Report of Preliminary Geotechnical Exploration
1555 Juniper Street
Charleston, South Carolina 29407

Prepared For:
Mr. Michael Kiefer
City of Charleston
Department of Housing and Community Development
75 Calhoun Street, Suite 3200
Charleston, South Carolina 29401

Prepared By:
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VOLKMAR CONSULTING SERVICES, LLC
PO BOX 2485
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September 13, 2021
VCS Project 21-3191
September 13, 2021

Mr. Michael Kiefer  
City of Charleston  
Department of Housing and Community Development  
75 Calhoun Street, Suite 3200  
Charleston, South Carolina 29401  
Transmitted via Email: Michael Kiefer <kieferm@charleston-sc.gov>

Subject: Report of Preliminary Geotechnical Exploration  
1555 Juniper Street  
Charleston, South Carolina 29407  
VCS Project 21-3191

Dear Mr. Kiefer:

Volkmar Consulting Services, LLC (VCS) is pleased to submit this report of a preliminary geotechnical exploration for the subject site. The purpose of this exploration was to obtain general information on the subsurface conditions at the site and provide recommendations for foundation support and site preparation relative to the proposed construction. This report presents our understanding of the project, a summary of the subsurface conditions, an evaluation of the data, and our geotechnical recommendations.

PROJECT INFORMATION

The subject site is located off Juniper Street in Charleston, Charleston County, South Carolina. The Charleston County Tax Assessor’s Office specifically identifies the subject site with the TMS Numbers of s350-03-00-185 and 350-03-00-186. VCS understands the subject site will consist of 5 residential units positioned on the perimeter of the site. Drives and parking will also be placed to serve the residential units. We understand that the drives are planned to consist of pervious materials. You provided conceptual layouts prepared by Bello Garris Architects, titled “Juniper Street Residences A100” dated 2/2/2021. The subject site is currently cleared.

We have received project information from recent conversations with you, our review of the provided documents, readily available aerial photographs, our work at the site, and work in surrounding areas. Based on our review of the provided information, VCS understands that the future construction will consist of residential buildings.

We understand this work is required for preliminary geotechnical evaluations of the subsurface soils of the subject site. Additional geotechnical work may be required as the design process progresses.

The US Army Corp of Engineers publication titled “Settlement Analysis” Table 1-2 presents typical loads on building foundations. The document presents “Individual Housing” as having line loads with 0.5 to 1 tons/ft with column loads with less than 5 tons. For the purposes of this assessment, we have evaluated the design life for the proposed structures at 50 years and the proposed average contact pressure to be less than or equal to 0.5 tsf.
EXPLORATION PROCEDURES
A total of two (2) cone penetration tests (CPT) soundings (designated as S-1 and S-2); and, ten (10) hand auger borings (designated as HA-1 through HA-10) with dynamic cone penetrometer (DCP) testing were performed at the subject site. The CPT sounding was advanced to approximate depths of approximately 35-feet below the ground surface (bgs), where our soundings were terminated. We additionally conducted an infiltration rate of soils in field using double-ring infiltrometer in general accordance with ASTM D3385-18.

CPT is used to assist in the determination of soil stratigraphy and the identification of soil type. This typically is accomplished using correlations of cone parameters to soil type. Early charts using qc and friction ratio, Rf [where: Rf = (fs/qc)100%] where proposed by Douglas and Olsen (1981), but the correlations proposed by Robertson et al. (1986) has become very popular (e.g. Long, 2008) and were used on this project. The original Robertson et al (1986) correlation chart based on qt and Rf is shown below. Although the chart is shown in terms of the corrected cone resistance qt, it can be used equally well with uncorrected cone resistance, qc, since the difference between qc and qt is small, except in soft fine grained soils, where qc < 1 MPa. The chart by Robertson et al (1986) uses the basic CPT measurements of qc and fs and has 12 soil types, whereas the chart by Robertson (1990) uses normalized parameters Soil Behavior Type from the CPT: an update P.K. Robertson Gregg Drilling & Testing Inc., Signal Hill, California, USA ABSTRACT: One of the most common applications of CPT results is to evaluate soil type and soil stratigraphy.

<table>
<thead>
<tr>
<th>Zone</th>
<th>Soil Behavior Type</th>
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<tbody>
<tr>
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<td>Sensitive, Fine Grained</td>
</tr>
<tr>
<td>2</td>
<td>Organic Material</td>
</tr>
<tr>
<td>3</td>
<td>Clay</td>
</tr>
<tr>
<td>4</td>
<td>Silty Clay to Clay</td>
</tr>
<tr>
<td>5</td>
<td>Clayey Silt to Silty Clay</td>
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<tr>
<td>6</td>
<td>Sandy Silt to Clayey Silt</td>
</tr>
<tr>
<td>7</td>
<td>Silty Sand to Sandy Silt</td>
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<td>8</td>
<td>Sand to Silty Sand</td>
</tr>
<tr>
<td>9</td>
<td>Sand</td>
</tr>
<tr>
<td>10</td>
<td>Gravelly Sand to Sand</td>
</tr>
<tr>
<td>11</td>
<td>Very Stiff Fine Grained*</td>
</tr>
<tr>
<td>12</td>
<td>Sand to Clayey Sand*</td>
</tr>
</tbody>
</table>

*Overconsolidated or Cemented

SBT chart by Robertson et al (1986) based on CPT cone resistance, qt, and friction ratio, Rf
(where Rf = (fs/qc)100%)

The approximate locations of the Hand Auger borings, CPT soundings, and ASTM D3385-18 “Standard Test Method of Infiltration Rate of Soils in Field Using Double-Ring Infiltrometer” test location are shown on the attached Figure 1: Boring Location Plan. The testing locations were placed in the field by VCS personnel during a site visit in the areas identified after our review of the Bello Garris drawings. All test locations shown on the attached figure should be considered approximate.
Drawing referenced from provided documents accessed on 9/8/2021.
Not to scale

**Figure 1: Boring Location Plan**

**Legend:**
- CPT Sounding Location
- Hand Auger Boring Location
- Double Ring Infiltration Rate Test Location

1555 Juniper Street
Charleston, South Carolina

Prepared by: TJA          Date: 9/8/2021

VCS Project 21-3191

Checked by: TEV          Date: 9/9/2021
An integrated, electronic, piezocone system (Vertek S4-Scorpion) was used to measure the subsurface soil strength parameters and determine the soil behavior type. Cone tip resistance, sleeve friction, and pore water pressure were measured at depth intervals of approximately two centimeters. The cone penetration test soundings were performed in general accordance with ASTM D5778.

The hand auger borings were advanced by manually twisting a bucket style auger into the soil to the test depth. The soil consistency at selected depths was measured using a dynamic cone penetrometer (DCP). The penetrometer’s conical point was first seated 2-inches to penetrate loose cuttings and then driven two additional 1-3/4-inch increments with blows from a 15-pound hammer falling 20-inches. The soil samples were classified in the field at the time of boring.

Groundwater level measurements, if encountered, were measured during the field work conducted on site. The groundwater was measured during the site work and the test locations were backfilled after drilling due to safety concerns; therefore, 24-hour levels were not obtained.
SUBSURFACE CONDITIONS

The US Department of Agricultural Natural Resource Conservation Service (USDA-NRCS) has published data regarding typical soil conditions in the area. The USDA has mapped the soils at the site and identified them as “Edisto.”

“EDISTO SERIES

The Edisto series consists of somewhat poorly drained, moderately permeable soils that formed in marine sediments. Slopes range from 0 to 2 percent. These soils are besequel; typically they have very dark grayish brown loamy fine sand A horizons, light olive brown fine sandy loam B horizons, light brownish gray loamy fine sand A2 horizons, and mottled fine sandy loam B2t horizons.

TAXONOMIC CLASS: Coarse-loamy, siliceous, active, thermic Glossaqui Hapludalfs

TYPICAL PEDON: Edisto loamy fine sand--cultivated field. (Colors are for moist soil unless otherwise stated.)

Ap--0 to 10 inches; very dark grayish-brown (10YR 3/2) loamy fine sand; weak fine granular structure; very friable; common fine roots; few fine dark reddish-brown concretions; strongly acid; clear smooth boundary. (7 to 11 inches thick)

E--10 to 14 inches; pale brown (10YR 6/3) loamy fine sand; weak fine granular structure; very friable; few fine roots; few fine dark reddish-brown concretions; strongly acid; clear wavy boundary. (4 to 6 inches thick)

Bt--14 to 19 inches; light olive-brown (2.5Y 5/4) fine sandy loam; common fine distinct yellowish-brown mottles; weak medium subangular blocky structure; friable; few fine roots; many fine and few medium root channels; strong brown staining around larger pores; sand grains coated with clay; common medium dark reddish-brown concretions; strongly acid; gradual wavy boundary. (4 to 12 inches thick)

A&B--19 to 27 inches; light brownish-gray (10YR 6/2) loamy fine sand A material; common medium faint yellowish-brown (10YR 5/6) and many medium faint brown (10YR 5/3) mottles of fine sandy loam B material; weak medium subangular blocky structure; friable; few fine roots; many fine root channels stained with strong brown; few fine dark reddish-brown concretions; medium acid; gradual wavy boundary. (6 to 10 inches thick)

E’--27 to 36 inches; light brownish-gray (10YR 6/2) loamy fine sand; common fine brown mottles; single grained; loose; few fine vesicular pores; brown-staining in pores; few fine irregularly shaped reddish-brown concretions; medium acid; abrupt smooth boundary. (8 to 10 inches thick)

B’t1--36 to 50 inches; mottled pale brown (10YR 6/3) yellowish-brown (10YR 5/6), and gray (10YR 6/1) fine sandy loam; moderate coarse and medium prismatic structure that parts into moderate medium subangular blocky structure; friable; brown portion is slightly brittle; few brown-stains in pores; thin patchy clay films on face of some peds;
interfingering of A2 material that is 2 to 5 mm. thick between prisms; strongly acid; gradual wavy boundary. (12 to 15 inches thick)

B't2--50 to 62 inches; mottled light gray (10YR 7/1) and strong brown (7.5YR 5/8) fine sandy loam; moderate medium subangular blocky structure; friable; brown portion is slightly brittle; thin patchy clay films on faces of some peds; thin streaks and pockets of clean sand grains; very strongly acid; gradual wavy boundary. (10 to 14 inches thick)

B't3--62 to 70 inches; mottled brownish-yellow (10YR 6/8), light brownish-gray (2.5Y 6/2), strong brown (7.5YR 5/8), and light gray (2.5Y 7/2) sandy clay loam; moderate medium subangular blocky structure; friable; thin patchy clay films on faces of some peds; thin streaks and pockets of clean sand grains; very strongly acid; gradual wavy boundary. (6 to 10 inches thick)

BC--70 to 84 inches; light gray (2.5Y 7/2) fine sand; common fine distinct strong brown mottles; single grained; loose; very strongly acid.

TYPE LOCATION: Charleston County, South Carolina, 1-1/2 miles southeast of Hollywood on north side of field road, 650 feet south of Seaboard Airline Railroad, and 950 feet west of County Road 79.

RANGE IN CHARACTERISTICS: Solum thickness is more than 60 inches. Reaction ranges from very strongly acid through medium acid, except for surface layers that has been limed. Base saturation is more than 35 percent, generally less than 55 percent.

The A or Ap horizon has hue of 10YR, value of 3 or 4, and chroma of 1 or 2. Texture is loamy sand, loamy fine sand; sandy loam, or fine sandy loam.

The E or E' horizon has hue of 10YR or 2.5Y, value of 4 to 6, and chroma of 2 or 3. Texture is loamy sand, loamy fine sand; sandy loam, or fine sandy loam.

The Bt or horizon has hue of 10YR or 2.5Y, value of 4 or 5, and chroma of 2 to 6. Few to common mottles mostly in shades of brown are in most pedons. Some pedons have a few fine gray mottles. It is sandy loam or fine sandy loam.

The B't horizon is mottled in shades of brown, yellow, and gray with hue of 10YR to 2.5Y, value of 5 or 6, and chroma of 2 to 8. It is fine sandy loam or sandy clay loam.

The BC horizon is mottled light gray to dark gray sand, fine sand, or loamy sand.

COMPETING SERIES: There are no other known series in the family. The Coteau, Farrenburg, Frizell, Longview, and Vidrine series are similar series in related families. Coteau, Frizell, Longview, and Vidrine soils have by weight, less than 15 percent fine sand or coarser material in the control section. Farrenburg soils have 18 to 35 percent clay in the control section.

GEOGRAPHIC SETTING: Edisto soils are on the Pamlico Terrace of the lower coastal plain. They formed in thick sandy marine sediments. Near the type location mean annual
temperature is 66 degrees F., mean annual precipitation is 48 inches, and the freeze-free season is 294 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Meggett, Seabrook, Stono, and Wando series, none of which have bisequal. In addition, Wando and Seabrook soils lack argillic horizons; Stono soils have mollic epipedons; and Meggett soils have more than 35 percent clay in the argillic horizons.

DRAINAGE AND PERMEABILITY: Somewhat poorly drained; slow surface runoff; moderate permeability. The water table is 1 to 3 feet during the spring and winter months.

USE AND VEGETATION: Most of these soils are in crops or pasture; the remainder is in loblolly pines. Common crops are cabbage, potatoes, snap beans, cucumbers, tomatoes, soybeans, corn, and small grain.

DISTRIBUTION AND EXTENT: Lower Coastal Plain of South Carolina, and possibly Georgia, Florida, and North Carolina. The series is of moderate extent; more than 14,000 acres is in Charleston County, South Carolina.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Raleigh, North Carolina

SERIES ESTABLISHED: Charleston County, South Carolina, 1955.”

The USDA-NRCS has rated construction in the above soil types without basements as “Somewhat Limited”. Shallow excavations are listed as “Very Limited.” The contractor should be prepared for excavation shoring or sloping as a safety precaution, should excavations take place.

The subject site is located on the southern boundary of Juniper Street. To the north, the subject site is bordered by Juniper Street with residential parcels beyond. To the south, the subject site is bordered by residential parcels. To the west, the subject site is bordered by residential parcels. To the east, the subject site is bordered by residential parcels. The surface remained stable under the weight of our drilling equipment. The site is moderately level.
A review of the National Flood Insurance Program Flood Insurance Rate Map (FIRM) for Charleston County (Map Number 45019C0492K) dated January 29, 2021, identified the site as Zone X. X zones are areas of minimal flood hazard, usually depicted on FIRMs as above the 500-year flood level. Zone X is the area determined to be outside the 500-year flood and protected by levee from 100-year flood.

The subsurface conditions encountered throughout the site are presented graphically on the CPT and Hand Auger Logs presented below. The subsurface stratigraphy indicated on the test records is for illustrative purposes only and the conditions in areas not penetrated by the test locations may vary from those shown.

The CPT soundings generally encountered loose to firm sands with varying amounts of silt from the ground surface to approximately 3-feet bgs (below the ground surface). Following this, our soundings generally encountered firm to stiff clays from 3 to 6-feet bgs. This soil was underlain by firm to loose sands with varying amounts of silt from approximately 6 to 8-feet bgs. Below this, our soundings generally encountered very loose sensitive fine grains from 8 to 17-feet bgs. Following this, our soundings generally encountered loose to very firm sands from 17 to 25-feet bgs. This soil was underlain by firm to stiff silt with varying amounts of sand from 25 to 35-feet bgs where our boring was terminated.
Our auger borings generally encountered loose to very firm clayey SAND from the ground surface to approximately 4.5-feet bgs, which is the termination depth of our hand auger borings.

SOIL CLASSIFICATION AND OBSERVATIONS

Moist, loose to firm, brown and tan silty SAND (SM)

Boring terminated at 4.5-feet below the ground surface.

**HAND AUGER BORING RECORD**

- **Sample**: DCP Blow Count
- **Grownwater Reading**
- **% Finer than No. 200 Sieve**
- **Natural Moisture Content (%)**

**Remarks**: Sample Type (Grab) indicates grab sample from auger bucket. Groundwater was not encountered at the time of the boring.
SOIL CLASSIFICATION AND OBSERVATIONS

<table>
<thead>
<tr>
<th>No.</th>
<th>DCP Blow Count</th>
<th>Grownwater Reading</th>
<th>% Finer than No. 200 Sieve</th>
<th>Natural Moisture Content (%)</th>
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<td>2</td>
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</table>

Moist, loose, brown and tan, silty SAND (SM)

Boring terminated at 4.5-feet below the ground surface.

Moist, stiff, brown and tan, CLAY (CL)

Remarks: Sample Type (Grab) indicates grab sample from auger bucket. Groundwater was not encountered at the time of the boring.
### SOIL CLASSIFICATION AND OBSERVATIONS

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Sample</th>
<th>DCP Blow Count</th>
<th>Groundwater Reading</th>
<th>% Finer than No. 200 Sieve</th>
<th>Natural Moisture Content (%)</th>
</tr>
</thead>
<tbody>
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<td>12</td>
<td>12</td>
<td>12</td>
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<tr>
<td>3-1 Grab</td>
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<td>11</td>
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<td>3-1 Grab</td>
<td>9</td>
<td>14</td>
<td>15</td>
<td>9</td>
<td>14</td>
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Boring terminated at 4.5-feet below the ground surface.

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**Hand Auger Boring Record**

**Boring: HA-3**

- **Field Personnel:** TJA
- **Equipment:** Hand Auger & Dynamic Cone Penetrometer
- **Hole Dia.:** 3-1/4 inches
- **Remarks:** Sample Type (Grab) indicates grab sample from auger bucket. Groundwater was not encountered at the time of the boring.
### SOIL CLASSIFICATION AND OBSERVATIONS

<table>
<thead>
<tr>
<th>SAMPLE</th>
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<tr>
<td>No.</td>
<td>1st 2&quot;</td>
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<tr>
<td></td>
<td>% Finer than No. 200 Sieve</td>
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#### Field Personnel:
TJA

#### Equipment:
Hand Auger & Dynamic Cone Penetrometer

#### Project:
1555 Juniper Street

#### Remarks:
Sample Type (Grab) indicates grab sample from auger bucket. Groundwater was not encountered at the time of the boring.

#### Boring Terminated at:
4.5-feet below the ground surface.

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**DCP Blow Count**

<table>
<thead>
<tr>
<th>Sample</th>
<th>DCP Blow Count</th>
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<tr>
<td>No.</td>
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**Hand Auger Boring Record**

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<th>Hole Dia.</th>
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**VCS Project:** 21-3191

**Page:** 1 of 1
### SOIL CLASSIFICATION AND OBSERVATIONS

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<th>E</th>
<th>P</th>
<th>T</th>
<th>H</th>
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<tbody>
<tr>
<td></td>
<td>Moist, loose, brown and orange clayey SAND (SC)</td>
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</table>

### HAND AUGER BORING RECORD

**BORING: HA-5**

**Project:** 1555 Juniper Street  
**Drilled:** 09/03/2021  
**Hole Dia.:** 3-1/4 inches  
**VCS Project:** 21-3191

**Remarks:** Sample Type (Grab) indicates grab sample from auger bucket. Groundwater was not encountered at the time of the boring.
Moist, loose, brown and orange clayey SAND (SC)

Boring terminated at 4.5-feet below the ground surface.
SOIL CLASSIFICATION AND OBSERVATIONS

<table>
<thead>
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<th>SAMPLE</th>
<th>DCP BLOW COUNT</th>
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<td>No.</td>
<td>1st 2&quot;</td>
</tr>
<tr>
<td>T</td>
<td>P</td>
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</table>

- Moist, firm to loose, brown and orange clayey SAND (SC)

FIELD PERSONNEL: TJA

equipment: Hand Auger & Dynamic Cone Penetrometer

HOLE DIA.: 3-1/4 inches

REMARKS: Sample Type (Grab) indicates grab sample from auger bucket. Groundwater was not encountered at the time of the boring.
Moist, loose to firm, brown and orange clayey SAND (SC)

Boring terminated at 4.5-feet below the ground surface.

BORING: HA-8

Field Personnel: TJA
Equipment: Hand Auger & Dynamic Cone Penetrometer
Hole Dia.: 3-1/4 inches
Remarks: Sample Type (Grab) indicates grab sample from auger bucket. Groundwater was not encountered at the time of the boring.
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<td>SOIL CLASSIFICATION AND OBSERVATIONS</td>
<td>SAMPLE</td>
<td>DCP BLOW COUNT</td>
<td>DCP BLOW COUNT</td>
<td>NATURAL MOISTURE CONTENT (%)</td>
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<td>Moist, loose, brown and orange clayey SAND (SC)</td>
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</table>

**BORING TERMINATED AT 4.5 FEET BELOW THE GROUND SURFACE.**

**FIELD PERSONNEL:** TJA  
**EQUIPMENT:** Hand Auger & Dynamic Cone Penetrometer  
**HOLE DIA.:** 3-1/4 inches  
**REMARKS:** Sample Type (Grab) indicates grab sample from auger bucket. Groundwater was not encountered at the time of the boring.
The groundwater level was approximated in the sounding to be approximately 3.2-feet bgs. Groundwater was not encountered at the time, in our hand auger borings. Fluctuations will occur with rainfall variations, construction operations, surface runoff, and other factors.
VCS performed moisture (ASTM D2216) and percent passing a number 200 sieve (ASTM D1140) laboratory testing on representative samples adjacent to the double ring infiltrometer test. The sample at the ground surface had a natural moisture of 6.3% with a percent passing a 200 sieve of 10.9%, which classifies this soil as a poorly graded SAND with some SILT (SM) in accordance with the USCS (Unified Soil Classification System). The sample from 2-inches below the surface had a natural moisture of 6.9% with a percent passing a 200 sieve of 8.2%, which classifies this soil as a poorly graded SAND with some SILT (SM) in accordance with the USCS (Unified Soil Classification System). The sample from 4-inches below the surface had a natural moisture of 6.3% with a percent passing a 200 sieve of 8.9%, which classifies this soil as a poorly graded SAND with some SILT (SM) in accordance with the USCS (Unified Soil Classification System). The sample from 6-inches below the surface had a natural moisture of 7.8% with a percent passing a 200 sieve of 9.2%, which classifies this soil as a poorly graded SAND with some SILT (SM) in accordance with the USCS (Unified Soil Classification System).
PROFESSIONAL OPINIONS AND RECOMMENDATIONS
The following sections present our recommendations for site preparation; fill placement; and, foundation design and construction.

Site Preparation: The subject site is currently cleared with light vegetation. Site preparation should include the removal of topsoil. Topsoil should be completely removed from structural areas and localized areas; stump holes may require more stripping. Topsoil and/or organic laden soils should be removed from the construction areas or sifted and re-used as topsoil in areas to be landscaped. The contractor should be prepared to remove up to 6-inches of material with areas of former root balls deeper.

During stripping and rough grading for the building pad positive surface drainage should be maintained to prevent the accumulation of water on the subgrade surface. Excavations resulting from the removal of trees and debris should be properly backfilled with structural fill.

The site preparation should be planned such that stripped areas, root holes or other excavation areas are filled prior to inclement weather; rubber-tired traffic is minimized across stripped areas; and positive drainage is maintained in all areas. Failure to plan in this manner could result in an otherwise stable area becoming unstable and requiring drying or undercut and replacement.

Proofrolling and Near Surface Soil Compaction: VCS recommends that a proofroll be conducted after stripping in future structural areas, particularly prior to fill placement, to identify any soft or wet areas that may require remediation and to densify the near surface soils. Proofrolling in saturated or wet conditions soils may degrade otherwise suitable soils and should be remediated by scarifying, drying to within ± two (2) percentage points of the optimum moisture content and compacted with a minimum three-foot to four-foot diameter vibratory roller operated in static mode. The proofroll should be conducted by rolling a slow-moving loaded dump truck or other pneumatic-tired vehicle of similar size and weight over the subgrade. Unsuitable or unstable materials observed to excessively rut or pump during the proofroll should be undercut and replaced with compacted fill or stabilized in-place. VCS should observe unsuitable areas, if encountered, to provide recommendations concerning the undercut depths.

The timing of the Proofrolling is important. It should be conducted near the time of stripping or subgrade compaction efforts, when the moisture of the subgrade is near optimum or at the moisture content that achieved compaction. This minimizes the subgrade becoming too wet or too dry for effective Proofrolling operation. After successful Proofrolling, the placement of structural fill should be conducted immediately to protect the subbase.

Groundwater Control: The groundwater level was estimated in the sounding to be approximately 3.2-feet below the ground surface. Groundwater control may be required in low-lying areas. Groundwater can be maintained with open ditches, french drains, well points, or sump pits. Groundwater levels can be controlled more easily during construction if small, excavated areas are open at any one time. Site grading plans should allow for sloping grades and subsurface drainage away from the building pad area.

Structural Fill Placement and Compaction: Off-site fill required to achieve finished site grades could be relatively clean sand having no more than 30-percent and no less than 10-percent non-plastic or low plasticity fines. Representative samples of the proposed fill materials should be tested to determine the maximum dry density, optimum moisture content, and gradation.
Fill soils should be sands classified as SP, SC, or SM according to the United Soil Classification System, with a Maximum Dry Density of at least 100 pounds per cubic foot (pcf) as per a Modified Proctor Compaction Test (ASTM D 1557). Compacted fill should be constructed by spreading acceptable soils in loose layers generally not more than 10 to 12-inches thick. A three-foot to four-foot diameter vibratory roller should be used to compact the structural fill. In areas where groundwater is shallow, the rollers should operate in the static mode. Structural fill should be compacted in thin lifts to at least 95 percent maximum dry density, as determined by the Modified Proctor method (ASTM D1557) and the moisture content should be maintained within ± two (2) percentage points of the optimum moisture content. Moisture content levels above this can be associated with moisture related issues for building materials. Controlled Fill material imported from offsite should be free of organics and debris and VCS should test the fill to verify compliance.

**Settlement Estimates:** At this writing, the final site grades are not known but are presumed to be at 1-foot above the current site grades. Soil compression under imposed static loads was estimated based on the field data and our experience with similar soils. Based on our understanding of the construction, conditions encountered at our sounding locations, it is our opinion that settlement (primary and consolidation), not considering seismic settlement, may be up to 1.0-inch, with one-half the settlement being differential.

**Shallow Spread Foundations:** Our hand auger borings and sounding generally encountered loose to firm soils from the ground surface to approximately 4.5-feet below the ground surface. These loose near surface soils should be improved by using three-foot to four-foot diameter vibratory roller. The roller should be operated, to compact these soils, in the static mode due to the shallow groundwater level, while VCS representatives observe the activities.

VCS personnel have used the aforementioned USACE loads, the documented loading criteria and have assumed the site grade will be at the existing grade elevation. The proposed structure can be supported on shallow spread foundations sized for a net allowable bearing pressure of 1,800 pounds per square foot (psf), given the above strict accordance with the recommendations in this report. Foundation footing dimensions should have the minimum footing dimensions of 18-inches deep and 24-inches wide. Foundations should bear on properly compacted structural fill or naturally occurring subgrade soils that have been evaluated by VCS after excavation. Should the design differ from our assumption made, deep foundations or other remedial soil measures may be required.

The net allowable soil bearing pressure is that pressure that may be transmitted to the foundation bearing soils in excess of the final minimum surrounding overburden pressure. The final footing elevation should be evaluated by VCS to document that the bearing soils are capable of supporting the recommended net allowable bearing pressure and that the area is suitable for foundation construction. These evaluations typically include visual observations, hand probing with a probe rod, and/or dynamic cone penetrometer testing in general accordance with ASTM STP 399, or other methods as deemed appropriate by VCS at the time of construction.

Footing concrete should be placed the same day they are excavated and should not remain open during inclement weather. Soils loosened by water intrusion or exposure should be removed before placing concrete. VCS should observe cleaned footings prior to concrete placement to confirm that the bearing grade is consistent with the recommendations presented in this report.
Grade Slabs: Site preparation and subgrade compaction should be as recommended in the previous sections of this report. Based upon results of the conditions encountered at our test locations and correlations with published data, compacted site soils would have a modulus of subgrade reaction (ks) on the order of 300 to 400 pounds per square inch per inch (psi/in) providing that the upper 18-inches of the slab subgrade soils have been uniformly compacted to at least 95% of their Modified Proctor maximum dry density at ±2% of their optimum moisture content as described above.

VCS recommends that slabs-on-grade be underlain by a minimum of 6-inches of open graded aggregate (builders’ sand) to assist in the prevention of capillary rise of subsurface moisture from adversely affecting the slab. VCS recommends that a vapor retarder be included in the floor slab design. The design of the vapor retarder should be in accordance with American Concrete Institute (ACI) guidelines.

The slab should be designed with proper control joints (time of placement, spacing, and depth) to minimize the potential for shrinkage cracking. Utility trenches should be properly backfilled using predominately granular material. The backfill should be placed as discussed in this report.

Seismic Considerations: This site is identified as a Site Class D in accordance with the ASCE41-17 Design document. Appropriate site hazard design values are presented below:

![Figure 1: ATC Horizontal Response Spectrum](image-url)
Table 1: ATC Seismic Design Values Using ASCE41-17

The Peak Ground Acceleration was used to compute the site specific deaggregation for the 1% return in 50-years, using a $V_{S30}$ (m/s) = 760.0. The 2014 NSHMP PSHA Interactive Deaggregation Seismic-hazard tool was used for the calculation. For the given location, the relative contribution for different magnitude-distance combinations are presented below:
Employing the soil data obtained in our exploration of the subject site, our deep foundation recommendations, and our experience with neighboring sites, our analyses indicates that the potential for damage from settlement due to liquefaction at this site is moderate with anticipated seismic related settlements of greater than 1-inch in a significant earthquake. The onsite soils most susceptible to liquefaction are sandy soils from the ground surface to approximately 20-feet below the ground surface.

Cost effective procedures to assist in minimizing liquefaction and lateral spread effects are listed below. These procedures should be implemented to reduce the potential for shallow foundation bearing failure. Differential settlements and lateral movements caused by soil liquefaction may be evident after a significant earthquake.

- Isolated foundations should not be used. Pier foundations should be tied together with continuous foundations and/or grade beams.
- Post tension grade beams can be utilized to limit differential settlement due to liquefaction induced settlement.
- The near surface soil density should be increased by rolling repeatedly with a vibratory roller. The purpose of this densification is to reduce the potential for shallow foundation bearing failure.
- Mitigation of seismic settlement can be accomplished by the installation of wick drains, piles, or other soil improvement techniques if critical structures are to be constructed or if sufficient “run time” is required for life safety.

**Construction Observations and Testing:** During construction, it is important to notify VCS at certain milestones to evaluate the soil conditions. These milestones are as follows:
- VCS should observe the subgrade soils prior to fill placement.
- VCS should perform in-place density testing on compacted fill to confirm compaction in accordance with the recommendations presented in this report.
- VCS should be onsite during any soil related remedial activities as mentioned in this report.

**Infiltration Rate of Soils in Field Using Double-Ring Infiltrometer Results:**

VCS performed a double-ring infiltration test in general accordance with ASTM D3385-18. The purpose of this testing is to report the rate of infiltration of water into soils using a 12-inch inner and 24-inch outer aluminum alloy reinforced apparatus.

The apparatus was driven into the soils at the location identified in the Figure 1 drawing above. The rings were partly filled with water and the volume of water required to maintain the level was measured over time. Below is a graph of the infiltration rate measured in centimeters per hour (cm/hr) of the inner ring. The outer ring was maintained to provide soil saturation to prevent inner ring errors in measurements.

The stabilized infiltration rate was measured as 2.00 cm/hr or 0.78 in/hr.

**REPORT QUALIFICATION**

Our evaluation of foundation support conditions is based on our understanding of the site and project information and the data obtained in our exploration. The general subsurface conditions utilized in our foundation evaluation are based on interpolation of subsurface data between and below the boring(s). In evaluating the field data, we examined previous correlations between penetration resistance, foundation bearing pressures, and liquefaction resistance observed in soil conditions similar to those at this site. If the project information is incorrect or if the structure(s) location (horizontal or vertical) and/or dimension(s) change, please contact us so that our recommendations can be reviewed. The discovery of any site or subsurface conditions during construction, which deviate from the data outlined in this exploration, should be reported to us for our evaluation. This geotechnical exploration was performed using the degree of skill and care ordinarily exercised.
under similar conditions by reputable members of VCS's profession practicing in the same or similar locality at the time of performance. No other warranty, express or implied, is made or intended and the same are specifically disclaimed.

This report is intended for the use of our Client (report addressee) and is subject to the contractual terms agreed to for this project. Reliance on this document by any other party is forbidden without the express written consent of VCS, and that party's acceptance of mutually agreeable terms and conditions. Use of this report for purposes beyond those reasonably intended and summarized in our Contract with the Client (report addressee) is forbidden.

CLOSING
We appreciate the opportunity to be of service. If you have any questions concerning this report, please contact us at (843) 900-5642.

Sincerely,
VOLKMAR CONSULTING SERVICES, LLC

[Signature]

Tyler J. Armentrout
Engineering Technician

[Signature]

Thomas E. Volkmar, PE
President/Principal Engineer
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