on .

Log of Boring B-3

GEOENGINEERS

Project: 23rd Street NE Apartments Development
Project Location: Stayton, Oregon
Project Number: 25088-005-00

Elevation (feet)	Depth (feet)	FIELD DATA: Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name / Testing	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	30		18	6		9 %F				7.1	93.6	
	35		18	6		10		ML	Gray silt (medium stiff, moist)			
								SM	Dark gray fine to medium sand (very dense, wet)			
	40		18	87/12"		11A						3 inches of heave at 40 feet
						11B		GP-GM	Gray fine to coarse gravel with sand (dense, wet)			

Date:2/27/23 Path:P:\25\25088005\GINT\2508800500.GPJ DBLibrary/Library:GEOENGINEERS_DF_STD_US_JUNE_2017.GLB/GEI8_GEOTECH_STANDARD_%F_NO_GW

Log of Boring B-3 (continued)

GEOENGINEERS

Project: 23rd Street NE Apartments Development
Project Location: Stayton, Oregon
Project Number: 25088-005-00

Date Excavated	2/8/2023	Total Depth (ft)	14	Logged By / Checked By	Excavator / Equipment Hitachi Zaxis 135US	Groundwater not observed / Caving not observed

Surface Elevation (ft) / Vertical Datum	Undetermined	Latitude / Longitude	Coordinate System / Horizontal Datum	Decimal Degrees / WGS84

Elevation (feet)	Depth (feet)	SAMPLE: Testing Sample	SAMPLE: Sample Name / Testing	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0				MOSS	Approximately 6 inches of moss			Abandoned 4-inch steel pipe in upper
	0.5				Fill	Recycled concrete (dense, moist)			
	3.5				ML	Brown silt with occasional sand (medium stiff, moist)			
	6					With sand			
	7.5–8	✓	1						
	9–9.5	✓	2						
	13.5–14	✓	3						

Depth scale (feet): 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14

Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on . Vertical approximated based on .

Date:2/27/23 Path:P:\25\25088005\GINT\2508800500.GPJ DBLibrary/Library:GEOENGINEERS_DF_STD_US_JUNE_2017.GLB/GEI8_TESTPIT_1P_GEOTEC_%F

Log of Test Pit TP-1

GeoEngineers

Project: 23rd Street NE Apartments Development
Project Location: Stayton, Oregon
Project Number: 25088-005-00

Date Excavated	2/8/2023	Total Depth (ft)	14	Logged By / Checked By	Excavator / Equipment Hitachi Zaxis 135US	Groundwater not observed / Caving not observed

Surface Elevation (ft) / Vertical Datum	Undetermined	Latitude / Longitude	Coordinate System / Horizontal Datum	Decimal Degrees / WGS84

Elevation (feet)	Depth (feet)	SAMPLE: Testing Sample	SAMPLE: Sample Name / Testing	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0–1				SM	Brown silty fine sand with occasional gravel (medium dense, moist)			
	1–6				Fill	Recycled concrete (dense, moist)			
	6–14				ML	Grayish brown silt with sand (medium stiff, moist)			
	6.5–7		1						
	9.5–10		2						
	13.5–14		3						

Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on . Vertical approximated based on .

Log of Test Pit TP-2

GeoEngineers

Project: 23rd Street NE Apartments Development
Project Location: Stayton, Oregon
Project Number: 25088-005-00

Figure A-6
Sheet 1 of 1

Date Excavated	2/8/2023	Total Depth (ft)	15	Logged By	Checked By	Excavator	Equipment Hitachi Zaxis 135US	Groundwater not observed	Caving not observed

Surface Elevation (ft) Vertical Datum	Undetermined	Latitude Longitude	Coordinate System Horizontal Datum	Decimal Degrees WGS84

Elevation (feet)	Depth (feet)	SAMPLE: Testing Sample	SAMPLE: Sample Name Testing	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0				SOD	Thin grass with fine roots to approximately 6 inches			
	0.5				SM	Brown silty fine to medium sand with gravel (loose, moist)			
	1				ML	Brown silt with sand (medium stiff, moist)			
	2		1						
	3					Becomes brown and gray with organic matter			
	3.5		2						
	5					Becomes grayish brown			
	8					Occasional deteriorating roots at 8 feet			
	8.5		3						
	11				ML	Grayish brown fine sandy silt (stiff, moist)			
	11.5		4						Operator notes harder digging at 11 feet
	15								

Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on . Vertical approximated based on .

Date:2/27/23 Path:P:\25\25088005\GINT\2508800500.GPJ DBLibrary/Library:GEOENGINEERS_DF_STD_US_JUNE_2017.GLB/GEI8_TESTPIT_1P_GEOTEC_%F

Log of Test Pit TP-3

GeoEngineers

Project: 23rd Street NE Apartments Development
Project Location: Stayton, Oregon
Project Number: 25088-005-00

Figure A-7
Sheet 1 of 1

Date Excavated	2/8/2023	Total Depth (ft)	9.5	Logged By Checked By	Excavator Equipment Hitachi Zaxis 135US	Groundwater not observed Caving not observed

Surface Elevation (ft) Vertical Datum	Undetermined	Latitude Longitude	Coordinate System Horizontal Datum	Decimal Degrees WGS84

Elevation (feet)	Depth (feet)	SAMPLE: Testing Sample	SAMPLE: Sample Name Testing	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0–2				SP-SM	Gray fine to medium sand with silt, gravel and occasional cobbles (medium dense, wet)			
	1					With concrete, construction debris and occasional gravel			
	2–9.5				ML	Brown silt with occasional sand and gravel (medium stiff, moist)			
	4					Brick debris, concrete debris, rebar and wire debris			

Test pit terminated at approximately 9½ feet due to concrete block

Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on . Vertical approximated based on .

Log of Test Pit TP-4

GeoEngineers

Project: 23rd Street NE Apartments Development
Project Location: Stayton, Oregon
Project Number: 25088-005-00

Figure A-8
Sheet 1 of 1

Date Excavated	2/8/2023	Total Depth (ft)	10	Logged By / Checked By	Excavator / Equipment Hitachi Zaxis 135US	Groundwater not observed / Caving not observed

Surface Elevation (ft) / Vertical Datum	Undetermined	Latitude / Longitude	Coordinate System / Horizontal Datum	Decimal Degrees / WGS84

Elevation (feet)	Depth (feet)	SAMPLE: Testing Sample	SAMPLE: Sample Name / Testing	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0				SP-SM	Brownish gray fine to medium sand with silt, gravel and occasional cobbles (medium dense, moist)			
	2				ML	Brown and gray mottled silt (soft to medium stiff, moist)			
	10								

Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on . Vertical approximated based on .

Log of Test Pit TP-5

GeoEngineers

Project: 23rd Street NE Apartments Development
Project Location: Stayton, Oregon
Project Number: 25088-005-00

Figure A-9
Sheet 1 of 1

Date Excavated	2/8/2023	Total Depth (ft)	3	Logged By Checked By	Excavator Equipment Hitachi Zaxis 135US	Groundwater not observed Caving not observed

Surface Elevation (ft) Vertical Datum	Undetermined	Latitude Longitude	Coordinate System Horizontal Datum	Decimal Degrees WGS84

Elevation (feet)	Depth (feet)	SAMPLE: Testing Sample	SAMPLE: Sample Name / Testing	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0–0.5				SOD	Thin grass with roots to 6 inches			
	0.5–3				Fill	Recycled concrete, potential concrete slab			

Depth scale: 1, 2, 3

Test pit terminated at approximately 3 feet below ground surface due to refusal

Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on . Vertical approximated based on .

Log of Test Pit TP-6

GeoEngineers

Project: 23rd Street NE Apartments Development
Project Location: Stayton, Oregon
Project Number: 25088-005-00

Figure A-10
Sheet 1 of 1

Date:2/27/23 Path:P:\25\25088005\GINT\2508800500.GPJ DBLibrary/Library:GEOENGINEERS_DF_STD_US_JUNE_2017.GLB/GEI8_TESTPIT_1P_GEOTEC_%F

Date Excavated	2/8/2023	Total Depth (ft)	15	Logged By / Checked By	Excavator / Equipment Hitachi Zaxis 135US	Groundwater not observed / Caving not observed

Surface Elevation (ft) / Vertical Datum	Undetermined	Latitude / Longitude	Coordinate System / Horizontal Datum	Decimal Degrees / WGS84

Elevation (feet)	Depth (feet)	SAMPLE: Testing Sample	SAMPLE: Sample Name / Testing	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0–1				SM	Brown silty fine to coarse sand with gravel and cobbles (loose, moist)			
	1				ML	Brown silt with occasional sand (medium stiff, moist)			
	2		1						
	3.5		2			Becomes gray brown with occasional sand and organic matter or deteriorating roots			
	6					Becomes grayish brown			
	8.5		3						
	12		4		ML	Brown sandy silt (medium stiff, moist)			Operator notes slower digging at 12 feet
	15								

Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on . Vertical approximated based on .

Log of Test Pit TP-7

GeoEngineers

Project: 23rd Street NE Apartments Development
Project Location: Stayton, Oregon
Project Number: 25088-005-00

Figure A-11
Sheet 1 of 1

Date Excavated	2/8/2023	Total Depth (ft)	15	Logged By / Checked By	Excavator / Equipment: Hitachi Zaxis 135US	Groundwater not observed / Caving not observed

Surface Elevation (ft) / Vertical Datum	Undetermined	Latitude / Longitude	Coordinate System / Horizontal Datum	Decimal Degrees / WGS84

Elevation (feet)	Depth (feet)	SAMPLE: Testing Sample	SAMPLE: Sample Name / Testing	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0				SOD	Grass with fine roots to 6 inches			
	0.5		1		ML	Brown silt with occasional sand (stiff, moist)			
	1					Becomes medium stiff			
	2.5		2						
	5				ML	Mottled brown and gray silt with organic matter (medium stiff, moist)			
	6.5		3						
	8					Becomes grayish brown			
	11		4		ML	Brown silt with sand (stiff, moist)			
	12					Becomes sandy and wet			
	14.5–15		5						

Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on . Vertical approximated based on .

Log of Test Pit TP-8

GEOENGINEERS

Project: 23rd Street NE Apartments Development
Project Location: Stayton, Oregon
Project Number: 25088-005-00

Date Excavated	2/8/2023	Total Depth (ft)	12	Logged By Checked By	Excavator Equipment Hitachi Zaxis 135US	Groundwater not observed Caving not observed

Surface Elevation (ft) Vertical Datum	Undetermined	Latitude Longitude	Coordinate System Horizontal Datum	Decimal Degrees WGS84

Elevation (feet)	Depth (feet)	SAMPLE: Testing Sample	SAMPLE: Sample Name Testing	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0				SOD	Thin grass layer with fine roots to 8 inches			
					SM	Brown silty fine to medium sand with gravel (loose, moist)			
	1				ML	Grayish brown silt with sand and occasional deteriorating roots (medium stiff, moist)			
	4		1						
	9								Slow digging at 9 feet
	12		2						

Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on . Vertical approximated based on .

Log of Test Pit TP-9

GeoEngineers

Project: 23rd Street NE Apartments Development
Project Location: Stayton, Oregon
Project Number: 25088-005-00

Date Excavated 2/8/2023	Total Depth (ft) 14	Logged By Checked By	Excavator Equipment Hitachi Zaxis 135US	See "Remarks" section for groundwater observed Caving not observed
Surface Elevation (ft) Vertical Datum Undetermined		Latitude Longitude	Coordinate System Decimal Degrees Horizontal Datum WGS84	

Elevation (feet)	Depth (feet)	SAMPLE: Testing Sample	SAMPLE: Sample Name / Testing	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0				SOD	Thin grass with trace roots to 6 inches			
	0.5				ML	Brown silt with occasional sand (stiff, moist)			
	2								4-inch steel waterline encountered at 2 feet
	3.5		1			Becomes mottled and medium stiff			Very slow groundwater seepage observed at 3½ feet
	6.5					Becomes grayish brown			
	7.5		2						
	8					With occasional sand to sandy			
	8.5								Operator notes slower digging at 8½ feet
	11.5		3						
	13					Moderate oxidation staining at 13 feet			
	14								

Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on . Vertical approximated based on .

Log of Test Pit TP-10

GEOENGINEERS

Project: 23rd Street NE Apartments Development
Project Location: Stayton, Oregon
Project Number: 25088-005-00

Date Excavated	2/8/2023	Total Depth (ft)	11	Logged By		Excavator		Groundwater not observed
				Checked By		Equipment	Hitachi Zaxis 135US	See "Remarks" section for caving observed

Surface Elevation (ft) Vertical Datum	Undetermined	Latitude Longitude		Coordinate System Horizontal Datum	Decimal Degrees WGS84

Elevation (feet)	Depth (feet)	SAMPLE Testing Sample	SAMPLE Sample Name Testing	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0				SOD	Thin grass with fine roots to 6 inches			
	0.5				SP-SM	Brown fine to medium sand with gravel, occasional cobbles and organic debris (medium dense, moist)			
	2				Fill	Recycled concrete, very dense with brick, plastic debris (very dense, moist) (fill)			Concrete debris around 4 to 5 feet
	5				ML	Brown sandy silt with occasional construction debris (medium stiff, moist)			Moderate caving observed from 6 to 9 feet
	6		1						
	6.5				GP	Brown and gray fine to coarse gravel with occasional construction debris (loose to medium dense, moist)			
	9				ML	Brown silt (medium stiff, moist)			
	11								

Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on . Vertical approximated based on .

Log of Test Pit TP-11

GeoEngineers

Project: 23rd Street NE Apartments Development
Project Location: Stayton, Oregon
Project Number: 25088-005-00

Figure A-15
Sheet 1 of 1

Date Excavated 2/8/2023	Total Depth (ft) 6.5	Logged By Checked By	Excavator Equipment Hitachi Zaxis 135US	Groundwater not observed Caving not observed

Surface Elevation (ft) Vertical Datum	Undetermined	Latitude Longitude	Coordinate System Horizontal Datum	Decimal Degrees WGS84

Elevation (feet)	Depth (feet)	SAMPLE: Testing Sample	SAMPLE: Sample Name / Testing	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
					SOD	Thin grass layer with trace roots to 6 inches			
					ML	Brown sandy silt (stiff, moist)			
	1				Fill	Recycled concrete with rebar, wires, glass and brick debris (very dense, moist)			
	2								
	3								
	4								
	5								
	6								

Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on . Vertical approximated based on .

Log of Test Pit TP-12

GeoEngineers

Project: 23rd Street NE Apartments Development
Project Location: Stayton, Oregon
Project Number: 25088-005-00

Figure A-16
Sheet 1 of 1

Date:2/27/23 Path:P:\25\25088005\GINT\2508800500.GPJ DBLibrary/Library:GEOENGINEERS_DF_STD_US_JUNE_2017.GLB/GEI8_TESTPIT_1P_GEOTEC_%F

Date Excavated	2/8/2023	Total Depth (ft)	12	Logged By	Checked By	Excavator	Equipment Hitachi Zaxis 135US	Groundwater not observed	Caving not observed

Surface Elevation (ft) Vertical Datum	Undetermined	Latitude Longitude	Coordinate System Horizontal Datum	Decimal Degrees WGS84

Elevation (feet)	Depth (feet)	SAMPLE: Testing Sample	SAMPLE: Sample Name Testing	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0				SOD	Thin layer of grass with fine roots to 6 inches			
	0.5				SP	Gray fine to medium sand with gravel (loose, moist)			
	1				ML	Brown silt with occasional sand (stiff, moist)			
	4		1			Becomes grayish brown and medium stiff			
	6					Becomes wet			
	8.5		2						
	12								

Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on . Vertical approximated based on .

Log of Test Pit TP-13

GeoEngineers

Project: 23rd Street NE Apartments Development
Project Location: Stayton, Oregon
Project Number: 25088-005-00

Figure A-17
Sheet 1 of 1

Date Excavated	2/8/2023	Total Depth (ft)	12	Logged By	Checked By	Excavator	Equipment Hitachi Zaxis 135US	Groundwater not observed	Caving not observed

Surface Elevation (ft) Vertical Datum	Undetermined	Latitude Longitude		Coordinate System Horizontal Datum	Decimal Degrees WGS84

Elevation (feet)	Depth (feet)	SAMPLE: Testing Sample	SAMPLE: Sample Name Testing	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0				SOD	Thin layer of grass with fine roots to 6 inches			
	0.5				ML	Brown sandy silt with occasional gravel (stiff, moist)			
	1.25				SP	Gray fine to coarse sand with gravel (medium dense, moist)			
	2				ML	Brown silt with occasional sand (stiff, moist)			
	4								Operator notes easy digging to 4 to 5 feet, then medium after
	5					Becomes grayish brown with organic matter			
	5	▯	1						
	8.5	▯	2						
	11.5	▯	3						
	12								

Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on . Vertical approximated based on .

Log of Test Pit TP-14

GeoEngineers

Project: 23rd Street NE Apartments Development
Project Location: Stayton, Oregon
Project Number: 25088-005-00

Date:2/27/23 Path:P:\25\25088005\GINT\2508800500.GPJ DBLibrary/Library:GEOENGINEERS_DF_STD_US_JUNE_2017.GLB/GEI8_TESTPIT_1P_GEOTEC_%F

APPENDIX B
Report Limitations and Guidelines for Use

APPENDIX B
REPORT LIMITATIONS AND GUIDELINES FOR USE[1]

This appendix provides information to help you manage your risks with respect to the use of this report.

Read These Provisions Closely

It is important to recognize that the geoscience practices (geotechnical engineering, geology and environmental science) rely on professional judgment and opinion to a greater extent than other engineering and natural science disciplines, where more precise and/or readily observable data may exist. To help clients better understand how this difference pertains to our services, GeoEngineers includes the following explanatory "limitations" provisions in its reports. Please confer with GeoEngineers if you need to know more how these "Report Limitations and Guidelines for Use" apply to your project or site.

Geotechnical Services Are Performed for Specific Purposes, Persons and Projects

This report has been prepared for Greenlight Development and their authorized agents and/or regulatory agencies for the project specifically identified in the report. The information contained herein is not applicable to other sites or projects.

GeoEngineers structures its services to meet the specific needs of its clients. No party other than the party to whom this report is addressed may rely on the product of our services unless we agree to such reliance in advance and in writing. Within the limitations of the agreed scope of services for the Project, and its schedule and budget, our services have been executed in accordance with our Agreement with Greenlight Development dated January 24, 2023 and generally accepted geotechnical practices in this area at the time this report was prepared. We do not authorize, and will not be responsible for, the use of this report for any purposes or projects other than those identified in the report.

A Geotechnical Engineering or Geologic Report is Based on a Unique Set of Project-Specific Factors

This report has been prepared for the proposed Salem 23rd & Center Apartments Development located at the area described in the report and listed as 2561 Center Street NE and 755 Medical Center Drive NE in Salem, Oregon. GeoEngineers considered a number of unique, project-specific factors when establishing the scope of services for this project and report. Unless GeoEngineers specifically indicates otherwise, it is important not to rely on this report if it was:

- Not prepared for you,
- Not prepared for your project,
- Not prepared for the specific site explored, or
- Completed before important project changes were made.

[1] Developed based on material provided by ASFE, Professional Firms Practicing in the Geosciences; www.asfe.org.

For example, changes that can affect the applicability of this report include those that affect:

- The function of the proposed structure;
- Elevation, configuration, location, orientation or weight of the proposed structure;
- Composition of the design team; or
- Project ownership.

If changes occur after the date of this report, GeoEngineers cannot be responsible for any consequences of such changes in relation to this report unless we have been given the opportunity to review our interpretations and recommendations. Based on that review, we can provide written modifications or confirmation, as appropriate.

Environmental Concerns Are Not Covered

Unless environmental services were specifically included in our scope of services, this report does not provide any environmental findings, conclusions, or recommendations, including but not limited to, the likelihood of encountering underground storage tanks or regulated contaminants.

Subsurface Conditions Can Change

This geotechnical or geologic report is based on conditions that existed at the time the study was performed. The findings and conclusions of this report may be affected by the passage of time, by man-made events such as construction on or adjacent to the site, new information or technology that becomes available subsequent to the report date, or by natural events such as floods, earthquakes, slope instability or groundwater fluctuations. If more than a few months have passed since issuance of our report or work product, or if any of the described events may have occurred, please contact GeoEngineers before applying this report for its intended purpose so that we may evaluate whether changed conditions affect the continued reliability or applicability of our conclusions and recommendations.

Geotechnical and Geologic Findings Are Professional Opinions

Our interpretations of subsurface conditions are based on field observations from widely spaced sampling locations at the site. Site exploration identifies the specific subsurface conditions only at those points where subsurface tests are conducted or samples are taken. GeoEngineers reviewed field and laboratory data and then applied its professional judgment to render an informed opinion about subsurface conditions at other locations. Actual subsurface conditions may differ, sometimes significantly, from the opinions presented in this report. Our report, conclusions and interpretations are not a warranty of the actual subsurface conditions.

Geotechnical Engineering Report Recommendations Are Not Final

We have developed the following recommendations based on data gathered from subsurface investigation(s). These investigations sample just a small percentage of a site to create a snapshot of the subsurface conditions elsewhere on the site. Such sampling on its own cannot provide a complete and accurate view of subsurface conditions for the entire site. Therefore, the recommendations included in this report are preliminary and should not be considered final. GeoEngineers' recommendations can be finalized only by observing actual subsurface conditions revealed during construction. GeoEngineers cannot assume responsibility or liability for the recommendations in this report if we do not perform construction observation.

We recommend that you allow sufficient monitoring, testing and consultation during construction by GeoEngineers to confirm that the conditions encountered are consistent with those indicated by the explorations, to provide recommendations for design changes if the conditions revealed during the work differ from those anticipated, and to evaluate whether earthwork activities are completed in accordance with our recommendations. Retaining GeoEngineers for construction observation for this project is the most effective means of managing the risks associated with unanticipated conditions. If another party performs field observation and confirms our expectations, the other party must take full responsibility for both the observations and recommendations. Please note, however, that another party would lack our project-specific knowledge and resources.

A Geotechnical Engineering or Geologic Report Could Be Subject to Misinterpretation

Misinterpretation of this report by members of the design team or by contractors can result in costly problems. GeoEngineers can help reduce the risks of misinterpretation by conferring with appropriate members of the design team after submitting the report, reviewing pertinent elements of the design team's plans and specifications, participating in pre-bid and preconstruction conferences, and providing construction observation.

Do Not Redraw the Exploration Logs

Geotechnical engineers and geologists prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. The logs included in a geotechnical engineering or geologic report should never be redrawn for inclusion in architectural or other design drawings. Photographic or electronic reproduction is acceptable but separating logs from the report can create a risk of misinterpretation.

Give Contractors a Complete Report and Guidance

To help reduce the risk of problems associated with unanticipated subsurface conditions, GeoEngineers recommends giving contractors the complete geotechnical engineering or geologic report, including these "Report Limitations and Guidelines for Use." When providing the report, you should preface it with a clearly written letter of transmittal that:

- Advises contractors that the report was not prepared for purposes of bid development and that its accuracy is limited; and
- Encourages contractors to confer with GeoEngineers and/or to conduct additional study to obtain the specific types of information they need or prefer.

Contractors Are Responsible for Site Safety on Their Own Construction Projects

Our geotechnical recommendations are not intended to direct the contractor's procedures, methods, schedule or management of the work site. The contractor is solely responsible for job site safety and for managing construction operations to minimize risks to on-site personnel and adjacent properties.

Biological Pollutants

GeoEngineers' Scope of Work specifically excludes the investigation, detection, prevention, or assessment of the presence of Biological Pollutants. Accordingly, this report does not include any interpretations, recommendations, findings or conclusions regarding the detecting, assessing, preventing or abating of Biological Pollutants, and no conclusions or inferences should be drawn regarding Biological Pollutants as they may relate to this project. The term "Biological Pollutants" includes, but is not limited to, molds, fungi, spores, bacteria and viruses, and/or any of their byproducts.

A Client that desires these specialized services is advised to obtain them from a consultant who offers services in this specialized field.

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