GEOTECHNICAL STUDY
PROPOSED LIFT STATION AT
PINE GROVE SUBDIVISION
SECTION 1
MONTGOMERY COUNTY, TEXAS

PROJECT NO. 19-388E

TO

PULTE GROUP
HOUSTON, TEXAS

BY

GEOTECH ENGINEERING AND TESTING
SERVICING
TEXAS, LOUISIANA, NEW MEXICO, OKLAHOMA

www.geotecheng.com

JUNE 2019
GEOTECHNICAL STUDY
PROPOSED LIFT STATION AT
PINE GROVE SUBDIVISION
SECTION 1
MONTGOMERY COUNTY, TEXAS

Gentlemen:

Submitted here are the results of Geotech Engineering and Testing (GET) geotechnical study for the proposed lift station at Pine Grove Subdivision, Section 1 in Montgomery County, Texas. This study was authorized by Mr. Brian Gates on May 20, 2019.

1.0 INTRODUCTION

It is planned to construct a lift station at Pine Grove Subdivision, Section 1 in Montgomery County, Texas. The proposed lift station will be cast in place concrete wet well. We understand that the depth of the lift station will be about 25-ft deep.

The purpose of our study was to explore subsurface conditions at the project site and using the information obtained, develop recommendations to guide design and construction of the proposed lift station.

2.0 FIELD EXPLORATION

At the request of the client, soil conditions were explored by one (1) soil boring, located approximately as shown on Plate 1. The soil samples were obtained continuously at the boring location from the ground surface to 10-ft and at five-ft intervals thereafter to the completion depth of the boring at 55-ft. The cohesive soils were sampled in general accordance with ASTM D 1587.

Cohesionless soils were generally sampled with a split-spoon sampler driven in general accordance with the Standard Penetration Test (SPT), ASTM D 1586. This test is conducted by recording the number of blows required for a 140-pound weight falling 30 inches to drive the sampler 12 inches into the soil. Driving resistance for the SPT, expressed as blows per foot of sampler resistance (N), is tabulated on the boring log.

Soil samples were examined and classified in the field, and cohesive soil strengths were estimated using a calibrated hand penetrometer. This data, together with a classification of the soils encountered and strata limits, is presented on the log of boring, Plate 2. A key to the log terms and symbols is shown on Plate 3.
Depth to groundwater will be important for design and construction of the proposed lift station. For this reason, boring was drilled dry and the depth at which groundwater was first encountered was recorded. Water level observations made during and shortly after drilling are indicated at the bottom portion of the log.

3.0 LABORATORY TESTS

3.1 General

Soil classifications were further evaluated by laboratory tests on representative samples of the major strata. The laboratory tests were performed in general accordance with ASTM Standards. Specifically, ASTM D 2487 is used for classification of soils for engineering purposes.

3.2 Classification Tests

As an aid to visual soil classifications, physical properties of the soils were evaluated by classification tests. These tests consisted of natural moisture content tests (ASTM D 4643), percent passing No. 200 sieve tests (ASTM D 1140), dry unit weight and Atterberg limit determination (ASTM D 4318). Similarity of these properties is indicative of uniform strength and compressibility characteristics for soils of essentially the same geological origin. Results of these tests are tabulated on the boring log at respective sample depths.

3.3 Strength Tests

Undrained shear strengths of the cohesive soils, measured in the field, were verified by calibrated hand penetrometer tests, unconfined compressive strength tests (ASTM D 2166) and torvane tests. Natural moisture content and dry unit weights were determined routinely for each unconfined compressive strength test. These test results are also presented on the boring log.

3.4 Soil Sample Storage

Soil samples tested or not tested in the laboratory will be stored for a period of seven days subsequent to submittal of this report. The samples will be discarded after this period, unless we are instructed otherwise.

4.0 GENERAL SOILS AND DESIGN CONDITIONS

4.1 Site Conditions

The project site and the surrounding areas are generally flat and exhibit topographic variation of less than three-ft. Currently, the project site is undeveloped and wooded. Project site pictures were taken during the time of our field exploration. These pictures are presented on cover page and on Plate 4.
4.2 Soil Stratigraphy

In general, the soils can be grouped into four (4) major strata with depth limit and characteristics as follows:

<table>
<thead>
<tr>
<th>Stratum No.</th>
<th>Range of Depth, ft.</th>
<th>Soil Description*</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>0 – 8</td>
<td>SANDY SILT (ML), medium dense, brown, light brown</td>
</tr>
<tr>
<td>II</td>
<td>8 – 28</td>
<td>LEAN CLAY (CL), very stiff to hard, light gray, brownish yellow, with ferrous nodules, sands</td>
</tr>
<tr>
<td>III</td>
<td>28 – 43</td>
<td>FAT CLAY (CH), firm to very stiff, light gray, brownish yellow, with calcareous and ferrous nodules</td>
</tr>
<tr>
<td>IV</td>
<td>43 – 55</td>
<td>LEAN CLAY (CL), stiff to very stiff, light gray, brownish yellow, with calcareous and ferrous nodules, sands</td>
</tr>
</tbody>
</table>

* Classification in general accordance with the Unified Soil Classification System (ASTM D 2487).

4.3 Soil Properties

Soil strength and index properties and how they relate to foundation design are summarized below:

<table>
<thead>
<tr>
<th>Stratum No.</th>
<th>Soil Type</th>
<th>PI(s)</th>
<th>SPT</th>
<th>Soil Expansivity</th>
<th>Soil Shear Strength, tsf</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Sandy Silt (ML)</td>
<td>–</td>
<td>15 – 17</td>
<td>Non-Expansive</td>
<td>–</td>
<td>Moisture Sensitive</td>
</tr>
<tr>
<td>II</td>
<td>Lean Clay (CL)</td>
<td>27</td>
<td>–</td>
<td>Moderately Expansive</td>
<td>1.50 – 2.38</td>
<td>–</td>
</tr>
<tr>
<td>III</td>
<td>Fat Clay (CH)</td>
<td>–</td>
<td>–</td>
<td>Expansive</td>
<td>0.39 – 1.50</td>
<td>–</td>
</tr>
<tr>
<td>IV</td>
<td>Lean Clay (CL)</td>
<td>–</td>
<td>–</td>
<td>Moderately Expansive</td>
<td>0.69 – 1.50</td>
<td>–</td>
</tr>
</tbody>
</table>

Legend: PI = Plasticity Index
SPT = Standard Penetration Test

4.4 Water-Level Measurements

The soil boring was first drilled dry to evaluate the presence of perched or free-water conditions. A wet rotary boring technique was used thereafter to the completion depth of the boring. The levels where free water was first encountered in the open borehole during our field exploration and shortly after drilling are shown on the boring log. Our groundwater measurements are as follows:

<table>
<thead>
<tr>
<th>Boring No.</th>
<th>Groundwater Depth, ft. at the Time of Drilling</th>
<th>Groundwater Depth, ft. at 2.0-Hour Later</th>
</tr>
</thead>
<tbody>
<tr>
<td>B-1</td>
<td>Dry</td>
<td>Dry</td>
</tr>
</tbody>
</table>

Project No. 19-388E
Fluctuations in groundwater generally occur as a function of seasonal moisture variation, temperature, groundwater withdrawal and future construction activities that may alter the surface drainage and subdrainage characteristics of this site.

An accurate evaluation of the hydrostatic water table in the relatively impermeable clays and low permeable sands/silts requires long term observation of monitoring wells and/or piezometers. It is not possible to accurately predict the pressure and/or level of groundwater that might occur based upon short-term site exploration.

We recommend that GET be immediately notified if a noticeable change in groundwater occurs from that mentioned in our report. We would be pleased to evaluate the effect of any groundwater changes on our design and construction sections of this report.

### 5.0 LIFT STATION FOUNDATION RECOMMENDATIONS

#### 5.1 General

We understand that the proposed lift station structure will be constructed using a sunken caisson (wet well) technique at a depth approximately 25-ft below the existing grade. The soil conditions were explored by conducting one (1) boring (B-1) at the proposed regional lift station site.

#### 5.2 Foundation Type

We understand that the proposed lift station structure will be constructed using a sunken caisson (wet well) technique at a depth approximately 25-ft below the existing grade. The allowable bearing pressures below the existing grade are as follows:

| Allowable Net Bearing Pressures, psf |
|-------------------------------|------------------|
| Dead Load                     | Total (Dead + Live) Load |
| 3,000                         | 4,500             |

Foundation proportioned in accordance with the above bearing capacity values will have a factor of safety of 3.0 and 2.0 with respect to shearing failure for dead and total loadings, respectively.

A detailed settlement analysis was not within the scope of this study. It is our opinion that the lift station foundation designed using the recommended allowable bearing pressures will experience small settlements that will be within the tolerable limit for the proposed lift station.
5.3 Groundwater Control

5.3.1 General

We understand that the proposed lift station structure will be constructed using a sunken caisson (wet well) technique at a depth approximately 25-ft below the existing grade. Our short-term field exploration indicates that no groundwater was encountered during and after drilling. Hence, dewatering may not be required.

Fluctuation in groundwater can occur as a function of seasonal moisture variation. Groundwater control recommendations are presented in the following report sections.

5.3.2 Dewatering Technique

In the event that groundwater is encountered during construction, it is our opinion that the lift station excavation can be dewatered using a wellpoint, multi-stage wellpoint system or ejector systems. Based on the field data, it is our opinion that groundwater should be lowered to a depth of at least three-ft below the deepest excavation grade in order to provide dry working conditions and firm bedding for construction of the lift station. Since the wellpoint suction lift is about 15-ft, multi-stage wellpoint system or ejector systems may be used for dewatering. Due to the presence of sandy silt, blow up may occur if an effective dewatering system is not in place at the time of construction.

Design of a dewatering system should consider the amount of groundwater to be lowered and the permeability of the affected soils. The selection and proper implementation of an effective groundwater control system is the responsibility of the contractor.

5.4 Buoyancy

We understand that the lift station will be founded at a depth of approximately 25-ft below the existing grade. This structure will experience uplift loads from the groundwater during flood conditions. The lift station should perform satisfactorily if a design factor of safety against uplift of 1.5 is used. If a sunken caisson (wet well) technique is used, the dead weight of the structure plus the frictional resistance developed between the walls and natural soils or fill soils can be used in resisting hydrostatic uplift. In an open cut installation technique, the foundation for the lift station may be extended out beyond the wall line to create a toe extension to provide sufficient weight of overburden soil to resist hydrostatic uplift at the bottom of the structure. Only the submerged weight of the soils mass directly above the toe extension and the dead weight of structure should be considered when calculating the uplift resistance due to unbalanced piezometric pressures.

An alternative to foundation toe extension would be to increase the mass of the lift station. A submerged soil unit weight of 60 pounds per cubic foot can be used compute the resistance to uplift loads.

The following values can be used for the calculation of frictional resistance to uplift developed along the wet well:
<table>
<thead>
<tr>
<th>Depth below Existing Grade, ft</th>
<th>Soil Type</th>
<th>Recommended Allowable Frictional Resistance, psf</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 – 28</td>
<td>Lean Clay (CL)</td>
<td>400</td>
</tr>
<tr>
<td>28 – 43</td>
<td>Fat Clay (CH)</td>
<td>300</td>
</tr>
<tr>
<td>43 – 55</td>
<td>Lean Clay (CL)</td>
<td>400</td>
</tr>
</tbody>
</table>

The above values include a factor of safety of 2.0. Frictional resistance for the upper eight-ft has been disregarded, since this zone is affected by seasonal moisture changes.

It must be noted that the above allowable frictional resistance values are based on the assumption that successful grouting between the lift station and the surrounding soils would be performed during the construction phase. In order for the values listed above to apply, the grout must fully displace all liquids from outside wet well and bond thoroughly with the soil outside the caisson. In the event that open excavation technique is used, the backfill soils should be compacted to a minimum of 95 percent Standard Proctor Density (ASTM D 698) between optimum and +3% of the Proctor optimum value.

5.5 Lateral Earth Pressures

The walls of the lift station can be designed for a lateral earth pressure equivalent to fluid having a density of 104 pounds per cubic foot. The design lateral pressure value is based upon the assumption that the groundwater level is near the ground surface, since this condition may exist after a heavy rain or flooding. The effect of surcharge loads at the ground surface should be added to compute later earth pressures. A surcharge load, q, will typically result in a lateral load equal to 0.7q. Lateral earth pressure diagram is presented on Plate 5.

5.6 OSHA Soil Classifications

The subsoils can be classified in accordance with Occupational Safety and Health Administration (OSHA) Standards, dated October 31, 1989 of the Federal Register. OSHA classification system categorizes the soil and rock in four types based on shear strength and stability. The description of four (4) types in classification system is summarized in the Appendix A.

Based on our geotechnical exploration and laboratory test results, details of soil classifications at each boring are summarized in the OSHA Soil Classifications and Trench Safety Recommendations, presented in Appendix A.

5.7 Excavations

We understand that the lift station will be installed using the sunken caisson method by excavating from the interior. Excavations should be performed with equipment capable of providing a relatively clean bearing area. Excavation equipment should not disturb the soil beneath the design excavation bottom and should not leave large amounts of loose soil in the excavation.
6.0 CONSTRUCTION CONSIDERATIONS

6.1 Suitability of On-Site Soils for Use as Fill

6.1.1 General

The on-site soils can be used as fill. There are typically three types of fill at a site. These fills can be classified as described in the following report sections.

6.1.2 Select Structural Fill

This is the type of fill that can be used under the floor slabs, paving, etc. These soils should consist of lean clays with liquid limit of less than 40 and plasticity indices between 12 and 20.

6.1.3 Structural Fill

This type of fill does not meet the Atterberg limit requirements for select structural fill. This fill should consist of lean clays or fat clays. They can be used under foundation or paving.

6.1.4 General Fill

This type of fill consists of sands and silts. These soils are moisture sensitive and are difficult to compact in a wet condition (they may pump). These soils can be used as structural fill on areas with the understanding that they can erode easily and if they get wet, they are difficult to compact (they may pump). These soils can result in a perched water table. The owner and the civil engineer must be aware of these potential issues.

6.1.5 On-Site Fill Soil Classification

The on-site soils can be used as fill materials as described below:

<table>
<thead>
<tr>
<th>Stratum No.(1)</th>
<th>Soil Type</th>
<th>Use as Fill</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Select Structural Fill</td>
<td>Structural Fill</td>
</tr>
<tr>
<td>I</td>
<td>Sandy Silt (ML)</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>II</td>
<td>Fat Clay (CH)</td>
<td>–</td>
<td>✓</td>
</tr>
<tr>
<td>I</td>
<td>Lean Clay (CL)</td>
<td>–</td>
<td>✓</td>
</tr>
<tr>
<td>I</td>
<td>Lean Clay (CL)</td>
<td>–</td>
<td>✓</td>
</tr>
</tbody>
</table>

Notes:
1. See soil stratigraphy and design conditions sections of this report for strata description.
2. All fill soils should be free of organics, roots, etc.
3. The on-site cohesionless soils are moisture sensitive and erode easily. These soils will pump when they get wet. Compaction difficulties will occur in these soils in a wet condition.
4. These soils, once lime modified (4% by dry weight), can be used as select structural fill.
5. These soils, once lime modified (5% by dry weight), can be used as select structural fill.
6.2 Earthwork

Difficult access and workability problems will most likely occur in the surficial cohesionless fill soils due to poor site drainage, wet season, or site geohydrology. Considering the soils stratigraphy, the construction of this project should be conducted during the dry season to avoid major earthwork problems. In the event the subgrade soils become wet and experience pumping problems, they can be improved by (a) improving drainage, (b) opening up to dry up, (c) mixing cohesionless soils with cohesive soils, (d) removing and replacing with dry cohesive soils or (e) chemically modifying or stabilizing the soil. These alternatives are discussed in the following report sections.

6.2.1 Improving Drainage

The project site drainage in the pumping soils can be accomplished by placing several shallow bleeder ditches (about 18-inches ±) in the surficial cohesionless soils. These bleeder ditches should be directed to a low area, such as a hole (detention pond) or another ditch in the lowest elevation area of the site. This will allow the surficial soils to drain the water and make the drying process faster. The hole/low area should not be under the building areas. The excess water can be pumped out of the hole and moved off-site.

6.2.2 Subgrade Drying

The on-site wet soils can be opened up so that it would dry up. However, opening up the surficial cohesionless soils for drying purposes may not be practical, due to cyclic rainfall in the Gulf-Coast area.

6.2.3 Soil Mixing

The on-site cohesionless (sandy silt, Stratum I) soils can be mixed with on-site cohesive soils (lean clay and fat clay, Strata II through IV) to reduce subgrade pumping. The soils can come from on-site detention pond, water and sewer excavations or imported in. GET can do a mix design to come up with soil mix percentages, if this option is considered.

6.2.4 Removal and Replacement

The surficial cohesionless soils can be removed and replaced with select structural fill. The actual depth of removal and replacement should be evaluated in the field, but it can be whole thickness of surficial cohesionless soils. This procedure will include removal of the surficial cohesionless soils, proofrolling and compacting the subgrade cohesive soils to a minimum of 95 percent standard proctor density (ASTM D 698). The site can then be backfilled with select structural fill, compacted to a minimum of 95 percent of standard Proctor density. The proofrolling should be in accordance with the site preparation section of this report. All of the fill soils should be placed and tested in accordance with the site preparation section of this report.

6.2.5 Modification/Stabilization

We recommend that the on-site cohesionless soils be modified (to dry up), using 5 to 10 percent fly ash by dry weight. The fly ash stabilization should be in accordance to Texas Department of Transportation (TxDOT) Specification, Item 265. The estimated amounts of fly ash per depth of modification are as follows:
<table>
<thead>
<tr>
<th>Modification Depth, in.</th>
<th>Fly Ash Weight Range, lbs. per Square Yard</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5%</td>
</tr>
<tr>
<td>6</td>
<td>23</td>
</tr>
<tr>
<td>12</td>
<td>46</td>
</tr>
<tr>
<td>18</td>
<td>69</td>
</tr>
<tr>
<td>24</td>
<td>92</td>
</tr>
</tbody>
</table>

We recommend that five percent fly ash be used if the surficial soils are relatively moist at the time of application. Higher levels (10 percent) of fly ash should be used if wet and soggy subgrade soils are encountered.

The subgrade soils should be removed to a depth of 24-inches (or more) below existing grade. These soils should be stockpiled. The soils below a depth of 24-inches should be modified to a depth of 12-inches. These soils should be compacted to a minimum of 95 percent of standard Proctor density (ASTM D 698). The stockpiled soils should then be modified and replaced in six-inch lifts and compacted to 95 percent of maximum dry density as determined by ASTM D 698 at moisture contents within ±2 percent of optimum.

Due to poor drainage and the depth of the cohesionless soils, the depth of stabilization may be as deep as depth of cohesionless soils. A test section can be implemented for this purpose. The subgrade soils should be modified in six-inch lifts and compacted within four hours of mixing and placement. All of the subgrade soils should be compacted to a minimum of 95 percent of the standard Proctor density at the moisture content of ±2 percent of optimum. The degree of compaction for the lifts, below a depth of 24-inches can be relaxed to 90 percent of maximum dry density to ease the construction procedures.

The subcontractor who will be doing the subgrade modification or stabilization should be experienced with stabilization procedures and methods. Furthermore, all of the earthwork at this project should be monitored by our geotechnician to assure compliance with the project specifications.

Once the subgrade is constructed, the soils at the top of subgrade should be slicked and the subgrade needs to be crowned such that the all surface water would drain away. No low areas should be left within the subgrade areas, since these areas would hold water and destroy the subgrade structure.

### 6.3 Construction Surveillance

Construction surveillance and quality control tests should be planned to verify materials and placement in accordance with the specifications. The recommendations presented in this report were based on one (1) soil test boring. Soil type and properties may vary across the site. As a part of quality control, if this condition is noted during the construction, we can then evaluate and revise the design and construction to minimize construction delays and cost overruns. We recommend the following quality control procedures be followed by a qualified engineer or technician during the construction of the facility:

- Monitor all phases of trench excavations and bracing.
o Observe the site stripping and proofrolling (if any).

o Verify the type, depth and amount of stabilizer.

o Verify the compaction of subgrade soils.

o Evaluate the quality of fill and monitor the fill compaction for all lifts.

o Monitor concrete placement, conduct slump tests and make concrete cylinders.

o Monitor all phases of excavation.

It is the responsibility of the client to notify GET when each phase of the construction is taking place so that proper quality control and procedures are implemented.

7.0 RECOMMENDED ADDITIONAL STUDIES

This report has been based on assumed conditions/characteristics of the proposed lift station where specific information was not available. It is recommended that civil engineer along with any other design professionals involved in this project carefully review these assumptions to ensure they are consistent with the actual planned development. When discrepancies exist, they should be brought to our attention to ensure they do not affect the conclusions and recommendations provided herein. We recommend that GET be retained to review the plans and specifications to ensure that the geotechnical related conclusions and recommendations provided herein have been correctly interpreted as intended.

8.0 STANDARD OF CARE

The recommendations described herein were conducted in a manner consistent with the level of care and skill ordinarily exercised by members of the geotechnical engineering profession practicing contemporaneously under similar conditions in the locality of the project. No other warranty or guarantee, expressed or implied, is made other than the work was performed in a proper and workmanlike manner.

9.0 REPORT DISTRIBUTION

This report was prepared for the sole and exclusive use by our client, based on specific and limited objectives. All reports, boring log, field data, laboratory test results, maps and other documents prepared by GET as instruments of service shall remain the property of GET. Reuse of these documents is not permitted without written approval by GET. GET assumes no responsibility or obligation for the unauthorized use of this report by other parties and for purposes beyond the stated project objectives and work limitations.
We appreciate the opportunity to assist on this project. Please call if there should be any questions.

Very truly yours,

GEOTECH ENGINEERING AND TESTING
TBPE Registration Number F-001183

Harry Nguyen, Ph.D.
Project Manager

Shailesh “James” Namekar, PhD., P.E.
Chief Engineer

HN/JN/DAE/hn

Copies Submitted:(1) Hard Copy – Pulte Group – Mr. Brian Gates
(1) PDF Copy Email – Mr. Brian Gates

10.0 ILLUSTRATIONS

<table>
<thead>
<tr>
<th>PLATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>5</td>
</tr>
</tbody>
</table>

Plan of Boring
Log of Boring
Key to Log Terms and Symbols
Project Site Pictures
Lateral Earth Pressure Diagram

Appendix A – OSHA Soil Classifications
PLAN OF BORING (boring location is approximate)

PROJECT: G/S for Proposed Lift Station at Pine Grove Subdivision, Section 1
Montgomery County, Texas

SCALE: NOT TO SCALE  DATE: JUNE 2019  PROJECT NO.: 19-388E

GEOTECH ENGINEERING AND TESTING

PLATE 1
## LOG OF BORING NO. B-1

**Geotech Engineering and Testing**  
17407 US Highway 59 North  
Houston, Texas 77396  
Phone: 713-699-4000  Fax: 713-699-9200

**PROJECT:** GIS for Proposed Lift Station at Pine Grove Subdivision  
**LOCATION:** Montgomery County, Texas  
**PROJECT NO.** 19-388E  **STATION NO.:**

**DATE:** 6-4-19  **COMPLETION DEPTH:** 55.0 ft.

### DESCRIPTION

**ELEVATION:** Existing Grade

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Silt (ML), brown, light brown</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 15</td>
<td>- medium dense 4' to 8'</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Clay (CL), hard, light gray, brownish yellow, with sand</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 - 15</td>
<td>- very stiff, with ferrous nodules 13' to 20'</td>
</tr>
<tr>
<td></td>
<td>- with ferrous nodules 23' to 25'</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Clay (CH), very stiff, light gray, brownish yellow, with ferrous nodules</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 - 40</td>
<td>- firm, with calcareous nodules 38' to 40'</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Clay (CL), stiff, light gray, brownish yellow, with calcareous and ferrous nodules, sand</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 - 55</td>
<td>- very stiff 48' to 55'</td>
</tr>
</tbody>
</table>

### WATER OBSERVATIONS:

**NO FREE WATER ENCOUNTERED DURING DRILLING**

**DRY AUGER:** 0 TO 55 ft  
**WET ROTARY:** TO ft

**DRILLED BY:** GET(I)  
**LOGGED BY:** Max

---

**UNDRAINED SHEAR STRENGTH, tsf**

- **HAND PNEUMATOGRAF**
- **TORVANE**
- **UNCONFINED COMPRESSION**
- **UNCONSOLIDATED-UNDRAINED TRIAXIAL**

---

**CWE2 19-388E GJW GGT 06/19**

GEOTECH ENGINEERING & TESTING  
PLATE 2
### UNIFIED SOIL CLASSIFICATIONS

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Material Descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>GW</td>
<td>WELL GRADED-GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES</td>
</tr>
<tr>
<td>GP</td>
<td>POORLY GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES</td>
</tr>
<tr>
<td>GM</td>
<td>SILTY GRAVELS, GRAVEL-SAND SILT MIXTURES</td>
</tr>
<tr>
<td>GC</td>
<td>CLAY GRAVELS, GRAVEL-SAND CLAY MIXTURES</td>
</tr>
<tr>
<td>SW</td>
<td>WELL GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES</td>
</tr>
<tr>
<td>SM</td>
<td>SILTY SANDS, SAND-SILT MIXTURES</td>
</tr>
<tr>
<td>SC</td>
<td>CLAYEY SANDS, SAND-SILT MIXTURES</td>
</tr>
<tr>
<td>ML</td>
<td>INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY</td>
</tr>
<tr>
<td>CL</td>
<td>INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY</td>
</tr>
<tr>
<td>OL</td>
<td>ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY</td>
</tr>
<tr>
<td>MH</td>
<td>INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SANDY OR SILTY SOILS, ELASTIC SILTS</td>
</tr>
<tr>
<td>CH</td>
<td>INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS</td>
</tr>
<tr>
<td>OH</td>
<td>ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS</td>
</tr>
<tr>
<td>PT</td>
<td>PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENT</td>
</tr>
</tbody>
</table>

### TERMS CHARACTERIZING SOIL STRUCTURE

<table>
<thead>
<tr>
<th>Descriptive Terms</th>
<th>Blows Per Foot*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Loose</td>
<td>0 – 4</td>
</tr>
<tr>
<td>Loose</td>
<td>5 – 10</td>
</tr>
<tr>
<td>Medium Dense</td>
<td>11 – 30</td>
</tr>
<tr>
<td>Dense</td>
<td>31 – 50</td>
</tr>
<tr>
<td>Very Dense</td>
<td>over 50</td>
</tr>
</tbody>
</table>

* 140 pound weight having a free fall of 30-inch

### TERMS CHARACTERIZING ROCK PROPERTIES

- **Very Soft**: Can be remolded in hand; corresponds in consistency up to very stiff in soils.
- **Soft**: Can be scratched with fingernail.
- **Moderately Hard**: Can be scratched easily with knife; cannot be scratched with fingernail. Difficult to scratch with knife.
- **Very Hard**: Cannot be scratched with knife.
- **Poorly Cemented or Friable Cemented**: Easily crumbled.
- **Unweathered**: Rock in its natural state before being exposed to atmospheric agents.
- **Slightly Weathered**: Noted predominantly by color change with no disintegrated zones.
- **Weathered**: Complete color change with zones of slightly decomposed rock.
- **Extremely Weathered**: Complete color change with consistency, texture, and general appearance or soil.

### SOIL SAMPLERS

- **SHELBY TUBE SAMPLER**
- **STANDARD PENETRATION TEST**
- **AUGER SAMPLING**

### KEY TO LOG TERMS AND SYMBOLS

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>GW</td>
<td>WELL GRADED-GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES</td>
</tr>
<tr>
<td>GP</td>
<td>POORLY GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES</td>
</tr>
<tr>
<td>GM</td>
<td>SILTY GRAVELS, GRAVEL-SAND SILT MIXTURES</td>
</tr>
<tr>
<td>GC</td>
<td>CLAY GRAVELS, GRAVEL-SAND CLAY MIXTURES</td>
</tr>
<tr>
<td>SW</td>
<td>WELL GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES</td>
</tr>
<tr>
<td>SM</td>
<td>SILTY SANDS, SAND-SILT MIXTURES</td>
</tr>
<tr>
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<td>PT</td>
<td>PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENT</td>
</tr>
<tr>
<td>F</td>
<td>FILL SOILS</td>
</tr>
</tbody>
</table>

**COARSE GRAINED SOILS** (major portion retained on No. 200 Sieve): Includes (1) clean gravels and sands, and (2) silty or clayey gravels and sands. Conditions rated according to standard penetration test (SPT)* as performed in the field.

**FINE GRAINED SOILS** (major portion passing No. 200 Sieve): Include (1) inorganic or organic silts and clays, (2) gravelly, sandy, or silty clays, and (3) clayey silts. Consistency is rated according to shearing strength as indicated by hand penetrometer readings or by unconfined compression tests.

### TERMS CHARACTERIZING SOIL STRUCTURE

- **Slickensided**: Having incline planes of weakness that are slick and glossy in appearance.
- **Fissured**: Containing shrinkage cracks frequently filled with fine sand or silt: usually vertical.
- **Laminated**: Composed of thin layers of varying colors and soil sample texture.
- **Interbedded**: Composed of alternate layers of different soil types.
- **Calcereous**: Containing appreciable quantities of calcium carbonate.
- **Well Graded**: Having wide range in grain sizes and substantial amounts of all intermediate particle sizes.
- **Poorly Graded**: Predominantly of one grain size, or having a range of sizes with some intermediate sizes missing.
- **Pocket**: Inclusion of material of different texture that is smaller than the diameter of the sample.
- **Parting**: Inclusion less than 1⁄8-inch thick extending through the sample.
- **Seam**: Inclusion 1⁄8- to 3-inch thick extending through the sample.
- **Layer**: Inclusion greater than 3-inch thick extending through the sample.
- **Interlayered**: Soils sample composed of alternating layers of different soil types.
- **Intermixed**: Soil samples composed of pockets of different soil type and layered or laminated structure is not evident.

### NOTE:
Slickensided and fissured clays may have lower unconfined compressive strengths than shown above because of weakness or cracks in the soil. The consistency ratings of such soils are based on hand penetrometer readings.
Note: The above picture(s) indicate a snap shot of the project and the surroundings. We request that the client review the picture(s) and make sure that they represent the project area. We must be contacted immediately if any discrepancy exists.
LATERAL EARTH PRESSURE DIAGRAM

Legend:
- - - - - - - - - - - - - Braced Excavation (stiff clays)
* * * * * * * * * * * * * Braced Excavation (sands)
- - - - - - - - - - - - - Cantilevered sheeting

Active Pressure:
(a) Braced Excavation (stiff clays) = 0.5q + 30H + 62.4H
(b) Braced Excavation (sands) = 0.4q + 18H + 62.4H
(c) Cantilevered sheeting = 0.7q + 42H + 62.4H

where: q = surcharge load, psf: A value of 250 psf can be assumed.
H = wall height, ft.

Notes:
1. The above Active Pressure Equations account for the groundwater at the surface.
2. The final lateral pressures should be reviewed prior to construction.
3. Trench excavation and construction should be observed by a geotechnical engineer.
4. The means and methods for a safe excavation is the responsibility of the contractor.
5. In case of layered soils, active pressure should be calculated based on the dominant or more critical soil conditions.
APPENDIX A

OSHA Soil Classification and Trench Safety Recommendations
OSHA SOIL CLASSIFICATION AND TRENCH SAFETY RECOMMENDATIONS

General

Occupational Safety and Health Administration (OSHA) requires a trench protective system for trenches deeper than five-ft. Trenches that are deeper than five-ft, should be shored, sheeted, braced or laid back to a stable slope, or some other appropriate means of protection should be provided where workers might be exposed to moving ground or caving. OSHA developed a soil classification system to be used as a guideline in determining protective requirements for trench excavations.

OSHA classification system categorizes the soil and rock in four types based on shear strength and stability. These classifications are summarized in the following report sections.

Stable Rock

means natural solid mineral matter that can be excavated with vertical sides and remain intact while exposed.

Type A Soil

means cohesive soils with an unconfined compressive strength of 1.5-ton per square foot (tsf) or greater. Examples of cohesive soils are: clay, silty clay, sandy clay, clay loam, silty clay loam, sandy clay loam, caliche and hardpan. No soil is Type A if:

- The soil is fissured; or
- The soil is subject to vibration from heavy traffic, pile driving or similar effects; or
- The soil has been previously disturbed; or
- The soil is part of a slope, layered system where the layers dip into the excavation on a slope of 4(h): 1(v) or greater; or
- The material is subject to other factors that would require it to be classified as a less stable material.

Type B Soil

- Cohesive soil with an unconfined compressive strength greater than 0.5 tsf but less than 1.5 tsf; or
- Granular cohesionless soils including: angular gravel, silt, silt loam, sandy loam, and in some case, silty clay loam and sandy clay loam; or
o Previously disturbed soils except those which would otherwise be classified as Type C soil; or
o Soil that meets the unconfined compressive strength or cementation requirements for Type A, but is fissured or subject to vibration; or
o Dry rock that is not stable; or
o Material that is part of a sloped, layered system where the layers dip into the excavation on a slope less steep than 4(h): 1(v), but only if the material would otherwise be classified as Type B.

Type C Soil

o Cohesive soil with an unconfined compressive strength of 0.5 tsf or less; or
o Granular soils including gravel, sand, and loamy sand; or
o Submerged soil or soil from which water is freely seeping; or
o Submerged rock that is not stable; or
o Materials in a sloped, layered system where the layers dip into the excavation on a slope 4 (h): 1(v) or steeper.

Under the assumption that appropriate groundwater control measures are carried out, and the groundwater table, if present, is lowered and maintained at least 3-ft below the excavation depths, the stable cohesive soils (CL) and (CH), with unconfined compressive strength greater than 0.5 tsf, are classified as OSHA soil Type “B”. The granular soils, which are less stable, are classified as OSHA soil Type “C”.

Based on our geotechnical exploration and laboratory test results, details of soil classifications at the boring locations are summarized below:

<table>
<thead>
<tr>
<th>Boring No.</th>
<th>Depth Range (1), ft</th>
<th>Soil Type</th>
<th>OSHA Soil Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>B-1</td>
<td>0 – 8</td>
<td>Sand Silt (ML)</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td>8 – 28</td>
<td>Lean Clay (CL)</td>
<td>B</td>
</tr>
<tr>
<td></td>
<td>28 – 43</td>
<td>Fat Clay (CH)</td>
<td>B</td>
</tr>
<tr>
<td></td>
<td>43 – 55</td>
<td>Lean Clay (CL)</td>
<td>B</td>
</tr>
</tbody>
</table>

Note: 1. Refer to each boring log of soils stratigraphy

Stockpiling of excavated materials may not be allowed near the banks of excavated areas. Generally, a distance of one-half the excavation depth on both sides of the trench should be kept clear of any excavated material.
Lift Station trenches should be provided with proper trench support system. The trenches should be provided with a temporary shoring system on excavations deeper than five-ft. We understand that the lift station will be placed at depth 25-ft below existing grade. The trenches can be made using shored, sheeted and braced, laid back stable slope or other means of appropriate protection system should be provided where workers are exposed to moving ground or caving. The slopes may be constructed in accordance with Table B-1 and shoring may be constructed in accordance with Table C-1.1, Table C-1.2 and Table C-1.3 of 29 CFR Part 1926 of OSHA.

In the event that trench sheeting is used, the sheeting can be constructed in the form of cantilever sheeting or with bracing. Lateral earth pressures for each method used are summarized on Plate A-1. The trenching and shoring operations should follow OSHA Standards. We recommend that a geotechnical engineer monitor all phases of trench excavation and bracing to assure trench safety.

Timber shoring as outlined in 29 CFR Part 1926 of OSHA recommendation may be used in the construction of trench supporting system.

For trench excavation, it is necessary to maintain the stability of the sides and base and not to disturb the soil below the excavation grade. In braced cuts, if the sheeting is terminated at the base of the cut, the bottom of the excavation can become unstable under certain conditions. The stability of the trench bottom is governed by the shear strength of the soils and the differential hydrostatic head. For cuts in cohesive soils (such as fat clay and lean clay) as encountered predominantly at this site, stability of the bottom can be evaluated in accordance with the procedure outlined on Plate A-2. Design soil parameters presented on Plate A-3 can be used for design.

Groundwater Control

We understand that the proposed lift station will be founded at a depth of approximately 25-ft below the existing grade. Our short-term field exploration indicates that no groundwater was encountered during and after 2.0-hour of drilling. Hence, groundwater dewatering may not be required. However, fluctuations in groundwater can occur as a function of seasonal moisture variation. Groundwater control recommendations are presented in the following report sections.

In the event that groundwater is encountered during construction, it is our opinion that the lift station excavation can be dewatered using a wellpoint, multi-stage wellpoint system or ejector systems. Based on the field data, it is our opinion that groundwater should be lowered to a depth of at least three-ft below the deepest excavation grade in order to provide dry working conditions and firm bedding for construction of the lift station. Any minor water inflow in cohesive soil layers can probably be removed using a sump-pump or trench sump-pump. Wellpoint system can be used in the area where sandy silt soils are present. Due to the presence of sandy silt subsoils and the hydrostatic pressure, blow up may occur in some areas if an effective dewatering system is not in place at the time of construction.

The results of our field exploration and laboratory testing indicate that unsatisfactory soils for excavation, such as sandy silt (ML) soils exist in the boring. A summary of the unsatisfactory soils location and depth are as follows:
If these conditions are encountered during the time of construction, suitable groundwater control measures should be implemented in accordance with the City of Conroe Specifications. Furthermore, the contractor may have to over excavate additional 6 inches and remove unstable or unsuitable materials with approval by geotechnical engineer, then place non-woven geotextile followed by compaction of 12-inch of crushed stone or 6-inch of reinforced concrete pad. A stable trench should be provided to allow proper bedding and installation.

Due to potential variability of the on-site soils, unstable trench conditions may still exist in the areas where we did not conduct borings. If these conditions are encountered during the time of construction, a stable trench should be provided to allow proper bedding and installation.

Our recommendation on trench safety at the project site does not address the effects of excavations on existing buildings/facilities at the project site. This study was outside the scope of our work.
LEGEND:

- Braced Excavation (stiff clays)
- Braced Excavation (sands)
- Cantilevered sheeting

ACTIVE PRESSURE:

(a) Braced Excavation (stiff clays) = 0.5q + 30H + 62.4H
(b) Braced Excavation (sands) = 0.4q + 18H + 62.4H
(c) Cantilevered sheeting = 0.7q + 42H + 62.4H

where: q = surcharge load, psf; A value of 250 psf can be assumed.
H = wall height, ft.

NOTES:

1. The above Active Pressure Equations account for the groundwater at the surface.
2. The final lateral pressures should be reviewed prior to construction.
3. Trench excavation and construction should be observed by a geotechnical engineer.
4. The means and methods for a safe excavation is the responsibility of the contractor.
5. In case of layered soils, active pressure should be calculated based on the dominant or more critical soil conditions.
CUT IN COHESIVE SOIL,
DEPTH OF COHESIVE SOIL UNLIMITED (T > 0.7 Bd)
L = LENGTH OF CUT

If sheeting terminates at base of cut:

Safety Factor, \(F_s = \frac{N_c c}{\gamma H + q}\)

\(N_c\) = Bearing capacity factor, which depends on dimensions of the excavation:
- Bd, L and H (use \(N_c\) from graph below)
- c = Undrained shear strength of clay in failure zone beneath and surrounding base of cut
- \(\gamma\) = Wet unit weight of soil
- \(q\) = Surcharge (assumed \(q = 250\) psf)

If safety factor is less than 1.5, sheeting or soldier piles must be carried below the base of cut to insure stability – (see note)

\(H_1 = \) Buried length = \(\frac{B_d}{2}\) ≥ 5 feet

Note: If soldier piles are used, the center to center spacing should not exceed 3 times the width or diameter of soldier pile.

Force on buried length, \(P_H\):

If \(H_1 > \frac{2\ B_d}{3\ \sqrt{2}}\), \(P_H = 0.7\ (\gamma B_d - 1.4CH - \pi c B_d)\) in lbs/linear foot

If \(H_1 < \frac{2\ B_d}{3\ \sqrt{2}}\), \(P_H = 1.5H_1\ (\gamma H - \frac{1.4CH}{B_d} - \pi c)\) in lbs/linear foot

STABILITY OF BOTTOM FOR BRACED CUT
## SOIL DESIGN PARAMETERS

(BASED ON BORING B-1)

<table>
<thead>
<tr>
<th>Soil Type</th>
<th>Depth Range, ft.</th>
<th>( \gamma ), pcf</th>
<th>( c ), psf</th>
<th>( \phi )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sandy Silt (ML)</td>
<td>0 – 8</td>
<td>120</td>
<td>–</td>
<td>28</td>
</tr>
<tr>
<td>Lean Clay (CL)</td>
<td>8 – 28</td>
<td>115</td>
<td>2,000</td>
<td>–</td>
</tr>
<tr>
<td>Fat Clay (CH)</td>
<td>28 – 38</td>
<td>105</td>
<td>2,000</td>
<td>–</td>
</tr>
<tr>
<td>Fat Clay (CH)</td>
<td>38 – 43</td>
<td>105</td>
<td>780</td>
<td>–</td>
</tr>
<tr>
<td>Lean Clay (CL)</td>
<td>43 – 48</td>
<td>115</td>
<td>1,380</td>
<td>–</td>
</tr>
<tr>
<td>Lean Clay (CL)</td>
<td>48 – 55</td>
<td>115</td>
<td>2,000</td>
<td>–</td>
</tr>
</tbody>
</table>