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February 26, 2021



# **GESSNER**

## **ENGINEERING**

### **GEOTECHNICAL ENGINEERING STUDY**

**Scorpio Building**  
State Highway 237  
Round Top, Texas  
Gessner Engineering Job No. 21-0124

February 26, 2021

Mr. James Weishuhn  
Weishuhn Engineering, Inc.  
P.O. Box 358  
Columbus, Texas 78934



Re: Geotechnical Engineering Study  
Scorpio Buildings  
State Highway 237  
Round Top, Texas  
Gessner Engineering Job No. 21-0124

Dear Mr. Weishuhn:

This report conveys our geotechnical engineering study conducted for the proposed Scorpio Buildings to be located in Round Top, Texas. The following report contains our design recommendations and considerations based on our understanding of the information provided to us. The purpose of this study was to drill borings within each proposed building footprint and pavement area, to perform laboratory testing to classify and characterize subsurface conditions, and to prepare an engineering report presenting foundation design and construction recommendations for the proposed structures, as well as pavement design and construction recommendations. We trust that this report is responsive to your project needs. Please contact us if you have any questions or if we can be of further assistance.

We are happy to be of service to you on this phase of the project and look forward to the opportunity to provide additional services for geotechnical engineering, structural engineering, civil engineering, land surveying, and construction materials testing as the project progresses.

Sincerely,  
GESSNER ENGINEERING, LLC F-7451

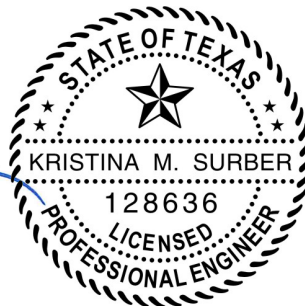
A handwritten signature in blue ink that reads 'Prashant M. Patil'.

Prashant M. Patil, M.S., E.I.T.

February 26, 2021

A handwritten signature in blue ink that reads 'Kristina M. Surber'.

Kristina M. Surber, M.E., P.E.



Copies Submitted:  
Mr. James Weishuhn

# CONTENTS

<b>CONTENTS</b> .....	<b>3</b>
<b>INTRODUCTION</b> .....	<b>4</b>
<b>PROJECT DESCRIPTION</b> .....	<b>4</b>
<b>SCOPE OF SERVICES</b> .....	<b>4</b>
<b>SITE INVESTIGATION PROCEDURES</b> .....	<b>5</b>
<b>LABORATORY TESTING</b> .....	<b>6</b>
<b>SITE CONDITIONS</b> .....	<b>8</b>
Site Geology.....	8
Surface Conditions.....	8
Subsurface Conditions.....	8
Groundwater Conditions.....	8
<b>ENGINEERING RECOMMENDATIONS</b> .....	<b>9</b>
General Foundation Considerations.....	9
Expansive Soil-Related Movements.....	10
Foundation Options.....	10
Stiffened Slab-on-Grade.....	11
Conventionally Reinforced System.....	11
Post-Tensioned System.....	12
Stiffened Slab-on-Grade Construction Considerations.....	13
Jointed Slab-on-Grade.....	14
Shallow Spread Footings.....	15
Deep Foundations.....	16
Temporary Casing.....	16
Earthwork.....	17
Foundation Earthwork.....	17
Select Fill.....	18
Site Fill.....	18
Drainage.....	18
Pavement Recommendations.....	19
Subgrade Conditions.....	19
Design Information.....	19
Rigid Pavement.....	19
Portland Cement Concrete.....	21
Garbage Dumpsters.....	21
Sidewalks.....	21
Flexible Pavement.....	21
Flexible Base Course.....	21
Asphaltic Concrete Surface Course.....	22
Subgrade Treatment.....	22
Lime.....	22
Cement.....	23
Stabilization Considerations.....	23
Pavement Earthwork.....	23
Pavement Drainage Considerations.....	24
Other Issues.....	24
Construction Materials Testing.....	24
General Comments.....	25
Limitations.....	25
<b>APPENDIX</b> .....	<b>26</b>

## Introduction

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This report describes the procedures utilized during this study and presents the results of our geotechnical engineering investigation for the proposed Scorpio Buildings. Gessner Engineering was authorized to provide the subsurface investigation and report for this project by Mr. James Weishuhn on January 28, 2021.

## Project Description

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The project consists of the proposed construction of two buildings at the site located at State Highway 237 in Round Top, Texas, in Fayette County. It is understood that the two proposed two-story structures will each have a footprint of approximately 7,500 square feet (sf). This project also includes ancillary driveway and parking area pavements.

Engineering recommendations are provided on the basis of existing conditions at the time of drilling.

## Scope of Services

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The Texas Section of the American Society of Civil Engineers defines an engineered foundation as one that includes a geotechnical engineering investigation. To act as this first phase of an engineered foundation, our scope of work for this project consisted of:

1. Drilling 7 test borings at the selected locations within the project site to evaluate the subsurface arrangement of strata and groundwater conditions.
2. Performing geotechnical laboratory tests on recovered samples to evaluate the physical and engineering properties of the strata observed.
3. Engineering analysis to develop recommendations with respect to:
  - Site, subgrade, and fill preparation
  - Foundation design and construction
  - Pavement design and construction

# SITE INVESTIGATION PROCEDURES

**Borings:**  
5 Borings  
Depth: 25 feet  
2 Borings  
Depth: 6 feet

Subsurface conditions at the site were evaluated by drilling 7 borings at the locations shown on the *Project Layout* in the Appendix. These locations are approximate and distances were measured using a hand-held GPS locator. On February 8 and 9, 2021, the borings for the buildings were drilled to a depth of approximately 25 feet below the existing ground surface and the borings for the pavement were drilled to a depth of 6 feet below the existing ground surface, using a track-mounted drill rig.

The *Logs of Borings*, presenting the subsurface soil descriptions, type of sampling used, laboratory results, and additional field data, are presented in the Appendix. The *Symbols and Terms*, which defines the terms and descriptive symbols used on the logs, is also provided in the Appendix.

Samples were taken continuously for the first 10 feet in 2 foot increments. Below 10 feet, samples were taken at 5 foot intervals to the termination of the boring.

Soil samples were generally recovered using thin-walled, open-tube samplers (Shelby tubes). Shelby tube samples are described as relatively undisturbed, and are obtained for specific laboratory testing. Pocket penetrometer tests were performed on samples of cohesive soils in the field to serve as a general measure of consistency and to give a relative measure of the strength of the sample.

Samples of soil for which a good quality thin-walled tube sample could not be recovered were obtained by means of a Split-Spoon with Standard Penetration Test (SPT). This test consists of measuring the number of blows

required for a free-falling hammer to drive a standard Split-Spoon sampler 12 inches into the subsurface material after being seated 6 inches. The test is terminated after 50 blows regardless of whether 12 inches of penetration has been achieved. If all 50 blows fall within the first 6 inches (seating blows), then refusal (Ref.) for 6 inches or less will be denoted on the *Logs of Borings*. This blow count, or SPT “N” value, is used to evaluate the engineering properties of the stratum. Correlations between the unconfined compressive strength and the “N” value for the in situ soils have been developed to estimate the bearing capacity of the soils.

All samples were removed from samplers in the field, visually classified, and sealed in sample containers to preserve their in situ moisture contents.

Throughout the report, the soils are referred to in terms used to describe their consistency. The term consistency refers to the degree of adhesion between the soil particles and to the resistance offered against forces that tend to deform or rupture the soil aggregate. Consistency of clays and other cohesive soils is usually described as very soft, soft, firm, stiff, very stiff, and hard. The correlation between the pocket penetrometer results and these consistency terms are provided on the *Symbols and Terms* in the Appendix. Additional consistency terms used on cohesive soils are plastic, lean, and fat. As a soil approaches the characteristics of a clay soil, the greater the variety of states of consistency in which it may be found. The physical properties of a plastic soil change depending upon the moisture content of the soil. The degree of plasticity is sometimes expressed by the terms fat and lean. Lean clay is only slightly plastic; whereas fat clay has a high plasticity.



Pocket Penetrometer

# LABORATORY TESTING

Samples obtained during the field program were visually classified in the laboratory by a geotechnical engineer or their representative. A testing program was conducted on selected samples in accordance with the ASTM Standard Test Procedures, as directed by the geotechnical engineer, to aid in classification and evaluation of engineering properties required for analysis.

The laboratory testing program for this project included sieve analyses, moisture contents, Atterberg limits, unit weights, and unconfined compressive strengths.

Sieve analyses were performed by passing the sample through a series of sieves to classify the soil based on their particle size. This allows a determination of the type of soils, distribution of the particle sizes and the interaction between the particles. Sieves used for this test include a series of screens of various sizes to determine the amount of various particle sizes in a sample.

Moisture content tests were performed in accordance with ASTM D 2216 by placing a sample into an oven with a constant temperature and comparing the mass before oven drying to the mass after oven drying. Changes in the moisture content have an effect on the behavior of plastic soils. Variations in the moisture content from the state observed during investigation to the moisture content from the state observed during construction can result in expansive soil-related movements. If the moisture content of the soil increases after construction, for example, the soil can induce uplift forces on the structure it is supporting.

The structure of clay consists of a random arrangement of flat plates. Edges of the particles are positively charged, and the face is negatively charged. Negative charges on the face of the clays bond with positive water ions in the soil, causing a volumetric change resulting in expansion of the soils. This water

may be released with the application of pressure from load, evaporation, or suction from gravity or vegetation. The specific chemical makeup of the various clays causes them to have a stronger or weaker ability to bond with water.

In order to relate moisture content and soil consistency, Atterberg limit tests were performed on the samples in accordance with ASTM D 4318. The Atterberg limit test is comprised of 2 separate tests: plastic limit and liquid limit. The plastic limit test determines the moisture content of the soil in its dry state while the liquid limit test determines the moisture content as the soil nears a liquid state.



The plastic limit is described as the moisture content of the soil where it transitions between brittle and plastic behavior. This point is determined by rolling the samples in threads 1/8 inch (3 mm) in diameter to the point at which they begin to crack and/or crumble.

The liquid limit describes the moisture content of the soil where it transitions between plastic and liquid behavior. In conducting this test, the sample is placed in the Casagrande cup, or liquid limit device. A standard grooving tool is used to create a gap in the center of the sample 0.53 inches (13.5 mm) in width. The cup is then dropped repeatedly onto the hard rubber base at a rate of 120 blows per minute. The liquid limit is the moisture content at which the groove closes at 25 blows.



The plasticity index (PI) is the difference between the liquid limit and the plastic limit and provides a description of the moisture states a soil can experience. The PI is an indicator of the potential for expansion or contraction of the soil.

Unit weights were determined by the ratio of the weight to given volume of a sample in accordance with ASTM D 7263. Dry density measurements are useful to determine the

degree of soil compaction, void ratio, and porosity.

The unconfined compressive strength of the soil can be used to estimate the shear strength of cohesive soils. Unconfined compression tests are a direct method to determine the strength of cohesive soils under unconfined conditions. Tests were performed in accordance with ASTM D2166 by placing a cylindrical soil sample with no confinement on the testing platform and applying a compressive load until it fails. The load is applied fairly rapidly, thus producing undrained conditions. In an undrained condition the pore water moves slowly through the sample, and excess pore pressures develop. Generally, structures are constructed and loads imposed on the soil more quickly than the rate of drainage of the soils.

Results of the laboratory tests are presented on the *Logs of Borings* in the Appendix and are discussed in the following sections. Samples will be retained in our laboratory for 30 days after submittal of this report.



All samples were returned to our laboratory in Brenham, Texas. Samples not tested in the lab will be stored for a period of thirty (30) days subsequent to submittal of this report and will be discarded after this period, unless Gessner Engineering is notified otherwise. Whenever possible, samples are used to fill subsequently drilled borings, or used to fill washed out areas or holes to prevent adding unnecessary waste to landfills.

# SITE CONDITIONS

## Site Geology

Major soil formations provide information with regards to the depth and magnitude of the conditions, as well as anticipated features of the soils in this area. This information provides typical data for the area. While it is valid as a general reference, it does not provide data accurate enough to replace site specific engineering analysis.

The site is mapped as being underlain by the Alluvium Formation and Fluvial terrace deposits as indicated on the Geologic Atlas of Texas, Austin Sheet as published by the University of Texas at Austin. The Alluvium Formation consists of clay, silt, sand, and gravel. The silt and clay is calcareous to the surface and is dark gray to dark brown in color. The sand is largely quartz and the gravel is siliceous and contains mostly chert, quartzite, limestone and petrified wood. The Fluvial Formation is composed of three or more levels which may correspond to coastal Pleistocene units. Gravel, sand, silt and clay exist in various proportions with gravel more prominent in the older, higher terraces. Gravel along the Guadalupe River is siliceous and coarse. Along the Colorado River the soil is mostly dolomite, limestone, chert, quartz, and various igneous and metamorphic rocks. The sand is mostly quartz.

In addition, the Oakville Sandstone Formation (clay and sandstone), Catahoula Formation (clay and sand), and Willis Formation (gravel, sand, silt, and clay) are also mapped nearby. Although not specifically mapped at the site, these may be encountered at construction.

## Surface Conditions

Based on online imagery, the topography is sloping across the proposed site. At the time of drilling, ground cover for the proposed site consisted of grass and weeds.

## Subsurface Conditions

Subsurface stratigraphy at this site varies drastically across the borings. The *Logs of Borings* should be consulted for more specific stratigraphic information. Each stratum has been designated by grouping soils that possess similar physical and engineering characteristics. Lines designating the interfaces between strata on the logs represent approximate boundaries, and transitions between strata may be gradual.

These soils generally exhibit up to high potential for volumetric change due to moisture variations, as indicated by the measured PI for each sample, which are presented on the *Logs of Borings* in the Appendix.

## Groundwater Conditions

The borings were dry augered to their completed depth in an attempt to observe groundwater conditions. Groundwater seepage was observed in the building borings at the time of the drilling and upon drilling completion at depths ranging from approximately 17 to 23 feet below the existing ground surface. Due to the shallow depth of exploration, the pavement borings remained dry during drilling operations. It should be noted that groundwater at the site occurs in the form of “perched” water traveling along pervious seams or layers within the soils. The frequency of such groundwater is expected to increase during and soon after periods of wet weather. Caution should be taken when constructing in wet seasons and all water accumulated during construction shall be removed prior to concrete placement.

An extensive groundwater study is beyond the scope of this report. Should construction activities require further evaluation of groundwater volumes, seasonal fluctuations, and direction, contact Gessner Engineering.

# ENGINEERING RECOMMENDATIONS

## General Foundation Considerations

Review of the borings and test data indicates that the factors discussed below may affect foundation design and construction at this site. This information may be used to help mitigate possible movement due to settlement over the life of the structures.

Some surficial sands encountered in the borings were less cohesive in nature. Settlement of less cohesive soils is primarily controlled by compressibility, or the tendency of sands to settle or compress under loads. Compressibility is influenced by relative density, grain shape, mineralogy, grain size distribution, overburden pressure, water, precompression or in situ stress state, and cohesive impurities. Relative density and overburden pressure are the primary factors that affect compressibility of soils. Due to the relatively low loads of the structures acting on the in situ soils, overburden pressure is of minimal concern for this project. Settlement due to sands with a low relative density is more of a concern; however, if the site is properly compacted as recommended in the *Foundation Earthwork* section of this report, the foundation is expected to experience minimal settlement.

Some soils encountered in our borings are plastic and exhibit expansive soil-related movement properties. Structures constructed on-grade may experience differential movements due to volumetric changes of the underlying and surrounding soils.

Movement of expansive soils is caused by fluctuations in the moisture content of soil particles. Because homogeneous expansive clay soils have relatively low permeability compared to granular soils, fluctuations in the moisture content of the soils might normally be expected to occur over a long period. However, permeability is increased with geotechnical phenomena such as ground faults, surface fractures due to desiccation of clays, and decomposition of tree roots that cause fissures and cracks that become widely disseminated over time.

Due to the repeated wetting, swelling, drying, and shrinking of the clay as it weathers, the fissures often fill with silt and sand, and create pathways for water that can exacerbate the infiltration process. Water can also easily move through naturally occurring sand strata, sand seams, and micro-cracks in clay soil caused by previous shrinkage. High negative pressures, also known as suction, in clay soils with low water content also increase the tendency for water to be absorbed into the clay.

Environmental factors other than climatic conditions can also affect expansive soils. Soil shrinkage may be caused by water extraction by trees and other vegetation, a process known as transpiration. Swelling can be a result of water infiltration into the soil from lawn irrigation systems, broken water pipes, flooded and leaking utility trenches, poor drainage, or leaking swimming pools; or it can be a result of slow moisture replenishment and equalization after the removal of a tree. The combined effect and variability of all of these possibilities make it difficult to accurately predict expansive soil ground movements.

Foundation movements are considered problematic only if they result in negative phenomena that detrimentally affect the performance or appearance of a building. The negative phenomena are considered to be structural if the load carrying capacity of the superstructure or foundation elements are affected, or are considered to be cosmetic if only the appearance of the exterior cladding or interior wall, floor, or ceiling finishes are affected.

Foundation movements can also affect the serviceability of a building, such as the opening or closing of doors. This type of movement typically occurs because of differential movements between various parts of a building. Differential movements often lead to high internal stresses in building components and subsequent cracking and separating of exterior cladding systems such as brick, cement-board panels, or in the interior finishes such as gypsum drywall panels, wood paneling, and flooring.

## **Expansive Soil-Related Movements**

Gessner Engineering has calculated the potential vertical rise (PVR) of the soils at this site using the Texas Department of Transportation Method Tex-124-E. Movement may be either heave or settlement depending on the changes in the moisture content. **The PVR at this site is calculated to range up to approximately 1.50 inches, assuming an active zone of 10 feet.** Due to assumptions and generalities required for the calculation of the potential vertical movement, it should only be taken as an approximation. It should be noted that moisture variations in the subgrade soils due to poor drainage, perched water in pervious layers, leakage of utilities, etc. could induce volumetric changes resulting in movements that are in excess of those estimated by the PVR procedure.

## **Foundation Options**

The following recommendations are based on the data obtained from our field and laboratory studies, our past experience with geotechnical conditions similar to those at this site, and our engineering design analyses.

**The following alternatives are available to support the structures:**

- **Stiffened Slab-on-Grade;**
- **Jointed Slab-on-Grade.**

These foundation alternatives are listed in order from lowest risk of expansive soil-related movements to highest risk of expansive soil-related movements. These foundation alternatives typically reduce in cost as the risk of expansive soil-related movements increases. The owner may select either one of these foundation systems depending on the performance criteria established for the structures. Cost analyses have not been conducted for any foundation system and are beyond the scope of this study.

Given the scale and use of the structures in the soil conditions at this site, a **stiffened slab-on-grade foundation system** is recommended to support the proposed structures. The soils on this site combined with the recommended foundation earthwork make this option feasible. If properly designed and constructed, the **stiffened slab-on-grade foundation system** can provide adequate foundation support with minimal deflections and maintenance to finishes over the life of the structures. Alternatively, a **jointed slab-on-grade foundation system** may be used at this site. For both options, foundation areas of high concentrated loads may be supported by shallow spread footings or piers.

## **Stiffened Slab-on-Grade**

A stiffened slab-on-grade, also known as a waffle slab or modified mat foundation, consists of a slab stiffened with beams spanning across the foundation in each direction. Stiffened slab-on-grade foundations are appropriate for foundations on expansive soils that are sensitive to deflection. Grade beams in these foundations should extend from edge to edge across the slab. The network of grade beams is intended to create a rigid plate that moves as a unit in response to soil movement. Stiffened slab-on-grade systems can be designed as conventionally reinforced or cable post tensioned systems.

A stiffened slab-on-grade can be supported on piers to help reduce structural risks associated with expansive soils, especially when the foundation will carry large concentrated loads. Similar to structural elevated foundation systems, piers are founded in soil strata deep enough to limit the magnitude of seasonal soil movement. **As recommended by the Texas Branch of the American Society of Civil Engineers, piers should be isolated from a stiffened slab-on-grade foundation in expansive soils to avoid failure from uplift pressure.** Even if the pier is designed for tensile forces, piers tied to the foundation system are subject to failure at the weakest point (often the slab around the pier) due to the extremely high loads swelling clays can generate beneath the slab. Properly designed and installed, piers can provide additional support for concentrated loads and minimize the movement of the foundation. Piers shall be designed in accordance with the *Deep Foundations* section of this report.

Parameters for the foundation design presented here are provided for the methods recommended by the Texas Branch of the American Society of Civil Engineers. Should the design engineer require additional parameters, please contact Gessner Engineering.

### **Conventionally Reinforced System**

The primary role of steel reinforcement in reinforced concrete is to carry the tensile forces due to flexure of the beams. Concrete has high compressive strength but lacks tensile strength. The conventionally reinforced stiffened slab-on-grade uses steel reinforcement in the grade beams to create the necessary stiffness in the foundation. Increasing the grade beam depth and size of reinforcement and decreasing the beam spacing provides additional stiffness for more expansive soils.

Presented below are the design parameters for the Building Research Advisory Board (B.R.A.B.) design method and the Wire Reinforcement Institute (W.R.I.) design method based upon the subsurface conditions observed at this project location. These methods are essentially empirical design techniques and the parameters provided are based on our interpretation of the project soil borings and criteria published in the B.R.A.B. design manual and the W.R.I. design manual.

Based on the existing soil, the effective PI for both structures is calculated at **26** and this may be used as the design effective PI for this site. This design effective PI is recommended based on our experience using the B.R.A.B. and W.R.I. methods of foundation design.

Due to some low-capacity soils in the vicinity of Boring BH-4, a value of **2,500 psf** may be used as the resulting allowable bearing pressure for the soils at 1 to 3 feet below ground surface with a properly prepared building pad at this site. This allowable bearing capacity was calculated with a factor of safety of 3. In the vicinity of weak surficial soils, it is recommended that a minimum of 2 feet

of this material be overexcavated and replaced with select fill. A proof roll shall be performed at the bottom of the excavation. Other measures recommended to reduce moisture infiltration into the subgrade are presented later in this subsection and in the *Drainage* section of this report. Presented in the table below are effective design parameters for this site after the recommended earthwork is performed.

Design Effective PI	26
Allowable Bearing Capacity (psf)	2,500
Climatic Rating	20
Soil Support Index (SSI)	0.90

*Table 1: B.R.A.B. or W.R.I. Design Parameters*

### Post-Tensioned System

Post tensioning relies on sleeved steel cables cast into the beams to prevent tensile forces from affecting the foundation. After the concrete has been placed, the cables are tensioned to impart compression in the concrete. The intent of post tensioning is that the compressive force imparted on the concrete, when combined with tension from bending, results in a zero or net compressive force in the concrete. The efficiencies inherent in the post tension system make it possible to support the load with a smaller beam; however, these efficiencies have little effect when it comes to deflection. In deflection critical foundations, such as those placed on expansive soils, properly designed post tensioned and conventionally reinforced foundations result in beams with similar depths.

Post Tensioning Institute (PTI) design parameters were estimated for existing stratigraphic conditions using the procedures and criteria discussed in the Post-Tensioning Institute Manual entitled *Design of Post-Tensioned Slabs-on-Ground*, Third Edition dated 2004 with the 2008 supplement.

Differential vertical swell has been estimated for center lift and edge lift conditions for use in designing foundation slabs for the stratigraphy encountered in our borings. These values were determined using a computer program entitled VOLFLO Win 1.5, as recommended by the Post Tensioning Institute. As recommended by PTI, differential swell has been evaluated for both 1) conditions varying from equilibrium and 2) conditions varying between extremes (wet/dry). The values for both of these conditions are presented in the tables below. Because moisture conditions are likely to vary from wet to dry and vice versa over many cycles during the lifetime of the structure, it is recommended that the latter conditions be assumed in design.

For both structures, the Estimated Differential Soil Movement ( $y_m$ ) as calculated based on the *Post Equilibrium Case* guidelines provided in the 3<sup>rd</sup> Edition PTI Manual, where pF varies from 2.9 to 4.5, are as follows:

Condition	$y_m$ , inches	Change in Suction Design Envelope
Center Lift (Shrinking)	0.50	Wet to Constant
Edge Lift (Swelling)	1.00	Dry to Constant

*Table 2: Differential Soil Movement Based on Post Equilibrium Case*

The Estimated Differential Soil Movement ( $y_m$ ) as calculated based on the *Post Construction Case* guidelines provided in the Addendum to the 3<sup>rd</sup> Edition PTI Manual, where pF varies from 2.9 to 4.5, are as follows:

Condition	$y_m$ , inches	Change in Suction Design Envelope
Center Lift (Shrinking)	1.25	Wet to Dry
Edge Lift (Swelling)	2.00	Dry to Wet

*Table 3: Differential Soil Movement Based on Post Construction Case*

The Estimated Edge Moisture Variation Distance ( $e_m$ ) due to shrinking soils (center lift condition) is about 9.0 feet, while the Estimated Edge Moisture Variation Distance due to swelling soils (edge lift condition) is about 5.6 feet. These values were calculated based on the guidelines provided in the PTI Third Edition manual.

The remaining soil and environmental parameters used to arrive at the differential swell values were assumed to be constant. These values are summarized in the following table:

Parameter	Design Value
Approximate Thornthwaite Moisture Index	-1
Constant Soil Suction	3.6 pF
Depth of Seasonal Moisture Variation	Approximately 10 feet
Soil Fabric Factor	1.2

*Table 4: Parameters for Differential Soil Movement Calculations*

The estimated moisture variation distance and the differential soil movements presented above do not consider the effects of non-climatic factors that might arise from conditions beyond the control of Gessner Engineering. The conditions include, but are not limited to, location of trees and landscaped areas in close proximity to the perimeter of the planned footings, the depth of exterior grade beams (or other vertical moisture barriers), location and use of irrigation systems, and area storm water management practices. The final PTI slab design should take into account such features that may exist or be anticipated.

### **Stiffened Slab-on-Grade Construction Considerations**

It is recommended that grade beams extend at least 12 inches below final grade into properly compacted select fill. This recommendation is to reduce surface water migration below the foundation elements and to develop proper bearing of the grade beams. According to Section 1809.4 of the 2018 International Building Code, the foundation is required to bear 12 inches below the adjacent soil. The grade beam width and depth should be properly evaluated by the structural engineer. Grade beams may be thickened and widened at column locations to serve as spread footings to support concentrated loads. It is also recommended that a vapor barrier be placed between the supporting soils and the concrete floor slab in accordance with ASTM E 1745-11, ASTM E 1643-11, and ACI 302.2R-06.

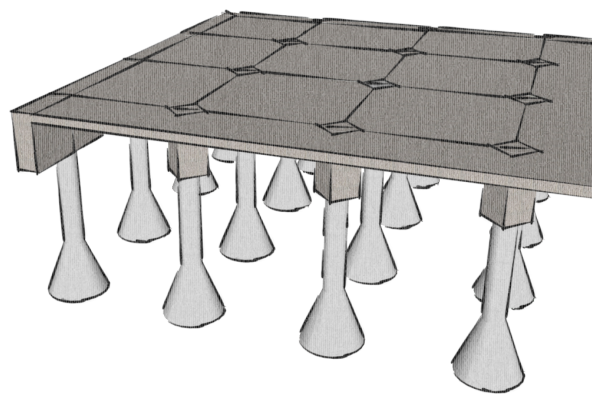
For a stiffened slab-on-grade foundation, it is recommended that measures be taken whenever practical to increase the tolerance of the Scorpio Building to post-construction foundation movements. An example of such measures would be to provide frequent control joints for masonry/brick/stucco veneer exteriors, if any, to control cracking across such walls and concentrate movement along the joints.

Care should be taken in all foundation systems to provide adequate drainage around the structure and prevent ponding of runoff adjacent to the foundation. In addition, systems that extend from the building into the shallow soils such as plumbing should be designed to accommodate the movement of the shallow soils.

Subgrade for a stiffened slab-on-grade foundation system shall be prepared in accordance with the *Foundation Earthwork* section of this report. Some of the native soils at this site are sandy and less cohesive in nature. Consequently, these soils may be susceptible to small changes in moisture content and to disturbance from foot traffic during the placement of steel reinforcement in beam trenches, particularly in periods of inclement weather. Disturbances in such foot traffic and from the accumulation of excess water can result in losses of bearing capacity and increased settlement. If inclement weather is anticipated at the time of construction, consideration should be given to protecting the bottoms of beam trenches by placing a thin mud mat (layer of flowable fill or lean concrete) at the bottom of trenches immediately following excavation. This will reduce disturbance from foot traffic and will impede the infiltration of surface water. Side slopes of beam trench excavations may also need to be flattened to reduce sloughing in cohesionless soils. All necessary precaution should be implemented to protect open excavation from the accumulation of surface water runoff and rain.

## **Jointed Slab-on-Grade**

For large developments, structures that can withstand movement, or developments that require flexibility, a jointed slab-on-grade may be the most appropriate system. A jointed slab-on-grade typically utilizes piers or spread footings to support concentrated loads. Perimeter walls or walls sensitive to movement should also be supported on beams to resist differential movement. Favoring flexibility over rigidity, the remainder of the foundation consists of a slab jointed to accommodate moderate movement of the subgrade. The joints should be placed to create as square sections of concrete as possible and should originate in areas where stresses concentrate. In addition, joints shall be provided between rigid or more stable elements, such as pier caps, and the open slab areas.



Due to some low-capacity soils in the vicinity of Boring BH-4, for each structure, the allowable bearing capacity of the shallow soils is **2,500 psf** for total load. This allowable bearing capacity was calculated with a factor of safety of 3. In the vicinity of weak surficial soils, it is recommended that a minimum of 2 feet of this material be overexcavated and replaced with select fill. A proof roll shall be performed at the bottom of the excavation.

For areas of high concentrated loads, the foundation may bear on shallow spread footings or piers. It should be noted that some shallow soils at this site may not have sufficient cohesion to remain stable during excavation or earth forming. For this reason, additional forming of the foundation elements may be required, and the *Foundation Earthwork* section of this report shall be referenced to ensure adequate bearing for the founding elements. The grade beam width and depth shall be properly evaluated by the structural engineer and designed to resist the PVR of the prepared subgrade soils.

It is also recommended that a vapor barrier be placed between the supporting soils and the concrete floor slab in accordance with ASTM E 1745-11, ASTM E 1643-11, and ACI 302.2R-06.

Subgrade recommendations for a jointed slab-on-grade foundation system shall be prepared in accordance with the *Foundation Earthwork* section of this report. Some of the native soils at this site are sandy and less cohesive in nature. Consequently, these soils may be susceptible to small changes in moisture content and to disturbance from foot traffic during the placement of steel reinforcement in beam trenches, particularly in periods of inclement weather. Disturbances in such foot traffic and from the accumulation of excess water can result in losses of bearing capacity and increased settlement. If inclement weather is anticipated at the time of construction, consideration should be given to protecting the bottoms of beam trenches by placing a thin mud mat (layer of flowable fill or lean concrete) at the bottom of trenches immediately following excavation. This will reduce disturbance from foot traffic and will impede the infiltration of surface water. The side slopes of beam trench excavation may also need to be flattened to reduce slouching in cohesionless soils. All necessary precaution should be implemented to protect open excavation from the accumulation of surface water runoff and rain.

## **Shallow Spread Footings**

The proposed structures may be supported on shallow spread footings. Footings founded at a depth of **1 to 3 feet** below the existing ground surface may be proportioned using a maximum allowable bearing capacity of **2,500 psf**. In the vicinity of weak surficial soils, it is recommended that a minimum of 2 feet of this material be overexcavated and replaced with select fill. A proof roll shall be performed at the bottom of the excavation. This was evaluated using a factor of safety of at least 3 with respect to the soil shear strength. The size and depth of footings can be adjusted as necessary to resist wind loads. For design purposes, 115 pounds per cubic feet (pcf) should be used for the unit weight of the on-site soils over the footings to resist uplift due to wind or lateral loading. If the potential expansive soil-related movements are excessive for the proposed structures, or if wind loads are greater than what the shallow foundations can resist, then deeper and oversized footings or drilled piers may be considered.

## **Deep Foundations**

Based on the current available project information and the soils data obtained, drilled piers or other deep foundation elements are not anticipated for this foundation. However, if high concentrated loads are anticipated, or if the client so desires, the foundation may be supported on drilled, straight-shaft piers. Founding soils at this site should provide sufficient cohesion to be able to remain stable during the augering of the shaft. **It should be noted that temporary casing will likely be needed due to the presence of cohesionless silts and sands as well as groundwater.**

Piers shall bear in **gray sandy silt or silty, clayey sand** and shall be designed for an allowable side shear resistance capacity of **850 psf** for the portion of the shaft extending below a depth of 10 feet. Piers shall bear to a minimum depth of **18 feet** below the existing ground surface. The allowable side shear resistance was evaluated using a calculated factor of safety of at least 2. Piers shall not be spaced closer than 3 times the pier diameter, center-on-center, without decreasing the pier capacity. It is recommended that piers be reinforced with minimum area of reinforcement of 0.5 percent of the pier cross sectional area to resist tensile forces on the pier from expansion of the clays in contact with it. **Pier reinforcement shall be isolated from the grade beams.** Piers shall be designed to resist uplift from the expansive soils. Note that ultimate pier depths from a level finished floor will vary due to the soil strata and slope of the site. Pier depths are based on the natural grade existing at the time of this investigation and shall not extend past 23 feet below the ground surface existing at the time of our study.

Drilled, straight-shaft piers may also be proportioned using a maximum allowable end bearing pressure of **9,000 psf for net dead plus sustained live load** and **13,500 psf for net total load.** These bearing pressures were evaluated using calculated factors of safety of 3 and 2 for net dead plus sustained live load and net total load, respectively. If end bearing capacity is included in the pier capacity for structural design, the side shear resistance should be neglected along the portion of the shaft located one shaft diameter from the bottom of the pier. In addition, we recommend that a minimum of 70 percent of the applied load be carried in side shear.

For bid purposes, the owner should anticipate that deeper piers will be required in some areas. Consequently, contractors bidding on the job should include unit costs for various depths of additional pier embedment. Unit costs should include those for both greater and lesser depth in soil.

**Water encountered during pier drilling shall be removed prior to the concrete pour.** If water is unable to be removed, concrete should be placed using the tremie method. Piers must be poured the same day they are drilled; pier shafts shall *not* be left open overnight. Piers that are unable to be poured on the same day as they are drilled shall be backfilled overnight.

### **Temporary Casing**

Groundwater seepage was observed in the test borings at the time of our subsurface exploration. Thus, groundwater seepage and/or side sloughing may be encountered at the time of construction, depending on climatic conditions prevalent at the time of construction. **Therefore, it is recommended that the bid documents require the foundation contractor to specify unit costs for different lengths of casing that may be required.**

## **Earthwork**

During earthwork, best practices shall be applied to limit erosion and pollution by sedimentation. At all times, the contractor shall work to maintain natural drainage and prevent the accumulation of runoff.

To achieve the required moisture content, the following recommendations are included as an aid to contractors. Where subgrade or layer of soil material requires moisture before compaction, uniformly apply water to surface of subgrade. Remove and replace, or scarify and air dry, soil material that is too wet to permit compaction to specified density. Soil material that has been removed because it is too wet to achieve compaction may be stockpiled or spread and allowed to dry. Assist drying by discing, harrowing, or pulverizing until moisture content is reduced to a satisfactory value. Alternate methods to achieve the end result of specified moisture content and compaction may also be used.

Four different methods may be utilized to successfully compact the soil. They include the processes of static weight, kneading action, impact, or vibration. Soil must be compacted using a compactor in accordance with the ASTM standards. A compactor is required to compact the soil to such a large degree. Track equipment such as bull dozers apply pressure across a large surface area and are therefore limited in their capabilities compared to a compactor. If the select fill is not compacted properly, the fill material and structures constructed on it are subject to settlement.

### **Foundation Earthwork**

The following earthwork recommendations are provided for the design parameters as described previously in the report. **For a stiffened slab-on-grade or a jointed slab-on-grade foundation system at this site, it is recommended that a minimum of 6 inches of existing material be overexcavated and minimum of 1 foot of select fill be compacted in place to form a level building pad. In the vicinity of weak surficial soils, it is recommended that a minimum of 2 feet of this material be overexcavated and replaced with select fill.** A proof roll shall be performed at the bottom of the excavation. **If the surficial material is processed of roots, vegetation, and deleterious materials, it may be used as select fill provided that it meets the select fill requirements in the following section.** **The building pad shall extend a minimum of 5 feet from the edge of the building footprint in all directions.** Select fill shall slope away at an angle that allows for proper drainage (see *Drainage* section).

Silty sands were encountered at the surface of some of our borings. Based on our prior experience with similar soils, it may be difficult to earth-form grade beams or achieve compaction at this site. If proper compaction is difficult to achieve, please contact Gessner Engineering for additional recommendations.

Construction areas should be stripped of all vegetation, loose topsoil, surficial concrete, etc. Roots of trees within the proposed building footprint should be excavated and removed from the construction area. Once final subgrade elevation has been achieved, exposed soil subgrade areas shall be proof rolled with a 15 ton roller (minimum) or equivalent equipment as approved by the engineer to detect weak zones. Weak areas detected during the proof rolling process, as well as zones containing debris and/or organics and voids resulting from removal of tree roots, etc., should be removed and replaced with soils exhibiting similar classification, moisture content, and density as the adjacent in situ soils. Finally, the minimum amount of select fill shall be placed to evenly build

up the pad. Select fill amounts may be increased to raise the building pad to the desired finished floor elevation or to decrease the movement potential of the site.

### Select Fill

Select fill to be utilized beneath the stiffened slab-on-grade limits should consist of a low plasticity soil with a PI between 8 and 18, a maximum gravel content (percentage retained on No. 4 sieve) of 40 percent, and rocks no larger than 2 inches in their largest dimension; or a crushed limestone base material meeting the requirements of the Texas Department of Transportation (TxDOT) 2004 Standard Specifications Item 247, Type A, Grade 3. Alternatively, a low-plasticity granular fill material that does not meet these specifications may be utilized only if approved by Gessner Engineering. All select fill should be placed on prepared surfaces in lifts not to exceed 8 inches loose measure, with compacted thickness not to exceed 6 inches. Select fill should be compacted to at least 95 percent of the Standard Proctor (ASTM D 698) density at a moisture content ranging within 2 percent of optimum moisture content for depths of 3 feet or less. If fill in excess of 3 feet is required, all select fill deeper than 3 feet shall be compacted to 98 percent of Standard Proctor (ASTM D 698).

### Site Fill

For site areas not below pavements or ground-supported structures, general fill may be used to achieve the desired grade. General fill shall have a PI no greater than 30 and shall be free of debris and organics. All general fill should be placed on prepared surfaces in lifts not to exceed 8 inches loose measure, with compacted thickness not to exceed 6 inches. General fill should be compacted to at least 92 percent of the Standard Proctor (ASTM D 698) density at a moisture content ranging within 2 percent of optimum moisture content.

All surficial backfill material within 5 feet of the foundation perimeter for the top foot of soil may be installed as a clay cap on fill materials to prevent migration of surface water beneath the structure. This material shall be placed as noted above and shall have a PI in excess of 30. Fill shall be free of debris and organics and shall be placed in accordance with the *Drainage* section of this report.

### Drainage

The performance of the foundation system for the proposed buildings will not only be dependent upon the quality of construction, but also upon the stability of the moisture content of the near surface soils. Therefore, Gessner Engineering recommends that site drainage be developed so that ponding of surface runoff near the structure does not occur. Accumulation of water near the structure foundation may cause moisture variations in the soils adjacent to the foundation, thus increasing the potential for structural distress.

Slope adjacent to foundations is addressed in Section 1804.4 of the 2018 International Building Code, which requires a 5 percent slope in the first 10 feet. Where sites do not allow this, the code allows drainage structures to accommodate the runoff. It should be noted that this requirement conflicts with accessibility standards, which would govern at entrances and other travel paths.

## **Pavement Recommendations**

Recommendations for both rigid and flexible pavements are presented in this report. The Owner and/or design team may select either pavement type depending on the performance criteria established for the project. In general, flexible pavement systems have a lower initial construction cost as compared to rigid pavements. However, maintenance requirements over the life of the pavement are typically much greater for flexible pavements. This typically requires regularly scheduled observation and repair, as well as overlays and/or other pavement rehabilitation at approximately one-half to two-thirds of the design life. Rigid pavements are generally more durable and require less maintenance after construction.

For either pavement type, drainage conditions will have an impact on long-term performance, particularly where permeable base materials are utilized in the pavement section. Pavement design should be in accordance with the *Pavement Drainage Considerations* section of this report.

### **Subgrade Conditions**

Gessner Engineering assumes that the subgrade in pavement areas will consist of the recompacted on-site materials, placed and compacted as recommended in the *Pavement Earthwork* section of this report. Based on our experience with similar subgrade soils, a California Bearing Ratio (CBR) value of 3.0 has been assigned for use in flexible pavement thickness design analyses.

### **Design Information**

Rigid pavement recommendations were prepared assuming traffic categories A for light-duty and C for heavy-duty pavements. An average daily truck traffic (ADTT) of 1 and 100 were assigned for light and heavy-duty pavements, respectively. Flexible pavement recommendations were prepared assuming a 20-year design life and Equivalent Single Axle Loads (ESAL's) of 15,000 for light-duty pavements (parking areas) and 100,000 for heavy-duty pavements (main drives, fire lanes).

**The Project Civil Engineer should review anticipated traffic loading and frequencies to verify that the assumed traffic loading and frequency is appropriate for the intended use of the facility.**

### **Rigid Pavement**

It is recommended that rigid pavements be considered in areas of channelized traffic, particularly in areas where truck or bus traffic is planned, and particularly where such traffic will make frequent turns, such as garbage dumpsters as described in the *Garbage Dumpsters* section of this report.

For the concrete parking lots, sidewalks and drives, frequent control joints should be used to direct shrinkage cracking with a maximum joint spacing as shown in the table below. It should be noted that the pavement thicknesses listed are minimum recommendations only and are not based on a pavement system design. Expansion joints shall be placed at anticipated stress points and dowels shall be placed across these joints. The concrete section may be reinforced and designed in accordance with ACI standard practices or may be designed as a jointed system in accordance with ACI 330R-08.

Subgrade stabilization shall comply with the *Subgrade Treatment* section of this report, with thickness as described in the following table.

Loading	Concrete Thickness (inches)	Chemically Stabilized Subgrade Thickness (inches)	Control Joint Maximum Spacing (feet)
Sidewalks	4.0	6.0	Sidewalk Width
Light-Duty Pavements	5.0	6.0	12.5
Heavy-Duty Pavements	7.0	6.0	15.0

*Table 5: Rigid Pavement System Recommendations*

It is recommended that the concrete pavements be reinforced with bar mats. Concrete reinforcing should be placed approximately 1/3 the slab thickness below the surface of the slab, but not less than 2 inches. In thinner slabs, the reinforcement should be centered in the slab. Reinforcing should not extend across expansion joints.

All control joints should be formed or sawed to a depth of at least 1/4 the thickness of the concrete slab. Sawing of control joints should begin as soon as the cutting can be performed without raveling of the concrete. Control joints may be hand formed or formed by using a premolded filler. It is recommended that all longitudinal and transverse construction joints be dowelled to promote load transfer. Expansion joints are needed to separate the concrete slab from fixed objects such as drop inlets, light standards and buildings. No expansion or construction joints should be located in a swale or drainage collection locations.

Based on Formula 3-3 in the ACI 330R-08 Guide for the Design and Construction of Concrete Parking Lots, the minimum area of steel required for a reinforced section shall be computed by the drag formula:

*Formula 1: Drag Formula*

$$A = \frac{(LC_f wh)}{24f_s}$$

Where:

- A = area of steel reinforcement (in<sup>2</sup>/ft)
- L = distance between joints (ft)
- C<sub>f</sub> = Coefficient of subgrade resistance (use 1.5)
- w = density of concrete (lb/ft<sup>3</sup>)
- h = slab thickness (in)
- f<sub>s</sub> = allowable tensile stress in steel reinforcement (psi)

If possible, the pavement should develop a minimum slope of 0.015 feet/feet to provide surface drainage. Reinforced concrete pavement should cure a minimum of 3 and 7 days before allowing automobile and truck traffic, respectively.

## Portland Cement Concrete

Portland cement concrete should have a maximum slump of 5 inches and should have a minimum 28-day compressive strength of 4,000 psi. Air entrainment is recommended and should meet the recommendations as outlined in ACI-330R-08, Table 4.1. A liquid membrane-forming curing compound should be applied as soon as practical after broom finishing the concrete surface. The curing compound will help reduce the loss of water from the concrete. The reduction in the rapid loss in water will help reduce shrinkage cracking of the concrete.

The  $M_r$  of concrete is a measure of the flexural strength of the concrete as determined by breaking concrete beam test specimens. An  $M_r$  of approximately 500 psi at 28 days was used in the analysis and is typical of local concrete production.

## Garbage Dumpsters

Where flexible pavements are constructed at any site, it is recommended that reinforced concrete pads be provided in front of and beneath trash receptacles. Dumpster trucks, if any, should be parked on the rigid pavement when trash receptacles are lifted.

It is suggested that such pads also be provided in drives where the dumpster trucks make turns with small radii to access the receptacles. Concrete pads at this site should be a minimum of 6 inches thick and reinforced with conventional steel reinforcing bars.

## Sidewalks

Concrete sidewalks are planned throughout the facility for pedestrian traffic. It is recommended that subgrade stabilization be extended beneath sidewalks to reduce movement that would interfere with required ADA specifications. Reference the concrete section above and subgrade section below for details.

## Flexible Pavement

Flexible pavement sections recommended for this site are as listed in the table below:

Loading	Asphaltic Concrete Thickness (inches)	Flexible Base Course Thickness (inches)	Chemically Stabilized Subgrade Thickness (inches)
Light-Duty Pavements	1.5	6.0	6.0
Heavy-Duty Pavements	3.0	6.0	6.0

Table 6: Flexible Pavement System Recommendations

## Flexible Base Course

Flexible base course should be crushed limestone conforming to TxDOT Standard Specifications, Item 247, Type A, Grades 1 or 2. Base course should be placed in lifts with a maximum thickness of 8 inches and compacted to a minimum of 95 percent of the maximum density at a moisture content within the range of 2 percentage points below to 2 percentage points above the optimum moisture content as determined by Tex-113-E.

## Asphaltic Concrete Surface Course

Asphaltic concrete surface course should conform to TxDOT Standard Specifications, Item 340, Type D. Asphaltic concrete should be compacted to a minimum of 92 percent of the maximum theoretical specific gravity (Rice) of the mixture determined according to Test Method Tex-227-F. Pavement specimens, which shall be either cores or sections of asphaltic pavement, will be tested according to Test Method Tex-207-F. The nuclear-density gauge or other methods that correlate satisfactorily with results obtained from project roadway specimens may be used when approved by the Engineer. Unless otherwise shown on the plans, the Contractor shall be responsible for obtaining the required roadway specimens at their expense and in a manner and at locations selected by the Engineer.

## Subgrade Treatment

The type of subgrade treatment to stabilize soils on the site depends on the type of soil located under pavements. Lime stabilization works by reacting chemically with clay, but it does not react properly with sand. Therefore, it is recommended that lime be used to stabilize expansive clayey material with a PI above 15 and cement be used to stabilize sandy material with a PI below 5. For material with a PI between 5 and 20, the stabilization method shall be either fly ash or fly ash and lime mixture, such as TRU-BLN®. In field evaluation is required to determine the required method. Subgrade treatment will add a structural component to the pavement section, and it is also recommended to provide a weather-resistant and workable surface for construction activity. It should be noted that stabilization recommendations are based on current grades. Should the site grading modify the surficial soils, variations from anticipated stabilization may be required. Stabilization shall meet local building code requirements.

### Lime

Some soils at this site are plastic and can be difficult to work with, particularly during periods of inclement weather. To provide a suitable, weather-resistant working surface for construction activity, the upper 6 inches of the plastic subgrade clays may be treated with hydrated lime.

Lime treatment of the subgrade soils should be in accordance with the TxDOT Standard Specifications, Item 260. A sufficient quantity of hydrated lime should be mixed with the subgrade soils to reduce the soil-lime mixture PI to 18 or less. For estimating purposes, it is recommended that 6 percent lime by weight be assumed for treatment. **For construction purposes, it is recommended that the optimum lime content of the subgrade soils be determined by laboratory testing.** Lime-treated subgrade soils should be compacted to a minimum of 95 percent of the maximum density at a moisture content within the range of optimum moisture content to 3 percentage points above the optimum moisture content as determined by Tex-114-E.

If lime treatment is considered as a method to improve pavement subgrade conditions, it is recommended to perform additional laboratory testing to determine the concentration of soluble sulfates in the subgrade soils to investigate the potential for a recently reported adverse reaction to lime in certain sulfate-containing soils. The adverse reaction, referred to as sulfate-induced heave, has been known to cause cohesive subgrade soils to swell in short periods of time, resulting in pavement heaving and possible failure.

## Cement

Some of the near-surface soils at this site are sandy. Therefore, it is recommended that cement be used to stabilize the cohesionless sandy material at this site. To provide a suitable, weather-resistant working surface for construction activity, the upper 6 inches of the cohesionless subgrade sand shall be treated with cement.

Gessner Engineering recommends the use of cement stabilizer for the treatment of the sand subgrade to help enhance the support characteristics of the subgrade. Subgrade shall be treated to a depth resulting in a 6 inch thick subgrade. Subgrade should be treated with cement meeting the requirements of TxDOT 2004 Standard Specifications Item 275. Cement treatment shall be accomplished such that a uniform subgrade mix is obtained. **Prior to the application of cement to the subgrade, the optimum percentage of cement to be added should be determined in the laboratory based on compressive strength tests on samples with varying percent cement and prepared in accordance with TEX-120-E.** The required cement selected shall provide a minimum strength of 50 psi. Cement shall be uniformly spread and mixed into the subgrade prior to the application of water. Stabilization shall be mixed and compacted in 1 lift and shall be completed the same day.

## Fly Ash or Fly Ash-Lime Mix

On site soils with a PI greater than 5 but less than 20 shall be treated with fly ash or a fly ash-lime mix to a depth of **6 inches**. A sufficient quantity of fly ash (or fly ash-lime mix) should be mixed with the subgrade soils to reduce the soil-fly ash mixture PI to 18 or less. For estimating purposes, it is recommended that 6 percent fly ash (or fly ash-lime mix) by weight be assumed for treatment. **For construction purposes, it is recommended that the optimum fly ash (or fly ash-lime mix) content of the subgrade soils be determined by laboratory testing.** Fly ash treatment shall be accomplished such that a uniform subgrade mix is obtained. Stabilization shall be mixed and compacted in 1 lift and shall be completed the same day. Fly ash-treated subgrade soils should be compacted to a minimum of 95 percent of the Standard Proctor (ASTM D 698) density at a moisture content within the range of optimum moisture content to 3 percentage points above the optimum moisture content.

## Stabilization Considerations

It is important that proper perimeter drainage be provided so that infiltration of surface water from unpaved areas surrounding the pavement is minimized, or if this is not possible, curbs should extend through the base and into the subgrade. A crack sealant compatible to both asphalt and concrete should be provided at concrete-asphalt interfaces. It should be noted that post-construction subgrade movements and cracking of asphaltic pavements is not uncommon for subgrade conditions such as those observed at this site.

## Pavement Earthwork

If required, fill used beneath pavement shall have a PI between 8 and 30. Any fill beneath pavement shall be compacted to a minimum of 95 percent of the maximum density as determined by the modified moisture/density relation (ASTM D 1557) at -2 to +2 percent of the optimum moisture content. (As an alternative, compaction to at least 98 percent of the ASTM D 698 maximum dry

density may be considered). The top portion of fill shall be chemically stabilized as recommended in the *Subgrade Treatment* section of this report.

## **Pavement Drainage Considerations**

As with any soil-supported structure, the satisfactory performance of a pavement system is contingent on the provision of adequate surface and subsurface drainage. Insufficient drainage that allows saturation of the pavement subgrade and/or the supporting granular pavement materials will reduce the performance and service life of the pavement systems.

Surface and subsurface drainage considerations crucial to the performance of pavements at this site include (but are not limited to) the following:

- 1) Any known natural or man-made subsurface seepage at the site that may occur at sufficiently shallow depths as to influence moisture contents within the subgrade should be intercepted by drainage ditches or below grade French drains.
- 2) Final site grading should eliminate isolated depressions adjacent to curbs which may allow surface water to pond and infiltrate into the underlying soils. **Curbs should completely penetrate subgrade materials and should be installed to sufficient depth to reduce infiltration of water beneath the curbs.**
- 3) Pavement surfaces should be maintained to help minimize surface ponding and to provide rapid sealing of any developing cracks. These measures will help reduce infiltration of surface water downward through the pavement section.

## **Other Issues**

Large trees adjacent to foundations should be avoided, as they can affect soil moisture contents significantly by creating concentrations of dry soils around the trees. If trees adjacent to a foundation cannot be avoided, property owners should maintain the drip line of the trees, which is typically consistent with the root system and can help keep the root system from causing foundation issues.

Maintenance of the entire landscape is a good practice for maintaining consistent moisture contents and minimizing foundation movement. Proper landscape maintenance uses vegetation as a natural moisture content indicator, as both over and under watering will result in distress of the plants.

Any elements that can affect the moisture content of the soils supporting a foundation, such as pools or plumbing, pose a risk to foundations. Care should be taken to prevent and quickly repair any leaks to minimize foundation damage.

Care should be taken when constructing adjacent to slopes to prevent bearing capacity failure due to nearby slope failure. For slopes steeper than 1 to 1, Section 1808.7.2 of the 2018 International Building Code recommends a minimum set back from slopes of 15 feet or one-half the height of the slope.

## **Construction Materials Testing**

The performance of foundation systems and pavements is dependent upon the quality of construction. Compaction testing of fill material and concrete strength tests are required by the 2018

International Building Code. Therefore, it is recommended that Gessner Engineering monitor foundation installation to identify the proper founding strata and depths and to help evaluate building pad and foundation construction. We would be pleased to develop a plan for foundation monitoring to be incorporated in the overall quality control program. For more information, please contact Gessner Engineering's dedicated dispatch number for materials testing at 979-325-TEST (8378).

## **General Comments**

Shallow foundation excavations should be observed by the Geotechnical Engineer or their representative prior to placement of reinforcing steel and concrete. This is necessary to observe that the founding soils at the bottom of the excavations are similar to those encountered in our borings and that excessive loose materials and water are not present in the excavations. If soft pockets of soil are encountered in the foundation excavations, they should be overexcavated and replaced with a compacted non-expansive fill material or lean concrete up to the design foundation bearing elevations. Gessner Engineering would be pleased to provide foundation design review, foundation inspection prior to the concrete pour, and construction materials testing.

The analysis and recommendations presented in this report are based upon the data obtained from the borings performed at the indicated locations and from other information discussed in this report. This report does not reflect variations that may occur between borings, across the site or due to the modifying effects of weather. The nature and extent of such variations may not become evident until during or after construction. If variations appear, Gessner Engineering should be immediately notified so that further evaluation and supplemental recommendations can be provided.

## **Limitations**

The scope of services for this project does not include, either specifically or by implication, any environmental or biological (e.g., mold, fungi, and 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.

For any excavation construction activities at this site, all Occupational Safety and Health Administration (OSHA) guidelines and directives should be followed by the Contractor during construction to ensure a safe working environment. In regards to worker safety, OSHA Safety and Health Standards require the protection of workers from excavation instability in trench situations.

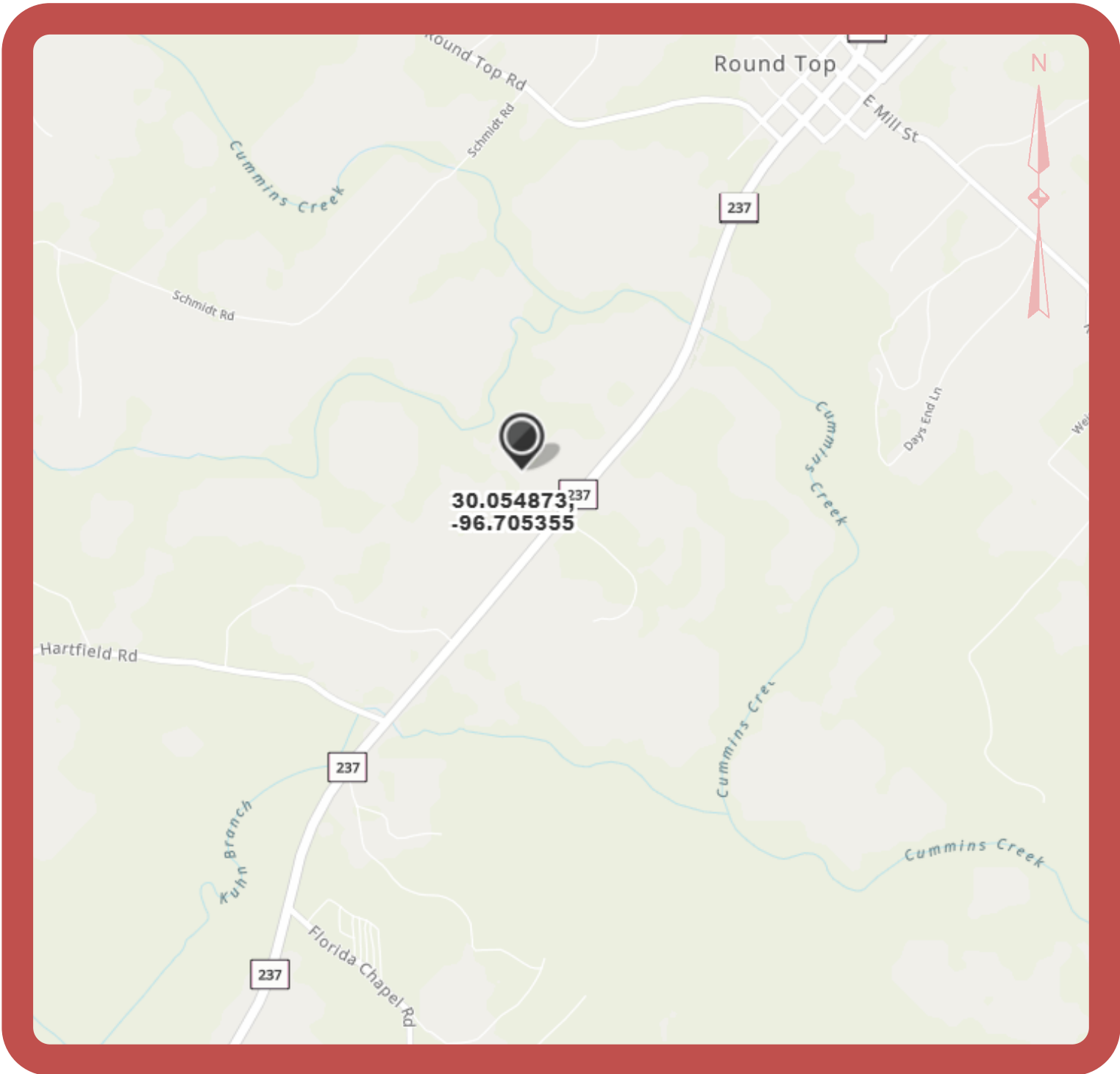
This report has been prepared for the use of Mr. James Weishuhn with Weishuhn Engineering, Inc. and their design representatives for the specific application to the project discussed and has been prepared in accordance with generally accepted geotechnical engineering practices. This report was written and recommendations were made based on the soil data collected on February 8 and 9, 2021. If construction is delayed or the proposed area experiences severe weather conditions, please contact the geotechnical engineer prior to construction. No warranties, either expressed or implied, are intended or made. In the event that changes in the nature, design, or location of the project as outlined in this report are planned, the conclusions and recommendations contained in this report shall not be considered valid unless Gessner Engineering reviews the changes and either verifies or modifies the conclusions of this report in writing.

# APPENDIX

- ✓ Project Location
- ✓ Project Layout
- ✓ Logs of Borings
- ✓ Symbols and Terms
- ✓ Glossary of Geological Terms

Mobile B-37 Drill Rig: Bubba Red





**GESSNER**  
ENGINEERING

### SCORPIO BUILDINGS

STATE HIGHWAY 237  
ROUND TOP, TEXAS

### PROJECT LOCATION

Corporate: 2501 Ashford Drive | College Station, Texas 77840  
[www.gessnerengineering.com](http://www.gessnerengineering.com) | 1-877-GESSNER  
 College Station | Brenham | Fort Worth | Georgetown | San Antonio

TBPLS F-1093910

PLAN | DESIGN | VERIFY

TBPE F-7451

Scale:	NTS
Job No.	21-0124
Drawn By:	PMP
Checked By:	KMS
Drawn Date:	02.10.21
Drawing No.	1



Boring	Approximate Location
BH-1	30.05487, -96.70535
BH-2	30.05427, -96.70535
BH-3	30.05429, -96.70485
BH-4	30.05417, -96.70586
BH-5	30.05381, -96.70536
PH-1	30.05398, -96.70618
PH-2	30.05358, -96.70562



**GESSNER**  
ENGINEERING

### SCORPIO BUILDINGS

STATE HIGHWAY 237  
ROUND TOP, TEXAS

### PROJECT LAYOUT

Corporate: 2501 Ashford Drive | College Station, Texas 77840  
www.gessnerengineering.com | 1-877-GESSNER  
College Station | Brenham | Fort Worth | Georgetown | San Antonio

TBPLS F-1093910

PLAN | DESIGN | VERIFY

TBPE F-7451

Scale: NTS  
Job No. 21-0124  
Drawn By: PMP  
Checked By: KMS  
Drawn Date: 02.10.21  
Drawing No. 2



# LOG OF BORING NO: BH-1

PAGE 1 OF 1

**CLIENT:** Weishuhn Engineering, Inc.  
**PROJECT:** Scorpio Building  
 State Highway 237  
 Round Top, Texas  
**PROJECT NO:** 21-0124  
**DATE:** 2/8/2021  
**DRILLER:** Gessner Engineering

**BOREHOLE LOCATION:** 30.05487, -96.70536  
**GROUND SURFACE ELEVATION:** 345 feet  
**BOREHOLE TERMINATION DEPTH:** 25 feet  
**INITIAL GROUNDWATER DEPTH:** 17 feet  
**FINAL GROUNDWATER DEPTH:** 17 feet  
**GROUND COVER:** Grass and Weeds  
 \*ALL DEPTHS, ELEVATIONS, AND LOCATIONS ARE APPROXIMATE

DEPTH (ft)	WATER LEVEL	GRAPHIC LOG	SAMPLE TYPE	PENETROMETER OR BLOW COUNT	LIQUID LIMIT	PLASTICITY INDEX	MOISTURE CONTENT (%)	DRY UNIT WT. (pcf)	FINES CONTENT (%)	UNCONFINED COMPRESSION (tsf)	USCS CLASSIFICATION	MATERIAL DESCRIPTION
0												
4.5				4.5			18.2					CLAY, Sandy, Stiff to Hard, Gray with calcareous deposits from 2 to 4 feet
2.0				4.5	42	26	14.7	117.4	67	9.85	CL	
5				4.5			16.0					
4.5				4.5	40	17	10.6		55		CL	
10				13/21/29			20.7					
15				8/22/30	26	9	22.6		56		CL	
20				16/22/37			27.0					SILT, Sandy, Hard, Gray
25				18/24/41			29.4					



# LOG OF BORING NO: BH-2

PAGE 1 OF 1

**CLIENT:** Weishuhn Engineering, Inc.  
**PROJECT:** Scorpio Building  
 State Highway 237  
 Round Top, Texas  
**PROJECT NO:** 21-0124  
**DATE:** 2/8/2021  
**DRILLER:** Gessner Engineering

**BOREHOLE LOCATION:** 30.05427, -96.70535  
**GROUND SURFACE ELEVATION:** 346 feet  
**BOREHOLE TERMINATION DEPTH:** 25 feet  
**INITIAL GROUNDWATER DEPTH:** 18 feet  
**FINAL GROUNDWATER DEPTH:** 22 feet  
**GROUND COVER:** Grass and Weeds  
**\*ALL DEPTHS, ELEVATIONS, AND LOCATIONS ARE APPROXIMATE**

DEPTH (ft)	WATER LEVEL	GRAPHIC LOG	SAMPLE TYPE	PENETROMETER OR BLOW COUNT	LIQUID LIMIT	PLASTICITY INDEX	MOISTURE CONTENT (%)	DRY UNIT WT. (pcf)	FINES CONTENT (%)	UNCONFINED COMPRESSION (tsf)	USCS CLASSIFICATION	MATERIAL DESCRIPTION
0												
1.5				23	10	13.5			51		CL	CLAY, Sandy, Stiff to Hard, Brown and Gray
4.5						11.2	119.4			16.48		with calcareous deposits and trace gravel from 4 to 6 feet
5				4.5		10.6						
					32	19	8.2		42		SC	SAND, Clayey, Gray, with trace gravel
10				5/16/23			17.8					CLAY, Hard, Gray and Tan, with silty sand seams
15				12/21/29	39	17	18.2		95		CL	
20				18/50-6"			21.5					SAND, Silty, Clayey, Very Dense, Gray
25				17/50-6"			25.7					



# LOG OF BORING NO: BH-3

PAGE 1 OF 1

**CLIENT:** Weishuhn Engineering, Inc.  
**PROJECT:** Scorpio Building  
 State Highway 237  
 Round Top, Texas  
**PROJECT NO:** 21-0124  
**DATE:** 2/9/2021  
**DRILLER:** Gessner Engineering

**BOREHOLE LOCATION:** 30.05429, -96.70485  
**GROUND SURFACE ELEVATION:** 348 feet  
**BOREHOLE TERMINATION DEPTH:** 25 feet  
**INITIAL GROUNDWATER DEPTH:** 21 feet  
**FINAL GROUNDWATER DEPTH:** 21 feet  
**GROUND COVER:** Grass and Weeds  
**\*ALL DEPTHS, ELEVATIONS, AND LOCATIONS ARE APPROXIMATE**

DEPTH (ft)	WATER LEVEL GRAPHIC LOG	SAMPLE TYPE	PENETROMETER OR BLOW COUNT	LIQUID LIMIT	PLASTICITY INDEX	MOISTURE CONTENT (%)	DRY UNIT WT. (pcf)	FINES CONTENT (%)	UNCONFINED COMPRESSION (tsf)	USCS CLASSIFICATION	MATERIAL DESCRIPTION
0						4.2					SAND, Silty, Brown with roots from 0 to 2 feet
5				22	10	6.8	114.5	28	3.55	SC	SAND, Clayey, Gray, Red, and Tan
10			4.5	45	20	27.9		91		CL	CLAY, Hard, Brown, Gray, and Tan with silty sand seams from 8 to 13 feet
15			17/25/40			23.0					SAND, Silty, Clayey, Very Dense, Gray
20			13/25/50-6"			24.8					
25			15/26/50-5"	23	6	28.4		40		SC-SM	



# LOG OF BORING NO: BH-4

PAGE 1 OF 1

**CLIENT:** Weishuhn Engineering, Inc.  
**PROJECT:** Scorpio Building  
 State Highway 237  
 Round Top, Texas  
**PROJECT NO:** 21-0124  
**DATE:** 2/9/2021  
**DRILLER:** Gessner Engineering

**BOREHOLE LOCATION:** 30.05417, -96.70586  
**GROUND SURFACE ELEVATION:** 347 feet  
**BOREHOLE TERMINATION DEPTH:** 25 feet  
**INITIAL GROUNDWATER DEPTH:** 23 feet  
**FINAL GROUNDWATER DEPTH:** 23 feet  
**GROUND COVER:** Grass and Weeds  
**\*ALL DEPTHS, ELEVATIONS, AND LOCATIONS ARE APPROXIMATE**

DEPTH (ft)	WATER LEVEL GRAPHIC LOG	SAMPLE TYPE	PENETROMETER OR BLOW COUNT	LIQUID LIMIT	PLASTICITY INDEX	MOISTURE CONTENT (%)	DRY UNIT WT. (pcf)	FINES CONTENT (%)	UNCONFINED COMPRESSION (tsf)	USCS CLASSIFICATION	MATERIAL DESCRIPTION
0											
0 - 5			2/2/2	14	3	6.7 8.1		27		SM	SAND, Silty, Very Loose, Brown
5 - 10				20	8	10.8 6.5		22		SC	SAND, Clayey, Gray, Red, and Tan with trace gravel from 6 to 8 feet
10 - 15			4.5			20.9					CLAY, Hard, Gray and Tan
15 - 20			4.5			14.1	92.5		0.93		
20 - 25			4.5			14.3					
25			13/24/ 50-3"			23.5					SILT, Sandy, Hard, Gray and Tan



# LOG OF BORING NO: BH-5

PAGE 1 OF 1

**CLIENT:** Weishuhn Engineering, Inc.  
**PROJECT:** Scorpio Building  
 State Highway 237  
 Round Top, Texas  
**PROJECT NO:** 21-0124  
**DATE:** 2/9/2021  
**DRILLER:** Gessner Engineering

**BOREHOLE LOCATION:** 30.05381, -96.70536  
**GROUND SURFACE ELEVATION:** 349 feet  
**BOREHOLE TERMINATION DEPTH:** 25 feet  
**INITIAL GROUNDWATER DEPTH:** 18 feet  
**FINAL GROUNDWATER DEPTH:** 18 feet  
**GROUND COVER:** Grass and Weeds  
 \*ALL DEPTHS, ELEVATIONS, AND LOCATIONS ARE APPROXIMATE

DEPTH (ft)	WATER LEVEL GRAPHIC LOG	SAMPLE TYPE	PENETROMETER OR BLOW COUNT	LIQUID LIMIT	PLASTICITY INDEX	MOISTURE CONTENT (%)	DRY UNIT WT. (pcf)	FINES CONTENT (%)	UNCONFINED COMPRESSION (tsf)	USCS CLASSIFICATION	MATERIAL DESCRIPTION
0											
4.5			4.5			12.4					CLAY, Hard, Gray and Tan, with sand with roots from 0 to 2 feet with trace gravel and calcareous deposits from 2 to 4 feet
4.5			4.5	41	26	10.2	118.3	73	15.82	CL	
5			4.5			9.0					
4.5			4.5	41	16	19.5		82		CL	
10			4.5			18.9					
15			6/16/50-6"	23	3	22.4		53		ML	SILT, Sandy, Hard, Gray
20			12/24/48			25.2					
25			16/23/20			27.1					






# LOG OF BORING NO: PH-1

PAGE 1 OF 1

**CLIENT:** Weishuhn Engineering, Inc.  
**PROJECT:** Scorpio Building  
 State Highway 237  
 Round Top, Texas  
**PROJECT NO:** 21-0124  
**DATE:** 2/9/2021  
**DRILLER:** Gessner Engineering

**BOREHOLE LOCATION:** 30.05398, -96.70618  
**GROUND SURFACE ELEVATION:** 348 feet  
**BOREHOLE TERMINATION DEPTH:** 6 feet  
**INITIAL GROUNDWATER DEPTH:** Not Encountered  
**FINAL GROUNDWATER DEPTH:** Dry at Completion  
**GROUND COVER:** Grass and Weeds  
**\*ALL DEPTHS, ELEVATIONS, AND LOCATIONS ARE APPROXIMATE**

DEPTH (ft)	WATER LEVEL	GRAPHIC LOG	SAMPLE TYPE	PENETROMETER OR BLOW COUNT	LIQUID LIMIT	PLASTICITY INDEX	MOISTURE CONTENT (%)	DRY UNIT WT. (pcf)	FINES CONTENT (%)	UNCONFINED COMPRESSION (tsf)	USCS CLASSIFICATION	MATERIAL DESCRIPTION
0												
					16	5	8.8		43		SC-SM	SAND, Clayey, Brown
				4.5			9.9					CLAY, Hard, Gray, with clayey sand seams
5				4.5	43	28	12.1		74		CL	with calcareous deposits from 4 to 6 feet









# LOG OF BORING NO: PH-2

PAGE 1 OF 1

**CLIENT:** Weishuhn Engineering, Inc.  
**PROJECT:** Scorpio Building  
 State Highway 237  
 Round Top, Texas  
**PROJECT NO:** 21-0124  
**DATE:** 2/9/2021  
**DRILLER:** Gessner Engineering

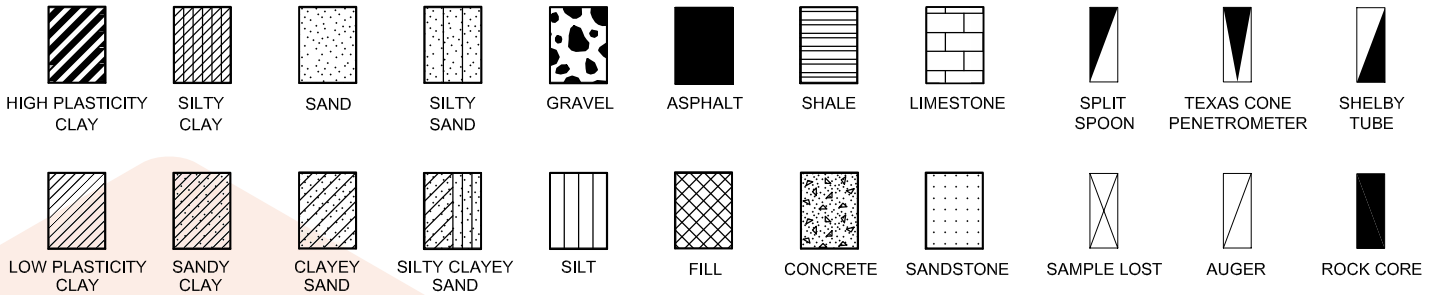
**BOREHOLE LOCATION:** 30.05358, -96.70562  
**GROUND SURFACE ELEVATION:** 351 feet  
**BOREHOLE TERMINATION DEPTH:** 6 feet  
**INITIAL GROUNDWATER DEPTH:** Not Encountered  
**FINAL GROUNDWATER DEPTH:** Dry at Completion  
**GROUND COVER:** Grass and Weeds  
**\*ALL DEPTHS, ELEVATIONS, AND LOCATIONS ARE APPROXIMATE**

DEPTH (ft)	WATER LEVEL	GRAPHIC LOG	SAMPLE TYPE	PENETROMETER OR BLOW COUNT	LIQUID LIMIT	PLASTICITY INDEX	MOISTURE CONTENT (%)	DRY UNIT WT. (pcf)	FINES CONTENT (%)	UNCONFINED COMPRESSION (tsf)	USCS CLASSIFICATION	MATERIAL DESCRIPTION
0												
					39	23	4.3		28		CS	SAND, Clayey, Brown, Gray, Red, and Tan with roots from 0 to 2 feet
5				4.5	23	9	6.6		65		CL	CLAY, Sandy, Hard, Gray and Tan, with vertical sand seams



# SYMBOLS AND TERMS USED ON BORING LOGS

## SOIL SYMBOLS AND DESCRIPTION



## SAMPLER TYPES

## GROUNDWATER SYMBOLS AND DESCRIPTION

- GROUNDWATER ENCOUNTERED DURING DRILLING
- GROUNDWATER DEPTH UPON DRILLING COMPLETION

## TERMS DESCRIBING CONSISTENCY OR CONDITION

**COARSE GRAINED SOILS** (Major Portion Retained on No. 200 Sieve): Includes (1) clean gravels and sands and (2) silty or clayey gravels and sands. Condition is rated according to relative density, as determined by laboratory tests.

Standard Penetration,  
N-Value, blows/ft

0-4  
4-10  
10-30  
30-50  
>50

Relative Density

Very Loose  
Loose  
Medium Dense  
Dense  
Very Dense

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

Standard Penetration,  
N-Value, blows/ft

0-2  
2-4  
4-8  
8-15  
15-30  
>30

Pocket Penetrometer

Reading

0-0.25  
0.25-0.5  
0.5-1.0  
1.0-2.0  
2.0-4.0  
>4.0

Consistency

Very Soft  
Soft  
Firm  
Stiff  
Very Stiff  
Hard

Cohesive Strength, tons/sf

less than 0.125  
0.125 to 0.25  
0.25 to 0.50  
0.50 to 1.00  
1.00 to 2.00  
2.00 and higher

Note: Slickensided and fissured clays may have lower unconfined compressive strengths than shown above due to planes of weakness or cracks in the soil.

## EXPANSION POTENTIAL OF COHESIVE SOILS

Plasticity Index

0-5  
5-10  
10-20  
20-40  
>40

Degree of Expansive Potential

Nonplastic  
Low  
Moderate  
High  
Very High

## ROCK QUALITY DESIGNATION

RQD=Rock Quality Designation

The percentage of intact rock retrieved from a bore hole. All pieces of intact rock core equal to or greater than 4 inches long are summed and divided by the total length of the core run.

REC = Recovery

This is the total percentage of material recovered from a run.

## TERMS CHARACTERIZING SOIL STRUCTURE

- Slickensided - having inclined planes of weakness that are slick and glossy in appearance
- Fissured - containing shrinkage cracks, frequently filled with fine sand or silt; usually more or less vertical
- Laminated - composed of thin layers of varying color and texture
- Interbedded - composed of alternate layers of different soil types
- Calcareous - 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 size missing
- Flocculated - pertaining to cohesive silts that exhibit a loose knit or flakey structure

# GLOSSARY OF GEOLOGIC TERMS

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Aphanitic	- dense, homogeneous rock with constituents so fine that they cannot be seen by the naked eye
Argillaceous	- containing, made of, or resembling clay; clayey
Bentonitic	- an absorbent aluminum silicate clay formed from volcanic ash and used in various adhesives, cements, and ceramic fillers
Carbonaceous	- consisting of, containing, relating to, or yielding carbon
Chert	- a siliceous rock of chalcedonic or opaline silica occurring in limestone
Conchoidal	- of, relating to, or being a surface characterized by smooth, shell-like convexities and concavities, as on fractured obsidian
Crossbedded	- intersecting layers of distinct soil deposits
Fluviatile	- produced by the action of a river or stream
Fossiliferous	- containing fossils
Friable	- readily crumbled, brittle
Glauconitic	- a greenish mineral of the mica group, a hydrous silicate of potassium, iron, aluminum, or magnesium found in <i>greensand</i> and used as a fertilizer and water softener
Gypsiferous	- containing gypsum; a widespread colorless, white, or yellowish mineral, used in the manufacture of various plaster products, and fertilizers
Igneous	- rocks formed by solidification from a molten state; pyrogenic
Inclusion	- a solid, liquid, or gaseous foreign body enclosed in a mineral or rock.
Indurated	- hardened soil that has been changed by extreme climate
Laminated	- a soil deposit divided into thin layers
Lateritic	- pertaining to red residual soil in humid tropical and subtropical regions that is leached of soluble minerals, aluminum hydroxides, and silica but still contains concentrations of iron oxides and iron hydroxides.
Lenticular	- lens-shaped grains of soil or rock
Lignitic	- pertaining to soft, brownish-black coal in which the alteration of vegetable matter has proceeded further than in peat but not as far as in bituminous coal; also called <i>brown coal</i>
Marl	- a loose and crumbling earthy deposit consisting mainly of calcite or dolomite; used as a fertilizer for soils deficient in lime
Metamorphic	- rocks changed in structure or composition as a result of metamorphism caused by chemical reaction or heat and pressure
Micaceous	- containing mica; any of a group of chemically and physically related aluminum silicate minerals, common in igneous and metamorphic rocks, characteristically splitting into flexible sheets used in insulation and electrical equipment
Montmorillonitic	- clays that are comprised mostly of montmorillonite; one of the three types of clay soil grains (illite, kaolinite, and montmorillonite)
Morphology	- refers to the geological characteristics, configuration, and evolution of rocks and landforms
Porous	- admitting the passage of gas or liquid through pores or interstices
Pyrite	- a brass-colored mineral occurring widely and used as an iron ore and in producing sulfur dioxide for sulfuric acid; also called <i>fool's gold</i>
Scarp	- a long steep slope or cliff at the edge of a plateau or ridge; usually formed by erosion
Siliceous	- containing, resembling, relating to, or consisting of silica; a white or colorless crystalline compound occurring abundantly as quartz, sand, flint, agate, and many other minerals and used to manufacture a wide variety of materials, especially glass and concrete
Surficial	- of, relating to, or occurring on or near the surface of the earth
Tuffaceous	- comprising rocks made of compacted volcanic ash varying in size from fine sand to coarse gravel; also called <i>tufa</i>