DUDLEY

May 16, 2023

Cattlemen Vail Court Holdings, LLC
1349 Whisper Willows
Haslet, Texas 76052

Attn: Mr. Eric Diaz

Re: Report of Geotechnical Study for
Cattlemen Single-Family Development
Block 79: Lots 112 to 115
Montgomery, Texas

Dear Mr. Diaz:

Dudley Engineering LLC (DUDLEY) is pleased to submit to you the accompanying report that documents the results of a geotechnical study performed for the proposed single-family residential development. More specifically, the proposed residential development consists of four residential lots, designated as Lots 112 through 115, located off Vail Court in Montgomery, Texas. The geotechnical study was performed in accordance with DUDLEY's Agreement dated May 1, 2023.

The accompanying report summarizes the results of the subsurface investigation and laboratory testing program. In addition, foundation recommendations and design parameters are presented for the proposed residential development based on the results of the geotechnical study.

DUDLEY sincerely appreciates the opportunity to work with you on this project. Please do not hesitate to contact us at (979) 777-0720 if you have any questions or if we can provide any additional assistance. We look forward to continuing our working relationship with you in the future.

Sincerely,
Dudley Engineering, LLC

G. Taylor Stinson

G. Taylor Stinson, P.E.
Principal

Enclosures: Geotechnical Report
Via E-mail: [eric.diaz@cattlemencs.com]

REPORT OF GEOTECHNICAL STUDY
CATTLEMEN SINGLE-FAMILY DEVELOPMENT
BLOCK 79: LOTS 112 TO 115
MONTGOMERY, TEXAS

Prepared For

Cattlemen Vail Court Holdings, LLC
1349 Whisper Willows
Haslet, Texas 76052

Prepared By

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DUDLEY Project No.: 23-00195

STATE OF TEXAS
G. TAYLOR STINSON
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May 16, 2023

5/16/2023

G. Taylor Stinson, PE, MS
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1.0 INTRODUCTION

1.1 OVERVIEW

This report was prepared by Dudley Engineering LLC (DUDLEY) for Cattlemen Vail Court Holdings, LLC to document the results of a geotechnical study performed for a residential development in Montgomery, Texas. The geotechnical study was performed in accordance with DUDLEY's Agreement dated May 1, 2023. The signed Agreement was returned on the same date.

The subsurface investigation was initiated on May 8, 2023 and was completed on the same date. The laboratory testing program was initiated shortly after the completion of drilling operations and was completed on May 11, 2023. A description of the subsurface information compiled during the field and laboratory phases of the project and an outline of DUDLEY's interpretation of the information is presented in this report for your review and consideration.

1.2 PROJECT DESCRIPTION

The project consists of four residential lots (Lots 112 to 115) located off Vail Court as illustrated on Figure 1 in Attachment A of this report. The residential structures are anticipated to be one to two stories in height. Each residential structure is expected to have a total footprint of 6,000 square feet or less. The superstructures are anticipated to consist of conventional wood framing. Finally, exterior finishes may consist of movement sensitive stone and/or brick.

Grading plans for the proposed residences are not currently available. Nevertheless, we anticipate that changes in grade will be on the order of **3 feet** or less. DUDLEY should be notified if this is incorrect because it may result in changes to the recommendations presented in this report.

1.3 SCOPE OF SERVICES

The scope of services associated with the current geotechnical study included the following:

- ***Task 1 – Subsurface Investigation:*** Secure information on subsurface conditions at the project site by drilling two (2) exploratory borings.

- ***Task 2 – Laboratory Testing Program:*** Perform laboratory tests on select soil samples recovered from the borings to aide in characterizing the subsurface materials.

- ***Task 3 – Engineering Analysis and Report Preparation:*** Evaluate the information developed from the subsurface investigation and laboratory testing program so that geotechnical recommendations and design parameters can be furnished for the proposed residential structures.

2.0 SUBSURFACE INVESTIGATION

2.1 BORING DESIGNATION AND LOCATION

Two (2) borings were drilled for the project. The borings were designated as B-1 and B-2 as illustrated on Figure 2 in Attachment A of this report. The borings illustrated on Figure 2 were established by the drilling crew using a recreational hand-held global positioning system (GPS) device. The ground surface elevation at each boring was not specifically measured during drilling operations.

2.2 DRILLING AND SAMPLING

The borings were drilled with a CME 550 drilling rig. The borings were advanced dry with flight augers so that water levels could be monitored during and immediately after the completion of drilling operations. Soil samples were collected in accordance with ASTM D1586 – *Standard Test Methods for Standard Penetration Tests (SPT) and Split-Barrel Sampling of Soil*. Furthermore, SPT sampling utilized an automatic hammer, which generally has a higher energy transfer efficiency than traditional SPT equipment, i.e., safety hammers. The energy transfer ratio of the automatic hammer was not specifically evaluated as part of the current investigation; however, it is generally assumed to be 1.33 times more than that recorded using a standard safety hammer.

Both borings were advanced 20 feet below the existing ground surface. Therefore, 40 linear feet of drilling was associated with the project. Representative soil samples were obtained at 1.5 -foot intervals within the upper 10 feet of the stratigraphy. Below a depth of 10 feet, samples were collected at 5-foot intervals to the 20-foot termination depth of drilling.

2.3 BORING LOGS

The subsurface materials encountered at the borings were continuously logged in the field by a trained representative of DUDLEY. Following removal from the samplers, the soils were visually classified in accordance with ASTM D2488 – *Standard Practice for Description and Identification of Soils (Visual-Manual Procedures)* and a color description was assigned using the Munsell Soil Color chart. Pocket penetrometer readings were also taken on cohesive and cohesive-granular soil samples recovered from the borings to estimate strength. This information is summarized in Attachment B on the boring logs. A key to the terms and symbols used on the boring logs is also presented in Attachment B immediately after the boring logs.

The boring logs represent our present evaluation of the subsurface materials encountered at the project site based on observations and classification of the materials in the laboratory. The lines designating the interfaces between different soil types/formations are approximate and may be more gradual or more distinct. Variations will naturally occur and should be expected across the project site and between boring locations.

2.4 SAMPLE CUSTODY

Samples obtained as part of the subsurface investigation are and remain the property of Cattlemen Vail Court Holdings, LLC. Unless other arrangements are requested by Cattlemen Vail Court Holdings, LLC and mutually accepted by DUDLEY in writing, DUDLEY will dispose of the samples ten (10) days after the date of this report. Samples consumed by laboratory testing procedures were discarded immediately after testing.

3.0 LABORATORY TESTING PROGRAM

The laboratory testing program was orientated in obtaining additional information on select soil samples recovered from the borings so that the soils could be classified in accordance with ASTM D2487 – *Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)*. The specific tests performed as part of the laboratory testing program, along with the number of each test, are summarized below in Table 1.

Table 1. Laboratory Classification Testing Procedures

ASTM Designation	Test Description	Number of Test Performed
ASTM D1140	Standard Test Methods for Determining the Amount of Material Finer than 75-µm (No. 200) Sieve in Soils by Washing	8
ASTM D2216	Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock Mass	8
ASTM D4318	Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils	8

The results of the laboratory tests are illustrated on the boring logs found in Attachment B of this report. In addition, the results are summarized below in Table 2. Soils that were not specifically tested in the laboratory were classified in accordance with ASTM D2488 – *Standard Practice for Description and Identification of Soils (Visual-Manual Procedures)* and based on similarities with soil samples that were tested in the laboratory.

Table 2. Summary of Laboratory Classification Test Results

Range in Material Finer than No. 200 Sieve (%)	Range in Moisture Content (%)	Range in Liquid Limit (LL)	Range in Plastic Limit (PL)	Range in Plasticity Index (PI)
31.3 – 99.0	9.9 – 31.0	35 – 93	17 – 26	18 – 67

4.0 SITE CONDITIONS

4.1 SURFACE CONDITIONS

Based on observations made during drilling operations, the project site is mostly vegetated by trees and some short grasses. In addition, the project site is bordered by existing residences. There did not appear to be any obvious surface features, such as open bodies of water or drainage channels, within the project area during drilling operations or in readily available historic aerial photographs dating back to 1995.

4.2 SUBSURFACE CONDITIONS

The subsurface conditions encountered at the borings is presented in detail on the boring logs found in Attachment B of this report. The boring logs should be reviewed for a detailed description of the stratigraphy encountered at each boring. In summary, the subsurface stratigraphy encountered during drilling consisted of clays and sands. More specifically, CH type soils (high plasticity or fat clays) were encountered in the lower portions of the stratigraphy at both borings and within the upper 2 feet at boring B-2. The consistency or strength of the CH type soils was estimated to range from stiff to hard. Alternatively, the sands were classified as either SC type soils (clayey sands) or SM type soils (silty sands) and were encountered at the upper and middle portions of the stratigraphy at both boring locations. The relative density or strength of the sands was estimated to range from very loose to dense, with very loose sands only encountered in the upper 2 feet of the stratigraphy at boring B-1.

4.3 WATER LEVEL OBSERVATIONS

Perched water or groundwater was not encountered in the borings during or immediately after the completion of drilling operations. The boreholes were subsequently backfilled with soil cuttings, and as a result, long-term water level readings could not be obtained for the project. It should be noted that subsurface water levels might change and can vary with seasonal rainfall patterns, long-term climate fluctuations, and with the influence of local site conditions. Therefore, the absence or presence of water during the subsurface investigation does not mean that subsurface water will not be present or will be present at the same depth during construction or over the design life of the structures.

5.0 ANALYSIS

Key considerations in the design of structures in this geographical area include: (1) the strength and settlement characteristics of the foundation soils, (2) the volumetric stability or potential shrink/swell movements of the foundation soils, and (3) seismic loading conditions for the project area. Each of these considerations is addressed in more detail in the following subsections based on the information compiled during the subsurface investigation and laboratory testing program.

5.1 STRENGTH AND SETTLEMENT

In general, the soils encountered at the boring locations exhibited enough strength to support the loads typically associated with a one- to two-story residential structure. Therefore, strength and settlement will not be a primary consideration in the design of the foundation system for the buildings. However, it should be recognized that weak soils were encountered within the upper 2 feet at boring B-1. Therefore, weak surficial soils may be encountered during construction. This is especially true if construction operations are initiated during or shortly after significant rainfall. If weak surficial soils are encountered at the time of construction, the soils should be removed from the building pad area prior to the placement of fill or foundation elements. However, under no circumstance shall more than 2 feet of existing soils be removed from a failed proof rolling area without first contacting DUDLEY for further evaluation and direction.

5.2 VOLUMETRIC STABILITY

5.2.1 Moisture and Movement Active Zone

The moisture active zone was estimated for the project site based on unsaturated soil mechanics and typical changes in climatic conditions for the Montgomery, Texas area. Based on these considerations and the soils encountered at the boring locations, the moisture active zone was estimated to extend approximately 12 feet below the existing ground surface.

The design movement active zone is almost always shallower than the moisture active zone. Based on unsaturated soil mechanics and horizontal flow, the design movement active zone was estimated to extend approximately 6 feet below the existing ground surface.

Assumptions related to the estimated depth of the movement active zone include the following: (1) measures are taken to protect against ponding of water at the ground surface and lateral flow of water from on and off site and (2) protections must be implemented against accidental subsurface leaks, such as the lining of pressurized utility lines and an associated subsurface drainage system above the poly sheeting or the installation of devices to continuously monitor leaks and shut off water supply as needed. **Failure to address these measures and/or protections could result in deep-seated swells below the estimated movement active zone and could result in volumetric movements greater than those estimated in the following subsections of this report**.

5.2.2 Shrink/Swell Potential

Calculations were performed to estimate the magnitude of total potential swell movements in the subsurface soils based upon Texas Department of Transportation (TxDOT) Test Method Tex-124-E (Updated January 2017). Under this methodology, the magnitude of swell movement is referred to as potential vertical rise (PVR). Based upon the soils encountered in the estimated movement active zone, PVR was computed to be approximately 1.5 inches or less for the dry-to-wet condition.

Calculations were also performed to estimate the magnitude of potential shrink/swell movements in the subsurface soils based upon the methodology outlined in the 3rd Edition of the Post-Tensioning Institute (PTI) publication entitled *Design of Post-Tensioned Slabs-on-Ground*. Under this methodology, potential unrestrained differential soil movements were estimated to be approximately 1.25 inches for the post-construction center-lift condition, i.e., wet-to-dry conditions, and 2.0 inches or less for the post-construction edge-lift condition, i.e., dry-to-wet condition. The estimated movements did not consider the presence of perimeter vertical moisture barriers.

5.2.3 Site Improvement Techniques

5.2.3.1 Excavation and Replacement

The excavation and replacement scheme is one (1) of the most effective site improvement techniques for reducing potential shrink/swell movements beneath a structure. However, preventative measures must be implemented to prevent water from infiltrating into the higher permeability select fill soils and migrating downward to clays present below the estimated zone of seasonal moisture fluctuation and movement active zone. This site improvement technique involves the excavation or removal of a significant depth of volumetrically unstable clays from the upper portions of the stratigraphy and the replacement of the existing soils with select fill soils prone to low magnitudes of shrink/swell movements. Potential reductions in volumetric movements through the excavation and replacement scheme are summarized below in Table 3.

Table 3. Reductions in Volumetric Movements by Placing Compacted, Select Fill

Excavation & Replacement Thickness (feet)	Estimated PVR (inches) Note 1 & Note 3	Estimated Unrestrained Differential Soil Movements (inches) Note 2 & Note 3
1 foot or less	1.25 inches or less	2.0 inches or less
2 feet	1.0-inch or less	1.25 inches or less
4 feet	Less than 1.0-inch	1.0-inch or less

Table 3 Notes:
1. Computed using Tex-124-E.
2. Computed using the 3rd Edition of the PTI publication. Does not consider reductions associated with the installation of vertical moisture barriers.
3. Deep-seated swell movements associated with poor drainage or breaks in utility lines have been excluded from the estimated unrestrained differential soil movements.

5.2.3.2 Vertical Moisture Barriers

Table 4 on the following page provides reductions in the estimated unrestrained differential soil movement based on the installation of perimeter vertical moisture barriers. The installation of vertical moisture barriers along the perimeter of the building can also assist with reducing unrestrained differential soil movements. The primary effect of moisture barriers is to extend edge effects away from the foundation and to minimize fluctuations of water content directly below the structure. Moisture barriers will not eliminate volumetric movements due to shrinking or swelling of the foundation soils. However, volumetric movements will generally occur slower and in a more uniform fashion.

Table 4. Reductions in Volumetric Movements with Vertical Moisture Barriers

Select Fill Pad Thickness (feet)	Vertical Moisture Barrier Depth Note 1 & Note 3	Estimated Post-Construction Unrestrained Differential Soil Movements (inches) Note 2 & Note 3
1 foot or less	2 feet	1.75 inches or less
1 foot or less	4 feet	1.5 inches or less
2 feet	4 feet	1.0-inch or less

Table 4 Notes:

1. Depth below adjacent ground surface established following construction.
2. Computed using the 3rd Edition of the PTI publication.
3. Deep-seated swell movements associated with poor drainage or breaks in utility lines have been excluded from the estimated unrestrained differential soil movements.

The vertical moisture barriers usually consist of an excavated trench lined with any impermeable membranes such as polyethylene, concrete, or impervious semi-hardening slurries. Polyethylene membranes should be durable enough to resist puncture and tearing during construction. A minimum thickness of 30 mils is recommended. Concrete or impervious semi-hardening slurries should have a minimum thickness of 6 inches; however, larger thickness may be more practical from a construction standpoint.

5.3 SEISMIC LOADING CONDITIONS

Based on the soils encountered at the boring locations and our experience with soils generally encountered in the upper 100 feet of the stratigraphy in this geographic area, Site Class D is recommended for the project site. Table 5 below summarizes basic seismic design parameters that were determined based on the Site Class, the project location, and the provisions outlined in ASCE/SEI 7-16 – *Minimum Design Loads and Associated Criteria for Buildings and Other Structures*.

Table 5. Seismic Design Parameters

Parameter	Description	Value
S_S	MCE_R ground motion (period = 0.2s)	0.070 g
S_1	MCE_R ground motion (period = 0.1s)	0.042 g
S_{DS}	Numeric seismic design value at 0.2s SA	0.075 g
S_{D1}	Numeric seismic design value at 0.1s SA	0.067 g

6.0 FOUNDATION RECOMMENDATIONS

Based on the results of the subsurface investigation and laboratory testing program, it is DUDLEY's opinion that a subgrade supported foundation system may be considered for foundation support of the proposed residences. However, the foundation systems must be designed to resist differential volume change in the foundation soils and to prevent structural damage to the supported structures as outlined in the 2021 International Residential Code or previous additions of the building code. The risk associated with a subgrade supported foundation system is outlined below in Table 6 based on ranges in unrestrained differential soil movement in the foundation soils.

Table 6. Subgrade Supported Foundation System Risk

Range in Potential Unrestrained Differential Soil Movement	Perceived Level of Risk for Structures with Limited Movement Sensitive Finishes	Perceived Level of Risk for Structures with Extensive Movement Sensitive Finishes
≤ 1.0-inch	Very Low	Low
Between 1.0-inch and 2.0 inches	Low	Low to moderate
2.0 inches to 4.0 inches	Low to moderate	Moderate to high
> 4 inches	Moderate to high	High to very high

Based on the existing conditions encountered at the borings and the assumption that at least 2 feet of select fill will be required beneath the building for grading purposes, the risk associated with the project site would be considered **low to moderate** if limited movement sensitive finishes are associated with the proposed structure. Alternatively, the risk would be considered **moderate to high** if extensive movement sensitive finishes are associated with the structure. Reductions in the perceived level of risk may be achieved by considering the prevalence of movement sensitive finishes along the interior and exterior of the structure and by implementing one or more of the site improvement techniques previously outlined in Section 5 to achieve the desired level of performance. For stiffened and reinforced, subgrade supported foundations, the term risk is generally associated with cosmetic and maintenance related issues, including but not limited to, cracking in movement sensitive elements, doors and windows sticking, unlevel floor surfaces, etc.

The levels of risk previously outlined in Table 6 assume that positive drainage and vegetation control will be established around the perimeter of the building as outlined in Section 8. In addition, it assumes that the shape factor for the building does not exceed 32 and that the simplified shape factor (combined overlapping rectangle perimeter^2/area of overlapping rectangles) does not exceed 24. If either of these factors are exceeded, the designer should considered one (1) or more of the following: (1) modification to the foundation footprint to reduce the shape factor, (2) strengthened foundation systems (additional stiffening ribs and deepened ribs in areas of high torsion or non-prestressed reinforcement), or (3) geotechnical approaches (such as moisture barriers, excavation/replacement, moisture conditioning, or moisture injection) to reduce potential unrestrained differential soil movements to approximately 1.0-inch or less.

7.0 FOUNDATION DESIGN PARAMETERS

7.1 GENERAL DESIGN PARAMETERS

Shallow foundation elements should be designed to resist potential axial, uplift, and lateral loading conditions. Specific shallow foundation element design parameters for these loading conditions are provided below in Table 7 for shallow foundation elements founded in either existing on-site soils or compacted, select fill soils. The actual bearing soils for grade beam elements will depend on the thickness of select fill placed beneath the buildings and the required depth of the grade beams as determined in Section 7.2.

Table 7. Shallow Foundation Design Parameters

Minimum Founding Depth Note 1	Exterior foundation elements: 12 inches below adjacent ground surface
	Interior foundation elements: 12 inches below proposed finished floor elevation
Minimum Width	10 inches
Allowable Unit Base Resistance Note 2	2,250 psf (maximum loading, FS = 2.0)
	1,500 psf (sustained loading, FS = 3.0)
Estimated Footing Movement based on Sustained Loading	Maximum settlement: 1.0-inch or less
	Differential settlement: 0.75 inches or less
Lateral Sliding Resistance	Coefficient of friction – 0.36 (FS = 1.5)
Modulus of Subgrade Reaction for 1-ft by 1-ft Plate	175 psi/in (slab supported by compacted, select fill)
	100 psi/in (slab supported by existing on site soils passing proof rolling observations)

Table 7 Notes:
1. Deeper founding depths may be required based on the design parameters furnished in Section 7.2.
2. Unit base resistance values can be increased by a factor of 1.33 if 4 feet of compacted, select fill is placed beneath the foundation as part of the excavation and replacement site improvement technique.

7.2 SHRINK/SWELL DESIGN PARAMETERS

As outlined in Section 1808.6 – *Design for expansive soils* of the 2021 International Building Code, moments, shears, and deflections for use in designing slab-on-ground, mat, or raft foundation supported by expansive soils shall be determined in accordance with WRI TF 700-R-07, PTI DC 10.5, or another rational design methodology. The following subsections provide geotechnical design parameters that can be utilized by the Structural Engineer for the WRI and PTI design methods. The recommended design parameters do not consider the potential effects of non-climatic factors. These conditions include, but are not limited to, the location of trees and planters around the structure, poor drainage conditions and/or breaks in utility lines.

7.2.1 WRI Design Parameters

Design information related to the WRI design method for subgrade supported foundations is provided below in Table 8. The design parameters were formulated based on a climatic rating (C_w) of 20, which is representative of drought durations on the order of 2.5 months. Table 8 provides design parameters for existing conditions and variable thickness of select fill that may be placed as part of grading operations and/or site improvements techniques orientated toward the excavation and replacement scheme.

Table 8. WRI Design Parameters

Excavation & Replacement Thickness	Effective Plasticity Index (PI)	Soil Climatic Rating (1 – C)
1 foot or less	30	0.15
2 feet	25	0.12
4 feet	20	0.10

Table 8 Notes:

1. The WRI/CRSI design procedure was formulated to limit deflections to L/480. The Structural Engineer should consider deeper beam depths and/or closer beam spacings than those computed using the WRI/CRSI procedure if stricter deflection criterion is required.

7.2.2 PTI Design Parameters

7.2.2.1 Excavation and Replacement

Design information related to the PTI design method for subgrade supported foundations is provided below in Table 9 for existing conditions and variable thicknesses of compacted, select fill. The design parameters were formulated based on a Thornthwaite Moisture Index (I_m) of +15, an equilibrium section of 4.1 pF, and an equilibrium suction depth of 12 feet.

Table 9. PTI Design Parameters

Excavation & Replacement Thickness	$e_{m\text{-center}}$ (feet)	$e_{m\text{-edge}}$ (feet)	$y_{m\text{-center}}$ (in)	$y_{m\text{-edge}}$ (in)
1-foot or less	9.0	4.7	1.25	2.0
2 feet	9.0	4.7	0.75	1.25
4 feet	9.0	4.7	0.5	1.0

7.2.2.2 Vertical Moisture Barriers

Design information related to the PTI design method for subgrade supported foundations is provided below in Table 10 for perimeter vertical moisture barriers that extend below the adjacent ground surface following the completion of construction.

Table 10. PTI Design Parameters for Perimeter Vertical Moisture Barriers

Select Fill Pad Thickness	Vertical Moisture Barrier Depth (ft) Note 1	$e_{m\text{-center}}$ (feet)	$e_{m\text{-edge}}$ (feet)	$y_{m\text{-center}}$ (in)	$y_{m\text{-edge}}$ (in)
1-foot or less	2 feet	8.8	4.3	1.0	1.75
1-foot or less	4 feet	7.0	2.7	0.75	1.5
2 feet	4 feet	7.0	2.7	0.5	1.0

7.2.2.3 Initial Tendon Stressing

A coefficient of friction of 0.75 is recommended for initial tendon stressing when the slab is cast directly on a polyethylene sheet. A coefficient of friction of 1.0 is recommended for initial tendon stressing when the slab is cast on a sand layer without a polyethylene sheet.

Reference Table 7 for recommended coefficient of friction or adhesion when evaluating sliding due to environmental forces such as wind.

7.3 ARCHITECTURAL AND STRUCTURAL ELEMENT DETAILING

The superstructure and architectural elements of the proposed buildings shall be designed to accommodate the potential shrink/swell movements or consolidation of the foundation soils. Jointing of interior dry walls above door and window openings and the use of slip joints between dry wall panels should be considered. If movement-sensitive floor coverings, such as ceramic tile, marble, or wood, must be placed in the structure, we recommend that strong consideration be given to the use of geotextile reinforcement layers and/or underlayment layers between the floor coverings and the slab. Also, the tile should be frequently jointed to minimize the manifestation of distress cracking associated with slab movement. The use of flexible plumbing connections for water and sewer piping can help reduce, but not eliminate, potential leakage frequently associated with slab movements. Similarly, the employment of "through-slab" sleeves for rigid electrical conduit can help to minimize distress to the electrical system. Furthermore, all drainage piping and general plumbing piping systems associated with the building or in proximity to the buildings should be leak tested following installation. Water produced from any leaks in drainage or pressure piping following construction could produce localized swelling movements in the foundation soils. The swelling movements may be of a greater magnitude than is typically associated with seasonal moisture variations as previously discussed in this report. These increased swelling movements could result in distress to foundation elements and the building superstructures.

8.0 CONSTRUCTION CONSIDERATIONS

8.1 SITE PREPARATION

8.1.1 Stripping and Clearing

Any vegetation existing within the building areas prior to construction shall be removed. In addition, any remaining organic matter and topsoil, as well as any weak, or wet soils, shall be stripped and removed from the building areas. The removal of the vegetation should include all roots, including the major root systems associated with large trees, both currently existing as well as previously existing on the site. The removal of the major root systems should include any desiccated soils present within the root bulbs of the trees. If the existing vegetation and organic materials are not removed from the proposed buildings, it is possible that the existing vegetation will interfere with the proposed construction and could potentially adversely impact the future performance of the proposed structures.

8.1.2 Proof Rolling

Prior to placing any fill soils, proof rolling should be performed with a 15-ton pneumatic roller or equivalent vehicle to identify weak surficial soil formations. Any weak surficial soils identified during proof rolling should be removed and replaced with acceptable fill. For the purposes of this report, weak soils are defined as soil exhibiting rutting deeper than 2 inches or elastic deformations greater than 1-inch during proof rolling observations.

8.1.3 Site Balancing

Site balancing may be required beneath some of the building areas due to the difference in ground surface elevation currently present across the site. Following stripping and clearing operations, the soil located on the high side of the site may be excavated and re-purposed on the low side site to level the pad(s) prior to the placement of compacted, select fill. The material re-purposed on the low side of the structure(s) beneath the compacted, select fill pad shall have a maximum plasticity index (PI) of 25. The soils used for site balancing shall be compacted to at least 95 percent of the maximum dry density determined in accordance with ASTM D698 (Standard Proctor). The moisture content shall be between the OMC and 4 percentage points above the OMC, inclusive.

8.2 BUILDING PAD DESIGN

8.2.1 Subgrade Preparation

Prior to placing any select fill soils, the exposed subgrade shall be scarified to a depth of 6 inches. The moisture content of the scarified soils shall be adjusted to at least the optimum moisture content and the soils shall be compacted to at least 95 percent of the maximum dry density determined in accordance with ASTM D698 (Standard Proctor).

8.2.2 Perimeter Clay Cap

If the excavation and replacement scheme is implemented or if select fill soils are placed to elevate the building pads, the select fill building pads should be of a uniform thickness to minimize potential differential movements in the foundation system. DUDLEY also recommends that the limits of the select fill pad should not extend beyond the face of the foundation elements. Otherwise, the more moisture permeable soils of the select fill pad, which extend beyond the face of the foundation system, could serve as preferential pathways for moisture migrating from outside the structure area to collect within the select fill pad (also referred to as the "bathtub effect"). This collected moisture could infiltrate into the clays still present within the stratigraphy following construction of the select fill pad and could result in increased magnitudes of swelling above those predicted in this report.

If the owner, designer, or contractor selects to extend the select fill pad beyond the foundation perimeter, a low permeability clay cap or approved equivalent is highly recommended to help minimize moisture infiltration into the select fill soil pad. The low permeability, clay "cap" should have a plasticity index (PI) between 20 and 35, inclusive, and shall be at least 1-foot in thickness. Compaction of the clay cap should be above the optimum moisture content (OMC) and at least 92 percent of the maximum dry density as determined by ASTM D698 in non-structural areas and 95 percent in structural areas. Alternatively, perimeter grade beams may be extended below the select fill pad to minimize stormwater infiltration.

There are certain situations where foundation elements such as drilled piers, continuous footings, spread footing, etc. may extend beyond the perimeter of the building. In this case, the select fill building pad must extend beyond the limits of these foundation elements, i.e. generally 3 to 5 feet. The clay "cap" previously referenced above and/or flatwork should be provided beyond the extended select fill building pad in these situations in order to minimize the potential for the development of the "bathtub effect".

8.3 FILL PLACEMENT REQUIREMENTS

Select fill used to replace weak surficial soils, to elevate the building pad above the existing ground surface to achieve drainage requirements, or as part of the excavation and replacement scheme should meet the material and compaction requirements outlined on the following page in Table 11. Compaction characteristics of the select fill shall be verified by in-place density tests. The tests should be performed on each 6-inch-thick lift at an average rate of one (1) test for every 2,000 square feet of plan area for the building pad. A minimum of three (3) tests should be performed for each distinct lift of fill.

Table 11. Select Fill Requirements

Unified Soil Classification System (USCS)	Plasticity Index (PI)	Compaction Standard	Dry Unit Weight Note 1	Moisture Content Note 2
SC or CL	7 to 20, inclusive	ASTM D698	≥ 95% D_A	W_{OPT} – 2% to W_{OPT} + 3.0%, inclusive

Table 11 Notes:
1. Maximum dry unit weight (D_A) determined in accordance with ASTM D698.
2. Optimum moisture content (W_{OPT}) determined in accordance with ASTM D698.

8.4 SURFACE GRADING AND DRAINAGE

Grading across the site and around the perimeter of the building is one of the most important factors in minimizing infiltration of surface water into the foundation soils. It is extremely important, particularly in areas where expansive soils are present, that water drains away from the foundation and not be allowed to pond against or near the foundation. Adequate slope of the ground surface is critical. The ground surface immediately adjacent to the building foundation shall be sloped away from the building at a slope of not less than 5 percent and, preferably more, for a minimum distance of 10 feet. In addition, small irregularities in the ground surface should be avoided over this 10-foot distance to prevent micro-ponding and subsequent surface water infiltration into the foundation soils. A slope of 2 percent is also recommended beyond this 10-foot distance. Impervious surfaces, such as flatwork or paving, within 10 feet of the building perimeter, should also be sloped not less than 2 percent. The minimum slopes are perpendicular to the perimeter of the foundation and not parallel to it. Slopes that are parallel to the foundation perimeter will distribute water along the foundation instead of removing it and result in surface water infiltration into the foundation soils. Finally, the slopes established on the site grading plan should consider maximum settlements outlined for the building foundation and any backfill placed adjacent to the foundation.

If physical obstructions or lot lines prohibit the 10-foot minimum horizontal distance, a 5 percent slope shall be established to an approved alternative method for diverting water away from the foundation. An approved alternative method would consist of a subsurface drainage system or swale. The subsurface drainage system or swale shall be sloped not less than 2 percent and must continue to divert water away from the foundation. The subsurface drainage system would generally consist of rigid perforated pipe, granular backfill, and a geotextile fabric or poly-liner. Furthermore, the subsurface drainage system would discharge into a sump, and area drain, or a suitable gravity outlet. If a sump is used, it must be equipped with a pump to drain water flowing into the sump. The pump should preferably discharge to an area-wide drainage system located well away from the foundation.

The roof drainage system, i.e. gutters and downspouts, serves to collect water from precipitation to carry it away from the foundation. The downspouts should be tight lined to extend at least 5 feet and, preferably 10 feet, beyond the perimeter of the foundation. This generally consist of connecting the downspouts to piping that will carry water to a sloping final grade at least 5 feet from the foundation or to an underground catchment system at least 10 feet from the foundation. This will reduce the chances of providing a supplemental source of water to the foundation soils and subsequent swelling movements.

8.5 VEGETATION CONTROL AND CLEARING PRACTICES

The effect of vegetation on expansive soil movement is dictated by the depth and extent of the root zone and the cracks in the soil that are generated by the growing roots. Trees and large vegetation near the foundation, either removed or planted during construction, cause most foundation problems requiring repair. Trees and large vegetation removed during construction tend to cause heave due to rehydration or increases in soil-moisture. This change in moisture generally occurs over a 5-year period, with approximately 50 percent of the moisture increase occurring over the first year of vegetation removal.

Trees planted within half of their mature height from the edge of the foundation have caused differential foundation movement because the root systems remove large quantities of water from the soil. If trees and large vegetation are planted near the foundation and if sufficient water is not supplied, the foundation soils may shrink resulting in subsidence in the foundation. Significant subsidence distress will usually not occur for 10 to 20 years as the tree matures. During dry periods, enough water should be supplied to trees to minimize shrinkage of expansive soils. Irrigation water should also be applied well away from the foundation to attract the tree roots in that direction. New trees and large vegetation should be planted away from the foundation. The rule of thumbs is that a tree should be at least 1 to 1.5 times its mature height away from the foundation. If trees are planted well away from the foundation in irrigated areas, the chances of subsequent foundation damage will be minimized.

On expansive soils, the main landscaping goal should be to minimize fluctuations in soil water content. Proper surface drainage, plant choices, sprinkling practices, and long-term maintenance are all important. Landscaping practices will have a significant influence on the wetting of the foundation soils. Xeriscape landscaping or landscaping requiring little or no irrigation should be considered within the first 5 to 10 feet of the foundation perimeter. This will eliminate the need for supplemental water from irrigation. Furthermore, sprinkler systems should be directed away from the foundation and should not spray water within 5 feet of the foundation. Landscaping practices must also be careful to maintain positive drainage away from the foundation. Watering should be limited to the minimum needed to maintain the landscaping. Furthermore, landscaping should not trap water against the foundation. Metal edging or other damming devices within 5 feet of the foundation should be avoided.

8.6 SHALLOW FOUNDATION CONSIDERATIONS

DUDLEY strongly recommends the prompt placement of concrete into the footing excavations immediately following completion of digging, cleaning, placement of reinforcing steel, and inspection of the excavation. Precautions should be taken during placement of the reinforcement and concrete to prevent any loose excavated soil from entering the excavation. Any clods of earth that slump into the footing excavation during concrete placement should be promptly removed. DUDLEY should also be contacted if the shallow foundation excavations become impacted by rainfall events that result in weak layers at the base of the excavations.

8.7 UTILITY TRENCH PROVISIONS

Provisions should be made to discourage the possibility that utility trenches will serve as pathways for water to migrate from areas outside of the structure area to beneath the structure following completion of construction. We recommend that the bottom of the utility trenches be sloped in a downward direction away from the structures. We also recommend that anti-seep collars be employed along the length of all utility trenches and at the face of the structure to serve as a barrier to moisture migration along the granular soils in the trenches to the interior portions of the structures.

9.0 BASIS OF RECOMMENDATIONS

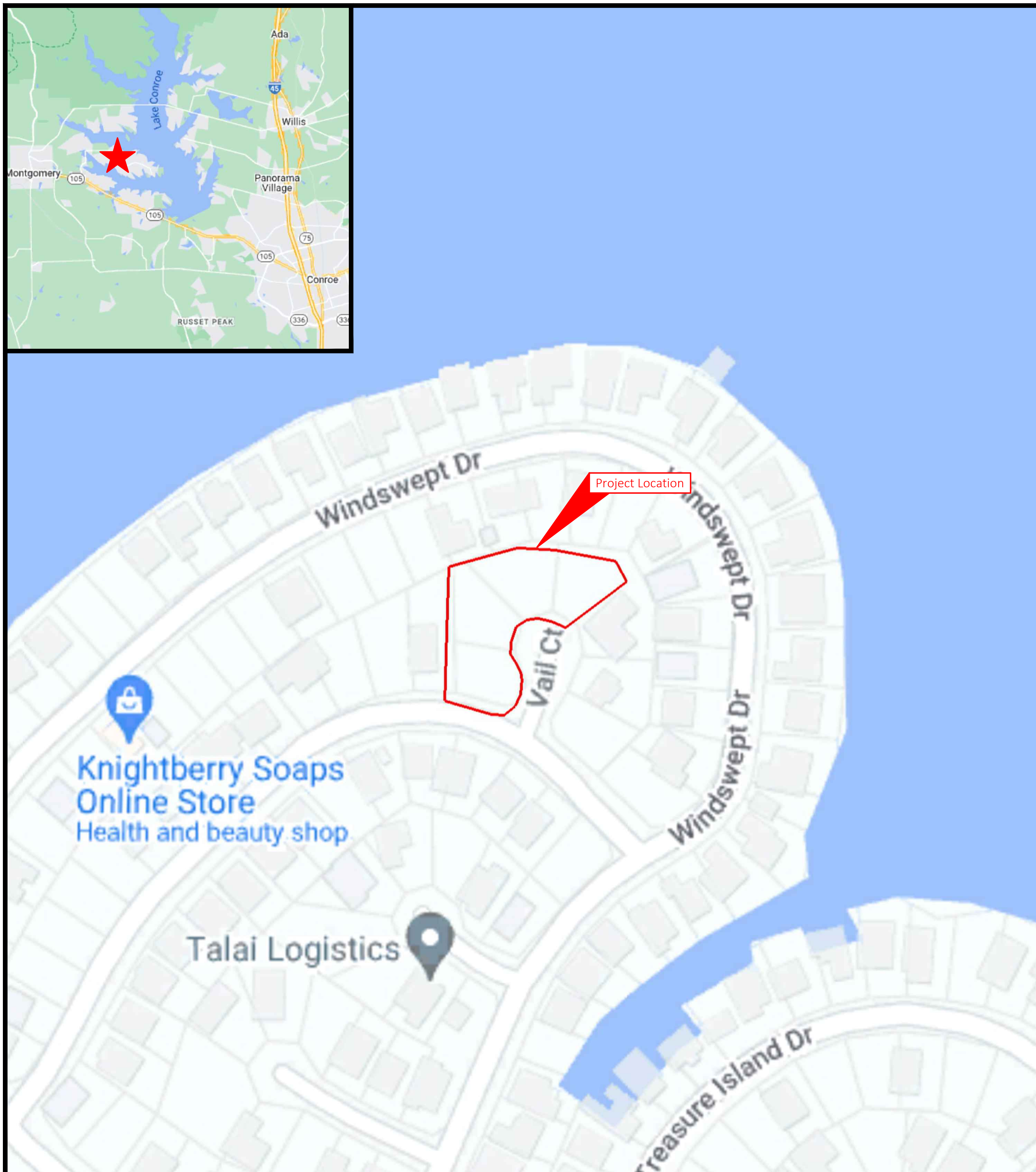
The subsurface information at the site was developed from the subsurface investigation and laboratory testing program and was based upon two (2) widely spaced borings across the project site. The borings were in enough detail and scope to form a reasonable basis for the conceptual planning and design of the foundation system for the proposed residential structures described in this report. Recommendations contained in this report were developed based upon a generalization of the subsurface conditions encountered at the boring locations across the site and the assumption that the generalized conditions are continuous throughout the areas under consideration. However, regardless of the thoroughness of a subsurface exploration, there is always a possibility that subsurface conditions encountered over a given area will be different from those present at specific, isolated boring locations. As a result, actual site conditions may be better or worse than the conditions indicated at the boring locations.

DUDLEY warrants that the findings, recommendations, specifications, or professional advice contained herein have been made in accordance with generally accepted professional engineering practice in the field of geotechnical engineering in this geographic area. No other warranty is implied or expressed.

The information presented in this report was presented for the specific site and the specific structure described in the report. The information should not be employed for the design of other structures or for other projects in the general area of this project without the written consent of DUDLEY.

ATTACHMENT A

Figures



Notes:

Scale:
1" = 200' (In Feet)
0 50' 100' 200' 400'

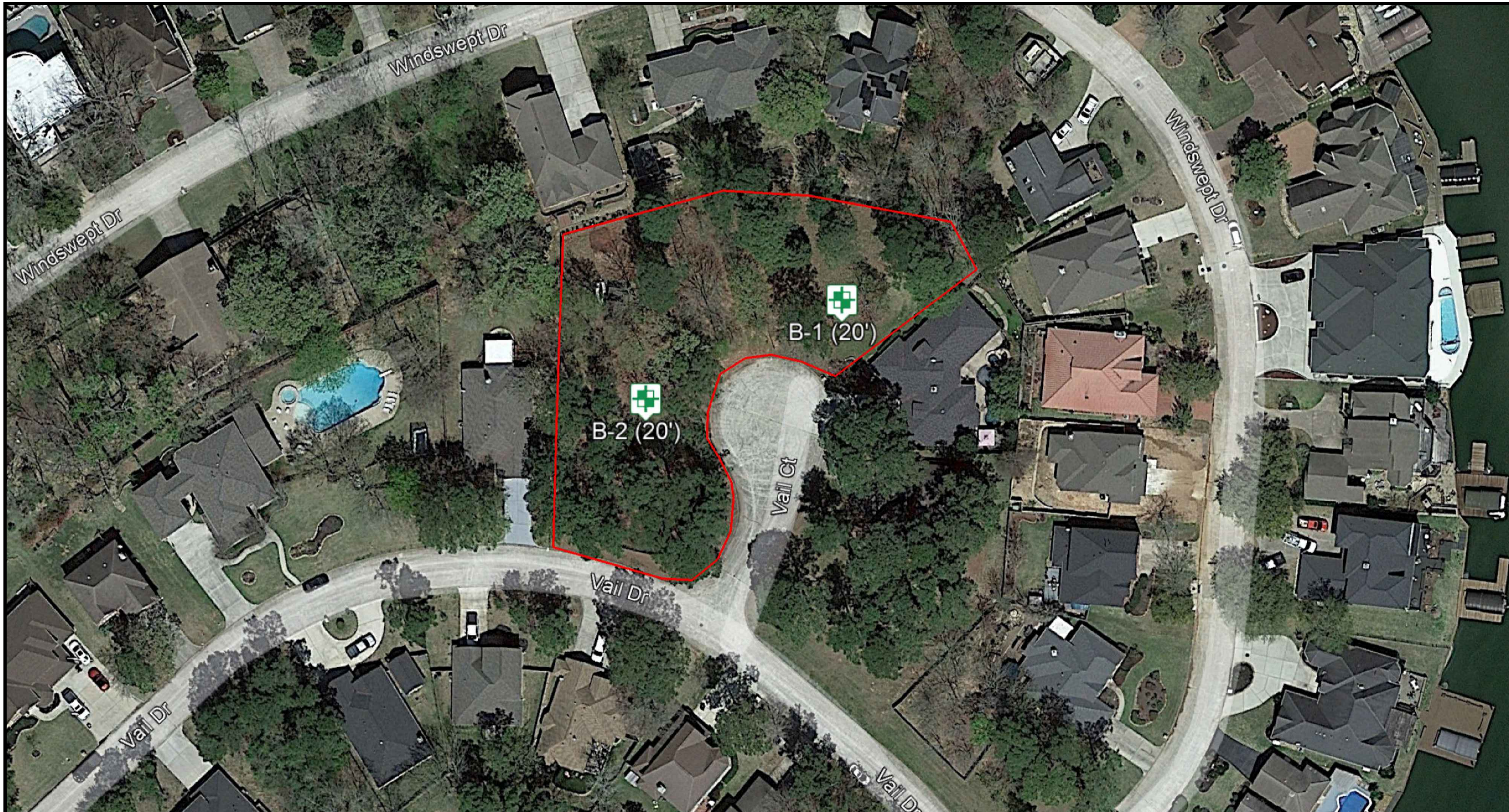
N W E S

Vicinity Map

Cattlemen Single-Family Development

Montgomery, Texas

Source:	Drawn By:	Date:	Project No.:	
Google Maps (2022)	TA	5/09/2023	23-00195	Figure 1



Key:

B-X (X') Boring Location, Designation, & Depth

Scale:

1" = 60' (In Feet)

0 15' 30' 60' 120'

N W E S

Notes:

Plan of Borings
Cattlemen Single-Family Development
Montgomery, Texas

Source: Google Earth (2022), Aerial Date: 03/2022

Drawn By: TA

Date: 5/09/2023

Project No.: 23-00195

Figure 2

ATTACHMENT B

Boring Logs
Log of Borings B-1 and B-2
Boring Log Key

DUDLEY

LOG OF BORING B-1

Cattlemen Single-Family Development
Block 79: Lots 112 to 115
Montgomery, Texas

DUDLEY Project No.: 23-00195

Drill Date: 5/08/2023

Location: Reference Figure 2 - Plan of Borings

Surface Elevation: Unknown

Depth (ft)	Sample	USCS Abbreviation	MATERIAL DESCRIPTION	Pocket Penetrometer Reading (tsf)	Uncorrected SPT N-Value (blows/ft)	Moisture Content (%)	Liquid Limit (LL)	Plastic Limit (PL)	Plasticity Index (PI)	Passing #40 Sieve (%)	Passing #200 Sieve (%)	Additional Laboratory Tests & Remarks
0			Very loose, brown, silty SAND, slightly moist									
	SPT	SC	Very loose to medium dense, reddish brown, clayey SAND, slightly moist	2.5	3	22.7	49	19	30		46.0	
	SPT	SC	-medium dense to dense and grayish-brown below 2'	4.5+	9	18.6	41	17	24		37.4	
5	SPT	SC	-yellowish-brown, light gray and dry below 4'		9	16.7	35	17	18		31.3	
	SPT			3.0	9							
	SPT	CH	Very stiff to hard, pale brown and light gray, fat CLAY, with black staining, slightly moist	4.5+	16	31.0	93	26	67		99.0	
10			-grayish-white, calcareous nodules and slickensides below 10'									
	SPT			4.5+	22							
15			-pale brown and yellowish brown below 15'									
	SPT			4.5+	28							
20			Drilling terminated at 20'									
25												

Field Strength Data: Pocket Penetrometer Reading (tsf) 1.0, 2.0, 3.0, 4.0; Uncorrected SPT N-Value (blows/ft) 20, 40, 60, 80

Natural Moisture Content & Atterberg Limits: Plastic Limit, Moisture Content, Liquid Limit; 20, 40, 60, 80

Sample Key: Split-Spoon (SPT), Shelby Tube, Disturbed, Texas Cone (TCP), Rock Core, No Recovery

Water Level Symbols: During Drilling, After Drilling

Water Level Observations Summary: Borehole dry during and after drilling.

Notes:
1. Borehole drilled with CME 550.
2. Drilling Method - 4" Ø Continuous Flight Augers.
3. Automatic SPT hammer.

LOG OF BORING B-2

DUDLEY

Cattlemen Single-Family Development
Block 79: Lots 112 to 115
Montgomery, Texas

DUDLEY Project No.: 23-00195

Drill Date: 5/08/2023

Location: Reference Figure 2 - Plan of Borings

Surface Elevation: Unknown

Depth (ft)	Sample	USCS Abbreviation	MATERIAL DESCRIPTION	Pocket Penetrometer Reading (tsf)	Uncorrected SPT N-Value (blows/ft)	Moisture Content (%)	Liquid Limit (LL)	Plastic Limit (PL)	Plasticity Index (PI)	Passing #40 Sieve (%)	Passing #200 Sieve (%)	Additional Laboratory Tests & Remarks
0–2	SPT	CH	Stiff to hard, grayish-brown and reddish brown, sandy, fat CLAY, slightly moist	4.5+	14	18.8	52	19	33		51.6	
2–4	SPT	SC	Medium dense to dense, reddish yellow, clayey SAND, dry	4.5+	19	14.4	43	18	25		42.0	
4–6	SPT	SC			25	10.7	36	17	19		33.6	
6–8	SPT	SC	-yellowish brown below 6'	4.5+	25	9.9	42	18	24		44.8	
8–10	SPT		Medium dense, brownish-yellow, silty SAND, with clay pockets, dry		16							
13–15	SPT		Very stiff to hard, light gray, fat CLAY, with black staining, slightly moist		23							
18–20	SPT		-yellow staining and slickensides below 15'	4.5+	16							
20			Drilling terminated at 20'									

Sample Key: Split-Spoon (SPT), Shelby Tube, Disturbed, Texas Cone (TCP), Rock Core, No Recovery

Water Level Symbols: During Drilling, After Drilling

Water Level Observations Summary: Borehole dry during and after drilling.

Notes:
1. Borehole drilled with CME 550.
2. Drilling Method - 4" Ø Continuous Flight Augers.
3. Automatic SPT hammer.

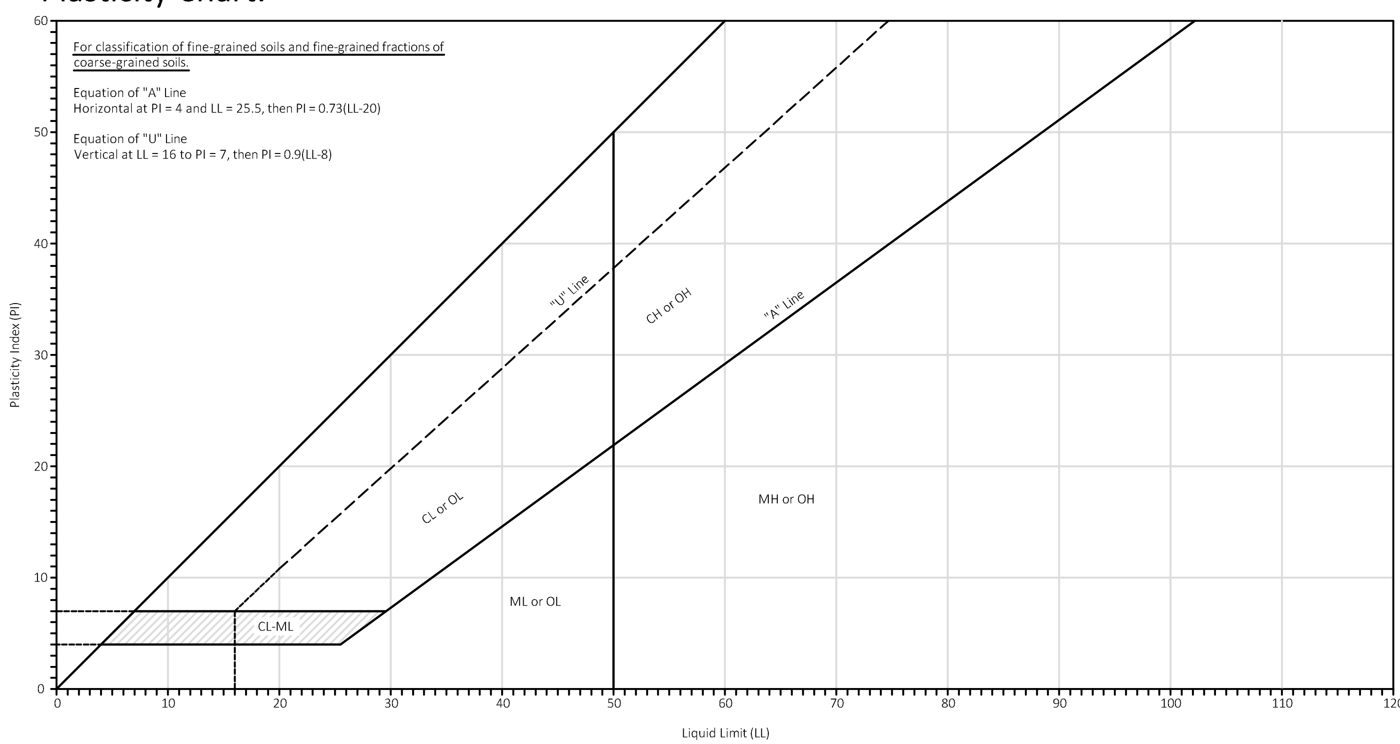
BORING LOG KEY (SHEET 1 OF 2)

Unified Soil Classification System (USCS):

Major Classification Group	Sub-Group		Group Hatch	Group Symbol	Group Name	Laboratory Classification Criteria
Coarse-Grained Soils (> 50% retained on the #200 sieve)	Gravels (> 50% of the coarse fraction is retained on the #4 sieve)	Clean gravels		GW	Well-graded gravel	$C_u \geq 4$ and $1 \leq C_c \leq 3$
				GP	Poorly-graded gravel	$C_u < 4$ and/or $1 < C_c$ or $C_c > 3$
		Gravels with fines		GM	Silty gravel	Fine classify as ML or MH
				GC	Clayey gravel	Fine classify as CL of CH
	Sands (≥ 50% of the coarse fraction passes the #4 sieve)	Clean sands		SW	Well-graded sand	$C_u \geq 6$ and $1 \leq C_c \leq 3$
				SP	Poorly graded sand	$C_u < 6$ and/or $1 < C_c$ or $C_c > 3$
		Clean gravels		SM	Silty sand	Fine classify as ML or MH
				SC	Clayey sand	Fine classify as CL of CH
Fine-Grained Soils (≥ 50% passes the #200 sieve)	Silts and clays with liquid limit < 50%			CL	Low plasticity or lean clay	PI > 7 and plots on or above "A" line (Must fall outside CL-ML hatched area)
				ML	Low plasticity silt	PI < 4 and plots below "A" line (Must fall outside CL-ML hatched area)
				OL	Low plasticity organic silt or clay	LL ratio < 0.75
	Silts and clays with liquid limit ≥ 50%			CH	High plasticity or fat clay	PI plots on or above "A" line
				MH	High plasticity elastic silt	PI plots below "A" line
				OH	High plasticity organic silt, organic clay	LL ratio < 0.75
Highly organic soils				Pt	Peat	

Prefix: G = Gravel, S = Sand, M = Silt, C = Clay, O = Organic
Suffix: W = Well-Graded, P = Poorly-Graded, M = Silty, L = Clay with LL<50%, H = Clay with LL≥50%
Ref. ASTM D2487 for dual symbol and modifier requirements.

Plasticity Chart:



BORING LOG KEY (SHEET 2 OF 2)

Gradation:

Particle Description	Particle Size (mm)	Retaining U.S. Sieve Size
Boulder	75 - 300	12"
Cobble	75 - 300	3"
Coarse Gravel	19 - 75	3/4"
Fine Sand	4.75 - 19	No. 4
Coarse Sand	2.0 - 4.75	No. 10
Medium Sand	0.42 - 2.0	No. 40
Fine Sand	0.075 - 0.42	No. 200
Silt	0.002 - 0.075	Hydrometer Analysis Required
Clay	< 0.002	

Volumetric Stability:

Liquid Limit (LL)	Swell Potential Classification
< 20	None/Very Low
20 - 35	Low
35 - 50	Moderate
50 - 70	High
70 - 90	Very High
> 90	Extremely High

Cohesionless Soil Strength:

Sands and Gravels				
Relative Density (Description)	N_{SPT} (blows/ft)	N_{TCP} (blows/ft)	Friction Angle (degrees)	Relative Density (%)
Very Loose	0 - 4	0 - 8	< 30	0 - 20
Loose	4 - 10	8 - 20	30 - 32	20 - 40
Medium Dense	10 - 30	20 - 60	32 - 37	40 - 70
Dense	30 - 50	60 - 100	37 - 42	70 - 90
Very Dense	> 50	> 100	> 42	90 - 100

Cohesive Soil Strength:

Silts and Clays			
Consistency	N_{SPT} (blows/ft)	N_{TCP} (blows/ft)	Unconfined Compressive Strength (tsf)
Very Soft	0 - 2	0 - 3	< 0.25
Soft	2 - 4	3 - 6	0.25 - 0.5
Firm	4 - 8	6 - 11	0.5 - 1.0
Stiff	8 - 16	11 - 22	1.0 - 2.0
Very Stiff	16 - 32	22 - 45	2.0 - 4.0
Hard	> 32	> 45	> 4.0

Dynamic Cone Penetrometer:

Penetration Range (mm/blow)	Penetration Range (in/blow)	Approximate California Bearing Ratio (CBR)	Approximate Mid-Range k-value (psi/in)
< 4	< 0.16	> 70	> 450
4 - 5	0.16 - 0.20	50 - 70	400 - 450
5 - 8	0.20 - 0.31	30 - 50	350 - 400
8 - 14	0.31 - 0.55	15 - 30	250 - 350
14 - 19	0.55 - 0.75	10 - 15	200 - 250
19 - 25	0.75 - 0.98	7 - 10	150 - 200
25 - 30	0.98 - 1.18	3 - 7	80 - 150
30 - 35	1.18 - 1.38	1 - 3	< 80
> 35	> 1.38	< 1	< 50

Sulfate Induced Heave Risk:

Risk	Soluble Sulfate Concentration (PPM)
Low	< 3,000
Moderate	3,000 - 5,000
Moderate to High	5,000 - 8,000
High to Unacceptable	> 8,000
Unacceptable	> 11,000

Rock Strength:

Hardness	N_{SPT} (blows/ft)	N_{TCP} (in./100 blows)	Unconfined Compressive Strength (psi)
Very Soft	1 - 30	> 6 in./100	< 4,000
Soft	30 - 50	4 in. - 6 in./100	4,000 - 8,000
Hard	50 - 100	1 in. - 5 in./100	8,000 - 16,000
Very Hard	1 - 30	0 in. - 2 in./100	16,000 - 32,000
Extremely Hard	No Penetration	No Penetration	> 32,000

Rock Quality:

Rock Description	Rock Quality Designation (RQD)
Very Poor	< 0.25
Poor	0.25 - 0.50
Fair	0.50 - 0.75
Good	0.75 - 0.90
Excellent	> 0.90

Moisture:

Description	Meaning
Dry	No water evident in sample. Moisture content less than plastic limit.
Moist	Sample feels damp. Moisture content at or slightly above plastic limit.
Very Moist	Water visible on sample. Moisture content between plastic limit and liquid limit.
Wet	Sample contains free water.