January 25, 2019

Georgetown County
Recreation & Community Services
Georgetown, SC 29440

Attn: Ms. Beth Goodale
P: 843.545.3550
E: bgoodale@gtcounty.org

Re: Geotechnical Engineering Report
Beck Recreation Center
Georgetown, South Carolina
Terracon Project No. ER185072

Dear Ms. Goodale:

Terracon Consultants, Inc. (Terracon) has completed the geotechnical engineering services for the above referenced project. This study was performed in general accordance with our proposal number PER185072 dated November 20, 2018. This report presents the findings of the subsurface exploration and provides geotechnical recommendations concerning earthwork and the design and construction of foundations and floor slabs for the proposed project.

We appreciate the opportunity to be of service to you on this project and look forward to providing additional Geotechnical Engineering and Construction Materials Testing services in the future. If you have any questions concerning this report, or if we may be of further service, please contact us.

Sincerely,

Terracon Consultants, Inc.

Kevin Meeks, E.I.T.
Field Engineer

Wendy H. Parsons, P.E.
Senior Engineer

Guoming Lin, Ph.D., P.E.
Senior Principal
REPORT TOPICS

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SUPPORTING INFORMATION
  ❖ Laboratory Results
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GEOTECHNICAL OVERVIEW

This report presents the results of our geotechnical investigation performed for the proposed Beck Recreation Center improvements located in Georgetown, SC. Our geotechnical scope of work for this project included conducting geotechnical fieldwork, associated engineering analysis, and this geotechnical engineering report. This report provides recommendations for foundation options, seismic considerations, site preparation, and the other geotechnical related conditions that might affect the proposed construction. The following geotechnical considerations were identified during our investigation:

- Based on the procedures outlined in IBC 2015 and the results of our field testing, a seismic Site Class D will be available for this project. However, the structural engineer should verify that the site class exemption provided by this code is available for the proposed facility.

- We estimate that unmitigated total liquefaction-induced settlements from the design seismic event may be up to 2 inches with differential settlement ranging from 50% to 100% of the total.

- With proper site preparation, the structures may be supported on a shallow foundation system. An allowable bearing pressure of 2000 psf can be utilized for design purposes.

- Total estimated static settlement for traditional shallow foundations is 1 inch or less, with differential settlements up to ½ inch.

The recommendations presented herein have been developed on the basis of the subsurface conditions encountered during field investigation and our understanding of the proposed construction. Should changes in the project criteria occur, a review must be made by Terracon to determine if modifications to our recommendations will be required.
INTRODUCTION

This report presents the results of our subsurface exploration and geotechnical engineering services performed for the proposed Beck Recreation Center project located in Georgetown, South Carolina. The purpose of these services is to provide information and geotechnical engineering recommendations relative to:

- subsurface soil conditions
- groundwater conditions
- site preparation and earthwork
- foundation design and construction
- floor slab design and construction
- seismic evaluation per IBC
- other geotechnical design parameters

The geotechnical engineering scope of work for this project included the advancement of one Seismic Cone Penetration Test (SCPT) to a depth of 40 feet below the existing ground surface. Adjacent to the SCPT test, an additional Hand Auger Boring (HAB) was performed to a depth of 4 feet below the existing ground surface.

Three field infiltration tests were also performed at the site with adjacent HABs performed to the depth of groundwater. In addition, eight HABs were performed in the proposed track, basketball courts, parking areas and drive areas to depths of 4 to 5 feet. HAB-05, HAB-06, and HAB-11 were terminated prior to the planned depth of 5 feet due to hole collapse. All depths are referenced from the existing ground surface at the time of our exploration.

Maps showing the site and testing locations are shown in the Site Location and Exploration Plan sections, respectively, and logs of the soundings are included in the Exploration Results section. The results of the laboratory testing performed on soil samples obtained from the site during the field exploration are included on the boring logs and are summarized in the Supporting Information section. These sections are included as an appendix to this report.
PROJECT DESCRIPTION

Our initial understanding of the project was provided in our Project Understanding section in the Project Planning stage. During the period of collaboration that has transpired since the project was initiated, our understanding of the project conditions has been modified to reflect the following:

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proposed development</td>
<td>We understand that the site will be developed with a one-story, approximately 500 sf, prefabricated restroom/concession building with associated parking/drives, an asphalt track, and basketball courts.</td>
</tr>
</tbody>
</table>
| Maximum loads      | Structural Loads have not been provided. We have assumed the following loads based on our experience with similar construction:  
\[\text{Walls}: 3 \text{ kips per linear foot} \]  
\[\text{Columns}: 25 \text{ kips} \] |
| Grading            | Grading information was not available at the time of this report. We have assumed 1 to 2 feet of fill will be required to elevate the building pad area to finished subgrade. |

SITE CONDITIONS

The following description of site conditions is based on our site visit in association with the field exploration.

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
</table>
| Site Location      | Project site is located at the intersection of Church Street and Washington Street in Georgetown, SC.  
\[\text{Latitude: 33.38299°} \]  
\[\text{Longitude: -79.29733°} \] |
| Existing improvements | The site is predominantly undeveloped.                                    |
| Current ground cover | The site is cleared and grassed with the exception of basketball courts and playground equipment on the south end. |
| Existing topography | The site appears to be relatively flat lying.                             |

EXPLORATION AND TESTING PROCEDURES

Field Exploration

Our field exploration services were performed in general accordance with the information provided in our Planned Exploration and Testing Procedures in the Project Planning stage of the GeoReport. The type and quantity of tests are outlined in the table below.
The approximate location of each test is indicated on the Exploration Plan in Appendix A. The test locations were determined by Terracon and located in the field by Terracon personnel utilizing a commercially available handheld Global Position System (GPS) unit which are typically considered accurate to within ±20 feet. The locations should be considered accurate only to the degree implied by the means and methods used to define them. The field exploration was performed on December 12, 2018 through December 27, 2018. The in situ tests were advanced with a track mounted Pagani TG73-200 rig.

The field logs and recovered samples were compiled and reviewed by the geotechnical engineer. Final in situ and Hand Auger Boring logs and details for each of the tests can be found in Exploration Results.

The following laboratory testing was performed by Terracon on select soil samples:

- Material Finer than 75-μm Sieve in Mineral Aggregates by Washing (ASTM D1140)

Laboratory testing results are presented on the individual boring logs in Exploration Results and summarized in Supporting Information.

GEOTECHNICAL MODEL

Subsurface Profile

Based on the results of the field exploration, subsurface conditions on the project site can be generalized as follows:
Stratification boundaries on the test records represent the approximate location of changes in soil types. The transition between materials may be gradual. Details for each of the tests can be found in Exploration Results.

**Groundwater Conditions**

At the time of our exploration, groundwater was encountered at depths ranging from 2 to 3 ½ feet below existing grade. Groundwater level fluctuations occur due to seasonal variations in the amount of rainfall, runoff and other factors not evident at the time the borings were performed. Therefore, groundwater levels during construction or at other times in the life of the structure may be higher or lower than the levels indicated on the logs. The possibility of groundwater level fluctuations should be considered when developing the design and construction plans for the project.

Groundwater levels were measured using the following criteria:

- Physical observation within hand auger borings (HAB).
- Where not physically encountered in HABs, groundwater levels are measured using a groundwater probe within the voids left by seismic cone penetration (SCPT) tests.
- Where not encountered within SCPT voids, groundwater levels are estimated using the hydrostatic line (height of water below the ground surface) on the CPT porewater pressure (U) graph shown on the CPT logs.
- Unless otherwise specified on the logs or in the report, all groundwater measurements are collected during or immediately after drilling.

**Soil Infiltration Testing**

The infiltration rate of in situ soils was evaluated at the locations requested by the client within the anticipated site drainage alignment. The infiltration tests was performed at a depth of...
approximately 1.5 to 2.5 feet below the existing ground surface. The infiltration is summarized in the following table and is presented in inches per hour (in/hr).

### Infiltration Test Results

<table>
<thead>
<tr>
<th>Test Location</th>
<th>Date of Test</th>
<th>Depth of Test (inches)</th>
<th>Infiltration Rate (in / hour)</th>
<th>Estimated Seasonal High Water Table (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>INF-02</td>
<td>12/19/2018</td>
<td>18 to 24</td>
<td>0.5</td>
<td>12</td>
</tr>
<tr>
<td>INF-03</td>
<td>12/19/2018</td>
<td>24 to 30</td>
<td>0.5</td>
<td>20</td>
</tr>
<tr>
<td>INF-04</td>
<td>12/19/2018</td>
<td>24 to 30</td>
<td>0.5</td>
<td>20</td>
</tr>
</tbody>
</table>

### SEISMIC CONSIDERATIONS

According to the International Building Code 2015 edition (IBC 2015), structures are required to avoid collapse during a design earthquake event. The design earthquake has a 50 year exposure period with a 2% probability of exceedance (i.e. a 2500 year design earthquake). The 2500 year design earthquake has a Moment Magnitude (Mw) of 7.3 and a design Peak Ground Acceleration (PGA) of 0.46 g, as determined by data provided by the IBC 2015 Code and ASCE 7-10. The seismic evaluation of the site identified potentially liquefiable soils. According to the IBC (2015) and ASCE 7-10, this potential for liquefaction classifies the site as Site Class F.

ASCE 7-10 (Section 20.3.1) provides an exception to the Site Class recommendation for structure(s) with a fundamental period equal to or less than 0.5 seconds. This exception states that a site can be classified without considering liquefaction to determine spectral accelerations for structural design. The structural engineer should verify this exception. If the proposed structures meet the requirements of the exception, Seismic Site Class D would be applicable and the following seismic design parameters can be used for the site:

<table>
<thead>
<tr>
<th>Code Used</th>
<th>Site Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015 International Building Code (IBC)(^1)</td>
<td>D(^2)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Seismic Design Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>(F_a)</td>
<td>1.2</td>
</tr>
<tr>
<td>(F_v)</td>
<td>1.89</td>
</tr>
<tr>
<td>(F_{PGA})</td>
<td>1.07</td>
</tr>
<tr>
<td>(S_{DS})</td>
<td>0.60 g</td>
</tr>
<tr>
<td>(S_{DF})</td>
<td>0.32 g</td>
</tr>
<tr>
<td>(PGA_{M}^3)</td>
<td>0.46 g</td>
</tr>
</tbody>
</table>
1. In general accordance with the 2015 International Building Code and ASCE 7-10 Table 20.3-1, and an average weighted shear wave velocity of 1005 feet per second collected from in situ testing methods at the site.

2. Based upon the fundamental period exception outlined in ASCE 7-10 Section 20.3.1

3. Based on procedures outlined in ASCE 7-10 for geotechnical hazards

**Liquefaction Potential**

Due to the high seismicity of the Coastal Plain of South Carolina, we performed a liquefaction potential analysis to evaluate the stability of the soils. Ground shaking at the foundation of structures and liquefaction of the soil under the foundation are the principal seismic hazards identified for the design of earthquake-resistant structures. Liquefaction occurs when a rapid buildup in water pressure, caused by the ground motion, pushes sand particles apart, resulting in a loss of strength and later densification as the water pressure dissipates. This loss of strength can cause bearing capacity failure while the densification can cause excessive settlement.

While the amount of settlement is dependent on the magnitude and distance from a seismic event, and geologic age of the soil deposit, we estimate that settlements from the design earthquake may be **up to 2 inches**. Differential settlement may range from 50% to 100% of the total settlement depending on depth and amount of liquefaction, and location relative to a seismic event epicenter. Design under the IBC allows for buildings to sustain damage during the design earthquake event, but they must remain standing. Therefore, our liquefaction settlement estimate should be reviewed from the standpoint of risk of total collapse of the structure. While the project structural engineer should review our estimates, in our experience, the calculated liquefaction potential can typically be accounted for in the structural design.

**SITE PREPARATION**

The following presents recommendations for site and subgrade preparation and the placement of Controlled Fill for this project. Earthwork on the project should be observed and evaluated by Terracon personnel. The evaluation of earthwork should include observation and sufficient testing of Controlled Fill and subgrade preparation, and other geotechnical conditions exposed during the construction of the project.

**Site Preparation Considerations**

Positive site drainage should be established prior to the start of earthwork activities. We recommend that a site drainage plan be established and implemented prior to large scale clearing/stripping activities. This can include directing runoff water to existing drainage features and drainage ditches and/or swales across the project site as needed. These measures will allow for perched water to be directed away from construction areas limiting the softening of near surface soils.
With positive drainage established, the proposed limits of construction should be stripped of trees, organic material, topsoil, root balls, and other deleterious material from within the proposed building footprint and parking areas. Stripping should extend a minimum of 5 feet outside the construction area footprint. We anticipate stripping depths to average 6 to 12 inches across the site. Voids remaining from the clearing/stripping operation should be backfilled with properly compacted Controlled Fill.

After stripping and subgrade repair is completed, the existing subgrade should be proofrolled with a loaded tandem axle dump truck or other similar approved construction equipment. A geotechnical engineer should monitor proofrolling operations. Areas that pump or rut excessively should be undercut and reworked or replaced with Controlled Fill.

The majority of near surface soils encountered during our field investigation consisted of clayey sands (USCS Classification SC) with fines contents ranging from 25 to 30 percent. While stable in a dry condition, these type soils will deteriorate rapidly when exposed to excess moisture. Due to the moisture sensitivity of in-situ soils, it is our opinion that subgrade stabilization may be required. Stabilization efforts can consist of undercutting to a stable material and backfilling with Controlled Fill. We have estimated undercut depths of approximately 18 to 24 inches. Undercutting may be deeper in isolated areas depending on soil conditions. Undercutting should extend a minimum of 1 foot outside of pavement areas and 5 feet outside of building perimeters. Undercut soils should be replaced with Controlled Fill as outlined below. The extent of the undercutting will be dependent on moisture conditions at the time of construction including weather conditions and the effectiveness of site drainage in place at the time earthwork is in progress. Undercut soils could be utilized as non-structural fill in landscaped and grassed areas.

Soil conditions indicate underdrains will be required to adequately drain the parking lot subgrades within the area of undercutting. The undercut subgrade should be graded to match final grading plans prior to placement of Controlled Fill to promote drainage to low areas where the underdrains will be located. After underdrain placement, Controlled Fill can be placed as required. In short, underdrain placement can proceed along with the overexcavation and replacement process. The configuration of underdrains would be dependent upon the project grading and drainage plans which can be reviewed to finalize underdrain placement. The underdrain plan should be coordinated with the site civil design engineer. Terracon can provide additional design criteria and input for underdrains as required.
Material Types

Controlled fill should meet the following soil property requirements:

<table>
<thead>
<tr>
<th>Fill Type¹</th>
<th>USCS Classification</th>
<th>Acceptable Location for Placement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Controlled/Imported Fill</td>
<td>SP, SP-SM, SP-SW, SW, SM (Passing #200&lt;12%)</td>
<td>All locations</td>
</tr>
</tbody>
</table>

1. Controlled, compacted fill should consist of approved materials that are free of organic matter and other deleterious debris.

Based on the field exploration, near surface soils will meet the requirements of controlled fill. Contractor should submit soil samples to verify that fill soils meet controlled fill requirements.

Compaction Requirements

<table>
<thead>
<tr>
<th>ITEM</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fill Lift Thickness</td>
<td>When heavy, self-propelled compaction equipment is used, fill lifts shall have a maximum of 8 inches in loose thickness. When hand-guided equipment (i.e. jumping jack or plate compactor) is used, fill lifts shall have a maximum of 2 to 4 inches in loose thickness.</td>
</tr>
<tr>
<td>Compaction Requirements¹</td>
<td>The pavement base course and the upper 12 inches of the floor slab subgrade should be compacted to 100% of the material’s maximum Modified Proctor dry density (ASTM D1557). Other structural areas and the upper 12 inches of the pavement subgrade should be compacted to 95% of the material’s maximum Modified Proctor dry density (ASTM D1557).</td>
</tr>
<tr>
<td>Moisture Content – Controlled Fill or Onsite Soils²</td>
<td>Within the range of ±2% of optimum moisture content value as determined by the Modified Proctor test.</td>
</tr>
</tbody>
</table>

1. Fill should be tested for moisture content and compaction during placement. If the results of the in-place density tests indicate the specified moisture or compaction limits have not been met, the area represented by the test should be reworked and retested as required until the specified moisture and compaction requirements are achieved.

2. Specifically, moisture levels should be maintained low enough to allow for satisfactory compaction to be achieved without the Controlled Fill material pumping when proofrolled.

Backfill Construction Observation and Testing

The exposed subgrade and each lift of compacted fill should be tested, evaluated, and reworked, as necessary, until approved by the geotechnical engineer’s representative prior to placement of additional lifts. We recommend that each lift of fill be tested for density and moisture content at a
frequency of one test for every 2,500 square feet for the building area. We recommend one density and moisture content test for every 50 linear feet of compacted utility trench backfill.

Earthwork Construction Considerations

It is anticipated that shallow excavations for the proposed construction can be accomplished with conventional earthmoving equipment. Upon completion of filling/cutting and grading, care should be taken to maintain the subgrade moisture content prior to construction of floor slabs. Construction traffic over the completed subgrade should be avoided to the extent practical. The site should also be graded to prevent ponding of surface water on the prepared subgrades or in excavations. If the subgrade should become desiccated, saturated, or disturbed, the affected material should be removed or these materials should be scarified, moisture conditioned, and recompacted prior to floor slab construction and observed by Terracon.

Surface water should not be allowed to pond on the site and soak into the soil during construction. Construction staging should provide drainage of surface water and precipitation away from the building areas. Any water that collects over or adjacent to construction areas should be promptly removed, along with any softened or disturbed soils. Surface water control in the form of sloping surfaces, drainage ditches and trenches, and sump pits and pumps will be important to avoid ponding and associated delays due to precipitation and seepage.

Terracon should be retained during the construction phase of the project to observe earthwork and to perform necessary tests and observations during subgrade preparation; proofrolling; placement and compaction of controlled compacted fills; backfilling of excavations into the completed subgrade, and just prior to construction of building floor slabs.

SHALLOW FOUNDATIONS

With proper site preparation, the proposed structures can be supported by a shallow spread footing foundation bearing on in situ or compacted Controlled Fill. Design recommendations for shallow foundations for the proposed structures are presented in the following paragraphs. Footing should be placed below anticipated the anticipated scour elevation.

Design Recommendations

<table>
<thead>
<tr>
<th>Description</th>
<th>Columns</th>
<th>Walls</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allowable bearing pressure(^1)</td>
<td>2,000 psf</td>
<td>2,000 psf</td>
</tr>
<tr>
<td>Minimum dimensions</td>
<td>24 inches</td>
<td>12 inches</td>
</tr>
<tr>
<td>Minimum embedment below finished grade</td>
<td>12 inches</td>
<td>12 inches</td>
</tr>
<tr>
<td>Estimated total static settlement(^2)</td>
<td>1 inch or less</td>
<td>1 inch or less</td>
</tr>
<tr>
<td>Description</td>
<td>Columns</td>
<td>Walls</td>
</tr>
<tr>
<td>-------------------------------------------------------</td>
<td>-----------------------------</td>
<td>------------------------------</td>
</tr>
<tr>
<td>Estimated differential static settlement(^{2,3})</td>
<td>&lt; ½ inch between columns</td>
<td>&lt; ½ inch over 20 feet</td>
</tr>
</tbody>
</table>

1. The recommended net allowable bearing pressure and seismic bearing pressure are the pressure in excess of the minimum surrounding overburden pressure at the footing base elevation. This assumes that any unsuitable fill, debris or soft soils, if encountered, will be undercut and replaced with Controlled Fill.

2. The settlement estimates are based on maximum loads of 25 kips for columns, 3 kips per linear foot strip footings and the above allowable bearing pressure. The foundation settlement will depend upon the variations within the subsurface soil profile, the structural loading conditions, the embedment depth and dimensions of the footings, the thickness of compacted fill, and the quality of the earthwork operations. These settlement magnitudes assume the foundation subgrade will be repaired as recommended in this report. The settlement calculations were based on footing sizes of 3.5 feet x 3.5 feet column footings and 1.5 foot wide strip footings.

3. If final loads vary from those listed above, a review must be made by Terracon to determine if modifications to our recommendations will be required.

**Foundation Construction Considerations**

The base of all foundation excavations should be free of water and loose soil prior to placing concrete. Concrete should be placed soon after excavating to reduce bearing soil disturbance. Care should be taken to prevent wetting or drying of the bearing materials during construction. Excessively wet or dry material or any loose/disturbed material in the bottom of the footing excavations should be removed before foundation concrete is placed. If the soils at bearing level become excessively dry, disturbed, saturated, or frozen, the affected soil should be removed prior to placing concrete.

If debris or unsuitable bearing soils are encountered in footing excavations, the excavation could be extended deeper to suitable soils and the footing could bear directly on these soils at the lower level or on lean concrete backfill placed in the excavations. As an alternative, the footings could also bear on properly compacted Controlled Fill extending down to the suitable soils. Overexcavation for compacted backfill placement below footings should extend laterally beyond all edges of the footings at least 8 inches per foot of overexcavation depth below the “Design Footing Level.” The overexcavation should then be backfilled up to the footing base elevation with well-graded granular material placed as recommended in the Site Preparation section. The overexcavation and backfill procedure is shown in the figure below.
FLOOR SLABS

Floor slabs can be supported by the in-situ soils or properly compacted Control Fill if prepared as described in Site Preparation. Concrete floor slabs constructed on grade can be designed using the modulus of subgrade reaction presented in the following table.

Design Recommendations

<table>
<thead>
<tr>
<th>ITEM</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modulus of subgrade reaction (Controlled Fill)(^1)</td>
<td>200 pounds per square inch per inch (psi/in) for point loading conditions(^2)</td>
</tr>
</tbody>
</table>

1. Modulus of subgrade reaction value is for a 1 ft by 1 ft area and should be adjusted for appropriate size.
2. This value may be increased depending on the depth of stone placed beneath the slab.

If a conventional slab and shallow foundation are used, the structural engineer should design the slab to limit differential movements between the slab and foundation to reduce the possibility of floor slab cracking. Where appropriate, saw-cut control joints and expansion joints should be placed in the slab to help control the location and extent of cracking. For additional recommendations refer to the ACI Design Manual. Floor slab subgrade should be compacted to 100% of its modified Proctor maximum dry density (ASTM D1557).

The use of a vapor retarder should be considered beneath concrete slabs on grade that will be covered with wood, tile, carpet or other moisture sensitive or impervious coverings, or when the slab will support equipment sensitive to moisture. When conditions warrant the use of a vapor retarder, the slab designer and slab contractor should refer to ACI 302 and ACI 360 for procedures and cautions regarding the use and placement of a vapor retarder/barrier.
Floor Slab Construction Considerations

On most project sites, the site grading is generally accomplished early in the construction phase. However as construction proceeds, the subgrade may be disturbed due to utility excavations, construction traffic, desiccation, rainfall, etc. As a result, the floor slab subgrade may not be suitable for placement of base rock and concrete, and corrective action will be required.

We recommend the area underlying the floor slab be rough graded and then proofrolled with a tandem axle dump truck prior to final grading and observed by geotechnical engineer. Areas where unsuitable conditions are located should be repaired by removing and replacing the affected material with properly compacted fill. All floor slab subgrade areas should be moisture conditioned and properly compacted to the recommendations in this report immediately prior to placement of the concrete. Any trenches should be backfilled with Controlled Fill as described in the Material Types section in this report.

PAVEMENT RECOMMENDATIONS

Subgrade Preparation

Pavement subgrades should be carefully evaluated by Terracon personnel as the time for pavement construction approaches. The moisture content and density of the subgrade should be evaluated and the pavement subgrades proofrolled prior to commencement of actual paving operations. Areas not in compliance with the required ranges of moisture or density should be moisture conditioned and recompacted (or removed and replaced). Particular attention should be paid to high traffic areas that were rutted and disturbed during earlier construction activities and to areas where backfilled trenches are located.

If a significant precipitation event occurs after the evaluation or if the surface becomes disturbed, the subgrade should be reviewed by qualified personnel immediately prior to paving. The subgrade should be in its finished form at the time of the final review.

Estimates of Minimum Pavement Thickness

Based on this information and the anticipated use of the proposed recreation center, we have provided minimum pavement thickness for “light duty” and “heavy duty” traffic areas. “Light duty” pavement is used in parking/drive areas subjected solely to light passenger car and light truck traffic. “Heavy duty” traffic should be used for the main drive lanes in parking and dock areas.

Pavement sections were evaluated using the American Association of State Highway and Transportation Official’s (AASHTO) “Structural Number” (Sn) system. For pavement design, the AASHTO system converts an estimated Average Daily Traffic (ADT) or Vehicles per Day (VPD)
to an Equivalent 18 kip Single Axle Loads (ESAL’s) placed on the pavement during its design life. In our analysis, light duty pavements are estimated to be subjected to a traffic load on the order of 100,000 ESAL’s whereas heavy duty pavements will be subjected to a loading on the order of 250,000 ESAL’s.

For new pavements, the minimum $S_N$ required by the traffic loading and the subgrade soil strength is calculated from the subgrade strength data, assumed traffic volumes, assumed traffic growth rate, and design life. Based on the implementation of subgrade stabilization outlined in the Site Preparation section of this report, we have assumed a CBR value of 10. The following table provides our recommendations for flexible pavements. Terracon should be contacted to review and revise these recommendations if traffic loading significantly differs from those assumed herein.

<table>
<thead>
<tr>
<th>Traffic Area</th>
<th>Alternative</th>
<th>AC Surface(^3) Course (SCDOT Type C)</th>
<th>AC Intermediate Course (SCDOT Type C)</th>
<th>Portland Cement Concrete(^1)</th>
<th>Graded Aggregate Base Course (SCDOT GABC)</th>
<th>Total Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light Duty (Car Parking)</td>
<td>AC</td>
<td>2.0</td>
<td>--</td>
<td>--</td>
<td>6.0</td>
<td>8.0</td>
</tr>
<tr>
<td>Heavy Duty (Truck and Drive Areas)</td>
<td>AC</td>
<td>1.5</td>
<td>1.5</td>
<td>--</td>
<td>8.0</td>
<td>11.0</td>
</tr>
<tr>
<td>Heavy Duty (Truck and Drive Areas and Trash Container Pad(^2))</td>
<td>PCC</td>
<td>--</td>
<td>--</td>
<td>6.0</td>
<td>4.0</td>
<td>10.0</td>
</tr>
</tbody>
</table>

1. 4,000 psi at 28 days, 4-inch maximum slump and 5 to 7% air entrained, 6-sack min. mix. PCC pavements are recommended for trash container pads and in any other areas subjected to heavy wheel loads and/or turning traffic.
2. The trash container pad should be large enough to support the container and the tipping axle of the collection truck.
3. AC: Asphalt Concrete

A concrete slab is recommended for any areas where dumpsters are to be located in order to provide a more durable wearing surface. If utilized, the pad should be large enough to encompass both the dumpster and refuse truck. Additionally, the use of concrete should be considered in areas where high turning stresses are expected, such as entrance and exit aprons and truck loading areas.
Pavement Construction Considerations

Construction methods and materials used in the development of pavement areas should meet the minimum requirements as directed by SCDOT Standard Specifications for Highway Construction, 2007 edition.

Pavement Drainage

Pavements should be sloped to provide rapid drainage of surface water. Water allowed to pond on or adjacent to the pavements could saturate the subgrade and contribute to premature pavement deterioration. In addition, the pavement subgrade should be graded to provide positive drainage within the granular base section. Appropriate sub-drainage or connection to a suitable daylight outlet should be provided to remove water from the granular subbase.

Pavement Maintenance

The pavement sections provided in this report represent minimum recommended thicknesses and, as such, periodic maintenance should be anticipated. Therefore, preventive maintenance should be planned and provided for through an on-going pavement management program. Maintenance activities are intended to slow the rate of pavement deterioration, and to preserve the pavement investment. Maintenance consists of both localized maintenance (e.g., crack and joint sealing and patching) and global maintenance (e.g., surface sealing). Preventive maintenance is usually the first priority when implementing a pavement maintenance program. Additional engineering observation is recommended to determine the type and extent of a cost effective program. Even with periodic maintenance, some movements and related cracking may still occur and repairs may be required.

GENERAL COMMENTS

Our work is conducted with the understanding of the project as described in the proposal, and will incorporate collaboration with the design team prior to completing our services. Terracon has requested verification of all stated assumptions. Revision of our understanding to reflect actual conditions important to our work will be based on these verifications and will be reflected in the final report. The design team should collaborate with Terracon to confirm these assumptions. The design team should also collaborate with Terracon to prepare the final design plans and specifications. This facilitates the incorporation of our opinions related to implementation of our geotechnical recommendations.

Our analysis and opinions are based upon our understanding of the geotechnical conditions in the area, the data obtained from the site exploration performed and from our understanding of the project. Variations will occur between exploration point locations, across the site, or due to the modifying effects of construction or weather. The nature and extent of such variations may not
become evident until during or after construction. So, Terracon should be retained to provide observation and testing services during grading, excavation, foundation construction and other earth-related construction phases of the project. If variations appear, we can provide further evaluation and supplemental recommendations. If variations are noted in the absence of our observation and testing services on-site, we should be immediately notified so that we can provide evaluation and supplemental recommendations.

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

Our services and any correspondence are intended for the exclusive use of our client for specific application to the project discussed and are accomplished in accordance with generally accepted geotechnical engineering practices. No warranties, either express or implied, are intended or made.

Site characteristics as provided are for design purposes and not to estimate excavation cost. Any use of our report in that regard is done at the sole risk of the excavating cost estimator as there may be variations on the site that are not apparent in the data that could significantly impact excavation cost. Any parties charged with estimating excavation costs should seek their own site characterization for that specific purposes to obtain the specific level of detail necessary for costing. Site safety, and cost estimating including, excavation support, and dewatering requirements/design are the responsibility of others. In the event that changes in the nature, design, or location of the project are planned, our conclusions and recommendations shall not be considered valid unless we review the changes and either verify or modify our conclusions in writing.
ATTACHMENTS - SITE LOCATION AND EXPLORATION PLAN
Beck Recreation Center
2030 Church Street
Georgetown, SC

SITE LOCATION

1"=2000'

Project Manager: WHP
Drawn by: KDM
Checked by: WHP
Approved by: WHP

Date: 01/25/19

File Name: BECK

Scale: 1"=2000'

Exhibit A-1
ATTACHMENTS - EXPLORATION RESULTS
CPT LOG NO. SCPT1

PROJECT: Beck Recreation Center
CLIENT: Georgetown County
Georgetown, SC

SITE: 2030 Church Street
Georgetown, SC

TEST LOCATION: See Exhibit A-2

Depth (ft) | Tip Resistance, qt (tsf) | Sleeve Friction, ft (tsf) | Friction Ratio, F (%) | Hydrostatic Pressure, u2 (tsf)
--- | --- | --- | --- | ---
0 | 60 | 0.8 | 2.75 | -0.5
5 | 120 | 1.6 | 5.00 | 0.0
10 | 180 | 2.4 | 8.25 | 0.5
15 | 240 | 3.2 | 15.0 | 1.0
20 | 0 | 25 | 2.0
30 | 30 | 2.5 | 3.0
35 | 35 | 3.0 | 3.5
40 | 40 | 3.5 | 4.0

CPT Terminated at 40.3 Feet

Material Description
1. Sensitive, fine grained
2. Organic soils - clay
3. Clay - silty clay to clay
4. Silt mixtures - clayey silt to silty clay
5. Sand mixtures - sandy silt to sandy silt
6. Sands - clean sand to silty sand
7. Gravelly sand to dense sand
8. Very stiff sand to clayey sand
9. Very stiff fine grained

WATER LEVEL OBSERVATION
Probe no. 4986 with net area ratio of 0.865
U2 pore pressure transducer location
Manufactured by Geotech A.B., calibrated 10/3/2017
Tip and sleeve areas of 10 cm² and 150 cm²
Ring friction reducer with O.D. of 1.875 in

CPT Terminated at 40.3 Feet

CPT sensor calibration reports available upon request.

See Terracon's CPT General Notes for explanation of symbols and abbreviations.

2.0625 ft estimated water depth
(used in normalizations and correlations)

1246 Howard Ave
Myrtle Beach, SC

CPT Started: 12/12/2018
Rig: Pagani TG73-200
Operator: BR
CPT Completed: 12/12/2018
Project No.: ER185072
ATTACHMENTS - SUPPORTING DOCUMENTS
## BORING LOG NO. HAB at SCPT-01

### PROJECT: Beck Recreation Center

### CLIENT: Georgetown County
Georgetown, SC

### SITE: 2030 Church Street
Georgetown, SC

---

**GRAPHIC LOG**

**DEPTH**

**TOPSOIL**

- **POORLY GRADED SAND (SP)**, tan, brown, and orange

---

**Boring Terminated at 4 Feet**

- Stratification lines are approximate. In-situ, the transition may be gradual.

---

**WATER LEVEL OBSERVATIONS**

- **Depth (Ft.)**
- **Water Level Observations**
- **Sample Type**
- **Percent Fines [%]**

---

**Notes:**

- Advancement Method: Hand Auger
- Abandonment Method: Boring backfilled with auger cuttings upon completion.

---

**Estimated 2 feet at Time of Boring.**

---

**1246 Howard Ave**
Myrtle Beach, SC

---

**Boring Started: 12-12-2019**
**Boring Completed: 12-12-2019**

**Drill Rig: Hand Auger**
**Driller: BR**

**Project No.: ER185072**
### BORING LOG NO. HAB at INF-02

**PROJECT:** Beck Recreation Center  
**CLIENT:** Georgetown County  
**SITE:** 2030 Church Street, Georgetown, SC

<table>
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<th>LOCATION</th>
<th>GRAPHIC LOG</th>
<th>DEPTH (Ft)</th>
<th>WATER LEVEL OBSERVATIONS</th>
<th>SAMPLE TYPE</th>
<th>Percent Fines [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOPSOIL</td>
<td></td>
<td>2.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CLAYEY SAND (SC)</td>
<td>dark brown and gray</td>
<td>3.0</td>
<td>Hand Auger Boring Terminated at 3 Feet due to Water Table</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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</table>

**Stratification lines are approximate. In-situ, the transition may be gradual.**

**Advancement Method:** Hand Auger  
**Abandonment Method:** Boring backfilled with auger cuttings upon completion.

**Notes:**

**WATER LEVEL OBSERVATIONS**

- Estimated 3 feet at Time of Boring.

---

1246 Howard Ave, Myrtle Beach, SC

Boring Started: 12-19-2019  
Boring Completed: 12-19-2019  
Drill Rig: Hand Auger  
Driller: DT, GR  
Project No.: ER185072
Hand Auger Boring Terminated at 3.5 Feet due to Water Table

Stratification lines are approximate. In-situ, the transition may be gradual.

Advancement Method:
Hand Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

WATER LEVEL OBSERVATIONS

Estimated 3.5 feet at Time of Boring.
**BORING LOG NO. HAB at INF-04**

**PROJECT:** Beck Recreation Center

**SITE:** 2030 Church Street
Georgetown, SC

**CLIENT:** Georgetown County
Georgetown, SC

---

**LOCATION**

<table>
<thead>
<tr>
<th>STRATUM</th>
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<tr>
<td>TOPSOIL</td>
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</tr>
<tr>
<td>POORLY GRADED SAND (SP)</td>
<td>1.0</td>
</tr>
<tr>
<td>CLAYEY SAND (SC)</td>
<td>3.0</td>
</tr>
</tbody>
</table>

**GRAPHIC LOG**

**DEPTH**

<table>
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<tr>
<th>DEPTH (Ft.)</th>
<th>SAMPLE TYPE</th>
<th>% Fines</th>
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<tbody>
<tr>
<td>0.5</td>
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<tr>
<td>24.5 %</td>
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<td>22.9 %</td>
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<tr>
<td>3.0</td>
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</tbody>
</table>

**Hand Auger Boring Terminated at 3 Feet due to Water Table**

**Stratification lines are approximate. In-situ, the transition may be gradual.**

- **Advancement Method:** Hand Auger
- **Abandonment Method:** Boring backfilled with auger cuttings upon completion.

---

**WATER LEVEL OBSERVATIONS**

- Estimated 3 feet at Time of Boring.

---

**Notes:**

1. **Estimated 3 feet at Time of Boring.**

---

**Terracon**

1246 Howard Ave
Myrtle Beach, SC

**Boring Started:** 12-19-2019  **Boring Completed:** 12-19-2019

**Drill Rig:** Hand Auger  **Driller:** DT, GR

**Project No.:** ER185072
**BORING LOG NO. HAB-05**

**PROJECT:** Beck Recreation Center  
**CLIENT:** Georgetown County  
**SITE:** 2030 Church Street  
Georgetown, SC

<table>
<thead>
<tr>
<th>LOCATION</th>
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<tr>
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<tr>
<td>TOPSOIL</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>CLAYEY SAND (SC), brown, tan and orange</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4.0</td>
<td>Hand Auger Boring Terminated at 4 Feet due to Hole Collapse</td>
</tr>
</tbody>
</table>

Stratification lines are approximate. In-situ, the transition may be gradual.  
Hammer Type: DCP

**Advancement Method:** Hand Auger  
**Abandonment Method:** Boring backfilled with auger cuttings upon completion.

**WATER LEVEL OBSERVATIONS**  
Estimated 2.5 feet at Time of Boring.

---

**RIDGECORE REPORT**  
1246 Howard Ave  
Myrtle Beach, SC

Boring Started: 12-27-2019  
Boring Completed: 12-27-2019  
Drill Rig: Hand Auger  
Driller: KM  
Project No.: ER185072
**BORING LOG NO. HAB-06**

**PROJECT:** Beck Recreation Center  
**SITE:** 2030 Church Street  
Georgetown, SC  
**CLIENT:** Georgetown County  
Georgetown, SC

---

**TOPSOIL**
- **POORLY GRADED SAND (SP), brown and orange**

**CLAYEY SAND (SC), tan and orange**

---

**Hand Auger Boring Terminated at 4 Feet due to Hole Collapse**

---

**WATER LEVEL OBSERVATIONS**

<table>
<thead>
<tr>
<th>LOCATION</th>
<th>DEPTH (Ft.)</th>
<th>DCP Results [n blows/1.75&quot;]</th>
<th>SAMPLE TYPE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.5</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>2.0</td>
<td>7 - 7 - 7</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>3.0</td>
<td>6 - 8 - 9</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>4.0</td>
<td>9 - 10 - 13</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>4.0</td>
<td>9 - 10 - 11</td>
<td>-</td>
</tr>
</tbody>
</table>

**Stratification lines are approximate. In-situ, the transition may be gradual.**

**Hammer Type:** DCP

---

**Advancement Method:** 
Hand Auger

**Abandonment Method:** 
Boring backfilled with auger cuttings upon completion.

**Notes:**

---

**WATER LEVEL OBSERVATIONS**

- **Estimated 2.5 feet at Time of Boring.**

---

**1246 Howard Ave**  
Myrtle Beach, SC  
**Drill Rig:** Hand Auger  
**Driller:** KM  
**Project No.:** ER185072  
**Boring Started:** 12-27-2019  
**Boring Completed:** 12-27-2019
Boring Terminated at 5 Feet

TOPSOIL

CLAYEY SAND (SC), dark brown, gray and tan

Hammer Type: DCP

Stratification lines are approximate. In-situ, the transition may be gradual.

WATER LEVEL OBSERVATIONS

- 5 - 5 - 5
- 8 - 10 - 12
- 17.8%
- 8 - 9 - 10
- 8 - 10 - 11
- 9 - 12 - 15

Notes:

Advancement Method:
Hand Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

Boring Started: 12-27-2019
Boring Completed: 12-27-2019
Drill Rig: Hand Auger
Driller: KM
Project No.: ER185072
**PROJECT:** Beck Recreation Center  
**SITE:** 2030 Church Street  
**CLIENT:** Georgetown County  
Georgetown, SC

---

**LOCATION**

**DEPTH (FT.)**

**SANDY LEAN CLAY/CLAYEY SAND (CL/SC), dark brown and orange**

**DEPTH**

**CLAYEY SAND (SC), dark brown and gray**

---

**Estimated 1.5 feet at Time of Boring.**

---

**WATER LEVEL OBSERVATIONS**

<table>
<thead>
<tr>
<th>DEPTH (FT.)</th>
<th>WATER LEVEL OBSERVATIONS</th>
<th>DCP Results [in blows/1.75&quot;]</th>
<th>Percent Fines [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

**Boring Terminated at 5 Feet**

---

**Notes:**

- Advancement Method: Hand Auger
- Abandonment Method: Boring backfilled with auger cuttings upon completion.
- Hammer Type: DCP

---

**Boring Log No. HAB-08**

**Georgetown County**

**SITE:** 2030 Church Street  
Georgetown, SC

---

**DRILLER:** KM  
**Boring Started:** 12-19-2019  
**Boring Completed:** 12-19-2019  
**Drill Rig:** Hand Auger  
**Project No.: ER185072**
Topsoil

- Clayey Sand (SC), tan and orange

Boring Terminated at 5 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.

**Hammer Type:** DCP

**Advancement Method:** Hand Auger

**Abandonment Method:** Boring backfilled with auger cuttings upon completion.

**WATER LEVEL OBSERVATIONS**

- Estimated 3.5 feet at Time of Boring.

**Estimated 3.5 feet at Time of Boring.**
**BORING LOG NO. HAB-10**

**PROJECT:** Beck Recreation Center  
**CLIENT:** Georgetown County  
**SITE:** Georgetown, SC

---

### WATER LEVEL OBSERVATIONS

<table>
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<tr>
<th>LOCATION</th>
<th>GRAPHIC LOG</th>
<th>DEPTH (Ft.)</th>
<th>DCP Results (blows/1.75&quot;)</th>
</tr>
</thead>
<tbody>
<tr>
<td>WATER LEVEL OBSERVATIONS</td>
<td>DEPTH</td>
<td>TOPSOIL</td>
<td>POORLY GRADED SAND WITH SILT (SP-SM), brown and tan</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CLAYEY SAND (SC), gray, orange, and tan</td>
<td>4-4-4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Boring Terminated at 5 Feet</td>
<td>6-10-8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>10-14-14</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>12-15-15+</td>
</tr>
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</table>

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: DCP

---

**Advancement Method:** Hand Auger  
**Abandonment Method:** Boring backfilled with auger cuttings upon completion.

**Notes:**

---

**1246 Howard Ave**  
**Myrtle Beach, SC**

---

**This Boring Log was not Validated or Separated from Original Report. GeoSmartLog: MG-04. UPDATE: 12/2/19**

---

**Boring Started:** 12-19-2019  
**Boring Completed:** 12-19-2019  
**Drill Rig:** Hand Auger  
**Driller:** KM  
**Project No.:** ER185072
### BORING LOG NO. HAB-11

**PROJECT:** Beck Recreation Center  
**CLIENT:** Georgetown County  
**SITE:** 2030 Church Street  
**Georgetown, SC**

<table>
<thead>
<tr>
<th>GRAPHIC LOG</th>
<th>LOCATION</th>
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</thead>
<tbody>
<tr>
<td>DEPTH (Ft.)</td>
<td>WATER LEVEL OBSERVATIONS</td>
</tr>
<tr>
<td>0.5</td>
<td>TOPSOIL</td>
</tr>
<tr>
<td>3.0</td>
<td>SILTY SAND (SM), brown, tan, and orange</td>
</tr>
<tr>
<td>4.0</td>
<td>CLAYEY SAND (SC), brown, tan, and gray</td>
</tr>
<tr>
<td>13 - 15+</td>
<td>Hand Auger Boring Terminated at 4 Feet due to Hole Collapse</td>
</tr>
</tbody>
</table>

Stratification lines are approximate. In-situ, the transition may be gradual.  
Hammer Type: DCP

**Notes:**
- Advancement Method: Hand Auger
- Abandonment Method: Boring backfilled with auger cuttings upon completion.

**WATER LEVEL OBSERVATIONS**

- Estimated 3 feet at Time of Boring.

---

**PROJECT:** Beck Recreation Center  
**SITE:** 1246 Howard Ave  
**Myrtle Beach, SC**

- **Driller:** KM  
- **Drill Rig:** Hand Auger  
- **Boring Started:** 12-27-2019  
- **Boring Completed:** 12-27-2019  
- **Boring Started:** 12-27-2019  
- **Boring Completed:** 12-27-2019  
- **Driller:** KM  
- **Project No.:** ER185072

---

**THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG NO WELL ER185072 HAB RE11 1/22/19**
### BORING LOG NO. HAB-12

**PROJECT:** Beck Recreation Center  
**SITE:** 2030 Church Street  
**CLIENT:** Georgetown County  
**Georgetown, SC**

#### Lorem ipsum dolor sit amet, consectetur adipiscing elit.

<table>
<thead>
<tr>
<th>LOCATION</th>
<th>DEPTH</th>
<th>WATER LEVEL OBSERVATIONS</th>
<th>SAMPLE TYPE</th>
<th>DCP Results (n blows/1.75&quot;)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TOPSOIL</strong></td>
<td>5.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>POORLY GRADED SAND WITH CLAY (SP-SC), dark brown and tan</strong></td>
<td>4.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>CLAYEY SAND (SC), dark brown and gray</strong></td>
<td>3.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>SANDY LEAN CLAY/CLAYEY SAND (CL/SC), gray, orange and tan</strong></td>
<td>2.0</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

_Boring Terminated at 5 Feet_

Stratification lines are approximate. In-situ, the transition may be gradual.  
Hammer Type: DCP

**Notes:**

- Advancement Method: Hand Auger
- Abandonment Method: Boring backfilled with auger cuttings upon completion.

#### WATER LEVEL OBSERVATIONS

- Estimated 2 feet at Time of Boring.

Boring Started: 12-19-2019  
Boring Completed: 12-19-2019

Drill Rig: Hand Auger  
Driller: KM

Project No.: ER185072

---

?<object>?

---

*Image of the page*
### GENERAL NOTES

#### DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

<table>
<thead>
<tr>
<th>SAMPLING</th>
<th>WATER LEVEL</th>
<th>FIELD TESTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auger</td>
<td>Water Initially Encountered</td>
<td>(HP) Hand Penetrometer</td>
</tr>
<tr>
<td>Split Spoon</td>
<td>Water Level After a Specified Period of Time</td>
<td>(T) Torvane</td>
</tr>
<tr>
<td>Shelby Tube</td>
<td>Water Level After a Specified Period of Time</td>
<td>(b/f) Standard Penetration Test (blows per foot)</td>
</tr>
<tr>
<td>Macro Core</td>
<td>Water Level After a Specified Period of Time</td>
<td>(PID) Photo-Ionization Detector</td>
</tr>
<tr>
<td>Ring Sampler</td>
<td>Water Level After a Specified Period of Time</td>
<td>(OVA) Organic Vapor Analyzer</td>
</tr>
<tr>
<td>Rock Core</td>
<td>Water Level After a Specified Period of Time</td>
<td></td>
</tr>
<tr>
<td>Grab Sample</td>
<td>Water Level After a Specified Period of Time</td>
<td></td>
</tr>
<tr>
<td>No Recovery</td>
<td>Water Level After a Specified Period of Time</td>
<td></td>
</tr>
</tbody>
</table>

Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations.

### DESCRIPTIVE SOIL CLASSIFICATION

Soil classification is based on the Unified Soil Classification System. Coarse Grained Soils have more than 50% of their dry weight retained on a #200 sieve; their principal descriptors are: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; they are principally described as clays if they are plastic, and silts if they are slightly plastic or non-plastic. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse-grained soils are defined on the basis of their in-place relative density and fine-grained soils on the basis of their consistency.

### LOCATION AND ELEVATION NOTES

Unless otherwise noted, Latitude and Longitude are approximately determined using a hand-held GPS device. The accuracy of such devices is variable. Surface elevation data annotated with +/- indicates that no actual topographical survey was conducted to confirm the surface elevation. Instead, the surface elevation was approximately determined from topographic maps of the area.

#### RELATIVE DENSITY OF COARSE-GRAINED SOILS

(More than 50% retained on No. 200 sieve.)
Density determined by Standard Penetration Resistance includes gravels, sands and silts.

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Very Loose</td>
<td>0 - 3</td>
<td>0 - 6</td>
<td>0 - 8</td>
<td>Very Soft</td>
<td>less than 0.25</td>
<td>0 - 1</td>
<td>&lt; 3</td>
</tr>
<tr>
<td>Loose</td>
<td>4 - 9</td>
<td>7 - 18</td>
<td>2 - 4</td>
<td>Soft</td>
<td>0.25 to 0.50</td>
<td>2 - 4</td>
<td>3 - 4</td>
</tr>
<tr>
<td>Medium Dense</td>
<td>10 - 29</td>
<td>19 - 58</td>
<td>4 - 8</td>
<td>Medium-Stiff</td>
<td>0.50 to 1.00</td>
<td>5 - 9</td>
<td>10 - 18</td>
</tr>
<tr>
<td>Dense</td>
<td>30 - 50</td>
<td>59 - 98</td>
<td>8 - 15</td>
<td>Stiff</td>
<td>1.00 to 2.00</td>
<td>10 - 18</td>
<td>19 - 42</td>
</tr>
<tr>
<td>Very Dense</td>
<td>&gt; 50</td>
<td>&gt; 99</td>
<td>2.00 to 4.00</td>
<td>Very Stiff</td>
<td>&gt; 4.00</td>
<td>&gt; 30</td>
<td>&gt; 42</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Hard</td>
<td>&gt; 4.00</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### RELATIVE PROPORTIONS OF SAND AND GRAVEL

<table>
<thead>
<tr>
<th>Descriptive Term(s) of other constituents</th>
<th>Percent of Dry Weight</th>
<th>Major Component of Sample</th>
<th>Particle Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trace</td>
<td>&lt; 15</td>
<td>Boulders</td>
<td>Over 12 in. (300 mm)</td>
</tr>
<tr>
<td>With</td>
<td>15 - 29</td>
<td>Cobbles</td>
<td>12 in. to 3 in. (300mm to 75mm)</td>
</tr>
<tr>
<td>Modifier</td>
<td>&gt; 30</td>
<td>Gravel</td>
<td>3 in. to #4 sieve (75mm to 4.75 mm)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sand</td>
<td>#4 to #200 sieve (4.75mm to 0.075mm)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Silt or Clay</td>
<td>Passing #200 sieve (0.075mm)</td>
</tr>
</tbody>
</table>

#### RELATIVE PROPORTIONS OF FINEs

<table>
<thead>
<tr>
<th>Descriptive Term(s) of other constituents</th>
<th>Percent of Dry Weight</th>
<th>Term</th>
<th>Plasticity Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trace</td>
<td>&lt; 5</td>
<td>Non-plastic</td>
<td>0</td>
</tr>
<tr>
<td>With</td>
<td>5 - 12</td>
<td>Low</td>
<td>1 - 10</td>
</tr>
<tr>
<td>Modifier</td>
<td>&gt; 12</td>
<td>Medium</td>
<td>11 - 30</td>
</tr>
<tr>
<td></td>
<td></td>
<td>High</td>
<td>&gt; 30</td>
</tr>
</tbody>
</table>

#### GRAIN SIZE TERMINOLOGY

#### PLASTICITY DESCRIPTION
### CPT General Notes

**Description of Measurements and Calibrations**

To be reported per ASTM D5778:

- Uncorrected Tip Resistance, $q_t$
- Measured force acting on the cone divided by the cone's projected area
- Corrected Tip Resistance, $q_c$
- Cone resistance corrected for porewater and net area ratio effects
- $q_c = q_t + U21 - a$
- Where $a$ is the net area ratio, a lab calibration of the cone typically between 0.70 and 0.85

- Pore Pressure, $U1/U2$
- Pore pressure generated during penetration
  - U1 - sensor on the face of the cone
  - U2 - sensor on the shoulder (more common)

- Sleeve Friction, $f_s$
- Frictional force acting on the sleeve divided by its surface area

- Normalized Friction Ratio, FR
- The ratio as a percentage of $f_s$ to $q_c$, accounting for overburden pressure

- Shear Wave Velocity, $V_s$
- Measured in a Seismic CPT and provides direct measure of soil stiffness

**Description of Geotechnical Correlations**

- Normalized Tip Resistance, $q_t$
  - $q_t = (q - \sigma_0\nu)/\sigma^\star$

- Over Consolidation Ratio, OCR
  - OCR (1) = 0.25$\log(q_0)$
  - OCR (2) = 0.33$\log(q_c)$

- Undrained Shear Strength, $S_u$
  - $S_u = q_c \times \sigma^\star N_u$
  - $N_u$ is a geographical factor (shown on Su plot)

- Sensitivity, $S_t$
  - $S_t = (q - \sigma^\star N_u)/\sigma^\star$

- Effective Friction Angle, $\phi'$
  - $\phi'(1) = \tan^{-1}(0.373\log(q_c/\sigma^\star) + 0.29)$
  - $\phi'(2) = 17.6 - 11\log(q_c)$

- Unit Weight, $UW$
  - $UW = (0.27\log(FR) - 0.36\log(q_c/\sigma^\star) + 1.236) \times UW_{prev}$
  - $\sigma_{prev}$ is taken as the incremental sum of the unit weights

- Small Strain Shear Modulus, $G_s$
  - $G_s(1) = \rho V_s^2$
  - $G_s(2) = 0.015 x 10^{0.55(\log(q_c/\sigma^\star) + 0.29)}$

- Constrained Modulus, $M$
  - $M = \alpha_a(q - \sigma^\star)$
    - For $I_c > 2.2$ (coarse-grained soils)
      - $\alpha_a = U_{1/2}$ with maximum of 14
    - For $I_c < 2.2$ (coarse-grained soils)
      - $\alpha_a = 0.0188 x 10^{0.153(q_c/\sigma^\star) + 1.68}$

- Conventional Parameters
  - hydraulic conductivity, $k$
  - For $1.0 < I_c < 2.27$, $k = \alpha^\star \rho g = 10^{-6}$
  - For $2.27 < I_c < 4.0$, $k = (I_c - 1.577)^{0.5}$

- Relative Density, $D_r$
  - $D_r = (q_c/\sigma^\star) \times 100$

**Reported Parameters**

CPT logs as provided, at a minimum, report the data as required by ASTM D5778 and ASTM D7400 (if applicable). This minimum data include tip resistance, sleeve resistance, and porewater pressure. Other correlated parameters may also be provided. These other correlated parameters are interpretations of the measured data based upon published and reliable references, but they do not necessarily represent the actual values that would be derived from direct testing to determine the various parameters.

The following chart illustrates estimates of reliability associated with correlated parameters based upon the literature referenced below.

#### Relative Reliability of CPT Correlations

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Low Reliability</th>
<th>High Reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Permeability, $k$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constrained Modulus, $M$</td>
<td>Sand</td>
<td>Clay and Silt</td>
</tr>
<tr>
<td>Unit Weight</td>
<td>Clay and Silt</td>
<td>Sand</td>
</tr>
<tr>
<td>Effective Friction Angle, $\phi'$</td>
<td>Clay and Silt</td>
<td>Sand</td>
</tr>
<tr>
<td>Sensitivity, $S_t$</td>
<td>Clay and Silt</td>
<td>Sand</td>
</tr>
<tr>
<td>Undrained Shear Strength, $S_u$</td>
<td>Clay and Silt</td>
<td>Sand</td>
</tr>
<tr>
<td>Relative Density, $D_r$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Over Consolidation Ratio, OCR</td>
<td>Clay and Silt</td>
<td>Sand</td>
</tr>
<tr>
<td>Small Strain Shear Modulus, $G_s$</td>
<td>Clay and Silt</td>
<td>Sand</td>
</tr>
<tr>
<td>Elastic Modulus, $E_s$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* improves with seismic $V_s$ measurements

Reliability of CPT-predicted $N_u$ values as commonly measured by the Standard Penetration Test (SPT) is not provided due to the inherent inaccuracy associated with the SPT test procedure.

### Water Level

The groundwater level at the CPT location is used to normalize the measurements for vertical overburden pressures and as a result influences the normalized soil behavior type classification and correlated soil parameters. The water level may either be measured or estimated:

- Measured - Depth to water directly measured in the field
- Estimated - Depth to water interpolated by the practitioner using pore pressure measurements in coarse grained soils and known site conditions

While groundwater levels displayed as “measured” more accurately represent site conditions at the time of testing than those “estimated,” in either case the groundwater should be further defined prior to construction as groundwater level variations will occur over time.

### Cone Penetration Soil Behavior Type

The estimated stratigraphic profiles included in the CPT logs are based on relationships between corrected tip resistance ($q_t$), friction resistance ($f_s$), and porewater pressure ($U2$). The normalized friction ratio (FR) is used to classify the soil behavior type.

Typically, silts and clays have high FR values and generate large excess penetration porewater pressures; sands have lower FRs and do not generate excess penetration porewater pressures. Negative pore pressure measurements are indicative of fissured fine-grained material. The adjacent graph (Roberson et al.) presents the soil behavior type correlation used for the logs. This normalized SBT chart, generally considered the most reliable, does not use pore pressure to determine SBT due to its lack of repeatability in onshore CPTs.

### References


Mayne, P.W., (2013). “Geotechnical Site Exploration in the Year 2013,” Georgia Institute of Technology, Atlanta, GA.


### Unified Soil Classification System

**Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests**

<table>
<thead>
<tr>
<th>Coarse Grained Soils: More than 50% retained on No. 200 sieve</th>
<th>Fine-Grained Soils: 50% or more passes the No. 200 sieve</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravels: More than 50% of coarse fraction retained on No. 4 sieve</td>
<td>Silts and Clays: Liquid limit less than 50</td>
</tr>
<tr>
<td>Sands: 50% or more of coarse fraction passes No. 4 sieve</td>
<td>Silts and Clays: Liquid limit 50 or more</td>
</tr>
</tbody>
</table>

**Clean Gravels:** Less than 5% fines

- Cu ≥ 4 and 1 ≤ Cc < 3
- Cu < 4 and/or 1 > Cc < 3
- Fines classify as ML or MH
- Fines classify as CL or CH
- Fines classify as ML or MH
- Fines classify as CL or CH

**Clean Sands:** Less than 5% fines

- Cu ≥ 6 and 1 ≤ Cc < 3
- Cu < 6 and/or 1 > Cc < 3
- Fines classify as ML or MH
- Fines classify as CL or CH

**Gravels with Fines:**

- More than 12% fines
- Fines classify as ML or MH
- Fines classify as CL or CH
- Fines classify as ML or MH
- Fines classify as CL or CH

**Sands with Fines:** More than 12% fines

- Fines classify as ML or MH
- Fines classify as CL or CH

**Sands:**

- 50% or more of coarse fraction passes No. 4 sieve
- Less than 5% fines

**Clean Sands:**

- Cu ≥ 6 and 1 ≤ Cc < 3
- Cu < 6 and/or 1 > Cc < 3
- Fines classify as ML or MH
- Fines classify as CL or CH

**Sands with Fines:** More than 12% fines

- Fines classify as ML or MH
- Fines classify as CL or CH

**Silty Gravels:**

- More than 12% fines
- Fines classify as ML or MH
- Fines classify as CL or CH

**Silty Sands:**

- More than 12% fines
- Fines classify as ML or MH
- Fines classify as CL or CH

**Organic:**

- Liquid limit - oven dried
- Liquid limit - not dried

**Inorganic:**

- PI > 7 and plots on or above “A” line
- PI < 4 or plots below “A” line

**Organic:**

- Liquid limit - oven dried
- Liquid limit - not dried

**Inorganic:**

- PI plots on or above “A” line
- PI plots below “A” line

**Organic:**

- Liquid limit - oven dried
- Liquid limit - not dried

**Highly organic soils:** Primarily organic matter, dark in color, and organic odor

- PT Peat

---

**Based on the material passing the 3-inch (75-mm) sieve**

**If field sample contained cobbles or boulders, or both, add “with cobbles or boulders, or both” to group name.**

**Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.**

**Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay.**

**If fines are organic, add “with organic fines” to group name.**

**If soil contains > 15% gravel, add “with gravel” to group name.**

**If soil contains 15 to 29% plus No. 200, add “with sand” or “with gravel,” whichever is predominant.**

**If soil contains ≥ 30% plus No. 200 predominantly sand, add “sandy” to group name.**

**If soil contains ≥ 30% plus No. 200 predominantly gravel, add “gravely” to group name.**

**If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.**

**If soil contains > 15% gravel, add “with gravel” to group name.**

**If fines classify as CL-ML, use dual symbol GC-GM, or SC-SC.**

---

**If fines classify as CL-ML, use dual symbol GC-GM, or SC-SC.**

---

**For classification of fine-grained soils and fine-grained fraction of coarse-grained soils**

- Equation of “A” line
  - Horizontal at PI=4 to LL=25.5, then PI=0.73 (LL=20)
  - Vertical at “U” line
  - Horizontal at LL=16 to PI=7, then PI=0.9 (LL=8)

---

**Notes:**

- Cu = D₆₀/D₁₀
- Cc = (D₆₀)² / (D₁₀ x D₆₀)
- PI ≥ 4 and plots on or above “A” line
- PI < 4 or plots below “A” line
- PI plots on or above “A” line
- PI plots below “A” line

---

**If soil contains ≥ 15% sand, add “with sand” to group name.**

**If fines classify as CL-ML, use dual symbol GC-GM, or SC-SC.**

---

**If soil contains > 15% gravel, add “with gravel” to group name.**

**If soil contains 15 to 29% plus No. 200, add “with sand” or “with gravel,” whichever is predominant.**

**If soil contains ≥ 30% plus No. 200 predominantly sand, add “sandy” to group name.**

**If soil contains ≥ 30% plus No. 200 predominantly gravel, add “gravely” to group name.**

**If fines are organic, add “with organic fines” to group name.**

**If fines classify as CL-ML, use dual symbol GC-GM, or SC-SC.**